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Author	Title	Page
Kanyesigye C., Sonko Kiwanuka, Kaggwa C. R. & Okurut T. O	Water quality improvement in the Inner Murchison Bay, Lake Victoria: A Case Study of algal removal at Gaba II Water Treatment Plant	1
Semalulu O., Magunda M. K., Idrakua L., & Okello L.	Non-point pollution into Lake Victoria from Bukora sub-catchment	23
Rukuunya E.	Effect of Sunken Water Hyacinth Biomass on Dissolved Oxygen And Food of Major Inshore Fish Species In Northern Lake Victoria, Uganda	41
Molo, R & Ogwang J. A	Potential of Fungal Pathogens for Biological Control of Water Hyacinth	54
Okurut T. O, Marron F, Kaggwa C. R & Okwerede E. L.	Assessment of industrial and municipal effluent and urban run-off loads discharged into Lake Victoria from the Uganda catchment	67
Magunda, M. K, Majaliwa, J. G M, Tenywa, M. M & Musitwa, F.	Runoff, soil and nutrient losses from major agricultural land-use practices in the Lake Victoria basin, Uganda	87
Wejuli M. S., Magunda M. K. & Lugudo A. B. M.	Persistence in soil and water of selected pesticides used in sugarcane production in the Northern Lake Victoria watershed	103
Wejuli M. S. Muir D., Hecky R. E., Magunda M. K., & Fellin P.	Atmospheric concentrations of organochlorine pesticides in the Northern Lake Victoria watershed	115
Abesiga N. K. C., Huising J., Mosango, M. Majaliwa M. J. Magunda M. K,	Effect of water harvesting on species diversity and overall rangeland recovery in Kagera Microcatchement	128
Busulwa H, Mafabi P., Malinga A., Kyambadde R. & Ssekamate J.	Buffering capacity studies in a rural and urban wetlands in Lake Victoria catchment in Uganda	145
Kansiime F. and Mwesigye P.	Potential impacts of Kirinya Wetland in treating secondary municipal effluent from Jinja Stabilisation Ponds	158

Water Quality Improvement in the Inner Murchison Bay, Lake Victoria: A Case Study of Algal Removal at Gaba II Water Treatment Plant

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ABSTRACT

Gaba II, a conventional water treatment plant in Uganda, draws its raw water from the Inner Murchison Bay of Lake Victoria. Over the last six years (1995-2000), the water quality has changed as evidenced by increase in colour, turbidity and algae (chlorophyll-*a*) concentrations. Increased algal blooms in the Bay have had negative effects on the water treatment especially the clarification and filtration processes. In this paper, the performance of the treatment plant in terms of organic matter and algae removal was assessed using colour, turbidity, permanganate value and chlorophyll-*a* as indicator parameters. Identification and quantification of the dominant algae groups in the treatment process was done, and pilot clarification tests were carried out to identify options for algal removal. The removal of the colour, turbidity, permanganate value and chlorophyll-*a* to the levels of 88%, 71%, 65% and 85% respectively was found to take place mostly at the clarification stage. The results show that Gaba II water treatment plant does not perform well in terms of chlorophyll-*a* removal, especially at the filtration stage. At all the treatment stages, green and blue-green algae were found to be the dominant algal groups. The clarification efficiencies achieved in the pilot tests were 60-80% when using alum alone, 45-50% for alum with lime, 45-75% for alum with copper sulphate and 50-75% for alum with chlorine. This showed that none of the combinations was a better algae removal option than the presently practised clarification using alum alone.

Keywords: Inner Murchison Bay, Algal blooms, Algae removal, Clarification, Filtration

Non-point Source Pollution into Lake Victoria from Bukora, Uganda Sub-catchment

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Abstract

Non-point source pollution from agricultural land is a major contributor of N, P and sediments resulting into eutrophication and siltation of water bodies. The extent of this pollution is accelerated by poor land management practices that lead to extensive soil erosion. Pollutant concentrations and loads from two micro-catchments of Bukora sub-catchment, a predominantly agro-pastoral area of Rakai district, were studied over a three-year period. The two micro-catchments are drained by two rivers, which eventually discharge into Lake Victoria. Three hydrological stations were constructed onto the two rivers and water sampling and river discharge measurement routinely carried out. During the study period, highest rainfall amounts were recorded in April, while peak river discharge (flow rate) occurred during July, signifying a 3-months ground recharge period. Concentrations and loads of Total N (TN) and Total P (TP) were related to Total Suspended Solids (TSS) indicating the contribution of N and P-rich sediments to N and P loading. Seasonal trends in TSS, TP and TN concentrations and loads were closely related to river discharge. Mean annual concentrations for TN ranged from 3.2 to 10.4 mg L^{-1} with loads of 40 to 70 ton yr^{-1}. Annual means for TP ranged from 0.2 to 0.4 mg L^{-1} with loads of 4 to 51 ton y^{-1}, while TSS ranged from 12 to 94 mg L^{-1} with loads of 2 to 40 ton yr^{-1}. Concentrations and loads of TSS, TN and TP were reduced across a wetland, especially during periods of low flow. High sediment, N and P pollutant concentrations and loads are likely a result of extensive soil erosion in the area. Results call for promotion of better land management practices so as to reduce non-point pollution of rivers and consequently, lake Victoria.

Keywords: Eutrophication, Water quality, Watershed management, Wetlands.

Effect of Sunken Decomposing Water Hyacinth (*Eichhornia crassipes*) Biomass on Dissolved Oxygen and Food of Major Inshore Fish Species in Northern Lake Victoria, Uganda

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ABSTRACT

This study examined the effect of the sunken decomposing water hyacinth biomass on dissolved oxygen and food of two major inshore fish species *Lates niloticus* and *Oreochromis niloticus* in the northern Lake Victoria, Uganda. Sampling was done in Thruston Bay where weed collapse occurred and Fielding Bay used as a control. Results reveal significant differences in dissolved oxygen concentration between the two bays ($p<0.05$). Dissolved oxygen fluctuated between 4.6 mg/l and 7.5 mg/l in Thruston Bay compared to 6.2 mg/l to 11.3 mg/l in Fielding Bay. The composition of food items varied in the two bays with *O. niloticus* from Thruston Bay feeding on a wider variety of phytoplankton genera than in Fielding Bay. The Chlorophyceae dominated the diet of *O. niloticus* in both bays, followed by Cyanobacteria, Bacilariophyceae and macro-invertebrates. Significant differences ($p<0.05$) were also observed in the frequency of occurrence of these phytoplanktons in the diet of *O. niloticus* within the two bays. Relative importance of food items to the diet of *O. niloticus* was higher in the inshore fish samples from Thruston Bay than in Fielding Bay indicating increased food availability. Overall, the relative importance of food items ingested by *L. niloticus* was higher in offshore fish from both bays but higher in Thruston than in Fielding Bay. The sunken water hyacinth can be considered as having increased the algal biomass favoring phytoplanktivores. Continued monitoring is recommended so as to understand fully the mortality, dynamics and resurgence potential of water hyacinth for proper guidance of effective weed control.

Keywords: Sunken, Decomposing, Water Hyacinth.

Potential of Fungal Pathogens for Biological Control of Water Hyacinth

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ABSTRACT

Surveys were undertaken in lakes Victoria, Kyoga and River Nile in Uganda between 2000 and 2001 to determine fungal pathogens associated with water hyacinth. Several potential pathogen isolates including *Alternaria eichhorniae*, *Cercospora* sp. and *Acremonium zonatum* were identified. Isolates of *Cercospora* sp. and *A. eichhorniae* were evaluated for their effectiveness on water hyacinth plants in the screen house. The disease incidence and severity progressed with time in both isolates although there was no significant difference ($P>0.05$) between the isolates and overall disease incidence and severity was not significant ($P>0.05$). There was no significant ($P>0.05$) effect of pathogens on overall plant fresh weight, number of living leaves and daughter plants, but linear regression analysis showed a significant ($P<0.01$) decrease in fresh weight of water hyacinth plants. Disease infection increased with increasing conidia concentration and was significantly ($P<0.05$) lower at the lower conidia doses. Host range tests on 9 cultivated plant species showed that sorghum was highly susceptible to *Cercospora* sp. while *A. eichhorniae* did not cause disease symptoms on any of the plants. This study suggests that both pathogens have potential for biological control of water hyacinth, but *A. eichhorniae* is safer to use than *Cercospora* sp.

Keywords: Fungal pathogens, water hyacinth control.

Assessment of Industrial and Municipal Effluent and Urban Run-off Loads Discharged into Lake Victoria from the Uganda Catchment

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Abstract

An assessment was carried out to determine the pollutant loads discharged into Lake Victoria from industrial and municipal sources as well as the contribution from urban run-off from the Uganda catchment from 1997 to 2000. This study was part of the Lake Victoria Environmental Management Project (LVEMP). The paper outlines the outcome of a case study which was the first ever done to quantify pollution loading into Lake Victoria emanating from municipal /urban and industrial sources located in the entire part of the lake catchment of Uganda. Similar work was carried out simultaneously in Kenya and Tanzania. Most urban centres and fishing villages with a potential pollution threat to Lake Victoria were identified. Similarly, factories in Kampala, Jinja and Entebbe with potential pollution threats have been identified. The results show that urban centres contributed a daily load of 6.17 tonnes BOD, 1.43 tonnes of nitrogen and 0.98 tonnes of phosphorus. 1.88 tonnes BOD, 0.26 tonnes of nitrogen and 0.13 tonnes of phosphorus are discharged daily from the 124 fishing villages with a total discharging human population of 92,000. Industrial loads reaching the lake were estimated to be 1 tonne BOD, 0.1 tonnes nitrogen and 0.1 tonnes phosphorus per day. Contrary to the previously long held perception that industries were responsible for much of the pollution loading entering the lake, this study demonstrated that the major pollution loading entering the lake was actually from the urban centres; they accounted for nearly 70 % of BOD and 80 % of other nutrient loads. Kampala accounted for about 60 % of the discharging population and 65 % of the total BOD load. Pollution management strategies proposed for urban centres should therefore focus on improved garbage collection and sanitation, particularly in the Nakivubo catchment of Kampala. There is a need also for a more proactive approach for the protection of wetlands since the study showed the significant role they play in the reduction of pollution loads. Sanitation improvements advocated include:

improved operation and maintenance of the existing municipal wastewater treatment works, strengthening of process engineering expertise (Cleaner production) and greater on-site sanitation coverage. Similar sanitation recommendations apply for fishing villages, but here, the strategy should be focused on improving the ability of fishing village communities to help themselves and access existing sanitation programmes. The strategy for industry is the use of the Pollution Control Manual produced for training and guidance, strengthening of process design capacity, a staged approach to treatment plant development, and strengthening of Discharge Agreements.

Keywords: Pollution loads, Municipal waste, Urban run-off, Fishing villages, Industrial effluent, Lake Victoria

INTRODUCTION

The Lake Victoria Environmental Management Project (LVEMP) was conceived and established as an international response to threats to the lake arising from human activity (World Bank, 1996). A multidisciplinary approach was adopted in an attempt to identify and quantify the key issues that were negatively affecting the lake ecosystem with a view to generating sustainable measures for the overall management of the lake. One of the approaches was implemented under the Management of Industrial and Municipal Effluent and Urban Run-off Component of the project. One of the aspects affecting the lake ecosystem arises from the discharges emanating from the several big and small towns, fishing towns/ villages, industrial establishments, domestic garbage and leachates from garbage dumps located within the catchment of Lake Victoria. However, little was known about the actual loads of pollution from these sources (IMWM, 2000). Further, the impact of the intervening swamps and river systems on these generated loads and the actual pollution load entering the lake was not known.

Previous studies in estimating or quantifying the pollution risk to the lake from point sources and their indexing were based on general perceptions, and yet actual data would provide better data for management purposes. The present waste management strategy used by government targets more on industrial discharges as evidenced by an elaborate legislation in the National Environment Statute (1995) and the attendant Sewage regulations (1999) and Discharge of Effluents into Water or land, (1999). The direct contribution from the run-off and stream discharges from the so many urban centres spread over the entire catchment has so far been ignored as a critical contributor to pollution loading to the lake.

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Runoff, Soil and Nutrient Losses from Major Agricultural Land-use Practices in the Lake Victoria Basin, Uganda

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ABSTRACT

Soil degradation by water erosion is recognized to be a major agricultural and environmental problem in the Lake Victoria basin. The objective of this study was to quantify runoff, soil and nutrient losses from major agricultural land-use types (Annual crops, banana, coffee and degraded rangelands) and assess the efficiency of contour bunds in reducing these losses in two selected micro-catchments of the Lake Victoria Basin. The experiment was conducted on 13 runoff plots of 15 by 10 m. Each land-use type was replicated three times, except banana. Contour bunds were hand constructed two years after establishment of runoff plots, at 20-m spacing interval. Before the establishment of contour bunds, the average annual runoff ranged between 315. 47 and 2438.92 m^3 ha^{-1}/yr, with relatively higher amount of rainfall water loss on rangelands compared to banana and coffee ($p=0.022$). The avarage annual soil loss ranged from 27.7 to 86.7 t/ha/yr, with higher soil loss on annuals compared to banana and coffee ($p=0.038$). Seasonal soil losses contributed for more than 75% of the annual losses for all agricultural land-use, while seasonal runoff contributed the same proportion only for banana and rangelands ($p<0.05$). Eroded sediments had relatively high nutrient concentrations than the remaining soils, and varied with land-use and /or seasons ($p<0.05$). The amount of N, P, K and organic matter (OM) lost through erosion was relatively high, and varied with seasons ($p<0.05$). The establishment of contour bunds increased OM, Ca and Na content in eroded sediments, while it decreased total OM, TN losses for all land-use types except on rangelands where they increased one year after. These exports from agricultural land play a major role in the nutrient enrichment of rivers and open bodies.

Key words: Pollution, Sustainability, Farming system, Land-use, Soil nutrient losses.

Persistence of Selected Pesticides used in Sugarcane Production in Soil and Water in the Northern Lake Victoria Catchment

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ABSTRACT

Pesticide use in the Lake Victoria catchment area of Uganda has continuously been increasing in the last ten years due to increase in the production of horticultural export crops and sugarcane. The farms have to use pesticides for increased crop productivity in order to meet market demands. This study was conducted to monitor pesticide levels in soils and runoff water following treatment of a sugarcane field in the Northern Lake Victoria watershed. Soil and water samples were collected over a period of 304 days after planting of the sugarcane and analysed for pesticide residues. In soils, glyphosate levels ranged from 0.8-135.5 µg/kg. Ametryn ranged from 44.9-1705.4 µg/kg, and Dichlorophenoxy acetic acid (2.4-D) 15.6 – 1835.2 µg/kg. In water, glyphosate levels ranged from 1.3 to 42.2 upstream and 0.4 to 9.3 downstream, ametryn ranged from < 15 to 31.5 µg/l upstream and from <15- 18.6 g/l downstream and, 2.4-D<10 to 15.7 µg/l upstream and <10 to 13.4 µg/l downstream. The quality of water obtained was compared with the Canadian Environmental Quality thresholds for fresh water, irrigation and livestock water for selected pesticides. At the applied rates the use of herbicides Touch down (48% glyphosate trimesium) and Gesapax-H (21% ametryn and 29%, 2,4-D) for the control of weeds in sugarcane farming system at Kakira was found to be within acceptable levels.

Keywords: Pesticides, soil, water, pollution, concentration.

Atmospheric Concentrations of Organochlorine Pesticides in the Northern Lake Victoria Watershed

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ABSTRACT

Organochlorine pesticides may still be in use in the Eastern African region for agricultural purposes and for the control of mosquitoes. Atmospheric concentrations of organochlorine pesticides are expected to be higher in the tropics compared to temperate regions due to prevailing high temperatures. However, no study has been conducted to investigate atmospheric transport and deposition of pesticides in East Africa. In this study atmospheric concentration of organochloride pesticides in the air were determined at Kakira near Jinja from November 1999 to March 2000. Total DDT was in the range 64.8-610.9 pg/m^3, dieldrin 23.6-90.8 (average 45.7) pg/m^3, α-endosulfan 32.5-206.1 (average 92.4) pg/m^3, lindane (γ-HCH) 20.3-183.6 (average 70.5) pg/m^3, chlordane and heptachlor and hexachlorobenzene (HCB) ranged from <0.1- 10.1 pg/m^3. The insecticide p,p'-DDT metabolite, p,p'-DDE was the predominant DDT isomer ranging from 22.6-390.1 pg/m^3. However, o,p'-DDT isomer was frequently detected (11.2-62.8 pg/m^3) and its metabolite p,p' DDE was relatively high ranging from 29.9-109.9 pg/m^3. The most predominant organochloride pesticides in decreasing average concentration levels DDT (total), α-endosulfan and lindane, p,p-DDT, p,p'-DDT, p,p'-DDE, dieldrin and

o,p'-DDT. Average levels of p,p'-DDT and p,p'-DDE at Kakira were lower than those reported for Brazzaville but higher than those reported for Lake Baikal and Southern Ontario while α-HCH, γ-HCH, total chlordane, and hexachlorobenzene (HCB) concentrations for Kakira were lower than those reported for Brazzaville, Lake Baikal in Russia, Southern Ontario. In comparison with data from Senga Bay, Lake Malawi in Malawi, average DDT (total), p,p'-DDE, p,p'-DDT, o,p'-DDT, lindane (γ-HCH) and ΣHCH levels were higher and average dieldrin, α-HCH, chlordane and HCB levels were lower. The presence of these chemicals in air at Kakira was most likely due to both local and regional inputs.

Keywords: Concentration levels, organochloride pesticides, air, Lake Victoria

INTRODUCTION

Lake Victoria is the second largest lake in the world. However, the quality of its waters and fisheries has been affected by the land-based activities such as agriculture. The increasing population pressure and socio-economic activities within the basin have led to increased agricultural activities. Increasing population pressure has also led to increased land pressure, which in turn, has prompted the need to increase agricultural production per unit area rather than increasing production by increasing acreage. This has compelled farmers to use agrochemicals in order to increase and sustain productivity. Increasing agrochemical use and the purchase of chemicals from uncontrolled sources has led to indiscriminate use. A survey conducted in the Uganda Lake Victoria catchment revealed continued use of organochlorine pesticides lindane (γ-HCH) and α-endosulfan (Wejuli and Magunda, 1998). The updated Agrochemicals Database (1999) of the Land Use Management Component of Lake Victoria Environmental Management Project (LVEMP) showed that over 1659.7 kg α-endosulfan and 398.7 kg lindane (γ-HCH) were used in the Uganda catchment area of the lake during 1999. Some chlorinated chemicals have also been reported to be present as micro-contaminants in other pesticides, for example, DDT in dicofol and hexachlorobenzene (HCB) in lindane (Bailey, 1998). DDT is also still used as a vector control in Southern and Eastern Africa. Chlorinated chemicals are very persistent in soil, air and water. Post-application volatilisation and subsequent atmospheric transport is a primary means by which these chemicals may be deposited in areas far from their source of application. Volatilisation is the source of pesticides found in air, rain, or fog that indicate local, regional and global transport (Eisenreich *et al.*, 1981; Glotfelty *et al*, 1987; Karlsson *et al.*, 2000). Consequently, the Lake Victoria system may be receiving chlorinated compounds from outside its watershed in addition to

Effect of Water Harvesting on Species Diversity and Overall Rangeland Recovery in Kagera Microcatchement

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ABSTRACT

Plant species diversity was investigated on ridges with and without water harvesting structures. The effect of water harvesting technology on the soil properties and rangeland recovery was also investigated. The experimental sites are located in Kifamba, Kakuuto County Rakai District. Plant species were recorded on a 50m horizontal transect aligned on the main transect running S-N on a 20 m lag. The quadrat method was used to sample grasses and herbs, whereas shrubs and trees were sampled on twenty five meter plots on consecutive horizontal transects. Soil physical and chemical properties, plant biomass and ground cover were determined along the landscape. Results indicate that, ridges with water harvesting structures had higher species diversity than those without water harvesting structures ($p<0.05$). The plant diversity on ridges with water harvesting (Shannon Diversity index) was $H' = 4.46$, while the diversity of ridges without water harvesting was $H' = 3.93$. The two types of ridges were significantly different ($p<0.001$) in terms of the diversity of plant species. The results further reveal that the introduction of water harvesting structures did not induce a landscape position pattern in the distribution of species, but that of grass biomass, despite the uniformity of chemical properties along the landscape ($p<0.05$).

Keywords: Ecology, Rangeland restoration, Species diversity, Land productivity.

Buffering Capacity Studies in a Rural and Urban Wetlands in Lake Victoria Catchment in Uganda

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ABSTRACT

Wetlands are known to filter water from catchments by retaining solid waste, and eroded sediments from catchment areas. Wetlands also reduce the impact of flooding, speed of flow, and hence store water while releasing it slowly. The extent to which the wetlands perform these roles was investigated in two wetlands, Kinawataka wetland with an industrial and heavily populated catchment, and Kisoma wetland with subsistence agricultural catchment between January 1999 to July 2001.

Water samples were collected once a month from streams entering the wetlands, along transects within the wetland and at the out flow. Parameters investigated included pH, temperature, dissolved oxygen (DO), electric conductivity (EC), Total Dissolved Solids (TDS), orthophosphates, Total Phosphorus (TP), nitrates, Total Nitrogen (TN) and chemical oxygen demand (COD).

Results showed that the urban Kinawataka wetland receives a lot of pollution from its catchment and this is considerably reduced as the water move through it to the out flow. Reductions of TN by 50% and TP by only 10% were noted. The rural Kisoma wetland however receives fewer nutrients from its catchment but releases more in its out flow. There were increases in orthophosphates to about 50%, TP to 40% and nitrates to 22%. In situations where large volumes of water was received especially after a heavy storm or during floods, the wetland capacity to buffer was impaired and the materials from the catchment would pass through it unbuffered.

It is suggested that wetland buffering depends on the amount of nutrients and water inflow from the catchment, the wetland-slope, nature of the vegetation, size of the wetland, catchment rainfall and anthropogenic characteristics. The conditions within the wetlands modify the nature of the nutrients as the water flow through them.

Key words: Buffering capacity, wetland buffering, catchment, reservoir, nutrients

Potential Impacts of Kirinya Wetland in Treating Secondary Municipal Effluent from Jinja Stabilisation Ponds

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ABSTRACT

Kirinya West wetland is located on the Northern shores of Lake Victoria in Jinja- Uganda. The wetland receives secondary treated effluent from the stabilisation ponds owned and operated by the National Water and Sewerage Corporation. The effluent finally enters Lake Victoria at the Napoleon Gulf. In this paper, we report the baseline water quality before the bio-manipulation of the wetland and demonstrate the impact of Kirinya West wetland in treating secondary municipal effluent from the existing waste stabilisation ponds. The bio-manipulation of the wetland will entail spreading the effluent from the stabilisation ponds over the northern edges of the wetland so as to increase the treatment area of the wetland and its treatment efficiency. Bio-manipulation will increase the current treatment efficiency of the wetland, as the contact between plants and the wastewater will increase. The baseline data indicate that there was significant improvement of water quality as the wastewater flowed through the ponds (61% decrease in NH_4-N, 46.9% in PO_4-P and 98% in faecal coliforms). There was a further reduction in the concentration of pollutants (80% for NH_4-N and 98% for faecal coliforms) as the wastewater flowed through the wetland before reaching Lake Victoria at the Napoleon Gulf. However, channelised flow allowed wastewater to flow at the western edge of the wetland and this is associated to the effluent from the stabilisation pond that discharge at the north-western edge of the wetland.

Keywords: Bio-manipulation, Kirinya West wetland, Lake Victoria, Wetlands, Wastewater treatment