S−25 ENVIRONMENT EDUCATION DEVELOPMENT THROUGH TEACHING/LEARNING MATERIALS FOR IDENTIFYING AND ATTENUATION OF POLLUTANTS IN THE ENVIRONMENTAL WATER (NATURAL ECOLOGICAL SYSTEMS)

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1. INTRODUCTION

Some of the environmental problems that affect developing countries and Zambia in particular include air pollution in mining areas, water pollution and inadequate sanitation, wildlife depletion, deforestation and general land degradation caused by among other things illegal landfills/inappropriate trash disposal. And these environmental challenges when combined have led to deterioration of the quality of life and are partially responsible for the changes in climate. Cutting down of trees (without replanting) lead to disruption of the natural sinks of CO_2 and loosens the soils leading to increased pollution, for example turbidity, in the natural water systems. Furthermore, illegal dumpsites containing decomposing organic matter or biomass can also contribute significantly methane to the environment apart from NO_3^-, NO_2^- and other pathogens.

The objective of this study was to perform a pollutant characterization of river water, ground water and surface water, and any other water destined for human consumption, with the aim of determining its suitability for use, the existing contamination models, and also develop guidelines for management of the environment through appropriate environmental education activities. From the results of the water pollution analysis, low-cost equipment were developed for water analysis, and filtration methods for reducing the pollutants based on activated charcoal (AC) prepared from tree species that can be obtained locally.

(1) Objectives of the Study

1. To investigate water pollutants in the Zambian water systems
2. To develop teaching/learning materials for analysis of pollutants based on the most acute environmental challenges most prevalent in Zambia
3. Devise methods of reducing or removing pollutants from contaminated water (e.g. use of activated charcoal, any suitable resins or natural products)

2. RESEARCH METHODOLOGY

The water samples were collected in September and October 2011, in which a total of 74 samples were collected. Addition twelve months (2011) water quality data of the Kariba dam/Zambezi River and its tributaries was obtained from the Zambezi River Authority (ZRA).

The study employed several methods and tools and these include: Inductively Coupled Plasma (ICP), Atomic Absorption Spectroscopy (AAS), Digital Water Analyser (DWA), and iodine number determination by Hanus Solution, Ion Chromatography (IC), Statistical Analysis, Low-cost colorimeter, Sumitomo Nemerow (WPI). The study focused on the anthropogenic and naturally occurring pollutants that can be found in water and **Table 1** shows the categories that were considered in this study.

3. RESULTS/DISCUSSION

This study found high nitrate (the highest registered value being 127.6ppm in drinking water) concentration in the Zambian water, a consequence of high unregulated dumpsites, cesspits, septic and un-piped sewer systems which are found across

Table 1 Parameters considered in this study

Inorganic	Heavy metals	Others
Boron	Iron	pH
Nitrite	Zinc	TOC
Nitrate	Gold	Ozone
Sodium	Silver	Phenol
Calcium	Lead	Turbidity
Cyanide	Cobalt	Phosphate
Chloride	Nickel	Temperature
Chlorine	Copper	Formaldehyde
Sulphate	Chromium	Total hardness
Potassium	Manganese	Total Phosphorus
Ammonium		Dissolved Oxygen
Magnesium		Hydrogen Peroxide
Hypochlorite		Alkalinity as $CaCO_3$
Silicon on Dioxide		Electro Conductivity
Ammonia nitrogen		Total Dissolved Solids
		Total Suspended Solids

most residential areas of Zambia. In addition, high concentration of sulphate (the largest value registered being 1659.7ppm) were found in the Zambian water. Furthermore, the study found high levels of manganese (the highest recordable was 10.4ppm) in some water samples from various locations. The other metals though detected in the water, were not in high concentration as compared to manganese. When pollutants were compared across season, from the Zambezi watershed, it was found that the late rain season (January to March) was most polluted along the Zambezi River (borderline of the Zambia and Zimbabwe). By far the biggest pollution problem was caused by turbidity followed by alkalinity as $CaCO_3$, then Total Suspended Solids (TSS) and to a less extent by phosphorus.

Nitrate is associated with fertilizer application in the field, animal manual or excrement and decaying organic matter. Some of the water samples that tested positive for nitrate also tested positive for nitrite which might indicate that the source was from decaying organic matter/animal manure. Decaying organic matter in landfills is also associated with the release of methane to the environment apart from the nitrate/nitrite issue.

In order, the most abundant greenhouse gases in Earth's atmosphere are: water vapour, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons. The contribution to the greenhouse effect by a gas is affected by both the characteristics of the gas and its abundance. For example, on a molecule-for-molecule basis, methane is about eighty times stronger greenhouse gas than carbon dioxide (Houghton, 2005).

The premise of the study is that raising alarm about the state of the water and finding remedies to the problems found can eventually solve global warming. Because water dissolves/carries a variety of pollutants that are found on the land and in the air, it is a good indicator of the state of the environment. Resolving the issue of nitrate in water as a result of decomposing biomass or poorly disposed of garbage can also solve the methane (generated anaerobically by methanogenesis as explained Kalia et al. (1992)) problem resulting from degradation of biomass.

As reported earlier, in the Zambezi watershed, high turbidity levels was one of the major problem determined. As storm water flows over the land surface which is heavily deforested, it picks up pollutants like sediments, nutrients, pathogens, debris, toxins and various other chemicals. Highlighting the problem of turbidity and how it is caused by the current deforestation in Zambia can bring to the fore the issue of afforestation/and or reforestation and put a new impetus to such programs. This issue is important in countries like Zambia because carbon dioxide increase in less industrialised countries is mainly caused by clearing of natural ecosystems for permanent croplands (cultivation) and clearing of natural ecosystems for permanent pastures (no cultivation); shifting cultivation (swidden agriculture) (repeated clearing, abandonment, and reclearing of forests) and; wood harvest (industrial wood as well as fuel wood) – in this regard, the CO_2 emissions estimates also include carbon from wood products (burned, stored in long-term pools, decayed over time). Land clearing has other consequences on the state of the water in the rivers and the ground and some of these consequences were analysed and a connection between them established.

From the most prevalent and acute forms of pollution, appropriate teaching/learning materials were explored. Some of the teaching materials that were explored include:

i) Use of low cost colorimetric technics for determination of heavy metal pollution was developed. The developed Low cost colorimeters (LCCs) demonstrated that it was, reasonable and a feasible option for use for strengthening environmental education in investigation of the condition of the water in the environment. The results show that using the LCC, it was possible to generate similar results as those generated by DWA and also similar to the more expensive and systematic instruments, namely ICP and AAS.

ii) Use of AC from indigenous tree species; preparation of different types of activated carbon was done from a variety of indigenous tree species. The tree biomass material which produced the highest effect in terms of reducing pollutants was determined by Iodine number method using the Hanus solution. The determination of the heavy metal adsorption ability of the charcoal was investigated using the DWA equipment.

(1) Colorimetric Technic

Several different parameters have been successfully determined by colorimetric method and systematized for routine determination (Kyoritsu Chemical Check Lab., Corp, n.d.) using the DWA. These are some of the parameters which have been determined successfully using colorimetric technics utilising a commercial colorimeter: dissolved oxygen, fluoride (Free), iron, formaldehyde, potassium, potassium permanganate consumption, manganese, ammonium, nickel, nitrite, nitrate, phenol, phosphate, sulphide (hydrogen sulphide), silica, sulphate, total hardness, total nitrogen, total phosphorus, turbidity, zinc, and absorbance... Many more parameters can be determined as long as a stable analyte can be generated whose colour varies linearly with increase or decrease in concentration. For this reason, the colorimetric technics was explored further in environmental education development.

The study demonstrated that the LCC is appropriate, reasonable and a feasible option for use at high school level for investigation of the condition of the water in the environment. The results show that using the LCC, it was possible to generate similar results to those generated by DWA and also similar to ICP and AAS. It is prudent that this simple application is considered for adoption in Zambia and other low income countries overwhelmed by lack of resources for effective teaching of science and especially investigation of water based pollutants in the environment.

(2) Suggested methods for combating the water pollution problems

Some of the available methods for reducing pollutants in water include: use of activated carbon to treat organic and heavy metals; precipitation of heavy metal ions as metal hydroxides from solutions of NaOH and/or $Ca(OH)_2$; Ion exchange using resin; UV lamp for disinfecting any microbes; reverse osmosis; chlorination/ozone/chlorine dioxide; sediment filtration and; use of chelating agents.

(3) Removal of pollutants

In developing of an effective filter for pollutant removal, 10 different types of charcoal were compared. The ACs considered in this study are as follows:1) Mubanga Tree (Pericopsis angolensis), 2) Mupundu (Parinari curatellifolia), 3) Mutondo (Julbernardia paniculata), 4) Muputu (Brachystegia Spiciformis), 5) Mutobo(Brachystegia Boehmii), 6) Musuku (Uapaca Kirkiania), 7) Mupetansofu (Albizia Adianthifolia), 8) Japanese Bamboo (Pleioblastus Argenteostriatus, 9) Cambodian Palm tree (Borassus Flabellofer), 10) Commercial 20μm Activated Carbon (cica reagents)

Brachystegia Spiciformis was found to be the most superior form of AC in getting rid of heavy metal contamination as 1gram, in one minute was able to adsorb 8.60ppm of a Mn^{2+} from a solution initially containing 10ppm of each of the heavy metal ions Cu^{2+}, Ni^{2+}, Fe^{3+} and Mn^{2+} and was able to treat Cu^{2+} to below the detection limit of DWA (< 0.1ppm). On the other hand, Albizia Adianthifolia was found to be the most effective in dealing with organic pollutants because it gave the highest Hanus Iodine number of 32.40.

(4) Expected Benefits

The expected inputs to society from this study are: creation of awareness of the problems; providing knowledge to deal with the problems; developing new attitudes towards environmental protection and sustainability; practical implementation of the environmental education activities; increasing participation and involvement of the students/community; responsibility for helping to solve environmental problems which in the long run can improve people's livelihoods by having accurate knowledge of what pollutants are in their water and how to treat them or prevent pollutant accumulation – remedies to such challenges have unintended benefits of lowering carbon emissions in the long term.

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