RUFORUM Working Document Series (ISSN 1607-9345), 2018, No. 17 (1): 417-423.
Available from *http://repository.ruforum.org*

Research Application Summary

Restoration status of Nakayiba wetland, Masaka, Uganda

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Abstract

Many wetlands in Uganda have been converted into uses that are injurious to nature. However, besides just a few of them being restored, the success of restoration for any of them has not been assessed to guide future restoration efforts in the country. The study evaluated the restoration status of the Nakayiba wetland that serves the function of filtering the partially treated municipal wastewater in Masaka District. The focus was on key vegetation and water quality attributes. Plant recolonization status along the wetland was followed using quadrats (4m2) while pollution attenuation capacity was evaluated at the main inflow (confluence) and outflow using appropriate meters and lab analyses. Plant recolonization was not even; vegetation in the wetland was mainly dominated by Impatiens tinctoria (40.7%) although the upstream (42.8%) and midstream portions (36.1%) were mostly covered by Cyperus latifolius. Other major plants present included Cyperus papyrus (9.7%) mainly downstream (18.3%) and Typha latifolia (1.8%) found only downstream. Water quality studies showed significant ($p<0.05$) reductions in the physico-chemical parameters. There was high phosphorus retention at 87% total phosphorus (TP), and 92% Ortho-phosphates (-PO4 3-) but low nitrate retention, NO3- (24.4%). Furthermore, fecal coliforms (FC) reduced from 9160 to 350 CFU/100 ml representing a 96.18% retention capacity while pH varied between 6.43 and 6.0 and electrical conductivity reduced from 811 to 280 µS/cm. Results indicate that Nakayiba wetland is steadily recovering and contributing to removal of nutrients and feacal coliforms, thereby improving water quality for downstream users. It is recommended that the municipal authorities should ensure that Nakayiba wetland is not re-encroached to allow for full recovery.

Key words: Cyperus papyrus, faecal coliforms, Impatiens tinctoria, Masaka, Uganda, wastewater, wetland encroachment, wetland function

Résumé

En Ouganda, de nombreuses zones humides ont été converties en utilisations nuisibles à la nature. Cependant, à part quelques-unes d’entre elles en cours de restauration, le succès de la restauration pour aucune d’entre elles n’a été évalué afin d’orienter les efforts de restauration futurs dans le pays. L’étude a évalué l’état de restauration de la zone marécageuse de Nakayiba qui sert à filtrer les eaux usées municipales partiellement traitées dans le district de Masaka. L’accent était mis sur les attributs clés de la végétation et de la qualité de l'eau. L'état de recolonisation des plantes le long de la zone marécageuse a été suivie à l'aide de quadrats (4 m2), tandis que la capacité d'atténuation de la pollution a été évaluée à l'entrée (confluence) et à la sortie principale à l'aide d'appareils de mesure et d'analyses de laboratoire appropriés. La recolonisation des plantes n'était pas égale; La végétation dans la zone marécageuse était principalement dominée par Impatiens tinctoria (40,7%), bien que les parties en amont (42,8%) et les parties médianes (36,1%) étaient principalement couvertes par Cyperus latifolius. Les autres plantes principales présentes comprennaient Cyperus papyrus (9,7%) principalement en aval (18,3%) et Typha latifolia (1,8%) ne se trouvant qu'en aval. Les études sur la qualité de l'eau ont montré des réductions significatives (p <0,05) des paramètres physico-chimiques. La rétention de phosphore était élevée, avec 87% de phosphore total (TP) et 92% d'ortho-phosphates (-PO4 3-) mais une faible rétention de nitrates, NO3- (24,4%). En outre, les coliformes fécaux (FC) ont été réduits de 9160 à 350 UFC / 100 ml, ce qui représente une capacité de rétention de 96,18%, tandis que le pH variait entre 6,43 et 6,0 et la conductivité électrique était réduite de 811 à 280 µS / cm. Les résultats indiquent que les zones marécageuses de Nakayiba se régénèrent progressivement et contribuent à éliminer les éléments nutritifs et les coliformes fécaux, améliorant ainsi la qualité de l'eau pour les utilisateurs en aval. Il est recommandé aux autorités municipales de veiller à ce que les zones marécageuses de Nakayiba ne soient pas envahies de nouveau pour permettre un rétablissement complet.

Mots clés: Cypyrus papyrus, coliformes fécaux, Impatiens tinctoria, Masaka, Ouganda, eaux usées, empiétement des zones marécageuses, fonction des zones marécageuses

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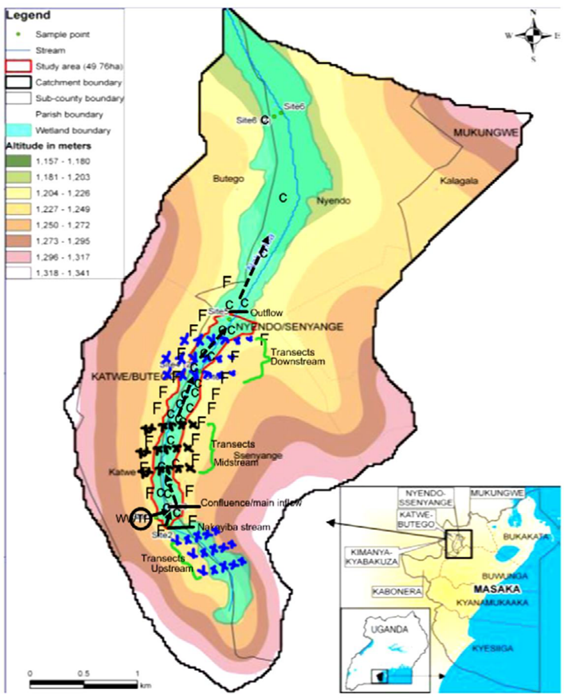
Background

Wetlands perform many functions including water purification, flood protection and carbon sequestration, among others (Busulwa *et al.,* 2003). These functions, however, are in jeopardy because wetlands are overly being converted to other uses mainly agriculture. The relationship between wetlands and agriculture has traditionally not been a harmonious one. It is reported that more than a half of the world's wetlands disappeared due to agricultural conversion (MEA, 2005). In Uganda, the need for large-scale wetland drainage for agriculture was heightened in the 1940s, when colonial officials recommended wetland conversion for agriculture to increase food production and this continued into the 1960s (Carswell, 1996). People in densely populated areas like the Kigezi in Western-Uganda increasingly relocated to wetlands for agriculture and water supply and this practice has spread all over the country.

By the time of the district inventory of 1995, Nakayiba wetland was a fully converted farmland, crops grown being mainly sugar cane, sweet potatoes, pineapples and vegetables (Namankambo, 1996). These changes in land use claimed over 99% of the upstream portion of the wetland (NEMA, 1997). More so, effluents from the National Wastewater Treatment Plant of Masaka municipality [WWTP] continued to be released into the wetland for secondary and tertiary treatment. At the time of restoration, the converted Nakayiba wetland possessed water channels that were dug by the farmers and settlers to drain the plots (WETwin, 2008). A combination of reduced vegetation cover and highly channelized wastewater increased the rate of effluent run off through the wetland. Consequently, the resulting reduced wastewater retention time inevitably hastened water quality deterioration in the Nakayiba wetland. Local communities downstream were not only concerned about the foul smell emerging from the wetland, they were also worried about their health due to the continued use of the nature-given free water from Nakayiba stream, the cheapest source of water in the region (NEMA, 1997). Therefore, a programme to restore Nakayiba wetland was developed and rolled out in 2007 such that the wetland could once again perform its ecological functions. This study thus aimed to assess the status of restoration of Nakayiba wetland, which was barely known yet such information is important in planning future restoration programmes in the country (Bruland *et al.,* 2003).

Materials and Methods

Study site. The study was carried out in Nakayiba wetland, a narrow papyrus wetland, located at latitude -0.25 (0° -15' 0 S) and longitude 31.72 (31° 43' 0 E), Masaka district is located in central Uganda (Fig1). Meandering through the wetland is the Nakayiba stream that drains the catchment including carrying wastewater from the sewerage plant. From Masaka town, the wetland stretches northwards downstream for about 15km before draining into Nabajjuzi wetland, a Ramsar protected site, which in turn finally joins the main swamp of River Katonga that drains into Lake Victoria (NEMA, 1997). There are two relatively short dry seasons (December-February, and June-July) frequently broken by thunderstorms. Rainfall is well distributed throughout the year with peaks around March-April-May (the main rainy season), and August -November; thus exhibiting a bimodal pattern of rainfall distribution. Mean annual rainfall is much higher at the Lake Victoria zone than in inland areas, and amounts range between 1250 -1500mm (NEMA, 1997).The study



WWTP- Wastewater treatment plant; C- wetland core; F- wetland Fringes; arrows indicate direction of wastewater flow

put seasonal variations into consideration and corresponding data were captured. Nakayiba wetland has important social and cultural values given that it is a source of raw materials for crafts and mulching, and it is source of water for both domestic and livestock use. In addition, Nakayiba is a principal wetland serving the ecological function of tertiary purification of the effluent discharged by Masaka wastewater treatment plant.

Methodology

The wetland was partitioned into three main sections that is, upstream, midstream and downstream.

Vegetation data collection. Vegetation was sampled using quadrats. Eight 2 m x 2 m (4 m^2) quadrats were placed systematically along each access transect, at intervals of 10 metres apart. These alternated positions in such a way that the preceding quadrat was on the opposite side of the transect from the one following it. Wherever it was not possible to place a quadrat like in very tall vegetation, a tape measure was used to measure off equivalent space. Pre-coded plant species falling in each quadrat were identified with their respective codes and recorded as present or absent straight away in the workbook. The codes assigned to the macrophytes were alphabetical letters, i.e., *A- C. latifolius, B- C. papyrus, C- Phragmites, D- Bulrush E- Persicaria decipiens, F- Impatiens tinctoria, G- Ferns* (Kayongo). The list kept growing as new plants were encountered. Specimens that could not be identified *in situ* were carried to Makerere University Herbarium for identification. This purpose necessitated that portions of the herbaceous plant stem, leaf, and flower (whenever present) were carefully cut, placed between old newspapers and then bundled up in plant presses to prevent desiccation which otherwise makes it difficult to identify key features. Some specimens were photographed to provide more details during identification. Whenever possible, native names were obtained in consultation with the locals in the vicinity of the wetland.

Towards the end of the study area (at the main outflow), however, it was a bit difficult to place a quadrat or a tape measure due to the much deep water present. So, cover was visually approximated.

Pollution attenuation data collection. Nutrients (nitrogen and phosphorus), conductivity, temperature, pH and faecal coliforms were the variables of interest. To deduce the pollution attenuation capacity of Nakayiba wetland, two major sampling points were considered, that is, the main inflow/confluence and the main outflow. However, samples were also collected from three other points along the longitudinal gradient namely Nakayiba stream, midstream, and downstream such that trends along the wetland could be followed to better understand the dynamics in the wetland.

Sample collection was done once a week per fortnight for four months (March 2012 to June 2012). This period was considered appropriate for collecting sufficient data. March was a dry month unlike the rest of the three months; thus, this allowed for comparison of water chemistry across seasons. Water samples were collected in plastic narrow mouth bottles

(500ml) pre-washed with dilute hydrochloric acid (HCl) and thoroughly rinsed with distilled water. Prior to collection, each sample bottle was again rinsed with the very site water and then collected at 0.4 m below the surface. At such depth, surface layer effects like irradiation which can kill the organisms and underestimate the counts, are avoided.

Samples collected were then put in an ice cool box and transferred to the laboratories for analysis within 24 hours from the time of sampling. Samples not analyzed immediately were preserved in a deep freezer at - 20 °C but allowed to warm to room temperature before analysis.

Chemical analyses were done following the standard analytical procedures described in APHA (1995) and as adopted in the Laboratory Procedure manual used at the NWSC central laboratories at Bugolobi. HACH DR 5000 spectrophotometer with a wavelength range of 190-1100nm was used to read the values. Precision and accuracy of the spectrophotometer was checked by comparing with the blanks.

Orthophosphates were determined by ascorbic method; the samples were first filtered over 0.45µm Whatman GF/C filter paper. Total phosphorus (TP) samples, on the other hand, were analyzed unfiltered using the persulphate digestion method. These phosphorus species were read at wavelength 885nm. Nitrate-Nitrogen was determined by cadmium reduction spectrophotometric method reading done at 507nm.

Faecal coliforms were cultured by membrane filtration method using Laurel sulphate nutrient broth. Samples were aseptically collected in clear, clean, sterile glass bottles with a stopper. For ease of reading the colonies, concentrated samples (<5 mls depending on the site) were diluted with distilled water to 100ml and then filtered over the cellulose esters. Prepared samples were incubated in an autoclave at 44^{o}C for 16 hours; after which typical yellow colonies were counted as coliform forming units (CFUs) per 100ml of water (APHA, 1995).

Results and Discussion

Vegetation status of Nakayiba wetland. Ten plant species, belonging to seven plant families, were identified. Family Poaceae contained the highest number of species namely *Elymus repens* L., *Phragmites australis* (Cav.) Trin and *Echinocloa pyramidalis* (Lam.) Hitch. and Chase. The second most abundant family was Cyperaceae, represented by two species namely *Cyperus latifolius* L. and *Cyperus papyrus* L. The remaining five families had each one representative species. Plant distribution was uneven; some plants exhibited habitat preference by occurring in some wetland sections and not others. The upstream and midstream zones, for example, were dominated by *Cyperus latifolius* while the downstream zone was dominated by *Impatiens tinctoria*, which was also the most dominant plant in the entire wetland.

Secondary data (baseline) for comparison (Table 1) showed that only 15.0% of the original plant community had been restored. Furthermore, seven new plants were identified in Nakayiba wetland. This implies that disturbance paved way for emergence of plants that never existed in the original community and plants that perhaps could not have emerged had the wetland not been converted. The survival of these other plants over time, however, should be investigated further as the restoration trend is followed because they could be good options to use in wetlands that have similarly been degraded. This means that if the wetland is not re-encroached, soon it will regain its previous ecological condition.

Wastewater pollution attenuation by Nakayiba wetland. Physico-chemical parameters were significantly ($p<0.05$) reduced between the confluence and the main outflow. This means that Nakayiba wetland is regaining its ability to attenuate pollutants in the effluent. This could be because of the resurging vegetation. Plants have an outstanding ability of assimilating nutrients in the sewage (Shutes, 2001) since they require nutrients for the production of new cells during growth. In the process, therefore, the pollutant load is lessened; thus improving the quality of the incoming wastewater.

Upon comparison with the baseline water quality data (Table 2) from Bateganya (2010), however, the difference was found not to be significant (paired t-test, $p>0.05$). This implies that although Nakayiba wetland is not fully restored, its contribution to pollution attenuation is comparable to the baseline. This means that, with more time allowed for the wetland vegetation to restore, the water will need a little cleaning to be suitable for domestic uses.

Table 1. Baseline vegetation data

Abundant (≥ 75%)	Common (51% -75%)	Occasional (25%-50%)	Rare (1≤25%)
Cyperus papyrus	*Acanthus pubescens* *Miscanthidium violaceum* *Miscanthus violeeus* *Phragmites australis*	*Cassia floribunda* *Desmodium salicifolium* *Leersai hexandra* *Penisetum purpureum* *Relypteris fadenii* *Solanum mauritianum* *Triumfetta macrophylla*	*Alcornea cordifolia* *Coix cycro-jobi* *Crassocephalum vitellium* *Echinochloa pyramidalis* *Ipomoea wightii* *Oryza longistaminata* *Polygonum senegalense* *Rubus rigidus*

Adopted from Bateganya (2010)

Table 2. Water quality in Nakayiba wetland and Nabajjuzi wetland

Parameter (units)	Site	
	Nabajjuzi wetland (outflow) (Baseline Water Quality data)	Nakayiba wetland (outflow)
Temperature (^{o}C)	23.3±1.4	19.0±0.20
pH	5.3±0.2	5.99±0.18
Conductivity (µS/cm)	54.95±19.34	280.4±70.6
TP (mg/L)	0.051±0.010	8.39±0.69
O-$PO_4$3-(mg/L)	0.018±0.009	3.03±0.87
NO_3--N (mg/L)	0.049±0.043	3.47±1.16

Conclusion

Nakayiba wetland vegetation has not been fully restored but there is evidence of improvement in water quality although the water is not potable enough for human consumption. It is important, also, to continue observing and documenting the succession changes that continue to occur to the system especially in plant colonization or changes in water quality coupled with social economic studies on the human communities which interact with the wetlands.

Acknowledgement

We thank the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) for availing a platform to share our findings and the Carnegie Corporation of New York for the Small Grants for Data Collection. This paper is a contribution to the 2018 Sixth African Higher Education Week and RUFORUM Biennial Conference.

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