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## INTRODUCTION

About 17% of the surface area of Uganda is covered by water. Some of the water systems (Lakes Victoria, Edward, Mobutu and River Nile) are shared with other countries (Kenya, Tanzania, Zaire, Sudan, etc). The water systems have several specific resource interests: fisheries, agriculture, industry, transport, recreation, domestic water supply, etc.

The pLIrpose of this paper is to present water quality problems facing Uganda, with special reference to Lake Vi.ctoria. The paper focuses on how human activities have influenced the water quality and resources of Lake Victoria, in order to high-Jight the general problem. Only recently has there been emphasis on a policy on water resources; this requires international collaborative approaches and support for water resources assessment, sound management and relevant training strategies.

### The Example of Lake Victot-ia:

Lake Victoria, the largest in Africa (69,000 km²), is a major water resource for three riparian countries: Kenya (about 6%), Tanzania (about 51%) and Uganda (about 43%). The basic characteristics of Lake Victoria are presented in Table I.

About twenty years ago, more than 300 cichlid fish species (Graham, 1929: Greenwood, 1965.: Van Oijen et al, 1981) and 50 non-cichlids (Lowe-McConnell, 1987) were still co-existing in Lake Victoria. This clearly illustrates the community diversity which some tropical water systems can support. However, in recent years, especially since the early 1980's, the species diversity dramatically declined to a three species system although a few other traditional taxa may still be encountered occasionally (Kudhongania, 1989).

While several factors, particularly prolonged over-fishing (Graham, 1929.: Beverton, 1959; Garrod, 1961; Kudhongania, 1972.: Kudhongania et al, 1988.: Lowe-McConnell, 1975; Ssentongo, 1975) and stocking with exotic species are held responsible for the decline in species diversity, the impact coincides with significant changes in water quality (Hecky and Bugenyi, 1989; Bugenyi and Balirwa, 1989). Both over-fishing and changes in water quality arose from human activities. This coincidence underscores the fragility of natural systems to excessive human intervention.

The water resources of Lake Victoria and its watershed appear to have received greater attention for exploitation than for prudent management. In time, however, negative consequences crept into the system following the socio-economic pattern of change.

## WATER QUALITY PROBLEMS

### a) Socioeconomic changes in Uganda:

For some years Uganda has been going through a dark phase of political turmoil and economic maladjustment. The unfavourable political atmosphere to the international community and the uncertain economic temperatures kept many friends and potential investors at bay. With the demographic trends, the domestic demand for food and other requirements continued to multiply. The demands exerted increasing pressure for the exploitation of the available natural resources although with limited planning overview.

Uganda is basically an agricultural country. More than 90% of the economy is agricultural and more than 80% of the population is rural. Increasing food demands are tackled by increased food production through agricultural, fishing and animal production activities.

Agricultural developments involve vegetation clearing, deforestation and draining of swamps for growing rice and other crops. These practices lead to soil erosion. In addition, pesticides, fertilizers and other agrochemicals are increasingly applied. These may be carried by surface run-off to streams and rivers and end up into the lakes. The monthly run-off into Lake Victoria from ten rivers are given by Balirwa and Bugenyi (1988).

There are efforts to develop a mixed economy so that a number of industries have developed mainly in the major towns situated along the lake shores. The industries are involved with various manufacturing activities such as textiles, mining, smelting, food and fish processing, beer brewing, cooking oil mills, abattoirs, coffee, soap, paper, tanneries, etc. which drain their waste products into the lake either directly or via some of the affluent rivers.

The location of most industrial activities in urban centers has stimulated more people to migrate from rural areas in search of employment opportunities. However the rate of population growth in industrial centers has been faster than the rate of increasing the necessary services such as domestic water supply and sewage and garbage disposal systems.

b) Major Water quality Problems:

Uganda's political upheavals between 1971 and 1986, high population growth rates, developing industries along water systems, unplanned migrations to urban centers, growing agriculture and fishing activities, etc. have either directly or indirectly contributed to water quality problems, especially in Lake Victoria.

i) Heavy algal blooms:

There has been increased algal biomass in Lake Victoria in recent years (Hecky and Bugenyi, 1989). The lake being relatively shallow and mixing at least once annually (Talling, 1966), its phytoplankton has periodic access to the abundant bottom nutrient deposits. In addition there have been increasing amounts of nutrient inputs from industrial, domestic sewage and agricultural run-off. The retention capacity of these inputs is quite high with 140 years' flushing time of the lake. The combined effects of the above factors induces prolific algal growth which is followed by algal death, decay and deoxygenation and, finally, fish kills. Massive fish kills have become more frequent in recent years (Bugenyi, 1986 and 1989.: Ochumba, 1987). Although fish kills could be caused by other factors such as clogging of gills by siltation, the onset of periodic fish kills in Lake Victoria coincides with algal bloom occurrences.

The evidence of increased algal biomass in Lake Victoria has been described as worrisome (Hecky and Bugenyi, 1989) because if the phenomenon is lakewide, eutrophication would lead to increased oxygen demand in the lake's deep waters while decreasing the hypolimnetic volume habitable by fish during seasonal stratification. This is quite significant given that in the tropics oxygen retention by water is low while oxygen consumption rates are higher due to the high temperatures. As a result, Lake Victoria biota have limited latitude to resist oxygen demanding phenomena (Bugenyi and Balirwa, 1989). The ultimate socio-economic implications of heavy algal blooms to Uganda's fishing industry are enormous particularly if much of the lake were to become anoxic. The industry employs more than 250,000 people and provides more protein than any other single animal protein source. In recent years, too, the export of Nile perch has become a lucrative business.

ii) Decline in aquatic species diversity.

The dramatic decline of the indigenous fish species in Lake Victoria has led to a transformation of the food chains involving reduced herbivory and detritivory which is hastening eutrophication (Bugenyi and Balirwa, 1989). Hecky and Bugenyi (1989) found that the nutrient chemistry of the lake has also changed over the same period of time (Table 2). While the

decrease in species diversity may lead to less efficient use of the lakes organic productivity, changes in the nutrient chemistry may influence production potential.

The decline in the species diversity means the loss of choice for the consumer, demand for modified fishing techniques, altered production potential, and significant changes in the trophic dynamics of the ecosystem.

iii) Water pollution

Although water pollution is not thought to be a major problem for Lake Victoria as yet, the setting for pollution is already in place. Increasing application of pesticides, fertilizers and other agrochemicals which may end up into the lake, and, the growing urban and industrial effluents, should no longer be ignored. The characteristics of Lake Victoria make it particularly vulnerable to pollution.

Tropical lakes have high evaporation rates which increase the retention time and accumulation of pollutants. Balirwa and Bugenyi (1998) gave the types of waste effluents, their origin, characteristics and BOD. It has become clear that continued injection of such pollutants into the lake may reach critical levels which would affect the fishery and domestic water supply with severe socio-economic ramification.

iv) Greenhouse Effect

The evidence for global warming due to the green house effect is weighing heavily on the entire world. The specific thermal expansion of water is high at the normal temperatures of tropical lakes (Livingstone and Melack, 1984) and a relatively small difference in temperature between the surface and deepwaters may produce considerable thermal stability and stratification. Therefore, forescasts suggesting global temperature increments through the greenhouse effect, albeit minimal in the tropics (1-2°C), may lead to prolonged thermal stratification in Lake Victoria (Hecky and Bugenyi, 1989; UNEP, 1988).

Prolonged thermal stratification would lead to extensive degradation of Lake Victoria through increased accumulation of pollutants in the sediments, increased anoxia, reduced productivity and biotic diversity of benthic organisms and demersal fish species.

POLICY RESPONSES TOWARDS WATER QUALITY PROBLEMS

Until very recently water quality problems were not significant in nature and magnitude as compared to other pressing National issues. Consequently existing regulations such as the prohibition of dumping dangerous materials into water systems, or the requirement for adequate treatment of industrial effluents,

were not vigorously enforced. Secondly, a number of water bodies (Lakes Victoria, Edward, Mobutu Sese Seko) are shared with other countries making the co-ordination of policy issues political.

However, the Uganda Freshwater Fisheries Research Organization (UFFRO) conducts water quality research investigations in selected areas as part of her National research responsibilities (Bugenyi, 1979; 1982; 1984a; 1984b; 1987). The purpose of the studies is to monitor the water environment with reference to the fisheries and advise Government as necessary. On regional basis the World Meteorological Organization (WMO) conducted a hydrobiological survey of the major lakes of East Africa, including the River Nile, for the purpose of assessing water level changes and predicting the impact of rainfall on the drainage basin. The survey had limited direct concern with water quality problems although the work would be continued by the Hydro-Meteorological Department in Uganda. The CIFlq Sub-committee for the Management and development of the Lake Victoria Fisheries and the Kagera River Basin Authority have more concern in exchanging views on water quality issues on the shared aquatic systems. However, the absence of adequate research data and the lack of strong co-ordinating mechanisms limit the effectiveness of these two bodies.

In harmony with the global increasing awareness of the importance of the environment the Uganda Government recently (1986) created the Ministry of Environmental Protection to handle the National environmental strategies. With 17% of the surface area of Uganda covered by water, and in order to sustain water quality (ILEC, 1989) a Committee on Wetlands has just been formed by the Ministry of Environmental Protection. The Committee will monitor the linkage between Water/land ecotones for rational management and sustainable utilization of the water resources. The Committee is quite young and its strategies and approaches are still in the formative stages. But initially the Committee is expected to liaise its work plans with the water quality scientist at UFFRO.

In this regard International resources and man power would be required to assist in establishing:

i) Basic water resources assessment.
ii) Extension of cooperation and networks with other riparian countries.
iii) Management and control of water use.
iv) Pollution levels and control of the dumping of toxic substances.
v) Establishment and monitoring of water quality criteria.

## MANPOWER DEVELOPMENT IN WATER QUALITY MANAGEMENT

With the increasing awareness for water quality management needs, manpower development is certainly one of the areas which need to be strengthened.

On the National front Makerere University (Kampala) is not yet equipped to provide training leadership directed to water qLla1ity management although related aspects such as water chemistry and basic hydrobiology courses can be offered. The newly formed Committee on Wetlands is not fully constituted to provide the necessary services and would certainly need training facilities in wide ranging disciplines of water quality management needs.

UFFRO is the main establishment handling research aspects of water quality. But her research capacity (one water quality scientist) is very 1imited in scope to handle the subject beyond water quality studies as related to the National fisheries. The broader context of strategies to promote the over-all water resources management is be'yond UFFRO's present capacity. Therefore, in light of the potential significance of environmenta11y induced changes in the aquatic systems" effor·ts should be made to facilitate material and intellectual collaborative channels that would adequately lead to sound management of the water resources in Uganda and the r'egionr More ca//aborative arrangements with UFFRO, Makerere University and the Committee on Wetlands on the one hand and UNCRD/ILEC/UNEP on the other would be essential. At the same time increased collaborative strategies should promote the necessary linkages between the Uganda Institutions and those in other riparian countries (Kenya, Tanzania, Zaire, Sudan, etc) on research and management issues affecting the shared water systems (Lakes Victoria, Edward, Mobutu and River Nile). Due to the magnitude of Institutional requirements in Uganda· particularly in terms of technical and professional manpower and in strategies for water resources management p1anning, relevant training at different levels would be required. Therefore, contributions from NGOs and Donor agencies would be necessary also.

The major areas of training needs include basic water resources assessment, land/water ecotone management, extension and networking, planning, etc. Initially the priority target groups for training should include research oriented Institutions (UFFRO and Makerere University) for p,-ob1em identification and assessment,and the Ministry of Environmental Protection (Extension work and administration) for policy formulation and strategy implementation. Clean water for Uganda is quality water for a wide world community.

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Table 1: Basic characteristics of Lake Victoria

| | | | |
|---|---|---|---|
| i) | Riparian Countries | : | Kenya (6.i;·), Taznania(59%), Uganda(43%) |
| ii) | Area | : | 69,000 km² |
| iii) | Catchment area* | : | 184,000 km² |
| iv) | Coast line | : | 3,440 km |
| v) | Altitude | : | 1 m |
| vi) | Volume | : | 2,760 km³ |
| vii) | Flushing time* | : | 140 years |
| viii) | Max. depth | : | 80 m |
| ix) | Mean depth | : | 40 m |
| x) | Rain fall** | : | 1450 mm per year |
| xi) | Fish fauna | : | 350+ species |
| xii) | Fish biomass (Est.)*** | | 700,000 metric tons (1971) |
| xiii) | Fish yield (Est.) | : | 260,000 metrictons(1988) |

* Hecky and Bugenyi (1989)

** Talling (1965)

*** Kudhongania and Cordone (1974)

Table 2. Past and present Chemistry of Lake Victoria.

| Date and source | Na | K | Ca | Mg | DIC | Cl | SO4 | Alkalinity | Si | NO3 | PO4 | Total P | Cond. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/l | | | | | meq/l | | mg/l | | | µS/cm |
| March 1961. | | | | | | | | | | | | | |
| Talling and Talling (1965). | 0.45 | 0.097 | 0.14 | 0.11 | | 0.11 | 0.024 | 0.92 | 69.8 | 0.0 | 0.42 | 1.52 | 97 |
| May 1988. | | | | | | | | | | | | | |
| Hecky and Bugenyi (1989). | 0.34 | 0.09 | 0.12 | 0.09 | 0.92 | 0.093 | 0.003 | 0.84 | 7.1 | 0.2 | 0.23 | 1.13 | 94 |

Dissolved Inorganic Compounds