

Full Length Research Paper

Investigating the effectiveness of aquatic plants (*Echinochloa L* and *Cyperus L*) in removing nutrients from wastewater: The case of Chemelil constructed wetland- Kenya

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This study focused on the effectiveness of wetland plants: *Echinochloa pyramidalis* (L) and *Cyperus papyrus* (L) in purifying wastewater from sugar factory stabilization pond effluent. This study was performed in a pilot-scale Free Water Surface Constructed Wetland (FWSCW) system in Chemelil sugar factory, Kenya. Four of the eight constructed wetlands (CWs) were planted with *C. papyrus* and the other half with *E. pyramidalis*. Water samples and plant specimen were taken fortnightly at inlets and outlets of the cells and analysed for total phosphates and total nitrates. The data was analysed by use of Microsoft excel and SPSS computer packages. Water analysis recorded a reduction in the nutrient levels between the inlet pond nine and the final outlet channel to River Nyando. The plants grown in the wetland experienced a reduction in the level of total foliar nitrogen and phosphorous, indicating that though the nutrients were being removed from the wetland, the same were not those assimilated by the plants either. The control plants had higher folia phosphorous and nitrogen, an indication that the system of the constructed wetland was able to eliminate the nutrients effectively from the plants.

Key words: Wastewater, eutrophication, assimilation, *Echinochloa pyramidalis*, *Cyperus papyrus*, sugar factory wastewater.

INTRODUCTION

Wetlands are among the most important ecosystems on Earth. In more recent biological and human times, wetlands have been valuable as sources, sinks, and transformers of a multitude of chemical, biological, and genetic materials. Although, the value of wetlands for fish and wildlife protection has been known for several decades, some of the other benefits have recently been identified (Mitsch and Gosselink). Wetlands also serve as nature's way of purifying water and eliminating wastes. As wastewater flows through the wetland, organic matter

and pathogens are eliminated by natural chemical and biological processes. It is further argued that wetlands also serve as "the kidneys of the landscape" because they function as the downstream receivers of water and wastewater from both natural and human sources. Constructed wetlands are an exciting new application of technology that is very effective at improving water quality. While they do not solve all water quality problems, they hold much promise as a new type of water treatment system that combines low cost and high efficiency. Those attributes alone make them attractive systems, especially to small and medium-sized cities and many industries (Simpson et al., 2001). Plants utilize nitrogen, phosphorus and simple compounds to grow and in turn produce Oxygen in the root zone. This fosters increased microbial

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activity in the wetland, resulting in an efficient method of treating wastewater (Reed et al., 1995). Consequently, wetland plant communities can remove a lot of nitrate from polluted water inputs. In addition, microbes that live on the surface of plant roots in a wetland remove 10 times more nitrates than do the plants themselves. These microbes change nitrate nitrogen (NO_3) to ammonia nitrogen (NH_4) in a process called assimilation (Kallner, 2002). Constructed wetlands are complex, integrated systems in which water; plants, animals, microorganisms and the environment, sun, soil and air interact to improve water quality. Whereas geology, hydrology and biology create natural wetlands, constructed wetlands are the result of human skill and technology. Humans design, build and operate constructed wetlands to treat wastewater. Yet to refer to constructed wetlands as purely artificial, human made or engineered is not entirely accurate and slights their most significant feature. By utilizing and attempting to optimize the physical, chemical and biological processes of the natural wetland ecosystem, constructed wetlands also are, to various extents, natural environments (Hammer, et al., 1992). If properly built, maintained and operated, constructed wetlands can effectively remove many pollutants associated with municipal and industrial wastewater and storm water. Such systems are especially efficient at removing contaminants such as BOD, suspended solids, nitrogen, phosphorus, hydrocarbons, and even metals. They are used to treat municipal effluent, industrial and commercial wastewater, agricultural runoff, and storm water runoff, animal wastes, acid mine drainage and landfill leachates.

Although a primary purpose of constructed wetlands is to treat various kinds of wastewater, the facilities usually serve other purposes as well. Wetlands (Hammer, 1992) also have other values as wildlife sites, to attract various animals and provide habitat and also a public attraction, welcoming visitors to explore its environmental and educational possibilities.

To function efficiently, the wetland plants should be allowed time to establish their root systems and then left in place to actively treat the wastewater from domestic utilities and factories (Watson, 2000). In this study, after the plants had extracted their required nutrients from the wetland and grown to some specific size, they were harvested away and fresh ones planted again. Emergent plants stabilize the substratum by physically binding it together with their roots and rhizomes and by preventing erosion and export of particulate matter. Sedimentation rates are increased as water velocity and turbulence are reduced, and suspended particles are trapped by the roots, rhizomes and stems. Therefore, various plant growths are necessary to ensure wetland functioning. Native local species are often preferred because they are adapted to the climate. This study focused on two emergent plants: *C. papyrus* (L) and *E. pyramidalis* (L) that are commonly found growing within the area of

study.

However, submerged aquatic vegetation communities exhibit phosphorous removal mechanisms not found in wetlands dominated by emergent macrophytes. Also, floating and submerged hydrophytes have been used in experimental systems to scavenge metals directly from the water (Watson, 2000). Maximum uptake of nutrients and contaminants typically occur during the early stages of plant growth and decreases as the plant matures. As plants senesce, they drop their leaves which decompose and release nutrients and organic matter back into the system. Hence, plant biomass must be harvested frequently in order to maintain these high growth rates, a practice that often proves impractical because of ecological considerations, cost and logistics (Coleman, 2001). In this study, the plant biomass was harvested after every three months to ensure high growth rates. Notably, the plants that were grown in cell 1 and 2 (the first ponds located at the inlet into the wetland) were seen to achieve maximum growth faster than those in the other cells. Within the broader perspective of Lake Victoria water quality and Eutrophication management, it is possible to conduct a project study that will come up with findings to aid in monitoring and management of the Lake through river Nyando. Both point and non-point sources of pollution occurring within the catchment of River Nyando, contributes a reasonable proportion of pollutant loads, which in turn find their way into Lake Victoria.

This threatens the livelihood of indigenous, national and international communities who use the water for domestic purposes and consume fish from the River and Lake Victoria at large (Raburu, 2003). Lakes can be categorized according to three trophic status arising from phosphorus concentration. Lakes with phosphorus concentrations below 0.010 mg/L are classified as oligotrophic, phosphorus concentrations between 0.010 and 0.020 mg/L are indicative of mesotrophic lakes, and eutrophic lakes have phosphorus concentrations exceeding 0.020 mg/L (Pearson et al., 1992). The levels of phosphorus rising above 0.02 mg/L may bring eutrophication to Lake Victoria, which is the final receiving water body of the River Nyando into which the final Chemelil wetland effluent flows.

Chemelil sugar factory makes use of water, either directly as part of the manufactured product or indirectly for cooling, cleaning and circulating. These activities generate liquid effluents, which may contain different chemicals, as well as organic matter. The overall objective of this study was to establish the role-played by macrophytes in nutrient removal in a constructed wetland. The specific objectives were to determine phosphate and nitrate levels in plants growing in the wetland cells and in the controls (plants growing outside the cells), to determine phosphate and nitrate levels in the wastewater at inlet to cells and at outlets of the cells and finally to compare the performance of *E. pyramidalis* (L) and *C. papyrus* (L) in the removal of nitrate and

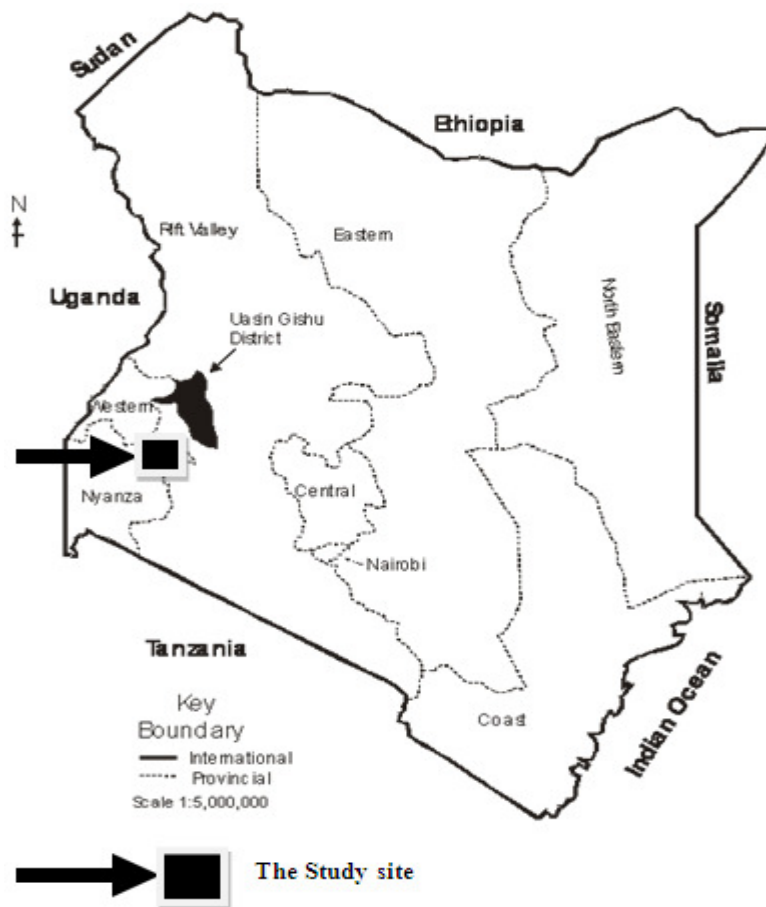


Figure 1. The location of Nyando district in Kenya (field data).

phosphates.

Hypothesis

Phosphate and nitrate levels are higher in plant tissues within the cell (pond) and lower in the ones growing outside the cells.

Study area

The study was conducted in constructed wetlands at Chemelil Sugar Company, Nyando District, in Nyanza province, Kenya. Chemelil sugar factory is the second largest sugar producing company in Kenya and covers an area of 2,700 hectares of land. It is situated 30 kilometers East of Kisumu City and a few kilometers off the Kericho-Eldoret road. Geographically, the company lies between latitude $00^{\circ} 03' 53''S$ and longitude $35^{\circ} 08' 34''E$ (Figure 1). The study site consisted of eight wetland cells (ponds), constructed on flat ground. However, some parts had slight slopes ranging up to 3% and with slight

depressions. The floor of the wetland was lined by heavy duty polyethylene paper to prevent leakage and water infiltration into the ground. Surface drainage was adequate for most crops, and internal drainage within the cells was controlled by sluice valves. The altitude of the study area is about 1269 m above mean sea level. The soil is fairly uniform consisting mainly of montmorillinitic clay with a high base exchange capacity, cracking and self-mulching clays (Kirui, 2002).

Temperature, rainfall and vegetation

The mean annual temperature is about $29.8^{\circ}C$ with mean monthly minimum temperature ranging between 15.0 to $18.7^{\circ}C$ and mean monthly maximum temperatures is over $38^{\circ}C$. Chemelil experiences seasonal variations in rainfall. The region is characterized by a bimodal rainfall distribution pattern with the long rains occurring in April / May while the short rains occur in August / September. Work was therefore done during the dry season, between November 2004 and February 2005. The mean annual down pour during the short rains ranges between 450 to

600 mm while that of the long rains ranges between 1100 and 1500 mm. The mean annual down pour in the region varies with altitude and the proximity of Nandi and Tinderet escarpments. January is dry and rainfall tends to be erratic from year to year. The soil dries out significantly from late December to March.

The area consists of two main ecosystems namely the flood plains and the permanent wetlands characterized by rich wetland biodiversity. Main crops in the flood plains are maize, sugarcane, rice and sorghum, which are grown mainly under subsistence systems. Horticultural farming also occurs within the permanent wetland ecosystems especially when the water level temporarily recedes during the dry period. Both the plains and the wetlands are highly fertile and when there is adequate rainfall, crop yields are high. However, the total annual rainfall during the rainy period does not allow cropping under rain-fed conditions (Kirui, 2002).

METHODOLOGY

Water samples (2 replicate samples were collected from each cell (pond) at the inlet and outlet) and plant specimens were collected twice a month and subjected to field and laboratory analyses. Other replicate samples were also collected from ponds 9 and pond 12. The water samples were collected using a sampler and transferred in 500 ml plastic bottles and kept in a cool box with ice for onward transfer to the laboratory. Analysis of the nutrients was done within 5 h of collection each time. The plant specimen (leaves and stem) were collected by cutting with a pair of secateurs, placed in newspapers then in transparent plastic bags, labeled and placed in a plastic box for transportation to the laboratory for analysis.

Figure 2 shows the experimental design adopted in this study. Eight horizontal subsurface constructed wetland (HSSCW) units were established in the year 2002 in parallel to receive effluent from a secondary facultative pond at Chemelil Sugar Company Waste Stabilization Ponds (WSP). The system consists of eight Constructed Wetland (CW) cells of rectangular shape and of varied measurements (CW 1: 20 mL X 3 mW X 1 mD, CW 2: 20 mL X 3 mW X 1 mD, CW 3: 20 mL X 3 mW X 1 mD, CW 4: 21 mL X 3 mW X 1 mD, CW 5: 21 mL X 3 mW X 1 mD, CW 6: 20.7 mL X 3 mW X 1 mD, CW 7: 20 mL X 3 mW X 1 mD, CW 8: 21 mL X 3 mW X 1 mD). The cells are located downstream of the secondary facultative pond (pond 9) Figure 2. The wastewater load was low (approximately 75 mm day⁻¹) to CWs 1 to 4 and high (about 225 mm day⁻¹) to 5 to 8. The beds of the wetlands were packed with sand and water was allowed to flow into the cells at different velocities by regulating using the sluice valves (plate 1). The beds were planted with locally available *C. papyrus* (Cp) and *E. pyramidalis* (Ep), alternately (plate 2), obtained from a nearby river. Four of the eight constructed wetland cells were planted with *C. papyrus* and the remaining with *E. pyramidalis*. Rhizomes and cuttings of these plant species were used as seeds. These plants were harvested twice; the first harvest took place in June, 2003 and the second harvest took place in September 2004. The waste water flowing within the cells took a maximum of 7 days to pass through the wetland system.

Analysis of nitrogen and phosphorus in plant tissues

Analysis of total nutrients requires complete oxidation of organic matter. This was accomplished through dry ashing of acid digestion of the plant material (Kjeldahl oxidation). The plant material was

dried and crushed into powder form then oxidized Hydrogen peroxide was added as additional oxidising agent, while selenium was used as a catalyst. Lithium sulphate was added to raise the boiling point of the mixture. Total nitrogen and phosphorus was then analysed using colorimetric procedures.

Sample treatment

The plant specimen was first dried in the sun and then in the oven at 70°C for a period of 1 h. The material was then ground using a blender to fine powder. 0.3 g of the dry powder was transferred into a clean, dry well-labelled digestion tube. 4.4 ml of the digestion mixture was added to each tube containing the plant tissues. 2 number distilled water blanks were also treated along side each batch of samples. The solutions were then digested at 360°C for 2 h till a clear colourless solution was obtained. 25 ml of distilled water was added to the tubes and mixed well. The prepared tubes were then allowed to cool and made up to 50 ml with distilled water. The solution was allowed to settle for a minimum of 30 min after which the clear supernatant was carefully siphoned out for the determination of nitrates and phosphates by colorimetric analysis as with the water samples.

Phosphate analysis

Ascorbic acid method (APHA, 1995) was used to analyse the total phosphate levels in the water samples. To release phosphorus from combination with organic matter, a digestion or wet oxidation technique was applied. For the digestion to take place, a combined reagent was used (50 ml of the 5 N Sulphuric acid were add 5 ml of potassium antimony, followed by 15 ml of the ammonium molybdate and 30 ml of ascorbic acid solution). The mixture was transferred to 100 ml volumetric flask and brought to the mark by distilled water. 50 ml of the sample was measured and transferred into a beaker and 8 ml of the combined reagent was added to it. The solution was allowed to react for 10 min. Orthophosphates reacted with ammonium molybdate to form molybdophosphoric acid. Addition of potassium antimonyl tartrate increased the coloration and the reaction velocity at room temperature. About 10 ml of the coloured solution was transferred into a clean acid washed spectrophotometer sample cell. Absorbance was measured at 690 nm, with the intensity of yellow colour being proportional to the phosphate concentration.

The following formula described by American Public Health Association (APHA) was used to calculate the concentration of total phosphates:

$$\text{TP (mg P/l)} = \frac{\text{mg P (in approx. 58 ml final volume)}}{\text{ml of sample}} \times 1000$$

Where,

TP = Total Phosphate

P = Absorbance of the phosphate

1000 = constant

58 ml sample = final volume of combined reagent plus sample
ml of sample = mls of sample used in reaction

Nitrates analysis

Total Nitrates was analyzed using the cadmium reduction method (APHA, 1995). The Hach DR/2000 spectrophotometer was used for the analysis at a wavelength of 500 nm. The total nitrate in mg/l was calculated using the following formula, as adopted from standard methods for the examination of water and waste water

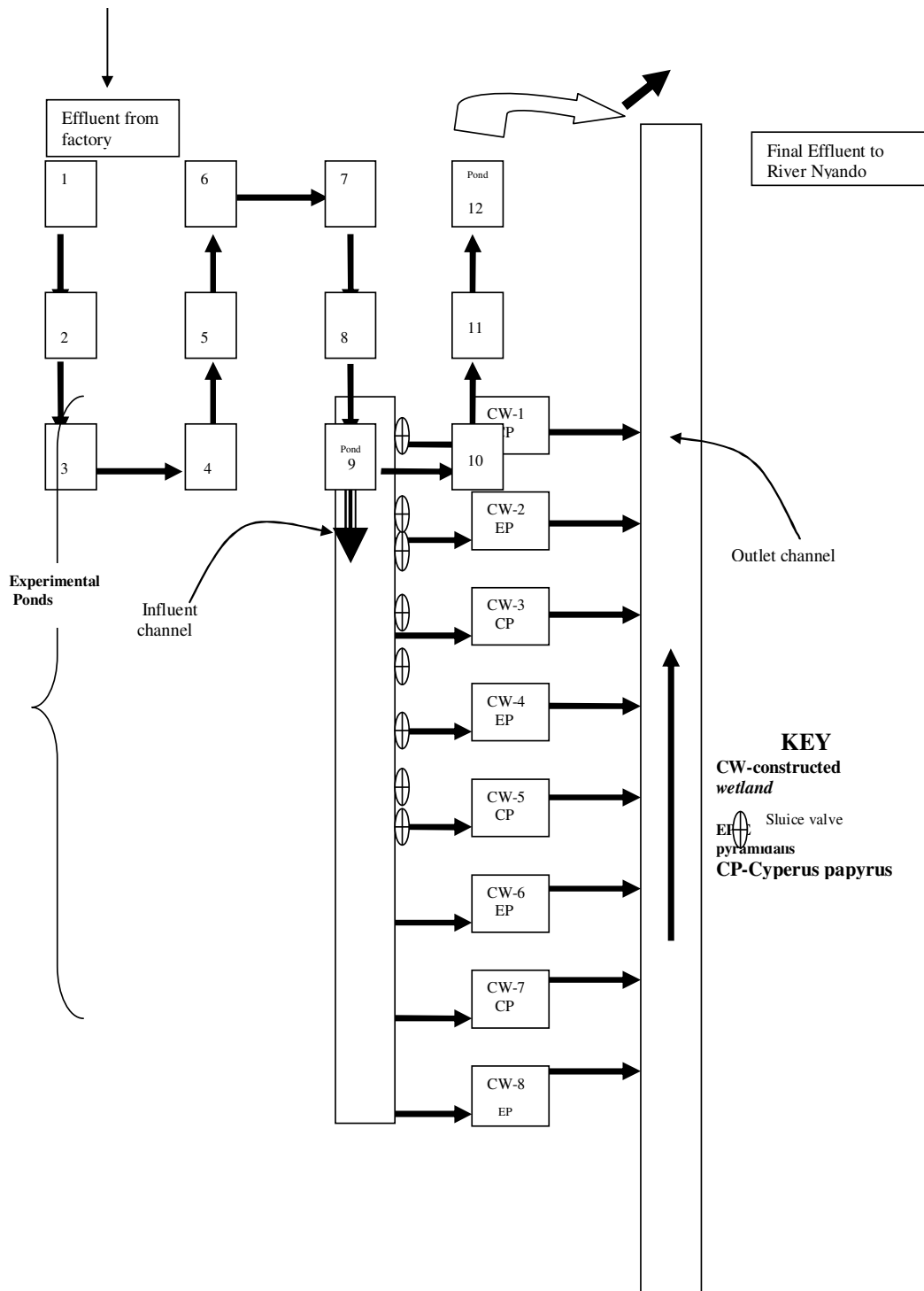


Figure 2. Schematic drawing of the free water surface constructed wetland system at Chemelil Sugar Company Ltd. In Kenya. Constructed wetlands 1, 3, 5 and 7 were planted with *Cyperus papyrus* and 2, 4, 6 and 8 were planted with *Echinochloa pyramidalis*. Drawing not to scale.

(APHA, 1995).

$$\text{TN (mg/l)} = \frac{\text{Corrected in ml of N/70 HCl} \times 0.2}{V}$$

Where:

TN = Total nitrates

0.2 = Constant

N/70 HCl = Normality of the HCl.

V = Volume of sample used in analysis



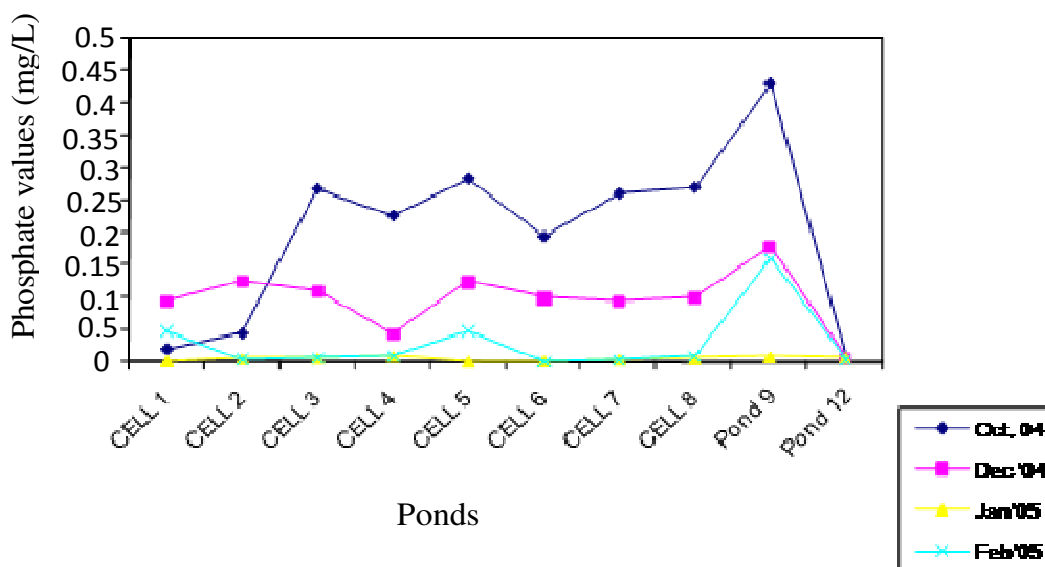
Plate 1. Construction of the experimental cell showing *E. pyramidalis*.



Plate 2. *C. papyrus* and *E. pyramidalis* planted in alternating sequence in the cells. (Blue arrow shows outlet channel for final effluent to River Nyando).

Table 1. Wetland nutrient removal efficiency for various sampling occasions (water analysis).

Cell no.	October 04		December 04		January 05		February 05		Mean values	S.D.	Mean values	S.D.
	NO ₃ (mg/L)	PO ₄ (mg/L)	NO ₃ (mg/L)	PO ₄ (mg/L)	NO ₃ (mg/L)	PO ₄ (mg/L)	NO ₃ (mg/L)	PO ₄ (mg/L)	NO ₃ (mg/L)		PO ₄ (mg/L)	
Cell 1	0.94	0.022	0.02	0.096	0	0.002	0.04	0.05	0.25	0.46029	0.0425	0.040739
Cell 2	0.11	0.046	0.072	0.127	0.03	0.006	0.03	0.006	0.0605	0.038484	0.04625	0.05704
Cell 3	0.082	0.268	0.057	0.11	0.04	0.007	0.04	0.007	0.05475	0.019856	0.098	0.123296
Cell 4	0.202	0.227	0.1	0.046	0.05	0.01	0.05	0.01	0.1005	0.071654	0.07325	0.103895
Cell 5	0.142	0.284	0.056	0.125	0.04	0.001	0.04	0.05	0.0695	0.048918	0.115	0.123669
Cell 6	0.244	0.195	0.131	0.1	0.05	0.002	0.05	0.002	0.11875	0.091816	0.07475	0.092525
Cell 7	0.247	0.261	0.041	0.095	0	0.005	0	0.005	0.072	0.118257	0.0915	0.120702
Cell 8	0.638	0.27	0.036	0.102	0	0.006	0.03	0.01	0.176	0.308402	0.097	0.123564
Pond 9	0.55	0.43	0.252	0.179	0.03	0.009	0.25	0.16	0.2705	0.213481	0.1945	0.174452
Outlet channel	0.06	0.008	0.06	0.008	0.06	0.008	0.06	0.005	0.06	0.0	0.00725	0.0015

Temporal Phosphate Variation between Wetland Ponds**Figure 3.** Temporal phosphate variations.

RESULTS AND DISCUSSION

There was a significant decrease in nutrient levels on the water samples from cell 1 to cell 4 in the month of October. However, there was an increase in the levels in cells 5, 6, 7 and 8 (Table 1). During the months of January and February, the levels maintained comparatively lower levels in all the sample cells. There was notable decrease in the nutrient levels found in the plant tissues 42 between pond 9 which formed the inlet of company waste into the constructed wetland cells and the outlet channel through which the final water from the cells flowed into the River Nyando. Figures 3 and 4

displays the temporal nutrient variations between the cells. There is significant variation with the months of October and December maintaining higher values than January and February. The month of January recorded the lowest values during the study. Ponds 9 and 12 (outlet to river Nyando), had slightly raised values. Values of Phosphate showed a sharp increase from cell 2 to cell 3 maintaining rather constant values within the other cells. Nitrate levels dropped sharply from cell 1 to cell 2 and only showed a significant increase from cell 6 to 8. There was a significant varying trend in nutrient retention between the cells. Cell 1 retained more nitrates and less phosphate. Cell 2 to 7 retained almost similar amounts of

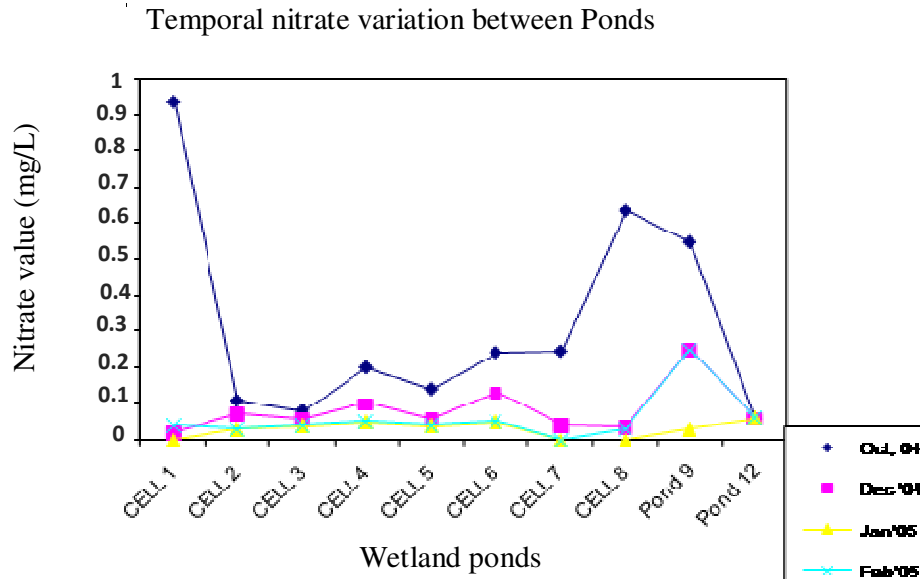


Figure 4. Temporal nitrate variations.

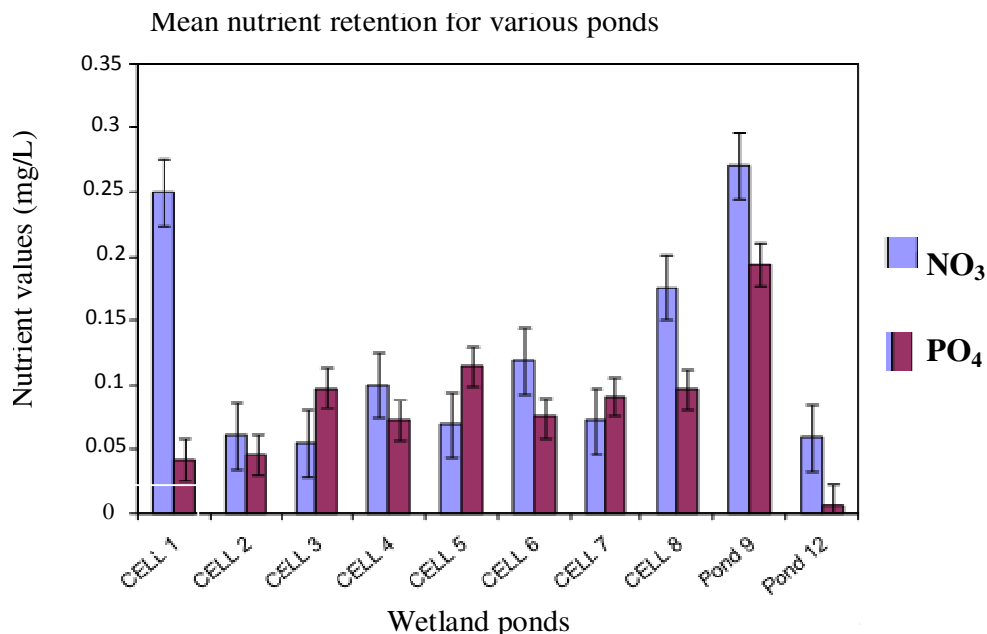


Figure 5. Phosphate and nitrate variations for folia analysis (the error bars show standard deviations).

both nutrients. Cell 8, ponds 9 and 12 retained more nitrates than phosphate. Cell 2 to 7 retained low nutrient levels while cells 1, 8 and 9 retained more of the nutrients as the water and folia results indicated (Figure 5). The nutrient levels in the inlets and outlets also varied within the cells. Only cell 1 had lower levels of phosphates at inlet than outlet. Cells 3 to 8 maintained higher phosphates levels at inlets and significant reductions at

outlets of the cells. Cell 5 had the highest values at inlet while cell 1 had the lowest value at outlet (Figure 6). Figure 7 shows the nitrate values for water and folia analysis at inlet and outlets of the wetland cells. It was noted that all the cells had higher nitrate values at the inlets and lower values at outlets of the cells with cell 4 having the lowest and highest values recorded. The folia results showed that nitrate levels on *C. papyrus* were

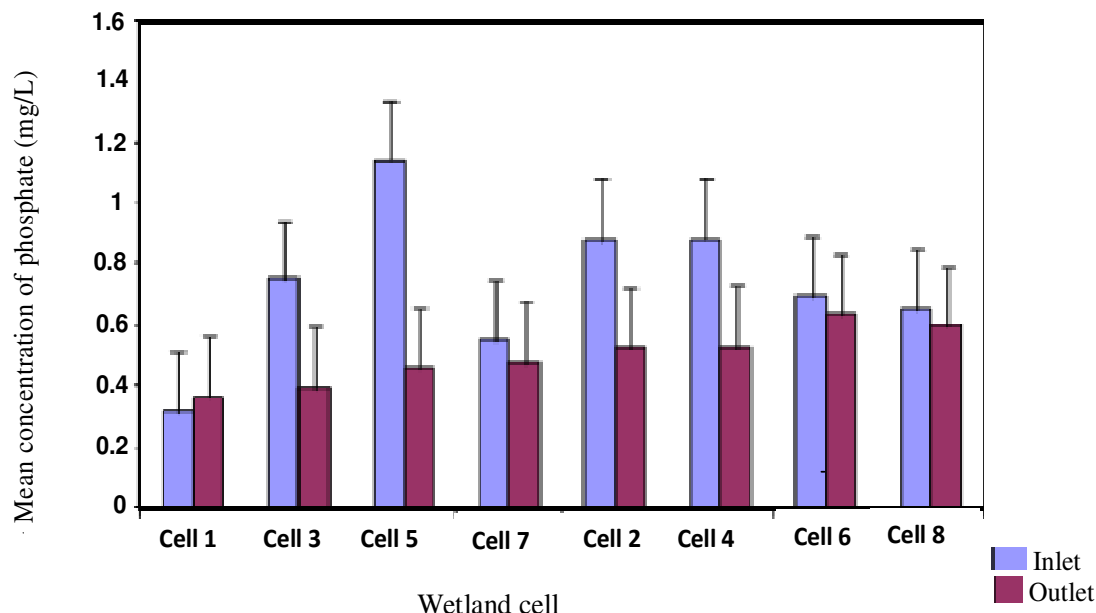


Figure 6. Phosphate variations for water analysis within the cells.

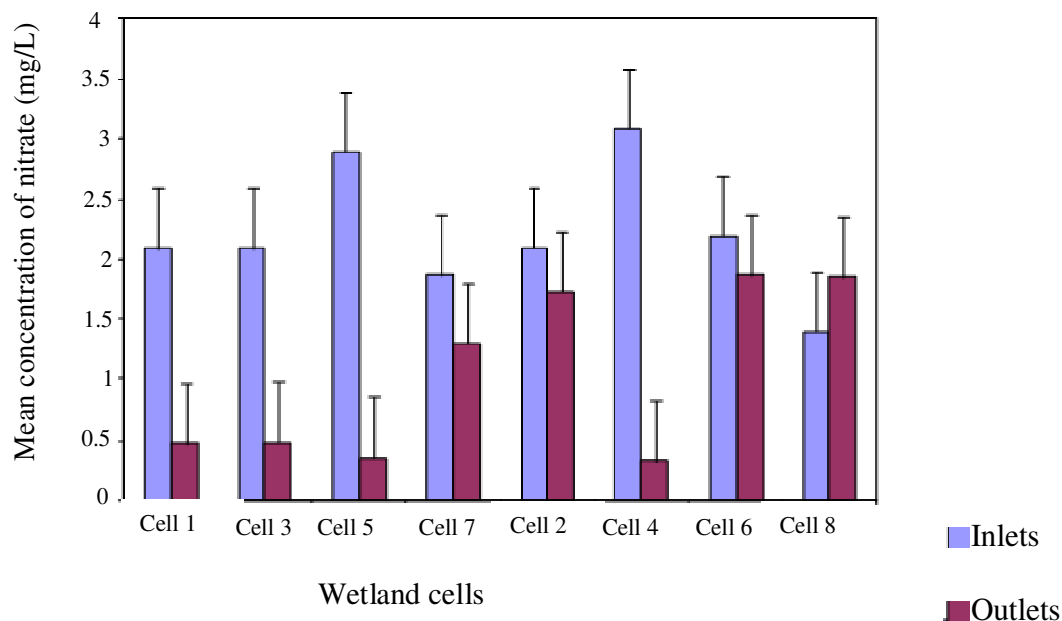


Figure 7. Nitrate variations for water analysis within the cells.

higher than the levels of *E. pyramidalis* with means ranging from 0.32 to 0.4 mg/l for *C. papyrus* and 0.5 to 1.0 mg/l for *E. pyramidalis*. The results on the phosphate analysis did not have significant differences on the two plant species. However, the control plants had higher nutrient values for *E. pyramidalis* than *C. papyrus*, with values of 0.065 mg/l for CP and 2.06 mg/l for EP on nitrates while phosphates values were 0.52 mg/l for CP

and 4.05 mg/l for EP (Table 2). From this study, the question as to what could explain the total foliar nitrogen and total foliar phosphorous reduction for plants in and out of the wetland arises. Perhaps this gives strength to the argument that microbes within the plants' rhizomes, such as bacteria and fungi, are the organisms most effective for nutrient absorption. This suggests that the active participants in nitrate and phosphate reduction are

Table 2. Foliar analyses.

Cells	NO ₃ (mg/l)			PO ₄ (mg/l)		
	Inlet	Outlet	Mean	inlet	Outlet	Mean
<i>C. papyrus</i> (L)						
1	0.08	0.56	0.32	0.56	0.414	0.487
3	0.45	0.35	0.4	0.497	0.354	0.4255
5	0.5	0.3	0.4	0.458	0.416	0.437
7	0.45	0.31	0.38	0.56	0.21	0.385
Control	0.065				0.52	
<i>E. pyramidalis</i> (L)						
2	0.6	0.54	0.57	0.429	0.254	0.254
4	1.02	0.35	0.685	0.5	0.423	0.423
6	1.21	0.79	1	0.54	0.46	0.46
8	0.36	0.55	0.455	0.51	0.47	0.47
Control	2.06				4.05	

not the plants themselves, but more likely to be the bacteria and fungi, which attach themselves to the root surface area and through the nitrogen cycle, are able to improve the quality of the wastewater. For this reason, it is argued that for wetlands to function efficiently (Watson, 2000), the wetland plants should be allowed time to establish their root systems, and then left in place to actively treat the wastewater from domestic utilities and factories. The nutrient demand in cell 1 may be the reason for the low nutrient levels that were observed in this cell. At the inlets, the waste water had higher nutrient levels because the plant roots had not been exposed to the water for longer periods. This nutrient variation at the inlets could also be attributed to the nutrient demand and nutrient uptake according to the growth rate of the plants within the cells. As the waste water flowed into the subsequent cells, the nutrients were used up for growth causing the varied levels within the cells. However, the nutrient levels were observed to increase again for example in cells 5 and 8, subsequently. The reason for this increase could be attributed to the fact that the wetland plants attained maximum growth at this cell or that the system was saturated with the nutrients at the time of sampling, or seasonal nutrient variation. During the month of December to January, it was the dry season and therefore there was a lot of evapotranspiration in the wetland cells. The high nutrient levels occurring during the wet season of study may have resulted from the storm runoff over the adjacent sugar plantations. The nutrient variations between inlets and outlets of the wetland cells is an indication that the nutrient load was depreciated by the plants using it up for growth, retaining some in the cells and only releasing the excess at the outlets. Indeed, the plants selected for this study were found to be responsible for the nutrient variations within the wetland cells and are thus able to effectively remove nutrients from wastewater. Phosphate levels greater than

1.0 mg/L may interfere with coagulation in water treatment plants. As a result, organic particles that harbor microorganisms may not be completely removed before distribution. The ANOVA for both nitrates and phosphates show the P value to be less than 0.05. This means that there is a difference in the nutrient levels in the individual cells and also within the different wetland cells.

Conclusion

Since the use of constructed wetlands to treat wastewater is relatively new, the impressive results achieved thus far have prompted great expectations about the technology and what it can achieve. Yet, as promising as the early work is, it is still early work, representing initial efforts to apply constructed wetland processes to the varied and complex wastewater treatment needs arising from human activities. In response to early enthusiasm, some researchers caution that constructed wetlands will not solve all water treatment problems. They point out that the full water quality possibilities and limitations of constructed wetlands are not fully known. Some express concern that the promotion of constructed wetlands may be outrunning the available knowledge and technology. For example, researchers are studying plants for the remediation of radioactive contamination. Yet, much more research will be needed to determine whether plants can be used for this task and to what extent that may possibly be achieved. Also, the ability of plants to remove certain chemicals from wastewater and the harvesting and use of wetland plants needs further examination.

The available constructed wetlands information and knowledge is extensive compared to even five years ago, and the database is growing. As more projects are planned and further research conducted, the treatment

possibilities of constructed wetlands will be better understood.

RECOMMENDATIONS

No national or state criteria have been established for concentrations of phosphorus compounds in water. However, to control eutrophication, the EPA (U.S) makes the following recommendations: total phosphate should not exceed 0.05 mg/L (as phosphorus) in a stream at a point where it enters a lake or reservoir and should not exceed 0.1 mg/L in streams that do not discharge directly into lakes or reservoirs (Harris, 1996).

Another precaution to take when introducing plants to help remove pollutants from an area is to take into consideration an invasive potential of each species. By evaluating their propensity to dominate an area and prevent other species from growing and thus out competing existing species.

The use of plants should be considered on a variety of scales and within a myriad of contexts, before being implemented. Such consideration will pave the way for the future success of these photoremediation alternatives. Constructed wetland treatment system is a cheap and low-cost alternative for wastewater treatment. They are engineered wetlands that are built to emulate the functions of natural wetlands for human needs. The wetland plants and microbes are the active agents in the treatment processes. The system can tolerate various pollutants and could be used by various users including governmental departments and agro based industries in treating wastewater before it is discharged into natural waterways. In addition to water purification, constructed wetlands may also serve as wildlife sanctuary and provide habitat for wildlife, but more research is necessary to determine whether constructed wetlands are good for all wildlife. The system can be aesthetically pleasing and serve as an attractive destination for tourists. The wetland can also be developed into an education center.

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