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SUSTAINABILITY OF WATER AND SANITATION SYSTEMS

Role of wetlands in wastewater purification

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KAMPALA CITY DISCHARGES raw and secondary treated wastewater into the Nakivubo swamp mainly via the Nakivubo Channel which ends 1.2km from Lake Victoria at the Inner Murchison Bay. The bulk of its water supply is drawn from the same bay at a location only about 4km from the wastewater discharge zone.

Although it has been appreciated that there is considerable improvement in quality between the water entering and that leaving the swamp, it is not known how much longer the swamp can take uncontrolled discharges without drastic effects on its ecosystem (Kizito, 1986; Taylor, 1991; Draft Wetlands Policy for Uganda, Version 7, 1992; Wozei, 1994). This is especially so since the nutrient-rich effluent from the municipal sewage treatment works at Bugolobi is discharged into the Nakivubo Channel without further treatment. If this effluent were to pass through the swamp unmodified, there would be a high risk of eutrophication of the Murchison Bay. This would eventually affect the quality of the city's water supply.

Elsewhere in the world, wetlands have been found to significantly improve the quality of water flowing through them(Maltby, 1986; Finlayson *et al.*, 1986; Taylor, 1991). This study was carried out to assess the role of this wetland in the control of water quality in the Murchison Bay.

Study objectives

Specific objectives of the study were:

- To determine the effect of the swamp on select physicochemical and biological parameters including: biochemical oxygen demand (BOD), Coliform bacteria count, pH, and electrical conductivity (EC).
- To compare the performance of Nakivubo swamp with that of other wetlands, elsewhere in the world, also receiving wastewater.

Materials and methods.

Three transects were cut laterally across the swamp. Transect 1 (T1) is a channel cut in the papyrus mat. Samples were collected and *in situ* measurements taken both in the channel and through holes in the papyrus mat at the side of the channel. On Transects 2 and 3 (T2 and T3) measurements were taken through holes cut in the mat.

Samples were collected just below the papyrus mat using a water column. Details of the sampling locations are given in Table I.

Dissolved oxygen (DO) levels, EC and temperature were measured *in situ* using microprocessor probes over a period of six months (November 1993-April 1994). Collection and analysis of water samples for coliform bacteria and 5-day BOD was done from February to April 1994. All measurement and sampling was done once to twice a month between 10am and 3pm.

Results and discussion

Measurements made in December 1993 along Transects 1 and 3 showed a maximum and minimum pH of 6.68 and 6.00 respectively. pH values varied little across T1, while on T3 the pH increased lakewards. On the whole, the pH levels in the swamp reduced lakewards as indicated in Figure 1. The acidity of the swamp water is seemingly due to organic acids from decomposing organic matter and does not show a conclusive pollution effect.

DO levels ranged between 0.0 and 0.5 mg / l. This is one of the characteristics of the water below the mat of a papyrus swamp (Taylor, 1991). Low DO levels, in combination with availability of nutrients, encourage a eutrophic environment (Chant, 1970). In anaerobic conditions, pollutants like ammonia-nitrogen will not be converted to gaseous nitrogen which can be lost to the atmosphere. In addition, it is believed that phosphorus release from sediments may be redox controlled (Bostrom & Pettersson, 1982). The naturally anaerobic conditions below the mat, therefore, heighten the risk of eutrophication of the adjacent waters in the Murchison Bay.

Table 1. Details of measurement and sampling points

Figure 1. Variations of pH from Nakivubo channel to transect 3

Figure 2. Variations of EC between transects 1 and 3

Figure 3. Variations of EC along the three transects showing peaks at certain points

EC measurements taken at the Nakivubo Channel Inlet and T1 gave values consistently greater than 400 µS / cm. This is more than twice the EC of 80-150 ìS / cm expected in a natural papyrus swamp (Taylor, 1991). The Inlet value was equalled at several points on T1 implying that the swamp between the Inlet and T1 may already be saturated with nutrients from the Channel water. It is possible that this is either a result of channelling of the wastewater flow in the swamp or the short residence time between the Channel Inlet and T1. Figure 2 shows, however, that there is a decline in EC between T1 and T3. This confirms the ability of the swamp to reduce the ionic species of influent waters. A similar trend was noted by Taylor(1991).

From the EC measurements it was ascertained that there are preferential routes of water flow below the mat. This was indicated by peaks in the EC measurements at given sampling points(See Figure 3). It was at these points of consistently maximum EC that the samples for the bacteriological analysis and the BOD test were collected. These were assumed to be the points of maximum pollution. Depth profiles showed that between 50 and 200cm below the papyrus mat EC values were largely unchanged. It is believed that at this depth, flow is largely unhindered by the plant roots above and the sediment below. The low contact results in reduced nutrient uptake and adsorption of other pollutants, hence the negligible EC reductions. This is one of the disadvantages of horizontal flow through floating wetlands like papyrus swamps.

Temperatures recorded varied between 18.6^{o}C and 26.3^{o}C. The effect of the swamp was probably modified due to shading by the plants, the presence of clearings along the transects and the exclusion of sunlight by the papyrus mat. Little or no difference (<2^{o}C) was shown between temperatures just below the water surface and up to 260cm depth at a given sampling point.

High coliform bacteria counts in the order of 10^4 to 10^6 MPN / 100ml were obtained from samples taken both at the Inlet and on the Transects. In spite of this, there is a significant reduction in both total and faecal coliform counts between the Inlet and T3 as depicted in Figure 4. Effective coliform bacteria removals of over 97% were recorded between the Inlet and T3 in April 1994. This compares favorably with the >80% removal efficiencies from both natural and artificial wetland systems in India, the U.S.A., and The Netherlands (Maltby, 1986).

Although the short study period did not elicit a definite trend in BOD values, the samples obtained from the swamp were generally oxygen deficient and contained large amounts of organic matter. BOD_5 values of up to 69 mg / l were recorded.

In this study, the effect of dilution and detention time in the swamp were not considered. The need to determine the role of these parameters on pollutant levels in the swamp was acknowledged. Already, further study is being carried out in several related areas including nutri-

Figure 4. Coliform bacteria counts, April 1994

ent uptake characteristics by the swamp, flow patterns, and seasonal variations of the purification effect of the swamp.

Conclusion

There is a general decline in pollution levels lakewards. This shows that the swamp is still buffering the environment even in the present uncontrolled situation. In essence, the swamp is providing the city with a relatively efficient wastewater treatment system. In addition, the swamp is protecting the city's source of water supply since the raw water quality in the Murchison Bay is probably dependent to a large extent on the swamp effect on the influent wastewater. Sustainable utilization of the swamp in this role will only be possible if its importance is recognized and suitable management measures are put in place by the relevant authorities.

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