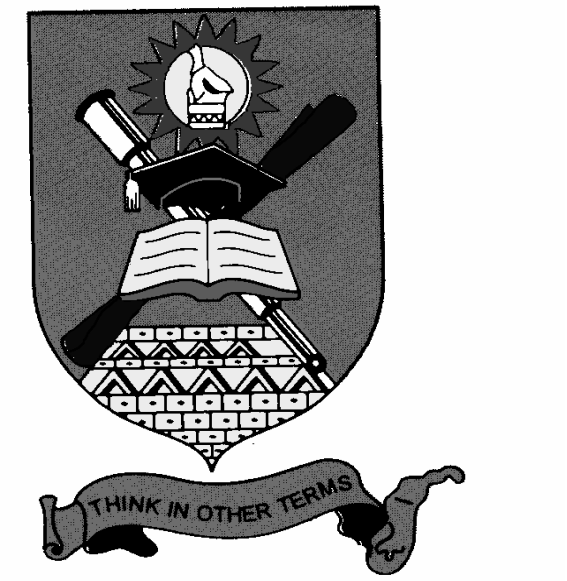
Proceedings from the 2nd International Conference on Appropriate Technology

Bulawayo, Zimbabwe
July 12-15, 2006

Hosted by the National University of Science and Technology (NUST)



Theme

Sharing the Knowledge from Research and Practice in Appropriate Technology, with a focus on Health-Related projects

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Sharing the Knowledge from Research and Practice
In Appropriate Technology with a Focus on Health-Related projects

The theme of our second international conference on 'Appropriate Technology' is designed to:

1) Facilitate the management, assessment, archiving and tracking of appropriate technology research and practical projects through the use of state of the art knowledge management practices
2) Focus on increasing the productivity and visibility of health related projects in a sustainable fashion, while being inclusive of all areas related to appropriate technology.

Background

Underdeveloped countries throughout the world face the most serious health issues. However in Africa, more money is spent on servicing foreign debt than providing health care. This is a serious problem. Malaria, while practically eliminated in developed countries is a major cause of death in underdeveloped countries. Africa is suffering from a pandemic due to the spread of HIV/AIDS. A major multi-discipline investigation employing appropriate technology is needed to address these and other health issues. To be effective this process of technology implementation must be sustainable, and culturally and environmentally sensitive.

The international and local planning committees were organized in June 2005 and the international call for papers was issued in July 2005. Work, submitted by over 50 authors, was reviewed for consideration. All papers were subject to a double blind peer review process. The following 18 papers reflect the international standard of this conference. At this second conference we expanded the poster session. The abstracts of posters presented are included in these proceedings.

Papers are organized in six broad categories: 1) Health related; 2) Knowledge Management; 3) Energy and Physics; 4) Water and Agriculture; 5) Environmental; and 6) Architecture and Small-scale industry.

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Keynote Address

Role of Natural Product Research to address Health Problems in Africa

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The research efforts of natural product research in Africa still remains connected more to the global R&D than to the local needs and priorities. As a result there is, understandably, considerable difficulty to initiate sustained support to such research from local authorities. Research done so far has undoubtedly served to train young people on a relevant subject. It has led to a better understanding of cultural practices of how we use plants as medicinal, preservative, flavor, fragrance and even as poison. Many compounds have been tested for various biological properties, but the criteria used to assess these activities have been heavily influenced by the interests of multinational drug companies. The latter are not interested in developing products that do not guarantee huge profits. Consequently, these companies have a tendency to judge many of our research results as unworthy for further development. It is, therefore, up to the African institutions to make sure that the research work done in their institutions, are of the right quality and relevance. Scientists should also double their efforts to overcome their isolation and establish inter-institutional and cross-boarder collaborative programs with other scientists in their regions.

The author is a strong believer in intra-African cooperation and has been collaborating with scientists in many African countries. The Department of Chemistry of the University of Botswana has excellent research facilities for Natural Products Research. These facilities have been made available to other African scientists under the auspices of the Network for analytical and Bioassay Services in Africa. This effort has led to the promotion of intra-African cooperation on Africa-specific problems. This lecture will reveal results of such cooperation with scientists in Cameroon, Zimbabawe and South Africa. Our interest is in finding bioactive substances, especially anti-infective agents. Accordingly, evaluation of plant extracts and natural products for anti-plasmodial activity has resulted in the isolation and characterization of many dimeric chalcones [1], flavonoids [2], quinones [3], sesquiterpenes [unpublished results]. Plants belonging to the families Anacardiaceae, Asphodelaceae, Asteraceae, and Moraceae have yielded several metabolites which have shown significant antiplasmodial properties. Typical examples include the novel biflavonoids: Rhuschalcone III IC_{50} 0.44 μg/ml, Rhuschalcone IV with IC_{50} 0.26 μg/ml, sulphated phenyl anthraquinone IC_{50} 4.13 μg/ml., trimeric catechins IC_{50} 7.9 μg/ml and some dimeric sesquiterpenes which show even more remarkable antiplasmodial activities than even chloroquine. Some of these compounds offer good potential to contribute to the fight against malaria. Aspects of phytochemistry and biological activities of these compounds will be presented.

We are also interested in discovering natural products that can reverse the resistance of the *Plasmodium falciparum* parasite to chlorquine. Chloroquine is an inexpensive and safe drug that is now considered almost useless due to resistance. Some preliminary results from this effort will also be presented.

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Production of Truly 'Healthy' Health Products

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Keywords: health products, toxicity, natural colorants

Abstract

Recently it has been revealed that commercial 'health' products are the source of various diseases. For instance, most cosmetic products have formaldehyde, which is considered to be carcinogen. Similarly, bodymists often contain butane and other hydrocarbon products, the harmfulness of which is well documented. Soap making utilizes a numerous chemical additives which are toxic and have serious health implications. The use of synthetic colouring pigments also makes the products harmful. The list of harmful chemicals used in these products is very long and includes practically all commercially available 'health' products used for skin care, facials, sun screens and others. In this paper, we studied the harmful effects of commercially available health products, focusing on cleansing products, general cosmetics (e.g. lip balm, lipstick, mascara, perfumes) and coloring agents (hair dye, shoe polish, bleaching agents). This paper presents a series of 'healthy' health products such as natural soap, non toxic shoe polish and sunscreen.

1. Introduction

Health products have been in use for thousands of years. In Persian, Egyptian or Chinese cultures, cosmetic use was common. What sets the modern age apart is the eruption of toxic chemical use in every application. Almost every product including health products, from toys to computers, carpet to clothes, furniture to washing powder are toxic. However, only recently has it become known that the list of toxic chemicals is very long and it is considered to be impractical to reverse the life style [1]. Most of them are manufactured petroleum derivates and other synthetic chemicals. Today's society is built on the assumption of "chemicals are chemicals"[2]. Even though this approach is attributed to a Nobel Laureate and Peace activist, Linus Pauling, characterizing chemicals based on the most obvious features is not scientific. It is unscientific to infer that chemicals with similar chemical formula whether they are from natural or synthetic origin, behave similarly. The properties of chemicals will be entirely different from each other depending on the origin and the pathway they travel, during the manufacturing process. Conventional approach does not differentiate between the synthetic chemicals manufactured in an industry and chemicals that are derived from natural elements such as plants. For example, the impact of sodium, derived naturally from sea salt, is different from that of sodium, manufactured in a chemical plant. Synthetic sodium hydroxides are used in many health products including soap production. Similar statements can be made for organic farming and chemical farming; and for every natural process and simulated engineering process [3].

Petroleum products are used as base material or as an additive for almost every product. The petroleum derivatives are highly toxic chemicals and have severe impact on human health [1]. Perfumes contain very little original musk and mostly synthetic musk and petroleum-based chemicals. More commonly the original musk (fermented flower extract) is entirely replaced by artificial musk and is added to a chemical base. An artificial musk is used to replace natural aromas and is added to many products like washing agents, soap and cosmetics [4]. These compounds are generally polycyclic and evidence indicates that some musks can interfere with hormone communication systems in fish and mammals [5]. Moreover, cosmetic products also contain formaldehyde and dioxane which are considered to be carcinogen. The body mist contains butane and other petroleum based hydrocarbon ingredients which are highly toxic compounds. Hexachlorophene used in mouthwash and shampoo are also hazardous materials. Mouthwash destroys the essential bacteria and the products that emerge are toxic. In addition, mouthwash base (both alcoholic or non-alcoholic) are extremely abrasive to the delicate tissues inside the mouth and produces toxins from saliva (that otherwise is a natural bactericide). Shampoos are harmful for both hair fibre and the skin. Lipstick or lip balm usually contains aluminum, which is also a known toxin. It was reported that various types of oestrogenic chemicals used in cosmetics are the major sources for women's breast cancer [6].

Figure 1 shows the schematic of pathway of production of conventional health products. Synthetic chemicals are used for almost every health product. The use of these toxic catalysts and chemicals in oil refining

result in the toxic contamination of personal care products. These products are eventually exposed to the environment causing water and air pollution. A number of toxic chemicals along with the various coloring pigments are used to make shoe polish. Certain toxic chemicals can be absorbed through the skin and or inhaled [7]. Some of these toxins are toluene (C_7H_8), aromatic hydrocarbons, trichloroethane, methylene chloride, nitrobenzene, and other chemicals**.** Trichloroethane is similar to chloroform. It is commonly used as a solvent and cleaning agent in spot removers during shoe polishing. Trichloroethane can be absorbed by inhalation and ingestion. It is an irritant to the eyes and nose and can result in damage of the central nervous system, liver and kidneys if ingested. Methylene chloride, known also as methylene dichloride and dichloromethane, irritates skin that comes in contact. Memory loss, liver and kidney damage are reported with chronic exposure. This is a known animal carcinogen and a suspected human carcinogen. The use of products containing methylene chloride by people with heart conditions may result in fatal heart attacks [8]. Nitrobenzene**,** is also a highly toxic substance, found in some shoe polish, furniture polish and floor polish. In addition to this, the coloring pigments used in the health products are mostly industrial and plastic based pigments. These pigments can create allergic reactions, scarring, phototoxic reactions and other adverse effects. These are notoriously toxic and radioactive.

This paper presents a detailed analysis of the impact of various synthetic additives added in health products. A series of 'healthy' health products that are prepared from natural materials which are beneficial to health and do not harm the environment are also presented.

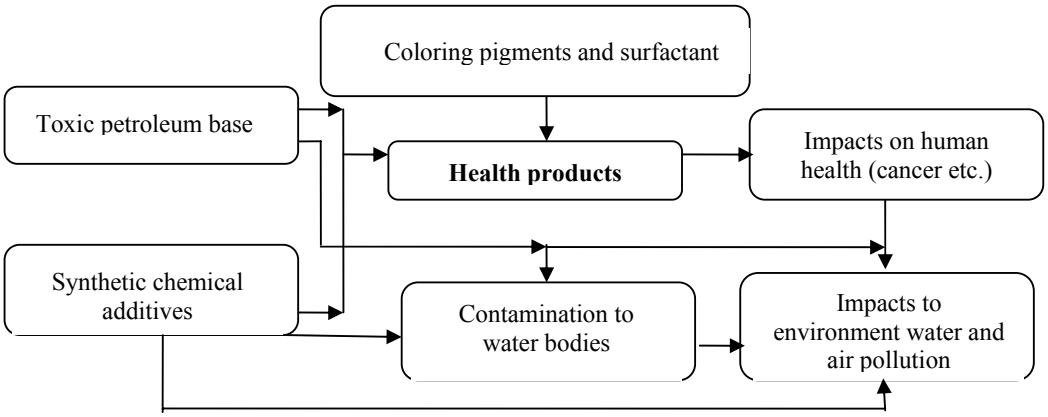

Figure 1. Schematic of pathway of production of health products.

2. Materials and Method

In this research, we studied the pathways of various chemicals used to produce different types of health products. Their impacts based on the pathways were analyzed. Based on this analysis, a series of 'healthy' health products were developed. The details on the use of materials and the process to make 'healthy' health products are discussed in the following section.

2.1 Natural soap

Ancient soap making was a completely natural process. The purpose of the bathing was to stay clean and treat skin diseases. All of the ingredients used came from the natural surroundings. The use of synthetic chemicals began in the late 19th century and expanded and proliferated as a result of military research during the First and Second World Wars. Since then, the use of synthetic chemicals has become standard in all commodities particularly in personal care products [9]. For example, the synthetic chemicals such as NaOH or KOH as alkaline agents are very toxic and corrosive compounds. Haynes (1976) [10] reported that a dose of 1.95 grams of sodium hydroxide can cause death. The most serious effects of sodium hydroxide at 50% by weight of active ingredient are corrosion of body tissues. Eye and skin contact can cause very serious burns. It has been reported that concentration of sodium hydroxide of 10 g/l cause nervousness, sore eyes, diarrhea and retarded growth in rats [10]. Even the vegetable oils that are produced using chemical fertilizers or are refined will have some toxic effects. Similarly, animal fats from animals injected with synthetic hormones also alter the natural course of the animal fat. Figure 2 is the schematic for the manufacturing of natural soap.

Olive oil

Olive oil is a triacylglyceride with three fatty acids attached to a glycerol molecule. It is a complex compound of fatty acids, vitamins, volatile compounds, water soluble compounds and some other micro compounds. The primary fatty acids available in olive oil are Oleic acid and linoleic acid with a small amount of linolenic acid. Oleic acid is monounsaturated (55-85%), linoleic acid is polyunsaturated (9%) and linolenic acid is also polyunsaturated with (0-1.5%) [11]. Olive oil has several other constituents such as tocopherols, chlorophyll and pheophytin, sterols, squalene, aroma and flavour compounds which exhibit a significant impact on human health. It is a highly monounsaturated oil and is therefore resistant to oxidation. The presence of phenols, tocopherols and other natural antioxidants prevent lipid oxidation within the body eliminating the formation of free radicals which may cause cell destruction. Use of olive oil in soap making is characterized by many of its advantages. Thus olive oil soap is very good from health point of view. In this research, olive oil was used as one of the major ingredients of natural soap.

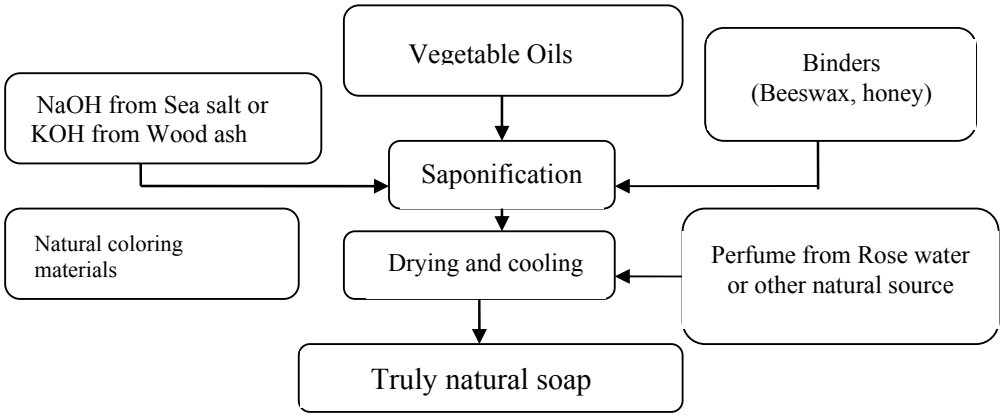

Figure 2. Flow process for natural soap making

Palm oil

Palm oil is semi solid at room temperature and is popular for manufacturing solid fat products. Palm oil has been in use for various edible and non edible products. It is also used in chemical, cosmetic and pharmaceutical application. Palm oil olein and stearin are used worldwide in making margarine, confectioneries, and in frying snack foods. The high content of natural antioxidants and its stability at high temperatures make palm oil excellent as a deep frying medium in the food industry. It also gives fried products a longer shelf life, while its bland taste brings out the natural flavors of food. Palm oil is a base material for manufacturing of soap, detergents and surfactants. In addition to this, this is a good raw material to make fatty acids, fatty alcohols, glycerol and other derivatives for the manufacture of cosmetics, pharmaceuticals, household as well as industrial products. Palm oil was also used to make natural soap in this research.

Beeswax and honey

Beeswax is a product secreted by honey bees. This is a natural product used for several purposes such as medicine, paint, material for shoe polish, candles, sealing materials, natural glue and others. This is a very complex material which contains hundreds of compounds. Honey has inhibitory effects on bacteria, fungi, yeast and viruses [12]. Honey application eradicates bacterial infections and accelerates wound healing. Honey is used even for dermatitis and dandruff treatment. Because beeswax and olive oils have similar antibacterial properties, a combination of beeswax, honey and olive oil which contain flavonoids, antioxidants and antibacterial ingredients useful for treatment in skin diseases was used in this study. The study showed that the mixture with honey, olive oil and beeswax (1:1:1) was successful in treating 75%, 71% and 62% of skin disease patients with pityriasis versicolor, (PV), tinea cruris and tinea corporis respectively. Honey mixtures appear to be useful in the management of dermatitis and psoriasis vulgaris. Considering these all benefits to the human health, beeswax and honey were used as ingredients in the soap prepared in this research.

2.2 Coloring and Fragrance Materials

The coloring and addition of fragrance of soap have become a tradition over time. However, the colors and fragrance used conventionally are from synthetic pigments or artificial musks. However, in this research, all natural colors and fragrance were used to give the desired colors to the finished products.

Turmeric, Neem leaf, Cinnamon powder

Turmeric is a perennial plant with roots or tubers oblong, palmate, and deep orange inside. Turmeric has a peculiar fragrance and bitter, slightly acidic taste exciting warmth in the mouth and colouring the saliva yellow. This is a mild aromatic stimulant and used for coloring. Turmeric tincture is used as a colouring agent. It dyes a rich yellow coating. Turmeric paper is prepared by soaking unglazed white paper in the tincture and drying. This is a completely natural colorant which also has some medicinal value. Coloring the soap with turmeric is beneficial for health. In this research, turmeric powder was used to color the soap and seems aesthetically pleasing. Neem leaf ground in powder form was used to add the natural color in soap. Neem is a tree that can thrive on various climates from 0^0C to 49^0C. It grows in almost all types of soil including clayey, saline and alkaline. The Neem tree thrives on dry, stony, shallow soils, and shallow depth. Neem leaf is used as anti bacterial medicine. To make the gentle green color of soap, Neem leaf was ground into power form to use as colorant. Cinnamon is the inner bark of a tropical evergreen tree. Cinnamon has been is use as spice, medicine and many other products. The lighter color of cinnamon bark has sweet properties gives soap making some flavor. Cinnamon bark was used medicinally and as a flavoring for beverages in ancient Egypt. Cinnamon powder was also used as coloring agent to make the soap.

Natural fragrance

A natural extract from rose water was used to give the fragrance for the finished soap product. No synthetic chemicals were used in the process.

Production of Natural Soap

Soap was prepared by using all natural ingredients (Figure 3 and 4). 34.0g with clean water at room temperature, 12.5g of sodium hydroxide (derived by the electrolysis of sea salt), 45.4g olive oil, 10.0g of beeswax , 15.0g of honey, 28.4g coconut oil, 17.0g palm oil, 5g of essential oil (tea oil) were used. In addition to this, cinnamon powder, turmeric powder, neem leaf powder were used as coloring agent. Natural fragrance could be added at a later stage not to heat. First a salt water solution was heated to 200^0F and cooled. Beeswax was melted and mixed with the oil ingredients and stirred. The mixture of olive oil, palm oil, coconut oil and bees wax was stirred. Both mixtures were heated and when both oils and salt water were near similar temperatures around 130^oF, then all ingredients were mixed. The honey and essential oils were added and stirred with a glass rod and transfer the mixture into mould. It normally takes 24-48 hours to get the desired hardness of the soap.

Figure 3. Natural soap with natural color

Figure 4. Natural soap

2.2 Non Toxic Shoe Polish

Commercial shoe polish contains various toxic substances. Generally, shoe polish is made from ingredients including naptha, lanolin, wax, bicarbonates of potassium and various types of coloring pigments. It also contains carbonates and bicarbonates of sodium and potassium. The burning of shoe polish will result in the yielding of carbon dioxide and/or carbon monoxide and traces of oxides of nitrogen and various toxic materials depending upon the chemicals, and solvents used to make the shoe polish.

To make a good and non-toxic shoe polish, olive oil, beeswax, and carbon soot collected by burning olive oil were used. Beeswax is a tough wax formed from a mixture of several compounds including

hydrocarbons (14 %), monoesters (35 %), diesters (14%), trimesters (3%), hydroxy monoesters (4%), hydroxy polyesters (8%), acid esters (1%), acid polyesters (2%), free acids (12%), free alcohols (1%) and some unidentified materials [13].

A good black shoe polish was prepared by collecting carbon from burnt olive oil and mixing with olive oil and beeswax (Figure 5). The beeswax was melted by heating the pan with hot water. The direct heating of wax results in breaking and color change. The ratio 1:3:3 of beeswax, olive oil and carbon particles will make a good viscous shoe polish. The beeswax, olive oil, carbon mixing ratio depends on the how viscous the polish is to be made. In countries where biomass cookstoves are used, carbon can also be collected from the chimneys of cookstoves by making a water oil trap. Various colors can be extracted from flowers, vegetations and Ocher, the naturally occurring colored earth that yield different colors. Beeswax forms a protective layer over the surface of the shoe and becomes a barrier against water, preventing its absorption by the leather. This beeswax mixed shoe polish is highly effective for use in wet or muddy conditions. This shoe polish has no toxicity and no harmful ingredients. Such shoe polish can be made easily at home.

Figure 5. Non toxic shoe polish made from beeswax, olive oil and carbon soots.

2.3 Sunscreen

The commercially available sunscreen is mostly made from synthetic materials which have several impacts on human health and the environment. The model of natural products manufacturing such as natural soap and non toxic shoe polish can be extended to make natural sunscreen. A mixture of beeswax, honey and olive oil can become an excellent sunscreen material. Beeswax has a high resistance to the passage of heat. This works as a good moisture retainer in the body. Honey, a substance contained in the beeswax is a natural hummectant, which means it draws and holds moisture, and is therefore soothing to dry and damaged skin. As a natural wax, beeswax protects the skin and leaves it feeling healthy and soft. Beeswax reduces inflammation, softens skin, and has antioxidant properties. After processing, beeswax remains a biologically active product retaining anti-bacterial properties. It also contains vitamin A, which is essential for human cell development. Throughout time, people have used it as an antiseptic and for healing wounds. Olive oil has antioxidant properties and absorbs certain ultraviolet rays. The polish material which is made out of beeswax, olive oil and carbon particles can be used as an excellent sunscreen or skin protector.

3. Results and Discussions

In this paper, the use of various chemicals in commercially available health products, focusing on cleansing products, general cosmetics (e.g. lip balm, lipstick, mascara, perfumes) and coloring agents (hair dye, show polish, bleaching agents) and their harmful effects on health were studied.

Saxena et al (2001) [14] reported that eye cosmetics are a common cause of eye lid dermatitis. These products contain coloring pigments, fragrances, resins and preservatives. Eye mascara may cause eye irritant, or allergic contact dermatitis of the eyelids. Black iron oxide used in mascara causes severe reaction to the eyelid. Iron oxide come in several forms and is used in pigment products. Black iron oxide is also known as magnitite ($Fe_3 O_4$), yellow or brown limonite ($2Fe_2 O_3 3H_2O$) contains 60% Iron, Red hematite (Fe_2O_3) contains 70% iron.

Iron oxides are used as pigments in many cosmetics, including mascara, eyeliner, eyeshadows, and lipsticks. However, these pigments are toxic to human health (Saxena et al, 2001).

Nikkie (2002) [15] reported that that mascara tubes made by Benson, Lecco (Italy), contains thin film, amorphous polyamide marked Selar PA by DuPont. Polyamide is a thermoplastic polycondensate, a nyclon resin compound and is very much hygroscopic in nature. It spears that this causes severe health problems because the plastic molecules enter the human body through the skin. Various chemicals used in health products include artificial musks, used to add scent to perfumes and perfumed products, and perfluorinated compounds, used in water-repellent coatings and to prepare non-stick surfaces such as teflon. It was also reported that flame-retardants suspected of causing learning and behavioural problems in animals, and the antibacterial agent triclosan, were used in antibacterial soap [16].

3.1 Chemicals used in health products

Alkali is one of the heavy chemicals used by industries such as petroleum refining industry, pulp and paper mills, battery industry, cosmetic industry, soap and detergent manufacturing, leather processing, metal processing, water treatment plants and biofuel processing industries such as biodiesel and ethanol. Synthetic chlorine and sodium hydroxide are among the top ten chemicals produced in the world and are used in the manufacturing of a wide variety of products including deodorants, detergents, disinfectants, herbicides, pesticides, and plastics. These are also major chemicals used in various health products. It was reported that the worldwide demand of sodium hydroxide was 44 million tones expressed as NaOH 100% in the year 1999 [17]. The total global demand of alkalis in 2005 was 62 million tones (Figure 6). The growth of alkali demand was approximately 3.1% per year.

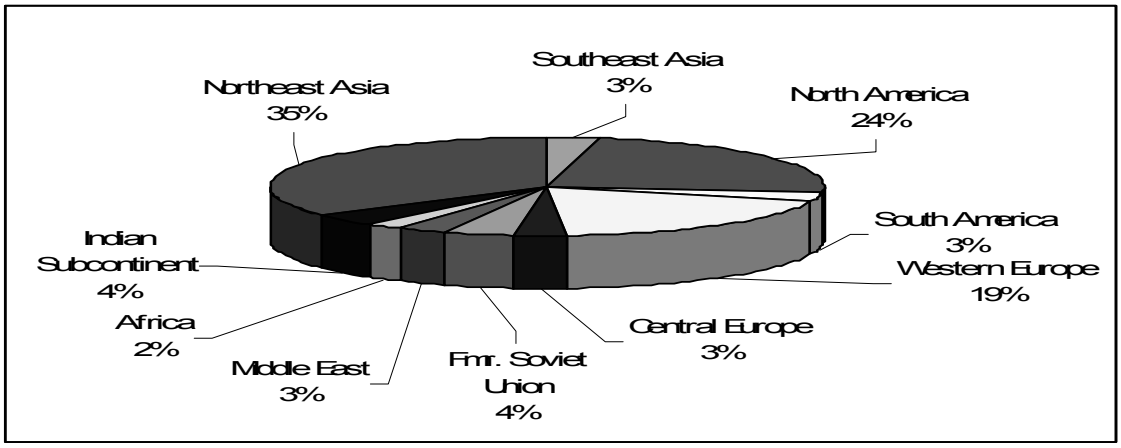

Figure 6. Global Chlor-Alkali Production (CMAI, 2005)

Alkalis are raw commercial products and need further processing before application. Huge amounts of these chemicals may leak during the transfer from one place to another directly or indirectly polluting the environment. It also has significant effect on human health. Inhalation of dust, mist, or aerosol of sodium hydroxide and other alkalis may cause irritation of the mucous membranes of the nose, throat, and respiratory tract. Exposure to the alkalis solid or in solution can cause skin and eye irritation. Direct contact with the solid or with concentrated solutions causes thermal and chemical burns leading to deep-tissue injuries and permanent damage to any tissue [18].

3.2 Surfactants used in health products

Personal cleansing products are potential sources of skin drying, a common problem among the dermatologic patients [19]. The major reason behind this is due to the use of synthetic detergents. The problem can further be aggravated by the use of synthetic personal care products including body mist, and body lotion. Various surfactants are added to the cleansing products that adhere to skin surface and decrease the amount of friction required to remove unwanted materials. Surfactants are the chemical substances incorporated into cleaning agents, due to the widely held belief that the dirt is not effectively removed by water alone even with vigorous

washing [20]. Anionic surfactants used in commercial cleaning products are synthetic surfactants including sodium lauryl sulfate (SLS), triethanolamine lauryl sulfate, ammonium lauryl sulfate, and sodium stearate. Surfactants such as SLS are also found in ointments and creams as well as in cleansers.

Walker et al (2005) [21] studied the acute and short-term toxicity in rats that have been made on the surfactants sodium lauryl sulphate, sodium lauryl (3EO) ethoxysulphate and their matches C_{12}–C_{15} alcohol sodium sulphate and C_{12}–C_{15} alcohol sodium (3EO) ethoxysulphate. The acute oral LD_{50}s of the four materials were found to range from 1 to 2 g/kg. This clearly indicates the toxicity level of sodium lauryl sulfate (SLS). SLS is reported to be a strong oxidizing agent and is a highly toxic compound. This causes respiratory, eye and skin irritation. Carcinogenic nitrates can form in the manufacturing of SLS or by its inter reaction with other nitrogen bearing ingredients which show permanent eye damage in young animals from skin contact in non eye areas. The studies indicated that SLS enters and maintains the residual levels in the heart, the liver, the lungs and the brain from skin contact. This poses a serious health threat by its use in shampoos, cleansers, and tooth pastes. SLS is used in almost all health products including soaps, shampoos, bubble baths, tooth paste, washing up liquid, Laundry detergent, children soaps and shampoos stain remover, carpet cleaner, fabric glue, body wash, shaving cream, mascara, mouth wash, skin cleanser, moisturizing lotion and sun screen.

Table 1

Common surfactant ingredients used in health products

Product	Ingredient	Common uses
Anionic-natural	Natural soap, Potassium cocoate	Skin cleansing
Anionic-synthetic	Sodium Lauryl sulfate Tryethanolamine lauryl sulfate Ammonium lauryl sulfate	Ointments, creams Skin cleansing Tooth paste
Cationic	Cetrimide Bemzalkonium chloride	Disinfectants Antimicrobial preservative
Amphoteric	Cocamidopropylbetaine	Baby shampoos, Foam boosters
Nonionic	Polysorbate 20, Polysorbate 60	Cosmetic, Food products, Pharmaceuticals
Alcohols	Isopropyl, Benzyl alcohol Cetyl or stearyl alcohol	Antimicrobial, preservatives, Emollients, thickeners in moisturizers and lubricants

Source: [22]

3.3 Humectants and Moisturizers

Various types of humectants such as glycerin, methyl glucose esters, lactates, lanolin derivates and mineral oils are added to the skin cleansing products because of their moisturizing properties. These synthetic chemicals are also harmful to the human health and hence the health products.

Most of the chemicals used in the health products (Table 1) are from petroleum derivates. The petroleum products are highly toxic chemicals as their refining process involves using heavy metals and highly toxic chemicals and high temperature [19;1]. For instance, oil refining uses hydrochloric acid and hydrofluoric acid. Similarly, gas processing involves use of glycol, amines and various other chemicals. These are all toxic chemicals and the petroleum derivates are contaminated with these chemicals. The use of these petroleum derivatives which are contaminated with toxic chemicals will have severe health impacts when used in health products manufacturing. These health products are inherently unsustainable as the manufacturing process follow the anti-natural path (1; 23]. Moreover, to consider a technology truly sustainable, it should fulfill the economic, social, environmental and time criteria [24]. Thus the conventional methods used to manufacture health products today are neither sustainable nor beneficial to the human and environment.

4. Conclusions

Commercial health products are the source of various diseases. This paper presents a series of 'healthy' health products which were produced by using all natural ingredients and non toxic chemicals. A natural soap was prepared by using sodium hydroxides obtained from natural sea salt and cold pressed vegetable oils such as olive oil, palm oil and coconut oil. Beeswax and honey were used as binding agents. Natural colouring agents such as cinnamon, turmeric and neem leaf were used. Similarly, a non toxic shoe polish was prepared from beeswax, olive oil and carbon soot collected by burning cotton thread soaked in olive oil. Coloring materials can be extracted from flowers and perfumes can also be produced by the fermentation of flowers. This model for

producing health products such as natural soap, non toxic shoe polish and sunscreen can be extended to all 'healthy' health products which are being commercially produced in the market.

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Spirostachys Africana – The Latex Content

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Key words
Spirostachys africana: Euphorbiaceae; uses and diterpene content of the latex

Abstract
Spirostachys africana is an endemic species of East and Southern Africa and is variously known in vernacular languages [7, 9]. The wood preserves very well and has many commercial uses. Its latex has several medicinal uses [3] which, as expected, depend on location. The latex is also reported to be toxic. Biological activity studies have shown that the latex has genotoxic effects [8]. We have been interested in the phytochemical studies of the latex since 1991. In our studies, we have found that the latex only contain diterpenes with the beyerane skeleton. The compounds are closely related to each other and only differ in the oxidation pattern, especially in ring A. Positions 2, 3 and 4 are commonly oxidized to obtain diols, diketones and hydroxyketones. Demethylation at position 4 of the diketones leads to diosphenols. Cleavage between positions 2 and 3 leads to secobeyeranes which gives acids [5], lactones and lactols. It was a challenge to separate these compounds. They were separated using chromatographic techniques, wet chemistry, acetylation and methylation. Spectroscopic methods were used to identify the isolates and derivatives.

Introduction
Spirostachys africana is a well known tree in Southern Africa. It spreads from Tanzania to South Africa. The trees are huge in rainy areas but small in poorly watered soils. Thus, east of the sub continent has large trees whereas the west, especially south of Botswana and north west of South Africa, has mainly small trees except in river basins. It has many uses because its huge heartwood. The heartwood makes 80 % of the trunk which is dark in colour. In dried trees, the heartwood is hardly affected by weather and feed ants. It is very durable. It has a characteristic smell which persists for many years- a piece of heartwood hundreds of years old will give a strong scent if scraped. It is the structural wood of the Great Zimbabwe Ruins [9].

It is very good for furniture and because of this it is a protected species in South Africa [7]. Many other artifacts are made from the heartwood such as necklaces, gunstocks and walking sticks. Fencing poles and rafters are often made from this tree. Its sawdust or powder or chopped pieces are used as anti-feedants or insect repellants. The leaves give milky latex while that from the heartwood is brown and viscous. The latex when mixed in porridge is a purgative or an emetic [3]. It is taken orally to quench stomach aches. It is smeared on boils to retard infection. Inhaled smoke is a reported method of driving away bad spirits. It is a malaria drug in Mozambique and Tanzania [4].

The latex is also a renowned poison. It does stupefy fish when mixed with water and often used as an arrow poison. Meat smoked with or roasted on *Spirostachys Africana* wood causes diarrhea. Ox-yokes made from the tree induce uncontrollable bruising when continuously used. The plant extract from the twigs and bark is genotoxic to micronuclei [8].

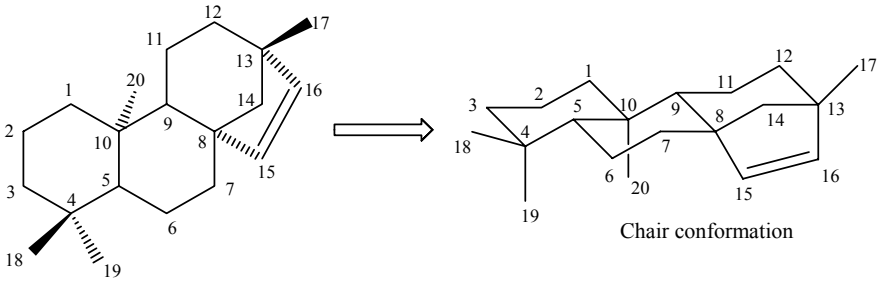
It was the anti-feedant property which prompted us to start the phytochemical study on *Spirostachys africana*. When we started, there were three compounds known from resin of the heartwood [1].

Experimental
The wet heartwood of plant was harvested from Rusape, Zimbabwe while dry heartwood was collected from Borotsi, Botswana. In all cases the dried heartwood was chopped into small pieces and ground to a powder.

A known amount of powder was extracted with CH_2Cl_2/MeOH mixture for twenty four hours. After evaporation, the syrup was made into slurry on silica gel. In general, chromatographic procedures were used to separate into fractions. The fractions were further resolved using liquid-liquid partition, recrystallisation, acetylation and methylation. The liquid-liquid partition employed sodium carbonate solution and chloroform to separate acids from non acid material. Neutralisation of the carbonate layer with dilute hydrochloric acid and subsequent extraction with chloroform yielded the acid material. These were further resolved by chromatography. Many a time, crystals were collected at this stage. Acetylation largely employed acetic anhydride and pyridine. Methylation was achieved using diazomethane. The compounds were identified using

spectroscopic techniques. The principle skeleton of compounds isolated from the latex is the beyerene or stachene type which is a diterpene and this is shown below

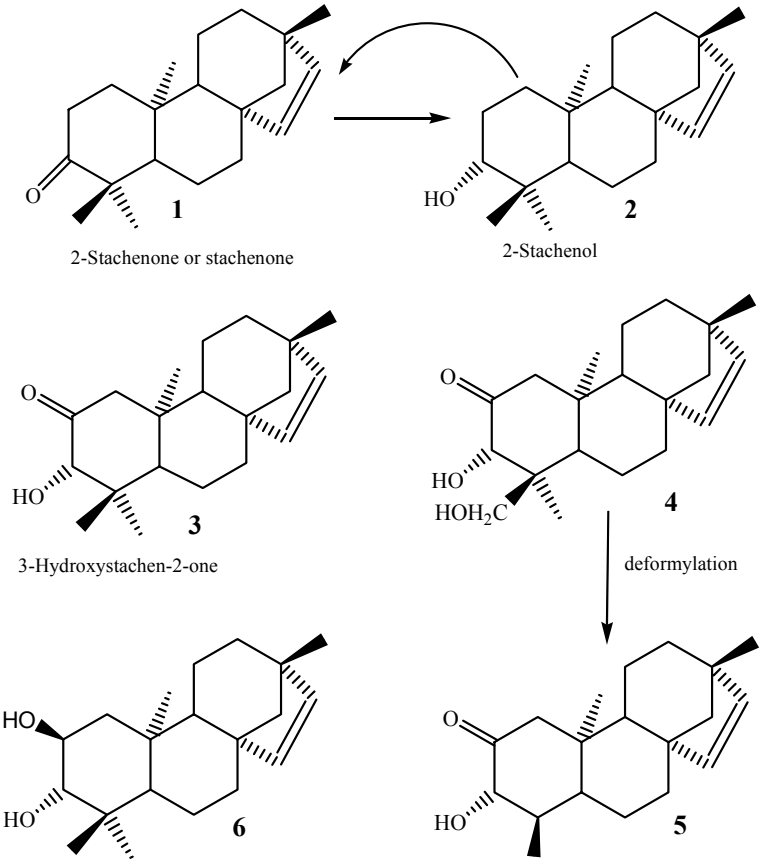
Beyerene or stachene skeleton



Results and Discussion

Compounds of the non acid material

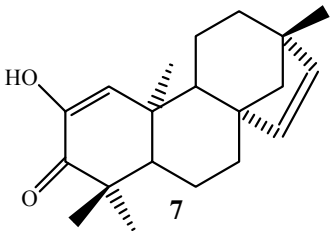
These were observed as nice colored spots (red to brown) on TLC when sprayed with 1 % vanillin and 5 % sulphuric acid in MeOH. The majority of these were 2-hydroxyketones [2]. 2-Stachenone has been known since 1962 and was reduced to stachenol [1]. We established that stachenol is present in the plant, as natural product and it is also readily oxidized to stachenone [6]. Like **1**, compounds **3** and **4** are present in large quantities. Compound **5** has only nineteen carbons and it may be as a result of deformylation of **4**. Compound **7** was only isolated recently.



A number of enolised 1,2-diketones (diosphenols)were isolated from the non acid material. These compounds do not readily burn on TLC. They appear as light brown spots at first before getting dark and they are also

visible under UV [6]. Their other unique characteristic was the presence of chelated hydrogen between the hydroxyl and carbonyl groups in their ^{1}H-NMR.

It has remained very difficult to confirm the presence of diosphenol **7**. However all the other three diosphenols may be postulated or predicted from **7**. The postulate is that demethylation of **7** followed by oxidation leads to other diosphenols. Deformylation may even be easier if **7** is hydroxylated at C-18 first.



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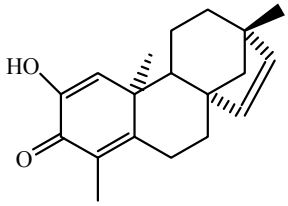
3-Hydroxystach-1, 15-dien-2-one
or diosphenol

Isolated by Baarschers et al



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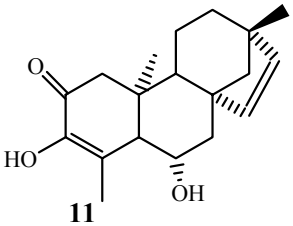

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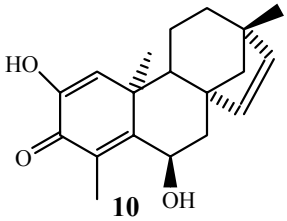

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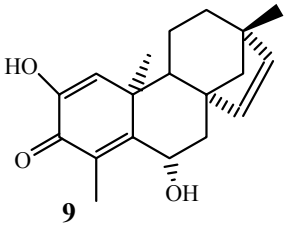
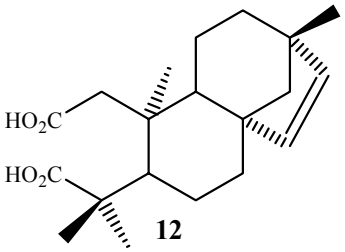


9

Diosphenols

Acids

Four have been charaterised this far. The diacid **1**2 is most abundant. In fact it spreads in many fractions. A number of its derivatives have been prepared in order to ascertain its characterization [5]. It appears that atmospheric oxidation of the diosphenol **7** cleaves it to give **12**, while oxidative induced rearrangement of **7** should give **15**. Compound **13** was observed as one of the products when **11** was kept in solution in air for a number of days.



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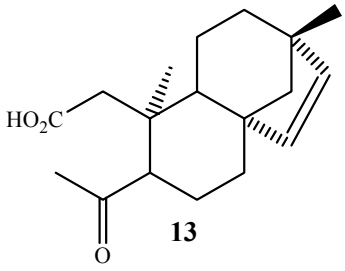

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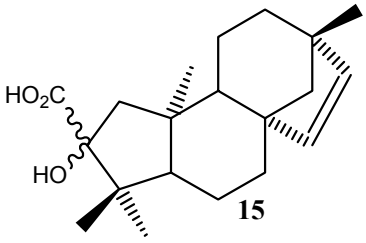

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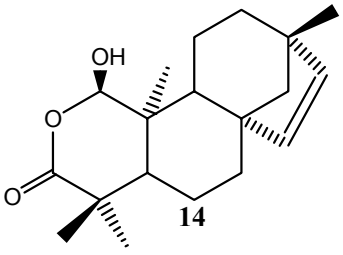

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Only compounds with the beyerene moiety have been isolated from this plant. Thus the biological activity reported for this plant is as a result of the action of these compounds. This is yet to be proved as very little biological assays have been carried out with the compounds.

Conclusions

The heartwood of *Spirostachys africana* is a rich source of beyerenes. Oxidation in ring A readily occurs at positions 2 and 3 to obtain diols and hydroxyketones. Further oxidation of diols (and hydroxyketones) leads to demethylation or deformylation giving C-19 and C-18 derivatives. Rearrangements have also been observed. The most abundant compounds are the hydroxyketones, diosphenols **9** and **10** and acid **1**2.

Acknowledgements

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Atmospheric Pressure Ionisation-Mass Spectrometry: A Tool for Food Security Policing and a Solution to Various Medicinal Problems

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Keyword: atmospheric pressure ionisation, mass spectrometry, veterinary drugs, anabolic compounds, sulfonamides, anthelmintics, proteomics, medicinal plants

Abstract:

Modern agriculture and animal husbandry increasingly require utilisation of advanced technology as exemplified by the large-scale use of veterinary drugs worldwide. Antibiotics in agriculture and veterinary medicine were introduced in the 1950s with oxytetracycline and chlortetracyclines being the first feed additives. Currently these drugs together with β-lactams, aminoglycosides, aminocyclitols chloramphenicols, peptides, ionophores, and macrolides are widely used for agricultural purposes.

Anabolic steroids, anthelmintics and sulfonamides are also popular antibiotics in animal husbandry. Drug administration to animals is usually aimed at treating or preventing the outbreak of animal diseases or promoting growth. Unfortunately, these drugs or their metabolites have a tendency of appearing as residues in edible products such as milk, eggs, animal tissue obtained from treated animals. Some of the drugs have been implicated as carcinogenic with others having adverse effects to humans even at low levels. The knowledge of the type of drugs and their metabolites at residual level is essential for the safety of the consumer. In order to control and monitor the levels of these drugs in edible products, the development of sensitive, selective and accurate analytical methods is fundamental. The first part of this presentation will focus on atmospheric pressure ionisation mass spectrometry as powerful analytical tool for policing of abuse of veterinary drugs in animal husbandry.

The second part of the presentation will demonstrate the importance of API-MS with respect to various medicinal problems. Coupling liquid chromatography with API-MS/MS is ideal for biomarker discovery, metabolite identification and human health research and drug development. The future of medicinal development is through proteomic research. With the availability of genomic and protein databases, mass spectrometry is fast becoming the preferred method of protein identification. It is hoped that our understanding of diseases would be improved through our understanding of protein of the diseased and normal cells.

Introduction:

Natural and synthetic hormones, together with other veterinary drugs are used worldwide as growth promoting agents in animal breeding. There is increased concern about residue in foodstuffs of animal origin in many countries, particularly in the European Union (EU) and countries that export meat and meat products to the EU. Public health authorities and the Agrofood industries are challenged in satisfying consumers and exportation market demands regarding the quality of meat and the safety and control of different residues in food. The use of some of these compounds is completely forbidden within the European Union (EU) while as other substances have been permitted for which maximum residue levels (MRLs) have been set. In the case of banned compounds, this directs the analyst to develop methods with the lowest possible limits of detection, i.e. 'chasing zero', while in case of permitted ones, the analyst's concern might be better directed towards more rapid and definitive methods with limits of detection adequate to police the MRLs. The policing method may be direct, i.e., identification or quantification of residues of the parent compound or the metabolites in the muscle or tissue or edible organs give the measure of exposure of these compounds of interest. In most cases however, the monitoring method is indirect via derivatisation.

The use of forbidden compounds is evidenced by their detection in sample types, which are easily obtained or analyzed, such as injection sites, urine, faeces, and kidney fats. The detection for example of artificial anabolic agents illegally used as growth promoters in industrial farming is considered as a priority in the EU. Nowadays public concern is not confined to anabolic hormones but include other veterinary drugs. Several new groups of substances have received publicity, particularly, the sulfonamides, tetracyclines, anthelmintics, β-agonists, tranquilizers and genetically engineered bovine - and porcine – growth hormone (BST, PST).
Some of these drugs are allowed but the maximum residue limits (MRLs) are violated due to misuse of the drug or poor animal management. The EC directive 86/469 expanded the control to all veterinary drugs [1]. The criteria document 87/410 was extended in Commission Decision 89/610 to include all veterinary residues [2]. This latter document is now further revised to cover both screening and confirmatory methods of analysis. The commonly acceptable official techniques used until now for these controls have a number of limitations. As a consequence, positive results have to be validated by other, more reliable analytical methods.

The confirmatory analysis techniques most commonly used are thin-layer chromatography [3,4] and low resolution mass spectrometry coupled with gas chromatography (GC-MS) [5]. However, most compounds of interest are non-volatile or thermal stable and therefore require derivatisation prior to GC-MS. In addition, extensive sample preparation is required before the analytical determination. Rapid procedures for the detection of anabolic compounds for example, involves solid-phase extraction (SPE) on C_{18} empore discs and amino (NH_2)- bonded columns for sample pre-treatment of large volumes of sample material e.g. urine (30 ml), followed by GC-MS-MS determination [6].

Mass spectrometry is a technique that provides molecular mass and structural information of organic and/or inorganic compounds. In mass spectrometry, the sample in gaseous phase is ionised. The ions and/or charged particles formed are then separated according to mass per charge ratio (*m/z*). The most commonly used ionisation sources are electron ionisation (EI) and chemical ionisation methods (CI). The requirement that compounds to be analysed be volatile and thermal stable can lead to a limitation to usefulness of the technique.

Therefore, a number of ionisation methods for the mass spectrometry have been developed to enable analyte that are non-volatile and/or unstable under electron ionisation (EI) and chemical ionisation methods (CI). Atmospheric pressure ionisation (API), mainly electrospray (ES) and atmospheric pressure chemical ionisation (APCI) is an example of such ionisation source that could be used for the analysis of compounds that are non-volatile and/or thermal unstable. The API source was originally developed as an interface for liquid chromatography-mass spectrometry (LC-MS) for macromolecules, such as protein and peptides by Fenn and co-workers [5]. Coupling LC to MS has several advantages over GC-MS, in particular in the multiresidue methods of monitoring veterinary drugs. In addition LC-MS has demonstrated great potential in medicinal related applications.

In this presentation the application of the atmospheric pressure ionisation-mass spectrometry to policing food security and medicinal application will be highlighted.

Experimental:

Materials and Reagents

i) Anabolic compounds used in this study included: 17α-trenbolone, 17β-trenbolone, 4-androstene-3,17-dione, 19-nortesterone, testosterone benzoate and, Testosterone enanthate, Epitestosterone, Nandrolone decanoate, Testosterone 17β-cypionate, Testosterone decanoate, Testosterone isocaproate, testosterone, all from Sigma (St. Louis, U.S.A).

ii) Sixteen sulfonamides; All the sixteen sulfonamides; 5-sulfaminouracil, sulfaguanidine, sulfadiazine, sulfamethizole, sulfamethoxazole, sulfathiazole, sulfabenzamide, sulfapyridine, sulfamerazine, sulfamonomethoxine, sulfamethazine, sulfamethoxypyridazine, sulfaquinoxaline, sulfadimethoxine, sulfasalazine used in this study were obtained from Sigma (St. Louis, USA)

iii) The benzimidazole anthelmintics (albendazole, fenbendazole, mebendazole, oxibendazole, and thiabendazole) were from Sigma (St. Louis, USA).

All organic solvents (e.g. methanol and acetonitrile) used in this work were filtered through a 0.45 μm organic membrane filter, type HVLP, Millipore (Dublin, Ireland) and were of HPLC grade and were from BDH Laboratory (Poole, England). Di-n-hexylether (99 %) was from Aldrich (Steinheim, German), sulphuric acid (99 %), sodium hydroxide pellets (98 %), sodium bicarbonate (98 %), acetic acid were from Saarchem (Krugerdorp, South Africa). Tri-n-octylphosphine oxide (TOPO), n-undecane and ammonium hydroxide used were from Sigma (St. Louis, USA). Formic acid was purchased from N.T. Laboratory Supplies, (Johannesburg, South Africa). HPLC grade methanol and acetonitrile were from BDH Laboratory (Poole, England). Ultra high purity water was processed through a Millipore Quantum Ultrapure Ionex Gradient A10 purification system (Millipore, Molsheim-France). Aqueous solvents were further filtered through 0.45 μm pore size cellulose nitrate membrane.

Preparation of Standard Solutions:

One mg of each of the veterinary compounds was dissolved in 1 ml of methanol to make a stock solution of 1000 ppm. From this, diluents of different concentrations were prepared in (1:1) methanol and water.

HPLC separation of mixtures

Samples were separated using a Hewlett Packard Series 1100 consisting of; binary pump system, photodiode array detector (DAD) detector, thermostated column compartment, vacuum degasser, and controlled by HP ChemStation. A gradient mode was used to separate the mixtures using mobile phase; A = 100 % methanol; B = 85 % 25 mM acetic acid in water + 15 % methanol. 20 μl of sample were injected into a Waters XTerra microbore C_8 (150 mm x 2.1 mm x 3.5 μm) column. The separation was performed at a flow rate of 100 μl/min and monitored either by ES-MS or UV/Vis.

ES-MS of compounds of interest (anabolics, sulfonamides, etc)

The samples were introduced to the electrospray ionisation source by direct infusion using a Harvard Apparatus 22 syringe pump (South Natick, Massachusetts, USA). 50 μl of dissolved sample were mixed with 200 μl of buffer

and the resulting solution infused at 3-5 µl/minute. The ionisation buffer used was (1:1) 25 mM acetic acid in water/methanol. The spectra were obtained using a ThermoQuest LCQ^{Deca} quadrupole ion trap mass spectrometer (San Jose, California, USA). The system used ThermoQuest Xcalibur software (San Jose, California, USA).

Preparation of bovine liver and kidney tissues samples of veterinary drugs mixtures

Finely sliced liver (after removal of the gall bladder) and kidney carcasses (~ 20 mg) from the local abattoir were minced and spiked with a known concentration of a mixture of anabolic androgenic compounds. The concentration of a mixture ranged from 1 ppt to 1 ppm. The spiked samples were homogenized by using a blender. The anabolic androgenic compounds were then solvolysed in 1 ml ethyl acetate containing 2 µl of 0.5 M H_2SO_4 at room temperature in a shaking incubator for 2 - 4 hours. The organic phase containing the androgenic compounds was washed with UHP H_2O and evaporated. The residues were dissolved in 1 ml of MeOH-H_2O (40:60, v/v) and then stored at 4 $^{\circ}C$ until required for enrichment and/or clean-up with SLM and SPE.

Preparation of milk and urine samples of veterinary drugs mixtures

A 10.0 ml aliquot of milk or urine was transferred into 25 ml centrifuge tubes and then spiked with similar concentrations of anabolic compounds as was for liver and kidney tissues. The mixtures were then subjected to solvolysis in a similar manner as was for liver and kidney tissues.

Results and Discussion

The use of prohibited substances with or without political and ethical considerations will have an effect on the consumer of the products from treated animals. In case where administration of these compounds is prohibited, there are many ways attempted to disguise their application by the producers. Hence, almost all parts of the animal are eligible for injection and thus certain edible tissues, such as tail base and neck muscle. Consumption of contaminated meat by athletes for example would result in unequivocal identification of banned substances in urine, such that an acute dose of hormone or drugs from contaminated meat constitute a serious liability to the consumer, in this case the athlete.

Steroid hormones are poorly soluble in aqueous media, and are not stored in gland cells. Instead, they are released directly into the blood stream after their synthesis therefore blood sera may be used as the sample from which to detect the presence of anabolic hormones. Steroid hormones and their metabolic products are ultimately disposed of via the excretory system, usually the kidneys hence it is possible to detect them in the urine of the consumer. Mammals are known to be unable to degrade the steroid backbone. Steroids are therefore ultimately excreted with the urine and to some extent with the bile. Methods for the detection of steroids in the urine can also be used to investigate the hormone metabolism.

An infringement of the hormonal substances for sportsmen is normally evident when these substances or metabolites appear in the urine or other body fluids. In some cases athletes could test positive due to consumption of contaminated meat or meat product Analysis of injected site of veterinary animals is suitable for determining the hormones that are illegally injected because the analysis of other biological matrices like faeces, kidney fat or urine may not be obtained owing to metabolization and selective excretion and/or deposition of these compounds.

The challenges, therefore to the analyst is to develop methods that can be utilised in monitoring of a variety of veterinary compounds in different biological matrices simultaneously. Traditionally a great majority of compounds had been monitored indirectly by GC-MS [10,11]. The advert of API interfaces has enabled the coupling of LC to MS with tremendous advantages over GC-MS. The use of LC as a multiresidue monitoring tool is more attractive than the GC. LC is not only limited to volatility or thermal stability of the analyte. In addition LC can utilise all the four modes of chromatography in the separation of the analyte. The addition of the mass spectrometry, with selected ion monitoring (SIM) capability not only enhances the selectivity but also sensitivity. It should be noted however, that MS as a detector for GC and LC is the same. In comparison with

GC, the LC methods have a number of advantages over the GC methods such as: i) no need to derivatize the compounds and ii) can analyze the samples in the same matrix as the sample without the need to evaporate.

Monitoring of Anabolic Compounds by LC-MS

This group of compounds is non-volatile, that is, it is and non-GC active therefore cannot be separated under direct GC or GC-MS. Gas chromatographic methods via derivatisation have been normally used for determination of these compounds by either performing silylation, benzylation and methylation derivatisation. Mass spectrometry as a detector for GC was found to be more sensitive and selective than the conventional GC detectors. However, methods based on gas chromatography had limitation in quantification of these compounds due to the possibility of thermal decomposition. In addition the technique also displayed non-reproducible ionization in the ionization source of the mass spectrometer. Atmospheric pressure ionisation interface, in ES or APCI modes has the capability of ionising or transporting ions of the parent anabolic compounds directly from the biological matrices. Therefore, the API-LC-MS used in monitoring anabolic compounds completely eliminates the need for derivatisation. In our research group we have successfully used LC-API-MS in monitoring anabolic compounds in a variety of biological matrices [12]. Figure 1 shows a typical example of a chromatogram of five anabolic compounds under APCI-LC-MS conditions. A 150 mm x 1.0 3.5µm XTerra RP18 column was used for this gradient separation.

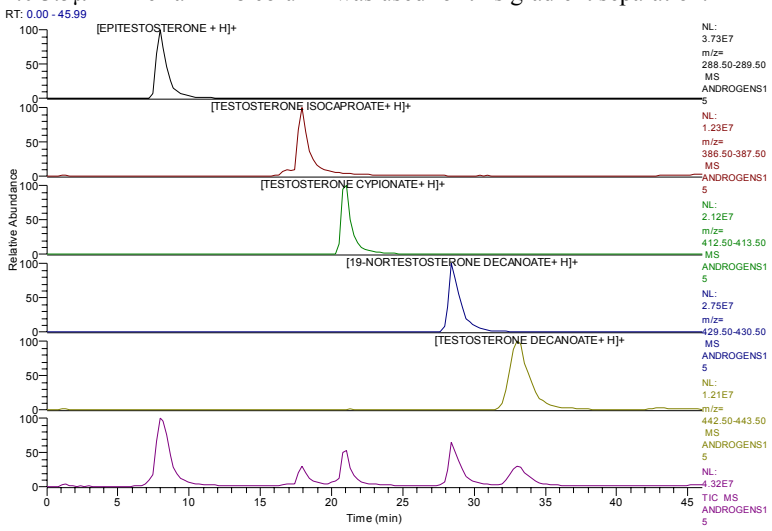

Figure 1 LC-APCI-SIM-MS chromatograms of testosterone and its methyl ester derivatives: Conc = 0.1 mg/L

Monitoring of Sulfonamides Compounds by LC-MS

Sulfonamides are a group of antibacterial agents commonly used in veterinary practice to prevent infections in livestock, to treat diseases, and to promote growth [14]. The presence of sulfonamide residue in food is of concern because some of the compounds are known to be carcinogenic [15] and they generally enhance the risk of developing antibiotic resistance [16], which makes the therapeutic use of similar medicine inefficient [17]. Recent evidence has implicated sulfamethazine as a possible thyroid carcinogenic agent [18]. Sulfonamide residue in food and animal tissues may be present in minute concentrations but may pose a health threat to consumers [19]. Therefore, monitoring of these compounds has attracted interest to the scientific communities.

Recently we have developed ES-LC-MS method of monitoring sixteen sulfonamides in variety of biological matrices [20]. Incorporation of sample supported liquid membrane (SLM) pre-treatment technique to ES-LC-MS allowed us to determine these compounds in concentrations below sub parts per billon (ppb). A typical ES-LC-MS chromatogram of sixteen sulfonamides drugs is shown in Figure 2a & b.

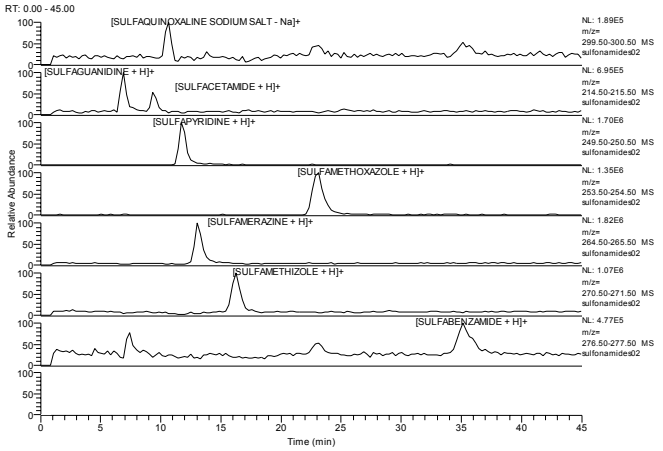

Figure 2a LC-ES-SIM-MS chromatograms of 1 mg/L of sulfonamides in UHP water

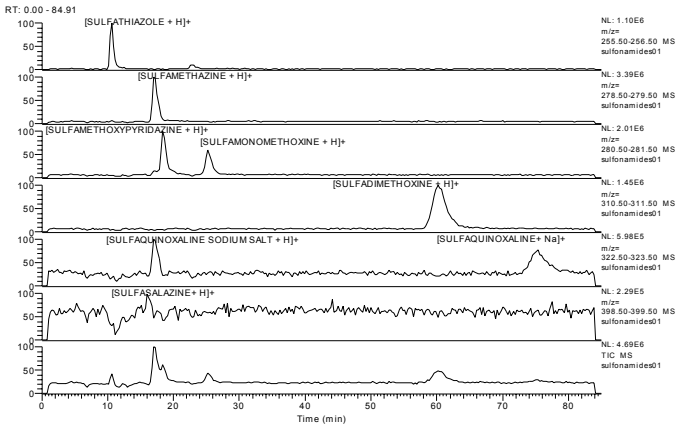

Figure 2 b LC-ES-SIM-MS chromatograms of 1 mg/L of sulfonamides in UHP water

Monitoring of Anthelmintics Compounds by LC-MS

Benzimidazole anthelmintic drugs are commonly used in the veterinary practices to treat gastro-intestinal infections and also for animal fattening purposes [21-23]. Generally, the presence of drug residues can be detected in various target organs/tissues, for example, liver, kidney, fat, skin, milk, eggs and blood; or in the metabolic by-products, such as, urine, feaces, bile and sweat [21]. The European Union (EU) has regulated the maximum residue limits (MRLs) for some of these compounds, ranging from 0.010 ppb to 1.00 ppb depending on the compound of interest and the type of food (type of tissue) [21-23]. Recently we demonstrated the use of LC and LC-ES-MS to monitor these compounds in various biological matrices [24, 25]. Figure 3 shows the separation of benzimidazole anthelmintics using a 150 mm x 2.1 mm x 3.5 μm XTerra column.

Medicinal Application of API-MS

Giant strides have been achieved in the field of medicine due to the use of API-MS as a tool especially when coupled to LC. In the area of traditional medicine LC-API-MS has been used in the monitoring of secondary metabolites [26,27]. Hyphenating liquid chromatography to mass spectrometry for many of the medicinal problems has several advantages. The combination of LC as a powerful separation technique to MS as a sensitive and selective detection technique makes an obvious marriage. The LC-API-MS/MS has in the developed world demonstrated its potential in the medicinal field through proteomics studies.

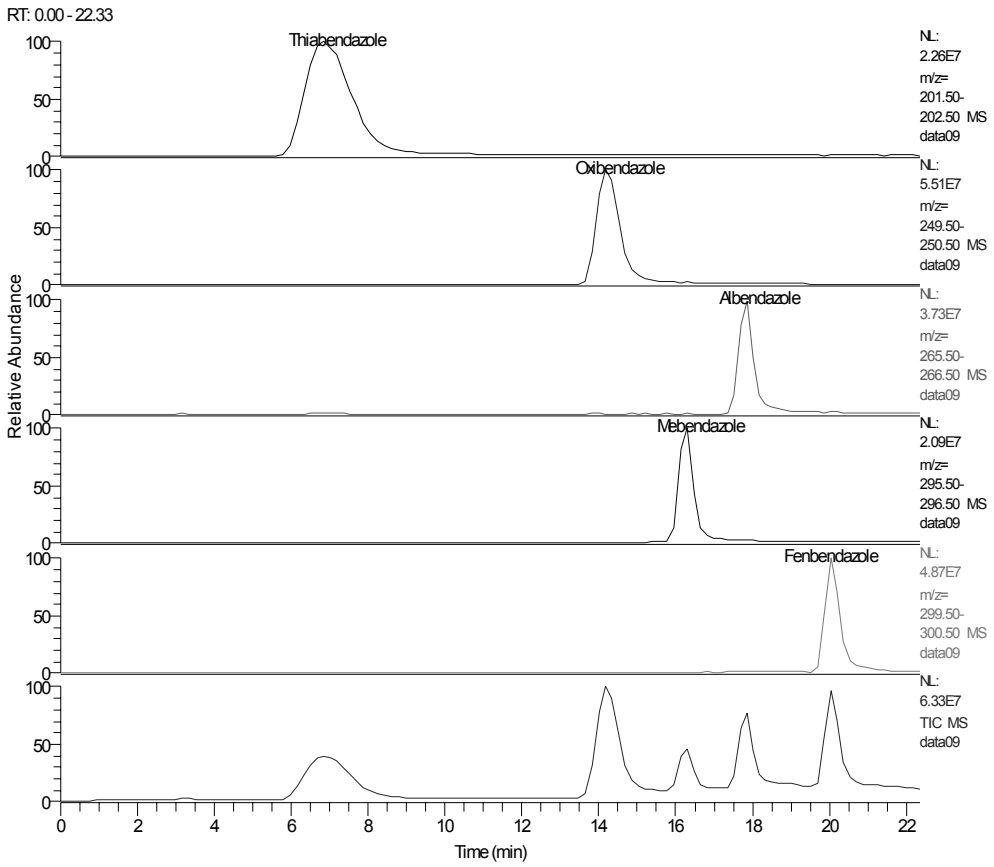

Figure 3 SLM/LC-ES-SIM-MS chromatograms of 1 mg/L mixture of benzimidazole anthelmintics in urine matrix

Proteomics is the study of protein composition of a cell, tissue, or organism. The primary objective in proteomics is to monitor changes in protein expression in response to changes or disturbance such as gene mutation or environmental stress. The focus to our understanding of the protein of diseases is that the possibility of development of disease specific drugs could be developed. This approach is totally different from the antibiotics type of approach treatment. In the developed world for example a great number of women are diagnosed with breast cancer each year, and hence breast cancer remains the major concern to public health. Proteomics using LC-API-MS/MS has to date contributed to our understanding of some forms of cancer [28]. In addition LC-API-MS/MS has also demonstrated great potential in the study and development biomakers and drugs for a variety of diseases [29,30]. We believe that Africa needs to invest into this technology so that it can start tackling some of its health related problems, which it does not share with the developed world.

Conclusions

The API-LC-MS technology has demonstrated its applicability as a monitoring tool to protect humans from abuse of restricted compounds targeted for veterinary use. This technology requires less time because the derivatisation step has been removed. The compounds of interest are monitored directly and in their environment. The potential of this technology with respect to medicinal application cannot be over estimated. Africa is a continent that is pledged with HIV/AIDS in addition to some diseases that mainly common to it.

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Anti-malarial Therapies in Africa. Preferred Dosing Combinations and New Potentials for Drug Development

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Keywordss

Abstract

The three mainstays in use for effective control of malaria are: anti-malarial drugs for the treatment of infection, pesticides to control the spread of the malarial vector, and pesticide-treated mosquito netting to prevent infection. Most recommended drug regimens for the treatment of malaria are based on artemisinin combination therapy (ACT). This presentation describes our work in West Africa and at Howard University to increase access to malaria drugs in Africa. The drugs halofantrine and lumefantrine (benflumetol) are addressed in this presentation. Halofantrine is a drug originally launched by Glaxo SmithKline that is very potent and possesses a convenient dosing schedule (two days of dosing at a one-week interval). Halofantrine is, however, essentially unavailable because of cost and poses a concern for cardiovascular toxicity. We will present new chemistry utilizing modest technology that greatly reduces the cost of this drug and points a way towards addressing concerns over potential cardiotoxicity. Lumefantrine is also a synthetic target for new chemistry to reduce the cost of the active pharmaceutical ingredient.

The Role of Intention in Technology Development

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Keywords: science of intangible, sustainable technology, chemical processing

Abstract:

If we follow the path of human intentions as a social form, how humans as individuals and collectives arrange their lives, we find that Intention is not a wish or an aspiration. Rather, it is a plan, a way to create a pathway. This paper posits that the overwhelmingly intention governing contemporary economic and social existence is the Establishment plan to control, contain, and sell off the whole world, again and again, and attempting to obliterate the natural world by transforming everything in it to products. This Intention has been imposed on all the peoples of the world. In this, the technology development has merely been a tool for sustaining status quo, which is aphenomenal in the context of nature, where everything is dynamic. This paper follows some of the dangerous pathways of contemporary attempts to control nature, and suggests another path for the world community.

1. Origin of Intention

For the last 200 years the role of intention in all social endeavors has been either ignored or carefully put aside. This includes practically all scientific analyses, and coincides with the commercialization of practically everything in our lives, including education [1] and charity [2]. The moment any action is judged against a commercial value, it is assumed that the intention of the action does not have any bearing on the action. This detachment from intention, which is actually the driver of all actions, is so embedded in all analyses that our research found no model that considers this factor in any model of the modern age.

Every action is preceded by intention. Every civilization, ranging from ancient Indian to European culture has recognized the role of intention. For instance, the relationship between 'Chetna' (inspiration) and 'Karma' (deed) was outlined in Mahabharat and in the scripts of Buddha. In Europe, the ancient criminal justice system was based on 'guilty mind' (*mens rea*). The most famous saying of Prophet Muhammad and the first one cited in the collection of Bukhari [3] is that any deed is based on the intention. A review of human history reveals that the perpetual conflict between good and evil has always been about opposing intentions. The good has always been characterized by the intention to serve a larger community while evil has been characterized as the intention to serve a self interest. Because nature itself is such that any act of serving others leads to serving the self in the long term, it is conceivable that all acts of serving others in fact amount to self interest in the long-term [2;4]. Some see this as the approach of obliquity. However, not many understand the value of this approach and the most dominant theme of the contemporary society is self-interest in the short-term is everything [5]. History also tells us that ruling entities have always covered up their intentions. From ancient Pharaohs to contemporary ruling elites, rulers have invariably maintained the façade of their good intentions. Whenever this covering up became exposed, the principle of "the King has been ill-advised" has been invoked. While the onset of the information age has begun to make it difficult to cover up intentions, recent events in this new millennium show clearly that covering up intentions is bound to be very costly and will have short-term consequences. The US invasion and occupation of Iraq for trumped-up reasons is the most recent example, with tragic ramifications for humankind [6;7].

Few would dispute seeking peace is the loftiest goal of humans in society, yet human history is marred by war [8]. Since the beginning of the 20th century wars have given impetus to economic and technological breakthroughs as research and the development of better weapons of destruction, and their production create jobs and potential new products to be sold in the civilian economy. In the United States a war president is almost

certain to be re-elected, and talking war is considered to be presidential. Ronald Reagan, the Star Wars president, was considered the most popular president ever, although the war (named for a popular science fiction television program) was to be about developing weapons systems to control outer space by the US against its perceived enemies. This scheme required such an enormous outlay of the collective wealth of the US that it was deemed, after long debate, unworkable. However, it has become a vastly successful commercial enterprise. Star Wars toys, stories, and movies are one of the most popular forms of entertainment even for adults. In the prevailing US culture, dominance is synonymous with weapons of mass destruction, which can be simultaneously morphed into consumer products engineered to becoming part of the human cultural space [9].

2. Nature for Sale

Energy

The sun shines 1.3 kW of energy per square meter on us, yet we burn some 50 million barrels of crude oil daily to have energy for our daily needs [10]. This crude oil is refined with numerous toxic additives that are particularly harmful when burned in all combustion engines. Natural gas is another form of energy on which we have become dependent. This gas is processed (to remove water, carbon dioxide, etc.) with toxic chemicals, such as, glycol, Diethylamine (DEA), and others. Even very small parts of these toxic chemicals are dangerous to humans, particularly when they too are burned, in every turbine and other type engines, and the gas stoves in our kitchens. Natural gas is also used to make fertilizers that can only be compared with drugs – the more taken the more needed. The ensuing dependency severely compromises inherent metabolic systems, and in the case of fertilizers, depleting the soil of its inherent nutrients. The cycle of poisoning does not stop here. Plastics are made from the toxic waste left after refining oil, 2.5 million tons of it every day. They are laid out on everything, from baby bottles (that emit dioxin when microwaved) and children's toys to carpets, wall paints, and pillow fillings. To make them user-friendly, more toxins are added. Meanwhile governmental agencies bombard the public is with slogans recommending, "Reduce, Reuse, and Recycle", knowing fully well that every cycle of re-use makes these plastics more toxic and oxidized, using very important oxygen molecules to produce even more harmful chemicals. This plastic is particularly poisonous when heated, yet they are marketed on non-stick™ cookware and recommend incineration as the ultimate fate of these plastics [11].

Air

Cigarettes (nicotine added tobacco) were introduced into the personal and public space less than 100 years ago, advertised as glamorous for women and masculine for men, who inhale toxic smoke directly into the lungs. Thus far, the only attempt to stop this human destruction, after years of research and law suits by the public, has been to put warnings on cigarette packs, and increase the price by value added taxes in the US and Canada. In the vast majority of developing countries, people who cannot afford food enough to sustain themselves, smoke billions of dollars of cigarettes daily, profiting only the entities that produce and sell these weapons of mass destruction. In addition many of these same countries are tobacco producers, whose economies to date are dependent on this crop [12], and although countries in Latin America and Africa have taken measures to prevent youthful smoking, Big Tobacco is leading an offensive against such measures in these areas of the world [13] .

Water

Nature offers free water through rainfall that, after passing through soil, becomes potable by picking up essential minerals. Every nation has access to this water, which is best consumed without any additive. Yet throughout the western world people have little option to drink this fresh water since the water supply system is infused with chlorine, possibly the most potent poison readily soluble in water. Chlorination of water was first introduced in England in 1908 and the US and Canada soon followed suit [14]. Products and services that result in 45% of the U.S. gross domestic product are rooted in chlorine chemistry. In addition to water disinfectants and pharmaceuticals, chlorine is critical to 25% of all medical plastics, 70% of all disposable medical applications, and 95% of crop protection chemicals; it also plays a significant role in the production of soaps and detergents, aluminum, and pulp and paper. The chlor-alkali sector is a solid job producer in the U.S., with a payroll of more than $360 million and more than 37,000jobs [15].

In addition, many cities in the US and Canada have added fluoride to the water, as was recommended by the US Dental Association, the same Dental Association that once promoted the addition of fluoride in toothpaste, followed by the 'invention' of fluoride-free toothpaste. This form of corporate control is so intense, that there are now discussions about the efficacy of adding Aspirin™ and even Lipitor™ to drinking water [16]. Chlorinated water has become synonymous with some government/corporate definitions of health. Even the World Health Organization of the UN deems chlorinated water the only potable water. Human civilization has survived and indeed thrived for thousands of years, yet we are forced to believe today's civilization cannot survive without the addition of a toxic chlorine tablet. Countries that once had the most access to drinking water have become the most behind in accessing 'potable' water.

Food

Nature offers us free food in the form of plants and animals that feed on these plants. As infants, the best food is mother's milk, which is also free. However, every aspect of the food chain has been engineered, making each 'process' inherently toxic, so that now mother's milk contains traces of all the toxins the mother has ingested and the presence of plastic in umbilical cords [17;18]. The food we eat has a very high price tag because it has become a matter of public policy to throw away excess food to avoid 'price shock' [19;20].

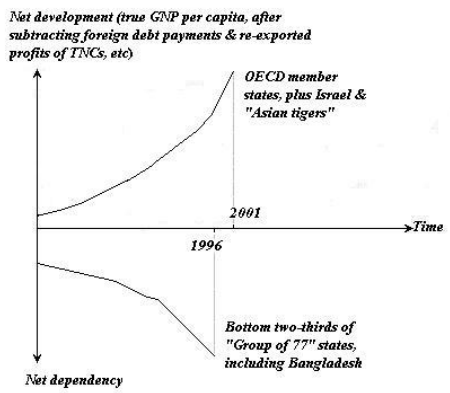
Few doubt that processed and 'engineered' food is the cause of obesity (the second biggest killer in North America), yet the developed countries continue to flood Asia and Africa with processed food product technology. In the modern age, there is not a single famine that could not be averted by the West, yet it remains the imposed savior of the world, particularly the developing world. The developed countries have made a contribution to civilization in the form of the plastic bottle to carry water, yet people in Somalia have carried their water in clay containers since they learned to make pottery. Which water is less contaminated? Anyone capable of browsing the website would know the dangers of plastic bottles and with any knowledge of science would understand that leaching doesn't stop just because we cannot measure the amount leached with available technology [4].

3. The science of inefficiency

Historically, human efficiency has been synonymous with doing more with less – the essence of waste minimization. In the Western capitalist world, wasting is built in to the system. Canada, the only country that topped the UN-designated best place to live five years in a row is also the country that has the most energy consumption per capita [21]. If cold climate is an indicator of energy needs, Canada's per capita energy consumption is much higher than colder parts of the world, such as Alaska, Norway, Siberia, and others [22]. In the developing world, Kuwait spends 40% of its energy needs in burning fossil fuel so this tiny country can be cooled with air conditioning [4]. How could this type of absurdity be promoted? You keep repeating certain messages over and over and make sure that people are fascinated enough to stop thinking. This principle in modern age was promoted by Bernays [23].

In contemporary Western society, there is an all- pervasive perception that intentions don't count. Nobel Laureate Linus Pauling – prizewinner both for Chemistry and for peace, transmuted his work into the notion that humanity could live better with itself and with nature through the widest possible use and/or ingestion of chemicals, that chemicals are chemicals, i.e that knowledge of chemical structure discloses everything we need to know about physical matter- that all chemicals of the same structure are identical regardless of how differently they may actually have been generated or existed in their current form [24]. Paralleling this idea, the Nobel Laureate in Economics, Joseph Stiglitz, has redefined the entire field and science of economics along the line of the notion that information is destiny. Such dogmas have proven especially harmful for health and quality of life in the developed world and for basic economic welfare in the developing countries of Africa, Asia and Latin America [25]. Scientists need to be asking if the catchphrase 'chemicals are chemicals' is true, every nation that fell or was pushed into the trap of chemical fertilizer use by agribusiness, is now searching for ways to escape its myriad problems. If money, or investment, is "destiny" why do we see repeated economic collapse in developing countries proportional to the money invested from developed donor countries? Figure 1 illustrates this point. Following a term of service as the head of the World Bank, it was Prof. Stiglitz, in an August 2003 speech in Bangladesh, stated that "the World Bank and IMF only serve the interest of developed countries". From the time institutions in these countries overhauled their basic posture during the Kennedy Administration, guided by the theories of "economic takeoff" [26], and reoriented and realigned their policies in the closest possible collaboration with the United States' Agency for International Development (AID) programs, such an outcome could never have been in doubt.

According to the U.S. motivational guru Brian Tracy, "today the greatest single source of wealth is between your ears". Human beings, by their labour, are the source of all wealth, yet modern civilization equates wealth with reducing the human population. With the exceptions of the U.S. and Canada, where population increases are now attributable entirely to immigration while the effective birth rate is zero and the natural rate of increase is below zero, population decline is the actual trend throughout the "developed" parts of the world. Yet, assistance from western industrial countries to countries of the developing world, whence the majority of immigrants originates, has been growing specifically in the form of aid to promote zero population growth – a hobby horse of George W Bush's grandfather Prescott Bush and of his father George H.W. Bush [27] – as a solution to their underdevelopment. In these countries, an entire two generations of governments have



routinely emulated the West, coming to consider population as their greatest impediment to prosperity. Countries rich with the resources of human population are considered to be the poorest [28].

Figure 1. As a result of the overextension of credit and subsequent manipulation (by the creditors: Paris Club etc) of the increasingly desperate condition of those placed in their debt, nostrums about "development" remain a chimera and cruel illusion in the lives of literally billions of people in many parts of Africa, Asia and Latin America. (Here the curves are developed from the year 1960.)

4. Why is the current technology development mode anti-Nature?

As discussed earlier in this article, the current process is driven by an economic model that is wasteful and profit driven, along with the built-in inability to consider the long-term. Nature is infinite and operates at zero-waste, hence waste-based technology is anti-nature. By taking the short-term approach, mechanisms have been created that make the world environment continuously worse. (Figure 2 elaborates this aspect for technology development. However, it may be readily extrapolated to other aspects of social development, including politics and education. The absence of good intention can only bring long-term disaster.

Early civilizations considered themselves the guardians and caretakers of all living things on the lands they inhabited, and held themselves responsible for future generations. Indigenous American Nations considered themselves one with all around them. There was no special word for Nature, no separation: plants, animals, and humans were considered interdependent. In this world it was the coming of the European invader, funded by their own rulers at home, that led to the eventual corporatizing of the earth which all living things share in common, into a commodity to be broken up at will, through wars and land appropriation. The advent of property laws made "legal" after the fact, what had actually been acts of misappropriation. In nineteenth-century America, following the Civil War, specifically in order to to protect and encourage corporate property, this "right" to retain control or ownership of *any* form of property – especially property already accounted as a business asset (whether it originated as a natural resource or as a claim on someone else's labour) but acquired without "colour of right" (*i.e.*, before there existed any law specifically defining or dealing with its legal existence as property [29]– was consciously elaborated as an exception to the Rule of Law. As the result of wars and other struggles waged to protect this corporatized form of property and the technological development that stemming from it – including associated long-term toxic effects – the world now finds itself in an environmental crisis [30].

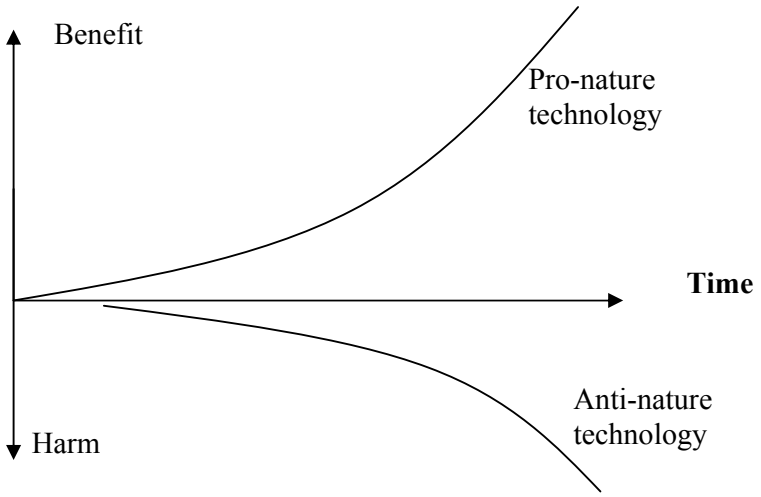


Figure 3. Pro-nature and anti-nature development schema diverge in beneficial impacts. Only intention can account for this failure of greed-driven initiatives in bringing long-term good.

The deepening of this crisis is marked by a simultaneous extension of corporate abuse of Humanity's rights of access to fresh air, clean water and other absolute necessities, alongside a growing rebellion by the human productive forces sustaining these corporations as their market, against government accommodation of the abusers and their abuses. Today, water and air have become commodities. Governments and corporations now own access to water. Overuse by industry and agriculture have made it into a scarce commodity over which future wars will be waged [31;32]. Contaminated by industrial and agricultural runoff, the sale of bottled water, or home filters to the public who can afford it, is promoted as 'uncontaminated'. Pollution itself, created by chemical poisons released into the air by industry, agriculture, and the automobile, has become a money-making commodity – with the sale of pollution 'credits' from one polluter to another. Home filters to 'clean' the air in

homes and public buildings, promote clean air, again for those who can afford it, autos in many places are required to have catalytic converters to filter out poisons emitted from the burning of fuel, to keep down air pollution. At the same time corporate activity, with its virtual immunity from prosecution, legal sanctions or legal responsibility in its home bases and main markets, is purchased and maintained by trying to dump unwanted wastes in various parts of Africa and Asia. This is arousing more and more people in the rest of the world against corporate fiat and dictate, energizing in its wake a rapidly widening discussion of alternative arrangements for Humanity's continued existence on this planet. Accordingly, the intention to control nature has become the last remaining pathway by which corporations hope to ensure a constant, n never-ending stream of profit – and a battleground on which the fate of Humanity for generations to come may be decided.

5. The myth of emulating Nature –The Aphenomenal Model

Few humans dispute that man is the most intelligent creation on this planet. No one disputes that nature is perfect (especially in the sense of complete). In fact, nature is so fully-formed and comprehensive that emulating nature has formed the basis for virtually all branches of knowledge, ranging from natural justice and dialectics of the social system to technology development. Unfortunately, however, no modern technology truly as yet emulates the *science* of nature. It has been quite the opposite: observations of nature have rarely been translated into pro-nature process development. Rather, it is the aphenomenal model [33] that which asserts relations between phenomena that do not exist, based on obscuring anything that contradicts a pre-determined outcome, followed by its justification through disinformation, that has taken the lead in all aspects of social life [2].

Even though it is widely accepted in the social framework that pro-nature arrangements such as would ensure natural justice and social equity, are absent – and not by accident but by design, few paid attention to the problem in so-called natural science. Today, some of the most important technological breakthroughs have been mere manifestations of the *linearization* of nature science: nature linearized by focusing only on its external features. Linearization forms the basis for the first line of disinformation involved [4].

Nature is non-linear and the claim of emulating nature with linear formulae is inherently untrue. Today, computers process information exactly opposite to how the human brain does. Turbines produce electrical energy while polluting the environment beyond repair even as electric eels produce much higher-intensity electricity while cleaning the environment [4]. Batteries store very little electricity while producing very toxic spent materials. Synthetic plastic materials look like natural plastic, yet their syntheses follow an exactly opposite path. Furthermore, synthetic plastics do not have a single positive impact on the environment, whereas natural plastic materials do not have a single negative impact. In medical science, every promise made at the onset of commercialization proven to be opposite what actually happened: witness Prozac™, Vioxx™, Viagra™, etc.

Nature did not allow a single product to impact the long-term negatively. Even the deadliest venom (e.g., cobra, poisoned arrow, tree frog) have numerous beneficial effects in the long-term. This catalogue carries on in all directions: microwave cooking, fluorescent lighting, nuclear energy, cellular phones, refrigeration cycles to combustion cycles. In essence, nature continues to improve matters in its quality, as modern technologies continue to degrade the same into baser qualities. Table 1 shows how engineering is diametrically opposed to natural processes.

Table 1. Natural processes Vs. Engineered Processes

Natural Processes	**Engineered Processes/Synthetic**
1. Multiple/flexible	1. Exactness/rigid
2.Non linear	2. Linear
3. Heterogeneous	3. Homogenous/uniform
4. Has its own natural process	4.Breaks natural process
5. Recycles, life cycle	5.Disposable/one time use
6. Infinite	6.Finite
7.Non symmetric	7.Symmetric
8.Productive design	8. Reproductive design
9.Reversible	9.Irreversible
10. Knowledge	10.Ignorance or anti knowledge
11. Phenomenal and sustainable	11.Aphenomenal and unsustainable
12.Dynamic/chaotic	12. Static
13. No boundary	12. Based on boundary conditions

Nature thrives on diversity and flexibility, gaining strength from heterogeneity, whereas the quest for homogeneity seems to motivate much of modern engineering. In its non-linearity, Nature inherently promotes multiplicity of solutions. Modern applied science, however, continues to define problems as linearly as possible, promoting "single"-ness of solution, while particularly avoiding non-linear problems. Nature is inherently sustainable and promotes zero-waste, both in mass and energy. Engineering solutions today start with a "safety factor" while promoting an obsession with excess (hence, waste). Nature is truly transient, never showing any exact repeatability or steady state. Engineering today is obsessed with standards and replicability, always seeking "steady-state" solutions. Similar observation can be made for socio-economical development [2].
How could this happen? Our research shows that none of these technologies emerged from any good intention. 'Good', here, implies long-term good, or good for the general public. The promoters of these products are not incapable of developing 'good' products, they are rather incapable of seeing that 'doing good is good business'. In business development, self-interest in the short-term reigns supreme and promoters of these models are so focused in their short-term gains beyond the quarterly profit. They are quite aware that their motive of amassing profit at the expense of natural justice would offend any consumer, so they resort to hiding their motives right from the beginning. This kind of mendacity results, for example, leads to the corruption of scientific research. Recently two medical researchers, one in Norway and one in South Korea have admitted to faking their research data [34]. Research has become a race to patent potential money-making developments and Nobel prizes that lead to more money, in the name of assisting humanity. The offending research institutions attempt to single out individual researchers to blame, the one rotten apple, to obscure their own culpability and the future of funding of their projects. Researchers and scientists work in a pressure cooker culture of getting there first.

In this, the fault of the consumer lies with the lack of research. In fact, consumers have been so captivated by the short-term and external gains themselves, that they cannot read between the lines that the overwhelming corporate message is "Shut up and buy!". Often, they forget the reason behind buying a product other than the fact that it was on sale, or was seen on TV, or the neighbor has one [23].

6. False Promises

In 1960, when birth control pills were first introduced, each pill contained 10 times more male hormone than necessary to abort the egg. The promise behind this was the Liberation of women. Soon after, the anti-nausea drug thalidomide was introduced for pregnant women. The promise here was that women could have easy pregnancies by removing nausea. In reality, 20% of babies who mothers were on the drug became severely deformed. This drug was banned in 1962 but now it is making a comeback. Today, even a 12 year old can get prescribed for birth control pills (at least in Canada) and the same industry is busy producing 'correction pills' that would 'eliminate' the inherent injustice of woman's biology by stopping menstruation altogether [35].

In 1940's, baby disposable diapers were introduced. The inventor, Marion Donovan noticed that her babies would 'nearly instantaneously' wet their cloth diapers as soon as they were changed. In 1946, she introduced the 'breakthrough' technology of disposable waterproof diaper. Did the habit of 'nearly instantaneously' wetting the diaper go away? Of course not. In fact, the first name of these diapers was 'the boat', indicating it was meant to keep babies afloat on their own urine! However we are convinced that disposable diapers are synonymous with keeping the babies dry and civilized. Cotton nappies are expensive, and even considered germ carriers now [1].

Overall, modern development and social progress can be characterized by its driver, greed. Nature, on the other hand, operates on the basis of need and therefore there is no need to make false promises or to institute opacity if one wishes to introduce pro-nature development. The result of the greed-driven social development has led to the current 'technological disaster' (as stated by Robert Curl, a Nobel Laureate in Chemistry). This process has led to a sharp decline in a population that cares for nature, while the number of people focused on self interest and short-term gains has skyrocketed. During this time, the quality of human health has suffered tremendously. For instance, in last 50 years, there has been an increase of 50 times per capita in the use of sugar ('refined', externally processed, carbohydrate) plastic ('wrinkle free' leather or fabric, 'durable' wood, cheap water container), fertilizer ('refined' biomass), spirit ('refined' alcohol), cigarettes ('refined' tobacco), chemicals ('preservatives', Pasteurization, antibiotics), and 'remediative' surgery, while the 'life' expectancy has increased somewhat In the words of Albert Einstein, this 'life' isn't worth living. Unfortunately, this 'life' is being promoted as the only life human beings should live for. Figure 3 illustrates this point.

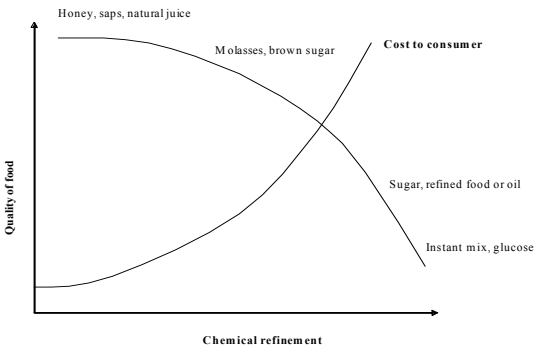


Figure 3. The outcome of greed-driven technology. The same applies to quality of human

beings that have been 'refined' with the greed-driven education system or to the quality of human health of people who adopted this anti-Nature culture.

Table 2. Some "breakthrough" technologies

Product	***Promise***	***Truth***
Microwave oven	Instant cooking (bursting with nutrition)	97% of the nutrients destroyed; produces dioxin from baby bottles
Fluorescent light (white light)	Simulates the sunlight and can eliminate 'cabin fever'	Used for torturing people, causes severe depression
Prozac (the wonder drug)	80% effective in reducing depression	Increases suicidal behavior
Anti-oxidants	Reduces aging symptoms	Gives lung cancer
Vioxx	Best drug for arthritis pain, no side effect	Increases the chance of cancer
Coke	Refreshing, revitalizing	Dehydrates; used as a pesticide in India
Transfat	Should replace saturated fats, incl. high-fiber diets	Primary source of obesity and asthma
Simulated wood, plastic gloss	Improve the appearance of wood	Contains formaldehyde that causes Alzheimer
Cell phone	Empowers, keep connected	Gives brain cancer, decreases sperm count among men.
Chemical hair colors	Keeps young, gives appeal	Gives skin cancer
Chemical fertilizer	Increases crop yield, makes soil fertile	Harmful crop; soil damaged
Chocolate and 'refined' sweets	Increases human body volume, increasing appeal	Increases obesity epidemic and related diseases
Pesticides, MTBE	Improves performance	Damages the ecosystem
Desalination	Purifies water	Necessary minerals removed
Wood paint/varnish	Improves durability	Numerous toxic chemicals released
Leather technology	Add luster, color, wrinkle-free	Toxic coating, carcinogenic dyes
Freon, aerosol, etc.	Replaced ammonia that was 'corrosive'	Global harms immeasurable and should be discarded

7. The Science of Intention

Consider the transition highlighted in Table 2. Society started off with natural use products. Any alteration in these natural products ended up making these products toxic in the long term. The question becomes, why did we allow this transition? For the perpetrators, it is clearly greed. For the victims (consumers), it is ignorance. In a way, both of them suffer from the same focus on tangibles. None of these products would have a chance, if people were consciously making decisions before any of their actions [36]. This consciousness can come only with the awareness of intentions. In the past, this important intangible has been ignored.

Intention should essentially mean good intention and has to be guided by the conscience, which is unique to human beings and is the core of what sets humans apart from other animals. Other animals, fortunately, act uniquely on instinct and hence do not risk violating their natural traits. This is also true of every other entity, including, one could argue, the inanimate objects. Only human beings have the ability to intervene in order to alter the natural course of nature. If this intervention is motivated by greed or self interest in the short-term, this intervention will invariably lead to disasters.

If human beings do not succeed in reversing this pattern, nature will make adjustments in order to alleviate the long-term harm of greed-driven initiatives. Here, we include effects that result from man-made activities. For instance, the use of 'refined' oil in combustion engines has led to global warming that destabilized the entire climate system. The reaction of nature is not the 'wrath of God', it is rather the ongoing effort to revert the current trend. The emergence of numerous diseases among humans is not 'God's revenge', it is the reaction of human bodies (a very natural system) trying to resist the ill effect of viruses. Note that viruses do not have natural microstructures or forms, they are rather the product of anti-nature processes [37]. Similar statement can be made for all chemicals that have been introduced since the industrial revolution, ranging from DDT to Freon.

8. Conclusions

It would be easy to say we can solve all our human and environmental problems by resorting to some atavistic memory of living in some imagined past. Fortunately, all tangible features of nature are dynamic and unidimensional and there is no way we can revert to a former physical existence. Any claims that this is possible, surely falls into the category of the perpetrators of the aphenomenal model. Take for instance, the following transition: Sugar cane sap → molasses → sugar → saccharine → Asparteme
Modern science tells us this transition has been devastating. So, *where* do we revert? Some suggest going back to molasses or brown sugar. But current methods of producing molasses are unacceptable. Today, developing countries engaged in these processes embrace toxic chemistry such as arsenic use to bleach molasses, while wealthy countries wouldn't hesitate to collect toxic residues from sugar factories to sell as molasses or brown sugars (some would even paint it brown (add "food coloring" to increase profitability). Others propose, 'Organic' sugar, at an extra cost. And although organic sugar means the sugar cane was not tainted with toxic pesticides or the use of chemical fertilizers, it doesn't guarantee that the 'refining' process itself was free from toxic chemicals (in fact, no sugar mill uses organic bleach). Similar statements can be made for other exotic varieties of sugar products that are currently flooding the market (including 'fair trade', kosher, etc.) None of these 'alternatives' can be considered good because, all of them have the same intention behind their marketing, which is to increase the profitability of the product, using the cheapest available means.

A late 20th century view of the world has emerged in Western nations, led by the US, which posits the world, including nature, as a market. Here everything is for sale, includin how people think and feel. As theories of the world, market based approaches need not only to be evaluated in terms of their success or failure, but also in terms of the symbolic and cultural effects they make possible by placing a cash value on people's needs.

Unless intention is changed, the pathway that we have traveled cannot be changed. Intentions can only change with knowledge. Knowledge can only come with long-term vision, which is the essence of education that is not equated with training or learning of skills. It helps us to see how focusing on the short-term has made it possible that whatever we long for eludes us. It is the kind of knowledge that allows us to see and plan for the long-term, mindful of where the path of our actions can take us. With this kind of knowledge, even in the short-term, doing good can be good business, for technology development as well as general social progress.

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The Role of University in Promoting Indigenous Knowledge Systems in Zimbabwe with Reference to Traditional Practices in Rural Areas

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ABSTRACT

University Outreach: Promoting Indigenous Knowledge Systems in Zimbabwe

This paper looks at the importance of Indigenous Knowledge Development (IKD) and the function of Universities, through relevant government ministries and other institutions of higher learning in promoting the role of culture, indigenous knowledge and cosmo-vision in agriculture and rural development. Traditional practices have not always been very effective to prevent over-exploitation of resources and environmental disaster. But it is within the framework of their own knowledge and experiences, that farmers take decisions and define their relationship with outside knowledge and agencies. Indigenous Knowledge Systems have been found to be dynamic, incorporating new elements and concepts as contacts with other people and new phenomena are established.

The paper analyses what is involved in Indigenous Knowledge Development and why it is important to look at indigenous methods of imparting knowledge, indigenous approaches to innovation and experimentation, indigenous games and indigenous specialists. Indigenous development is based mainly on locally available resources such as land, water, local knowledge; culture and the way people organize themselves. Indigenous development strives to optimize the dynamics of these resources, thus enhancing cultural diversity, human welfare and ecological stability.

Universities have a role to play in creating sustainable livelihood systems through Indigenous Knowledge Development. This can be done basing on social spiritual and natural realities as expressed in the cosmo visions or worldviews of the communities in Zimbabwe.

By virtue of their position in academia and society, the universities can create an enabling environment for Indigenous Knowledge Systems with sustainable livelihood systems. The paper looks at the need for supportive research policy, inter-scientific dialogue enhancement, joint learning and capacity building, deliberate stimulation of local and country wide regional economies, dealing with controversies and the traditional resources rights.

In conclusion, possible challenges and fundamental issues on approaches are highlighted coming up with activities to be utilised.

INTRODUCTION

The current wave of globalisation has contributed significantly to the economic growth, but this growth is not proportionally distributed throughout the nations. A lot of people still cannot afford the mere basics for sustenance. Poverty is reflected in various ways ranging from lack of purchasing power, ill health, political influence, economic dislocation and resort to violence.

The quest for better resource benefit has, in some instances, caused traditional human societies to break-up. Numerous customs expressions and languages are vanishing. Global awareness of these problems and their

recognition by government is increasing. This has resulted in a number of international conventions and initiatives on biodiversity, desertification, and water and climate changes. Universities are appropriately placed to bring about awareness on the value of the earth's ecosystem and the recognition that indigenous knowledge and traditional cultures may contain key characteristics to meet the local and global challenge of bio-cultural sustainability.

This paper is meant to give additional tools for involvement and uplifting of the knowledge understanding and participation in indigenous knowledge development.

BACKGROUND ON INDIGENOUS KNOWLEDGE SYSTEMS

Indigenous knowledge is knowledge generated, developed and used by people in a certain area. It is not limited to indigenous peoples and can include knowledge originating from elsewhere but has been internalized by local people through local processes of learning, testing and adaptation. It forms the basis for the art of identifying combining, unfolding and protecting local resources. It is rooted in and stems from the local practices hence it is specific to local context. We also talk of Endogenous Development, which refers to development based mainly, on locally available resources such as land water vegetation local knowledge, culture and the way people have organized themselves. External knowledge and resources are considered important to complement the local resources. Endogenous development strives to enhance cultural diversity, human welfare and ecological stability. It is the reason to the current process of modernization, which, in many respects, is having the opposite effects.

It should be realized that for a developing country to depend on foreign expertise and experiences alone for transformation, it will not and cannot be the sole remedy for the problems encountered. All possible avenues of democracy, peace and development initiatives from within must always be explored. This highlights the need for domestic capacities and/or potentials to take precedence to the external ones.
The success of Universities' development initiatives in integrating indigenous knowledge capacities and potentials in the curriculum can be a drastic milestone in educational development.

In developing countries it is noted that there are three stocks of knowledge; namely modern and scientific knowledge (expert) knowledge; traditional or people's knowledge, and the new knowledge which is a blend of expert and people's knowledge. In a number of cases the tendency has been for the expert Western systems to dominate or subdue the indigenous systems. The debates on these issues impinge greatly on the local people's capacity and capability to maintain and effectively utilize natural resources sustainably and beneficially. This has to be done in close liaison with other facilitating relevant institutions for the purposes of developing appropriate skills. Of late there has been a growing tendency in the Sub-Saharan Africa Region to pay close attention at how traditional systems of governance, local institutions and indigenous knowledge systems may be fruitfully incorporated into sustainable development initiatives. Therefore, Zimbabwe is by no means an exception to this progressive challenge.

IMPORTANCE OF INDIGENOUS KNOWLEDGE DEVELOPMENT

Studying and **conserving indigenous knowledge is important** for several reasons:

- Indigenous knowledge is generally an under-utilised resource.
- It is important and relevant for the development process.
- It provides a basis for problem solving strategies for local communities particularly the poor.
- It is a fundamental representative of an important contribution to global development knowledge.
- Investigating first what local communities know about indigenous knowledge helps improve understanding of local conditions and provide productive context for activities designed to help the communities.
- Indigenous development strives to optimize the dynamics of locally available natural resources. [1]
- A lot of indigenous knowledge systems are at risk of getting extinct; e.g. (the system of passing on knowledge to young generation by grandparents at an informal gathering).

- It is possible to create sustainable livelihood systems through Indigenous Knowledge Development.

In their operations and at policy level, the universities or institutions of higher learning should involve all sectors of society, government officials, and district councils, community members and leaders. The process should involve strategic decision-making in which institutions of higher learning, local communities, traditional leaders and government authorities identify solutions and priorities. The general realisation is that the success of promoting Indigenous Knowledge Systems relies mainly on motivation, interest and commitment of local people and the non-governmental organizations involved. There should be an implementation framework and action plans detailing responsibilities and specific budgets. Grassroots participation has to be encouraged and sanctioned starting from the strategy document preparation. The universities should come up with feasibility studies for action research. The process should achieve the following:

- Identification of local talent, and empowerment of the local people to conserve and utilize natural resources through the sustainable use approach.
- Reduction of environmental degradation through participatory approach, particularly in the rural areas.
- Provision of linkages between social and natural resources activities at district level.
- Supporting and enhancing local demonstrations of sustainable development initiatives and common practices.

GROUNDWORK FOR THE UNIVERSITIES.

Creation of an Enabling Environment.
For Indigenous Knowledge Development programmes to be more meaningful and effective, there is need for supportive legal framework and a close liaison with the environmental conservation authority. The intervention and analysis by relevant policy makers is paramount to avoid possible conflicts and resistance to the new initiatives at various levels.

The universities can institute intercultural dialogues by initiating open partnerships with other countries regionally and /or internationally. This creates a platform for exchanging ideas with a deliberate intention to learn and understand the co-evolution of diversity of cultures. Workshops and scientific conferences can be organized centered on specific themes. Undertaking joint research and discussing the outcomes is crucial and critical because general perspectives on solutions are shared and disseminated to various users.

ANTICIPATED CHALLENGES.

To identify and establish the scientific paradigm of particular knowledge systems is quite challenging because it implies making indigenous theories, concepts and research methodologies explicit for development and transfer into university conventional curriculum.

We are looking at the new scientific paradigms such as the sciences of complexity, and the chaos theory. They are governed by principles in which causality is cyclic; and cause and effect are not separable. Quite a number of indigenous knowledge systems have subtle engagement with the natural processes and intuition as a vehicle of understanding. There is need to understand from traditional leaders the role and techniques of meditation, the role of ceremonial music and rituals, just to mention a few. However tradition sometimes has fundamental challenges; like where the children are not supposed to ask questions or are told to ask later but the opportunity never comes. The modern feeling maybe that such culture can be a culprit that keeps creative energies trapped by conformity and compliance. Some controversies relate to spiritual traditional leaders who may come up with beliefs contrary to representatives of formal religion.

Such issues pose an ongoing challenge in dealing with issues of indigenous knowledge systems.

It is gratifying to note that some structures were formed to resuscitate and promote traditional knowledge systems. The Association of Zimbabwe Traditional Environmental Conservationists (AZTREC) was formed in 1985 to focus on environmental conservation and cultural survival. The association is comprised of war veterans, groups of chiefs, traditional leaders, spirit mediums, traditional medical practitioners and natural spirit driven experts. Activities of this association are centered on eco-cultural villages where many income-generating activities are taking place. Such structures invite the participation from institutions of higher

learning to facilitate with the validation, documentation and publication of indigenous knowledge. This scenario pauses a number of challenges to the academia in terms of the precedence set by such organizations.

THERMATIC AREAS OF ENDOGENOUS DEVELOPMENT AS FOCUS FOR RESEARCH.

The universities may focus their research mainly on the five thematic areas of Endogenous Development. These are supposed to cover the following,

- Nature and conservation knowledge systems,
- Health delivery knowledge systems,
- Agriculture knowledge systems,
- Technology knowledge systems,
- Culture and cosmovision knowledge systems.

Experience has revealed that within the communities there are natural experts in all facets that constitute endogenous development. Generally in African perspective, these natural experts are the custodians of specific indigenous knowledge systems because they take the lead in the new initiatives. However there is need for in-depth research and validation of these initiatives and this can be authenticated through action research, experimentation and testing by universities and other institutions of higher learning.

Details on Thematic Areas.

(a) Nature and conservation knowledge systems refer to knowledge on the characteristics of woodlands, wetlands and sacred groves. The experts jealously guard against any random destruction of the environment. Through leadership and guidance of the chiefs and spirit mediums, rehabilitation of woodlands, wetlands and mountain eco-systems has been successfully undertaken in improving the state of bio-cultural diversity.

(b) Health delivery knowledge systems refer to natural health delivery experts or health spirit mediums who care for mortal human being's health requirements. These experts never attended any formal medical school. They may be spirited medical practitioners or herbalists.

(c) Agricultural knowledge systems refer to farming being done according to the dictates of nature resulting in well above average yields. Experiments can be done on water conservation, natural pest and disease management, seed selection, organic crop production, storage of traditional crop varieties and performance of agricultural rituals and ceremonies.

(d) Technological knowledge systems: Some individuals are specialists in traditional trades like blacksmith. Sculpture, pottery, carpentry basket making and building. The communities used to depend mainly on these experts for their technological requirements.

(e) Cultural knowledge systems; Culture refers to an integrated pattern of human knowledge, language customs, ideas, beliefs, taboos, techniques, tools artifacts, ceremonies, ritual, folklores and gender. Some cultural villages have been established. These are regarded as centers of excellence in disseminating culture, religion and teachings such as rituals, ceremonies, spirited world worshipping and traditional assemblies. [2]

Cosmo-vision or worldview refers to the premise on which people organise themselves and determines the moral and scientific bases for intervention in nature. It describes the relationship between human beings and nature, the perceived role of supernatural powers and the way natural processes take place.

FUNDAMENTAL CHARACTERISTICS OF INDIGENOUS KNOWLEDGE DEVELOPMENT TO BE OBSERVED.

In serving the needs of the rural communities a wide range of activities can be addressed centered on **supporting local initiatives.**

In-situ development of local knowledge; this involves a combination of local and external resources in experimentation and adaptation to the changing circumstances and opportunities. It has to be based on the local people's own way of explaining reality, sharing and transforming information and learning from former experiences.

Maximizing on local control; There are many ways that communities use to take decision in the local context. It is useful to enhance this process of local control. However there are subcultures abound and differences in gender, class ethnic group, religious affiliation, education, language and power that lead to different needs and objectives. Addressing these subcultures is a delicate process and there is a lot to learn on the issue from the locals.

Retention of benefits; The action research outcomes should be such that they benefit all the participating stakeholders. The locals should benefit from the utilization of the new innovations and gaining the new knowledge, and publications of the results should reward researchers.

Utilisation of identified niches; Production and marketing of region specific food products and craftwork is part of the indigenous development activities, which can attract trade with interested groups. Currently the roadside sell of craftwork is without any form of pricing system. Negotiation or consensus is the prevailing method of setting price for the individual customer. Formalisation of the situation will result in benefits to both parties involved with some revenue going to the state.
The issue of intellectual property rights has to be viewed seriously to ensure patenting of inventions or other discoveries. The locals should benefit from their intellectual property rights.

Therefore universities have the task to ensure that all the participants in the research initiatives are aware and conform to all these far-reaching logistics.

UNIVERSITY ACTIVITIES:

For the university to fulfill its mandate in contributing to the **resuscitation and preservation of indigenous knowledge systems**, there is need to embark on the following activities.

(i) Development of strategic plans, which will, incorporates community service and outreach programmes as one of the objectives. Representatives from all stakeholders, traditional leaders and local authority should be involved.

(ii) Initiating and conducting needs assessment workshops and come up with relevant training programmes and subsequently compile information for writing training modules to serve as guidelines.

(iii) Carrying out training programmes for university staff, students and other participants to address attitudinal aspects as well as participatory development of indigenous knowledge in a cultural context. The training would be done by academics, traditional leaders and traditional experts. Accountability should be towards community development, the rural people and the scientific community.

(iv) Initiating and coordinating research programmes by sharing areas and topics for research, methodologies, assessment of findings and publications. [3]

(v) Creating information-sharing platform for the participating universities to exchange ideas on progress and findings from the research programmes.

(vi) Establishing exchange programmes for staff, students and traditional leaders between the different partners for intercultural dialogues on methods, concepts and theories.

(vii) Instituting systems of presenting findings to the government to influence the future investment in science, research technology and development.

(viii) Putting in place periodical and systematic evaluation of training and research programmes to make appropriate adjustments and rectifications. [4]

(ix) Assessment of the impact of the entire initiative with regards to the overall goal of the Indigenous Knowledge Development Programme.

(x) Identification of additional training needs to ensure capacity building and establish mechanisms for conflict resolution and management.

These activities create the fabric of the entire outreach initiative as a result all the stakeholders have to be groomed to fit easily into the system. A systematic schedule of forward planning will enhance a practical approach to the initiative. The above activities call for a lot of funds therefore sourcing and lobbying for funds should be on the agenda to ensure success of the programmes.

CONCLUSION

We are all reminded of an old adage that a hundred mile journey begins with the first step. Some universities in the country may have already started working on **indigenous knowledge development initiatives** at a very small scale; however, there is need for enhanced complementary support to ensure more coverage countrywide. A lot of brilliant practical ideas have been generated with no immediate practical implementation. This reflects a clear vacuum in our curriculum with regards to Indigenous Knowledge Development. Our current programmes cater for the formal micro-needs of our society. There is need to analyse our curriculum structure and systems closely to incorporate Indigenous Knowledge Development and cater for the macro-needs of our nation.

Universities and other institutions of higher learning should raise awareness of the value and importance of community based practices in enriching the indigenous knowledge development process. To ensure effective and deliberate contribution to local community development, it is essential that all participating members of the community share a common vision for development. The vision must be well articulated for members to understand and own it. The universities can also facilitate the mainstreaming of indigenous knowledge application into the national development programmes and internationally supported projects. This necessitates proactive lobbying through the community-based organizations, relevant government authority and other stakeholders.

The general outcry of local indigenous knowledge and natural resources being tapped modified and utilised elsewhere should gradually be an issue of the past.

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Managing Knowledge in Public Health
(TB programme in Sudan case study)

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Keywords

Knowledge Representation, Knowledge Management, Conceptual Mapping, Case-Based Reasoning, Geographic Information System, Sudan

Abstract

This paper examines the use of a combined conceptual mapping and case-based reasoning approach as means to develop knowledge-based components for the tuberculosis surveillance and management programme in Sudan. The programme has a large and diverse group of stakeholders scattered throughout the country. The research involved capturing knowledge models of experienced programme staff and service users to preserve and use, as well as to identify recurring patterns in disease management failure and success. Standard knowledge elicitation methods like interviews and group discussions were used to identify key elements of the programme and understand the relationships among resources, activities, and the results it hopes to achieve. Preliminary concept maps were created and validated by our domain Experts. The activities of the next phases of the project consist of organising and facilitating group discussion sessions with participants from stakeholder groups on the areas proposed. This will be followed by the process of codifying and validating the maps. The scenarios told during group discussion can be examined to identify cases of good practice in management of organisation, diagnosis and treatment of disease. ICT (Information and Communication Technology) solutions, within budget constraints will be considered to find appropriate means to disseminate the knowledge gathered. The overall objective of this research is creating knowledge assets that can aid decision making and learning from experience in the organisation. However, just as political and resource commitment are essential for effective health policy and practice, commitment to a data-sharing culture by individuals in the organisation is essential to successful implementation of a knowledge management approach.

1. Introduction

In CEN, Knowledge is defined as the "…combination of data and information, to which is added expert opinion, skills and experience, to result in a valuable asset which can be used to aid decision making. Knowledge may be explicit and/or tacit, individual and/or collective. [5]". The development of Knowledge management strategies is motivated by immense interest to understand how knowledge can be used to improve the effectiveness of organisations. This led many organisations to adopt techniques and strategies to bring together what they know, along with the goals and measures, in one place, at one time, to support individual/group learning and decision-making processes.

This paper examines the use of a combined conceptual mapping and case-based reasoning approach as means to develop knowledge-based components for the tuberculosis surveillance and management programme in Sudan. In general, public health programmes face three knowledge challenges. First, is sharing knowledge by encouraging staff to take advantage of the knowledge, experience, and expertise available in their own

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organisation and other relevant groups. Second, is learning from experience by drawing on proven practices and lessons learnt. Third, is coping with too much information (technical and management advice, statistical data, and research findings) [25], or too little given the relatively poor status of local information systems [7]. The programme has a large and diverse group of stakeholders scattered throughout the country. The overall objective of the research is to model knowledge of experienced programme staff and service users to preserve and use, as well as to identify recurring patterns in disease management failure and success.

Standard knowledge elicitation methods like interviews and group discussions were used to identify key elements of the programme and understand the relationships among resources, activities, and the outcomes it hopes to achieve. Preliminary concept maps were created and validated by domain experts. The next phase is to elicit and conceptualise knowledge in the proposed areas where by the stakeholders are introduced to the tools, and can actively participate in the process of validating and discussing the researcher's maps as well as develop their own knowledge models. This will initially involve a sample of representative groups, to include Central Unit staff, programme co-ordinators, epidemiologists and users of services. Our aim however, is to involve staff and users from various locations and levels of service to identify similar and different concepts, inevitable in a large country like Sudan. The final part of the project aims to compile the generated maps into case libraries that allow storage, retrieval and management of interrelated concepts and knowledge models of stakeholders, as well as identify cases of good practice in management of organisation, diagnosis and treatment of disease using the CBR components in the software.

The following section gives an overview of the tools used in the project. In section 3, the knowledge obtained on the organisation and preliminary work to represent this knowledge is discussed. Section 4 considers ways to extend these knowledge models. The final section specifies factors that are critical for the success of the project and its future direction.

2 The Tools

The *concept mapping* approach is based on the idea that concepts and propositions are the building blocks for knowledge in any domain. A concept is a name in the domain defined as a perceived regularity in events or objects designated by a label. The label for most concepts is a word (e.g. training, treatment, stigma…etc.). Propositions are statements about these objects or events containing two or more concepts connected with other words to form a meaningful statement (semantic units or units of meaning). A concept map is a two-dimensional graphical representation of a set of concepts (usually enclosed in circles or boxes) connected by directed arcs representing propositions, thus forming a web of short sentences representing knowledge in some domain. Novak and Gowin [21] popularised the role of concept mapping, and co-development, in thinking and in learning, focusing on the potential for using it as a means of structuring and visualising cognition, both as an individual aid to thinking and to support collaborative learning in groups. A number of concept-mapping tools have been developed, and have since been used to elicit and represent large-scale knowledge models of local scientists in complex domains such as, weather forecasting [6], as well as general tasks such as how researchers search for and consult information resources [20]. Examples of use are also available in participatory public health research [4] and evaluation of national public health program [1].

Case-based reasoning is a rather new addition to the current set of Artificial Intelligence methods. Problem solving is achieved by storing a case-base of historical knowledge to find a solution for a new situation. It is based on Roger Shank's work on dynamic memory and human reasoning that emphasises the use of concrete instances as guidance for solutions [15]. Expert knowledge is used to describe the cases, establish similarity measures (used to identify the solution space or the most relevant cases to the new problem), adapt retrieved solutions, and evaluate the learnt lesson for inclusion into the case-base. This four-step process (retrieve, reuse, revise and retain) is repeated to achieve the ultimate goal which is to retain the new solution, i.e. learning [18]. How well a CBR system performs depends on choices made in setting the rules for these processes. For instance, too many retrieved cases signal loose similarity measures, while a case base with too few cases may produce no prediction at all. More recently, CBR and knowledge modelling are coming closer, where they are seen to complement each other, as used in the *CmapTools* [19]. The operational knowledge that a case represents is one of the strengths of the CBR approach. Representing operational knowledge is also a knowledge management and adaptive learning theory of 'learning by doing'. Codifying the lessons learnt is fundamental to 'keep on learning'. The CBR component in the *CmapTools* will be used at a later stage in the project to represent cases of experience in the areas discussed in section 4.

3. The Concepts in the Domain

This section summarises the knowledge we gained during our domain understanding phase on the disease, its extent and implications on national and individual socio-economy, how the programme is run, the data recorded/reported, and information used in managing activities of the programme. Preliminary maps that were generated during our domain understanding phase are presented in the Appendix.

3.1 The Disease and Burden

Tuberculosis (TB) is a leading infectious killer of young people and adults worldwide, taking nearly 3 million lives a year. According to the world health organization (WHO) nearly one-third of world's population is infected with TB. Most will never come down with the active disease, because the human immune system keeps the bug in check. However weakened by other diseases and stresses such as HIV, poverty, malnutrition and aging, that immunity can be jeopardised and those who have been exposed may develop active TB. More than 90% of global TB cases and deaths occur in developing world, where 75% of cases are in the most economically productive age (15-54 years). There, an adult with the TB loses on average three to four months of work time. This results in the loss of 20-30% of annual household income and, if the patient dies of TB, an average of 15 years of lost income. In addition to the devastating economic costs, TB imposes indirect negative consequences – children leave school because of their parents' illness, and women are abandoned by their families as a result of their disease.

3.2 The Organisation

The main objective of Sudan National Tuberculosis Programme (SNTP), as with any other public health initiative, is to ultimately eradicate the disease. The means to this end is controlling its spread by effectively identifying and treating as many infectious cases as possible. The programme uses a network of management units (TBMU) and DOTS (Directly-Observed Treatment System) centres located in 22 (out of 26) States. A Central Unit (CU), under the judiciary of the Federal Ministry of Health in Khartoum, manages the reports and data forwarded by the States using a database management system. The system is used to generate various reports used in planning, surveillance as well as to assess the overall performance of the programme in meeting targets at national and global levels (to detect at least 70% of all infectious cases, cure 85% and achieve DOTS all over). The long term goals of the programme include integration within the general health services, country wide coverage, and adaptation of the services provided to the needs of the population served. [12]

3.3 The Data

The programme established systematic procedures to collect, record and report data from the lower management levels to the State and Central Unit. Data on cases detected, laboratory tests results, and treatment follow-up and outcome, is collected and transferred up the chain in command through periodic reports on new cases and relapses, and results of treatment. These reports are used by the CU to measure the performance of the services provided based on international prevention and treatment indicators, and to calculate the Annual Risk of Infection (ARI) in the population. Detection rate is a measure of prevention and is calculated annually as the ratio of actual new smear +ve cases to the Country's estimate. Treatment indicators measure coverage of DOTS (ratio of population living in areas identified as DOTS to the total population), and success of treatment (the ratio of the sum of the number of patients that were cured or completed the DOTS course to the total number of registered patients). [24] To augment the treatment success rate, the programme uses an additional treatment measure that is calculated at the end of the first part of the treatment course as the ratio of the number of cases that were converted to smear –ve (non-infectious) to the number of smear +ve cases.

3.4 The Information

The raw data collected at the service-level of the programme generate information on the size of the health problem in terms of incidence by region and nationally, common strains of TB, and is used to calculate the various indicators. This gives the programme management some of the information required to plan, monitor, coordinate and evaluate services provided. For instance, a low detection rate in a specific location can indicate inadequacy in services provided amongst other possible reasons. Accordingly, management can act on information by providing focused training or improve coverage. On the other hand, a high detection rate can warrant investigation on possible explanations such as presence of simultaneous health issues as is often the case with HIV, drug-resistance, or the emergence of a new bacilli.

Findings of research work provide further insight into epidemiological patterns or trends in incidence, disease or treatment that are useful in identifying and responding to areas of concern. Examples include, decentralisation of

TB services improves access for women and older age groups [10], variation in clinical features of TB [9], and factors influencing women adherence to treatment [11]. Management can use this type of information to evaluate an anti- tuberculosis measure, cater for vulnerable groups, plan budget or procure supplies, update educational material (training, awareness), organise surveys or investigative missions, etc.

The importance of new technologies such as GIS is increasingly noted in public health research and evaluation. The literature points to examples of GIS use in the developing world in areas such as conflict, urban planning as well as in public health [23, 22, 17]. In our interviews, this need was illustrated in the types of information of interest to local epidemiologists. Examples include TB distribution in population (by age, gender, socio-economic status, village, locality or a combination of these), rural/urban variations, inaccessible population, and distribution of NTP and general health services. A final year project is currently tackling the task of implementing a GIS component using ArcGIS version 9 and MapObject tools. The scope of the project is to create an easy-to-use interface capable of superimposing 5 basic layers of information. These include general health facilities, population data, DOTS centres location data, new case finding, conversion rate and treatment outcome. We are currently looking at ways to introduce analyses on distances patients travel to reach the nearest DOTS centre and relationships to performance indicators, and HIV prevalence effect on TB fatality rates.

4. Proposed Knowledge areas

The structure of the organisation and particularly the administration of standardised methods to collect, record and report data are considered by our domain Experts as the main strengths of the programme. The programme is gradually achieving its short term goals of meeting the (Millennium Development Goals (MDGs) [13]. The TB programme has also been implemented at the level of administration within the health sector in accordance with IUATLD and WHO approved criteria – the effective 8-month TB treatment has been introduced into health centres that meet well-defined quality requirements. Knowledge on these success factors may therefore be a useful guide to deal with other public health issues such as Malaria and HIV/AIDS. In explicit form, this knowledge exists in reports, manuals, registers and forms, as well as in the minds of *experienced* workers.

The concept mapping approach can be used to capture experiential knowledge of the core stakeholders in the domain – the programme, health care, and patient. Knowledge models of skilled personnel can be used to train less competent or new staff. In the next phase, these episodes of experiences in selected areas will be used to populate a case-base of good practice at management and service levels. The case-base acts as a repository of past experiences and provides the basis for finding solutions for a new problem as well as used as a teaching or training tool. At the other end of the service there are the patients who have knowledge on their concerns, challenges, and self-help tools. This perspective can raise training or awareness issues, and suggest solutions to problems causing delay or failure in treatment.

The following are possible focal questions that came out of the phase of understanding and eliciting knowledge in the domain. They will be used in discussion groups representing programme (State coordinators), health care (TBMU and DOTS centre staff) and patient (TB Association).

- ***Programme***
  - What are the key qualities or personal skills required in personnel? (e.g. *militancy*, *attention to detail*)
  - What are the priorities and constraints to consider when deciding on allocating a resource (*drug, Lab. Equipment, trained personnel*) or dealing with a difficult situation (e.g. *high rates of relapse, providing service to moving or displaced community*?
  - Describe the set of activities that require focused training or regular supervision.
  - What signals does a high or low value of *performance* indicator give you? What information sources you consult to find an explanation? What types of response action do you consider?
- ***Heath Care***
  - *Treatment*:
    - What must be in place to achieve a success with a TB case?
    - Who is likely to default, relapse or transfer out?
    - What actions, skills, and knowledge should you have to deal with the situation (e.g. *treatment failure, side effect, complication, MDR*)?
  - *Diagnosis:*
    - Describe, categorise and relate the symptoms of types of TB you came across.
    - How do you decide on diagnosis based on a single examination or X-ray alone?

        - How do you diagnose a child?
- ***Patient***
    - What are the main concerns you feel and challenges you face after and during your TB episode? Indicate importance and effect on your life.
    - What are the tools/methods/measures that are useful in addressing identified areas of concern? Who makes decisions about them and how effective they are?

5. Conclusions and Future Work

Working in developing countries usually imply the necessity to play in conditions of uncertainty (missing data or information), and of emergency (natural catastrophes, wars etc.). The approach and techniques we adopted for our research have proved useful in expressing knowledge in various other domains. Change, the most predictable of forces as often said, and applicable to the domain, is addressed by the informal and flexible nature of conceptual mapping, which allows augmenting the knowledge model when new information becomes available. The maps facilitate construction of knowledge components from-scratch and being simple to use and manipulate, they allow people from various backgrounds to communicate in a shared space. They are also useful in identifying gaps in our knowledge by organising what we already know.

The activities of the next phases of the project consist of organising and facilitating group discussion sessions with participants from stakeholder groups on the areas discussed in the previous section. This will be followed by the process of codifying and validating the maps. The scenarios told during group discussion can be examined for use in the CBR component of the knowledge model. ICT (Information and Communication Technology) solutions, within budget constraints (e.g. a minority of Management Units have access to computers), will be considered to find appropriate means to disseminate the knowledge gathered.

The objective of this research is creating knowledge assets that can aid decision making and learning from experience in the organisation. However, just as political and resource commitment are essential for effective health policy and practice [8], commitment to a data-sharing culture by individuals in the organisation is essential to successful implementation of a knowledge management approach [2]. Notwithstanding this, much remain to be understood about the transmission dynamics in developing countries [26], and to be solved in terms of equity in access to health service and relationship between poverty and disease.

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Appendix: *Concept Maps*

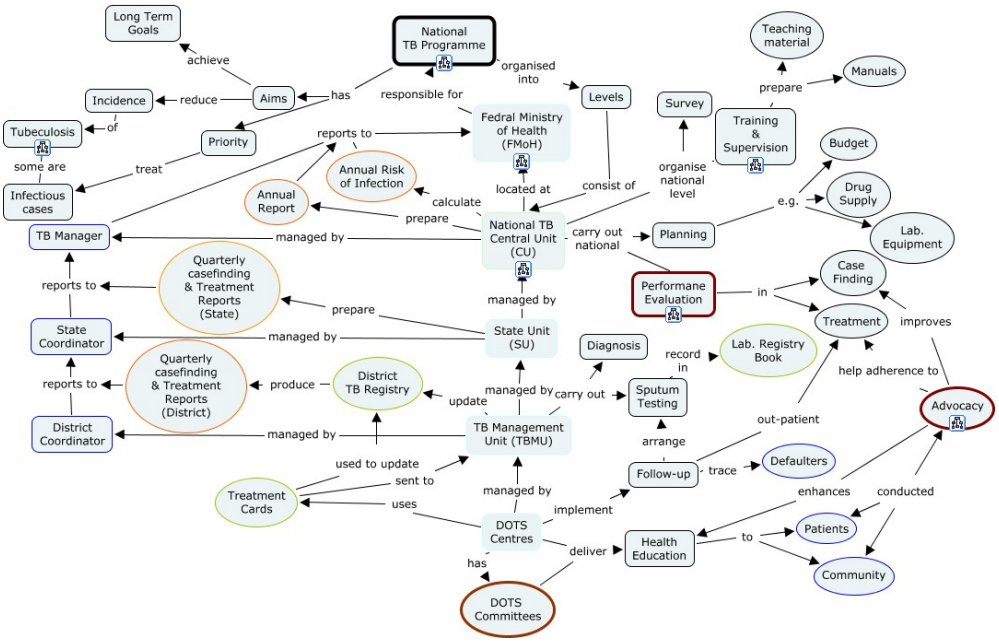

Figure 1. National Tuberculosis Programme – *Organisation*

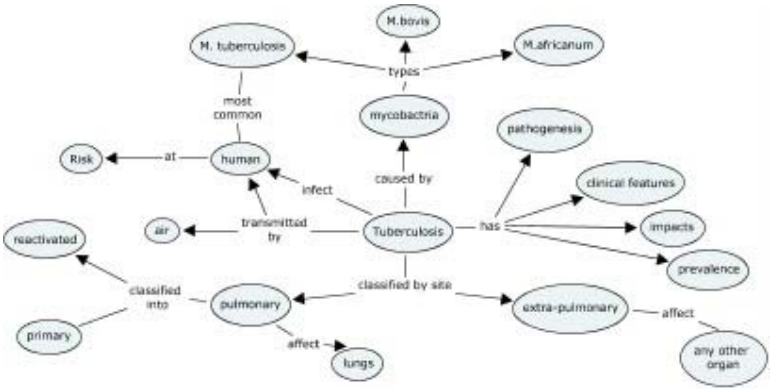

Figure 2. TB Infection and Disease

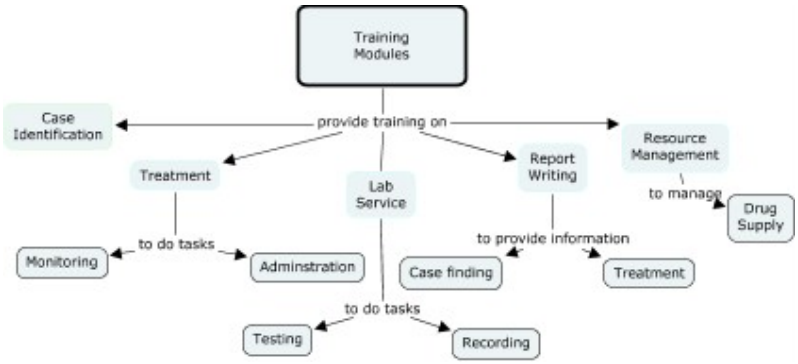

Figure 3. Training

Applying Historical Materialism to Promote Appropriate Technology

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ABSTRACT

While most intellectuals have come to realize the bias in the presentation of history, anthropology, and other so-called social sciences, technologies based on 'hard science' have been broadly accepted as unbiased. In recent years many have come to realize that the most effective technology is context dependent. The purchase of a late-model tractor may be the most productive choice for a farmer in the USA, but prove too costly to purchase, maintain and repair for the same size farm in Zimbabwe.

Historical materialism has been used as a tool to provide political, economic and social analysis of the various modes of production but has focused on capitalism. Historical materialism provides an examination of the complementary and contradictory connection between the productive forces (labor power and means of production) and relations of production (technical relations and relations of economic control). The tension in this connection is heightened with the increase in the skills, knowledge and experience of the work force which is driven in large part by the advance in tools, machines, techniques and technologies that compose the means of production.

Our research thesis is that the tension in this historical connection between productive forces and relations of production is ultimately controlled by the choices of techniques and technologies. This effort uses historical materialism to analyze how technological development is being directed on a global scale to maintain power relations. Insights gained through applying historical materialism to recent developments in Africa point to the necessity to focus on understanding and applying appropriate technology on a continental-wide basis in Africa. Particular attention will be paid to information and knowledge technologies to prove the thesis of our research. An outline for university education to focus on national and global development through threading 'appropriate technology' across the curriculum will be presented.

1 INTRODUCTION

1.1 Historical Materialism and Class Analysis

Engels's 1892 *Socialism: Utopian and Scientific* presents the term, "historical materialism", to designate that view of the course of history which seeks the ultimate cause and the great moving power of all important historic events in the economic development of society, in the changes in the modes of production and exchange, in the consequent division of society into distinct classes, and in the struggles of these classes against one another. [4]

Every 'mode of production' has as its nexus the 'Forces of production' and the corresponding 'relations of production'. The forces of production have two main categories: 1) means of production (tools, machinery, factories, power grids, water systems, electronic communication systems, etc. and 2) labor power (the people at work and the skills, knowledge and experience they possess). The 'relations of production' have two main expressions: 1) technical relations that facilitate the production process – how people relate, communicate and cooperate to produce from the work experience; and 2) relations of economic control – what level of control over the means of production, labor power and products of production does one have.

A social group which shares the same 'relations of production' forms a class. Most broadly, classes have been divided into 'exploiting' classes and 'exploited' classes. Not all differences in how one relates in the process of production constitute class division. The distinguishing feature is the competitive or antagonistic nature that is fostered in the relationship. Sekou Ture refers to these two groups as the 'anti-people's class' and the 'people's class'. To attain a more profound understanding of the contradiction between the forces of production and relations of production, one must dig deeper in analyzing and defining class grouping in society historically and currently [18].

Class analysis requires examining the current class divisions, tensions between classes and their impact on one's expression or suppression of humanist, collective and egalitarian tendencies. A constant assessment of

how the forces of production can be directed to shift the relations of production, to better empower and organize the people most committed to change and the mass of oppressed people must be a principle goal of class analysis. This analysis must start with a self-assessment by each individual. Most people's working lives are dominated by the job or profession one performs on a daily basis to pay the bills. We must carefully examine the short and long range economic and social impact these realities have. With the domination of capitalism we are forced into relations of production in these work settings.

Amilcar Cabral noted that "the reality of our times, allows us to state that the history of one human group or of humanity goes through at least three stages. The first is characterized by a low level of productive forces — of man's domination over nature; the mode of production is of a rudimentary character, private appropriation of the means of production does not yet exist, there are no classes, nor, consequently, is there any class struggle. In the second stage, the increased level of productive forces leads to private appropriation of the means of production, progressively complicates the mode of production, provokes conflicts of interests within the socio-economic whole in movement, and makes possible the appearance of the phenomena 'class' and hence of class struggle, the social expression of the contradiction in the economic field between the mode of production and private appropriation of the means of production. In the third stage, once a certain level of productive forces is reached, the elimination of private appropriation of the means of production is made possible, and is carried out, together with the elimination of the phenomenon 'class' and hence of class struggle; new and hitherto unknown forces in the historical process of the socio-economic whole are then unleashed." [2]

1.2 Technology on a Global Scale –

There has been much debate over the merits and consequences of globalization. Statistics show some nations growing at phenomenal rates, while much of the world's population remains in poverty. Regardless of one's position on the merits of globalization two facts are indisputable: 1) recent years have seen exponential growth in global trade, and 2) globalization is being driven by technological advances. Multinational corporations have benefited the most from this technology with record profits, while small underdeveloped countries have suffered the most accumulating massive foreign debt.

> "A major innovation that ended up radically altering global trade was the development of containerization on ships … The development of shipping containers ended up having an even greater effect on lowering shipping costs than the development of the diesel engines had … A by-product of the fall in shipping costs was the emergence of the global product – which has different parts produced and marketed from a number of countries around the world. One study found that a particular brand of car sold in America, for instance, was produced in nine different countries. Only 37 percent of the car's production value was accounted for by work performed in the United States; assembly in South Korea accounted for another 30 per cent; 17.5 per cent was components and advanced technology made in Japan; 7.5 per cent was design in Germany; 4 per cent was minor parts made in Taiwan and Singapore; 2.5 per cent was advertising and marketing done in Britain and 1.5 per cent was data processing performed in Ireland and Barbados." [1 p. 27]

This global division of work associated with final products is most pronounced with technologically complex products. Products which are composed of a large number of complex subcomponents are a composite of production at the most diverse sources.

The outsourcing of data processing has been particularly pronounced. Highly technically capable countries in the Caribbean and Eastern Europe, along with Ireland and particularly India are taking advantage of lower labor costs to increase their share of this growing information technology services and products industry. Many underdeveloped countries see this as a potential 'appropriate technology' to focus on in an effort to increase economic growth.

1.3 Technology and Power Relationships –

Technology has played a critical role in the expansion of global exploration, global land seizure, the domination of select nations and global trade. Advances in naval transport and military science allowed the military expansion of European forces into the Americas, Africa and Asia. After achieving colonial domination, the dominating European countries restricted access to technological developments. This was a conscious tactic to maintain economic and social control by restricting the development of the forces of production.

While direct political control has been returned to indigenous leaders, economic domination remains through the control of technology. The technologies of global transport, infrastructure construction, agri-business, mineral extraction and industrial production are still in the hands of a few. This control – power relationships – is exercised through multinational corporate control and international financial institutions.

Historically these power relationships have been exercised by a minority of the world population – controlling the majority of the world's labor and resources. The 'relations of production' are such that this powerful minority controls the means of production and therefore the technologies behind the productive processes. This is possible through their domination in the realm of 'ideas'. By dominating ideologically, this minority convinces a sufficient number of the majority population that the actions of the minority in control are

justified. For centuries this ideological domination convinced many people that slavery was justified and until recently had convinced millions that apartheid was justified. The communication of ideas, information and knowledge convinced people of the illogic of apartheid. Today communications plays a pivotal role in exposing people to new perspectives on power relationships. Computer, telecommunications, information and decision technologies play a key role in the sharing of information and knowledge that will reshape power relationships.

2 SHIFTING POWER RELATIONSHIPS

2.1 Appropriate Technology and Shifting Power Relationships

The task of organizations and institutions concerned with empowering the people is to use these technologies and techniques to transfer control of resources and production to the people. The first step in shifting these power relationships is gaining a thorough understanding of their historical development. Global trade is central to power relationships and energy technologies play a key role in global trade and therefore will play a critical role in any shift in control of resources. "Like empires, energy technology has also been hugely influential in shaping global trade: the development of steam transport – in the form of ships and trains – in the early nineteenth century massively expanded the world's trading opportunities, as did the opening of the Suez and Panama canals and the development of the diesel engine. Energy supplies and energy technology are the arteries of today's global trade network." [1, P 270].

The advance in technology will itself contribute to this power shift because the increase use of energy dictates the increase in mineral use and increase in cost of oil, other energy generating ores as well as metals used for production. Table 1 below illustrates the pattern of increased mineral costs that is directly related to increased demand. Note that price gains in the past year for copper aluminum, zinc and lead are all over 30%.

	Copper	Aluminum	Zinc	Lead	Nickel	Tin
2004	$2,874	$1,716	$1,045	$885	$13,779	$7,047
2005	$3,679	$1,898	$1,380	$974	$14,744	$6,131
2006	$5,000	$2,500	$2,100	$1,300	$15,100	$7,500

Table 1: Average Cost per ton of Major minerals from 2004 – 2006 [12]

"If we want to buy time with global oil consumption we have to use it more sparingly and that means increasing its price. But a major rise in the price of oil will fundamentally affect trade and transport. A significant increase in the price of oil cannot help but reduce the amount of global trade. With the quantity of oil used by transport set to double over the next twenty years there is no doubt that the future of oil will continue to dictate much of the future of trade." [1, p.194]

Worldwide people are awakening to the need to address global warming caused by ever increasing oil consumption as well as deforestation. "Global warming will radically change the world as we know it unless we act soon. But acting on global warming means addressing fossil fuel use and the use of oil in particular. With transport using about half the world's oil we cannot address global warming without addressing transport and trade." [1, P.199]

One shift of note is the increased use of nuclear power to compensate for the limitations of oil-based systems. "Today, nuclear energy accounts for 17%-20% of global power generation but capacity is expanding. As of end-2004, world nuclear capacity was 361 gigawatts of electricity generated (GWe). This is projected to reach 378GWe, 446GWe and 524 GWe, respectively, by 2010, 2020, 2030. There are currently 441 commercial reactors operating worldwide with a further 25 reactors having a combined capacity of 20GWe are expected online within the next 10 years. [13, p. 46] However, nuclear power presents significant problems regarding safety, nuclear waste and long term damage to our planet. It is not the solution.

"But manufacturing systems have become a lot more flexible in recent decades and some can be adapted to small scales that may be sympathetic to the development needs of many low-income countries. Moreover, economic structures drive technological development to a large extent these days: protectionist structures are likely to stimulate development of more small-scaled manufacturing systems and could create a whole new 'small-is-beautiful' technology sector." [1, p.278] This new small-scale manufacturing effort does not mean the use of old technology or 'low-technology'. The advances in computer-aided design and computer-aided manufacturing (CAD/CAM) allow for innovative new technology that is best suited for small-scale, low-power environments. The proper use of CAD/CAM technology can foster sustainability and workforce development and utilization.

2.2 African continental unity and Power Relationships

The case for African continental unity is presented in this work as a basis for more effective empowerment through technology decisions that embrace the broader mass and resources of Africa. The case is based on an examination of major powers in recent history and emerging powers today. For much of the later half of the 20th century the dual over technology and power was waged between the Soviet Union and the United States of America. Both had significant land masses with abundant natural resources and populations of over 250 million.

Today the fastest growing economies and the two countries most effectively moving from the ranks of the underdeveloped to developing countries are China and India. It is no coincidence that they are also the two most populous countries worldwide. The advances of China and India are highly linked to their developments in technology and industrial production. In the case of Africa countries, the lack of development is linked to the limitation that size places on the ability to initiate substantive technological advances and production schemes.

The African Union's (AU) emphasis on regional cooperation and development, the recent creation of the Pan-African parliament, as well as the provision for including Africans in the Diaspora as a 6th region of the African Union are all indications that African governments recognize that continental and global African cooperation is critical to future development.

3 FOCUS ON INFORMATION, COMMUNICATION AND KNOWLEDGE TECHNOLOGY

3.1 Computer Technology

Advances in information, communication and knowledge technology are driven by advances in computer technology. The fundamental components of computing: processors, input/output devices, central memory, storage devices and communication links have all experienced stellar technological developments. Advances in processors have not only led to exponential speed increases in the central computing tasks, but have also placed specialized processors in input, output and communication devices. Exponential advances in memory and storage capacity and speed have created a whole new world of possible computing applications. The linking of computing devices through advances in communication technology from high-speed buses to satellite connections is perhaps the most profound advance in information communication technology (ICT) because it has created the global ICT community. Global telephony, widespread cellular phone utilization, electronic mail and the internet owe their existence to these advances in communication technology.

3.2 Telecommunications Technology

The ITU world telecommunication Indicator's database contains statistics that show a sharp increase in cellular, PC and internet usage in the world, but particularly for 'developing countries. Mobile phone subscribers per 100 inhabitants went from 0.1 in 1992 to 10.7 in 2002 in developing countries [2]. This increase in communication has been both local and global. The global communication tends to strengthen the current global power relations, while increased local communication contributes to people's awareness and productivity and has the potential to support local empowerment.

The spread of fiber cables and increased utilization of wireless technology in conjunction with the expanded deployment of communication satellites has resulted in reduced communication costs with a significant increase in bandwidth (speed of communication). This in turn has expanded the quantity and type of media transmitted. One of the latest technology developments to contribute to telecommunication expansion is the implementation of 'WiMax' which has the potential to significantly reduce the 'digital divide' [2].

"WiMAX is a broadband wireless technology that is largely supported by the computer and the telecom industry, cost-effective and standard base. It is engineered to deliver the latest type of ubiquitous fixed and mobile services such as VoIP, Information Technology and Video at very low cost. WiMAX systems are able to cover a large geographical area, up to 50 km and to deliver significant bandwidth to end-users up to 72 Mbps" [2]. In countries that have not laid extensive copper and fiber cable network this is a fast and economical alternative that will allow underdeveloped countries to quickly move into the high-speed digital communication world.

3.3 Information Systems Technology

The widespread use of database products ranging from small scale projects using Microsoft Access to large multinational applications using Oracle have been instrumental in making information accessible to individuals and organizations. These databases have a range of applications that cover a wide domain of financial management, human resource management, inventory control and monitoring production.

Automatic data collection, ranging from that used by sensors that monitor water quality to satellite images, now feed directly into databases. The most extensive use of automatic data collection is in the area of

consumer behavior. Applications range from monitoring health to monitoring consumer purchases. Advances in computing speed and communication systems allow these automatic data collection systems to fuel the collections of databases at an exponential rate. This quantum leap in information available to assist decision-makers can prove to be overwhelming. It has led to the creation of a whole new field – 'data mining'. A range of techniques have emerged to sift through large volumes of data and information to gather the critical pieces and identify patterns among the valuable data and information contributions.

The development of the worldwide web has taken advantage of the hardware advances and allowed users to develop a massive network of linked and shared data and information. The key issue is how to get what you really need from this network of data and information. With millions of pages being added or dropped daily this is no small task. Another important task is how to make your site visible to the desired audience and not go unnoticed like a 'needle in a haystack'. While Google was noted as leading developers in using sophisticated algorithms to search the internet, the latest development in extending the utilization of web-based materials come through the development of the 'semantic web'. The use of internet based markup scripting languages like XML and its various extensions combined with the ontology development to provide structured taxonomies for different domains are the basis for the design, development and utilization of intelligent web pages and services. The ability to embed intelligence in web pages and associated service programs has unlimited potentials in automating complex collaborative applications on the internet providing the ultimate in sophisticated information systems.

These advances in information systems can provide policy-makers access to an expansive maze of information and knowledge, selecting and collating precise solutions to a wide range of problems. These policy-makers can in turn use this power to enhance human development and environmental welfare. On the other hand, this power can be used to enrich the few who have access to these systems and can impact policy. These advances in information systems can be used to reduce the dependency on human labor in the production process, eliminating the need for data collectors, data entry, quality control, and even software developers. Alternatively, these advances can be seen to eliminate the less creative jobs while increasing productivity in the process providing time and other resources to allow people to become involved in more meaningful pursuits.

3.4 Decision Technology

"Decision technology is the application of decision-support modeling and computer software to problems in business, government, and other types of organizations. It is a value-added activity dedicated to improving the quality of the decision-making process. The benefits of decision technology include identifying and valuing potential problem solutions and offering penetrating insights into the problem's structure and interrelationships. Knowledge of decision technology is critical – to understand today's and tomorrow's business and industrial worlds one has to have knowledge of how decisions are made and how decision technology can play an important role in supporting the decision-making process." [9]

Historical materialism and class analysis are qualitative decision methodologies and tools of analysis. They can be applied in a global, regional or local context to give a dynamic perspective of the collective human tensions that make up our socio-political reality. Nkrumah's use of predicate logic and positive and negative forces in *Consciencism* advances class analysis by placing it in a discrete mathematical and logical framework. Both approaches share with system dynamics a focus on causality. [10]

Complex systems theory posits that any model formulated to represent real world systems must recognize the world's non-linear reality and uncertainties. [12] System dynamics is a type of system theory that focuses on closed loop representations of systems where the focus is on causality and feedback. System dynamics originated with the work of Jay Forrester in the early 1960s [7]. "System dynamics is most useful for understanding how policies affect behavior. Emphasis should be on designing policies that will yield systems with more favorable behavior. One builds a simulation model from policies that in turn make decisions. The model generates streams of decisions controlled by policies built into the model. The policies make all the decisions step-by-step in time as the simulation unfolds. Then, if the resulting behavior is undesirable, one searches for a better set of policies that yield improved results." [8]

The importance placed on policies and decision making is the basis of a detailed examination of the relationship between system dynamics and knowledge acquisition [16]. These concepts are central to understanding the functioning any system and most importantly understanding how one can impact system change or control of the system. System dynamics has been effectively utilized in a wide range of disciplines, from business management [15] to environment planning [6]. What is key in all these efforts is its ability to empower the decision-makers by providing quantitative insights into policy impacts through its use of computer modeling.

While decision technology can be a helpful positive set of tools to empower people to make decisions that benefit institutions, the environment and the mass of people in a sustainable fashion, it can also be used negatively. The selective use of data, information and statistics has led to the creation of models, simulations, and forecasts to support the interest of powerful individuals motivated to increasing their power. Numerous

examples of the abuse of decision technology are pointed out in [11]. The focus of that abuse is the creation of econometric models which generate over-optimistic forecasts that led to an increase in debts and loss of power for several underdeveloped countries. In his autobiographic book, *Confessions of an Economic Hit Man*, John Perkins points out how he was told, "A large part of your job is to encourage world leaders to become part of a vast network that promotes U.S. commercial interests. In the end, those leaders become ensnared in a web of debt that ensures their loyalty. We can draw on them whenever we desire – to satisfy our political, economic, or military needs. … Meanwhile, the owners of U.S. engineering and construction companies become very wealthy" [11 p.17]. Perkins and other economists and statistical analysts were tasked with creating pseudo-statistical analysis and econometric studies that projected unusually high growth provided that a nation spend large sums of money with western (imperialist) engineering, consulting and construction companies to finance large infrastructure projects. Table 2 below points out some positive and negative approaches used in decision technology.

Negatively Used	Positively used
Select statistics	System dynamics
Correlations	Causal models
Econometric models	Focus groups - Nominal group technique
Select experts	Diverse stakeholders

Table 2: Negative and positive use of 'decision technology'

The nominal group technique is a multistage group technique that fosters a level playing field when making suggestions and the quantification of alternatives in a collective fashion. Its use is detailed in [16] and [17]. It can be used to identify and rate best practices, bottlenecks, positive factors and negative influences in a number of situations. This ability to quantify options can be linked to causal models such as those used in system dynamics to add validity to the model building process. The focus on decision technology grounded in causal relationships draws attention to why and how policies and decisions impact system outcomes. The ability to control system outcomes is empowering and points to the potential of this approach in transforming relations of production.

4 APPROPRIATE TECHNOLOGY ACROSS THE CURRICULUM

The concept of 'appropriate technology' should be integrated throughout the educational process from K-12, through tertiary education and even in adult education beyond the university years. It should be seen as a cross disciplinary approach that strives to make science, technology and engineering more accountable to the needs of the people and the sustainability of the environment.

4.1 Primary and Secondary Education

Efforts are being made to include system dynamics in 'Primary and Secondary' curriculum to initiate a paradigm shift at an earlier age. Educational material has been developed that models both physical systems and social systems [8]. At an early age, hygiene, public health, and indigenous medicine can be emphasized laying the groundwork for medical and health sciences at the tertiary and higher levels. The importance of water, fuel and energy; indigenous plants and foods can be the basis of physics, chemistry and biology.

Physics should be seen as a core science in shifting the education paradigm toward appropriate technology. "Physics can aid in achieving Millennium Development goal of 'a 50% cut in the number of people who do not have sustainable access to safe drinking water, as well as targets for reducing poverty and improving public healthcare'. Taking clean water as an example, membranes that are made from carbon nanotubes – rolled-up 2D sheets of graphite – can be used to block the passage of bacteria, viruses, heavy metals and other pollutants. They can therefore be used as effective filters for purifying water." [14] Physics is the fundamental science on which much of engineering and technology is built. An appreciation for the fundamentals of physics and its potentials should inspire young students in their academic pursuits. At the secondary level the curriculum should also emphasize critical thinking and involve students in group projects that focus on community projects that foster appropriate technology.

4.2 University curriculum

The Basic sciences (particularly Physics) and applied mathematics should be viewed as central to infusing appropriate technology across the science and engineering curricula as well as exposing non-technical majors to the importance of appropriate technology.

The Engineering curricula must be designed to foster sustainability and community-based needs. "The concept of sustainable development emerged during the 1970s following worldwide realization of how human

activities were harming the environment and putting humans at risk. Major issues included deforestation, desertification, climate change, global warming, environmental pollution, increasing poverty, depletion of natural resources and other problems"[4].

Most western based textbooks direct the study of applied science and engineering toward the needs of large-scale industries that use the latest technology. This approach to teaching, learning and training is of great benefit to highly technical multinational enterprises. However, it has much less bearing on the needs of the people in underdeveloped countries. It is required that attention be given to the design, writing and printing of textbooks and curriculum materials that are better suited for the level of development and the needs of underdeveloped countries. A clearer understanding of the role of appropriate technology in empowering the people will lead to the development of more relevant textbooks, classroom exercises, course projects, examinations and other curricula materials.

There needs to be a concerted effort to link Computing, Operations Research and Management curricula through Information Systems and Decision Technologies geared toward empowering people. Students trained in the non-technical fields of commerce, business management, public policy, educational administration, and public administration need to understand the role information, communication and decision technologies play in their futures. These students have a role to play in supporting the development of appropriate technologies as future decision-makers.

The students in computing, operations research and information science are the future developers of the information, communication and decision technologies. It is critical that their curriculum be reshaped to emphasize the need to develop these disciplines in a manner that fosters sustainability and empowerment of the communities, underdeveloped countries and people.

5 CONCLUSIONS

Historical materialism is a useful 'Tool of Analysis' in understanding the role and directing the development of technology. Understanding 1) the nature of relations of production and 2) the extent and nature of the technology developments (key components of forces of production) are critical to determining how to best direct advances in science and technology. This work must be directed to alleviating class division and class conflict. This work is critical to empowering those members of society that currently are parts of oppressed classes.

A qualitative leap – Revolutionary transformation – requires 'thinking in other terms' therefore it is critical on a regional and global basis to reshape power relationship through technological shifts. Efforts such as this International Conference on 'Appropriate Technology' are critical to forging the regional and global relationships and structures instrumental in the design and implementation of appropriate technologies that will play a leading role in this 'REVOLUTIONARY TRANSFORMATION'.

Decision technology sits on top of information, communication and knowledge technologies that must be used to develop an intelligentsia and technical workforce dedicated to the appropriate use and development of technologies. Policy-makers as well as technical workers must be trained in these decision science methodologies.

Infusing 'appropriate technology across the curriculum' is essential in developing this dedicated technical workforce and intelligentsia. Physics is the science that serves as the backbone of much of the appropriate technology development and is essential to primary, secondary and tertiary education. 'Appropriate technology' is integrally linked to 'sustainability'. "Balancing development and sustainability will not be easy in developing nations, particularly given their growing populations and their fast-increasing energy needs. But two things are clear. First, there are not enough resources on the planet for the developing world to follow the same path to economic growth that the industrialized countries followed themselves. The developing world has to show greater ingenuity and generate alternative solutions, which calls for even greater investment in science. Second, the rest of the world has to become an engaged and design partner in the fate of the developing nations. The consequences of unsustainable development in one part of the world will irretrievably damage us all". [14]

6 FUTURE WORK

Further historical studies on 'technology and power relationships' are needed to clarify the role of historical materialism in providing a qualitative and quantitative analysis of how to empower people and transform society through the more effective development of technology. Collaborative work between social scientists and technologists is critical.

The examination of 'the current impact of information and knowledge technologies on empowerment' will receive further attention. Case studies of how knowledge and decision sciences have been used to empower employees and communities can be developed. This will prove valuable for academic and practical use.

Curriculum development and implementation should command a lot of attention in the future. The training of a new generation of scientists, engineers and policy-makers is necessary to infuse appropriate technology into the productive processes of underdeveloped countries. Developing curriculum that links classroom and laboratory work with community-based field projects should be a focus of curriculum development in appropriate technology.

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Investigating Light Propagation In Turbid Media By Evaluating Optical Properties Of Phantom Tissues

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Abstract

To study how light behaves inside a highly diffusing medium such as biological tissues; it is necessary to know the optical properties of the media. We investigated how light propagates inside turbid media by evaluating the optical properties of phantom tissues. The studies were performed, *in vitro* by measuring optical properties of the medium. The properties to be measured were the absorption coefficient μ_a, the scattering coefficient, μ_s' and the asymmetry factor g. The phantom tissue which was evaluated was milk with the following results being obtained: μ_a = 3.5 x 10^{-1} mm^{-1}, μ_s' = 0.567 mm^{-1}, μ_s = 25.57 mm^{-1}, and g = 0.8803.

Keywords: Turbid Media, phantom tissues, total extinction, transmissometric measurements, fluency rate

Introduction

Lasers are used for therapeutic, diagnostic and surgical purposes. The main challenge lies in being able to control the laser and bio-tissue interactions. This paper explores the role of optical properties and their validity as a measure of the amount of thermal energy most likely to be deposited on various tissues following these interactions. The application of laser technology has completely changed the medical fraternity. Recent advances in optics, particularly in the field of lasers have made biomedical imaging faster and even cheaper. In most cases, they have also reduced the need for surgery [Arridge et al,1992]. Understanding the optical properties of different tissues is a prerequisite for every professional working or intending to work with medical lasers. The optical properties are essential for the description of light propagation through mammalian tissue and also give useful information about the state of the tissue. The knowledge on levels of absorption by different target tissues and the effects of the absorbed radiation to the surrounding tissues and body fluids is of paramount importance. Understanding optical effects of different tissues to incident laser beams will provide a better understanding of the choice of laser type for a particular application. It is only when armed with this knowledge that the precise control of thermal energy in tissues can be achieved.

Methods for measuring the optical properties

Various methods have been proposed to evaluate the optical properties of biological tissues. The techniques differ in their capabilities. Some of the evaluation methods include *in vivo* or *in vitro*, i.e. by direct or indirect method of analysis. We discuss *in vitro* methods in this paper.

Measurements of the optical properties:

In measuring the optical properties of phantom tissues, two experiments were performed;

i) The collimated transmission or transmissometric measurements, and
ii) The fluence rate measurements.

Collimated transmission Measurements.

A 30 mW He-Ne laser source emitting at 632.8 nm (Melles Griot), operating in continuous wave (CW), was directed horizontally to a transparent scattering cell of thickness 30 mm containing the sample as shown in Figure 1. The laser beam was first passed through a densometer with 20% transmittance before it was modulated using a chopper (Stanford Research Systems SR 540) and then incident on the sample. The reference signal was obtained from the chopper controller and fed into the Lock-in amplifier (Stanford Research Systems SR 830 DSP). The collimated transmitted light that passed through the sample was passed through two

diaphragms and received at a large distance, d, from the sample. This was done to avoid the scattered light from entering the detector. The unscattered light was detected with a photodiode (Newport 818 SL) connected to a lock- in amplifier. The photo diode used had a broad spectral response of 400 – 1100 nm.

The initial intensity of light, I_0, was first passed through the sample cell containing only distilled water and the output intensity was measured. This was done to compensate for the refractive index mismatches between the external medium and the surface of the cell. Then the corresponding intensities, *I*, of light passing through different concentrations of the sample in the light path were measured. The concentration was increased gradually until on average, 10 values were recorded.
Multiple scattering was avoided in this part of the experiment by keeping the optical thickness $\tau = \mu_t L \leq 1$, were L is the cell geometrical thickness and μ_t is the total extinction coefficient. In other words, we were only interested in measuring the ballistic component of the light beam. To achieve this two diaphragms were employed to filter the scattered component of *I*. The first one was placed just after the sample whilst the second one was just before the detector as shown in Figure 1.

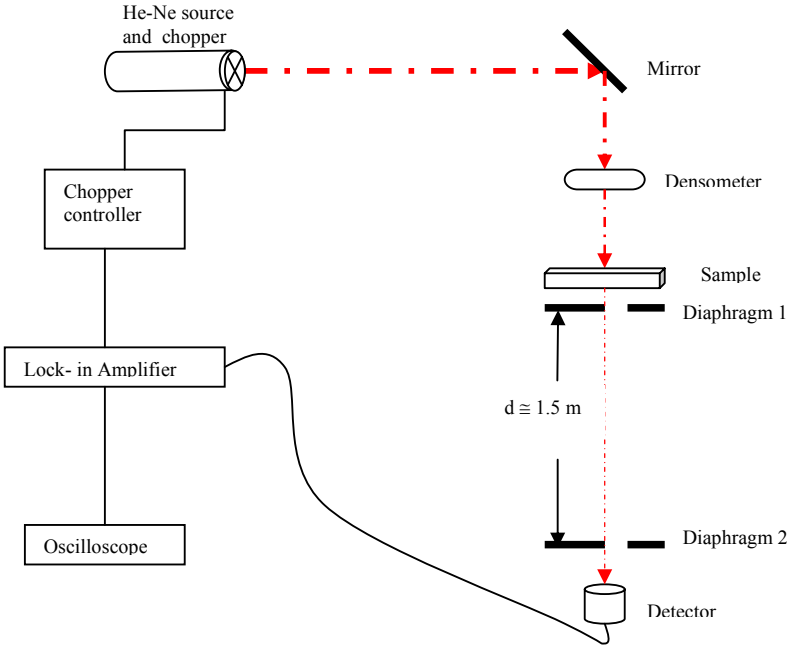

Figure 1. ***The schematic diagram of the experimental set-up for the transmissometric measurements***

From the transmissometric or collimated transmission method, the total extinction coefficient of light by the sample, μ_t, was obtained from the experimental measurements. The transmissometric method was used to calibrate the optical parameters for a pure scatterer (milk) as well as a pure absorber (India ink) and then applying Beer-Lambert's law.

According to the law;

$$I = I_0 \exp(-\mu_t c \cdot r), \text{ and}$$

$$\mu_t c = \frac{\ln(I_0 / I)}{r}, \quad \text{Where:}$$

I_0 is the measured intensity with water as a sample,
I is the measured intensity with milk/ India ink as the sample,
r is the thickness of the sample,
C is the concentration of the sample, and
μ_t is the total extinction coefficient for the sample.

The relationship was plotted for $\frac{1}{r}\ln\left(\frac{I_0}{I}\right)$ versus the concentration c, of the sample.

Fluence rate measurements

A multi-distance measurement of spatially fluence rate inside a highly diffusing medium was carried out. The experimental arrangement is shown in Figure 2. A He-Ne laser source (Melles Griot), linearly polarised and emitting at 632.8 nm with an output power of 30 mW in CW was used. A chopper was placed orthogonal to the laser beam serving as the beam modulator. The reference signal was obtained from the chopper controller to the lock-in amplifier. A lens was used for coupling the beam to the optical fibre with isotropic spherical tips and incident on the diffusing medium through the source or output fibre. A similar fibre was placed beside the source fibre to collect the light to the detector. The diffusing medium was composed of milk samples diluted with distilled water.

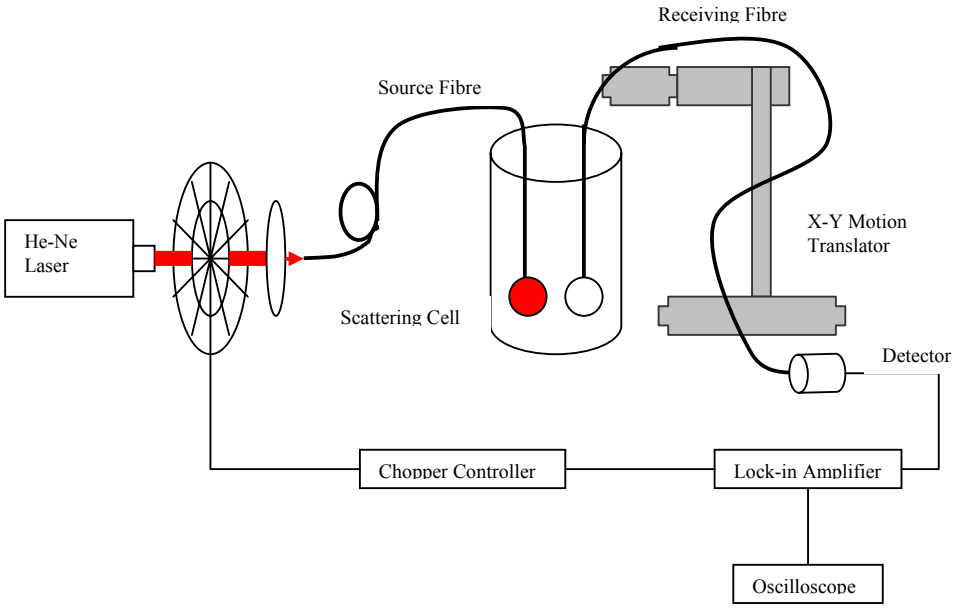

Figure 2. ***Schematic diagram of the multi- distance measurements set-up for measuring fluence rate.***

Both the source and the detection fibres were positioned vertically and adjacent to each other, initially at a distance of 10 mm inside the diffusing medium. The Optical Fibres were immersed into the medium to a depth of approximately 70 mm from both the bottom of the scattering cell and the meniscus (top surface) of the diffusing medium, and 60 mm from the sidewalls of the scattering cell. The source -detector distance r, was varied manually using a micrometer scale mounted x-y translator stage with an accuracy of 0.1 mm. The scattering cell was a white cylindrical tank with height 180 mm and 140 mm [Zaccanti 2003, Martelli et al 2000], operated as an infinitely extended medium.

To be able to deduce μ_a and μ_s' separately from μ_{eff}, two measurements were taken in connection with the multi-distance CW measurements of the fluence rate. Firstly, the fluence rate of the medium was measured for different concentrations of only the milk (Figure 4 and Figure 5). Secondly, the fluence rate was again measured after adding small quantities (approximately 0.5 *ml*) of the absorber, 'the added absorber method' to vary the absorption property of the medium μ_a [Wilson et al 1986, Bassani et al 1987, van Starveren et al 1991]. Measurements of the fluence rate were carried out for the source-detector distance that was varied between 10 and 30 mm in steps of 2 mm. The concentrations of the scatterer were increased gradually, such that the reduced

scattering coefficient μ_s' increased. In each concentration the fluence rate measurements were scanned in the x-axis.

A graph of $\ln(\phi(\vec{r}).r)$ against source detector distance r, was plotted for each value of μ_s'. The effective attenuation μ_{eff}, of the medium was evaluated from the slopes of the graphs and μ^2_{eff} was plotted against the concentration of the diffusing medium. A calibrated amount of India ink (0.5 *ml*) (serving as an absorber) was added to the diffusing medium. Then the multi-distance CW measurements of the fluence rate were repeated every time the absorber was added. A graph for $\ln(\phi(\vec{r}).r)$ against source-detector distance r was plotted for different values of $\Delta\mu_a$, which has been added to the scattering medium. From the slopes of the graphs, the effective attenuation μ_{eff} of the medium was evaluated. The square off the effective attenuation μ^2_{eff} was plotted versus the absorption $\Delta\mu_a$. The values of μ_a and μ_s' were obtained from the intercept and the slope respectively.

RESULTS AND DISCUSSION

The optical properties of phantom tissues:
The total extinction coefficient of phantom tissues were investigated to simulate measurements of optical properties of biological tissues. The diffusing media used, which are optically tissue-like media, were aqueous solutions of evaporated, powdered and condensed cow milk. The India ink was calibrated to serve as an absorber added to the diffusing medium.

The Total extinction coefficient:
The total extinction coefficient of the medium was measured using the measurements obtained from the transmissometric techniques as described previously. Results for the powdered, condensed and evaporated milk are shown if Figure 3.

For low concentration experiments, the Lambert-Beer relation is considered:

$$I = I_0 \exp(-c\varepsilon_t.r) \qquad (1)$$

where *r* is the thickness of the sample, I_0 and *I* are the measured intensities without and with the samples, ε_t is the total extinction coefficient of the sample and *c* is the concentration of the sample. The relation was plotted for $\frac{1}{r}\ln\left(\frac{I_0}{I}\right)$ versus the concentrations, *c* of the sample.

Figure 3a refers to the results of the Nestle Ideal full Cream Evaporated milk with measurements of concentration ranging from 9.08x 10^{-4} to 1.34 x 10^{-2} in steps of 10. Figure 3b refers to the results of the Nestle Carnation Tea Creamer milk for measurements corresponding to concentrations that start from 1.23 x 10^{-4} to 6.09 x 10^{-3} in 10 steps.

The results of transmissometric measurements were linearly fitted for all the measurements taken on the samples as described above. The slope represents ε_t and the intercept is very small relative to the slope value. The linearity of the results shows that the equation (1) is well applicable in the range of concentrations studied. The total extinction coefficients, ε_t, were found for diluted concentrations of different milk types, ε_t ranging from 16.33 mm^{-1} to 26.65 mm^{-1}. India ink was also calibrated as an absorbing phantom medium and the results are shown in Figure 4.

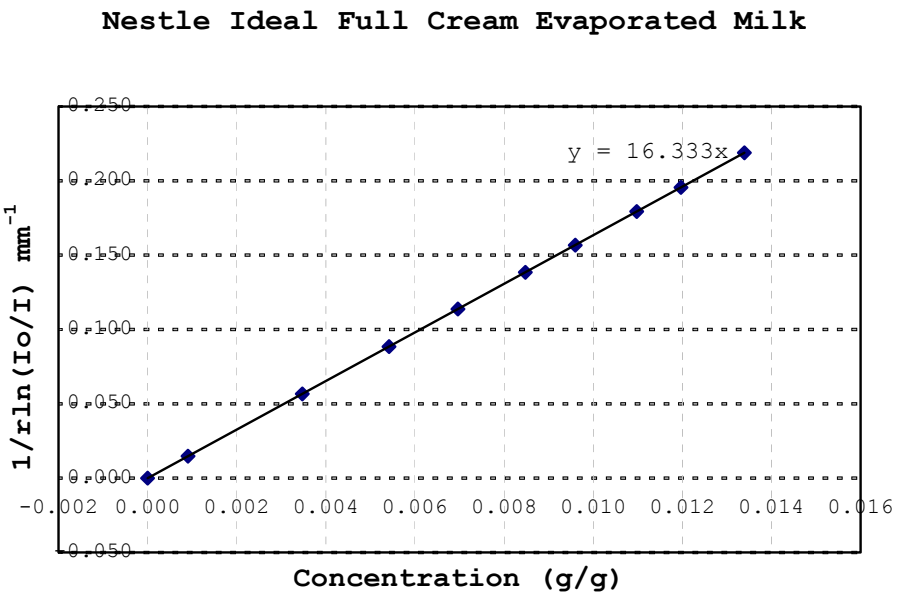

Figure 3(a)). Nestle Ideal Full Cream Evaporated Milk

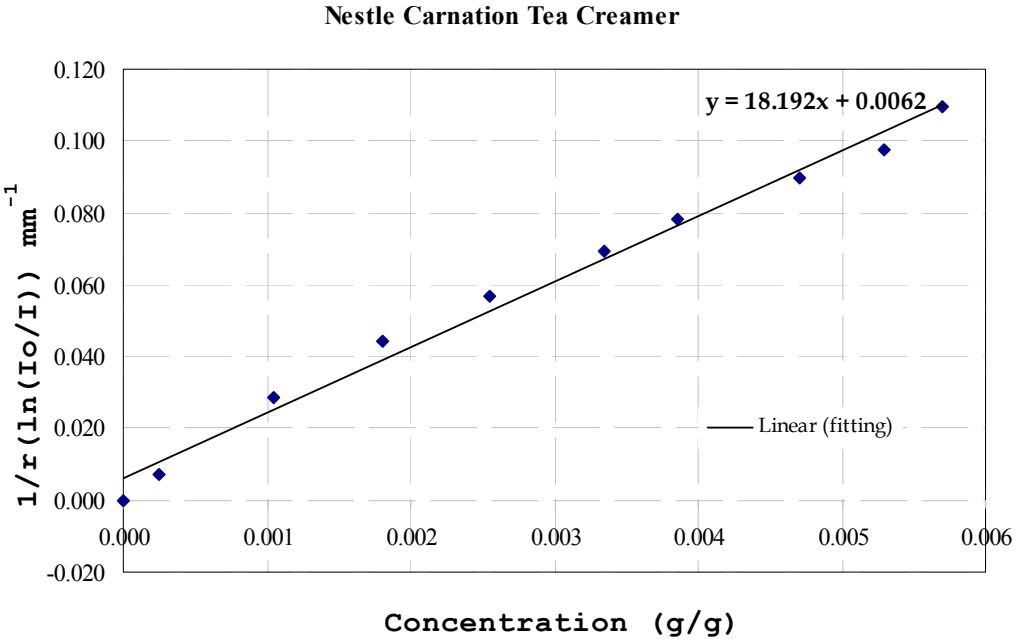

Figure 3(b)). Nestle Carnation Tea Creamer milk

Figure 3: The total extinction measurements for different concentrations of diffusing media, 1/rln(Io/I) vs concentrations.

The reduced scattering coefficient, the absorption coefficient and the asymmetry factor results

The multi-distance experiment, previously mentioned was employed to measure the fluence rate, $\phi(r)$, and to obtain the reduced scattering coefficient μ_s' and the absorption coefficient μ_a. The fluence rate experiment deals with a diffusing medium regime. The solution of the DE for the infinite medium shows that the fluence rate ϕ depends on the properties and the distance as:

$$\phi(r) = \frac{1}{4\pi\ rD}\exp(\ -\mu_{eff}\ .r) \qquad (2)$$

Therefore, the quantity $\ln(\phi(r).r)$ results:

$$\ln(\phi(r).r) = \ln\left(\frac{1}{4\pi\ D}\right) - r.\mu_{eff} = \ln\left(\frac{3\mu'_s}{4\pi}\right) - r.\mu_{eff} \qquad (3)$$

thus, has a linear dependence on the source-detector distance r.

The profile nature of the spatially resolved fluence rate inside the diffusing medium (milk) exponentially decaying is shown in Figure 4. The figure was plotted for the fluence rate, $\phi(r)$ versus the source detector distance r for different concentrations of the diffusing medium, the values of the concentrations are indicated on the right of the graph. The concentration of the milk was increased gradually in different steps. The source-detector distance measurements ranged between 10 and 30 mm.

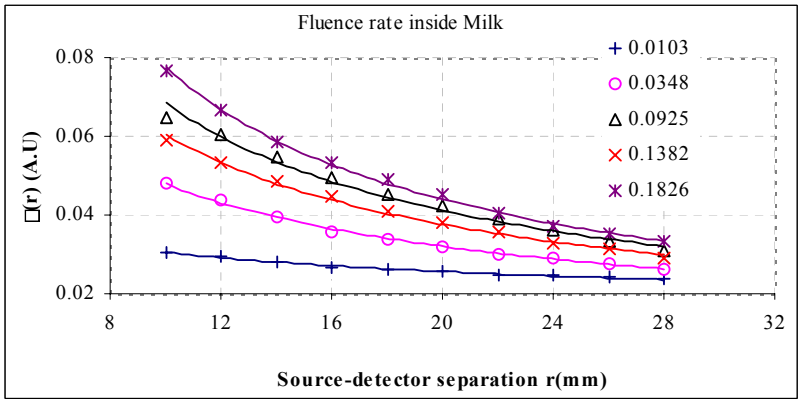

Figure 4. *The spatial resolved fluence rate profile inside a diffusing medium in terms of source- detector separation for various milk concentrations. c recorded in the legend.*

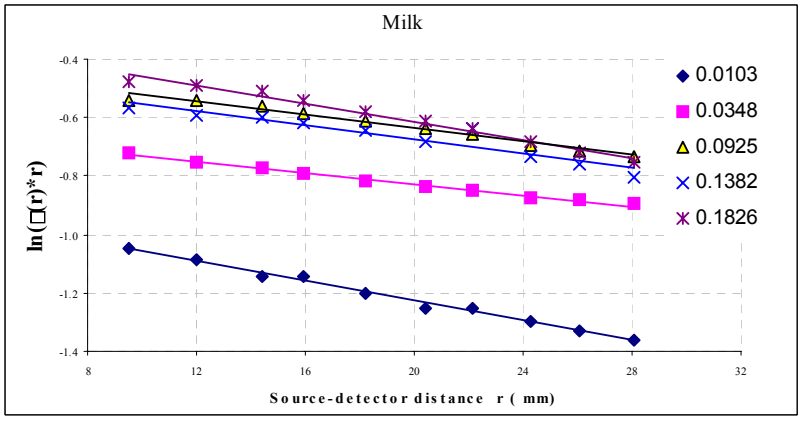

Figure 5. The $\ln(\phi(r).r)$ ***vs r in the multi-distance experiment for different concentrations of the milk. The concentrations are recorded in the legend.***

In Figure 5, the linearity dependence of the expression in equation (3), is shown by the results represented. The evaluation of the slope of $\ln(\phi(r).r)$ as a function of source detector distance, r, gives us the effective attenuation coefficient $\mu_{eff} = \sqrt{3\mu_a\mu'_s}$. The lower lines in the figure signify measurements made on the milk with higher concentrations. But while increasing the concentrations of the diffusing medium in the multi-distance measurements experiment, the light radiance was highly increased. In order not to saturate the lock-in amplifier, the voltage was then reduced. On the contrary, while adding the absorber in the second part of the experiments the measured intensity decreased, and thus there was need to increase the voltage once again.

The information on the absorption coefficient μ_a and on the reduced scattering coefficient μ'_s was obtained by studying how μ_{eff} changes when then concentration of the scatterers or of the absorber were altered. In particular, we refer to $\mu^2{}_{eff} = 3\mu_a\mu'_s$. The μ'_s is simply proportional to the concentration of scatterers, whereas in general the absorption coefficient in the scattering medium is due to:

- The scatterers
- The added absorber, and also
- The absorption of the distilled water used for dilution which has an absorption coefficient of 2.6 x 10^{-4} [Driver *et al* 1989].

When the concentration of the scatterers, *c,* is the only variable, $\mu^2{}_{eff}$ can be expressed as:

$$\mu^2{}_{eff} = 3\varepsilon'_s c(\varepsilon_a + \mu_{aw}) \qquad (4)$$

where ε'_s and ε_a indicate the reduced scattering coefficient and the absorption coefficient of scatterers and μ_{aw} is the absorption due to pure water.

Examples of results of $\mu^2{}_{eff}$ as a function of the concentration of scatterers are reported inn Figure 5. The experimental results of milk were fitted by a straight line as shown in the figure. This indicates that at these concentrations, the absorption of milk is negligible with respect to the absorption of the water. For this reason, milk can be assumed to be a pure scatterer with μ_a = 0, and only water is responsible for the absorption.

To obtain the reduced scattering coefficient and the absorption coefficient of the diffusing medium, the multi-distance measurements were carried out once again with the added absorber method. The multi-distance measurements of fluence rate have been repeated after adding known quantities of a calibrated absorber, India ink [Wilson *et al* 1986, Bassani *et al* 1997, van Starveren *et al* 1991]. The adding absorber method is based on the solution of the RTE for a point source in an infinite medium in the DE approximation {Star *et al* 1988].

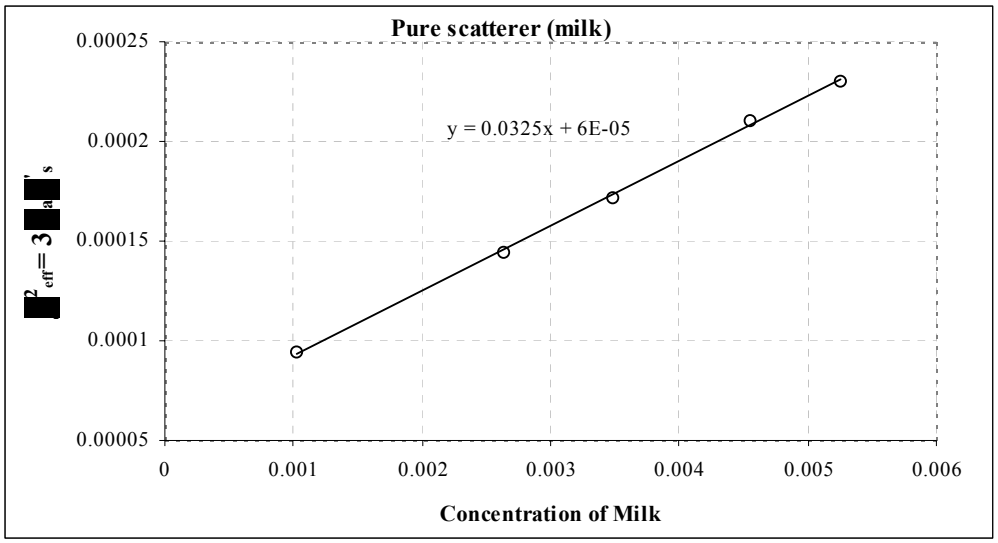

Figure 6. $\mu^2{}_{eff}$ ***vs the concentration of the milk***

The India ink was added into the milk with different concentrations ranging from 1.65 x 10^{-3} to 8.45 x 10^{-3}, for which the fluence rate intensity was attenuated by approximately 5%. Examples of the experimental results are shown in Figure 7. Each curve corresponds to a different value of the absorption coefficient of the absorber, and the values are shown on the graphs. The curves in the figure are descending according to the absorber coefficient.

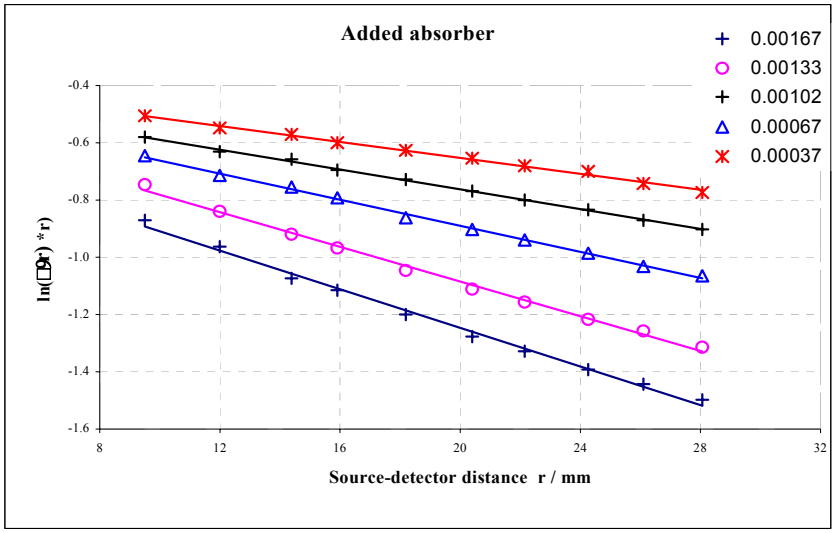

Figure 7. ***The*** $\ln(\phi(r).r)$ ***vs r in the multidistance experiment for different concentrations of the absorber. The concentration of the Milk was 0.1853.***

The effective attenuation coefficient μ_{eff}, was deduced from each curve which corresponds to such absorption coefficient, $\Delta\mu_a$. Then, the quantity $\mu^2{}_{eff}$ was plotted as a function of the $\Delta\mu_a$ as shown in Figure 8. The relationship between $\Delta\mu_a$ and the optical properties of the diffusing medium (μ'_s, μ_a) is:

$$\mu^{2}{}_{eff} = 3\mu'_s(\mu_a + \Delta\mu_a) \qquad (5)$$

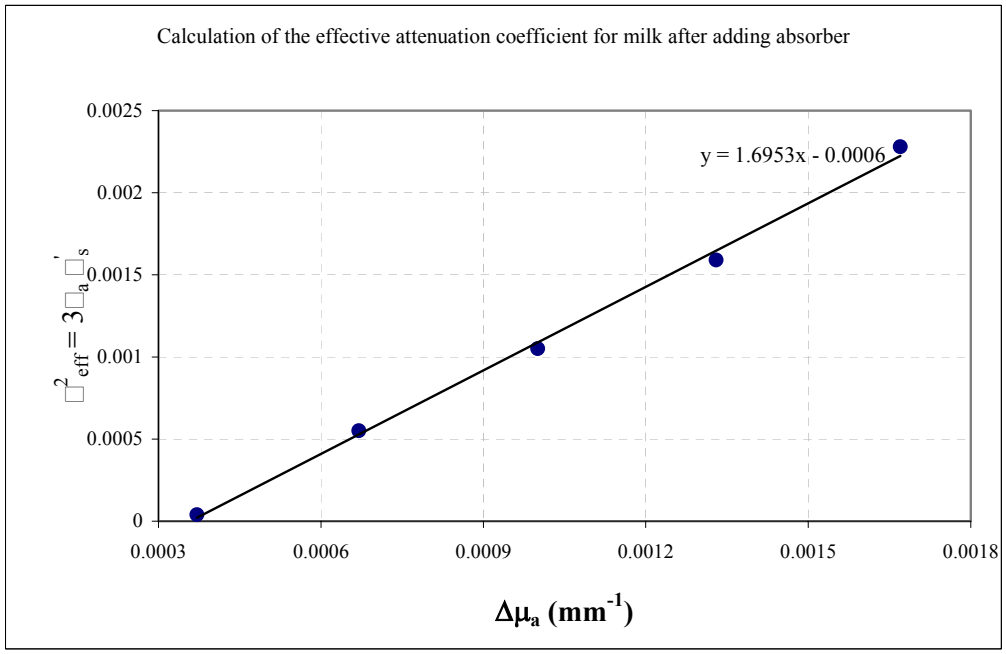

Figure 8. $\mu^2{}_{eff}$ vs the absorption coefficient of the absorber (India ink). The concentration of the milk was 0.1853

Thus, from a linear fit of the experimental results both μ'_s and μ_a can be obtained as:

$$\mu_s' = A/3$$

and (6)

$$\mu_a = B/A$$

where A = 3 μ_s' is the slope and B = 3 μ_s' μ_a is the intercept, of the straight line that best fits the results.

From the measurements on the milk for a concentration maintained at c = 0.1853, the values of μ_s' = 0.567 mm^{-1} and μ_a = 3.53 x 10^{-4} mm^{-1} were obtained. The value μ_a was observed to be very close to the absorption coefficient of water (μ_a = 2.6 x 10^{-4} mm^{-1}) and is very small with respect to μ_s'. Since $\mu_a << \mu_s'$ it also results that $\mu_a << \mu_s$ and thus for milk, $\varepsilon_s \approx \varepsilon_t$ could be assumed. From this assumption, the scattering coefficient was deduced from the extinction coefficient results ε_s = 25.6 mm^{-1}. The asymmetry factor, g has been obtained from μ_s and μ_s', by using the relation:

$$g = 1 - \frac{\mu_s'}{\mu_s} \qquad (7)$$

The value of g obtained for the Milk is g = 0.8803

The results of the optical properties of the phantom tissue investigated (Peak unsweetened full cream condensed milk) were summarised (see Table 1 below). The table reports the values of μ_s' and μ_a for the concentration at which the measurements with the added absorber techniques have been carried out. Also included in the table are the values for the non-diluting scatterers $\varepsilon_s' = \mu_s'/c$ and $\varepsilon_s = \mu_s/c$, together with the value of the asymmetry factor.

Table 1. The summarised optical properties of tissue-like medium (Phantom tissue).

Phantom	c	μ_s' (mm)$^{-1}$	μ_a (mm)$^{-1}$	ε_s' (mm)$^{-1}$	ε_s (mm)$^{-1}$	μ_s (mm)$^{-1}$	g-value
Milk	0.1853	0.567	0.00035	***3.060***	***25.57***	4.738	0.8803

Discussions

The results presented in this paper are based on two main studies:
(i) The transmissometric measurements, and (ii) The fluence rate measurements.

Knowledge of the optical properties is essential in order to investigate the propagation of the laser light inside the medium. As the first step in the presentation of the experimental results, the medium was calibrated using two sets of experiments. Four batches of freshly prepared cow milk from the cans were studied as tissue phantoms to calibrate the optical properties. The results are presented in Figures 3a and 3b (other two figures not included) for the transmissometric measurements. The value of μ_t was obtained with an error of ± 1% from the transmissometric measurements. To obtain the reduced scattering coefficient, μ_s', independent of the absorption coefficient μ_a, other set of results were obtained from the fluence rate measurements. Results are presented in the Figures 4 to 8. In obtaining μ_s' the error was ≅ 5% from the multidistance fluence rate measurements with the adding absorber method. The error was mainly due to the finite size of the scattering cell used for the experiment.

Comparing our results of the optical properties of the phantom tissues with those from other researchers, (μ_s = 4.77 mm^{-1}, ε_s = 26.5 mm^{-1}, μ_a = 0.00049 mm^{-1} and g = 0.787) [Mohamed T. S 2000], we see that they are in the same order of magnitude of those obtained from other literature as well (μ_a =0.00052 mm^{-1},*g = 0.9,*

ε_s =52 mm^{-1}) [Waterworth *et al* 1995]. The differences in the results may be due to the different types of milk (full cream or low fat) or due to the different ways of processing (pasteurised, homogenised, sterilised etc). This gives rise to different concentrations and size distribution of fat particles within the milk sample. The absorption coefficient values of the media are mainly due to the absorption of light by water, at 633 nm μ_a = 2.6 x 10^{-4} mm^{-1} [Litjens *et al* 1999; Pope *et al*, 1997].

The experimental method with its high accuracy can be applied to the monitoring of fat concentrations as well as a quality control technique for cow milk samples. A study of the variation in the optical properties of cow milk has revealed that a higher fat concentration gives a higher scattering coefficient value. Milk can be used as a phantom tissue in light propagation experiments in place of intralipid (most preferred but expensive phantom tissue) because it is inexpensive, readily available and easy to preserve at room temperature during the experimenting period.

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WIND ENERGY RESOURCE ASSESSMENT: A CASE STUDY

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Key words:
Wind resource, WAsP, wind climate, geostrophic, energy production.

ABSTRACT

Global warming and high cost of fossil fuels dictates the exploitation of alternative sources of energy such as wind. This paper presents a background to standard methods of wind energy resource assessment using a case study of Lynch Knoll and Beaufort Court wind farms in England. The Wind atlas analysis and applications Program software, WAsP, is used to assess wind energy potential and to predict wind climate from geostrophic winds of a given area. In this paper, meteorological data from Lyneham meteorological station was used to predict the wind resource and wind turbine energy production at Lynch Knoll, while data from Heathrow meteorological station was used for similar predictions at Beaufort Court. Data from both meteorological stations were used to draw up observed wind climates at the anemometer sites. Site contour maps were digitised using the WAsP Map Editor.

Observed wind climates, digitized contour maps, terrain roughness length, obstacle groups and their porosity were used as input to the WAsP model. In the Beaufort Court model, Vestas V29, 225 kW turbine was used while for Lynch Knoll, Vestas V39, 500 kW turbine was used in place of the Enercon 500 kW turbine which was not available in the WAsP model folder. WAsP predictions are highly influenced by terrain topography. Weibull probability distribution graphs of wind speed, power density and annual energy production were drawn. A directional wind rose for January 204 were drawn for each site. The predictions were close to the actual turbine output in both cases. Such validation of WAsP predictions means that WAsP can be used for wind resource assessment of any site. Other studies have shown poor predictions for rugged terrain with gradients greater than 0.3. Similar predictions can be carried out in Zimbabwe. Small 1kW wind turbines were installed in Temaruru and Vungu 2 in 1999 without wind resource assessment.

1.0. Introduction

The use of fossil fuels has resulted in global warming caused by the greenhouse emissions associated with carbon-based fuels. Wind energy is available and is known to have been used as early as the 17th century BC in Mesopotamia to drive windmills [1]. Today wind turbines have been developed in Europe, Asia, America and are in use in a number of African countries as well [2,3]. The power potential of wind is determined by its speed and the power varies as the cube of the wind speed. Wind is defined as the movement of air caused by pressure differences in the atmosphere as a result of temperature gradients. It is greatly affected by the local physical features like the landscape, obstacles such as buildings and vegetation cover. Accuracy in measuring wind speed is of fundamental importance in the assessment of wind power potential [4]. The computer software called the Wind atlas analysis and application program, WAsP, is the standard tool for wind energy assessment [5,6]. The program has been successfully used to predict wind energy resource for both offshore and onshore wind turbine candidate sites.

In this work, WAsP was used to predict wind conditions and energy production of wind turbine installations at Lynch Knoll and Beaufort Court. The author developed wind climate models using wind data from meteorological stations near the sites. Details of the terrain topography were provided in the form of digitized contour maps of the turbine locations. There were no direct measurements at the sites and WAsP was used to predict turbine output using regional wind climate and topographic features only, with details on longitude, latitude and altitude specified. Specifications of the Lynch Knoll turbine were taken from Ecotricity [7] and

those for Beaufort Court from Renewable Energy Systems Limited [8]. Prediction results from each site were retrieved from WAsP, analysed and compared with actual turbine output.

2.0. Wind Atlas Methodology

2.1. *Summary of the Wind atlas methodology*

The method employed by WAsP is called the Wind atlas methodology. Long-term wind speeds and directions from a reference site, usually a meteorological station, are used to create an observed wind climate (OWC) for the site. In its analysis mode, WAsP extrapolates the wind data in the OWC into a Weibull probability distribution and removes the effects of local obstacles, topography and terrain roughness, to form a geostrophic wind climate (GWC) also known as the regional wind atlas of the area.

The geostrophic wind is characteristic of the wind flow above the inner boundary layer over 100 m above ground level. In its application mode, WAsP extrapolates down the wind atlas data at the candidate site to include local terrain effects, creating an observed wind climate of the site [9]. WAsP requires the following conditions to be satisfied for accurate predictions:

- both the meteorological station and turbine sites must be subjected to the same weather regime
- reference data from the meteorological station must be reliable
- atmospheric conditions at the meteorological station and turbine site should be neutrally stable.
- the surrounding terrain at the meteorological station and turbine site must be sufficiently gentle to avoid flow separation
- topographic model inputs should be adequate and reliable.

2.2. *Topographic models*

Contour maps of the two turbine sites were digitized and used as input to describe the terrain features of the sites. The maps provide information on altitude, speed-up and turning effects, and the ruggedness index (RIX).

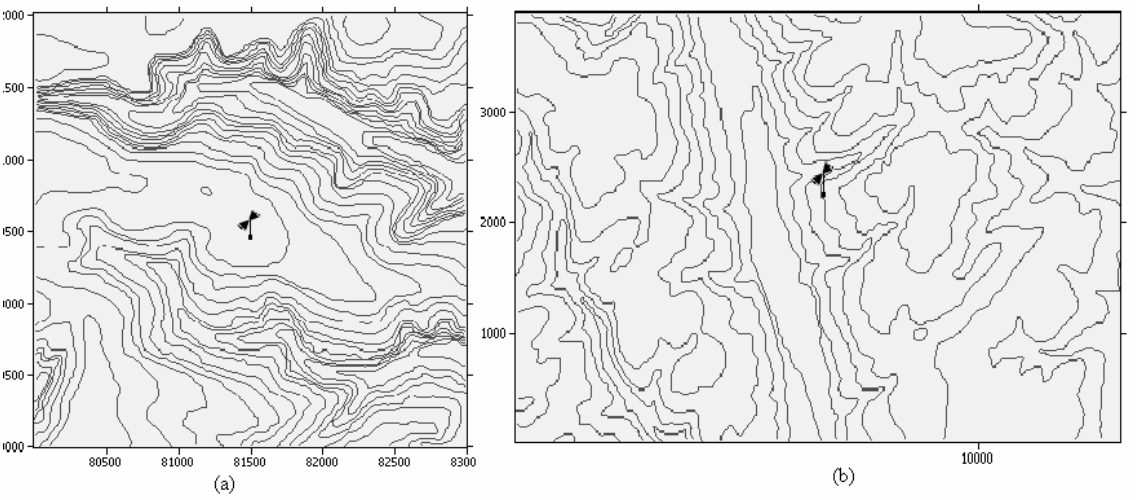

Fig.*1 shows the digitized maps with turbine locations (a) Lynch Knoll, (b) Beaufort Court*

Wind speed profile is affected by the roughness of the landscape which is measured by the surface roughness length z_0. Roughness length is the distance in metres above the ground at which wind speed is zero. The physical maps of Lynch Knoll and Beaufort Court have moderate vegetation cover which makes the areas to fall under surface roughness class 1 with a roughness length of 0.03 m [9].

Wind speed at any height is calculated using the expression $u_z = u_{ref}\left[\frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{z_{ref}}{z_0}\right)}\right]$,

where, u_z – wind speed at height z above ground level
u_{ref} – wind speed at reference height (anemometer)
z – height above ground level
z_{ref} - anemometer height at reference site
z_0 – roughness length.

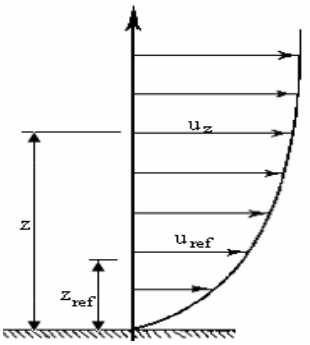

Fig. 2 shows the wind shear profile and the speeds at different heights above ground level.

2.3. ***Data collection***

The wind atlas methodology requires that wind data be collected for a period not less than one year [10]. In this work hourly wind speeds and directions were provided from Lyneham and Heathrow meteorological stations. The nearest wind data source for Lynch Knoll was Lyneham meteorological station 29 km from Lynch Knoll and for Beaufort Court data was obtained from Heathrow meteorological station 10.8 km away. The meteorological data was used to create observed wind climates (OWC) at respective stations [11]. Monthly mean wind speeds for 2004 are shown in table 1 below.

Table 1. Monthly wind speeds at the meteorological stations measured at 10 metres above ground level.

Month	**Lyneham,**	**Heathrow**
	U m/s	**U m/s**
Jan	9.5	9.3
Feb	9.4	8.7
Mar	8.8	81
Apr	8.2	7.3
May	6.5	5.9
Jun	8.1	8.2
Jul	7.1	7.7
Aug	7.0	7.5
Sep	10.1	9.7
Oct	9.8	9.8
Nov	7.0	6.3
Dec	7.0	7.0
Annual Mean	**8.2**	**8.0**

The time-series hourly wind speed and direction readings from each station were checked for instrument reading errors according to the validation process described in the Wind Resource Assessment Handbook (NREL 1997), [10] and then used to create OWC for each month.

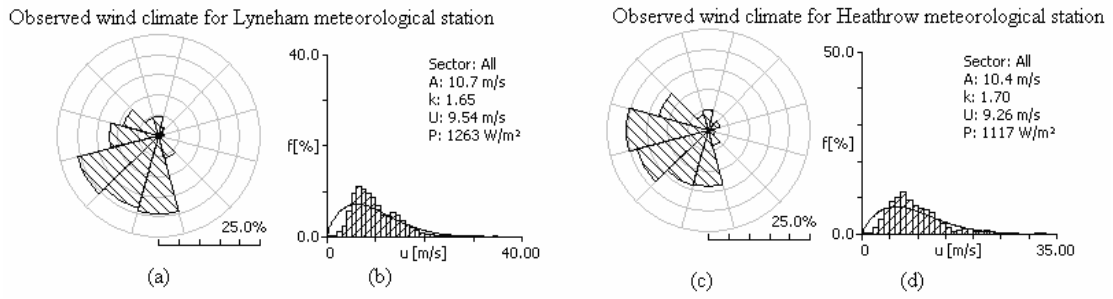

Fig.3 shows the OWCs for January 2004.

In figure 3, (a) and (c) are wind roses showing the percentage variation in wind direction during the month of January over Lyneham and Heathrow respectively. Diagrams (b) and (d) show the percentage frequency of wind speed distribution with a Weibull fit, for the month of January over Lyneham and Heathrow respectively.

3.0. Results and discussion

3.1. ***Wind speed and power predictions***

In its analysis mode, WAsP uses the data from meteorological stations to produce the observed wind climate at these stations. It then removes the local topographic effects to create a regional wind atlas for a wider area which covers the turbine sites. In its application mode, WAsP combines the topographic effects from the turbine sites with the regional wind atlas data to predict the wind climate (wind speed and direction) at the turbine sites. Rotor diameter of the installed wind turbine is used to calculate the power density. The predicted wind climate is applied to the wind turbine generator characteristics of the installed turbine to predict the annual energy production (AEP). The predicted results for Beaufort Court and Lynch Knoll turbines are shown in table 2 below. Predictions for Lynch Knoll are at 40.5 m above ground level and those for Beaufort Court at 32.5 m above ground level. These heights correspond to the hub heights of the installed turbines.

Table 2. Wind speed, power density and annual energy production predictions

Month	**Lynch Knoll Predictions (40.5 m a.g.l.)**			**Beaufort Court Predictions (32.5 m a.g.l.)**		
	U, m/s	P, W/m^2	AEP MWh	U, m/s	P, W/m^2	AEP, MWh
Jan	11.5	2126	2402	11.3	1902	1175
Feb	11.4	1826	2533	10.5	1552	1112
Mar	10.8	1657	2373	10.4	1670	1064
Apr	10.1	1124	2360	8.9	856	979
May	8.2	553	1708	7.4	394	747
Jun	10.0	1262	2244	9.8	1205	1067
Jul	9.2	1045	1950	9.4	915	1067
Aug	8.8	747	1957	9.2	764	1083
Sep	12.1	1712	2973	11.6	1645	1328
Oct	12.0	1775	2793	11.9	1764	1334
Nov	8.7	779	1824	79	549	814
Dec	9.2	973	1968	8.5	827	920
Annual Mean	**10.2**	**1298**	**2257**	**9.7**	**1170**	**1058**

3.1.1 ***Wind speed***

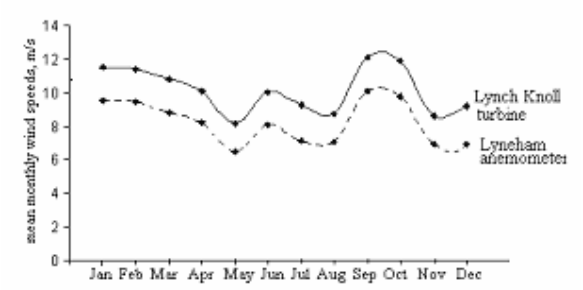

Figure 4. Wind speed at Lynch Knoll compared to that at Lyneham

Figure 5. Wind speed at Beaufort Court compared to that at Heathrow

The WAsP model extrapolates wind speed from 10m at the meteorological station upwards to the hub height of the turbine. Vertical wind shear follows the 1/7th power law represented by the following formula: $u_z = u_{ref}\left(\frac{h_z}{h_{ref}}\right)^{\frac{1}{7}}$, where u_z and u_{ref} are wind speeds at the hub height and meteorological anemometer height respectively; h_z and h_{ref} are the hub height and anemometer height respectively. Figures 4 and 5 above indicate similar variations in wind speed at each turbine site and its corresponding meteorological station. This satisfies WAsP's requirement for a similar weather regime at the turbine site and reference site.

3.1.2. ***Power density***

Power density is the of power produced per unit area of turbine rotor swept area and is equal to $\frac{4P}{\pi d^2}$ w/m^2, where *P* is power in watts and *d* is the turbine rotor diameter. The graphs in figures 6 and 7 below show the predicted power density at the turbines and the power density that would be expected if the turbines were installed at the meteorological stations with hub heights at 10 metres above ground level. Increase in power output with height is evident from the graphs.

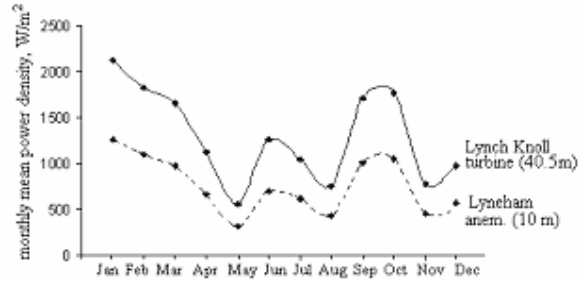

Figure 7. Power density at Lynch Knoll compared to that at Lyneham.

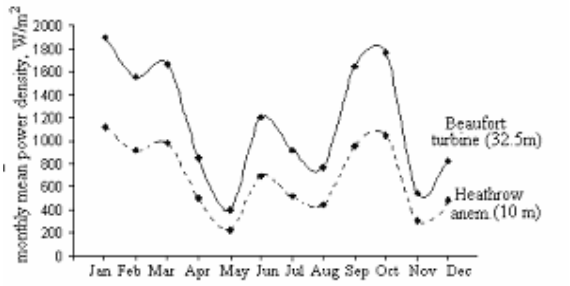

Figure 8. Power density at Beaufort Court compared to that at Heathrow

3.1.3. ***Annual energy production (AEP)***

Annual energy production is the energy in mega-watt-hours (MWh) produced per year for the total number of hours that the wind turbine was operational. In this study, WAsP predicted an annual energy production of 2257 MWh and 1057 MWh for Lynch Knoll and Beaufort Court turbines respectively assuming 8 760 production hours in 365 days of the year. The prediction figures are higher than the actual production for the following reasons:

- availability, the turbines may have not operated for all the 8 760 hours of the year due to maintenance time or wind speed being below cut-in speed or higher than cut-out speed
- according to Betz' law, only less than 59% of the kinetic energy in the wind can be converted to mechanical energy using a wind turbine as shown by the power ratio;

  power extracted from the wind $P_{turbine} = 0.5m(v_1^2 - v_2^2)$

  power in the undisturbed wind $P_{wind} = 0.5\rho A v_1^3$

  power ratio $\frac{P_{turbine}}{P_{wind}} = 0.5\left[1 - \left(\frac{v_2}{v_1}\right)^2\right]\left[1 + \left(\frac{v_2}{v_1}\right)\right] \leq 0.59$.

  In the above formulae, *m* and ρ are the mass and density respectively, of the air flowing across the turbine rotor swept area A; v_1 and v_2 is the wind speed before and after the turbine rotor respectively.

In order to compare the predictions with the actual production at the wind turbines, predicted AEP has to be reduced to at least 59% to get practical mechanical energy conversion and then further reduced by the electrical efficiency of the turbine system. The maximum practical mechanical energy conversion is 40% and a mechanical to electrical efficiency of 95% giving an overall maximum efficiency of 38% [12]. Using the maximum overall efficiency the annual energy production would be 857.7 MWh and 402 MWh for Lynch Knoll turbine and Beaufort turbine respectively. According to [13], a complete wind energy system, including rotor, transmission, generator, storage and other devices will (depending on the model) deliver up to 30% of the original energy available in the wind. This gives a maximum energy production of 677 MWh and 317 MWh for Lynch Knoll turbine and Beaufort turbine respectively.

Actual annual energy production for Beaufort Court for 2004 was 202.15 MWh with 600 hours of unavailability [8], giving an over prediction of 46%. High uncertainty arises from the absence of actual performance characteristics of the installed turbine and on site wind speed readings. The actual energy production for Lynch Knoll was not available.

4.0. *Conclusion*

Wind energy resource assessment was conducted using the WAsP model for the turbine sites in Lynch Knoll and Beaufort Court using wind data from the United Kingdom meteorological office. Wind regimes at the turbine sites were found to be similar to those at the meteorological stations as is required in WAsP modelling. Power density and annual energy production were shown to increase with increase in mean wind speed, which in turn increases with altitude. Lack of site wind speed and surface roughness measurements at the turbine sites and information on mechanical efficiency of the turbines increased the uncertainties of the predictions. It is recommended that on-site measurements be carried out especially for a wind turbine candidate site in order to

narrow prediction errors. WAsP modelling can be used successfully for wind energy resource assessment of any candidate site provided adequate data is given for analysis and application by the model.

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Design of Alternative Energy Systems: A Self-Starting Vertical Axis Wind Turbine for Stand-Alone Applications (charging batteries)

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Key Words:

vertical axis wind turbine, wind energy, thin airfoil optimization, aerodynamic optimization, wind turbine rotor optimization

Abstract

A general aerodynamic optimization method was used to improve the torque characteristics of a multi-blade vertical axis wind turbine. A decomposition, deformation, and reassembly method was developed to accommodate the variable geometry of the blade during the optimization process. The deformation of the grid was accomplished by a modified version of the Transfinite Interpolation (TFI) method. The method is first applied to a single blade of the turbine and yields a 27% improvement in overall torque. Further analyses were performed on a single blade with a spanwise slot and two-blade configuration with and without the slots and results indicated more than 10% further improvement in the overall torque with the slots in place.

Two small-scale multi-bladed (3-blades and 5-blades) prototype turbines were built and tested in the low speed wind speed at stream mean velocity of 2.5 m/sec, which correspond, to Reynolds numbers based on cord length of 1.225 X 10^5. The experiments were performed in free air stream on raised ground and in a closed room with a 3-speed stand fan. Results show that at the free stream mean velocity of 2.5 ms^{-1}, the turbines were self-starting and the 5-blade turbine could turn a 6V rated bicycle dynamo generating 4.83V of electricity. At increased wind speeds, the turbines still produced electricity without damage. The power coefficients for the optimized blades extend to a tip speed ratio of 1.6.

Notation

P_w	-	power in the wind [W],
P_{mw}	-	minimum power in the wind [W],
P_t	-	the turbine rotor power [W],
P_m	-	mechanical power of the turbine due to rotation [W],
T_{dar}	-	torque produced by the turbine [N m]
P_{dar}	-	power produced by turbine [W]
A_{swept}	-	the cross-sectional area in square meters swept out by the wind turbine blades,
v	-	the wind speed [m s^{-1}],
v_{mw}	-	minimum wind speed [m s^{-1}],
ρ_{air}	–	the air density = 1.225 kgm^{-3}
λ	-	the tip speed ratio ***tsr = 2.6***
R	-	the radius of the blades [m]
H	-	the height of the blades [m]
C	-	the chord length of the blades [m]
D	-	the diameter of the turbine [m]
S	-	Solidity $S = \frac{N_B C}{D} = 0.4$
C_p	-	co-efficient of power
N_B	-	Number of turbine blades
ρ_B	-	density of blade material → plastic PET $\rho_B = 1.8*10^{-3}$ kgm^{-3}

t_B	-	thickness of turbine blade [m]
W_B	-	blade width
I_{shaft}	-	moment of inertia of the rotor about the rotating shaft [ ]
η_{wt}	-	wind turbine efficiency
ω	-	rpm rotational speed for the turbine shaft [rpm]
V	-	voltage measured from the PMG [V]
ω_{dar}	-	wind turbine's rotational speed

1. Introduction

With a growing focus on renewable energy, interest in the design of wind turbines has also been expanding. In today's market, the horizontal axis wind turbines (HAWTs) is the most common type in use, but vertical axis wind turbines (VAWTs) have certain advantages. A VAWT need not be oriented with respect to wind direction. Because the shaft is vertical, the transmission and generator can be mounted at ground level allowing easier servicing and a lighter weight, lower cost tower.

However, their designs are not as efficient at harvesting wind energy as the HAWT designs. The basic VAWT designs are the Darrieus, which has curved blades, the Giromill, which has straight blades, and the Savonius, which uses scoops to catch the wind. Wind turbines are either lift-type (pulled by the wind) or drag-type (pushed by the wind). HAWT are lift-type and VAWT are drag, except the Darrieus turbine.

In general, VAWT lift driven turbines, have a higher power potential than HAWT, or drag-driven turbines. A generalized wind pattern map of Zimbabwe shows wind speeds exceeding ***3.0 ms^{-1}*** stretching diagonally across the country, with the rest of the country experiencing moderate to low wind speeds, below ***3.0 ms^{-1}***. The relatively low wind speeds that occur in most of Zimbabwe are generally considered insufficient to allow for the cost effective use of wind generators for electricity [1].

This report describes the ***design and evaluation a low wind speed wind turbine***, for stand-alone application use in the Zimbabwean environment.

2.0 Basic Wind Energy Theory

2.1 What is a wind turbine

A wind energy turbine transforms the kinetic energy of the wind into mechanical or if the turbine if coupled to a generator, electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations. While, wind electric turbines generate electricity which can be used for homes, institutes and businesses.

2.2 Basic Designs

Wind turbines are classified into two general types: horizontal axis and vertical axis. A horizontal axis machine has its blades rotating on an axis parallel to the ground. A vertical axis machine has its blades rotating on an axis perpendicular to the ground. There are a number of available designs for both and each type has certain advantages and disadvantages. However, compared with the horizontal axis type, very few vertical axis machines are available commercially.

3. VAWT Concept Generation

The most complicated and important aspect of the design was the need to design blades that extract as much energy from the wind as possible throughout a wide range of low to moderate wind speeds, be self-starting, durable, quiet and easy to manufacture. From the mode of operation of wind energy harvesting machines (lift and drag modes) two favorable designs were proposed and analysed.

3.1 Transforming blades concept

The first idea proposed was having blades that form an open-ended triangle that would operate as a drag device (Savonius type) and when rotating would transform from a drag device into an airfoil after which, there will have sufficient lift to drive the blades. By doing this, the blades would operate like a lift device (Darrieus type) at high speeds. If two (or more) of these blades mounted on a shaft, a net torque will be produced due to the sharp nose.

3.2 Helical blades concept

The second idea proposed was to have helical shaped blades, attached to the shaft like Tropeskian with teardrop shaped central support bars that would create sufficient drag to naturally turn the turbine in slow winds, and generates lift in high winds. Several small models with different numbers of blades (three and five) were built to test the idea in a rotational test. A touch test was observed to generate significant torque at low speeds. The results from these crude tests were encouraging.

4.0 Wind turbine design calculations

4.1 Design constraints: Input and output

The turbine was expected to produce between ***50*** and ***500 Watts***, while operating at wind speeds ranging between ***2.0*** to ***+4.0ms^{-1}.*** Assuming that the attached generator will produce about ***15V*** in order to trickle charge a battery.

4.2 Wind turbine efficiency calculations

Rotor power efficiencies were calculated using the formula:

$$Efficiency = \eta_{wt} = \frac{P_t}{P_w} \quad \text{.....(1)}$$

Where, *Pw* is the available power in the wind, which is given by:

$$P_w = \frac{A * \rho_{air} * v^3}{2} \quad \text{.....(2)}$$

Pt is the power of a wind turbine is given by:

$$P_t = 0.5 * \eta_{wt} * \rho_{air} * A * v^{(3)} \quad \text{.....(3)}$$

The ***tsr (λ)*** is the ratio of the speed at the tip of the wind turbine blade to the wind speed and is given by:

$$\lambda = \frac{\omega_{dar} * R}{v} \quad \text{.....(4)}$$

The efficiency in the function of ***tsr (λ)*** was derived from the following curve fit equation for the ***tsr(λ)*** graphs.

Ideal Vertical Wind Turbine	
$For \quad 0.5 \le \lambda \le 1.0$	$\eta_{wt} = 0.196 * \lambda + 0.23233$
$For \quad 1.0 \le \lambda \le 1.5$	$\eta_{wt} = 0.104 * \lambda + 0.32433$
$For \quad 1.5 \le \lambda \le 2.5$	$\eta_{wt} = 0.055 * \lambda + 0.399$
$For \quad 2.5 \le \lambda \le 4.0$	$\eta_{wt} = 0.022 * \lambda + 0.481$
$For \quad \lambda \ge 4.0$	$\eta_{wt} = -0.078369 * \lambda^2 + 0.92146 * \lambda - 2.3532$

The mechanical power of the turbine due to the rotation with the wind power that is captured by the turbine is given by:

$$P_m = 0.5 * I_{shaft} * \omega_{dar}^3 \quad \text{.....(5)}$$

To calculate the rotational speed, ω_{dar}, we equated this mechanical power to the wind power that is captured by the turbine, i.e.,

$$0.5 * \eta_{wt} * \rho_{air} * A * v^{(3)} = 0.5 * I_{shaft} * \omega_{dar}^3 \quad \text{.....(5)}$$

where $\boldsymbol{I_{shaft}}$ is the moment of inertia of the rotor about the rotation shaft which is found by the expression:

$$I_{shaft} = N_B \rho_B (L_B W_B T_B) R^2 + \frac{N_B \rho_B (L_B W_B T_B)(W_B^2 + t_B^2)}{12} \quad \text{.....(6)}$$

With two equations (5) and (6) and two unknowns, the rotational speed and the wind turbine efficiency can be solved iteratively.

4.3 Aerodynamic Calculations

The torque produced was determined by the use of basic fluid mechanics calculations. The coefficient of drag and lift were determined for the blades. The net torque was then optimized by using a general aerodynamic optimization method. To accommodate the variable geometry of the blade a decomposition, deformation and assembly method was applied. The deformation of the grid was accomplished by a modified version of the transfinite interpolation (TFI) method [2].

To determine the torque produced, the power produced by the turbine was calculated by the use of the following calculation:

$$P_{dar} = \frac{C_p * R * v^3 * A}{2} \quad \text{.....(7)}$$

The solidity of the turbine being calculated as follows:

$$S = \frac{N_B * C}{D} \quad \text{.....(8)}$$

The rotational speed of the turbine can then be determined:

$$\omega_{dar} = \frac{2 * \lambda * v_{air} * \pi}{60 * R} \quad \text{.....(9)}$$

The torque produced by the turbine can then be determined from the power and rotational speed, thus:

$$T_{dar} = \frac{P_{dar}}{\omega_{dar}} \quad \text{.....(10)}$$

The results of the calculations are in appendix B. In brief, the dimensions chosen for the turbine are: radius ***R=0.9m***, height ***H=1.4m*** and chord length ***C=0.16m***. For the turbine to initiate rotation, it must produce enough torque to overcome the frictional torque in the system. The frictional torque in the system was estimated to be less than ***1 N-m*** in the design phase.

It can be seen that the main parameter in determining the torque is the length of the chord. The turbine will produce enough torque in wind speeds of ***0.5-1.5 ms^{-1}*** to overcome the frictional torque.

Also, it was observed that, the higher the solidity, the higher the power produced and therefore the higher the torque produced. Hence, it may be desirable to have the solidity as high as possible. Generally, rotors with higher solidities run at lower rotational speeds. Therefore optimal solidities have been found to be in the range of ***0.267 to 0.44***. In conclusion, a solidity of ***0.4*** was chosen for the design.

4.4 Critical Speed Calculations

This turbine has five blades, a solidity of ***0.4***, and a diameter of ***1.8m*** so, from eqn [4], the chord length should be ***0.16m***. It was observed that the turbines produce power at tip speed ratios of ***1.6*** and greater. If it is desired to

have the turbine start in wind speeds of ***1.5 ms^{-1}*** then the blades should be moving at ***1.6*** times the speed of the wind. The rotational speed, ω_{dar} is found to be ***42.44 rpm*** from [5], using a ***tsr*** of ***1.5***, radius of ***0.9m***.

5.0 Testing, results and discussion

Two VAWT with the suggested design specifications were made. They were subjected to the same laboratory tests using a three speeded pedestal fan to simulate a wind current. The same response variables were noted. For each fan speed, the output voltage from the (permanent magnet generator) PMG was measured, and compared to the calculated value. The ***rpm*** of the turbine shaft and the torque produced was also calculated.

The results obtained are shown in Appendices B and C. The tests show that the response is well acceptable and within predicted limits. From these measurements and calculations for the dimensions chosen, the following conclusions can be made:

- There are many variables within the design of a vertical axis wind turbine (VAWT), which influence its operation and efficiency. These include:
    - The radius ***R*** of the blades
    - The height ***H*** of the blades
    - The chord length ***C*** of the blades
    - The 'cut-in' speed and
    - The air/wind velocity
- The turbine will produce enough torque in wind speeds of ***0 to 1.5ms^{-1}*** to overcome the frictional torque.
- The higher the solidity, the higher the power produced and therefore the higher the torque produced. It is therefore desirable to have as high a solidity as possible so it can operate in as low a wind speed as possible.

6. Conclusion

The initial goal of the project was accomplished, as this is a solution to low wind speed areas. The potential of the concept has been proven to function. This design fills the functions required of a self-starting vertical axis wind turbine for use in low wind areas. It represents a new breed of VAWT suitable even for the urban environment.

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APPENDIX A : DESIGN CALCULATIONS IN DETAIL

i. 1.Design specifications and limitations Minimum power to be extracted from the wind $P_{mw} = 75\ W$

ii. Minimum wind speed to extract that power $v_{mw} = 2.5\ ms^{-1}$

iii. For stability, diameter to height ratio fixed at $\frac{D}{H} = 1.2, \leftrightarrow .D = 1.2 * H$

iv. From the selected concept, the turbine is elliptically shaped, hence the swept area is
$A_{swept} = \pi * D * H \quad \leftrightarrow \quad A_{swept} = 1.2 * \pi * H^2$

2.Performance calculations

$$P_{mw} = 75 = 0.625 * 1.2 * H^2 * (2.5)^3$$

$$75 = 36.816 * \mathrm{H}^2$$

$$Hence \quad H = \sqrt{75 \diagup 36.316}$$

$$= \sqrt{2.037}$$

$$= 1.427m$$

$$D = 1.2 * 1.427$$

$$= 1.713m$$

$$Take \Rightarrow H = 1.4m \quad and \quad D = 1.8m$$

$$Hence \quad \frac{D}{H} = \frac{1.8}{1.4} = 1.29 \approx 1.3$$

Swept area

$$A_{swept} = \pi * 1.8 * 1.4$$

$$= 7.92m^2$$

Actual extracted power at $v = 2.5ms^{-1}$ *wind speed*

$$P_w = 0.625 * 7.92 * v^3$$

$$P_w = 0.625 * 7.92 * (2.5)^3$$

$$= 77.312W$$

Expected power output at various wind speeds maintaining the turbine swept area constant $A_{swpet} = 7.92m^2$ are tabulated below:

V [ms^{-1}]	***P_w =4.948*v^3***
1.0	4.948
1.5	16.700
2.0	39.584
2.5	77.313
3.0	133.596
3.5	212.146
4.0	316.672
5.0	618.500
6.0	1068.768

At 6.0ms^{-1} maximum rating power will be above 1kW↑.

Assume $\lambda = 1.6 \rightarrow 1.5 \le \lambda \le 2.5$

Then $\eta_{wt} = 0.055\lambda + 0.399$

$= 0.055 * 1.6 + 0.399$

$= 0.487 \rightarrow \eta_{wt} = 48.7\%$

Turbine rotational speed

$$\omega = \frac{\lambda * v}{R} * \frac{60}{2\pi}$$

$$= \frac{1.6 * 2.5 * 60}{0.9 * 2 * \pi}$$

$= 42.44$ *rpm*

Torque produced

$$T = \frac{P_w}{\omega}$$

$$= \frac{77.313}{42.44}$$

$= 1.82$ *N.m*

Check / Proof Calculations

$$\lambda = \frac{\omega * R * 2\pi}{v * 60}$$

$$= \frac{42.44 * 0.9 * 2\pi}{2.5 * 60}$$

$= 1.599 \cong 1.6$

Solidity

For a $3-$*blade turbine*

$$S = \frac{N_B * C}{D}$$

$$= \frac{3 * 0.16}{1.8}$$

$= 0.267$

For a $5-$*blade turbine*

$$S = \frac{N_B * C}{D}$$

$$= \frac{5 * 0.16}{1.8}$$

$= 0.444$

Mechanical Power from the rotation of the turbine

Adopting the following values W_B=0.16; N_B=5; L_B=2.83m; t_B=0.024m and ρ_B=1.8*10^3 kgm^{-3}

$$From \quad eqn(6) \quad \rightarrow I_{shaft} = N_B \rho_B (L_B W_B T_B) R^2 + \frac{N_B \rho_B (L_B W_B T_B)(W_B^2 + t_B^2)}{12}$$

Then let

$$I_1 = N_B \rho_B (L_B W_B T_B) R^2$$
$$= 5 * 1800 * 2.83 * 0.16 * 0.024 * 0.9^2$$
$$= 79.22$$

and let

$$I_2 = \frac{N_B \rho_B (L_B W_B T_B)(W_B^2 + t_B^2)}{12}$$
$$= \frac{5 * 1800 * 2.83 * 0.16 * 0.024 * (0.16^2 + 0.9^2)}{12}$$
$$= 0.213$$

hence

$$I_{shaft} = I_1 + I_2 = 79.22 + 0.213$$
$$= 79.43$$

$$P_m = 0.5 * I_{shaft} * \omega^3$$
$$= 0.5 * 79.43 * 42.44^3$$
$$= 1685.505 \quad \text{W}$$

Incorporating a module to determine public health impacts in an integrated catchment Water Allocation Decision Support Tool

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Keywords: *Integrated Catchment Assessment and Modelling, public health impacts*

Abstract

Zimbabwean policy advocates for integrated water resources management; with the Water Act of 1998 stating that allocation of water resources in a catchment should be on the basis of a Catchment Outline Plan (COP). As yet no catchment has the mandatory COP, in spite of efforts by the relevant institutions to produce the documents. There is therefore an urgent need to avail policy makers with tools to properly integrate issues when making decisions on water allocation in a river basin. The negative externalities associated with irrigation development, especially public health issues; also need to be explored since the tendency is for rural irrigators to use canal water for domestic purposes, thereby exposing themselves to water borne diseases. This paper presents a conceptual Water Allocation Decision support system (WAdss) model with a public health impacts module incorporated. This WADss will aid scenario analysis of the possible impacts and trade offs arising from different water allocation options in the Mupfure catchment. The Mupfure model further develops concepts, code and a framework originally developed at the Australian National University for the Namoi and Gwydir river catchments in Australia. It is built in Interactive Component Modelling Software (ICMS); a semi object-oriented software that enables linking of models and independent implementation of user interfaces. The framework is generic, allowing it to be transposed to different climatic regimes, policy options and agricultural production economies. Component models can be structured to capture location specific features. It also allows easy access into the source codes, including the capacity to 'plug-and-play' with different model formulations. Independently developed models can be easily coupled in. This paper discusses incorporation of a public health module which relates water quality and nutritional status of the community to explore public health impacts.

1. Introduction

The objective of this paper is to discuss why and how a conceptual public health impact module may be incorporated into a generic Water Allocation Decision support system (WADss) tool to enable scenario analysis of the possible impacts and trade offs arising from different water allocation and irrigation technology options. A conceptual WADss has been developed for the Mupfure catchment in Zimbabwe based on the modelling framework originally developed at the integrated Catchment Assessment and Management centre (iCAM) at the Australian National University for the Namoi and Gwydir river catchments in Australia [9]. The WADss is built in the Interactive Component Modelling Software (ICMS); a semi object-oriented software that enables the linking of models, and hence the feasibility of linking up an independently developed public health impact module into the existing framework. The framework is made up of biophysical models and socio-economic decision models. It is generic, allowing it to be transposed to different climatic regimes, policy options and agricultural production economies. The details of the different components is what can be location-specific, as the framework allows easy access into the source codes of the different models, to swap and/or modify them as necessary. Models are developed and coded independently, then linked up in ICMS. The approach is multi-disciplinary. Here, it is proposed to couple a model relating water quality to population morbidity, the implication being that change in water quality from a certain irrigation technology option will have a direct bearing on public health. The loss in revenue in the treatment of the resulting illness will then be subtracted from the economic gains from a certain irrigation technology option, as calculated in the regional production /economic model.

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2. The study area

The study area is the Mupfure catchment (127 000 inhabitants, A = 12 000 km^2) in central Zimbabwe. The catchment was subdivided into homogeneous regions (see Figure 2) by land tenure or production types. The base case was set according to land tenure distribution prior to the fast track land reform program. Land tenure in Zimbabwe has always had a direct bearing on production structure and groundwater and surface water policy. Each land tenure system has its own distinct features in terms of water access (irrigation technology and water permits), agricultural production structure and groundwater yield characteristics. Therefore, each region generally represents a single water allocation policy and a single production type. These regions are modelled as a single farmer and then aggregated to regional level. The hydrological node representing each region forms the basis of the links between the different components of the modelling framework. The inherent assumption is that water, land and capital can be costlessly transferred between farmers within the region, but that barriers exist to movement of these resources between regions [10].

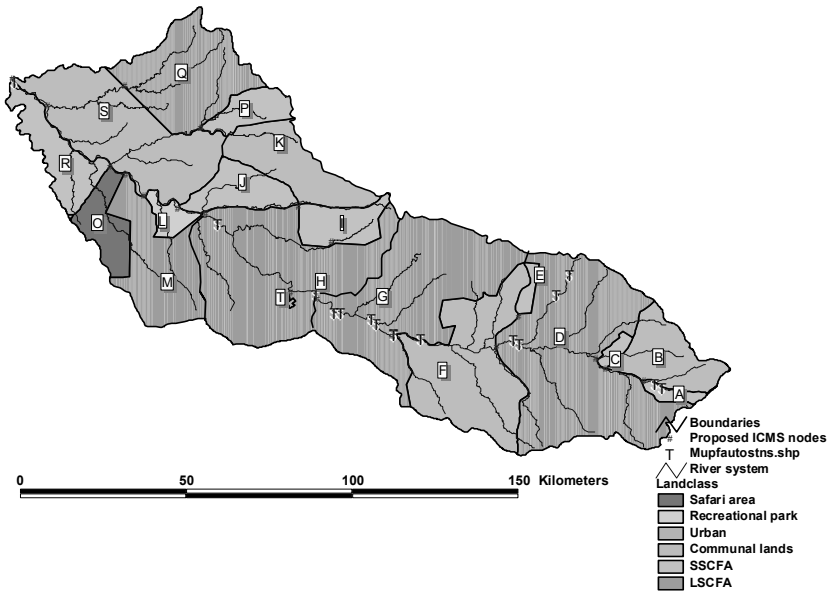

Fig 1: The proposed catchment subdivision into homogeneous regions, and the corresponding nodes

The stream network is distinguished into regulated and unregulated reaches and each region has an extraction node. A regulated reach is defined as a controlled reach with a dam upstream of it. Regulated nodes are affected by reservoir release operations. Unregulated nodes do not have reservoirs upstream, and as a consequence are not subject to reservoir operation regulations. This is the basis of water allocation policies. An example of policy in a region could be; regulated and unregulated access with no carryover for both, or unregulated and groundwater access. Other policy constraints modelled include environmental flow requirements, pumping limits, and for Zimbabwe drought mitigation rules like the 21 month rule [12].

The homogeneous regions modelled are communal areas, small scale commercial farming areas and large scale commercial farming areas. Communal areas fall both under regulated and unregulated river reaches, but they are generally constrained as far as access is concerned. There is currently no infrastructure on an individual level for further irrigation development, and there is no individual capacity for increasing hectarage. Agriculture is mainly rain-fed; and modelling for the base case will principally be to determine whether subsistence levels are achieved each year or not from rainfall. The communal areas have negligible significance in the WADss before the public health model is incorporated. However, in view of policy issues, sidelining these areas would be tantamount to neglecting some of the very topical issues that need to be included in river basin management to ensure equity. As well, there is scope for communal large scale irrigation schemes to benefit the rural poor [10]. Scenario analysis therefore involves increased access to runoff generated by the catchment, introduction of various irrigation technologies, and due regard to the public health impacts emanating thereof.

Small scale commercial farmers have capacity for increasing areas laid out to irrigation, but to a lesser extent in comparison to large scale commercial farmers. Both large scale and small scale farmers have capacity for improving irrigation efficiency, capacity to have on farm storages and to practise both wet and dry season cropping. They lie on both regulated and unregulated river reaches. Access may be constrained by water permits.

3. The WADss framework

The WADss is developed to consider allocation for the groundwater and surface water resources in a catchment. It consists of a complement of models simulating the decision making process when allocating water resources i.e., what amount of water is available from the climatic conditions in the catchment; what are the policies governing how much of this water can be allocated in a particular region, how can this amount be allocated to the different sectors in a way that ensures equitability, profitability and sustainability; what amounts are actually extractable per day by each user given It assists in keeping track of all the issues involved and their points of integration. Minus the public health component proposed herein, the framework does not necessarily deal with water quality issues, although ecological flow requirements for in-stream river health can be considered. Part of the reason is because of the way space is represented, with each homogeneous region being modelled as a single regional farmer. This places a limitation on properly accounting for process dynamics of changes in water quality due to production practices on the land. However it is proposed here to conceptualise water quality issues as described in the public health model presented later in the text.

The interactions of the different disciplinary fields involved in integrated water assessment and management are represented as output of one model being a boundary condition of the next model in the chain (e.g a hydrological model imposing the amount of water available for extraction by a water policy model, the policy model imposing what proportion of this amount can actually be extracted, thus limiting the farmer decisions to crop rotations which are supportable by this amount). The point on the stream network best representing the proportion of flow abstracted from the river for each region is identified with a node (Figure 2). A hydrological model simulates daily flow at the node. The policy model calculates the yearly volume of water available to that region from the node and then the production model optimizes the choice of investments, i.e. it determines what crop rotations will give the highest profits taking into account the available water, land and irrigation technology. These farmer decisions are subsequently represented as a yearly amount of water use. This is input into an extraction model which translates the yearly use to a daily use, checks on available flow and determines the amount that is actually extracted from the flow on a daily basis (see Figure 3). The remainder is routed to the next node downstream, where the procedure repeats itself up till the catchment outlet.

While the adopted conceptual Water Allocation decision support system has a firm grasp on the economic outcomes of certain production choices by the agricultural community, it tended to sideline somewhat the rural communities, providing a lumped outcome which is not truly representative of the complex tapestry of factors that makes up poverty ridden rural areas utilizing common pool resources. There seems to be a general consensus that improving agriculture and enhancing agricultural productivity will remain a key strategy for rural poverty alleviation in low income areas [8]. As a production input in agriculture, irrigation water is an important socioeconomic ‘‘good’’, with a positive role in poverty alleviation. Irrigation water can also become a socioeconomic ‘‘bad’’ when it leads to waterborne diseases like malaria and schistosomiasis, land degradation including waterlogging and salinity, water pollution and associated destruction of natural habitats [8]. The poor population, which with limited resources remain unable to adopt preventive or defensive measures, are most affected by consequences of water as a socioeconomic ‘‘bad’’. Hence, from a whole-catchment viewpoint, loss in revenue due to medical costs arising from irrigation water as a socioeconomic “bad” may be negligible, but it is still necessary to give the issue a higher “weighting factor”, when considering trade offs and impacts in the final analysis. The order of magnitudes of the revenue from improved agricultural production in the communal farming areas may be small in comparison with that from commercial farming areas, and thereby from a purely economics discipline standpoint, one may neglect it altogether from a water allocation decision support system tool. However, from a governance and policy perspective, the wellbeing of the rural population may outweigh pure economics ‘sense’. It is from this line of thought that the idea of incorporating public health impacts of irrigation schemes arose, because this lifts the communal farming areas from the obscurity of being relegated to two simplistic scenarios; rainfed agriculture and determining whether subsistence levels are reached and; irrigated agriculture and determining the extra revenue arising thereof. The public health impacts model is obviously more important for the rural communities than the commercial farming areas.

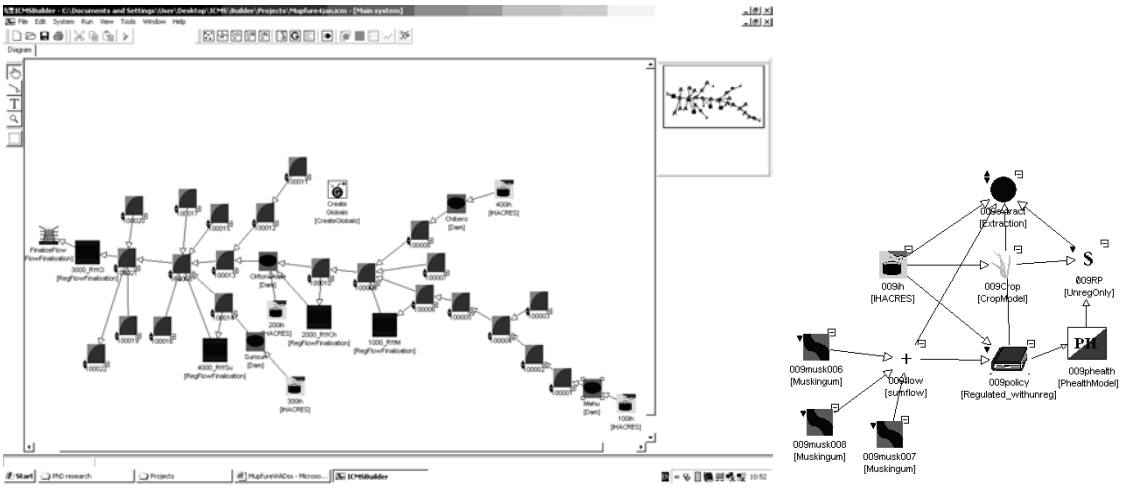

Figure 2: The hydrological nodes after coding into ICMS. Each region is represented by a numerical code and a 'parent' node denoted by the icon. Each parent node has an underlying system of model interactions, representing a system of model couplings. Other nodes/icons represent models not represented in the parent node subsystem.

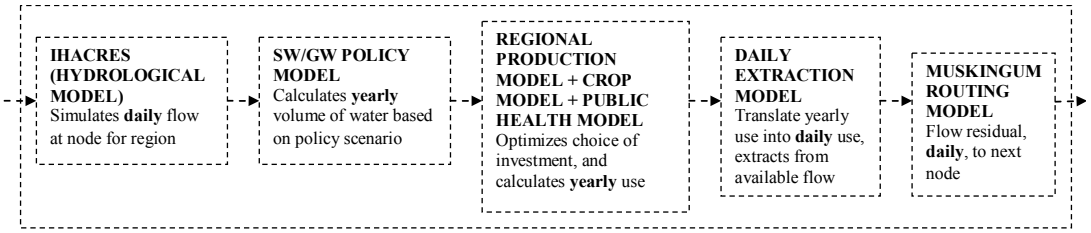

Figure 3: The system of model interactions at each node

4. Justification of incorporating public health module

In irrigation communities, those living at the tail end of the system and relying on water from canals to meet their domestic needs may be exposed to increased levels of water pollution. They may also be exposed to increased transmission of vector-borne diseases. Public health impacts can be derived from firstly the physical construction of irrigation systems resulting in a proliferation of invertebrate and vertebrate pests and disease carriers; soil erosion and sedimentation, and then the management of irrigation systems. For example schistosomiasis has been demonstrated to have increased dramatically in the population following reservoir construction for irrigation and hydropower generation [13]. When negative health impacts occur, they represent a hidden cost of the project. They also represent an increase in pain, suffering, and loss of productivity for the affected community.

Health was not accepted as an integral part of planning for the Diama and Manantali dams in Senegal [13]. An epidemic of Rift Valley Fever occurred when the dams were filled, schistosomiasis prevalence rates reached record levels and riverside inhabitants experienced diarrhoeal disease, malnutrition and malaria. In South America, in 1988, more than 80 deaths and 2,000 illnesses due to severe gastroenteritis have also been directly linked with toxic cyanobacteria in a newly constructed dam. In China, a high incidence of primary liver cancer has been linked to the presence of cyanobacterial toxins in drinking water [5]. Recent studies in Ethiopia using community based incidence surveys revealed a 7.3 fold increase of malaria incidence associated with the presence of microdams [7]. Health impact assessment has built on the understanding that human health and wellbeing relate to economic, environmental, social, psychological and constitutional (e.g., age, sex and genetic constitution) influences. All but the last are likely to be influenced by irrigation development [3]. With this realisation, coming up with a mathematical model properly representing all the processes and variables resulting in morbidity as resultant of irrigated agriculture presents a daunting task. A conceptual mathematical model which accounts for all factors and yet is simplistic enough as to be generic is required.

To arrive at that, the focus can be shifted from the disease causing processes themselves to the quality of the water and the health status of the community consuming that water at any given time. The presence of pathogens or chemical pollutants in the water and the irrigating community's poor nutritional status are the major causes of increased morbidity [2]. An understanding of the interactions between the environmental (water quality) and nutritional (health status of an individual) factors is important.

5. A description of the models in the WADss

The models in the integrated toolbox are based on spatially lumped representation of processes. Model selection is to serve the purpose of the DSS, not the other way around. The starting point is the problem definition, the resources available to solve the problem and then the development of a set of tools to solve the problem. Model selection is a compromise between rigour and utility. The spatial scales vary from nodes to land units scales. Time steps for models range from daily to annual, while outputs may be aggregated up to seasonal, annual or higher depending on the length of the simulation. The node is the unifying spatial scale. The time clocks of different models are synchronized at these nodes. The model code is written in MickL, a subset of C programming language which is the ICMS internal language. It contains an extensive range of mathematical and program control functions purpose-built to provide powerful model processing ability.

The focus of the hydrological model Identification of unit Hydrographs and Component Flows from Rainfall, Evaporation and Streamflow, IHACRES [6], is to determine availability of water for crop irrigation. It is a parsimonious lumped conceptual model capable of modelling arid and semi-arid catchments with a combination of perennial and ephemeral streams. The model is capable of separating the flow into quick and slow flow components, and it also facilitates regionalisation to ungauged catchments using simple catchment attributes such as forest cover and catchment area. The structure consists of a non-linear loss module that converts rainfall to effective rainfall, and a linear routing module that converts rainfall excess to streamflow, taking into consideration antecedent conditions. Routing of flow between nodes is undertaken using a Muskingum routing technique.

Water policy models calculate the annual unregulated and regulated surface water extraction limits for each region based on flow pump limits and bulk extraction limits, giving due cognisance to water access policies in the region, including supplementary water access, additional rainfall or runoff generated at the node from the residual subcatchment area and residual flows routed from upstream nodes.

The crop model has a set of discrete yields and applied water values for each crop which are derived from empirical yield relationships. A global data set of the crop production functions are created; the crop identity, the applied water threshold to produce a yield, the slope of the water/yield relationship and the maximum yields achievable for each crop. Rainfall volumes available for each crop option for each season are also specified. For an irrigated crop, water use is the shortfall of the rainfall volume from the crop water requirements. For a dryland crop, if the rainfall is less than the applied water threshold to produce yield, a zero yield is returned by the model. Otherwise, the yield is calculated with respect to the slope of the water yield function and the maximum yield achievable taking into account yield variations.

The economic models or regional production models are based on the assumption that the regional farmer aims at maximizing profit given a choice of crop rotations and the inherent constraints of land, water and labour available to them. Indicators are used to explore the impacts of water allocation options. Variables in the models include crop yields, crop water demand, irrigation amount, post extraction streamflow, cash returns from agriculture, hire costs and the staple crop deficit (for communal farmers), for instance. Irrigation technology options are expressed as irrigation efficiencies typical for each method of irrigation. Decisions are made in each year at each possible state in the capital state-space vector, which has land, water and labour as state variables.

Once a production decision has been simulated by the regional scale economic model, total annual water usage at a node is distributed across each day of the simulation using a daily extraction model. This model assumes that extraction during the irrigation season is proportional for each day in a given month to the total volume that is able to be extracted, taking into account the presence or absence of on-farm storage (OFS). During a non-growing month, a farmer with OFS can extract an amount equal to the monthly extraction limit per region if they have space, otherwise they can only extract a smaller amount to top up the OFS capacity deficit.

5.1. Public health module

A literature review of medical and human biology journals yields various complex process models relating water quality to increased morbidity. In a study by Bhargava et al, [2], the effect of faecal and total coliforms as water quality indicators on the spells of gastrointestinal morbidity in rural Bangladeshi children was analysed. This study was done only on children, and not on the total population. However, the resultant model has the desired structure, one which relates some water quality indicator with the health of the community, and which does not require an exhaustive water quality parameter or disease cycle process analysis. Bharghava et al [2] used faecal and total coliforms in the stored water as significant predictors of morbidity and modelled the relationship using dynamic random effects models. Nutritional status of the children was also an important variable; with children with better haemoglobin (Hb) status experiencing lower morbidity. An empirical model for the proximate determinants of haemoglobin concentration showed significant negative associations between children's hookworm loads, a symptom of morbidity, and haemoglobin.

While testing water for certain disease causing pathogens is complicated by their short survival time, quantitative measures based on faecal and other coliforms are useful indicators of water contamination [2]. The present author proposes to extrapolate this argument to other water quality indicators as significant predictors of morbidity. The Bharghava surveys compiled background information on household members such as their age, occupation, and education. Morbidity is also linked to the population's nutritional heath status, approximated by body mass index parameters such as weight, height, haemoglobin concentration, and nutrient intakes. From a medical standpoint, weight reflects the history of energy imbalances and is likely to be lowered by illnesses that reduce dietary intakes and increase protein loss. For the Bharghava study, height of a child is taken as a body mass index parameter which reflects the quality of diet.

Denoting the i^{th} child's morbidity by an index M_{it} (i = 1,2, . . . ,n; t = 2,3), they postulated the following model for Bangladeshi children:

$$M_{it} = a_0(\text{Constant}) + a_1(\text{Age})_{it} + a_2(\text{Age})^2_{it} + a_3(\text{Height})_{it} + a_4(\text{Hemoglobin})_{it} + a_5(\text{Weight})_{it} + a_6(\text{Fecal coliforms in source})_{it} + a_7(\text{Fecal coliforms in storage})_{it} + a_8(M)_{it-1} + u_{it} ,$$

where M_{it} is the morbidity index, $a_0, \ldots, a_8$ are regression coefficients, u_{it} is an error term, and M_{it-1} is the previous measurement on the morbidity index with coefficient a_8. The quadratic relationship between children's age and morbidity was a flexible formulation in view of the likely increases in resistance to diseases with age and the increased exposure to contaminated food and water. Haemoglobin concentration was used as an indicator of iron status because it has been found to be negatively associated with child morbidity in the analysis of other data from developing countries ([4] and [1]). The empirical model for children's Hb status was:

$$Hb = b_0(\text{Constant}) + b_1(\text{Age})_{it} + b_2(\text{Hookworm})_{it} + b_3(\text{Bioavailable iron})_{it} + b_4(\text{Height})_{it} + b_5(Hb)_{it-1} + u_{2it} ,$$

where $b_0, \ldots, b5$ are the regression coefficients and u_{it} is an error term. The potential differences in children's Hb status due to genetic factors were partially accounted for in the model by including random effects (the error term). Children's weight was dropped from the Hb model because it was not a significant predictor in any of the specifications. Also, it was conceivable that the association between Hb and morbidity in the first model may be due to reverse causation, i.e., children's gastrointestinal morbidity in the previous month could lower the current Hb concentrations.

One can now derive the following generalised equations for morbidity resulting from consumption of contaminated water;

$$M_{it} = a_0(\text{Constant}) + a_{nj}\sum_{1}^{n}(\text{BMI})_{it} + a_{mj}\sum_{1}^{m}(\text{BMI})_{it}^{\,2} + a_2(Hb)_{it} + ap_k\sum_{1}^{p}(\text{Water quality parameter})_{it} + a_5(M)_{it-1} + u_{it}$$

and,

$$Hb = b_0(\text{Constant}) + bn_1\sum_{1}^{n}(\text{BMI})_{it} + b_2(\text{Morbidity symptom})_{it} + b_3(\text{Nutritional health indicator})_{it} + b_4(Hb)_{it-1} + u_{2it}$$

Having determined a morbidity index, one can then use a simple look up table to relate disease frequency in a community with the associated health costs. These are then deducted from the forecast revenue accruing from production choices in the economic model.

6. Discussion and conclusions

Health impacts from irrigation projects tend to be site specific. They are linked to the geographic variation in health conditions associated with standing or open bodies of water in different ecological and epidemiological settings. It is therefore difficult to come up with mathematically tractable relationships for exploring these impacts, more so coupling this into a broader decision support tool. The public health component suggested in this paper attempts to relate population nutritional health characteristics and changing water quality to morbidity. Data from an irrigating community can be used to calibrate the model, and when coupled into the WADss, the cost associated with treatment of the community can be deducted from the profit margins. Evidently, the data requirements of the entire WADss will be extensive. In spite of the many sources of uncertainty and some inherent deficiencies related to issues of scale, propagation of model uncertainty and error, difficulty in obtaining some of the requisite field data, difficulty in calibration and validation of some models and etcetera, it may be argued that a policy maker would still be better off with one than with no WADss at all. At the very least, the tool will guide them in considering the important issues in catchment management and their points of integration. The simulation results can guide impact assessment studies of the environmental, social and economic aspects by exploring the relative outcomes associated with different project scenarios, comparing these with various initial assumptions and conducting sensitivity analysis. Any disputes arising around water resources development plans are then objectively guided to reasonable decisions through following a consistent methodology for assessment of trade-offs between the project and no project options, or between the different project alternatives.

6. Acknowledgements

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Optimisation of a Bone-char Cartridge used for

Defluoridation of Drinking Water

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Keywords: Bone char, PVC cartridge, batch defluoridation, flow-through defluoridation, optimum conditions, defluoridation efficiency.

Abstract

Due to the relatively high costs, the bulkiness and the inconveniences associated with the use of the batch defluoridation buckets sold by the Catholic Diocese of Nakuru (CDN) Water Program, an attempt has been made to construct a cartridge to be used for the same purpose. The cartridge packed with bone char material could be fixed onto a domestic faucet as a flow through defluoridizer. PVC cartridges of various sizes were made from a ¾ inch pipe. The efficiency of fluoride removal was determined for the following parameters: cartridge length, flow rate of water, compactness of bone char material and particle size with the aim of determining the optimum conditions for a good cartridge. It was found that the optimal conditions for the F^- filter that gave the best results in removing of F^- from water with minimum inconvenience were: particle size, 0.2 mm mean diameter; the flow rate, equal or less than 20 ml/minute; cartridge length, 10 cm filled with 20 g of bone char material.

Introduction

The removal of F^- from potable water has seen many attempts over the years, using a wide variety of material giving various efficiencies. The Nalgonda Technique where alum is mixed with lime at the ratio 700/300 mg/L respectively, was tested at a research station in Arusha, Tanzania and reduces fluoride concentration from 21 to 5 mg/L at pH 6.9 [1]. Clays, ion exchange resins, activated carbons, sulphonated coals, magnesium compounds, serpentine, iron and aluminium salts have been applied [2]. Use of activated alumina (2000 grains/ft^3) as filter-bed shows that fluoride removal efficiency approaches 100% [3]. The use of Polyaluminium Chloride and Magnesite has also been demonstrated to have efficiencies of 95% and 81% respectively [4]. An electrocoagulation process has been suggested by Mameri [5], where aluminium bipolar electrodes were used with encouraging results. The process had to be optimised in terms of: inter-electrode distance, fluoride concentration, temperature and pH of the solution and the influence of current density. Local Kenyan soil derived from volcanic ash i.e. Ando soils or soils with 'andic' properties has been used as a fluoride sorbent. [6]. Defluoridation by bone char has been studied by several workers including Jacobsen, Mavura, Watanek, [7], [8], [9] respectively, with remarkable efficiency. The removal process is the ion exchange adsorption between fluoride in the solution and carbonate of the apatite comprising bone char.

Irrespective of the material or method used, there are generally two methods of Fluoride removal namely: batch and continuous flow defluoridation. The bucket filter marketed by the CDN [8], is an example of batch method and is designed such that water has to sit in the container for a minimum of 15 minutes before it is collected in one batch. The F^- free water is then transferred into another container for use by the family for a day or two depending on the capacity of the filter. This method is not only potentially costly because it requires a large container filled with bone char material, but also the water is likely to be contaminated since it has to be collected and transferred into a second container for storage before it is used.

The second form of filter, the continuous type, is usually a tube or cartridge fitted onto a domestic faucet, with an inlet and an outlet tube. Fluoridated water enters the cartridge and passes through the active material and comes out through the opposite side of the cartridge as defluoridated water. A typical example is the one reported by ENFO News (1989) [10], where a bone char filter was developed for use in Thailand villages. This particular filter was made of a 75 cm plastic tube equipped with inlet pipe and outlet water tap. In the filter is 300 g charcoal, 1 kg bone char and pebbles. When water of 5 mgF^-/L is run through the filter with a flow rate of 4 L/h, 480 L can be treated to less than 1 mg/L. The price for such a filter is US$ 4 for the filter and US$ 0.70 for new filter material.

In this study, smaller size cartridges than in the previous study were made and the filter material used were only bone char, unlike the previous study where a mixture was used. Optimisation of physical conditions to provide

the best F^- removal from drinking water was carried out. The conditions included: bone char particle size, water flow rate, cartridge length and compactness of the filter material.

Experimental

The cartridges were constructed by the use of PVC tubing cut into small pieces of desired lengths. The internal diameter of the tubing was ¾", the same as standard domestic faucets. The cartridge construction procedure is as follows: 1. Using adhesives, a rubber stopper with connector tubing was attached to one end of the of PVC pipe of desired length. 2. Using an analytical balance the desired amount of bone char was weighed and placed into the PVC tubing. For parameters other than compaction effect, 2 g bone-char per cm of PVC pipe length were packed. 3. A rubber stopper with tubing was fixed to the other end of the PVC pipe. After packing and sealing, the cartridges were left for at least 15 minutes before use, for the adhesive to dry properly. The water samples were collected in the following procedure: 1. The cartridge was attached to the tap using a laboratory clip or any other device that is suitable. 2. Water was allowed to flow through the cartridge for 15 minutes. 3. The flow was adjusted to desired rate. 4. A sample of 100 ml is collected in a graduated cylinder.

The fluoride meter used was an Ion Selective Combination Electrode, model: Thermo ORION, 96-09 manufactured by Orion Research, Inc. of Beverly Mass, USA. A TISAB (Total Ionic Strength Adjustment Buffer) and Fluoride standards were obtained from the same company. Prior to analysis, the samples were treated as follows: 1. All samples and standards were placed in a water bath (25^0C) for at least 30 minutes. 2. A 50 ml sample and 5 ml TISAB III were placed in a 150 ml beaker and the mixture was stirred thoroughly using a magnetic stirrer. 3. The electrode sensing element was immersed in the mixture at least 1cm, and the millivolt reading was taken after stabilization. The method of "Standard Addition" was used, where known concentration of F^- was added to prepared sample, the total potential difference before and after addition was recorded and the F^- in water determined.

The filter material was bought from the CDN in various particle size sets of 0.2 mm, 0.6 mm, 2 mm, and 4 mm mean diameter. The PVC tube was cut into various lengths of 5 cm, 10 cm, 15 cm and 20 cm. The flow rate was varied from 5 to 60 ml/min. Optimum compaction was achieved by varying bone char mass from 20 g to 35 g in a 10 cm cartridge after optimising the rest of the parameters.

Results and Discussion

The findings for the study of the effect of particle size on Fluoride removal are presented in Figure 1. The smaller the particle size of the material, the higher is the efficiency of removal. The smallest size, 0.2 mm gives the highest efficiency, where only 0.02 mg/L of F^- remain after filtration of water originally containing 3.96 mg/L. This is equivalent to 99.5% removal efficiency. Other particle sizes with their efficiencies under the same experimental conditions were: 0.6 mm, 74%; 2 mm, 41%; and 4 mm, only above 4%. The higher efficiency of smaller particle size is due to the provision of larger surface area necessary for adsorption of F^- from water onto the bone char material.

The set of data reported for the effect of flow rate (Figure 2), was obtained from a cartridge of 10 cm and 0.2 mm particles size. The two parameters were optimised before the flow rate. The flow rate effect seems to be levelled at near 100% (actually 99.7%) for 5, 10 and 15 ml/min. At flow rates higher than 15ml/min the efficiency started to decrease such that it had dropped to about 97% at 20ml/min. At 40 ml/min, the efficiency was still above 90%. It dropped to about 70% at 60 ml/min. Practically, when the filter is used at a flow rate below 20 ml/min., it is too slow and therefore inconvenient. On the other hand, the higher the flow rate of water, the lower is the resident time in the filter, thus there is not enough time for F^- to interact with the bone material to be adsorbed.

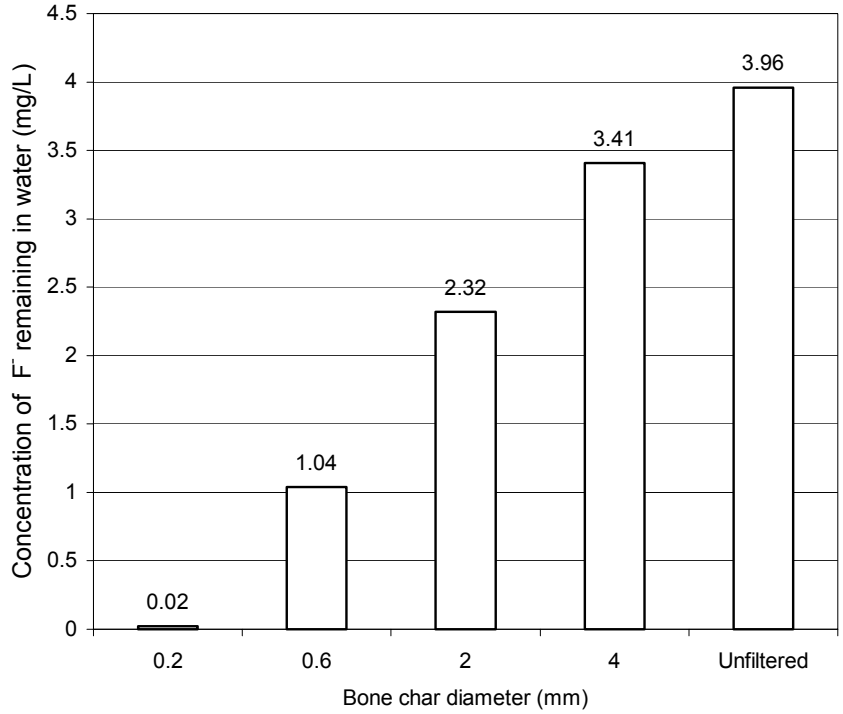

Figure 1: Effect of bone char particle size on fluoride removal from water

The other parameter studied was the cartridge length effect (Figure 3). The figure shows that using the smallest length of 5 cm (and packed with 2 g/cm as optimised in Table 1), only about 94 % F^- was removed. The removal efficiency increases sharply to 99.5% when the length is doubled. This percentage remains almost constant when the length is doubled again to 20 cm, to about 99.7%. This means that for economical purposes, one does not have to make a cartridge that is longer than 10 cm because there is no significant gain in terms of F^- removal efficiency beyond 10 cm. For convenience sake, therefore it is advisable to make a 10 cm long cartridge that can easily be fixed onto a kitchen faucet without taking too much space. The effect of length is similar to that of flow rate in that, there is an optimum length for F^- present in water to adequately interact with the active material. At least 10 cm appears to be the compromise length when all other parameters namely flow rate, particle size and compactness are optimised as reported here.

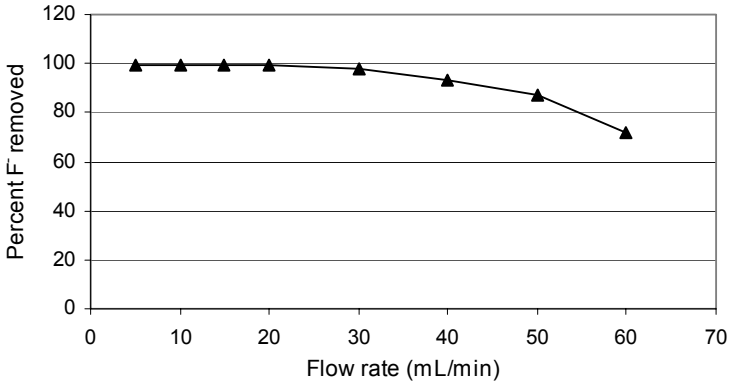

Figure 2: Effect of flow rate of water on the removal of fluoride

Table 1: Effect of compactness of bone char material

Bone char mass packed in 10cm cartridge	[F^-] Remaining from the original (3.96 ppm)	Efficiency of removal
20 g	0.02 ppm	99.5%
25 g	0.02 ppm	99.5%
30 g	0.01 ppm	99.7%
35 g	0.01 ppm	99.7%

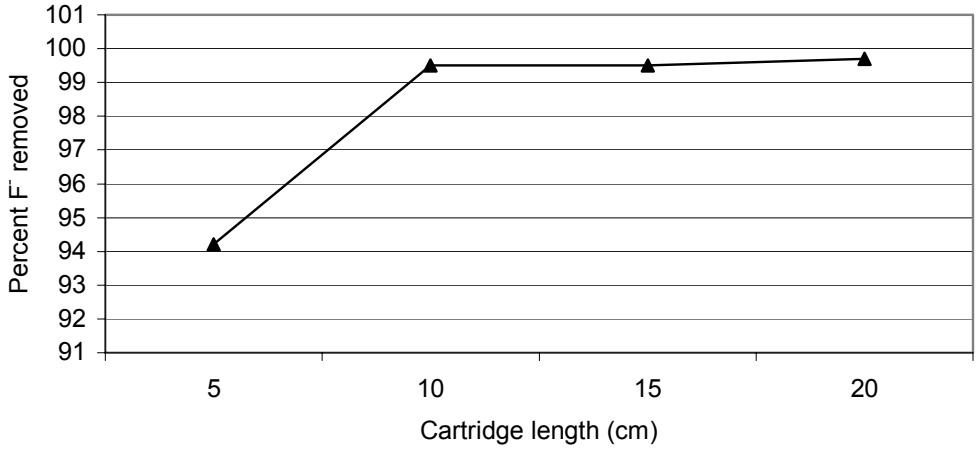

Figure 3: Effect of cartridge length on fluoride removal from water

The effect of compactness of packing or density of the filter material in the cartridge is presented in Table 1. Twenty grams of bone char represent a compactness of 2 g/cm using a 10 cm cartridge length. This length was the optimised size in the previous sets of experiments (Figure 3). The table shows that by increasing the compactness from 2.0 to 2.5, 3.0 and 3.5 g/cm, we are increasing the amount of F^- removed from 99.5% to 99.7% only. This is a very small gain on efficiency. Other observations showed that, this insignificant gain is also associated with creation of too much backpressure in the cartridge as well as significantly reducing the flow rate. As a result of these twin drawbacks (back pressure coupled with reduced flow rate), the optimised condition is to make a cartridge with 2 g/cm of cartridge material packing, specifically 20 g in 10 cm cartridge. The compactness of cartridge packing is technically a measure of the pressure of water passing through the cartridge. The more compact the packing, the higher is the pressure. However, if a higher pressure is desired, it will be at the expense of reduced flow rate and higher backpressure.

Conclusion

The study has shown that the optimal conditions for the locally manufactured F^- filter which gave the best results in terms of removal of F^- from water with minimum inconvenience were: particle size of the bone char grains, 0.2 mm mean diameter, which was the smallest size; the flow rate, 20 ml/minute which was a medium rate; cartridge length, 10 cm filled with 20 g of bone char material. The latter condition reflects the compactness or density of cartridge packing, i.e. 2 g/cm. Higher compactions of 3 g/cm or 3.5 g/cm produced too much backpressure and lower, non optimal flow rate. In future this research group will focus on refining the engineering of the cartridge, especially to alleviate the backpressure problem on the one hand and on the other, to determine the life span of the cartridge or the maximum duration for use before the capacity of the material to adsorb F^- is exhausted. Equally important to find out is the quality of the drinking water after passage through the cartridge. In evaluating the efficiency of a locally manufactured bucket defluoridation filter, it was reported (8) that the concentration of K increased in the fluoride free water. This was attributed to leaching of K from the charred bone material to the water. On the other hand Ca concentration was significantly reduced, perhaps as a result of adsorption by the bone matter. It should be important therefore to investigate the quality of water from

the new cartridges in terms of metal ions and microbial contents as well as other physico-chemical properties including the pH.

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Appropriate Technologies for Water Use and Conservation in Public Health

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Abstract

This paper focuses on the development and implementation of an appropriate technology for sourcing, collection, treatment, storage, conservation and management of water, focused on public health improvement. Potable water availability and sanitary treatment and disposal of wastes are two critical prerequisites for the improvement of public health, and for the development and maintenance of a viable and sustainable public health infrastructure. Public health development indices will only show improvement with diverse appropriate technology development and implementation for water treatment and availability, and maintenance of adequate water supplies. This paper discusses rainwater harvesting and water harvesting as appropriate water collection technologies, highlighting some of the best available technologies and discussing their application in, and pertinence to, productive and sustainable public health efforts.

INTRODUCTION

One of the necessary and critical infrastructural needs for the development and maintenance of public health is the availability of clean potable water. Without clean water, any effort to improve and maintain public health would fail miserably. Water is life as there can be no life without water, and there is a growing consensus that access to safe potable water should be a basic human right. As less developed and developing countries grow their economies and struggle to improve both the quality of life and the standard of living for their citizens, access to clean potable water becomes critical. Lacking the capital and expertise for large-scale infrastructural projects focused on developing water resources, these countries and economies often find themselves unable to dedicate the resources necessary to fulfill public health focused water needs. In this context, it is instructive to study the experiences of communities in other developing economies that have focused on the use of appropriate technologies and sustainable resource management to fulfill these water needs. Appropriate technologies for water become critical resources for development.

Appropriate technology, or AT, is difficult to define and its development and implementation have been a source of debate for some time [1]. There is general agreement, however, that AT only requires small amounts of capital, emphasizes use of local materials, is relatively labor intensive and should be small scale and affordable. AT should also be understandable, controllable and maintainable without high levels of education and training and AT should be adaptable and include local communities in innovation and implementation without adverse impacts on the environment [2]. An earlier paper [3] provided a broad over view of appropriate technologies available for water collection, treatment and storage.

Water has been labeled the 'blue gold' of the 21st century. In March 2003, the World Water Forum (WWF) was held in Japan and the Ministerial Declaration[3] of the WWF stressed that access to clean water was the driving force for sustainable development and the eradication of poverty. Water resources must be managed with good governance and a stronger focus on community-based approaches that address equity with technical and knowledge capacity building and grass-roots empowerment. In January 2004, the People's World Water Forum (PWWF) convened in New Delhi, India[4] stressing the need for recognition of access to potable water as

[3] http://www.world.water-forum3.com/jp/mc/md_info.html
[4] http://www.pwwf.org/events&programme.html

a human right and strong opposition to water resource privatization. As the PWWF noted, it is critical that the local community retain control over water resources for sustainable development and social empowerment[5].

In the global North, the National Council for Science and Environment (NCSE) held its 4th National Conference on Science, Policy and the Environment and in 2004 focused on Water for a Sustainable and Secure Future. Various UN, US government, non-profit, non-governmental, corporate and academic representatives provided a diverse cross section of views on water use and policy, asking important questions: Who owns water? Should water be privatized? If so, how much should it cost? How much responsibility do corporate and individual water users have to pay for what they extract? Who cleans up (and to what level?) what they discharge [5]? Although no definitive answers were provided, it was clear stakeholder views were in alignment with their interests. Positions ranged from potable water availability as an absolute human right to water as commodity to be privatized and "market" priced to maximize profit.

Water availability, potable quality, cost and pricing, has become a singular source of contention and dispute, pitting global private capital's search for higher profits against local community needs for sustainable development. The policies followed by any developing nation seeking to improve the quality of life of its citizens have tremendous implications for public health. What is clear is that public health needs necessitate the development of water resources for all. Communities on the ground need to be equitably resourced with water. Failing this, the success of any public health program will be in jeopardy. Water availability and quality must be integrated into public health efforts. The only way this can be done is through the development and implementation of additional water collection, storage, treatment and conservation technologies. To be successful, newer and appropriate technologies must be developed and implemented.

This paper examines appropriate technologies for water recovery and use, focusing to a large extent on the work of the Center for Science and Environment (CSE) based in New Delhi, India, and reviews their successful efforts in addressing water quality and availability problems in both urban and rural settings there. The groundbreaking and creative solutions developed and implemented by the CSE in India garnered the Stockholm World Water Prize in August 2005 and are exemplary of appropriate technologies developed and utilized in satisfying the water needs of rural and urban communities in the social and infrastructural context of the global South[6].

Water Business

In March 2001, the Center for Science and Environment in New Delhi, India, published a seminal collection of policy and technology papers [6] focused on the practices and policies of water harvesting under the editorship of the late Anil Agarwal. This was subsequently reprinted and updated, first in 2003 [7] and again in 2005 [8]. The latest edition focused on rural and urban water harvesting programs and technologies with a serious analysis of the implications for water development policies. The interested reader may go to these sources to get an excellent overview of the various successful programs in diverse urban and rural settings; in the following sections, this paper will focus on the basic technology that has been developed and implemented for water harvesting.

Prior to a discussion of water harvesting and other appropriate technologies for the development of potable water resources, it is instructive in the context of water business to examine how corporate entities are focusing on water technologies. Thameswater[7], one of the largest private water companies in the world, is actively researching and developing water re-use technologies for water conservation, making an exhibition to enhance public awareness of water re-use out of the Millennium Dome in London. Unilever has developed the SWIM® (Sustainable Water Integrated Management) process and applies it in their privatized water resource recovery projects. Although the incorporation of such sustainable thinking into corporate water sourcing technology development is commendable, the flip side of the coin is the loss of community control over local water resources to corporate and privatized interests that no longer see service to and needs of the community as primary but rather the maximization of return on investment and profit as the main objectives[8]. The actions of companies such as Vivendi and the now defunct Enron's Azurix are excellent examples of corporate failure to adequately address community water needs, and also instructive of attendant loss of community control and of

[5] Vandana Shiva's *Water Wars: Privatization, Pollution and Profit* (2002) has critically examined water rights where she has argued that the "market paradigm" for water use and distribution is flawed, and that corporate control over water erodes not only the water resources but also democratic structures that have historically governed community water use [4].

[6] http://www.siwi.org/press/presrel_05_SWP_Winner_Eng.htm

[7] http://www.thames-water.com

[8] http://www.wateractivist.org; http://www.publiccitizen.org

how communities are fighting back to regain control over the precious life-sustaining resource, 21st century "Blue Gold".

Water Harvesting

When water precipitates out of the sky in the form of rain, it percolates through the ground to replenish groundwater and feed subsurface aquifers and streams, runs-off impervious surfaces until it reaches a surface water body or pervious soil surface, or it evaporates back into the atmosphere. Although the hydrologic cycle makes it difficult to mark a beginning or end to waters cyclic journey through the environment, rain can be considered a primary source of water. In this context, secondary sources of water include rivers, lakes and groundwater, all of which get recharged from the primary water source through time. Most development experts and technocrats tend to focus more on the secondary water sources as the major input streams to water collection, treatment and storage systems. This ignores the primary water source – which feeds all the secondary water sources – and hence such thinking undervalues or devalues the importance of the primary water source and of incorporating primary water sources into the design and development of water resources. Through rainwater harvesting, the value and importance of rainwater is reestablished and incorporating water harvesting into the spectrum of potential water sourcing technologies brings the development and harnessing of this precious resource into the realm of sustainability [9].

The principles underlying rainwater harvesting and the calculations that enter into the determination of the design are straightforward. If one knows the amount of rainfall that an area receives, multiplying this by the efficiency with which the rainfall can be collected (harvested) will provide the potential amount of water that can be harvested. Usually, the amount of rainfall multiplied by the area of 'catchment' will provide the volume of water that can be collected. Following the discussion in *A Water Harvesting Manual* [10] as an example, a rooftop with an area of 100 sq.m receiving 2200 mm of rain in a year could potentially provide 220 cu.m. (220,000 liters) of water. If the water harvesting system design permitted 60% efficiency in collection, then at least 132,000 liters would be available.

In its simplest form, the basic elements of a simple rainwater harvesting system are shown in Figure 1 [11]. The catchment area is established and then a conduit or pipe is connected to this area which permits the water to be sent to a storage facility and to a recharge facility. The storage facility provides immediate water for ready use and can be below ground or above ground, while the recharge facility provides a mechanism by which longer-term water storage can be recharged for later withdrawal.

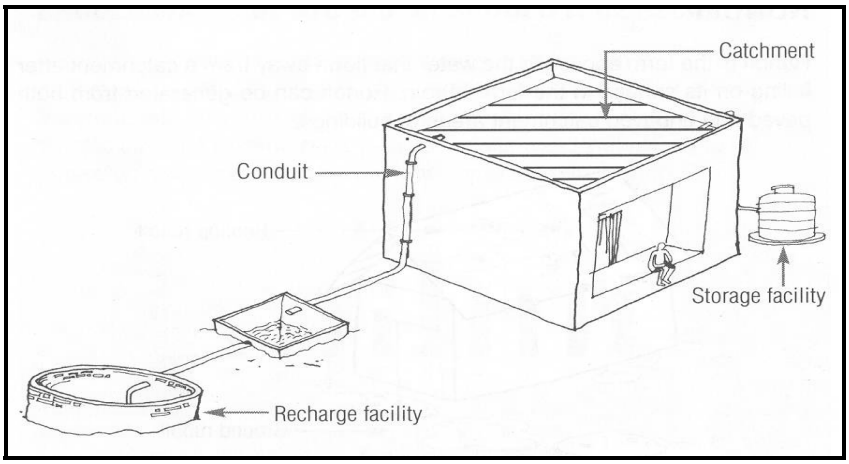

Figure 1: Basic elements of a rainwater harvesting system. From [10]

Since falling rainwater will bring with it any dust, particles and debris that was in the atmosphere or on the catchment area, it is beneficial to insert a filtration mechanism at the head of the conduit collecting from the catchment area to trap all such materials. This level of filtration is often sufficient for many water uses. Additional filtration will be required for potable water, and slow sand filtration is often adequate for this end-use [12]. Slow sand filtration will clean water supply sufficiently to make a significant improvement in public health. For complete elimination of pathogenic organisms and to ensure that public health is maintained through the elimination of unclean water as a disease transmission vehicle, disinfection of the water will be required. This may be accomplished through various additional point-of-use technologies such as boiling,

chemical disinfection or filtration. Boiling is perhaps the most effective in sterilizing water but energy requirements are high and will add to the cost of the water to the public user. Requiring the public consumer to boil their water prior to consumption will carry the risk of many failing to do so and thus raising the risk to maintenance of public health. Chemical disinfection is often the quickest but requires the addition of a disinfecting agent such as chlorine, which kills all types of bacteria and makes water safe for drinking. However, chlorination of water is known to generate harmful byproducts and this method, although easiest and cheaper then boiling, may have long-term adverse consequences for public health.

Perhaps the simplest and least expensive method is through in-line filtration devices built into the water harvesting, collection and storage system design. A simple charcoal filter can be constructed of sand and charcoal layered one over the other sandwiched between two coarse-pebble or gravel layers that facilitates percolation of water and prevents clogging of the filter. The sand efficiently removes particulates and the charcoal acts as an adsorbent to bind microbial contaminants, other colloidal and suspended contaminants and also serves to remove organics and metals. An example of a simple low-cost filtration media configuration is shown in Figure 2. This filtration set up has been shown to remove pathogenic bacteria as well as other microbes such as parasites and amoebas, the causative agents in dysentery and diarrhea.

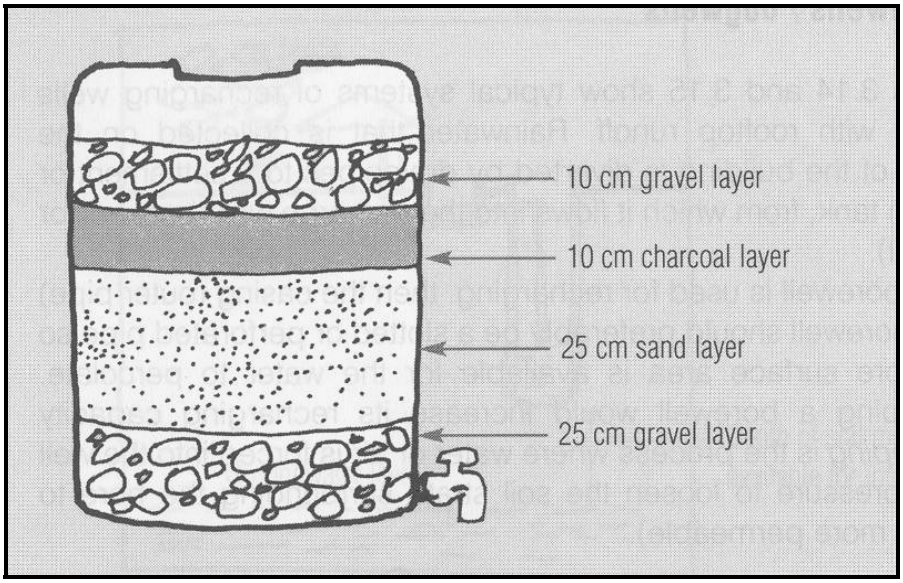

Figure 2: Basic elements of a sand-charcoal filter configuration. From [10]. The size of the filtration set-up can be increased with ease and material costs are very low.

There are other simple methods of disinfecting water, such as through distillation. A recently developed low-cost, low-maintenance solar disinfection unit has demonstrated quite a bit of promise as an appropriate, low cost technology for the production of potable, disinfected water. This unit eradicated over 99.99% of bacteria in water samples and was able to provide six liters of pure drinking water on a daily basis [13]. Such technologies can also be incorporated into water resource development schemes to benefit local communities and people at the grass roots.

The potential for problems with contamination of the stored water are real but can be avoided with the implementation of suitable measures to minimize the risk and prevent contamination. It is important that the storage tanks be cleaned prior to the start of the rainy season and the catchement area be swept and cleaned as well. Conduits for conveyance of the harvested water to the storage receptacles should be kept clean and unclogged. The in-line filtration apparatus must also be cleaned and maintained so that the water can freely percolate through the media. This might require periodic cleaning out of the filter. In terms of end-use, it would be necessary to change the charcoal and sand media in the sand-charcoal filter on a periodic basis. When the filter media are changed, it is important that the new filter media be flushed completely prior to the water being used as potable water.

The design of the water harvesting system and the configuration of the filtration/disinfection set-up will depend on the context within which the water collection system is being developed and implemented. Designs and systems for rural areas will be very different from those that would be implemented in urban settings. Despite this, the basic components of these systems – a catchment area, conduits to channel the

harvested water, means for filtration and disinfection, and storage reservoirs – will be the same. As in the development and implementation of any appropriate technology, the specific system to be established and the specific design to be implemented and constructed will necessarily be highly dependent on the local situation. The configuration that is finally settled on within a particular context must be thoroughly examined and tested through actual use. Amounts of water that are harvested, water quality and the time required for collection must be recorded and these results need to be evaluated after a given period of use. Depending on the situation and the local context, there may be a need for redesign and reconfiguration. This is part of the process of technology development and implementation and must not be neglected so as to optimize the final design that is implemented on a larger scale within a given region and context.

As with the process of any development technology that is being designed and implemented, serious and critical consideration must be given to how well the local community's needs are being met and what the benefits and costs of the technology implementation are. Care must be taken that the community feedback is taken into account and that the community is itself engaged in the entire process. Successful development and implementation of appropriate technologies will only result if the local community that the technology will serve is engaged in the process from the outset. This would necessarily include community training and knowledge technology transfer so that community input forms a substantive and integral part of the design and implementation process.

Alternative Appropriate Technologies for Water Treatment

Water harvesting is perhaps the most simple and straightforward, as well as most ecologically and environmental sustainable, water sourcing and collection technology available for urban and rural communities in developing and underdeveloped nations lacking the large capital inputs necessary to maintain more sophisticated water collection, treatment and supply technologies and infrastructures. Most of these technologies are centralized and depend on a single source of water that is sucked into a treatment facility and then sent forward through a centrally controlled distribution network. Communities in developing nations lack the infrastructure as well as the finance capital to invest at the scale necessary to make these types of technologies viable. Hence, alternative technologies for water sourcing, like water harvesting, have to be decentralized and community based. Sometimes it is necessary for the success of such a simple and low cost technology for it to be based within a single family unit. In the case of institutions such as local schools and clinics, the appropriate technology must be designed around the institution itself and with the sole intent of supplying that particular institutions' needs.

Water wells are perhaps the most common water supply technology in the less developed world. This is especially true in rural areas, where dug wells, bore wells and other well configurations draw on groundwater resources for water supply. Well drilling and excavation have been extensively studied and discussed in the AT literature; many books and booklets are available from non-governmental, governmental and multilateral development organizations [14 - 17] that describe the best available technologies in various development contexts.

Choosing an Appropriate Technology

There are numerous appropriate technologies that exist for water collection, treatment, and conservation. Many of these have a long history, having been developed and used for centuries by people indigenous to particular regions [9], and these have served communities extremely well. More recent technologies have also been developed and catalogued [18]. In the development and implementation of appropriate technologies, often the initial selection of the 'right' appropriate technology from a range of different choices is the key element in determining long-term successful implementation, adoption and operation of the chosen technology. There is a range of analytical heuristics that one can apply to the process of making the decision as to which technology would be best. There has been considerable research done on technology choices in developing communities [19], where the analysis proceeds through three separate stages.

In the first stage, the objectives are clarified and established. The question here is straightforward – what exactly is trying to be achieved? Some corollary questions follow, such as whether the goal is achievable and realistic and whether this is indeed the solution to the primary problem. In the case of water treatment for public health, the goal is straightforward. Simply put, it is that clean potable water be provided to the entire population and equitably across all communities.

The second stage of the technology selection process is analysis. In this stage, it is important to identify what the constraints on the proposed developments might be. Constraints here are not limited to physical constraints. Certainly it is important that those be identified, including what are the actual water

resources available, what is the land availability and any other physical constraints that would impact technology choice, development and implementation. However, just as important are a set of other constraints, including social, health, technological, economic, financial, institutional and environmental. These various constraints have been bundled into a concise acronym for analysis, called SHTEFIE [19]. This heuristic algorithm for analysis was originally developed at Loughborough University as a tool for the evaluation of various development program alternatives. Once this analysis is completed and all the various elements that would impact the success of a particular technology choice have been evaluated and assessed, it is then possible to make a decision on technology selection.

The selection is the third and final stage of the analysis process and is termed the output. The output will clearly answer the question as to what particular technology is appropriate, given the problems and constraints of the particular context – social, health, technological, economic, financial, institutional and environmental – where the technology is sought to be implemented.

Conclusion

Access to clean potable water and adequate supplies of the same are critical to the development and maintenance of public health. Use of appropriate technologies to develop water resources and make clean water available to all is crucially important to the maintenance of public health. The design, development and implementation of specific water harvesting systems must take into account the context-specific situations and factor in community and infrastructural considerations as the water resource technologies are developed and put in place. Rigorous analysis and evaluation using the SHTEFIE process of the various inputs, situational variables and parameters must be conducted to reveal what is the most appropriate and optimum technology choice for water treatment in a given situation.

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COMMUNITY BASED WASTE MANAGEMENT IN URBAN AREAS

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ABSTRACT
Throughout Zimbabwe, urban waste collection rates dropped from at least 80% (mid 1990s) to as low as 30% in some large cities and small towns [1]. Currently, more than 2.5 million tonnes of household and industrial wastes are produced per annum in urban areas and this continues to rise due to unprecedented urban growth rates and absence of waste minimization strategies. Areas worst affected are low-income residential areas and informal settlements, with some not receiving service at all.

The low waste collection levels have triggered widespread illegal open dumping and backyard incineration. This has created negative environmental impacts and increased the health risk of the residents. Open waste dumps are prime breeding sites for houseflies, rodents, mosquitoes and other vectors of communicable diseases such as fever, dysentery, diarrhea, cholera and malaria. Fumes from burning waste causes acute respiratory infections and the odours make the environment uninhabitable. The leachate from the dumpsite pollutes underground water, which is an important alternative water source for the residents. Loose papers and plastics blown by wind result in an aesthetic intrusion of the surrounding environment.

There are various waste management strategies and Practical Action has thus adopted an integrated waste management system to address the problem. The system has 3 ways in which waste is being properly managed in Chitungwiza, Epworth and Mbare. Through technological interventions waste is being converted into marketable products. There are micro-enterprises providing low cost waste management services. Through community health and hygiene extension education and training waste handling has improved and thus contributed to improved health and hygienic standards. One of the key success factors is the effective working partnerships formed between communities, local authorities and private sector. Although the project is still in its infancy, this paper shares the concept, steps followed, impacts and lessons drawn so far.

INTRODUCTION
The challenge of waste management has been a growing concern for the national government, local authorities, environmentalists, researchers and the communities at large. Throughout Zimbabwe there has been an increase in the amount of waste generated at household level yet there has not been the requisite collection and disposal services, let alone an effective waste management strategy to meet the rising challenge. At present about 2.5 million tonnes of both industrial and household waste is generated per annum and only 30% of this waste is collected and disposed off in many large towns and cities. This is a far cry from the previous case of 80% in the mid 90s, which was considered adequate given the urban population then
The situation has been compounded by the rapid urbanisation, which stands at 30% for Zimbabwe that has seen the demand soaring on the available resources and facilities offered by the Local Authorities (LAs) in the country. Taking the example of three urban areas namely Harare the capital city, Chitungwiza a dormitory town and Epworth which has a combination of both formal and informal settlements there seem to be no solution in sight. Harare has an estimated population of about 3 million inhabitants and the available refuse collection and disposal equipment do not suffice to meet the needs of the city as shown in table 1 below

Table 1: Current waste fleet disposition. [2]

Type of Equipment	Operational	Broken Down	Ideal
Compactor Trucks	13	10	60
Skip Trucks	1	1	6
Tipper Truck	0	1	6
Tractors	3	4	20
Front End Loaders	0	1	2
Dozer	0	1	1
Landfill Compactors	0	1	1

Chitungwiza is resident to 35,000 households and 60 commercial entities which are serviced by only 7 refuse trucks and the only loader and compactor truck available are broken down while Epworth has 6,000 households in the formal areas that are serviced by only one tractor and the remaining 16,000 households in the informal areas do not receive any refuse removal service at all

Without delving into the impact of economic crunch currently bedevilling the nation, fuel shortages corruption and mismanagement within the LAs the lack of adequate service provision has resulted in the mushrooming of illegal waste dumps in most open spaces within the urban areas. The chaotic solid waste disposal has put the health of residents at great risk as the open waste dumps are prime breeding sites for houseflies, rats and mosquitoes and other vectors of communicable diseases such as fever, dysentery, diarrhoea, cholera and malaria. These waste dumps are a source of environmental problems such as odours and smoke emissions resulting from rampant waste burning cause acute respiratory infections.

The leachate from the dumpsites pollute the underground water which has emerged as an alternative a source given the current water shortages while loose papers and plastics are blown by wind resulting in aesthetic intrusion of the surrounding environment.

These challenges in urban waste management have continued unabated despite the existence of a conducive policy and legislative environment, which is provided for by, a number of policies and legislative instruments that deal with waste management issues, such as the Environmental Impact Assessment (EIA) Policy, National Sustainable Development Policy, Science and Technology Policy, and the Draft National Environmental Policy, Environmental Management Act (CAP 20:27), Urban Councils Act (CAP 29:15), Water Act (CAP 20:22), Public Health Act (CAP 15:09) and Municipal By-laws.

The absence of an effective enforcement strategy coupled with the lack of innovative initiatives of handling waste has left the local authorities with a mammoth task in their hands. It is against this background that Practical Action is implementing community based waste management initiatives to improve the urban environment with organisations of men and women. The initiatives were born from the realisation that communities themselves can be drivers of change within

THE INTERVENTION STRATEGY

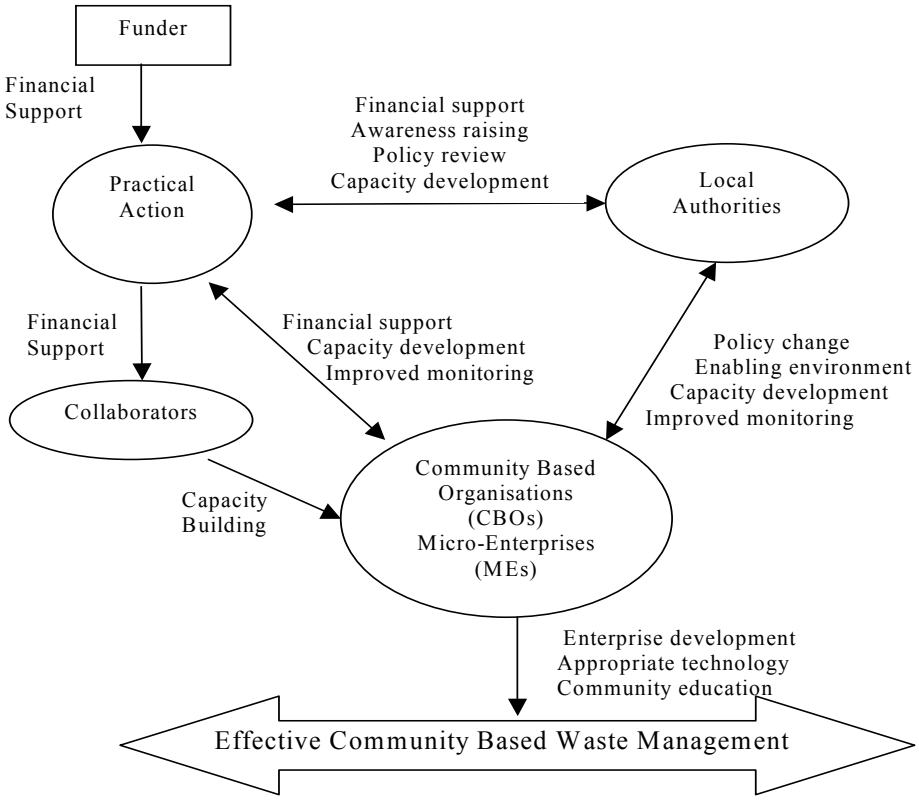

Figure 1: Implementation Model

The intervention strategy hinges on the strength of the partnerships formed and the role of each player is thus illustrated in the implementation model above

Identifying Areas Of Intervention

Baseline surveys were conducted in three Local Authority areas namely Chitungwiza, Epworth and Mbare (Harare). The main purpose of the surveys sought to:,

- To inform of the situation on the ground with regards to the current practises
- Establish the quantities and the types of waste being generated
- Investigate the health dimensions relating to waste
- Analyse and review the policy and legislative environment in waste management, identifying existing gaps
- Assess the technologies in use in waste management
- Conduct a waste market chain analysis
- Identify key players in waste management

The findings pointed out to the priority areas of intervention as well as help in the establishment of benchmarks against which the impact of the interventions would be measured

Liasing With Local Authorities

Since the handling of urban waste is the responsibility of the LAs as enshrined in the Urban Councils Act consultations were done at all levels within the LAs so as to introduce the concept of Community Based Waste Management (CBWM). The acceptance of the concept however, was rather slow, as there appeared to be some hesitation on the part of local authorities when it came to communities offering refuse collection services. These consultation were key because LAs:

- Have the mandate to handle waste hence offloading that responsibility to communities would mean a shift in their traditional practices
- Could easily mobilise the communities through their socials services department when the need arises
- Could create an enabling environment for SEs and CBOs to operate without being exposed to the usual bureaucracy associated with LAs
- Could provide the requisite technical and logistical support in waste transportation and disposal
- Could provide ideal and legal operating spaces for the SEs and CBOs

Community Mobilisation

The mobilisation of communities was done through the local authorities, and existing community leadership structures. The identified people formed themselves into either Community Based Organisations (CBOs) which are groups formed within a local community [3] or Micro-Enterprises (MEs), which are defined as a service delivery or production business, usually low capital intensive and consisting of an individual or up to about 20 persons, either registered or operating informally in an area [4]. These have proper leadership structures where gender equality was greatly encouraged to ensure that women take up positions of leadership

Implementing Ground Activities

Before the ground activities could be done, a business perspective approach was used where the established CBOs and MEs are oriented to look at waste management as a business venture and not just community service to ensure sustainability of their interventions. As a result the CBOs or MEs and had to produce business proposals which demonstrated the viability of their businesses. When it came to the implementation stages there was need in some cases to engage in pilot activities as was the case in Epworth where one of the MEs (CNM Environmental Action Group) started with a 6-month pilot refuse collection initiative. This was done as a way of demonstrating the Epworth Local Board that they were capable of offering a consistent and reliable service after which they signed a service provision contract to provide refuse collection services to 961 stands which are home to at least three households per stand. These

Figure 2: Business Training for CBOs and MEs

households received no such service before despite the fact that they were regularly paying for the service.

Figure 3: Community Based Waste Disposal in Epworth

Figure 4: Community Clean Up In Zengeza 3 Extension (Chitungwiza)

To augment the waste management services, Participatory Health and Hygiene Education (PHHE) has been offered the communities through community-based trainers who use tools which cover various diseases, water and sanitation issues and general hygiene aspects. These trainings enabled communities to not only benefit from proper waste management services but also from good health and hygiene practices. To date 3888 (2474 women &1414 men) people have been trained in health and hygiene issues a move that benefited their households through the cascading effect

As the implementation gathered momentum the need to raise awareness of the new approaches in urban waste management among the communities became apparent, awareness campaigns were used and as a result there has been tremendous support given to the CBOs and MEs involved in both refuse collection and recycling activities to

Figure 4: Community PHHE Training At Epworth Polyclinic

Capacity Building

The effective operation of the CBOs and MEs has been through enhanced capacity, which encompassed various trainings, which include: Social trainings, to enable them to relate constructively with the communities they serve as well as address the social challenges they would face. The requisite business trainings were given to ensure that all operations are business focused while technical trainings ensured that both the CBOs and the MEs are capable of managing and fully utilising the waste they were handling.

The profile of the CBOs and MEs were raised through participating at multi-stakeholder foras where they would present papers on their experiences and as a result they managed to clinch some new markets as well as drumming up institutional support from participating stakeholders

Progress Monitoring

The monitoring process provided for by both Practical Action and the LAs was done through site visits which enabled interaction with the CBOs and MEs when they are in their field of operation while regular meetings provided for an opportunity to critically analyse progress and plan for the future

Community surveys provided for opportunities to assess the impact of the initiatives on lives of the people and on the environment

Results from the monitoring process show a significant reduction on indiscriminately dumped waste in the areas that used to receive no refuse collection service. Opinions of residents indicate a high level of satisfaction and appreciation of the new initiatives especially with the reduction of diarrhoeal and malaria cases which were caused by poor hygienic practices and vectors from indiscriminately dumped wast

CHALLENGES AND CONSTRAINTS

The implementation of the community-based initiatives was not without its own challenges, which emanated from various issues such as the stigma associated with waste handling and bureaucracy form LAs. The impression that waste is a 'dirty' job has been imprinted in the minds of many people to the extent that mobilisation of the community to be involved in the waste related initiative took a considerable time before people could participate.

Hesitation from LAs to allow for CBWM was a major stumbling block, as the concerned LAs could not decide progressively so as to embrace the concepts. The commonly cited example s was the failed attempt by Harare City Council to sub contract refuse collection services, at the turn of the decade a move that proved to be their major undoing with regards to service provision.

LESSONS LEARNED

The implementation of the CBWM has so far given valuable lessons among them are the following:

- The health and hygienic conditions of communities can be significantly improved by participatory innovative approaches that take knowledge to the people
- Peer education has worked and needs to be replicated in other areas. It is an effective tool and works effectively as a low cost awareness raising technique that builds the confidence and trust among the community members and helps to bring the community together
- Enterprise development need financial and technical support especially in low income areas as many may have the energy and passion but will be incapacitated by a poor asset base
- Access to markets is limited for individuals involved in waste management activities like recycling because many recycling companies only accept bulk supplies which are normally difficulty to gather
- There is need to look for alternative markets for the recovered products from waste as the available markets offer low and unattractive prices to sustain MEs
- Giving up or sub contracting of services in the traditional sector occupied by LAs has been a challenge taking a cue from past experiences from the City of Harare
- Policy issues need to be addressed around handling of waste so that the sector can be opened up to more players to ensure a healthy and hygienic environment for the communities.

SCALING UP TO OTHER TOWNS AND CITIES

Based on the lessons learned so far the integrated waste management system can be best adopted in other towns and cities if the **community based waste management** model is embraced by all stakeholders as a working model worth implementing. A wholistic approach is required which will not only look at waste when it becomes a problem but one that will address the policy and legislative environment, health and hygienic issues and the socio-economic dimensions relating to waste. There is need for an effective participatory engagement of the key stakeholders who include: the Ministry of Environment and Tourism, the Ministry of Health and Child Welfare, Ministry of Local Government and Urban Development, LAs, finance institutions, NGOs, private sector and the communities at large.

The role of the Ministry of Environment and Tourism will be to spearhead the formulation of a comprehensive national strategy that provides for a conducive policy and legislative environment which takes into cognisance the afore mentioned issues relating to waste. The Ministry of Health and Child Welfare will have to play an active role in addressing the health and hygienic issues and design programmes that can easily reach the people at the grassroots level. The Ministry of Local Government and Urban Development, the parent ministry for LAs will have to render more support for the technical and budgetary decisions taken by different LAs towards this new initiative. LAs who are mandated by the law to ensure that waste is managed well within the areas of their jurisdiction will have to provide a conducive operating environment for the local people by providing legal operating spaces, technical and financial support in cases where they contract CBOs or MEs to do refuse collection on their behalf. Finance institutions and NGOs will be key in the provision of the much needed start-up capital while NGOs can further provide the requisite business and technical skills. The private sector who are the major consumers of recyclable materials will have to come up with competitive pricing structures for the goods they buy from the community for sustainability purposes while at the same time introducing technology transfer programmes that would enable CBOs, MEs or even individuals to add value to the waste they would have collected. The interested communities be they CBOs, MEs or individuals have to approach the whole process with a business focus so that they take up the different waste management activities as a source of livelihood that has a benefit of improving their living environment.

The successful adoption of the **community based waste management model** can be achieved if it is preceded and supported by effective public awareness campaigns in which case both the print and the electronic media become very handy

CONCLUSION

The community based waste management model has so far proved to work when there is full Local Authority support and success is possible when the members of CBOs or SEs offering the service are form within the same community. The model has not only addressed the environmental problems resulting from poor waste management but has to a great extent contributed to the establishment of good health and hygienic standards which have led to the reduction of diseases such as fever, dysentery, diarrhoea, cholera and malaria. . Although the project in its infancy the results achieved so far indicate great potential for the improvement of the living environment through processes that are managed by communities

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A Sustainable, Community-based Response to Deforestation in Haiti With a Focus on its Water-Resource Systems

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Abstract:

This paper introduces the 1804 Memory Garden Reforestation Project currently under development in the town of Arcahaie, Haiti. The Garden is a privately funded response to the present environmental, sociological, and economic crisis in Haiti, considered the poorest country in the western hemisphere. When completed, the project will be an example of sustainable design and green architecture. It will utilize renewable energy sources; recycle wastewater for agricultural use; generate compost to replenish topsoil; use native plants to stabilize eroded slopes; demonstrate appropriate solutions to water collection, water storage, water treatment, and irrigation; and employ locally-available materials for building and pavement construction. Creating a botanical garden and reforestation center here will improve the ecological, educational, vocational, and economic life of the region. Two dimensions of the Garden's planning are presented. The first is the engineering design solution for water collection, water treatment, water storage, and irrigation. Foundational to the design are the principles of sustainability, appropriateness, and local replicability. Secondly, the paper looks at the organization behind the Garden, in search of an approach which can be replicated in other developing nations. Specifically, the project combines the resources and resolve of Haitian expatriates in the United States with the commitment and direct accessibility of indigenous community leaders to address one of Haiti's complex social and environmental problems in a sustainable manner.

Introduction

A slave revolt in 1791 on the island of Saint Domingue ignited a revolution which culminated in an independent Haiti in 1804. In that year, the Haitian flag was created in the town of Arcahaie. The 1804 Memory Garden Reforestation project (the Garden) celebrates that history and sets to address one of Haiti's most difficulty problems: land erosion caused by massive deforestation. The idea of the Garden was engendered by the Haitian Institute located in Washington, DC, USA with a mission "to create understanding of Haiti's ecological systems, promote good agricultural practices, and halt the loss of biodiversity through education, reforestation, rehabilitation, and conservation, with a focus on the historical, socio-cultural contexts of Haiti." The Garden project occupies 120 square meters in the denuded hills north of Arcahaie, Haiti. The completed development will be: a living classroom to demonstrate how deforested lands can be repaired into renewable, economic assets; the home of an economic co-operative for fruits, vegetables, medicinal herbs, crafts, and artifacts; a repository of Haiti's rich horticultural bio-diversity; a seed distribution center to peasant farmers and schools; site of an educational conference center where world-wide experts come to observe best practices and exchange knowledge in horticulture, alternative renewable energy sources, and sustainable agriculture; a national treasure, a source of pride and a place for cultural enhancement; an archival resource for the abundant flora of the island and the history of land management in Haiti.

"The island is extremely mountainous, with numerous small streams flowing down from the uplands, most of them being swift and shallow, navigable only by canoes, and for only a few miles above the mouths. Three hundred years of deforestation have completely altered the vegetation in all the accessible areas. Valuable species have been exhausted, and the great areas of original forest growth replaced by agriculture. More than 90 percent of Haiti is deforested. As trees disappear and good farmland shrinks, tracts valued only for their habitats are getting harder to defend. The poor are constantly on the march for good wood and soil. And wealthy Haitians are building elaborate homes and businesses on the high ground surrounding Port-au-Prince. Neither group is hindered by law. Haiti's environmental laws are sporadically enforced and land ownership is poorly documented" [1]. Trees have been cut for fuel-wood and charcoal. The global crisis of deforestation is not grasped at the individual level. The country lacks a national policy which either proclaims or enforces any corrective actions. Non-governmental agencies have taken some of the initiative to address this problem.

"Heavy rains come to the region annually in two peaks. The first peak comes in the months of April / May and ranges from 6 inches to 9 inches each month. The second peak occurs during the months August,

September, and October and averages between 6 and 7 inches each month [2]. With the rains, come the floods. With the floods, comes massive erosion. Good soil is washed away, crops are damaged, public health is compromised, and the local economic base is thrown into chaos. In the advanced stages of flooding, there is often death.

In May 2004, flooding from heavy rains killed some 1,700 in the south of Haiti near the Dominican Republic. Tropical Storm Jeanne arrived in September 18 of the same year. A wall of water and mud buried much of Gonaives, Haiti where some 2,500 died. Gonaives and the surrounding land, the Artibonite region, is the country's breadbasket [3]. Much of this land was no longer cultivable. A Haitian government study in 1998 estimated that 37 million tons of topsoil washes away every year, most of it in the Artibonite [4]. In 1994, Tropical Storm Gordon caused mudslides that buried at least 829 Haitians [5]. "The heavy drops hit the soft soil hard, sending water down barren slopes so steep that peasant farmers must hang by ropes to till tiny plots of land "[6]. Water is both a bringer of life and the herald of death.

The compounding influence of erosion in Haiti has contributed to dysfunction in all areas of life and screams an "SOS" of global proportions. For the most part, the screams are inaudible. Those who hear have no clue as to how to effectively provide help. Patchwork aid leads only to shredded hopes, failing to consider the historically interwoven threads of culture, politics, language, geography, and external imperialism which are this proud nation's fabric. Corrective (appropriate) actions must stem from a comprehensive evaluation of all interdependent factors. Teaching through example, the Garden will demonstrate to citizens at a grassroots level that the mountains around the region can be reclaimed and made green again. Its intent is to have elements of its design reproduced throughout the island. While there are many facets to this project, this paper highlights only the water resources component of the Garden's design.

Site Description and Environment

Land was purchased for the garden site by the Haitian Institute, an expatriate organization of Haitians living in the United States. Sited in the Morne Abrules hills north of Arcahaie, the land features breathtaking views of two mountain peaks to the north, the Mare Zoramger (Elev 1100 m) and Morne Corall Eler (Elev. 1252 m). To the south, the Caribbean sea lies silent and blue, graced by the island of Gonave.. In the foreground, the town of Arcahaie is hidden below and among the tree cover of the lowlands. The Aubrey River flows from these mountains down to the town.

Trees and ground cover are almost absent from the site and the surrounding mountains; a consequence of the long legacy of erosion on the island. The land is dry and rocky. There is little topsoil present to support vegetation. A variety of hardy grasses and shrubs are able to sustain an existence in spite of these barren conditions. Only a generation ago, the site was a forest. The site is presently unable to be cultivated and cannot sustain human livelihood. People tend to live where the land can support them; at the lower elevations. The hope is that if this site can be revitalized into a lush garden, then, so can any other area of the island.

Water for the Garden

The approach to solving the problem of potable water and land irrigation was bounded by design criteria of appropriateness, replicability, economics, and environmental sustainability. The garden site is located approximately 450 meters to the west of and 80 meters above the Aubrey River at its closest point. Water for the town of Arcahaie and its environs comes from this river. A small portion of the river flow is diverted into a network of concrete open channels which extend throughout the lowland community. At elevations above the river, such as at the garden site, there is no access to water. Water must either be pumped up from the river or collected on-site from intercepted rainfall. There is also no public source of electricity in the area.

The proposed design for water collection to this site involves tapping the river and pumping it to a storage pond located on-site. A micro-turbine generator placed in the river is used to power the pump. As a backup water supply, rainfall is intercepted from higher ground at the site, filtered, and then stored in an underground cistern. Domestic use water is treated with a low-flow sand filter and is pumped to an above-ground storage tank. A gravity-based water distribution system then transports the treated water to the buildings, as needed. Irrigation for the garden begins at a storage pond and will use a drip irrigation system organized into five zones. Each component of the water resources system will be described herein.

Water Collection from Aubrey River

Reconnaissance surveys were performed to identify the best and shortest route to lay pipe from the Aubrey River to the site. Estimates of the river flow volume were made to confirm availability of this as a viable water source, both for the wet and dry seasons. There is little published information on rainfall and hydrology in Haiti. Projections of rainfall patterns were, therefore, determined from records available by the National Oceanic and Atmospheric Administration for city of Port-au-Prince in Haiti, the Dominican Republic, and other adjacent Caribbean islands.

A micro-turbine system was designed to generate the energy needed to pump water from the river to the site. Water from the river is diverted to a pipe which flows down to a hydro micro-turbine. The pressure of the water rotates a turbine, which spins the generator shaft thereby producing electricity. Four main components define the system: Screen, Turbine, Pump and Piping. These four components are designed to work together to efficiently transmit water up to the site.

A diversion structure placed in the river guides some of the river flows towards a screening system. A two screen system is designed to prevent fish and wildlife from entering the water collection system. It also removes debris that may damage the turbine. An angled louver (bar rack) placed at the entrance of the channel is used to screen fish and direct them to a bypass. A perforated stainless steel metal screen placed 2 meters from the louver system helps to screen out debris. Both screens are supported by pillars at the bank of the channel. A 60 degree staggered center metal plate was chosen for this purpose because of its sturdiness. Since the two screening system impacts head loss and velocity in the diversion channel, a trapezoidal short-crested weir is placed 2 meter from the perforated metal plate to increase the flow rates. The water then enters a one-foot square flume which leads to the turbine.

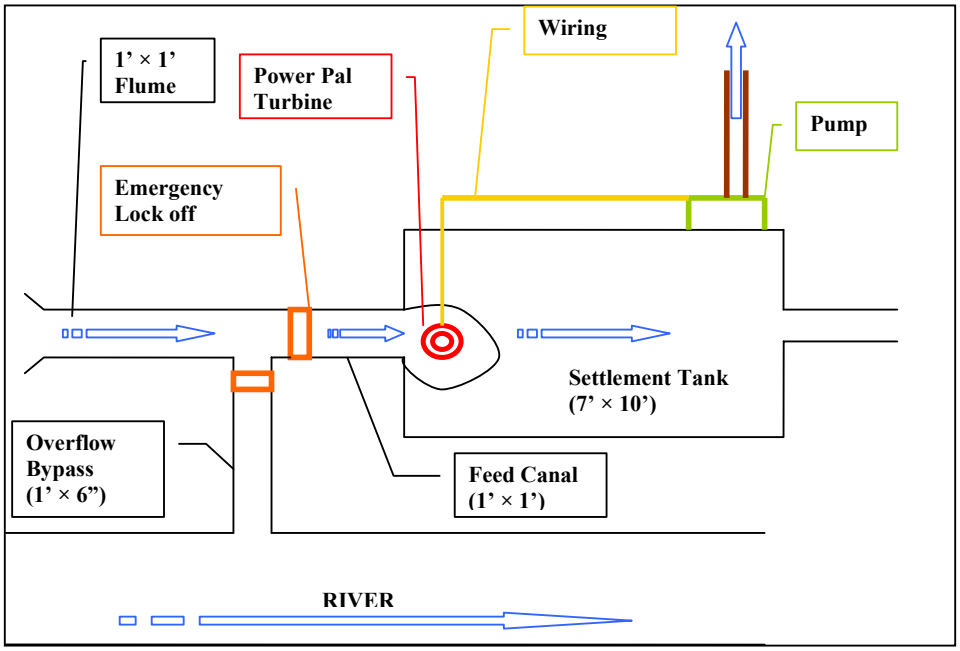

Fig 1.0 Plan schematic for flume, turbine settlement tank and pump housing.

The Power Pal Low Head High Output Turbine, MGH-500LH, was selected to generate electricity. It demands little water to produce the necessary energy for the pump. It is relatively easy to setup and maintain since it utilizes a side channel feeding system. A head of 5 feet can produce an output of 500W. When fed through an inverter, voltage is boosted from 12 volts DC to 220 volts AC.

The pump used, the KTZ411-60, is a centrifugal pump system which is very efficient as it only demands a high load rating at startup and produces high pressure ratings for pumping conditions with a large head. A lock off switch will be located between the pump and the alternator for shut-off. This may be needed during periods of flooding to prevent damage to the pump. The pump was the most compatible with the turbine compared with other alternatives. It also has a high head setting. The KTZ411-60 model has a maximum capacity of 377 gallons per minute, a maximum head of 167 feet, and a solids diameter of 0.344 inches. It offers the most economical solution for transporting the water up to an aeration pond located on the site. The three phase pump is suitable for operation by alternating current and can receive a charge from the battery by the turbine. The pump remains effective even when river volumes are low. The KTZ411-60 pump operates at 80 percent efficiency within the range of 150-350 gallons per minute.

A rectangular settling tank was chosen to allow the flow rate of the water to slow dramatically. Larger particles settle and do not block the pump intake strainer. The settling tank has an overflow outlet that leads back to the river. PVC pipe was selected to transmit water up to the site from the river. Its relatively low cost, accessibility, and durability made it an easy choice when compared with other piping systems.

Water Collection of Intercepted Rainfall

A second means of collecting water for the facilities at Arcahaie is by intercepting rainfall and storing it in a cistern. Cisterns are containers located to harvest rainwater that has been collected from rooftops with a

gutter and pipe system, or an open grate and pipe system when collecting water from paved, impermeable surfaces [7]. It is typically used as a supplement for an inadequate groundwater supply.

Heavily utilized since ancient times, modern cisterns now take the form of simple geometric structures but place greater emphasis on eliminating contaminants. Air-borne pollutants are not a significant factor in the region of Arcahaie. Pollutants of concern are: plant debris, soot, bird droppings, and biological contaminants. A sand filter is used to capture most of the contaminants prior to entry in the cistern.

Cistern

A reinforced concrete underground cistern was selected because of its durability and ease of construction. Dimensions of the cistern are 45 feet long by 25 feet wide and 6 feet deep. Design capacity is 50,494 gallons. Based on the rainfall distribution and catchment area, the cistern was computed to be at 100 percent capacity after approximately 23 in of rainfall has occurred. Components of the cistern include a manhole, a vent, a cleanout sump and an overflow pipe. A vertical fill pipe provides access to haul water manually. Both the inlet and outlet are designed to minimize stirring of the solids settled on the tank bottom. The cistern was sized based on the estimated maximum demand on the developed garden site. The potable water demand was driven by the conference and training center which is projected to hold as many as 200 persons at one time. The demand was estimated at 20 gallons/ person/day for a 5 day period. This is a conservative estimate and takes into account water conservation techniques such as using low-pressure fixtures and plumbing. For the region of Arcahaie, the estimated annual volume for rainfall is 53 in. Recognizing water losses which occur through evaporation, infiltration and other effects, the available precipitation to the site was assumed to be 50 percent of the annual volume. A catchment area of 4,630 square feet was computed as adequate. Regular microbiological testing will be performed to ensure the water does not contain any harmful forms of bacteria. Certification under Protocol P151 and Standard 61 provides assurance that the system components are safe for use [8].

Catchment Area

The cistern and the catchment area were placed at the northern perimeter of the site to take advantage of the higher elevations there. At the highest point of the site is a moderately sloped hill. A concrete lined open channel system will be terraced within this hillside to intercept rainfall. The design involves a 1 meter wide by one-half meter deep channel inset into the ground which follows the contours of the hill (estimated slope of 12 percent) but maintains a one percent grade across the contour. The channel switches back and forth until it reaches the cistern. Between the switchbacks, the ground surface will be compacted with small stones to increase the runoff coefficient. This will allow native grasses and wild flowers to be cultivated on the slope as a natural filter while minimizing ground infiltration. The grasses also help minimize the erosive potential during heavy downpours. The channels will intercept this runoff volume and direct it to the sand filters. This solution creates the necessary impervious surface yet maintains and enhances the natural aesthetic of the hillside.

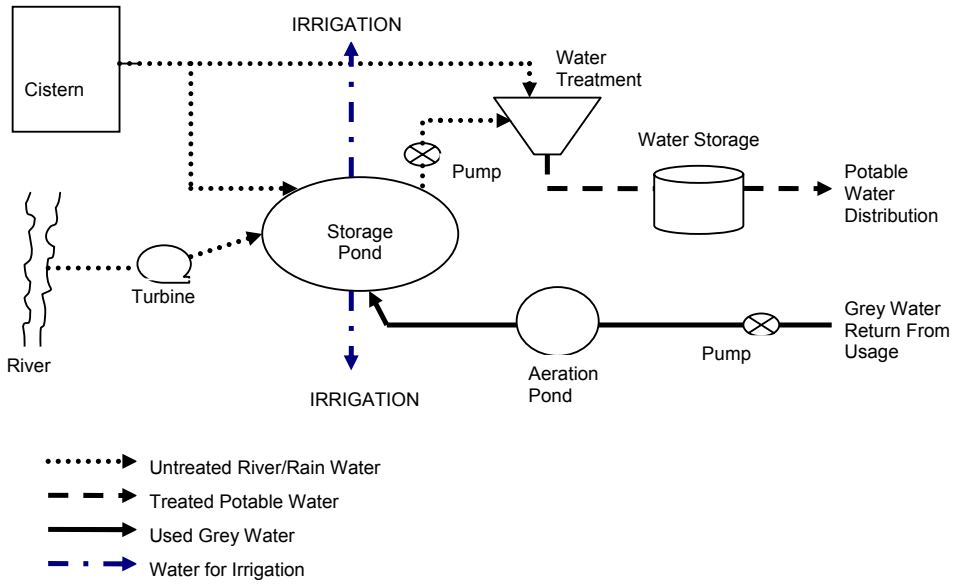

Fig 2.0 Water Resources Systems Master Plan **Water Storage and Treatment**

Two ponds, an aeration pond and a storage pond, will be constructed at the north end of the site. The area is relatively flat, and far enough away from the conference center that odors are not objectionable. Embankments will be constructed of soil excavated from the site. The aeration pond will treat gray water from the conference/research center. The storage pond receives water pumped from the Aubrey River. A portion of this water is to be treated and stored in an above-ground water tank. The rest is directed to the irrigation system for the Garden. Water from the aeration pond will be recycled into the irrigation system.

Aeration Pond

All the gray water from the building facilities will be pumped to the aeration pond via a 2" diameter PVC pipe. This system will be powered by a single 1 horsepower pump with a 1 horsepower booster. The electricity demands are minimal.

The circular plan aerobic pond, compacted with small gravel or coarse sand and lined with 18" thick clay, is designed to remove BOD from the influent gray water by settling the solids. It can accommodate temperatures greater than its average annual minimum temperature of 20°C. The pond is designed to process 11.2 thousand gallons of influent per day, assuming each person generates 34 gallons of wastewater per day. The dimensions of the pond will include a radius of 15ft, and a depth of 6 ft. The aerobic pond is in the shape of a truncated cone. The radius follows a 2:3 ratio to avoid formation of sludge banks near the inlet to the pond, as well as a depth that will ensure that the pond remains fully-mixed. Total pond surface area is 500 ft^2, with a retention time of two days to limit algae growth. Assuming influent BOD is 100 g/m^{-3}.day-1, there will be an 87.5% removal of BOD from the aeration pond. Remaining effluent, 20 g/m^{-3} BOD, is low enough and can be discharge to the sand filter for further disinfection. The EPA standard for BOD is 20 mg/l. The pond will be aerated with an electric powered propeller aspirator pump for cost efficiency [9].

Storage Pond

The secondary storage pond, designed to store water from the three discharges, will be adjoined to the aerobic pond along its length. A weir will allow influents at a combined flow rate of 4963 cubic feet per day to enter the pond for storage purposes. The dimensions of the elliptical pond will include a major diameter of length of 252 ft and a minor diameter of 84 ft following a 3:1 major-to-minor ratio. The depth of the pond will be 5 ft. The surface area of the pond is 16540 ft^2, with a retention time of 20 days. The pond is situated such that it receives a high level of wind-mixing, allowing for optimal settling and thus TSS removal. The pond designs included using local and renewable resources.

Potable water is required for the conference center and research center complex. To achieve this several systems were evaluated including point of source and point of entry systems. The solution chosen was sand filtration followed by chlorination. This system is designed to remove a significant amount of pollutants that may be present with the influent from the river.

The system removes sediment from the water by a use of a sediment tank and a sand filter. The sand filter also removes heavy metals, some level of microbial pollutants, reduces turbidity, and reduces the BOD level of the water thereby hindering further microbial growth and making it safe for consumption. After the water has passed through the sand filter, it flows to the chlorination tank. In this facility, the water will be treated with chlorine tablets to kill any remaining bacteria and other microbial pollutants that may be present. The water will then be safe for consumption. It will be pumped to a water storage tank for use on-demand [10].

Water Storage

A ferrocement tank with a capacity of 8,000 gallons will be used for water storage. Ferrocement was chosen because its constituent materials are available in Haiti, it is a strong material, and it is can be easily and cheaply constructed with limited skilled manpower. The material takes advantage of the compressive strength of cement and the tensile strength of straight wire to generate an incredibly strong tank. It thereby overcomes the weakness of traditional reinforced concrete construction under tensile stresses.

Ferrocement tanks or wire-reinforced cement-mortar tanks have been successfully employed in rural areas of the developing world to facilitate the storage of diverse materials, most notably drinking water. The construction likewise requires simple equipment so local people can contribute local labor and materials. Complicated formwork and plastering works are minimal. Roofing for the tank consists of sheets of 0.5mm galvanized sheeting supported on two lengths of angle iron. These tanks have a life span of approximately 25 years much higher than tanks constructed from other materials.

Water will be distributed from the storage tank using a single 2" PVC pipe which takes the water down to the center of the building site and branches off to provide water for each building. PVC was used as the material of choice because it is cheap, durable, has minimal pressure losses and will not contaminate the potable water. This system will be powered by a single 1 horsepower pump. The electricity demands are, therefore, small.

Irrigation System

A system of clay or adobe brick canals and small man made ponds will be used to separate the site into five irrigation zones, each with a small pond with a radius of 6.3 meters and depth of 0.5 meters. The irrigation zones would each then be irrigated utilizing a process where a single above-ground 1.25" PVC pressurized lateral pipe feeds into a network of 3" porous clay pipes. Water is stored in the pipe and slowly drip irrigates into the soil. This system was chosen because minimal pressure is required (a single 1 horsepower pump for each zone) and it is highly efficient with regards to water use. Also, it does not need to be run everyday. Each pump will be situated at the edge of the pond with an inlet suction pipe going into the pond, and an outlet pipe connecting to the mainline. When the clay pipes are filled, the pumps are turned off until the pipes empty again; typically in 2 to 4 days. This saves time, electricity, money, and manpower. Because of the simplicity of this system maintenance should be very limited. The PVC laterals should last for a long time and any sections of the clay pipes that become damaged can be replaced by new pipes molded locally. This system can be used by other farmers/gardeners on the same or a smaller scale with simple modifications.

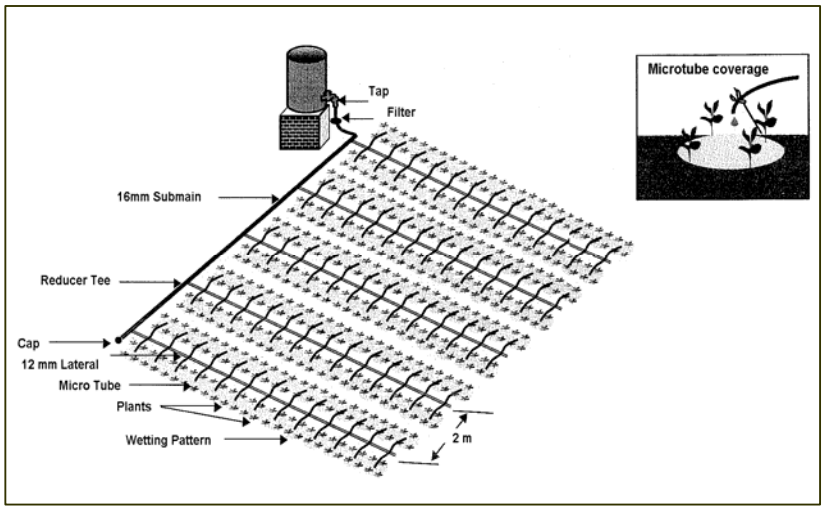

Figure 3. Schematic of Low-Cost Micro Tube Drip Irrigation System

These drip systems are low-cost, require a minimum of filtration, are available in small packages, operate at low inlet pressure, and are easy to understand and maintain by smallholders. The affordable design is made possible because: 1) The systems operate at inlet pressure heads of from 1 to 3 m, so lightweight tubing and inexpensive fittings can be used and leaks are easily repaired. 2) The system components are simple and easy to assemble without sophisticated tools; therefore, farmers can either install their own systems at the rate of 1,000 to 2,000 m^2 of field per day. These low-cost drip systems only cost about fifth as much as standard commercial drip systems. Drip irrigation uniformly delivers water to each plant through a closed pipe system which limits waste through evapotranspiration.

A Community-based Response to Sustainable Development

This paper has presented only one dimension of the Garden project's design; that of water collection, treatment, storage, and distribution. Sustainability, appropriateness, and replicability have also been governing principles for the building design, roadway and walkway systems, and energy production. Beyond these technical dimensions, an equally important aspect of the project is the organization and the beliefs which sustain it.

The implementation of appropriate technology requires an organization willing to examine the long-term consequences of its decisions and make hard choices which promote sustainability over immediate savings. Success of the Garden project also hinges on the transformation of people's habits. It is critical that the surrounding community see the Garden as "theirs"; that they learn from its example; and that they embrace its values.

Reversing the complex forces which have contributed to deforestation is an overwhelming task. Environmental sustainability is an attempt to introduce balance between competing social, environmental, and economic goals. Inherent is the need for a hierarchal organizational structure from which to implement, monitor, and enforce good land use policy. "Haiti's land laws are rooted in Napoleonic law, giving equal rights to each child of a deceased landowner. A single brother or sister in a large family can, therefore, prevent sale or development of a parcel. This sometimes ties up land use for generations. Large peasant families control small parcels of land through a series of oral contracts passed down for generations. With each generation, the land has been carved into ever smaller pieces, making it difficult to mount large-scale agricultural and conservation programs. In Haiti, everyone seems to own, or at least occupy, a little bit of land. Getting landowners and farmers to think past the next harvest and about such high-minded endeavors as soil conservation and environmental protection is difficult [11]".

The Garden project relies on the local community and its leaders to sustain itself. Community representatives in Arcahaie currently hold a stewardship role for the care and improvement of the property. In Haiti, local leaders typically act autonomously, with decision-making authority entrusted to them by the surrounding community. The role of national government remains, for the most part, dormant. These leaders must be educated and convinced of the environmental and economic imperatives of sustainable development if change is to come. Central to communicating these ideas, is a command of Creole, the language of the masses. Passing the ideas down to school children demands a presentation in Creole, not French.

The Haitian Institute – An Organization of Expatriates

One long established tenet of appropriate technology is that it is embraced by and benefits the local. The solutions must be appropriate to the community being served. Generational habits which must be broken cannot occur at arms length. The philosophical question then arises as to whether or not an organization of expatriates can offer meaningful and relevant contributions to the enhancement of their native land when most Haitian citizens would consider them disconnected. The Haitian Institute is fundamentally an organization of Haitian expatriates living in the United States. Many of the members share a common heritage but are now somewhat distanced from their homeland. In the context of this project, the answer must be a strong affirmative.

For the Garden to become a sustainable reality, the community of Arcahaie must be invested in it. This is addressed by focusing on educating children, farmers, and teachers. The approach introduces environmental education combined with an affirmation of Haiti's rich, cultural legacy directed to those most likely to transfer the knowledge. Furthermore, there must be a tenable connection between the expatriate community and the actual project. These two criteria are satisfied as follows: 1) respected leaders within the community of Arcahaie are committed to and are a key part of the planning and execution of the project. They have facilitated site acquisition, site selection, and community participation through compost stations around the town. These compost stations contribute to creating topsoil for the Garden and are replicable everywhere. Using compost in highly erosive areas can decrease erosion and allow quicker establishment of vegetation. One study conducted showed compost application reduced soil loss by 86 percent compared to bare soils, and sediments reaching nearby surface waters decreased by 99 percent when compared to silt fences**,** and 38 percent when compared to hydro-seeding applications [12]. 2) The land acquired for the Garden is owned by the Haitian Institute. The president of the Haitian Institute, though residing in the US, has affirmed connectivity with his native land, having founded a primary/secondary school in his hometown of St. Marc and makes frequent visits there. Other leaders within the institute have followed his lead and made several trips back to Haiti since the project's inception. Some have purchased plots of land surrounding the project site. For over 13 years, the institute has earned the trust of both Haitian nationals and expatriates in the US.

Expatriates bring a number of assets to address the problems of sustainable development in developing nations. Quite often, those who have left were those with the educational and/or financial strength to leave. Often leaving home for greater opportunity or leaving because of conditions of oppressive / restrictive governance, the intent is commonly to return. Unfortunately, the returns are rare. Where poverty abounds in the home country, the expatriates become an economic force because of their greater earning power abroad as they send back money and goods to family still at home.

Members of the Haitian Institute are an asset to establishment and sustainability of the Garden through their access to technology in the U.S. which aids in planning, communication, fund raising, and promotion of the Garden project. Their language skills include English, Creole, and French. They are able to access a wide range of resources critical to making the Garden project a reality. Being distanced from the day-to-day dilemmas faced by Haitian residents softens their sense of urgency with the challenges there. Conversely, being away from these challenges enables them to see it with a fresher (and maybe deeper) perspective. Their strong educational background, typically, empowers them with a more intimate grasp of their nation's history, culture, politics, and its global place in the world.

In the long term operation of the Garden, governance of the institute will be through a Board of Directors, based in Haiti. They will be responsible for establishing broad-based management objectives and empowering the director of the Garden to implement them. The Board will consist of local leaders, outside stakeholders, and officers of the Haitian Institute. Partnerships will be pursued with national and international organizations, research institutions, and global knowledge forums that identify with the vision for the Garden. Financial and economic sustainability of the Garden is primarily achieved by designing the Garden for minimum operational and maintenance costs. Revenue will be generated to cover operational costs through site-grown crops and seeds, visitor fees, facilities rental, and sale of crafts. Sound principles of financial accountability and management will be established by the Board. The Garden will not rely on the government for operational funds.

The Garden project and the Haitian Institute demonstrate how an expatriate community can become an effective asset to nation building. It is, however, imperative that their motives and values be unselfishly aligned

with the needs and welfare of the common man at home. Only then can expatriates be full partners in the quest for sustainable solutions.

Summary

In a nation where the structure of government for the people has been maligned, environmental policies which protect the interests of future generations are often non-existent. Implementing corrective actions, to be executed through the efforts of common citizens, may require the initiative and leadership of external change agents. The Haitian Institute is actively demonstrating the value of expatriates in such a capacity. Their vision and resolve to apply appropriate, sustainable criteria when addressing Haiti's national crisis has led to the creation of the 1804 Memory Garden Reforestation Project. This paper highlights how these criteria have been manifested in the water resources engineering design for the Garden. It is hoped that the Garden will play a leading role in disseminating appropriate solutions to reforestation and land stewardship which ultimately become an integral part of the social fabric for the many small communities which populate the island.

Fig. 4 View of Garden Site Facing Sea

Fig. 5 Typical Surface Area of Site

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A Study of Trace Metal Ions Enrichment in Aquatic Environments by Saccharomyces cerevisiae (baker's yeast); a Bioremediation Strategy

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A study of the trace metal enrichment of metal ions from various aquatic environment, under different condition of pH, biomass and modifier concentrations will be discussed. Sorption characteristics of baker's yeast cells, characterised as *Sacccharomyces cerevisiae* evaluated for trace enrichment of Cd^{2+}, Cr^{3+}, Cr^{6+}, Pb^{2+} and Zn^{2+} will be presented. The studies showed that treatment of yeast with 10-20 mM glucose concentration enhanced metal uptake with the exception of Cr^{6+}, whose metal enrichment capacity decreased at a glucose concentration of 60 mM. Trace enrichment of metal ions from stream water, dam water, treated wastewater from sewage plant and wastewater from an electroplating plant achieved enrichment factors varying from 1-98, without pre-treatment of sample. Generally, enrichment time of 30 minutes gave an optimal metal uptake. The presence of Na^{+}, K^{+} and Ca^{2+} was observed to suppress the uptake of Pb^{2+} by less than 5%, but suppressed the uptake of Zn^{2+} up to 25%.

Cd^{2+} adsorption kinetics were studied, under different initial conditions of metal concentration, buffer and water hardness. Cd^{2+} uptake increased with biomass dose exhibiting an equilibrium that was well described by the Langmuir adsorption model, suggesting monolayer coverage of the yeast cell wall. The uptake of cadmium was a rapid process, with over 60% sorption in the first 15 min, followed by a pseudo-second order adsorption with a maximum rate constant of 36.32 g/mg min. Sorption capacity increased with pH, with a maximum value of 0.7428 mg/g being recorded at pH 7.3. Three sorption stages were observed at the initial cadmium concentration of 2 mg/L (200 ml), 0.400g yeast, shaking rate of 150 rpm, thus suggesting involvement of at least three different functional groups in the adsorption process. The results of this study are important for optimizing trace metal enrichment conditions in aqueous environment.

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The Architecture for Sustainable Development and Ecological Living

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Abstract

Many are becoming increasingly aware of the environmental problems facing our planet Earth, and hence our everyday healthy living. The cumulative negative impact of human development activities on the environment since the industrial revolution is both real and startling. In recent times, the feeling of hopelessness provoked by the persistent revelation of the imminent end-of-the-road for nature (humanity inclusive), has led to a frantic search by scientists, for the next possible habitable planet outside mother earth. On the other hand, environmentalists argue that a prodigal son's return to that simple, old-fashioned, tested and true practice, which made strong and great, the homes of our ancestors, who built this good earth, and who, in building, left us our heritage, remains a sustainable option for Homo sapiens.

In this regard, this paper takes a critical look at one of man's extensive "production line" – architecture, as a major depletory of the earth's renewable resources since the early 20th Century [4]. It argues that the era of efficiency in the use of materials by the industrialists should be done with and advocates for a "zero waste" paradigm. The paper agrees with McDonough [6] on his calls for a second industrial revolution in design and architecture.
Citing the remarkable success achieved through the principles of eco-efficient green architecture, the paper recommends the imitation of nature's efficient cradle-to-cradle life cycling of materials for the design and production of the sustainable and healthy built environment.

Keywords: Sustainability, Nature's processes, Holism, Eco-efficiency, Zero-waste, Industrial revolution.

Introduction

"(We want) to design elegant living (and working) environments that can be built to the highest of resource conservation and land-ethic standards using cutting-edge, architectural and echo-engineering design in green building system".
Jim Melton [9]

In recent times, and as technological advancement takes place at a mind-boggling speed, increasing concern has been expressed over the unsustainable nature of humanity's development agenda, especially with reference to the consequences on the natural environment. In this context we hypothesize that architecture and construction constitute a major group of human activities with the largest single contribution to the environmental malaise, as a result of their depletive usage of renewable resources since the industrial revolution. The advent of industrial revolution encouraged the spirit of mass production amongst industrial designers such as Hans Gugelot and of industrial and machine aesthetics of the modernist architects such as Le Corbusier and Frank Lloyd Wright[1]. It marked a departure from traditional ecological knowledge, which encompass the sophisticated arrays of information, understandings and interpretations that guide human societies around the globe in their innumerable interactions with the natural milieu: in agriculture and animal husbandry; hunting, fishing and gathering; struggles against disease and injury; naming and explanation of natural phenomena; and strategies to cope with fluctuating environments [10]. It was the beginning of the loss of valuable traditional wisdom, ethics and science and its replacement with abstract knowledge and academic ways of learning.

Furthermore, with the modernist' ideal of "one building for all nations and climates" and "the house as a machine for living", the stage was set for the "take, make and waste" design sensibility amongst architects and industrialists (the design professionals). This scenario has, for more than a century, produced buildings and cities which are both mechanistic and anti-nature. In their architecture, "form" is conceived to "follow function", regardless of the culture of the locale and the environmental consequences.

It is a truism that buildings conceived as mass-produced machines impoverish the concept of cultural diversity and leave their inhabitants cut-off from the wonders and delights of nature [6]. An explanation can be traced to

humanity's urge for economic prosperity as well as the inordinate ambition for technological advancement. Thus, contemporary architecture continues to deplete the earth's assets, turning them into liabilities [4]. Besides, most of the materials and the technology used in buildings today are harmful to human health. They easily fail the energy consciousness test. The designs and means of building exploitation have disastrous effect on the local ecosystems. Environmentalists and scientists have raised alarm at the negative impact of our designs ranging from global warning and pollution to loss of biodiversity and natural resources. The call for sustainability, as a development paradigm which meets the needs of the present without compromising the ability of future generations to meet their own needs, resonates louder and clearer. In a desperate response, successive paradigm shifts have evolved ranging from such concepts as "less is more", appropriate (alternative) technology, to energy conscious design, permaculture, eco-architecture etc. Although increasingly popular, the eco-movement, which advocates for the integral and holistic design approach, is yet to be fully developed. It promises to be a viable alternative in humanity's development agenda and quest for healthy living.

Building – An Industrial Product

A critical examination of current design and build (or manufacture) practices shows its close tie to trends in conventional industry, which "take, make and waste" ideal can only produce what environmentalists refer to as "cradle-to-grave materials and products, designed for a one-way trip to the landfill"[7]. Under exploitation, these products generate waste which are toxic, dangerous to health, impacts negatively on the environment and are not renewable – hence the search for a burial place for them after use. Within their life span as buildings, they unsustainably consume energy and other non-renewable resources with the emission of abundant waste. And at the end of their useful life, the body parts remain a nuisance to the natural system.

In order to achieve sustainable development in tandem with economic abundance, and ensure the future of the terrestrial and aquatic ecosystems, the design agenda must be such that the impact is positive and good. This calls for a holistic approach to the design process, integrating environmental sustainability with the economic

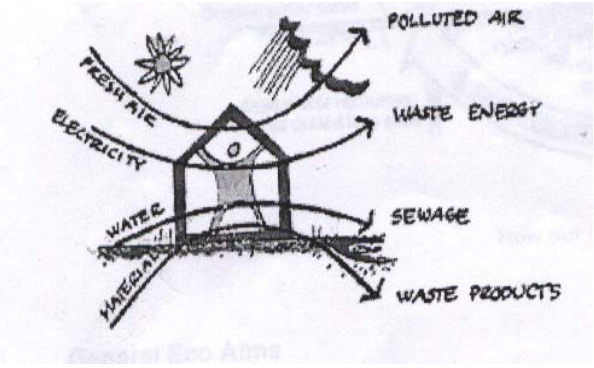

Fig.1 - How contemporary buildings work.
Source: [16]

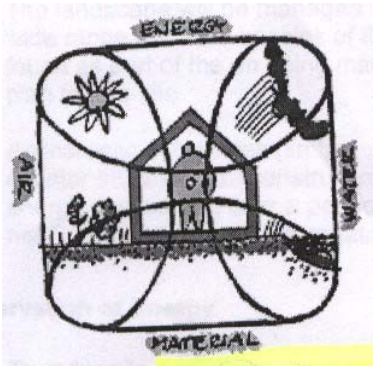

Fig. 2 - How eco-conscious buildings work. Source: [16]

and social realities of the global village. This concept demands a clear appreciation of the natural systems and the processes of regeneration. In the natural ecosystem, all components are in a complex network of relationships, empowered by solar energy. The energy circuit, facilitated by the food chains' tropic relationships, guarantees ecological balance. Most ecosystems take hundreds of years to establish a dynamic ecological balance between plants, animal communities and their environment, but they are very easily dis-stabilized. By studying the dynamics of the natural systems (Fig. 3), we lay the foundation for the appreciation of the interactions of the living and non-living systems, the natural laws that govern the growth of human populations and the basic principles of environmental management and conservation (Fig.2).

During the era of colonialism, the industrialized countries practiced the secret emptying of ship-loads of industrial wastes at ocean banks of developing economies, fully cognizant of the danger such wastes posed to the immediate ecosystem. They were knowledgeable about the natural "food chain" principle and that of the inter-relatedness of ecosystems. Yet such environmental crime is still committed today. The waste dumpers appreciate the fact of the distant effect of local actions and the local effects of distant actions but would prefer to remain recalcitrant. Once outside their national boundaries, it is considered okay, at least temporarily.

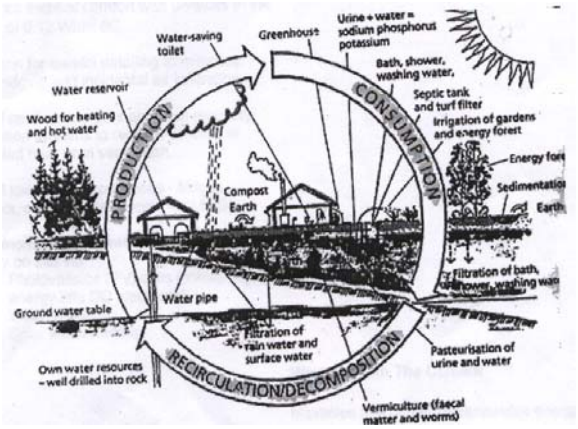

Fig. 3 How buildings work in an ecologically balanced natural system. Source: [16].

Fig.4 York Environment Education Centre - inspiring Community project on solar panels and wind turbine for energy. Source:[16].

It has recently been exposed that since 1999, French Scientists have been researching into the feasibility of a safe burying of nuclear and industrial wastes deep down the rocks of the upper mantle (the Lithosphere) of the earth. After seven years of inconclusive research, the scientists now advise, that though it is safe, they are unable to guarantee it as a permanent (sustainable) solution. Surely, such practice is tantamount to shelving the evils of our days for future generations. In reality whether the industrial "mess" from humanity's intransigence is buried in the deepest ocean bed or the rocks of the earth's core, they will in future resurface to haunt us, or rather the generations to come. After all, the Lithosphere contains the fossil fuel and the minerals we use. It contains the soil nutrients to support plants life and such elements as oxygen (46.6%) silicon (27.7%), aluminum (8.1%), iron (5%) and magnesium (2.1%). What these examples of our unsuccessful efforts to bury our environmental ills suggest is the need for what McDonough [6] calls "the next (second) industrial revolution" in 21st Century design. The task of the second industrial revolution in design would be to gradually re-construct our mindset to accept the building as an artifact which must exist, be exploited and "die" to become a nutrient in the natural ecosystem.

What humanity needs to succeed in the bid for the second industrial revolution in the built environment is a new design sensibility, which seeks to replace dominion over nature with the cherishing of our kingship with nature. The author's research in Kenya and Nigeria [13] on "Ornamental Plants for urban environment design" in the 90's was intended, amongst others, to prove the hypothesis that man's kingship with nature laid the foundation for cultural diversity and architectural identity. It is our position that institutions of learning should exploit the unique potential of architecture and construction to impact change and development which promote ecological efficiency concepts in future design professionals.

The Architecture of Sustainability

By definition sustainability evokes minimalist tendencies, specifying just the basic precondition for the environment to remain good enough for future generations. For some it is the appreciation of the legacy of our designs with regards to the long term health of nature and human culture. In general, sustainability calls for minimizing human impact on the environment. Environmentalists term it striving to be "less bad" [8]. But, the environmental question is more serious than the "less bad" option. The idea should be to make products (buildings), which create ecological, social and economic value and not simply those with limited impact.

Currently, the sustainability paradigm can only aspire to minimize the negative human impacts on the environment and make it "less bad". Such strategies may be good in the interim but is not enough for the ultimate goal of cradle-to-cradle" design or "zero waste" ideal [7]. When the "zero waste" paradigm is fully adopted, the need to bury the non-renewable, environmentally damaging waste will become history. Thus, design and production of artifacts for development will exploit materials in two cradle-to-cradle cycles: Nature's Cycle in which biological materials flow from "growth-decay-rebirth" and Industrial Cycle in which manufactured products flow from "producer-customer-industry" [11].

According to McDonough [4], this should pave the way for the "redesigning of the very foundation of architecture". Certainly, this will redefine the nature of design education in particular. Specifically, design students will learn to design systems which:

- do not require regulations to stop humanity from killing itself too quickly;
- do not introduce hazardous materials into the air, water and soil (environment) (Fig. 1);
- celebrate the abundance of biological and cultural diversity and renewable energy;
- produce nothing that will require future generations to maintain constant vigilance.

These embody the tenets of the architecture of the second industrial revolution; the architecture of the truly sustainable development and ecological living in the 21st century. To this end the sustainable design curricula for architects can be restructured to achieve the following values: development of students' sensibility to the beautiful in art and nature, and the wonderful synergy between aesthetic excellence and ecological design intelligence.

The Spherically shaped new London's City Hall by Norman Foster clearly demonstrates that an ecologically intelligent building can also display aesthetic excellence. Foster also demonstrated the same feat in the Commerzbank Tower building in Germany [5].

The other two values of design based on the "zero waste" paradigm, outside ecological intelligence, are economic and social. On the economic front, it must be acknowledged that the "hidden agenda" behind the refusal of some industrialized economies to co-operate in the signing of the famous Kyoto Protocol of the Green Peace Movement is economic. America sees herself as the most powerful economy in the world and is not prepared to risk the position in the quest for eco-efficient industrialization. During the author's research trip to the University of Hanover in 1996, he was amazed at the role the roof garden or green roof concept could play in environmental conservation. But on return home, efforts to promote the practice locally failed initially because developers considered it unnecessary expenses. Even, in some developed economies such as North America, there was no single green roof some 10 years ago for the same reason.

Fig.5 Typical green roof. Planted roof preserve the site putting back into the environment the nature the buildings remove. Source [17]

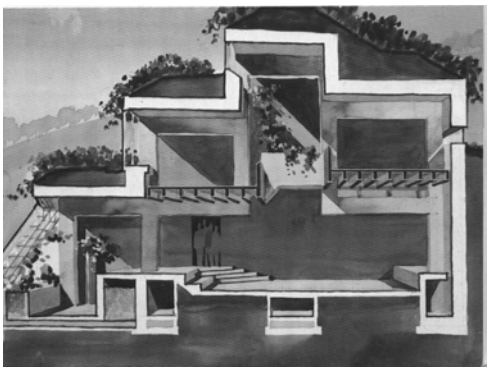

Fig.6 - Cross section through Malcom Well's buried house at Raven Rocks, Ohio, shows that respect for site helps to achieve nature preservation with solar energy collected through roof windows. Source: [17]

Today however, there are numerous examples which have successfully met both budget and time constraints (Fig.5). These have since turned round peoples' mindset concerning building and landscape because the economic viability of ecological design is no more in doubt. Successful cases of building development, which did not change the original form of the landscape but instead "begged" to be accommodated in the natural set-up, have since been documented (Fig.6). Such cases have created a new way of design thinking with regards to the relationship between buildings and the landscape. And when the materials and technology for such developments are intelligently specified, the product do not only conserve the local landscape, but can be made to accrue solar income, filter water, create habitat for living things in a biosphere, which according to Orr [5] operates by the laws of ecology and thermodynamics. Thus the "zero waste" paradigm is achievable.

Apart from the cost dilemma, many developers consider ecologically intelligent designs as incapable of products, which are aesthetically expressive. They agree with Nicholas Pevsner (1974) that "a bicycle shed is a building; a cathedral is architecture". Surely, they had a case in the 1970's, when solar buildings were a new concept and were indeed like bicycle sheds. But today, prominent architects, such as Norman Foster have demonstrated that ecological design and aesthetic excellence can create a wonderful synergy.

Hill and Brilliant [5] cite the Reichstag's Commerzbank Tower in Germany, the New City Hall in London as exemplary. In these cases, Foster was successful in exploiting the expressive potential of low-energy construction to create buildings as elegant as any in the world.

In the Council House 2 Office Design in Melbourne, Australia, designed by Mick Pearse (Fig.7), the Six Green Stars Award was in recognition of the comprehensive, interrelated approach in the articulation of sustainable technologies for energy and water efficiency, quality of indoor environments, resource conservation, etc. Pearce, who is also the architect of the visionary Eastgate Complex in Harare, Zimbabwe, has firmly demonstrated how well-known principles such as: the use of thermal mass for cooling, wavy concrete ceilings, a façade of louvers, powered by solar energy to track the sun, even pot plants to filter light, etc, can be put together to achieve ecologically sustainable design.

Fig. 7 Council House 2 (CH2), Melbourne, Australia.
by Architect Mick Pearce. Source: [2]

Eco-efficiency

As discussed above, the minimalist approach to materials employed and waste produced merely scratches the problem of unsustainable development on the surface. Ultimately, it remains a system that takes, makes and wastes, unable to achieve eco-efficiency in the built environment. However, it falls in step with the conventional industrial, "one way trip" life cycle of the cradle-to-cradle ideal. For example, according to the World Resources Institute's recent report, despite the increasingly efficient use of resources in Japan, Germany, the Netherlands, Austria, etc., increase in industrial waste and pollution since the last 25 years is recorded at 28% [8]. To achieve eco-efficiency in architecture for sustainable development and healthy living, we must seize from the principle of fine-tuning a damaging system. Instead, we should imitate nature's cradle-to-cradle life cycle[7] by ensuring that every design product (building) is a potential biological nutrient for something new after its useful life. This innovative concept is more comprehensive than the dematerialization strategy as it goes beyond using nature efficiently. It is the concept of re-materialization. Besides, when architects design, they must not aspire to create pleasant, healthy environment for the Homo sapiens only. The ideal product - the building, must be considered as responsive to a locale, including birds, grasses, climate, landscape, etc.

In a dramatic venture, which transformed a century old, Rouge River manufacturing plant and a worn-out industrial landscape, the Ford Motor Company demonstrated how ecological design can enhance the well-being of workers and create productivity and economic growth. What is most striking is that the icon of industry,

unlike the 21st Century Scientists who are now preoccupied with the search for alternative planet for humanity to live in, chose not to abandon the site but invest in its comprehensive regeneration in a rare case of ecological design. This is revolution in which innovations in the built environment means producing architecture and community facilities as safe biological or technical nutrients. The design sensibility which demands that architects and players in the building industry see their products as nutrients will not go down easily. But this does not mean that the emergence of ecological intelligent design cannot take place before we run out of oil [8]. A striking analogy is Saudi Arabia's OPEC Minister, Sheik Yamani's assertion that the Stone Age did not end because we ran out of stones.

Conclusion

A major impediment to environment conservation paradigms for eco-efficient development of human settlements is commerce related. For commerce to grow there has to be high industrial productivity. The process is both energy and pollution intensive. Hence, industrial life cycle is characterized as cradle-to-grave. They create by-products which pollute the environment. The conditions for sustainable development and ecological living demand that manufactured products, including buildings, are recyclable providing nutrients for other processes. For the predicted second industrial revolution to be acceptable and popular, the values of intelligent eco-design must begin to permeate our daily lives resulting in a desirous paradigm shift for sustaining humanity's diverse culture and ecology. The fact that the icon of Industry has demonstrated the economic viability of ecological design makes commerce a major driving force for a quick, successful achievement of this feat. In contrast, regulatory instruments and authoritative bye-laws of national, regional and international stakeholders such as those of the Green Peace Movement and United Nations will never be able to achieve such a lasting solution to humanity's environmental and health questions.

The "zero-waste option" in building/product manufacture should therefore be a viable alternative in architectural design and construction if sustainable development and healthy living are to be achieved. Our pseudo and speculative scientists are better advised to abandon the wild-goose chase for an alternative planet for humanity.

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Towards Sustainable Incomes and Health for Communities: Practical

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ABSTRACT

Access to income and medicinal drugs are two key challenges that are faced by poor rural communities in Zimbabwe at present. In response, Practical Action has been working with rural communities in Chimanimani district over the last four years to address these challenges. On the income generating side, interventions have focused on assisting communities to identify, plan and implement activities that have potential to increase income. Activities that communities are currently working on include beekeeping and honey production and mushroom production. In response to the current scarcity and high cost of conventional drugs, effort has been directed towards production and use of herbs with known therapeutic value. Production of the herbs serves two purposes. First, communities sell the herbs and generate income. Second, the herbs are helping communities to cope with the impact of the HIV and AIDS pandemic.

This paper describes how Practical Action has been working with communities in Chimanimani district to test a number of technologies for the benefit of participating households. The paper summarises the results and impacts that have been created. Finally, it highlights four important lessons that have emerged from the work. It is hoped that understanding of these lessons will help to improve current and shape future interventions.

1. INTRODUCTION

Practical Action has been working with communities in Chimanimani District, Manicaland Province to reduce vulnerability and increase household incomes. Communities targeted by Practical Action live in semi arid parts of the district. These include Nyanyadzi, Chakohwa, Guhune and Chayamiti areas. Rainfall is erratic and averages 350-500mm per year. The areas are prone to drought and rain-fed crops fail at least once in every three years. In fact, due to low and unreliable rainfall, a number of irrigation schemes have been established in the areas to enable communities to realize crop harvests and ensure household food security.

Notwithstanding the availability of irrigation facilities, most of the households in these areas remain vulnerable to food insecurity. For a variety of reasons that include sub-economic plot sizes, high cost of inputs and low production skills, more than 80% of the households are still poor. Income among farmers averages Z$20 million per year, a figure that is far below the poverty datum line currently estimated at Z$52 million per month in urban areas. HIV and AIDS pandemic has wrought a wide range of challenges to communities in the project area. Large numbers of infected people have died and hundreds of orphans have been created in the process. Our assessments in the project areas show that at least 650 children have lost one or both parents to the pandemic. Practical Action's intervention in Chimanimani district was motivated by the need to assist communities to

develop and implement an effective and sustainable response to challenges wrought by HIV and AIDS pandemic. We are working with communities to build their capacity to address the needs of orphans and other vulnerable children (OVC). This is being achieved through income generation and provision of education and other basic needs to OVC. We are also building the capacity of households to meet the needs of HIV and AIDS infected people through access to improved nutrition and herbal remedies.

2. PROJECT INTERVENTIONS

As a way to address income generation, nutrition and medical needs of communities, we have focused our work with communities on three strands. First, we work together with communities to identify enterprise opportunities, develop business plans and secure funding to implement identified enterprises that show viability. Second, we have worked together with communities to assist them to establish and run nutrition gardens. In these gardens, communities grow a wide range of vegetables that help to improve household consumption of nutritious food products. Finally, communities have expanded the range of crops they grow in their gardens to include herbs that have medicinal value. In many cases, knowledge on the nutraceutical value of the herbs is indigenous to the communities. Our role has been mainly to improve production skills to increase quality and output of the herbs.

2.1 Enterprise development

Although Practical Action has facilitated the development of a wide range of enterprises in Chimanimani, we report here on those that not only generate income but also directly increase access to nutritious food by beneficiaries. These are beekeeping and mushroom production.

2.1.1 Beekeeping and honey production

Since 2002, Practical Action has been working with small-scale beekeepers to improve their production skills and increase the quantity and quality of honey that they produce. Modern and improved beekeeping technologies have been introduced for uptake by beekeepers. These include Kenya Top Bar (KTB) hives, smokers and honey harvesting suits. Adoption of these technologies has increased the number of women participating in beekeeping activities. For example, at the start of the project there was one woman for every five men participating in beekeeping activities. The ratio has since increased to three women for every five men.

In order to give beekeepers a collective voice to identify and address the problems they face, we have also been assisting beekeepers to create a viable and functional small-scale beekeepers association. The association has attracted members from across the country and at present 5,000 small-scale beekeepers are members.

In response to the support they have received and enhanced collaboration now taking place among beekeepers, the quantity and quality of honey produced by small-scale beekeepers has significantly improved. For example, honey produced increased from 15 tons in 204/05 to 21 tons in the 2005/06 season. The fact that honey produced by small-scale beekeepers is taking an increasing share in discerning market outlets like supermarkets is ample testimony of improved quality. Some of the more enterprising beekeepers display their honey at provincial agricultural shows each year. As a result, they have been able to expand the market for their honey.

The nutraceutical value of honey is well known among small-scale honey producers. Other than producing honey for sale, small-scale beekeepers also widely use honey for their own consumption. In particular, they use the honey as a spread on bread and as a tea sweetener. Honey is also being widely used to produce remedies for coughs, stomach pain and rheumatism. One prominent beekeeper in Chimanimani district is now popularly referred to as “doctor” by fellow beekeepers due to his well known skills in producing honey formulations to treat the ailments mentioned above. In the 2005/06 season, the same beekeeper was able to harvest 7 tons of honey and earned at least Z$450 million from honey sales.

2.1.2 Mushroom production

The value of mushrooms in boosting household nutrition and health is widely recognised among rural and urban communities in Zimbabwe. Practical Action embarked on supporting small-scale farmers to produce mushrooms for sale and for own consumption. At present, the demand for mushrooms in Zimbabwe far exceeds supply. 35 women at Chakohwa village in Chimanimani have been participating in the production of oyster mushrooms since 2002.

In order to test and demonstrate the viability of mushroom production at small-scale level, a small house was built at Chakohwa to enable the women to produce mushrooms throughout the year. At full capacity, the mushroom house can hold 720 bags. Under acceptable temperatures (25-27 degrees Celsius) and humidity (70-80%), each bag can produce 2kg of mushrooms. The women are currently producing and selling oyster mushrooms at Z$250,000/kg. On average, the women are generating Z$15 million per month.

An interesting feature of the project is that all the women participating in the project are foster mothers to 350 orphans in Chakohwa ward. Income generated from sale of mushrooms is mainly used to pay school fees for orphans and to meet their other day-to-day needs like clothing and food.

Given the well-known nutritional value of mushrooms, at least 70% of the mushrooms being produced are sold locally for consumption by households. Ministry of Health and Child Welfare staff at the local clinic at Chakohwa are playing a leading role in highlighting the nutritional value of mushrooms in the diet. Mushrooms have at least 30% protein content and high fibre. Communities have noticed that regular consumption of mushrooms has a positive impact on health.

2.2 Improved nutrition through gardens

A total of 33 community nutrition gardens have been established in 21 wards of the district. A wide range of vegetables are grown in these gardens for sale and own consumption. Vegetables grown include rape, covo, cucumbers, tsunga, tomatoes, onions, spinach, maize and fruits such as mangoes, peaches, pine apples, oranges and lemons. Community monthly reports indicate a total figure of 3,696 OVC are directly benefiting from these nutritional gardens through increased access to nutritious food. Surplus products are sold to raise income which is used to meet the needs of OVC.

Project beneficiaries have been trained and acquired improved skills in the preservation of vegetables. In periods of high production, excess vegetables are dried using solar dryers. This method of drying ensures that vegetables retain their nutritional value. Dried vegetables provide communities with a ready source of nutritious and affordable vegetables during periods of scarcity.

2.3 Production and consumption of medicinal herbs

Notwithstanding the advent of ARVs, the sad reality in Zimbabwe, and indeed most of Africa, is that they remain largely out of the reach of the poor. The enormity of the problem in Zimbabwe is amply demonstrated by the fact that 80% of the people are now living in poverty. In such a situation, access to alternative medicines that can help alleviate pain and suffering and reduce progression to full blown AIDS becomes critical. In this respect, communities that Practical Action works with in Chimanimani district have done particularly well.

At present, 160 households are actively participating in the production of medicinal herbs. Production of the herbs is concentrated in Rupise, Changazi and Chakohwa wards. The main herbs grown by project beneficiaries are moringa, rosemary, lavender, calendula and camfrey. Table 1 summarises the herbs being grown, ailments treated, benefits being created and how the herbs are being used by communities to improve the health of people in Chimanimani district.

Table 1: Herbs and benefits

Ward	Herbs Grown	Ailments treated	Benefits	Use of Herbs
Rupise	Lemon Grass	• Back ache • High blood pressure	20gm sold at Z$20,000. Some producers generating at least Z$4 million per month from sales	• Used as green or dried leaves • Added to boiling water and drunk as tea three times per day
	Moringa	• Immune system booster • Diabetes • Diarrhoea • High blood pressure • Skin infections	Table spoon of powder sold at Z$50,000. households generating average of Z$5 million per month from sales	• Leaves and roots are dried and ground into a powder • One table spoon of powder is added to 100ml of boiling water and drunk three times per day • Fresh leaves are cooked and eaten as relish
	Rosemary	• Fever • Stomach ache • Head ache	Currently sold at Z$30,000 per gram. Participating households generate at least Z$5 million per household per month	• Leaves are added to 100ml of boiling water and left to cool • Cooled liquid is sieved and drunk two times a day for two weeks
	Lavendar	• Influenza • Improves breathing for those with breathing difficulties	20gm of flowers is currently sold at Z$40,000. Participating households are generating at least Z$8 million per household per month	• Flowers harvested at bud stage and dried • 5gm of dried flowers are added to 100ml of water and boiled for ten minutes • Liquid is drunk three times daily in between meals
Changazi	Moringa	• As above	As above	• As above
Chakohwa	Moringa	• As above	As above	• As above
	Calendula	• Improves digestive system • Menstrual cycle pains	• 10 households are involved in production ad sale • 10gm are currently sold at Z$30,000	• Green leaves are added to boiling water and simmered for three minutes • Liquid is drunk two times daily for four continuous days
	Camfrey	• High blood pressure • Joint inflammation and pains • Ulcers	• 10 households are involved in production and sale • 20gm are sold at Z$25,000 at present	• Roots or leaves are dried and ground into powder • 5gm of powder are added to 100ml of water and boiled • Cooled liquid is drunk three times per day

Source: Practical Action (2006), Project Monitoring Reports

3. RESULTS AND IMPACTS

3.1 Improved household nutrition

Project monitoring surveys conducted by Practical Action show that at least 8,000 people have directly benefited from participating in the various activities that we have supported in Chimanimani district over the last four years. The people are involved in production and sale of honey, mushrooms, vegetables and medicinal herbs. Increased availability of these products in the district has enabled many households to buy and consume the products. With 80% of rural households currently considered poor in Zimbabwe, the ability of households to produce crops with high nutrition at the local level is making a significant contribution to improvement of household nutrition and welfare. Our surveys indicate that malnutrition, especially among children and infants has fallen by more than 20% over the last four years.

3.2 Access to alternative medicines

In the age of HIV and AIDS, rising poverty, scarcity and high cost of drugs, the ability of communities to grow and utilize medicinal herbs can make the difference between life and death. It is now paramount that communities acquire skills to grow, process and sell medicinal herbs to improve health care in rural areas.

In many cases, the tradition of utilizing herbs to treat a wide range of ailments has been known by communities for generations. The distinct contribution we are making through our interventions is by supporting communities to grow some of the herbs to ensure increased and long term availability. The therapeutic value of the herbs being used by communities is established. What is missing so far are studies and research that can help to quantify appropriate dosages. Availability of such information will encourage more production and expand the market for such products. This will go a long way in improving health of communities, especially in rural areas.

3.3 Increased access to income

All the products being produced by communities we are working with are consumed and also sold to generate household income. Based on project monitoring data, participants are currently realizing significant income from sale of mushrooms, vegetables and medicinal herbs. For example, 35 women at Chakohwa village are generating at least Z$5 million per month from sale of mushrooms. There are indications that income realized will increase as production and business management skills improve.

A fascinating feature of the Chakohwa mushroom production project is that all participating women are foster mothers to orphans. As foster mothers, the women provide parental advice and support to the children to ensure that they enjoy all the benefits that other children with parents enjoy. The foster mothers also provide for the material needs of the children by paying school fees, buying uniforms, food, books and stationery. When the children fall ill, they also ensure that they get adequate medical attention and treatment. At least 90% of the income generated from sale of mushrooms is used to meet the needs of orphans.

Households participating in the production and sale of medicinal herbs have reported average monthly incomes of Z$4 million. There is potential for this amount to increase at least three-fold as production skills improve. Those participating in beekeeping and honey production have reported annual incomes of Z$40-60 million.

3.4 Linkages with policy makers and other support institutions

Communities in Chimanimani district are now well connected with policy makers and other support institutions operating in the district. These include Chimanimani Rural District Council, District AIDS Action Committee, AREX, Catholic Development Commission (CADEC) and Towards Sustainable Use of Resources Organization (TSURO). DAAC is now more responsive in delivering support services following adoption of community based planning and management approaches. It is now taking a lead in supporting communities to grow and utilize traditional and other tested herbs for treatment of diseases. In addition, DAAC has piloted two learning and distribution centres for herbs at Chimanimani Hospital and Nyanyadzi Clinic.

Community-based planning approach that has been applied in the execution of project activities has put project beneficiaries firmly in the driving seat. Project beneficiaries take lead in deciding priorities and implementation of interventions. Support institutions facilitate and catalyse the process. The foundation for long term sustainability of project activities and benefits has therefore been firmly established.

4. CONCLUSIONS AND EMERGING LESSONS

Over the last four years, Practical Action has been making a modest contribution to improve livelihoods of poor and marginalized communities in Chimanimani district of Manicaland Province. The organization has focused on supporting communities to identify and prioritise needs and problems and to develop and implement actions. As a result of the support, communities are generating incomes, improving household nutrition and taking care of OVC. In addition, the capacity of communities to cope with the impact of HIV and AIDS pandemic has been

strengthened. Production and utilization of medicinal herbs is now widespread in the district. This has gone a long way in enhancing health given the current scarcity and high cost of conventional drugs.

Some important lessons have emerged that will help to shape current and future direction of interventions. First, community interventions are likely to thrive and deliver impact if they are locally driven. Communities in Chimanimani district now largely drive local development interventions because they take the lead in identification of needs and problems and implementation of actions. The foundation of long term sustainability of project activities and benefits has therefore been created.

Second, the community-based approach to address the needs of OVC is proving to be a viable and sustainable way of coping with the impact of HIV and AIDS pandemic. Under the foster mother arrangement, orphans are being afforded an opportunity to grow under normal family conditions. The foster mothers are playing a critical role by paying school fees and meeting the other day-to-day needs of orphans. The support provides hope that the orphans will grow into responsible and productive adults.

Third, there is great potential for rural households to earn significant income from mushrooms, honey and medicinal herbs. The market for the first two products is huge while that for medicinal herbs is still small but rapidly growing. As communities improve their production and business management skills, quantities will increase and more incomes will be earned.

Finally, research should focus on quantifying suitable dosages for various medicinal herbs that communities currently grow and use in the treatment of various ailments. Once such information becomes readily available, the market for medicinal herbs will expand. Producers of herbs will be able to generate more income while large numbers of people will have access to more affordable drugs. This will have a positive impact on the health of poor rural and urban households.

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A Study of Trace Metal Ions Enrichment in Aquatic Environments by *Saccharomyces cerevisiae* (baker's yeast); ***a bioremediation strategy***

ABSTRACTS FROM POSTER SESSION

Design of a Shepherd Crook Bending Machine

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Abstract
The product, Shepherd Crook is made from 16mm deformed bar and is used to hold mine ceilings. These ceilings hold some rocks falling from tunnel roofs to prevent dangers from mine workers. The crook should be strong enough to be able to hold heavy loads of soils, stones and rocks. The product was previously being imported but now due to escalating costs, the shepherd crook heating and forging the product. This process of forging has serious side effects that weaken the crook material due to repeated changes in internal grain structures. Heat-treating the product could solve the problem but the costs so involved are too prohibitive. In addition to the above problems, the process of forging takes too much time and requires a lot of labor, a factor that is proving to be costly to the company. Setting up times is too long and as workers get tired and exposed to occupational hazards like poisonous fumes and manual labour causes production of rejects. This method no-longer suffices since the product demand is increasing day in day out. This paper discusses the design of a Shepherd Crook Bending machine to improve quality of the product and eliminating industrial ergonomics and safety hazards to the workers due to the current manufacturing method.

Stress Tolerance n *Vigna Unguiculata* (L. Walp)

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Abstract

Cowpea, *Vigna unguiculata*, is the most important legume crop in the Savannah and Lowland tropics of Africa. It is a rich source of vegetable protein but has a drawback in its use as a baby weaning food due to the presence of flatulence causing factors that occur in the mature grain. These flatulence-causing factors might be due to the presence of raffinose family oligosaccharides (RFO) namely raffinose, starchyose and verbascose. Galactinol synthase (GS) catalyses the committed step in the biosynthesis of RFO. In an attempt to reduce these RFO, our laboratory has been interested in down regulating the activity of GS using Ribonucleic Acid Interference (RNAi). A 450 bp fragment of GS cDNA was cloned into pGEM-T Easy vector and sequenced. A BLAST search revealed high nucleotide sequence homology to pea and *Arabidopsis* GS. *Arabidopsis* has seven homologues of GS and three of these encode for three different groups of stress-related proteins that have been implicated with cold, salinity and drought stresses.

In an attempt to establish the presence of these seven homologues in cowpea, reverse transcription-polymerase chain reaction (RT-PCR) was performed on total RNA isolated from differentially treated 9-leaf cowpea plants. Results from these experiments should serve three purposes: to identify (i) which homologues are induced by abiotic stresses, (ii) which developmental stage to use when isolating mRNA to construct a cDNA library, (iii) which homologue needs silencing by RNAi. Stress treatments revealed that at least three homologues were induced by drought, salinity and cold. The Atgols 1 and 2 homologues were induced by drought and salinity while the Atgols 3 homologue was induced by cold stress as observed for *Arabidopsis*.

The Construction of a Cfferdam for the Repair of a Dry Dock at Guyana National Industrial Corporation, Guyana

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Abstract

Guyana is known as a land of many waters. The network of rivers, creeks, and lakes supports a tropical rain forest, intermediate savannahs, a range of agricultural products, a rich diversity of animals, and mining in “El Dorado”.

Through its rivers the populace and foreigners traverse from coast to interior and visa versa. Air transportation the unreliable, and very expensive relative to wages in Guyana. Roads are mainly along the coast of the country with one exception. Therefore, without boats, speedboats, and ships on the rivers economic development has suffocated.

In October 2005, the authors of this project were approached to build a cofferdam so as to facilitate the repairs to a dry dock where ships have been built since the 1950s. The design of the cofferdam was prepared by one of them. The other had the task of doing an appropriate construction using locally available wood and clay. The design of the cofferdam is attached.

Integrated Weed Management: A Possible Solution to Weed Problems in Zimbabw

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Key words: Weed pressure, Mechanical control, Herbicides, Cultural control, integrated weed control, safe environment

Abstract

Weed pressure is becoming more severe in New Farms due to over reliance on chemical and mechanical weed control methods. Increasing weed population is caused by lack of availability of herbicides on the market, skill in weed identification and correct matching of herbicide to weed. Availability of draught power makes mechanical method ineffective. In addition, over reliance on the two methods can damage soil structure and the environment. A safe, cheap and effective option for farmers could be integrating all methods available, ranging from biological, cultural, mechanical and finally chemicals in that order of preference. This ensures a limit to the introduction and spread of weeds, help the crop to compete with weeds and finally make it difficult for weds to adapt.. The overall benefits to the farmer will include cost minimisation, crop yield and quality improvement and safe environment for useful organism in the crop-soil ecosystem.

Introduction

Above average rainfall experienced during the 2005-2006 season made farmers experience a serious weed problem in Zimbabwe. Weeds are any undesirable plants that can be both a nuisance and a hazard in agriculture. They can cause injury to man and animals. Weeds compete with field crops for soil nutrients, light and water. They harbour insect and disease pests. Weeds interfere with agronomic operations such as fertiliser application and harvesting. Overally weeds increase the cost of crop production.

In Zimbabwe most maize farmers rely on mechanical and chemical methods (Parsons, 1988; King, 1987). Reliance on only one or a limited number of methods in maize production is dangerous because it gives weeds a chance to adapt. Perennial weeds like the Shamva grass (*Rottboelia cochinchinensis)*, couch grass (*Cynodon dactylon*) can make mechanical cultivators slip away, while weeds with a watery stem and those with a vegetative mode of reproduction like common purselane (*Portulaca oleracea*)and purple garden sorrel (O*xalis latifolia*) can re-establish after being shredded into smaller parts. Over reliance on chemicals with the same mode of action results in weeds that are resistant to herbicides. Chemicals cause harm to the user and to millions of micro organisms in the soil crop ecosystem. Herbicides are expensive and in some cases, they are not available on the market. Some farmers may also fail to match weed type to appropriate chemical control method and end up incurring loss when the weed has not been killed by the wrongly applied chemical.

With problems as those cited above, it becomes essential to broaden and diversify control methods. Research indicates that there is good potential to reduce the number of herbicide applications and utilize lower herbicide doses within competitive cropping systems to ensure a safe environment for all life on the farm (Pannell, 2004).

Integrated Weed Management

Weed management requires an integrated approach which is referred to as Integrated Weed Management (IWM). IWM requires the incorporation of all appropriate management techniques including chemical, mechanical, and cultural practices in a weed control program. The approach employs strategies ranging from simple monitoring of pests, through cultural and mechanical to proper timing of application of pesticides with the aim of preventing. economically damaging weed out breaks, while reducing risks to human health and the environment.

Strategies

Scouting

The first process is scouting. Scouting involves walking in the fields and evaluating population of key weed species in the field. Scouting defines the scope of the problem and allows the best management practices to be selected. Number of weeds, species present, and their locations are important. Farmers must take note of the dominant species along with uncommon or perennial weeds. The management strategies to be adopted must control the dominant species, while preventing the spread of uncommon weeds. With proper scouting and weed identification the right chemical, dilution and timing can be determined, and thus reducing the quantities of pesticides as well as mechanical effort required to control weeds.

During scouting the farmers must differentiate weeds by their life cycles into winter annuals, summer annuals, biennials, simple perennials and spreading perennials. Each of these have characteristic well detailed in any standard weed science textbook and farmers should refer to these for clear understanding of weeds in their fields.. Also differentiate weeds into broadleaved (*Amaranthus hybridus*) and grasses types (*Echnochloa colona*).

Both life cycle and the classes help to determine timing of control and the best combination of strategies to adopt. Annuals and biennials for example are best controlled before they seed so as to reduce next season infestation, while spreading perennials propagate by seed and underground reproductive structures which make their control. Weed population and density helps in determining economic threshold, the density at which control measures can be implemented.

Cultural methods

Cultural weed control is the management of the crop to make it more competitive against weeds. If properly employed cultural techniques reduce weed numbers in the crop field and the few weeds that appear can easily be controlled using reduced levels of chemicals and limited mechanical effort. Cultural control measures include winter tillage and good seed bed preparation, optimising planting date, seeding rate and depth, fertility management, understanding of the crop, field sanitation and the use of adapted varieties (Blackshaw *et al,* 2006)..

Deep winter tillage ensures that weeds are buried to deep levels that have a high carbon dioxide to oxygen ratio where they die from lack of oxygen (Gardner *et al*, 1985). In addition, early land preparation allows the farmers to plant their crops early enough to ensure fast canopy development before the weeds emerge. Proper seed bed preparation also ensures that the crop, and not the weed, is placed on an ideal environment which gives the latter competitive edge. Practices of minimum and conservation tillage should also be part of an integrated weed management programme, as they leave crop residue in between rows, shading the soil and suppressing weed emergence. With few weeds in the field spot treatment of weeds becomes possible, thus achieving the goal of cost minimisation and environmental protection.

High seeding rates help in shading the weeds and make it difficult for them to take water and nutrients. This weakening gives herbicides in spot treatment a boost. in small holder systems low seeding rates allow light to penetrate into the wide spaces in the canopy and stimulate weed growth (Cralle, 1986). Farmers should also calibrate their equipment in order to ensure uniform seeding at correct depth, for fast crop emergence and good establishment, thus making the crop more competitive.

Fertiliser application methods like broadcasting benefit the weed as well, while placing the fertiliser where the crop only has access allows the crop to outcompete and suppress weeds. After banding nitrogenous fertiliser for four consecutive years, the density of *Eulesine indica* in maize under both conventional and reduced tillage systems was found reduced by 95 % by Kelner, and Derksen (1996).

Recommended planting dates are important in IWM and must be adhered to. Weeds that emerge after the crop has emerged cause less yield loss than those that emerge before (Liphadzi and Dille, 2005). Late planting makes the need for pre-emergence herbicides, post emergence herbicides and early cultivation to control germinating weeds a necessity. Winter annuals like the wild oats (*Avena fatua*) and wild mustard (*Sinapsis arvensis,* aka *Brassica kaber*) are a problem in early sown crop, while summer annuals like upright starbur (*Acanthospermum hispidum*) and black jack (*Bidens pilosa*) are of concern with late crop. Choice of the correct weed control

programme becomes easy if the planting time is planned and well distributed across the season within recommended range.

Farmers should have a clear understand their crop. Maize grows slowly and develop a full canopy after 6-8 weeks and weed control effort should be strong during this period. IWM technique would also require that correct hybrids adapted to the agroecological zone are planted so that the crops grow vigorous to out compete weeds.

Field sanitation prevents weeds from spreading into the field. Practices such as use of clean seed, clean equipment are examples of good field sanitation. Controlling weeds on the edges of the filed, patches of new invading weeds and herbicide resistant weeds should also be done. Weeds should be removed before they seed.
Mechanical methods

Mechanical weed control methods can be employed right from the period before crop establishment. Incorporation of mechanical weed control strategies ensures a reduction of weed pressure late in the season and the few remaining weeds that escape destruction can be controlled using chemical spot spraying. Mechanical weed control methods include, hand weeding, hand hoeing, interrow ploughing and interrow cultivation.

Hand weeding is important for removing weeds within crop rows and too near crop plants for them to be controlled. Hand-weeding is often used as a supplement and in combination with other control techniques. Success with hand-weeding depends on the proper timing of removal, size of the weeds, size of the field and the thoroughness of the people doing the weeding. It is most effective when the weeds are small and not well-established.

However, hand weeding does not control large or perennial weeds like shamva grass (*Rottboellia cochinchinensis*), those with mechanical strength like cats tail (*Sporobolus pyramidalis*) and rapoko grass (*Eleusine indica*). Most importantly, hand-weeding is very labour intensive, thus potentially expensive.

The hoe is used to cultivate the interrow space, digging out, cutting and burying weeds, thus leaving the crop field clean. In large scale commercial farms it is used as supplement in combination with other control techniques. As with hand weeding, success with hoeing depends on the proper timing for removal, size of the weeds, size of the field and the thoroughness of the people doing the weeding. It is also most effective when the weeds are small and not well-established.

Mouldboard ploughing, chisel ploughing, discing or harrowing are commonly used before planting to eliminate emerged annual weeds and to suppress perennial weeds. Use of plough to till the interrow space is not uncommon in communal and small scale commercial farming areas in Zimbabwe. Ploughing can bring the rhizomes of perennial weeds to the soil surface where they are killed by desiccation and freezing depending on the season and location.

Row cultivators are widely used in the production of crops established in rows. Cultivators dislodge or cover many weed seedlings and they work best when weeds are small, before they reach the 3 to 4 leaf stage. A layer of dry soil placed in the crop row by cultivation can also assist in weed control by preventing germination.

However large weeds with extensive root systems require deep tillage for adequate kill, a practice that is now discouraged for its damaging effect on soil structure. Deep tillage also increases the potential for damaging crop root systems. Effective mechanical control requires precise row spacing, a practice which most farmers are failing to achieve due to shortage of equipment. Weather conditions influence the effectiveness of tillage, with wet conditions causing delays and allowing weeds to proliferate. Rainfall or irrigation soon after mechanical control allows weeds to re-root.

Chemical methods

Herbicides kill weeds by inhibiting biochemical processes necessary for growth. Herbicides should be selected based on: crop being grown, crop rotations being used, weed species present, costs, and ease of application and farmers should work closely with extension staff for specific details on herbicide compatibility with their crops. The chemical management of weeds should be minimal due the elevated costs of herbicides and negative impact of chemicals to the environment. Farmers should only resort to this method in dealing with spot problems.

Herbicides can be divided into classes that are well detailed in standard crop protection textbook. For example, selective herbicides like atrazine can be directly applied to maize and other crops listed on their labels without causing injury, while nonselective herbicides such as glyphosate must be applied without coming into contact

with the crop. Other classes include preemergence and postemergence. Farmers should always read instructions and understand the class of the chemicals before they use these.

Calibrating crop protection equipment correctly does not only save money, but also helps the farmer to reduce environmental damage and harm to the person applying the herbicide. Herbicides can alter soil chemical properties and affect microbial life in the soil, therefore proper amount of herbicide should be applied evenly on target areas.

Conclusion

Integrated weed management in maize and other field crops identifies the weed problem through scouting and combines preventative, cultural, mechanical, biological, and chemical control methods in a compatible manner to solve it. Integrated weed management avoids relying solely on one management tool and helps reduce the need for chemical weed management. The approach combines a series of strategies to profitably produce a marketable maize and other crops without harming the environment. The overall benefits include, clean weed free crop, high quality crop produce, high yield, reduced costs of production, high profit and environmental safety.

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Project Dawn

Transfer of "Appropriate Skills Technology" from Britain to historically disadvantaged adults in South Africa

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Key Words: Transfer of Equine Skills: Technology Transfer: Upskilling underprivileged South Africans.

Abstract

With the change of Government in South Africa in 1994, the upliftment of previously disadvantaged and socially, vocationally or educationally deprived members of society was given high priority. The transfer of technical skills was recognised as one way to achieve this outcome. This research is an investigation of a collaborative upskilling programme, 'Project African Dawn' (PAD), launched in 2003, comprising the transfer of equine technical skills from Britain to South Africa. Equines are the main means of income generation for many underprivileged families in Cape Town.

PAD is funded by The International League for the Protection of Horses (ILPH) England, and hosted by the Cart Horse Protection Association (CHPA) Epping, Cape. It aims to educate 20 apprentices per annum in Farriery, Saddlery and Harnessry, to improve the overall health and welfare of working horses. A fit horse can work harder, thereby potentially generating an increased income for the owner/driver (the 'Cartie'), leading to upliftment and a better standard of living.

The main participants in this research evaluation are a self-selected sample of 13 of the 27 currently graduated PAD apprentices who reported that the technical training they received had improved their lives in many ways. Additional to technical skills, this improvement included increased self-esteem; a sense of pride and achievement; greater self-knowledge and self-empowerment; greater respect from the carting community; a desire to share their knowledge with and/ or teach others; and an increased interest in further learning.

Introduction

The purposes of this on-going research project are to:

1. Investigate the impact of PAD on the lives of a convenient sample of 13 of the 27 adult graduate apprentices who participated in the ILPH/CHPA collaborative sustainable development apprenticeship programme 'Project African Dawn' during the period 2003 – 2005.

2. Assess its possible relevance to local South African collaborative up-skilling programmes.

3. Identify its possible contribution to sustainable development, the upliftment of previous socially, educationally or vocationally disadvantaged members of the underprivileged carting community and the health and welfare of their working equines.

In this paper, the focus is on purpose number l.

Programme: 'Project African Dawn'

13 out of the 27 graduate apprentices who succeeded during the years 2003 and 2004 of the 5-year collaborative apprenticeships programme 'Project African Dawn' funded by the ILPH England, and hosted by the CHPA in Epping form the basis of this paper. All adult apprentices come from previously socially, vocationally, or educationally disadvantaged communities, and were selected to be representative of the programme population in terms of age, educational standard, first language, and racial and cultural background.

Methodology

Ethnographic Action Research (EAR) is based on the work of Tacchi, Slater & Hearn [1]. Data collection was multi-modal with face-to–face interviews for apprentices, ILPH master trainers, and CHPA staff. In addition, apprentices were surveyed by self-reporting questionnaire, in-class and in-field observations, and examination of extensive CHPA records, field notes, video films, tape recordings and photographs.

'Action research produces knowledge grounded in local realities that is also useful to local participants.' [2] This research examines if and how 'PAD' has generally impacted on the post-course lives of the 13 apprentices, and in particular their practices relative to the health and welfare of equines in and around the carting community of the Cape Flats. It also assesses, what they had gained from the courses; what further courses they would like, for example, Adult Basic Education & Training (ABET) Language, Literacy, Numeracy and Small Business Development; and if and how they had experienced upliftment through this technical skills development project.

Findings and Discussion

In order to attend the PAD courses, many of the apprentices had to endure hardship by foregoing the need to work every day to provide an income for their families. Some even had to face unfavourable peer pressure against self-improvement. Several of these 'second chance' learners had only primary school Standard 2 (4-years) schooling, and lacked writing/reading skills. Their learning was assisted by applying the Wee & Yu [3] Problem Based Learning (PBL) method. In brief this comprises, 'Start', 'Problem posed', 'Identify' what we need to know, 'Learn it', 'Apply it'.

The technical instruction used by the ILPH master trainers and based on PBL was framed as: Observe the animal. What is the physical/behavioural problem? What do I know already about the problem? What do I need to know to effectively address this problem? What resources can I access to determine and apply a proposed solution? In this way, apprentices are taught carefully to observe equines, their gait, posture, structure, and real or potential physical/behavioural issues in order to diagnose the nature of any problems and to correctly determine and apply the solution. This process leads to the application of improved equine skills, thereby improving the health and welfare of the working horses.

Apprentices who lacked formal literacy skills were allowed to undertake verbal examinations/assignments, but had to satisfy the examiners that they knew the equine anatomical parts/ purposes/ locations, names of and the correct use of the unique tools, and the procedures to remedy physical problems being presented by the animals. In this way they were able to meet the stringent ILPH International standards required to successfully graduate.

When asked if they would like further courses such as ABET Language, Literacy, Numeracy and Small Business Development, even those who had lacked formal education or qualifications did not perceive such courses as a priority. However, interest was expressed in equine courses such as veterinarian nursing, or first aid. Recently we reported that the impact of succeeding in the 'Project African Dawn' technical equine skills programme and graduating with an ILPH certificate was reflected in their greater self-confidence, pride and sense of achievement, resulting in a burgeoning new identity. Increasingly other carties were seeking their help and advice. This gained the ILPH graduates greater respect within the carting community [4]

A threefold benefit is now emerging from this technology (PAD skills) transfer. First, there has been a tangible improvement in horsecare within the carting community. Building on the CHPA work since 1995, which includes improvement in feeding practices, respect for animals, and more regular vaccinations and health checks, the graduates' knowledge of correct equine practices has further benefited the lives, health and welfare of the working horses. The impact of this has resulted in a reduction in court cases/confiscations under the Animal Protection Act, and since 2003, of the 458 working horses registered with the CHPA, there have been only 7 cases/confiscations under the Act. Thus, the importance of regular maintenance and correct care to benefit the health and welfare of the animals is now gaining greater acceptance within the carting community.
Second, all of the graduate apprentices continue to report a feeling of personal pride and achievement; increased self-esteem and respect from the carting community; and a sense of empowerment and place within society. By applying their new-found skills and removing the physical problems which hinder an animal's full capabilities they demonstrate to the carting community the importance of ensuring the fitness of their horses. It has been shown that a fit and healthy horse can work harder thereby potentially generating a greater income.

Third, a greater income generated by a fitter/ healthier horse can provide upliftment for impoverished families by improving their living standard, and their general health and welfare, as well as that of their animals. In sum, there can be great gain from the knowledge imparted by the ILPH/ CHPA PAD sustainable development programme. This may be an iterative process that will continue long after the official programme has concluded and will proceed as an example of the type of action research that UNESCO [1] has encouraged in Africa in recent years.

Conclusion

During the three years since its inception, the collaborative ILPH/ CHPA 'Project African Dawn' equine technology skills transfer adult apprenticeship programme has succeeded substantially in meeting its intended sustainable development aims and purpose. Successful apprentices have graduated from the programme with internationally recognised ILPH certificates. There has been a tangible improvement in the standard of horsecare in the Cape Town carting community, and the graduates have reported a number of additional personal gains and improved self-esteem.

Thus, the outcome of the ILPH/ CHPA 'Project African Dawn' collaborative programme can be seen as a successful 'Technology Transfer' of equine skills training. As such it is consistent with the South African Government's vision of upliftment through skills development for previously disadvantaged communities and is in keeping with the UNESCO policy of poverty alleviation for poorer communities in developing countries.

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Evaluation of the Potential of Using the Modified Jensen – Haise Model as an Irrigation Scheduling Technique in Zimbabwe.

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ABSTRACT

The majority of farmers in Zimbabwe do not practice any form of irrigation scheduling at all. The few that schedule their crops mainly use the US Bureau Class A Pan evaporimeter. Techniques such as the use of tensiometers, neutron probes, electrical resistance blocks, Time Domain Reflectrometry and also such methods as the Penman-Monteith still remain within the domain of researchers, and may be just a few commercial farmers. The accuracy of the pan evaporimeter is dependent upon several factors which the majority of farmers fail to take cognizance of. A need to develop or try another method which can be easier to use by farmers has long been outstanding. The objective of this study was to evaluate the performance of the modified Jensen-Haise (MJH) model calibrated to the local conditions of Banket area in Mashonaland West Province of Zimbabwe. The results showed that the daily evapotranspiration rates estimated using the MJH model were less fluctuating than those measured using the pan evaporimeter. The two methods gave monthly and annual values of the evapotranspiration rate that were comparable (standard estimation error of 7.98% and 6.19% respectively). According to these results the MJH model calibrated for local Banket area can be used successfully for irrigation scheduling and also for hydrological modeling and planning. The study also revealed that the MJH model is strongly sensitive to air temperature. During winter, the MJH model gave values that were lower than those measured from the pan evaporimeter and during summer when temperatures are high, the MJH model proportioned evapotranspiration rates which were generally higher than those from the pan evaporimeter.

Key Words: Modified Jensen-Haise model, Class Pan Evaporimeter, Irrigation Scheduling

INTRODUCTION

Optimum efficiency of overall water use can be attained if water is applied only when needed and in the correct amount. Many irrigators have no scheduling system at all [11], merely applying water when the spirit moves them, and thus not even accepting the maxim that "any method of irrigation control is better than none". A survey carried out in the selected irrigation zone districts in Mashonaland West Province revealed that the majority of farmers in Zimbabwe do not practice any form of irrigation scheduling at all [8]. The few farmers that are involved in some form of irrigation scheduling techniques mainly use the US Class A pan evaporimeter [13]. The pan evaporation method has been found to be particularly applicable to countries like Zimbabwe where measurements of instantaneous net radiation, humidity and wind speed is still restricted to research. More sophisticated and yet accurate evapotranspiration estimation methods like the Penman and Penman-Monteith methods remain out of reach by the majority of farmers [7]. The evaporation pan method is one of the simplest and least time consuming methods of irrigation scheduling and has been used successfully in most parts of the world [12]. However, a common problem is that the evaporation rates of pans differ considerably from that of a grass surface depending on site characteristics and weather circumstances [5]. Again, measurements from an evaporation pan are affected by poor maintenance of the pan, errors due to leaks, failure to accurately incorporate rainfall data, growth of algae inside the pan, difficulty to take measurements during rainy seasons and most importantly accurate selection and use of the pan factor which is dependent on the pan surroundings. The pan factor (K_{pan}) has to be selected carefully after consideration of such important parameters such as average wind speed and mean relative humidity which are clearly highlighted by [4, 3]. With agriculture contributing between 18

percent to 20 percent of the country's Gross Domestic Product (GDP), certainly more work should be done either to improve the only widely used pan evaporation method or to develop or adopt some other methods that have been developed and successfully use in some other countries with climatic conditions which may be nearer to the ones prevailing in Zimbabwe. It is for this reason that this research was done for the purposes of evaluating the performance of the modified Jensen-Haise method under the Zimbabwean conditions for Banket area. The modified Jensen-Haise method is one of the many models for indirectly estimating ET from climatic data. The modified Jensen-Haise method for the estimation of evapotranspiration has been used successfully in other countries [9, 3]. This method requires measurements of daily solar radiation (R_s), elevation of the area and average daily air temperature for the site in question along with historical temperature data. With appropriate calibrations for a specific area, the MJH method will only require that the farmer measures the daily maximum and minimum temperatures to estimate evapotranspiration which may make it attractive to farmers and easier use.

MATERIALS AND METHODS

The study was carried out from the month of June 2004 to June 2005 at Banket Tobacco Research Station, in Banket, Mashonaland West province in Zimbabwe. The station is located at 17.19 ^{0}S and 30.24 ^{0}E, with an altitude of 1244 m above sea level. This falls under Natural Region IIa of the agro-ecological zones of Zimbabwe [15] with average annual rainfall of 850 mm and average mean temperature of 21 °C. The instruments site was located at about 50 m downwind of an office building, with the surrounding grass green and cut to about 5 cm during summer and of radius about 50 m. During winter the grass was generally dry. The whole area was fenced out in order to protect it from animals which can interfere with the readings of the instruments. The maximum and minimum air temperature thermometers (type, ZEAL) were used to measure the daily maximum and minimum temperatures respectively. The thermometers were housed in the Stevenson screen at about 2.2 m above the ground. The standard US Bureau Class A pan evaporimeter was used to estimate ET. The values of N (maximum possible sunshine hours) for the months under study for the area were obtained from standard meteorological tables which can be found in [4, 1, 6, 10] and some climate text books. The daily values of ***n*** for the location were obtained using the Campbell-Stokes sunshine recorder located at the station. R_a is the extra terrestrial solar radiation dependent on latitude and time of the year only [1], expressed in mm/day and is also obtainable from standard meteorological tables. The long term monthly mean maximum and mean minimum air temperature, and the daily average sunshine hours (***n***) for each month for the station for the period of study were processed from the data obtained from the Meteorological Services Department of Zimbabwe. This was data collected at the station for the past ten years. The average monthly maximum and minimum air temperature values for each month were summed up and divided by ten for the ten years period. This was used to identify the warmest month in a year for Banket, and the values of T_{max} and T_{min}. T_m is the mean daily air temperature as obtained from the maximum and minimum thermometers recorded daily at 0800 hours. The pan readings (E_{pan}) were made daily at 0800 hours and were adjusted for rainfall if there was any. In winter when the ground was generally dry around the pan and humidity low, K_{pan} = 0.6 was used, and in summers when the ground was generally wet and with grass cut to about 5 cm, K_{pan} = 0.75 was used. The daily pan ET_o values were obtained using the relation $ET_o = K_{pan} \times E_{pan}$.

RESULTS AND DISCUSSION

The MJH models for each month from June 2004 to June 2005 are outlined in Table 1. Also in Table 1 is the general model which was obtained through averaging the constants for all the months within the given period. Using the models in Table 1 and T_m, Table 2 shows the average daily, monthly and annual values of the evapotranspiration rates from the two methods. It can be observed that the two methods gave monthly and annual values of the evapotranspiration rate that were comparable (standard estimation error of 7.98% and 6.19% respectively). According to these results, the MJH model calibrated for local Banket area can be used successfully for irrigation scheduling and hydrological modeling and planning. An attempt was made to produce a general model that can be applicable for the whole year at Banket and this is shown in Table 1. The general MJH (GMJH) was obtained through averaging the constants of the monthly models for the whole year. The performance of the GMJH model in terms of average daily, monthly and annual values is also shown in Table 2. The estimated daily evapotranspiration rates from the MJH model was less fluctuating as compared to the evaporation rates measured using the pan evaporimeter for all the months during the period of study. The evapotranspiration rates from the MJH model were generally lower than the evaporation rates measured using the pan evaporimeter during winter, and generally higher than those obtained from the pan evaporimeter during summer. The pattern observed from this study suggests that the MJH model is strongly sensitive to air temperature. It can also be observed from Table 2 that the MJHG proportioned results comparable to the other methods. This can be attractive since its one equation used throughout the year and can make computations even easier for farmers.

Table 1. Models of the Modified Jensen – Haise Models Calibrated for Banket for different Months and the General Model Applicable for the entire Year.

Month and Year	**Final Model of the Modified Jensen – Haise Model**
June 2004	$ET_o = 0.16260(Tm + 8.58008)$
July 2004	$ET_o = 0.16797(Tm + 8.58008)$
August 2004	$ET_o = 0.19232(Tm + 8.58008)$
September 2004	$ET_o = 0.21981(Tm + 8.58008)$
October 2004	$ET_o = 0.23183(Tm + 8.58008)$
November 2004	$ET_o = 0.22046(Tm + 8.58008)$
December 2004	$ET_o = 0.20394(Tm + 8.58008)$
January 2005	$ET_o = 0.19919(Tm + 8.58008)$
February 2005	$ET_o = 0.20834(Tm + 8.58008)$
March 2005	$ET_o = 0.20886(Tm + 8.58008)$
April 2005	$ET_o = 0.19436(Tm + 8.58008)$
May 2005	$ET_o = 0.17266(Tm + 8.58008)$
June 2005	$ET_o = 0.16230(Tm + 8.58008)$

Average General	**$ET_o = 0.19574(Tm + 8.58008)$**

In Zimbabwean irrigated agriculture, most irrigation cycles for field crops are usually a week (seven days) and above. The standard error of estimation (SEE) was applied on the cumulative values at day number five of each month for both methods. Seven months (June 2004 to January 2005) gave SEE values less than 20%, and the remaining months gave the SEE values higher than 20% with the month of April 2005 and June 2005 giving the worst results of 53.63% and 36.11% respectively.

Table 2. Comparison of the values of evapotranspiration rates obtained from the two methods.

	Total Values (mm)			Average Daily Values (mm)		
Month / Year	**E_{pan}**	**ET_o MJH**	**ET_o MJHG**	**E_{pan}**	**ET_o MJH**	**ET_o MJHG**
June 2004	98.30	107.280	116.9700	3.277	3.576	3.899
July 2004	137.60	129.552	150.9708	4.439	4.179	4.870
August 2004	181.70	169.397	170.7210	5.861	5.464	5.507
September 2004	206.90	199.376	177.5464	6.897	6.646	5.918
October 2004	208.80	226.382	170.9521	6.735	7.303	5.515
November 2004	137.60	170.038	150.9708	4.587	5.668	5.032
December 2004	132.00	159.927	153.5000	4.258	5.159	4.952
January 2005	145.90	188.626	185.3565	4.706	6.085	5.979
February 2005	143.80	180.915	176.4189	5.136	6.461	6.301
March 2005	140.50	198.264	185.8067	4.532	6.396	5.994
April 2005	168.50	175.971	177.2235	5.617	5.866	5.907
May 2005	191.30	150.647	170.7797	6.171	4.900	5.509
June 2005	166.50	130.427	157.2971	5.550	4.348	5.243
Total Annual	**2059.4**	**2186.802**	**2144.514**			

Conclusion

The study showed that the daily evaporation rates measured from the pan evaporimeter were fluctuating more than the rates estimated using the modified Jensen-Haise model calibrated for local conditions. However, the monthly and annual values from the two methods were similar. That makes the modified Jensen-Haise model more attractive for use for hydrological modeling and planning and as an irrigation scheduling technique as it is less prone to measurements errors compared to the pan evaporimeter which is currently widely used in Zimbabwe. The general modified Jensen-Haise model which can be applicable for the entire year was developed and proportioned values comparable to the other two methods. More research work should be done in order to establish the daily performance of the modified Jensen-Haise model for Zimbabwean conditions.

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Use of Wastewater for Irrigation: Public Health Concerns and Dangers to the Environment (A Case Study of Aisleby Farm)

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Abstract

This study evaluates the extent of chemical pollution due to wastewater irrigation on the groundwater in the vicinity of Aisleby and Good Hope farms in Bulawayo with special reference to the immediate and the future potential of the groundwater to augment public water supplies in Bulawayo. Historical data (1991-2001) on the changes in the chemical characteristics of the water from eleven boreholes obtained from the Criterion laboratory was analysed using the **Analyse-it**® statistical software and the Cox-Stuart statistical method. No trend could be established in the temporal trends in all the analysed parameters using both methods at 5% significance level. However, it was concluded that though wastewater irrigation was contributing to the deterioration of groundwater more factors like the hydro-geological setting of the aquifer, septic tank effluents and the land use outside the farms could also be playing a big role. Parameters like nitrates and fluorides were found to be above the drinking water limit guidelines [10] while others like chlorides and sodium were well above their taste thresholds explaining the unpalatability observed by most of the users. Moderately high Kendall Tau rank correlation coefficients were obtained for the correlation of the average concentration of most parameters with annual rainfall. Tests were carried out to reveal the current status of eight bore holes in the area and it was concluded that chlorides, calcium and fluorides were still above permissible limits. It was concluded that the water from the area is not suitable for public water supply.

***Key words**: groundwater, hydrogeological, irrigation, pollution, trend, wastewater*

Introduction

The city of Bulawayo lies on the watershed between the northern and the southern catchments, in the semi-arid region 4 of Zimbawe. Characteristic of semi-arid regions, the rainfall patterns of Bulawayo are erratic and high temperatures are often encountered. Usually the periods of low rainfall are coincidental with the highest evaporation potentials. These climatic conditions render the surface based water supplies unreliable. In spite of the unreliability of the surface supplies the public water supplies of Bulawayo are mainly derived from surfaces sources. Groundwater is an alternative which can be exploited to the city's ultimate benefit.

Project objectives

The main objective of this work is to characterize the effects of waste water irrigation on groundwater quality in Aisleby and Good Hope farms and it environs (mainly North Trenance). It is hoped that the results and recommendations of this project will be used not only for these areas but also for other situations were wastewater irrigation is practiced. This work was not in any way intended to cause the abandonment of wastewater irrigation but to ensure that a reasonable compromise between wastewater disposal and environmental conservation is maintained. The objectives can be summarised as:

- Predict the groundwater quality changes by historical data analysis.
- Assess the potability of groundwater and detect anthropogenic effects on groundwater resources.

Geology and Hydrogeology

The geological formation of the Aisleby Farm area is the Umganin Formation of the Upper Greenstone. The term greenstone belt refers to the metavolcanic, metavolcanosedimentary and associated meta-intrusive rocks of Bulawayan Group sequence of Archean age in the Bulawayo area [4]. The greenstone formation is classified as having a high groundwater development potential. Three of the boreholes right on Aiselby have depths of 60, 65, 65 metres. The depths of most of the boreholes could not be established [8]. An adjacent aquifer, Matsheumhlope Wellfield, which is of the same geological formation have boreholes of average depth 40 m. The Matsheumhlope Wellfield is a shallow and mostly unconfined aquifer [9]. Details of the aquifer underlying the study area such as size, recharge, and storage capacity and abstraction rates are not well understood. A site map of the area showing the sampling points is shown in Fig. 1.

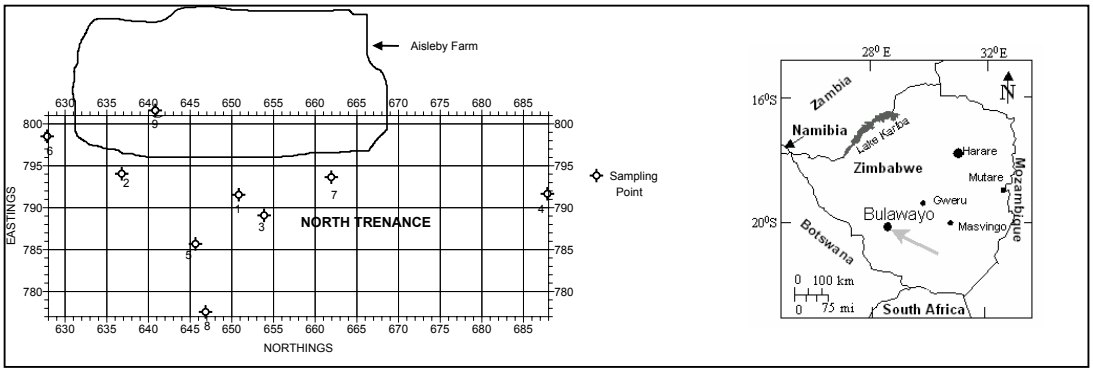

Figure 1: Borehole Location Map

Materials and Methods

Eight sampling points were selected in North Trenance (farm environs). The boreholes right on the farm were non-functional. The sampling points are shown on Fig. 1. Samples were collected and analysed to assess the current groundwater quality status. The results of the tests were compared with historical data. Field interviews were conducted to investigate the groundwater usage in the area. Rainfall data from the nearest meteorological station (about 10 km north of the area) was used to assess the effects of the annual rainfall on groundwater quality. The parameters to be analysed were selected based on their effect on the acceptability of the groundwater for potable use and those pertinent to groundwater pollution by wastewater irrigation. Due to technical constraints, some of parameters were not analysed for (e.g cadmium, lead and mercury). The parameters that were analysed included: pH, electrical conductivity (EC), Calcium, chloride, fluoride, phosphate, nitrate, potassium, iron and manganese. Historical data (1991-2001) of North Trenance groundwater obtained from the Bulawayo City Council was used to establish variations in chemical quality with total seasonal rainfall, time and distance from the farm.

Analytical procedures

Methods of analysis were adapted from the Standard Methods[1]. Conductivity and pH were analysed in the field [5]. The other chemical parameters were analysed in the laboratory using the ELE Paqualab photometer [11].

Data analysis

Historical data from the municipal water laboratory was used to investigate trends in water quality parameters. An Excel based software **Analyse-it** [13] was used in the correlation of seasonal rainfall and the analytes levels in the groundwater by the calculation of a measure of correlation known as the Kendall coefficient, at 5% significance level. The Kendall Tau rank correlation test was preffered to the Cox-Stuart method since it has a higher asymptotic relative efficiency (ARE) [3]. The moving average method was used to smoothen the irregularities in the time series [2].

Results and Discussions

Preliminary distribution graphs revealed that the historical data do not follow a particular distribution pattern and thus non-parametric methods of analysis apply. Results of the tests to evaluate the current status of the boreholes are shown in Table 1 and the annual rainfalls in Table 2.

Discussions

Calcium and total hardness

Calcium hardness ranged from 40-948mg/L with the majority of the observations being in the 242-342mg/L range. Total hardness ranged between 44-1651mg/L. There is no health-based guideline for calcium hardness in drinking water. However the taste threshold for calcium is in the region of 100-300mg/L [12]. Calcium showed a negative correlation with rainfall with $\tau = -0.45$ and that for total hardness was $\tau = -0.56$. No trend could be observed for both calcium and total hardness at the 0.05 level of significance using both the Cox-Stuart and the Kendall Tau rank correlation tests.

Manganese

Manganese ranged between 0.01 and 1.26mg/L with most values lying between 0.01 and 0.21mg/L.
Metarmorphic rocks are known to contain large concentrations of manga-ferrous minerals (containing

manganese), hence it is likely that wastewater irrigation increased the amounts of soluble manganese leading to the elevated concentrations of the metal in the groundwater

Table 1: Results of water samples collected in Jan 2005

Location/Parameter	pH	EC	TH	Ca	SO_4	Cl	F	PO_4^3	NO_3	Na	K	Fe	Mn
R/Water		202t	-	72	-	50	1.20	-	0.18	-	12.0	0.19	-
13 Byo Dr	7.38	253	-	455	-	232	1.00	0.4	1.7	-	0.4	.02	0.006
12 Byo Dr	7.27	271	-	415	-	250	1.05	2.9	2.00	-	0.4	0.19	0.05
A/Farm	6.73	265	-	355	-	410	1.15	0.4	2.80	-	0.4	0.04	0.013
96b Gard	6.21	71.2	-	185	-	129	0.5	2.9	1.26	-	0.4	0.13	0.05
54 Prim	6.5	217	-	305	-	211	0.9	0.7	1.44	-	<0.4	0.53	0.015
49 Prim	6.43	248	-	268	-	225	0.65	1.8	1.52	-		0.02	0.08
19 Nerine	6.57	230	-	305	-	232	0.95	0.7	1.26	-	<0.4	0.55	0.013
103 Jasm	6.38	176	-	215	-	100	1.2	0.7	1.20	-	<0.4	0.07	0.013

Table 2: Total annual rainfalls for the period 1990 – 2001

Season	1990/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Total rainfall/mm	595	372	563	448	327	600	675	465	532	1040	740

Sodium

The possible sources of sodium in the groundwater of Trenance include wastewater irrigation, septic tank effluents and the sodium rich plagioclase feldspar, which also makes up the greenstone geological formation. Sodium concentrations varied between 10.5-172mg/L. There is no health-based limit to sodium levels in drinking water [12] however the taste threshold usually gives a reasonable restriction to the levels. The taste thresholds usually depend upon the associated anions for example its 20mg/L, 220mg/L and 150mg/L for sodium carbonate, sodium sulphate and sodium chloride respectively [12]. No temporal trends could be obtained at the 0.05 confidence interval using both the Cox-Stuart and the Kendall Tau rank correlation tests. A sodium-rainfall tau correlation of –0.49 showed a negative correlation between rainfall and chloride. Sodium concentrations generally decreased with distance from the farms.

Iron

Iron levels ranged between 0.03 and 1.49mg/L. Typically iron concentrations in groundwater are below 0.5mg/L [6, 7], however the acidic nature of the groundwater (shown by pH values mostly below 7) may have led to the high levels of iron. There is no health-based limit to iron in drinking water [12]. However concentrations greater than 0.3mg/L usually cause undesirable taste in water and the staining of laundry. Iron was not analysed consistently enough to allow determinations of a trend or correlation with rainfall.

Nitrates

Nitrate concentration observations ranged from 0.04mg/L to 27.3mg/L. The [12] limit for nitrates in drinking water is 10mg/L. Possible sources of nitrates in the boreholes include wastewater irrigation, septic tank effluents, use of fertilisers and sludge farming occurring at the farm. Nitrate levels above this limit can be fatal to infants as it leads to methemoglobinemia. The plots of spatial variation of nitrates with distance from the farms do not show any trends revealing that the nitrate concentrations depend on more than just wastewater irrigation [8]. No temporal trend in the variation of average nitrate concentrations could be detected at the 5% confidence interval. There is a positive correlation between rainfall and nitrate which can be attributed to the intensification of agricultural activities (increase in application of nitrogen fertilisers and manure) in years of high rainfall quantities.

Sulphates

Sulphate concentrations varied between 16.22mg/L and 521mg/L. Sources of sulphates in Trenance include wastewater irrigation infiltration, septic tank effluents and the use of gypsum fertilizers. There is no health-based limit to sulphates in drinking water [12]. No temporal trend in the variation of average sulphate concentrations could be detected at the 5% confidence interval using both the Kendall Tau correlation test and the Cox- Stuart method.

Phosphates

The phosphate observations were mostly small varying between 0.004-0.388mg/L. These values are very small compared to the average phosphate concentrations of 9mg/L [8] in the wastewater effluent. This shows the good treatment capacity of the soil with respect to phosphates. Phosphates were not analysed consistently enough to attempt a sensible correlation with rainfall or to establish temporal trends.

Chloride

Chloride levels ranged from 8-1017mg/L with most observations in the 8-209mg/L interval. There is no health-based limit for chloride. However the upper limits are usually governed by the palatability of water since chlorides tend to impact undesirable tastes to water. Possible sources of chlorides are septic tank effluents, wastewater irrigation return flows; however the general decrease in chlorides with distance from the Aisleby and Good Hope farms seem to indicate that wastewater irrigation is responsible for the elevated chloride levels. However, no trend could be observed indicating the built up of chlorides for the period 1991-2001 at the 5% level of significance. There is a negative association between total annual rainfall and groundwater chloride concentration.

Fluorides

Most of the observations for fluoride are in the 0-0.9mg/L range but some are up to 5mg/L. The upper limit of the observation is a bit high considering that the boreholes are within a greenstone formation (which is not known of consisting of fluoride bearing rocks. Levels of fluoride above 1.5mg/L can lead to fluorisis [12]. There is a weak correlation between fluoride and seasonal. No trend could be established using both the Cox-Stuart and the Kendall Tau rank correlation tests at the 5% confidence interval.

Conductivity

The weighted average plot for conductivity shows the same shape as that of chlorides, calcium and total hardness. The conductivity varied between 63-568mS/m, which is quite high. Conductivity generally decreased with distance from the farms indicating that wastewater irrigation is causing the increase in conductivity in the water. The correlation of conductivity and seasonal rainfall showed a moderately high negative coefficient of –0.56.

Conclusion and Recommendations

The quality of groundwater was observed to generally deteriorate in years of low total seasonal rainfall. Nitrates and sulphates were an exception in this trend indicating that the source of these pollutants might be different to that of the other pollutants and it was presumed that the source is fertilizers or some agriculture based activity besides wastewater irrigation. Analytes like nitrates, iron, and fluorides were occasionally above the WHO drinking water standards and the levels of sulphates, chlorides, calcium and total hardness were usually well above their taste thresholds concurring with the general sentiments of the residents of Trenance who observed bad taste in the water. No temporal trends could be deduced at the 5% confidence limit using both the Cox-Stuart and the Kendall Tau rank correlation tests. The fact that no trend could be established means that more factors than just wastewater irrigation could be affecting the groundwater quality these factors are likely to include the hydro-geological setting of the aquifer, methods of sewerage disposal in Trenance and agricultural activities taking place outside the farm. Besides wastewater irrigation some factors like the use of fertilizers, the use of septic tanks and the weathering of the geological formation making up the aquifer could be affecting the groundwater quality. Future work should include the in-depth analysis of contaminant transport and the performance of the wastewater treatment plant.

Acknowledgements

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Distance Learning in Sudan – The Potential and Challenges

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Keywords: Distance Education, e-learning, Web-based Applications

Abstract

Distance learning is one of the results of revaluation of the ICT; it is any type of learning that is enhanced by online electronic communication using the latest information and telecommunication technology (ICT). Sudan has some way to go to benefit from developments in ICT and distance learning. As in many African countries, poor network infrastructure is a main challenge, in addition to lack of awareness and commitment of teachers and institutions. The objective of this research is to explore e-learning issues and open educational applications that are relevant to Sudanese and by and large African context. The project is in its first phase and the author is currently conducting a needs assessment survey of the networks infrastructure in Sudan and distance learning technologies as well as evaluation study on the use of distance education in two sectors, public health and education.

The aim is to investigate the needs of these two sectors and the methods by which we can enhance the process of making new information and knowledge accessible with as high speed as possible. Distance learning is potentially useful in developing countries setting to provide continuous education and training for people in the workforce or for adult education.

Introduction

Distance learning became popular in the 1990s due to the spreading use of the World Wide Web and the concept of knowledge-based economies. Historically, distance learning can be traced back to 18th century, print-base correspondence study in the US. In the mid 19th century correspondence education started to develop and spread in Europe and the United States. By the late 1960s and early 1970s significant changes in distance learning occurred due to development of new media technologies and delivery Systems. The Open University (OU) in Great Britain became the first autonomous institution to offer college degrees through distance education. The OU now uses all possible forms of technology to deliver learning to students[1].

We can say Distance learning is the delivery of educational services where students are in one location and instructor in another. The Delivery can be through cable or satellite hook-ups, the internet, CD or via an institution's intranet, to get both speed and performance. Distance education potentially enhances the educational level of population to face the challenges of globalization, create new opportunities for employment and address expanding the need for trained human resource in different sectors[5]. In Africa there is a need for utilizing resources to effectively develop and use ICT solutions. There are a lot of previous experiences in different African countries like Sierra Leone and Nigeria, they use many methodologies of the distance learning from corresponding courses, CD-Rom, Internet, TV and world wide web. Table (1) shows Cost and Yield of these methodologies [2].

One of the African Union objectives is to advance the development of the content by promoting research in all fields, in particular science and technology, and promote cooperation in all fields of human activity to raise the living standards of African peoples [1].

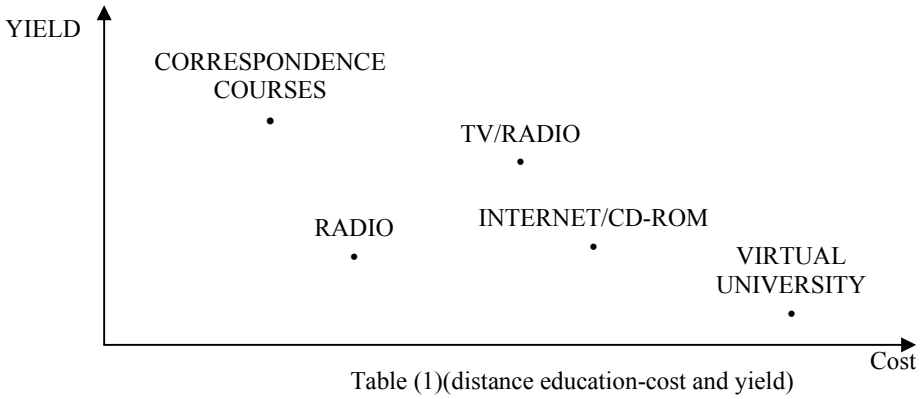

Table (1)(distance education-cost and yield)

Overview of Research

Sudan As in many African countries, poor network infrastructure is a main challenge, in addition to lack of awareness and commitment of teachers and institutions. The Sudan Open University is the first initiative in this area. It is prime initial phase of development, depends on printed material, lectures in CD Room, cassette, TV, Radio and new one video conference (between the main center and one state for one time).SOU(Sudan Open University) has electronic library on line and now enrolled 93,000 students since 2003 in (Educational, Administration, Computers collages) .Their future plans include develop a video conference capabilities to enable access to their online library for their students.

The objective of this research is to explore the e-learning issues and open educational applications that are relevant to Sudanese and by and large African Universities. The aim is to investigate the needs of tow sectors, public health and higher education and the methods by which we can enhance the process of making new information and knowledge accessible with as high speed as possible6 . In health we need to increase need for real-time communication from actual public health threats making information on best practices readily available health professionals are "knowledge workers," professionals who interpret and apply information to create and provide "value added" solutions and who make informed recommendations in continuously changing work environments (Winslow and Bramer, 1994).the internet technology is great potential for the lifelong training and education of public health workers. a few countries including India have initiated distance professional health education[4].the benefit from using distance learning is including (1) health professional-patient relations, (2) individuals' exposure to, search for, and use of health information. The future challenge includes provision of qualitative need-based health education and training programs to a variety of heterogeneous clients. Since health sciences deal with life and death and are therefore are more skill-oriented (rather than more knowledge-based), it is felt that providing basic beginning or early training in the field of health may not be feasible through distance learning. Being an innovative and flexible system, and having the ability to respond to emerging training and educational needs, distance education is more appropriate for inservice training of health personnel.

Perspective Case Study

1. SNTP(Sudanese National Tuberculosis Programme).This center in Sudan context many dots under it. The main idea to benefit from distance education in offer good training for their employees and support them with the knowledge and new develop immediately. And make the follow of the information and feedback between the dots of the center and the top management.
2. new experience in adult education, it is vocational training for women. It provide training for the teenagers girls, girls from the lack of higher education, women in prisons and all women who want to have certain occupation, so they can have chances for better income. The vocational training like nursing. The distance learning will wide the chance for many women and make generalize this experience easy for all the states of Sudan.

Telecommunication Issues

The project is in its first phase and the author is currently conducting a needs assessment survey of the networks infrastructure in Sudan and distance learning technologies.

Sudatel company is national and the ISP main which supply the most of Sudan with internet. It offers two types of connection, dial up and DSL. few Organization using Vsat Satellite. All the Sudan states have access to the telephone lines. The project will consider some of solutions from some previous experiences in poor countries or research groups on network problems like FIRST MILE SOLOUTION (DakNet) group - India, Sámi Network connectivity Project, and Delay Tolerant Networking Group[7].These experiences will offers solutions for the small bandwidth and the cost. The other part of this project will be designing a generic package to be used by teachers to provide an electronic front to their courses. This package will avoid the lack of face-to-face interaction and the missing feed back in e_learning.It will include a course Website template; Course Description and material offering existing online resource materials as well as the teacher's own material (for uploading); and teacher-learner Communication tools. The usability aspect of the produced package is important to suit the target novice user population. This includes issues of consistency of web page layout and design, clear organization and presentation of information, consistency and easy to use navigation[8]. The package will use the same general interface for related courses (same field), this decreases the learning curve for learner[3].

Conclusion:

Distance learning is potentially useful in a developing country setting to provide continuous education and training for people in the workforce or for adult education. In country like Sudan, education is often limited to those with the capacity to move to larger towns which excludes large sectors of the society such as women and the poor. Even though, the number of higher education institutions has tripled in the last decade; the services offered to students outside the main cities remain inadequate. This work is greatly dependent on support from national telecommunication companies, government bodies and decision makers concerned with education. We will also explore coordinating our work with African initiatives such as the African Virtual University as well as seek support from international bodies. The economic return of making education widely accessible is a powerful incentive for this work.

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Adoption of Low Cost Drip Irrigation Systems to Small Scale Farmers

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Abstract

Agricultural production cannot be sustained by dry land farming alone due to unreliable and insufficient rainfall. Irrigation is seen as the answer to increased and sustained agricultural production. However water demand will increase due to population growth and development, hence the need to save the allocated irrigation water. Drip irrigation has the potential to conserve the scarce irrigation water as well as improving yields. Thus it can work as a tool for poverty alleviation and economic empowerment in rural areas. However the use of drip irrigation is low amongst small-scale holders because investment costs and inherent risks are very high. Low cost drip irrigation has been developed so that the poor small-scale holders can also benefit from use of this form of micro-irrigation. Use of low cost drip irrigation has been growing rapidly in Asian and some African countries. Their uptake in small-scale farmers in Zimbabwe has been slow. This is a major concern because small-scale farmers constitute a large proportion of the farming community in Zimbabwe.

The Adoption and Diffusion Theory, and the SPSS statistical package were used to identify factors affecting adoption and continued use of low cost drip irrigation systems in small-scale holders. Primary information was obtained from staff of Non Governmental Organizations, irrigation industry officials, government departments and farmers themselves.

Drip kits were found to be adaptable to this sub-sector with sufficient technical and financial support. Their main impact is water conservation and labour saving. Further more it is necessary for the farmers to have a reliable but limited water supply, access to markets, relevant cultural background and good information network within the community for higher adoption rates.

Success of low cost drip irrigation will result in water saving, increased yields and income, food security, employment creation and less dependence on food aid. Their adaptability poses a major challenge to innovators to develop low cost technologies, which will help empower the majority of Zimbabweans who cannot afford the conventional systems.

Key words
Low-cost, smallholder farmer, drip irrigation adoption, innovation, SPSS

Introduction

Drip irrigation is one of the latest irrigation techniques and a growing technology with the potential to produce high value crops, increase crop yields and reduce water use as compared to the traditional ways of cultivating and irrigating. In Zimbabwe drip irrigation is fast becoming popular with the area under irrigation, having grown from a few hundred hectares in 1985 to 30 000hactares in 2004 [1]. But mainly commercial farmers practice it. This is because of high initial costs (between US$1000 to US$3000 per hectare [1]), high technical management demands of the systems as well as the inherent operational costs and risks. This means that the small-scale farmers are not realizing the benefits that accrue from using drip irrigation. This is a major concern because smallholder farmers constitute a large proportion of the farming community in Zimbabwe. They constitute over 95 % of the total number of farmers, disregarding farm sizes and over 65 % of the total agricultural land [3]

This category of farmers require affordable, simple, robust and low-pressure systems for them to realize the benefit that drip irrigation can offer.

Low cost drip irrigation

With the high investment costs in mind, the challenge has been to develop low cost innovations that attempt to retain the benefits of conventional drip irrigation technologies whilst removing the following aspects

- Requirement for a pressurized supply
- Resultant pumping costs
- High capital costs
- Complexity of operation and maintenance

This has led to the development of low cost, low head drip irrigation systems which

- Use substitute emitters and drip lines
- Have no pressurized pumping i.e. low head
- Small in size, to reduce the initial investment costs

The promotion of low cost drip irrigation amongst small-scale farmers has gained considerable momentum with promising results obtained in both the lab and the field. And indeed some of the results have been applied with great success. This has given rise to much optimism concerning the agricultural use of this method. The optimism leaves a room for further studies to uncover the systems' following

- Potentialities
- Acceptance and adoption
- Performances, both in the field and laboratory
- Socio-economic impact on small scale users

Purpose of study

In Zimbabwe, the Germany Development Services (DED), under the umbrella of the Give-A Dam Campaign put forward an idea of low cost, gravity based drip irrigation using LDPE pipes as drip line. A pilot scheme was designed at Makosha in Insiza and later replicated to three other dams. IDE developed and tested another low cost drip irrigation technology in form of small units at household level. These units are in form of ready to use kits, assembled and purchased so that they can be sold off the shelf and used by farmers on their own. In Zimbabwe they were introduced both on relief and commercial basis. This research sought to investigate factors that affect adaptability of low cost irrigation systems as a new innovation amongst the small-scale farmers.

Methods

One question that must be pondering the minds of many inventors or innovators is why do technology initiatives fail despite their promises and their boundless possibilities. Rogers [4] states that getting a new idea adopted, even when it has obvious advantages is difficult. To small holders, low pressure, low cost drip irrigation is perceived to be new. Therefore according to the diffusion and adoption theory, it is an innovation and the diffusion is the rate of adoption of the kits in small holders. According to Slurry [5] adoption and diffusion cannot be based solely on the worth or quality of the innovation. The clients, their culture, their wants and their environment must be considered in the design process to help ensure adoption.

To determine the technical suitability, the performance of a drip system, test runs on a bucket kit. The head was one meter and five drip lines were used. The following parameters were monitored using municipal water.

- Variation of emitter discharge with time
- Variation of discharge with length of drip line
- Comparison of micro-tube and drip hole emitters

Informal and formal interviews were carried out with irrigation specialists, Agritex officers, NGOs and farmers themselves to determine factors that lead to adoption or non-adoption of the drip kits. In addition a survey instrument was carried out in the Matabeleland region. Results of the survey were analyzed by SPSS.

Results

The measured discharge from both types of emitters was found to

- Gradually decrease with time, with some drip holes clogging completely after some weeks.
- Vary with length of lateral.

Although micro-tubes do not clog easily as the drip holes, in general emitter uniformity was found to be very low in these low cost emitters. Clogging of emitters will definitely impact negatively on the adoption rates of this innovation taking cognisant of the quality of water used in this sub-sector. The study found out that technical, social and economic factors all contribute to adoption or non-adoption of drip kits. Table 1.0 shows factors that were found to affect the farmer's decisions on the uptake of drip irrigation.

ADOPTION	**NON-ADOPTION**
Economic Factors	
Availability of land in abundance	Lack of financial resolve to purchase kits, seeds, fertilizers, pesticides etc
Improved crop quality	
Abundant labour for operation	
Well established supply chain	
High yields	
Availability of markets	
Social factors	
Strong social organizational frame work	Lack of commercial edge which is necessary for success of drip irrigation
Good support network by implementing agencies	Top-down approach of the new innovation
Agricultural based livelihood, thus necessary farming background	Theft and vandalism by humans and animals
Operation of kits by farmers themselves	
Technical factors	
Compatibility of system to crops grown	Clogging and non-uniformity of discharge
Compatibility of system to different soil types	Poor quality of water used
Training of farmers on installation, operation and maintenance	Ownership of water sources

Water saving technique of this spoon feeding technology	Long distances to water sources
	Reliability of water source

Table 1.0 Factors affecting adoption of low cost drip irrigation

Conclusion

Drip kits are the most common form, of all forms of drip irrigation in smallholder farmers. The results of this study can be taken to represent the general perception of low cost drip irrigation in Zimbabwe. Adoption of drip kits was found to be a function of complex interaction of technical, social and economic factors.

Low cost drip irrigation systems can be adopted with financial and technical support. Nevertheless there is a limit to the area that can be taken up. This is because peasant farmers have other time consuming activities such as dry land farming and livestock production. In addition irrigation is not considered to be a primary water use. When problems of water supply arise, irrigation is one of the uses that are done away with.

For uptake of appropriate low cost drip irrigation to increase, the need to save water is necessary. Farmers must also have an adequate water supply. Thus the technology is most adopted where farmers have a reliable but limited water supply. Efficient marketing facilities and good communication network within the community must be present.

Water conservation was found to be the main impact of this innovation.

Low cost drip irrigation in small holders can help increase agricultural productivity, providing them with a basis for food security, integration with markets and beginning of an outward spiral out of poverty. This is a technology that helps the poor get less poor.

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Mechanization: Panacea to Zimbabwe's Agricultural Productivity

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Agricultural mechanization being the scientific and systematic approach to the provision and use of tools, equipment and machinery to fulfill agricultural operations and enhance farm labour productivity is essential in Zimbabwe for the Land Reform Program to be a success. Agricultural mechanization has been the most significant factor in the development of production agriculture in the world in the 20th century. Fewer people than before are involved in production agriculture. Most agricultural operations are time-sensitive and crop yields suffer if such operations are not completed with due timeliness. However, the majority of beneficiaries of Land Reform Program in Zimbabwe are yet to acquire basic agricultural implements necessary for improving production in the agricultural sector. The objective of this paper is to point out the role and importance of agricultural mechanization as it applies to production agriculture in Zimbabwe.

Keywords: Agricultural Mechanization, Productivity, and Land Reform Programme

Agricultural; mechanization is the use of various machines, power units, controls, systems and techniques to replace human or animal power [3, 4]. It has been the most significant factor in the development of production agriculture in the world in the 20th century. Along with improvements in plant genetics and plant breeding programmes, fertilizers, herbicides and pesticides, mechanization has been a key factor in producing food surpluses in Western Europe, North America and Australasia. The main benefits of mechanization have been the removal of drudgery and the improved timeliness and precision of field operations. Hence, if developing agricultures are to progress, mechanization must be an integral part of the overall development [2]. As agriculture is the backbone of the Zimbabwean economy so is mechanization to agriculture. No agriculture can flourish with poor mechanization. It is acknowledged that any change that can take place in agriculture, land being the basis for plant and animal growth, still it has to be tilled, seeds placed in the soil, the growing crop must be nurtured and cured and harvested [1]. Since 2000 agricultural production in Zimbabwe has been on the downward trend, Table 1. This has been attributed to a myriad of factors, among them drought and the disturbances associated with the Fast Track Land Reform (FTLR) programme. The effects or impact of the FTLR programme on mechanization has remained unevaluated. More so, the status of agricultural mechanization with the newly resettled farmers needs to be established which can help in the re-building of the country's economic base. The result of this research can be of value towards the formation of the National Mechanization Programme muted by [6] whose objective will be to revamp mechanization in Zimbabwe, consequently it's agricultural production. It is because of the reasons stated that a research was carried out in order to assess the status of agricultural mechanization in Mashonaland West Province of Zimbabwe. The province lies in the country's prime agricultural land.

Table 1. Comparison of agricultural situation in Zimbabwe after the FTLR programme.

	Before FTLR	Current Status 2006	Deficit
Tractors (operating)	44 000 Units	12 000 units	32 000 units
Irrigable land	150 00 ha	90 000 ha	60 000 ha
Fertilizer	Readily available	Not readily available	69%
Crop chemicals	Readily available	Not readily available	45%
Fuel	Readily available	Not readily available	70%
Funds	Well structured: • Core services • Support services	Structures not followed	Funds & resources misused and not reaching the intended beneficiaries

Source: Global Agricultural Development (Pvt.), Ltd., 2006. **[5]**

METHODOLOGY

A study was carried out in Mashonaland West Province of Zimbabwe during the 2005 winter wheat production. Three farms in the Zvimba North district with a total of about 310 hectares under wheat were studied. During the same period four farms in Makonde district with a total wheat hectarage of 200 were also studied. The study was in the form of informal interviews with farm managers and actual assessments of the availability and status of the farming equipment on the visited farms. Key agricultural production aspects such as: tillage systems (primary and secondary), fertilising units (spreaders and distributors), crop protection equipment (sprayers), planting equipment (drill seeders and planters) and harvesting equipment were assessed.

RESULTS AND DISCUSSIONS

The most glaring feature from the survey was that most of the agricultural production equipment available on the studied farms was old and nor properly maintained. Of all the seven farms, no new equipment was found. All farmers indicated that they had problems with servicing their equipment. The unavailability of required components or high costs of replacement of components was one common problem with the farmers. As such, broken down or incomplete equipment, which included: disc ploughs, planters, oscillating spout spreaders and boom sprayers were observed. About 79 % of the farmers owned at least tractor, which they were utilizing for their operations, the remaining 29 % rely on animal draught power or hiring tractors from their colleagues. This indeed is a healthy sign for Zimbabwean farmers. Besides servicing problems, the owners of tractors mentioned problems in securing adequate fuel (diesel) timeously. Consequently, that impacted negatively on the execution of farm operations like tilling their lands, planting, weeding and spraying in time resulting in poor wheat crop quality which was visually evident during the survey. Only two of the seven farmers owned combine harvesters, which they hired out to neighbouring farmers for crop harvesting. It was also established that farmers were not receiving the necessary support in terms of training from the agricultural extension workers.

CONCLUSIONS

This study revealed that the status of mechanisation on the farms in Mashonaland West (which could easily be national) is poor. Most of the equipment available on farms was either vandalised or is poorly maintained because of lack of relevant training and capital resources by the farm owners. Efforts can be made towards agricultural development in Zimbabwe, but unless parallel efforts are similarly put in the improvement of agricultural mechanisation by the government and other agricultural bodies productivity from the farms will remain low.

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Valuable Products Derived from Nigerian Grasses

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Appropriate, Green, Sustainable corollary = *Access* to needed products

Example

WHO Millenium Report, 2005 **"…the richest 15% of the world's population consumes 91% of finished medicines"** *THEREFORE*

- **5.5 Bn of the world's 6.5 Bn people have inadequate access**
- **Most of the "ROW" lacks capacity**

The Institute for Access to Essential Products & Medicines

address gaps:

- **Consistent with existing international IP laws**
- **A winning proposition for *BOTH* Big Corporations and developing nations**

Institute for Access to Essential Products & Medicines (IAEPM)

- **Encouraging regional capability and *capacity***
- **Technologies appropriate for use in essential products**

– Howard Univ. (Chemistry/PharmSci/Engineering/IT)
– Nigerian Institute of Pharmaceutical R&D
– University of Alabama GCMI
– Carnegie Mellon IGOC
– Multiple Pharmaceutical companies
– Foundations

Cellulose

- **Most common biomass in green plants.**
- **Microcrystalline cellulose (MCC) is a processed, "value-added" form**

– Food, pharmaceutical, personal care

- **Nigerian MCC use is approximately 5,000 MT/A; 100% imported**
- **Critical for production:**

– analytical technologies that provide meaningful measurements
– understand variability and limits for raw materials and processing
– appropriate tests and specifications for RM's & IPCs

Replace use of cotton and woody (old growth) plants as sources of cellulose

Cellulose structure

- **Linear polymer of □-(1-4)-D-glucopyranose units**
- **Fully equatorial conformation minimizes strain**

Conformation, hydrogen bonding lends crystallinity

Elephant Grass – *Andropogon gayanus*

- **Indigenous to Africa (Uganda grass)**
- **Dense clumps up to 10 ft. tall**

***A. gayanus* Characteristics**

- **Among the highest-yielding tropical forage grasses (70 MT DM/ha-yr)**
- **Stems primarily lignocellulose, virtually no juice sugars in mature plants**
- **Total carbohydrate content (DM) about 74-76%**
- **Remaining mass**
  - 5-8% protein
  - 2-5% fats
  - 11-15% ashable substances

Materials and Process

Luffa cylindrica

Materials

- Sodium hydroxide pellets
- Sodium hypochlorite, 3.5% w/v
- Hydrochloric acid, 37%
- Water

- **Two processing stages**
  - Extraction of □-cellulose
  - Refinement to microcrystalline cellulose

Current Process Steps

□-Cellulase

- **Rough-chop**
- **Dry at 60 ^{o}C to constant weight**
- **Chip & seive (NMT 1.8 mm)**
- **2% aq. NaOH w/v at 80 ^{o}C for 3 hours**
- **Dilute hypochlorite at 100 ^{o}C for 30 min.**
- **17.5% w/v aq. NaOH at 80 ^{o}C for 1 hour**
- **Wash until neutral**

- **Filter press to rough-dry**

Current Process Steps

Microcrystalline cellulose

- **2.4N hydrochloric acid at 105 ^{o}C for NMT 1 hour**
- **Filter**
- **Wash with H_2O until neutral**
- **Dry until H_2O NMT 5.0%**
- **Mill / sieve to pass 710 □m pore size**

C haracterization Found

- **pH 6.8**
- **LOD 3.3%**
- **ROI 0.03%**
- **H_2O soluble 0.06%**
- **Metals LT 10 ppm**
- **Assay (dry) 98.7%**

USP NF Limits

- **5.5 – 7.0**
- **NMT 5.0%**
- **NMT 0.05%**
- **NMT 0.16%**
- **NMT 10 ppm**
- **97.0 – 102.0%**

Typical Properties

- **Angle of repose 35^{o} (34.4^{o})**
- **Bulk density 0.27 - 0.34 g/cm^3**
- **Flow 1.65 g/s (1.41 for Emcocel 90M)**
- **Chars at >260 ^{o}C**
- **Hygroscopic, absorbing water slowly to equilibrium values >8% at RH 70% and above**
- **Compressibility and swell match published ranges for MCC**

X-Ray Powder Pattern

Environmental Scanning Electron Microscopy

ESEM

Conclusion: materials produced do meet the limits of behavior and characterization for MCC

Next Directions – New Materials and Properties

Cellulose and Ionic Liquids

- **Characterization by 13C NMR in solution**
- ***Chem Commun*., 2006, 714, 1557 & 1971 (Swatloski, Moyna, Moyna, Rogers, Moulthrop & Remsing)**

2. Methylcellulose, Carboxymethylcellulose

- Coating agent for tablets, disintegrant

3. New crosslinking agents for cellulose; imparting more rigidity and higher crystallinity (??)

Cellulose 15% in [BMIM]Cl & DMSO-d6@ 25 ^{o}C

Methylcellulose

- **Typical MC has 30% of hydroxyl groups methylated**
- **Ionic Liquid and methyl tosylate gives >80% methylation of free hydroxyls**
- **OR: >90% selectivity for only primary methylation!**

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