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THE POTENTIAL OF NAKIVUBO SWAMP (PAPYRUS WETLAND) IN MAINTAINING WATER QUALITY OF INNER MURCHISON BAY - LAKE VICTORIA.

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ABSTRACT

Nakivubo swamp (papyrus wetland) is located in the south east of the city of Kampala, Uganda. This swamp has been receiving waste water from Nakivubo channel for more than two decades. This investigation was aimed at monitoring the level of pollutants (nutrients and faecal coliforms) as the waste water filtrates through the swamp and the flow patterns of waste water through the swamp. From this preliminary investigation it was found out that the waste water is not evenly distributed over the swamp. Also high levels of pollutants seem to filtrate through the swamp and enter Inner Murchison Bay - lake Victoria. Further research is under way to investigate in more detail the capacity of Nakivubo swamp to remove nutrients/pollutants from waste water flowing through it and the dominant mechanisms/processes involved.

INTRODUCTION:

Industrialisation and population increase have resulted in increased production of waste water which has also accelerated eutrophication of surface waters and spreading of waterborne diseases.

Wetlands are currently seen as cheaper technologies to remove nutrients from waste water (tertiary treatment) as they have low investment and operational costs. However, more land is required compared to conventional treatment systems (HAMMER & BASTIAN, 1989).

Wetlands remove nutrients from waste water through physico-chemical and biological mechanisms. Nitrogen is removed from waste water through processes of ammonification, nitrification, denitrification and plant uptake (BREEN, 1990; HAMMER and KNIGHT, 1992). Plant uptake is the only mechanisms through which phosphorus can be removed from wetlands as there is no equivalent of denitrification during phosphorus transformation (PATRICK, 1990). Phosphorus is usually absorbed by or adsorbed to the sediment temporarily and when the sediment is saturated the reverse process (desorption) takes place. Export of phosphorus from wetlands has actually been reported (GEHRELS and MULAMOOTTIL, 1989). Henceforth, harvesting of wetland plants has been recommended by several authors as the only management option for removing phosphorus from wetlands (MUTHURI et al; 1989; BREEN, 1990).

Papyrus wetlands, because of their locations (between land and open water) have been used for treatment of sewage effluents and run-off from towns and agricultural areas. These wetlands have been reported to remove nutrients from waste water (CHALE, 1987; TAYLOR, 1991; KIZITO, 1986).

Papyrus wetlands are both emergent and floating and have high biomass productivity compared to other macrophytes (GAUDET, 1977). These characteristics, make papyrus wetlands promising for waste water treatment. It has recently been demonstrated that, *C. papyrus* can significantly remove nutrients (nitrogen and phosphorus) from synthetic waste water under green house conditions (VAN BRUGGEN et al., 1992; KANSIIME, 1993; OKIA 1993). However, from available literature on constructed and natural wetlands, it is still uncertain as to what degree of efficiency can be achieved by *C. papyrus* in waste water treatment. Furthermore, the performance of wetlands has been reported to vary from one geographic region to another (HAMMER AND KNIGHT, 1992). Henceforth, a research programme is currently going on to develop a strategy for sustainable use of Nakivubo swamp for waste water treatment and other anthropogenic uses. The aim of this investigation was to establish the fate of major pollutants and flow patterns of the waste water flowing through the swamp into Inner Murchison Bay - Lake Victoria.

MATERIALS AND METHODS

Description of the Study Area

This investigation was carried out in Nakivubo swamp during the period of August to September 1993. The schematic representation of the swamp is depicted in Fig. 1.

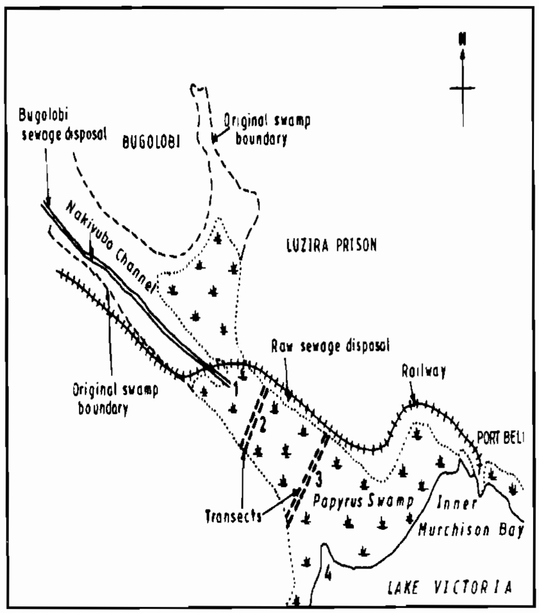

Fig. 1. Schematic map showing the study area (Nakivubo swamp) and the sampling sites.

Nakivubo swamp receives secondary treated effluent from Bugolobi sewage works and storm water run-off from Nakivubo Channel. It also receives raw sewage from Luzira Prisons. Samples were taken from sites 1 to 4. Site 1 represents the point where waste water from Nakivubo Channel enters Nakivubo swamp. At site 2 a channel was dug across the swamp at 230 m from the beginning of transect 1, as this part of the swamp was inaccessible. A canoe was used to reach most parts of this transect to take samples. Transect 2 was cut across site 3. Site 4 is the interface between the swamp and Inner Murchison Bay. At this site, two locations (LKA and LKB) were used in this study. LKA is at the lake - swamp interface while LKB is 20 m from LKA.

Analyses

Electrical conductivity, pH, dissolved oxygen and temperature were measured in situ using appropriate probes and according to manufacturers instructions. Ammonium nitrogen and orthophosphate, were determined according to Standard Methods (APHA, 1989) using salicylate and ascorbic acid methods respectively. A Hach spectrophotometer (DR 2000) was used. Precision and accuracy of the spectrophotometer and the procedures used for the analysis of samples, were counter - checked by determining the concentration of a known standards.

Faecal coliforms were determined according to standard methods, using the Most Probable Number technique (APHA, 1989).

RESULTS AND DISCUSSION

Level of Pollutants in Nakivubo Swamp

The fate of pollutants (nutrients and bacteriological indicators) were monitored as the waste water (carried by Nakivubo Channel) enters the swamp, within the swamp, and at the interface between the swamp and Inner Murchison Bay (Fig.1).

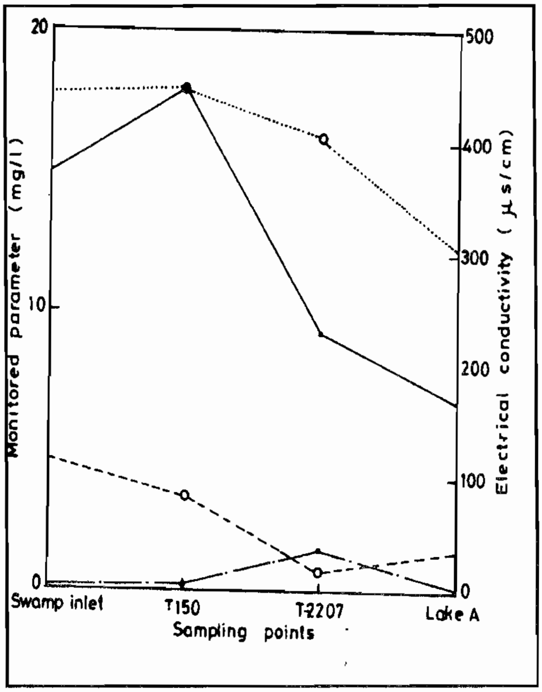

Fig. 2. Variation of ammonia (- ● -) nitrate (●- , -●) phosphate (--o--) and conductivity (. o ..) as waste matter filtrates through the swamp. Swamp inlet is the point where the waste water from Nakivubo channel enters the swamp; T150 is a point 50m along channel 1,T2207 is 207m along transect 2 and lake A is the interphase between the swamp and Inner Murchison Bay - lake Victoria (site 4, Fig.1).

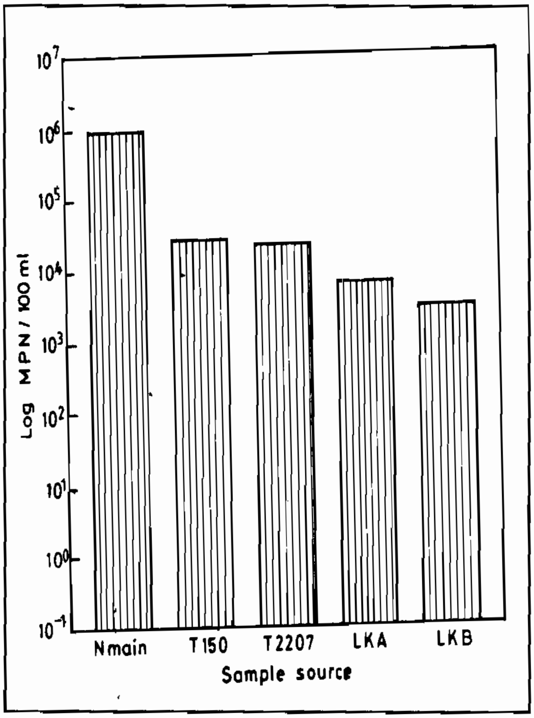

Fig. 3. Level of the feacal coliforms as waste water filtrates through the swamp N. main is the point where the waste water Nakivubo channel enters the swamp; T150 and 207m and T2207 are points at 50m and 207m along channel 1 and transect 2 respectively; and LKA is a point at the Lake - swamp interphase while LKB is 20m from LKA.

The variations of measured parameters are presented in figures 2 and 3. As can be seen from the graphs there was general decrease in the levels of all measured parameters (nutrients and faecal coliforms) as the waste water from Nakivubo Channel filtrates through the swamp though high levels of pollutants reach Inner Murchison Bay - lake Victoria.

The effect of these pollutants on Lake Victoria (Inner Murchison Bay) depends on the pollutant loads into the swamp and also on the duration of discharge. Continuous discharge without information on the carrying capacity of the swamp could later lead to saturation and subsequently most pollutants would flow through the swamp unaffected.

It should also be noted that dilution and mixing in the lake may largely account for the decrease in the levels of pollutants and more specifically faecal coliforms as depicted in Fig.3. This is because LKA is at the interface between the swamp and open water, whereas LKB is just 20m from LKA (LKA & LKB are located at site 4, Fig. 1). Decrease in levels of faecal coliforms (which might be more dramatic far towards the lake side from site 4) cannot be fully explained by removal processes.

Flow Patterns of Pollutants in Nakivubo Swamp.

To get an insight into the flow patterns as the waste water flows through Nakivubo swamp electrical conductivity and faecal coliforms were used as tracers.

Monitoring of these parameters was done along transects 1 and 2 (sampling sites 2 and 3, Fig. 1) and the results are presented in figures 4 and 5).As can be seen from the graphs, the peak of the waste water plume apparently flows through transect 1 at T150 (T150 = 50 m from the beginning of channel 1) and transect 2 at T 2207. The electrical conductivity of the swamp influent was more less the same as that found at T150 (444 μ/cm). More or less the same value was observed along channel 1 towards Luzira (prisons side) implying that, the waste water

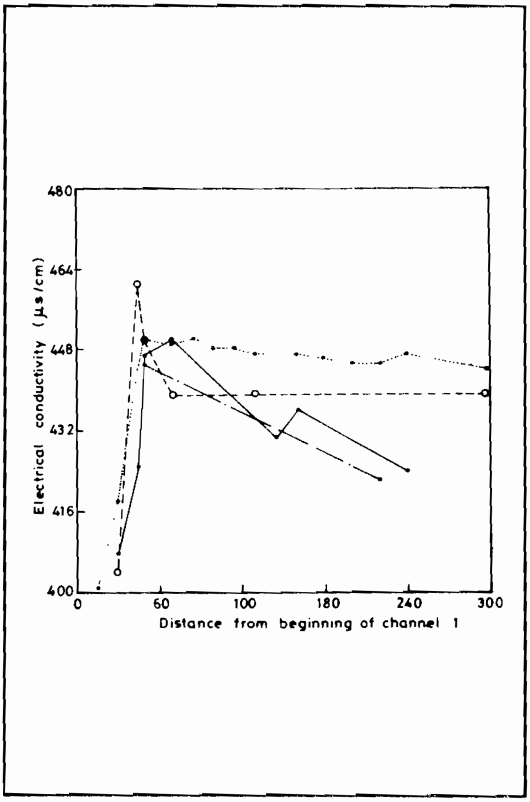

Fig. 4. Variation of Electrical conductivity with distance along channel 1. (● - . -● 0cm; -o- 50 cm; ...o... 100 cm; -•- side water).

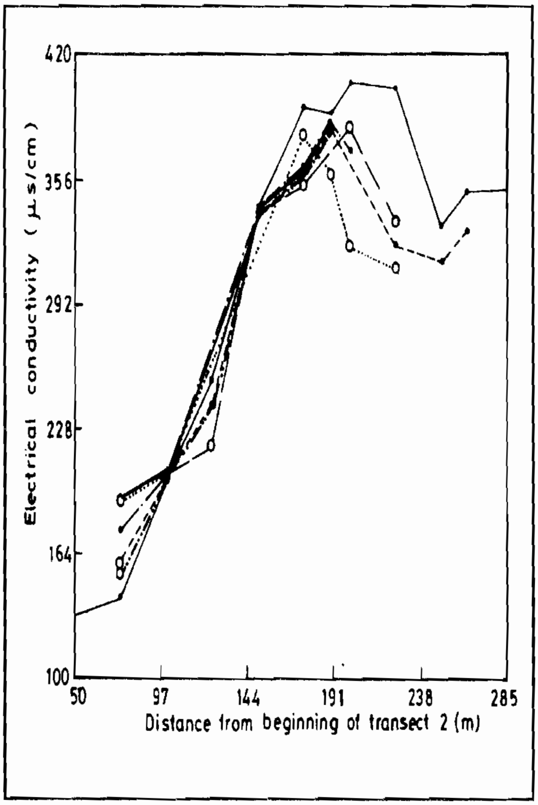

Fig. 5. Variation of Electrical conductivity with distance along transect 2 (●- ●) 0cm; o- . . -o 30 cm; o - - o 40 cm; ● -- -- ● 60 cm; ●- . - ● 80 cm; o - o 100 cm; o . . . . . . o 120 cm).

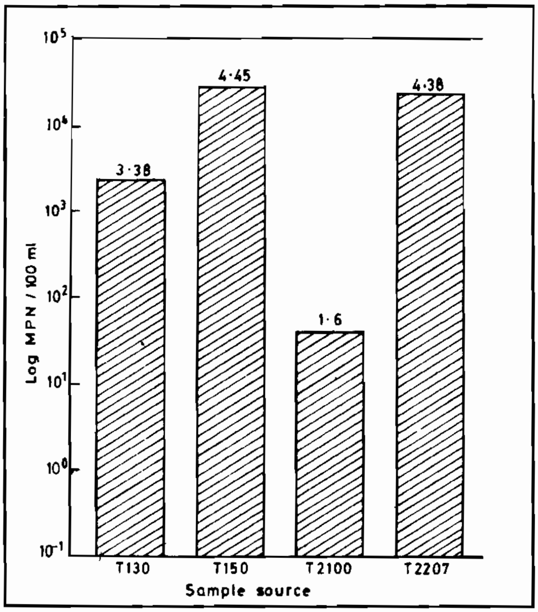

Fig. 6. Variation of feacal coliforms at given distances along channel 1at a distance of 30 m while T2100 is transect 2 at distance of 100m.

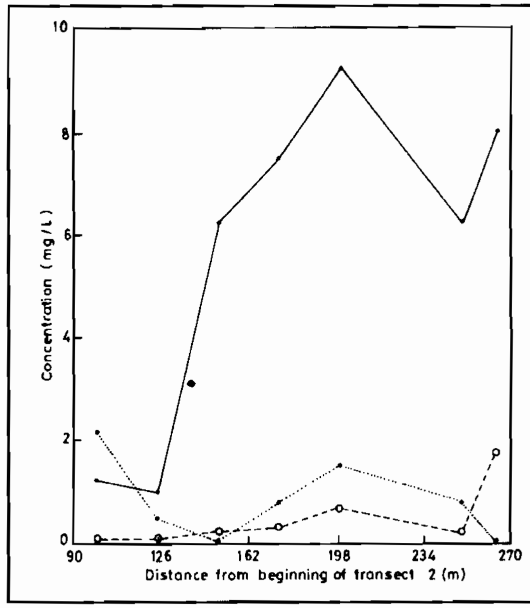

Fig. 7. Variation of ammonia (● - ●); nitrate (● . . . . ●) and phosphat (O - - O) along transect 2.

tends to flow towards Luzira (up to 15m from the end of the swamp) after entering transect 1 before eventually flowing to the lake through transect 2.

The flow pattern of waste water was also predicted by the visual appearance of papyrus plants. Plants along the predicted path of waste water were lush and more green compared to those at the edge of the swamp towards Bukasa side (Muyenga Hill). The latter were stunted and yellowish in appearance and generally shorter in height. Since the green colour indirectly implies that the plants are getting more nutrients, it was also stipulated that the level of pollutants in waste water should be higher along the predicted path of waste water. As a result, the level of nutrients were monitored and the results for transect 2 are depicted in Fig. 7. As can be seen from the graph, high concentrations of nutrients were obtained at a distance of 207 m from the beginning of transect 2. This is the same spot where maximum electrical conductivity (Fig. 5) and faecal coliforms (Fig.6) were detected.

CONCLUSIONS

The results presented clearly demonstrate that waste water from Nakivubo channel is not evenly distributed over Nakivubo swamp. However, there is also need to investigate the flow patterns of waste water during a rainy season.

The observed flow pattern implies that waste water purification is carried out by a small portion of the swamp. Earlier reports, KIZITO, (1968); TAYLOR, (1991) mentioned that there was significant improvement of water quality as the waste water flows through Nakivubo swamp. However, their observations might have been influenced by dilution and mixing at the swamp - lake interface. Since, we also could not carry out a detailed investigation at the interface (the place was in most cases covered by the water Hyacinth, making navigation difficult), we could not predict accurately the whole area of the lake - swamp interface where the waste water flows into Inner Murchison Bay. However, use of transects within the swamp, gave a clear indication on the flow patterns of waste water in the swamp and the portion of the swamp under the influence of waste water.

Since high levels of pollutants (NH_4-N and faecal coliforms) were detected at the lake - swamp interface of Inner Murchison bay, and Nakivubo channel is continuously discharging into Nakivubo swamp, this implies that pollutants are continuously reaching Inner Murchison bay. This is an undesirable situation as it might eventually lead to the eutrophication of Inner Murchison bay and Lake Victoria in general. Henceforth, there is need to reduce/minimise the pollutants carried by Nakivubo channel to desirable levels.

Recommendations for future work

(i) Making a mass balance for N and P for Nakivubo swamp.

(ii) Quantifying the predominant mechanisms/processes involved in N and P transformations.

(iii) Water balance of the swamp.

(iv) Substantiate the role played by *C. papyrus* in Nakivubo swamp .

SUMMARY

This study was carried out in Nakivubo swamp which is dominated by *Cyperus papyrus* and is located in the south east of the city of Kampala, Uganda. The swamp has been receiving waste water from Nakivubo channel for more than two decades now. Nakivubo channel carries secondary treated effluent from Bugolobi sewage works and storm water run-off from the city of Kampala.

This investigation was aimed at monitoring the level of pollutants (nutrients and faecal coliforms) as the waste water filtrates through the swamp and the flow patterns of waste water through the swamp. The results indicate that waste water is not evenly distributed over the swamp but has preferential flow paths. This was also revealed by the lushness of the vegetation (papyrus plants whereby plants under the influence of the waste water were more healthy (green, thick and tall plants).

The results further indicate that high levels of pollutants seem to filtrate through the swamp and enter Inner Murchison Bay - Lake Victoria. This is because high levels of pollutants (NH_4-N and coliforms) were detected at the swamp-lake interface. Despite the fact that there was a reduction in pollutants towards the lake from swamp-lake interface, this decrease could largely be attributed to dilution and mixing in the lake than removal processes.

Since Nakivubo channel is continuously discharging into Nakivubo swamp, this implies that pollutants are continuously reaching Inner Murchison bay. This is not a desirable situation as it might eventually lead to the eutrophication of Inner Murchison bay and Lake Victoria in general. Henceforth, there is need to reduce/minimise the pollutants carried by Nakivubo channel to desirable levels.

This study has diverted from the 'black box approach' (in-out approach) of studying Nakivubo swamp by using transects which were cut across the swamp. The transects helped us to monitor pollutants as they enter the swamp, within the swamp and at the lake-swamp interface.

Further research is under way to investigate in more detail, the capacity of Nakivubo swamp to remove nutrients/pollutants from waste water flowing through it and the dominant mechanisms/processes involved.

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REFERENCES

APHA, (1989). Standard methods for examination of water and waste water. American Public Health Association, Washing. D.C.

Breen, P.F. (1990). A mass balance method for assessing the potential of artificial wetlands in waste water treatment. *Wat. Res.* 24: 689-692.

Chale, F.M.M. (1987). Plant biomass and nutrient levels of a tropical macrophyte (*Cyperus papyrus* L.) receiving domestic waste water. *Hydrobiol. Bull.* 21: 167 - 170.

Hammer, D.A. and Bastian R.K. (1989). Wetlands ecosystems: natural water purifiers? *In:* Hammer, D.A. (ed.). *Constructed wetlands for waste water treatment.* Lewis Publishers, Inc. Michigan, pp 5-19.

Hammer, D.A. and Knight, R.L. (1992). Designing constructed wetlands for nitrogen removal. *In: Proceedings of the International Specialist Conference on Wetlands Systems in Water Pollution Control.* Nov. 30th to 3rd Dec. 1992, Sydney, Australia. pp 3.1 - 3.37.

Gaudet, J.J. (1977). Uptake, accumulation and loss of nutrients in tropical swamps. *Ecology* 50: 415 - 422.

Gehrels, J. and Mulamoottil, G. (1989). The transformation and export of phosphorus from wetlands. *Hydrobiological processes* 3: 365 - 370.

Kansiime, F. (1993). The role of floating *Cyperus papyrus* purifying waste water in a segmented constructed wetland. M.Sc. Thesis, EE 124, IHE, Delft, The Netherlands.

Kizito, H.S. (1986). The evaluation of pollution levels in Nakivubo Channel, Kampala - Uganda. M.Sc. Thesis, Makerere University, Uganda.

Muthuri F.M., Jone, M.B. and Imbamba, S.K. (1989). Primary productivity of papyrus (*Cyperus papyrus*) in a tropical swamp; Lake Naivasha, Kenya. *Biomass* 18: 1-14.

Okia, O.T. (1993). Characterization of waste water purification by *Cyperus papyrus* floating in a segmented channel. M.Sc. Thesis, EE 107; IHE Delft, The Netherlands.

Patrick Jr. W.H. (1990). Microbial reactions of nitrogen and phosphorus in wetlands. In: can Oorschot, M.M. P. and Verhoeven, J.T.A. (eds.) *The Utrecht Plant Ecology News Report*, Utrecht, pp 52 - 63.

Taylor, A.R.D (1991). Status of Nakivubo and Luzira swamps in Kampala. Report prepared for the Ministry of Environment Protection, Natural Wetlands conservation and; management programme, Kampala - Uganda.

van Bruggen, J.J.A., Zhao, Qun and van Vierssen, W. (1992). Purification of waste water by *Cyperus Payrus*. *In: Proceedings of the International Specialist Conference on Wetland Systems in Water Pollution Control.* Nov. 30th to 3rd December 1992. Sydney, Australia.