

Wetland Plant Dominance, Density And Biomass In Mara River Basin Wetland Upstream Of Lake Victoria In Tanzania

Marwa Muraza, Aloyce W. Mayo, Joel Norbert

Abstract: The dominance, density and biomass of wetland plants were investigated in Mara River wetland upstream of Kirumi Bridge. The study site was surveyed to identify the suitable sampling points in the wetland. *In-situ* identification of plants was done in order to determine the vegetation zonation. Transects were developed at the inlet and outlet zones of the wetland where sampling points were established and identified by global positioning system. A transect survey was conducted through the wetland prior to determination of plant types, dominance and density. A vegetation zonation by dominant plant community was estimated using ground transects surveys. The determination of above ground and below ground biomass was done by separating plants into leaves/umbel, stack/culm, shoot, rhizomes and roots, depending on the plant type. The results show that the dominant plant species were *Cyperus papyrus*, *Typha domingensis*, *Phragmites australis*, *Thelpteris interrupta*, *Echnocloa pyramidalis*, *Cyperus articulatus*, *Chara* spp., *Eichhornia crassipes* "water hyacinth" and *Azola* spp., which accounted for more than 50% of all the species recorded are an indication of a typical wetland habitat. *Cyperus papyrus*, *Typha domingensis* and *Phragmites australis* were the most dominant species in the wetland. *Cyperus Papyrus* had higher biomass content of 4.3 kgDWm⁻² than the rest of the species followed by *Phragmites* (3.74 kgDWm⁻²), but *Typha domingensis* had the least biomass content of the three with only 2.71 kgDWm⁻². The above ground biomass for *Cyperus Papyrus* accounted for 65% of the total biomass for the same plant. However, *Typha domingensis* had only 57% of the total biomass above ground. The average plant density was 3.2 plants/m² and the mean plants nitrogen content was found to be 67.88 gNm⁻².

Index Terms: Lake Victoria, Mara River Wetland, Plant dominance, biomass, *Cyperus papyrus*, *Typha domingensis*, *Phragmites australis*

1 INTRODUCTION

Global justification of the conservation, restoration and creation of wetlands is often met in terms of the beneficial functions and values they contribute to the wider environment. Benefits of such schemes include conserving wildlife, maintenance of biodiversity, provision of products (such as fish, reeds, timber, firewood and medicines), microclimate stabilization, flood control, ground water recharge and water quality improvements [1], [2], [3], [4]. Wetlands are often cited as being effective at reducing nutrients loadings, acting as "the kidneys of the catchment" ([5], [6]) thereby reducing eutrophication in adjacent water bodies. This has led to wetlands being managed or constructed as buffers or for treatment of domestic or industrial waste [7]. Such water management policy has been built on the assumption that wetlands perform specific hydrological and water quality functions.

The reviewed water quality functions of wetlands by Bullock and Acreman [8] found that some researchers have reported negative effects of wetlands. Therefore, it is important to review the effectiveness of wetlands in improving water quality particularly because of a number of concerns regarding the use of wetlands to reduce nutrient loadings. For example, it has been found that wetlands used to reduce nutrient loading may become degraded [9] and incomplete denitrification may release the green house and ozone depleting gas, nitrous oxide [10]. These issues are particularly topical given the use of wetlands as an important element in river basin management strategies, for instance, within the Mara River catchments. The Mara River Basin faces serious environmental and water resources problems, primarily from the intensive settlement and cultivation in the Mara River Basin leading to loss of vegetation cover, widespread soil erosion, decreased water infiltration capacity, decreased soil fertility, and increased sedimentation as well as water pollution in the river [11], [12], [13]. The Mara river basin wetlands have been receiving pollutants from large and small scale gold mines, agricultural activities and animal husbandry. These economic and social activities adversely pollute the River. As a result, information on water quality of the river is needed for the planning its management and the control of eutrophication in the river and Lake Victoria in general [11], [12], [13]. It is currently assumed that the Mara river basin wetlands retain the nutrients carried with the water, but there is no quantification of this function. Such information is necessary for the efficient planning of long-term sustainable use of the Mara river basin wetlands [11], [12], [13]. Wetland vegetation and soils significantly contribute to naturally storage and filtration of pathogens, nutrients and sediments. Plants reduce turbulence of water in wetlands, with their flat surface and flow characteristics, allow these materials to settle out of the water column, where plants take up some nutrients from the water. As a result, Mara River basin wetland has a potentially of providing Lake

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Victoria with a relatively cleaner water. Wetlands are characterized by the presence of water that saturates the soil or covers the land for most or all of the year. This leads to the development of plant and animal communities that are adapted to these conditions and which differ from those in purely aquatic (lakes, rivers) or dry land environments. Wetland plants are useful in that they remove nutrients and pathogens from water body [14], [15], [16], [17] and help in reducing water velocity and therefore make water cleaner [18]. This research was therefore carried out to determine vegetation dominance, density and in the Mara River basin wetland in order to address some of the unanswered questions.

2. Materials and Methods

2.1 Study Area

Mara River is an international river shared between Kenya

and Tanzania. Its basin is about 13,750 km² of which about 65% is located in Kenya and 35% in Tanzania. The river originates from the forested Mau escarpment along the western rim of the Eastern Great Rift Valley in Kenya (at an altitude of 2,900 meters above mean sea level), meanders through large scale agricultural farms, enters the Maasai-Mara and Serengeti National Parks in Kenya and Tanzania, respectively and ends its 395 km journey in Lake Victoria through Mara wetland (Fig. 1). Annual rainfall on the Mara headwater watersheds ranges from 1400 to 1800 mm, while the lower regions receive only about 500 to 800 mm. The main hydrological processes in Mara wetland are mainly run-offs from Mara river inflows from upstream catchment that brings water into the wetland. From the wetland, water flows into Lake Victoria contributing to 37.5m³/s, this is about 4.8% of total discharge into Lake Victoria [19].

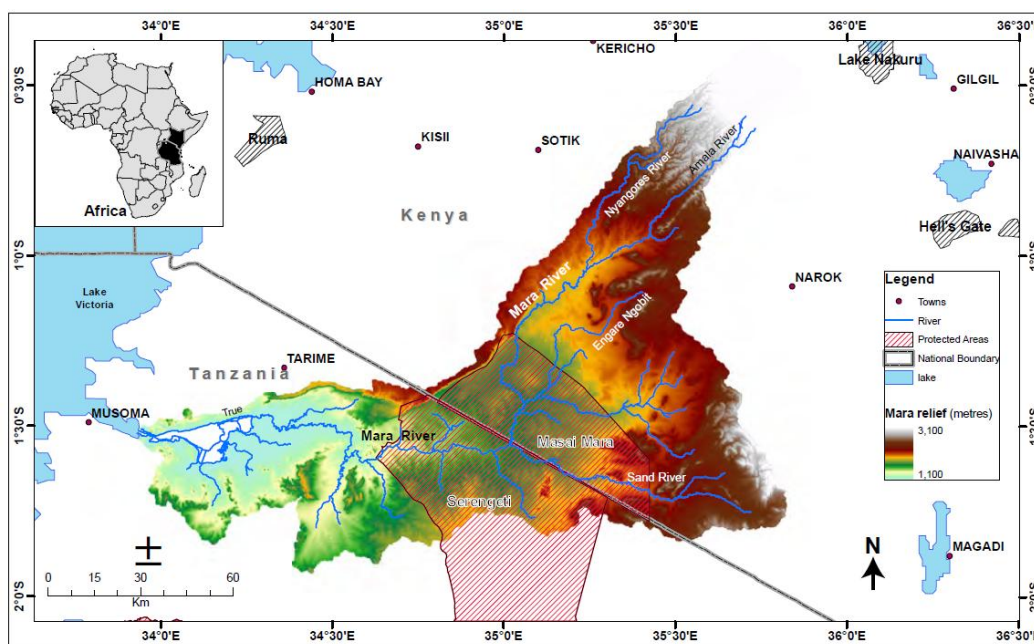


Figure 1: The location and relief of the Mara River Basin in Kenya and Tanzania [20].

Mara wetland covers a total area of 204.46 km²; its length is 36.8 km with a maximum width of 12.9 km [21]. The wetland is situated between longitudes 34°00' East and 34°25' East and between latitudes 1°08' South and 1°39' South. At downstream part of the wetland at Kirumi Bridge, the wetland is about 6 km upstream of Lake Victoria. Administratively, the wetland lies between Tarime and Musoma rural districts of Mara region [21].

2.2 Sampling Design

The study site was surveyed to identify the suitable sampling points in the wetland (Fig. 2). In some areas, some vegetation was cleared in order to provide accessibility and support during the sampling exercise. Sampling preparations also involved *in-situ* identification of

vegetation species located in various places in order to determine the vegetation zonation. After the reconnaissance survey was done, transects were developed in the inlet and outlet zones in the wetland. Transect Pt-1, which was largely covered by floating *papyrus* mats, was located at the upstream end near Bisarwi village. Transect Pt-2 was located downstream at about 100 meters upstream of the Kirumi bridge and is dominated by mixed floating *papyrus* and the rooted *typha*. Through these transects three sampling points were established at each transect. For each sampling location a global positioning system (GPS) was used to record the coordinates of the sampling site in order to it whenever sampling was done.

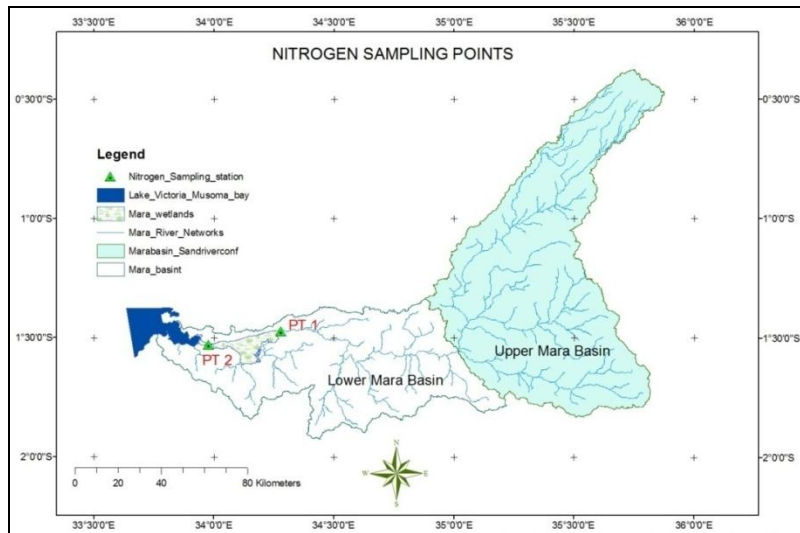


Figure 2: Location of sampling points at transversal axis in the wetland.

2.3 Plant Sampling

A transect survey was conducted through the wetland prior to determination of vegetation types, dominance and density. The interior transects along Mara River were by a boat, but other transects were accessed by a car or on foot. A vegetation zonation by dominant community was estimated using ground transect surveys in order to get the existing major vegetation zones in the wetland. A 1m x 1m quadrants grid system marked with permanent numbered sisal poles was used to identify the location of vegetation communities in each wetland. A vegetation Community Diversity Index (CDI) was developed to quantify the diversity in the wetland zonations (eq. 1).

$$CDI = -\sum_{i=1}^n C_i \ln C_i \dots\dots\dots(1)$$

Where C_i = approximated percentage vegetation cover of a given community “i” (0 to 1) and N= number of transects under consideration. The index used relative areas of vegetation community discovered from the transect survey followed by the calculation of the Shannon-Weaver diversity index (S-W DI), with area of each community instead of number of individuals of each species used (equation 2).

$$S - W DI = e^{CDI} \dots\dots\dots (2)$$

From the Shannon Weaver diversity index, major vegetation zones were marked and it is in these zones where by determination of vegetation dominance and vegetation density were done.

2.4 Determination of Plant Dominance

Following the transect survey conducted, four major vegetation zones were identified along the wetland depending on types of vegetation observed during the transect survey and the Shannon Weaver diversity index calculations. These zones were marked with the use of GPS and recorded. Thereafter different types of vegetations were identified and named with the help of the botanical and natural resources where necessary. To determine the

vegetation dominance in the given zones, the established quadrants were employed. Dominant species are the most abundant and exert the most influence or control on the habitat and other species [22], [23], [24]. Dominance forms can differ with species, and species can change their form of dominance over time [25]. Vegetation data were collected from 4 vegetation zones, which represent a random sample of the whole wetland. In each of the vegetation zones, the cover of plant species rooted in 1m x1m quadrants was visually assessed. Species dominance index (SDI) was modeled after Frieswyk [25] approach. The collected vegetation data were used to derive three attributes of dominance; tendency toward high cover (THC), mean species suppression (MSS), and mean cover (MC). Tendency toward high cover (THC) is a ratio of the number of times a species is “influential” in a plot, i.e. having greater than 25% absolute cover and the most cover, to the number of times it is present in a plot. The > 25% is adopted since it is the one recommended for given species to be regarded as having a tendency towards high cover i.e. those usually occur in the top class; in contrast to those usually have medium cover and bell-shaped distribution data [25]. Mean species suppression (MSS) is the mean of the inverse of the number of species (1/number of species) in a plot where the species of interest is “influential”. Mean cover (MC) is the average cover of a species. The species dominance index (SDI) was computed as the average of the three attributes of dominance namely mean species suppression (MSS), mean cover (MC) and tendency towards high cover (THC) (eqn. 3). SDI was computed for species that were considered to be potentially dominant based on two criteria. Potentially dominant species must be “influential” in at least one quadrant and be present in at least 1/3 of the quadrants in transects of interest. These attributes are inter-connected through the seven forms of dominance shown under Table 1.

$$SDI = \frac{MC + MSS + THC}{3} \dots\dots\dots (3)$$

The SDI was computed for each of the potentially dominant species. The dominant species were then selected using

mean SDI as a cut-off. Species with SDI above the mean were dominant. Then, using the mean value as a cut-off to dichotomize each of the three components of the SDI into "high" and "low" values, seven forms of dominance were differentiated. In this way, a dominance form was assigned to each occurrence of dominant species. After the dominant species were established in each quadrant, the mean value of the dominant species was estimated for each vegetation zone by finding the average dominance per zone from which the overall dominant species in the wetland was computed.

Table 1: Framework for 7 forms of dominance based on the assessment of 3 attributes.

	MC	MSS	THC
Monotype	high	high	high
Matrix	high	low	high
Compressed	low	high	high
Patchy	high	low	high
Ubiquitous	high	high	low
Aberrant	low	high	low
Diffuse	high	low	low
Not dominant	Low	Low	Low

$$\text{Average plant density in the transect} = \frac{\text{Summation of plant density in each quadrant}}{\text{Number of quadrants}} \quad (4)$$

$$\text{Average plant density in the wetland} = \frac{\text{Average plant density in the transect}}{\text{Number of transects}} \dots \dots \dots (5)$$

2.6 Plant Biomass Determination

Plants sampling for biomass determination was done in April and July 2012. For determination of biomass of plants, three most dominant plants in the wetland were analyzed. Plots of 1m x1m were demarcated and all plants in these plots were harvested. The above ground biomass was cut and separated into leaves/umbel, stalk/culm, and shoot depending on the plant type. Then these parts were weighed using a spring balance suspended from a fixed cross bar erected at the site to obtain the total wet weight of each plant part. The below ground biomass was removed by digging up all rhizomes and roots in 1m x1m plot and washing off all the dead materials and soil. Out of the total wet weight of each plant part in a 1m x1m plot, a sub-sample of 1kg of each plant part was taken for sun drying at Musoma Water Laboratory. The sun-dried samples of each plant part were thereafter oven dried at 105°C. The wet weight to dry weight ratio of the 1 kg sub sample was used to calculate the total dry weight in the 1m x 1m plots in the respective transects. Total nitrogen of dried plant parts was determined in accordance with Novozamsky *et al.* [26]. Total nitrogen was chosen as the basic element for nitrogen used up by the plants.

2.7 Determination of Plants Nitrogen Content

Following the biomass determination, for each part of a given plant species, nitrogen content was determined. To

2.5 Determination of Plant Density

From the major vegetation zones, plant density was determined by the use of the quadrant sampling method from the established quadrants. In each quadrant the plants existing were counted and recorded in the field book. The plants density for each quadrant was then established by summing up number of all existing types falling under the quadrant in consideration. To get the mean value of plants density in each transect, densities from the respective quadrates forming that transect were summed and divided by number of quadrants (equation 4). Determination of average plants density for the wetland in general was done by averaging the densities from the respective transects (equation 5).

undertake the analysis, fine materials out of every plant part was formed by grinding a portion of dried plant parts in a mortar and pestle sieved through a 0.5 mm sieve and preserved following the preparation methodology devised by Muthuri and Jones [27]. The portions of dried samples were then determined and transferred quantitatively into the destruction tubes in which digestion was done in a block using concentrated sulphuric-salicylic mixture with selenium as a catalyst. Analysis of nitrogen on digested samples was then done in accordance with the Standard methods of examination of water and wastewater [28].

3 RESULTS AND DISCUSSION

3.1 Plant Dominance

The analysis of plants dominance indicated that 20 species were dominant, out of which 18 were monotype form, 16 were ubiquitous form, 15 were compressed form, 10 were aberrant form, 17 were matrix form, 6 were diffuse form, and 14 were patchy form. Monotype and matrix forms were the most common dominant forms in four transects of the vegetation zones making up the wetland. *Typha domingensis* and *Cyperus papyrus* showed monotype form more often than matrix form with monotype to matrix form ratios of 2:1. *Azola* species showed no monotype form, but had a high matrix form appearance of 7. The species which didn't show up the monotype form were the *Azola* species

and *Ipomea* species. All the other species showed the monotype in at least one of the quadrates. *Sesbania* species, *Acacia brevispic* and *Psidium guajava* species didn't show any matrix form in all the sampled quadrates. On the other hand, *Ocimum* species showed only two forms; matrix and monotype forms, respectively (Fig. 3). Dominance was observed to be a function of both species and location.

3.2 Plant Density

Table 2 presents the results of the average density of plants from the four transects in consideration. It can be seen that plants density ranged from 3.1 ± 0.3 to 3.3 ± 0.3 plants/m² with a mean value of 3.2 ± 0.3 plants/m². Hume *et al.* [29]

reported that plants can affect the nitrifying and denitrifying bacteria in the wetland in many ways. In wetlands, the organic carbon is supplied mainly by plants. This organic matter is used directly as a carbon and energy source for heterotrophic bacteria. Plant tissue provides a large amount of surface areas for microbial growth; attached bacteria are more active and more abundant than free living bacteria in aquatic systems. This attachment of microorganisms to submersed solid surfaces such as sediment and aquatic macrophytes, leads to the formation of biofilms. From the plant density findings it can be suggested that the biofilms formation will enhance bacterial activity in the wetland hence favoring nitrification/denitrification processes.

Table 2: Results of plants density determination

Transect	1	2	3	4	Average
Plant density (plants/m ²)	3.1 ± 0.3	3.2 ± 0.2	3.3 ± 0.3	3.1 ± 0.3	3.2 ± 0.3

3.3 Plant Biomass

Cyperus papyrus, *Typha domingensis* and *Phragmites australis* were the most dominant species in the wetland (Fig. 3), hence are the ones whose biomass and nitrogen content were analyzed. Table 3 (A-D) shows the results for the plants biomass production. *Cyperus Papyrus* had a higher biomass content than the rest of the species followed by *Phragmites*, but *Typha* had the least biomass content (Table 3A-C and Fig. 4A). For any given plant species the biomass generally decreased from the inlet zone (T-1) towards the outlet zone (T-4). This may be attributed by the fact that total ammonia nitrogen, which is preferentially utilized by plants for cellular matter production, decreases from the inlet towards the outlet. The maximum above ground *Papyrus* biomass (umbel and culm) recorded in this study was 2.98 ± 0.51 kgDWm⁻² and the maximum below ground papyrus recorded was 2.3 ± 0.1 kgDWm⁻². The above ground biomass (umbel and culm) production was relatively higher than the below ground (roots and rhizome) biomass production accounting for 58% of the total biomass while the below ground biomass was 42 % (Fig. 4B).

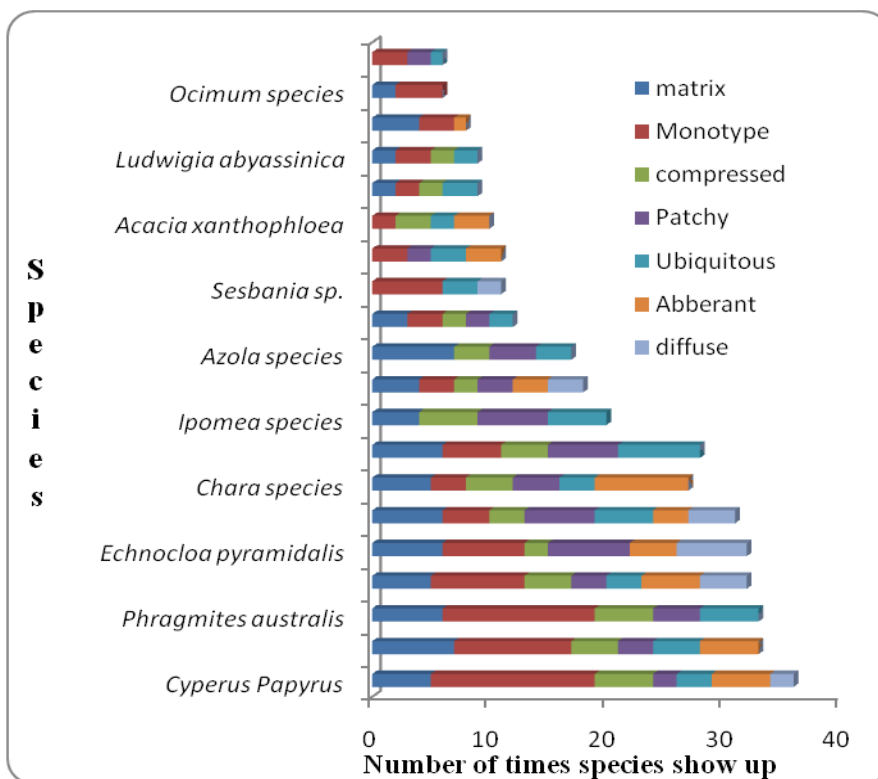


Figure 3: Dominant species and showing up of the seven types of dominance

Biomass production for *Phragmites Australis* was decreasing from the inlet (T-1) toward the outlet (T-4), with the maximum above ground biomass record of 3.08 ± 0.3 kgDWm⁻² and the maximum below ground biomass recorded as 1.63 ± 0.1 kgDWm⁻². The above ground biomass like *Cyperus papyrus*, had higher percentage than the below ground biomass, whereby the above ground biomass accounted for 61.5%

while the below ground biomass accounted for 38.5% of the total biomass (Fig. 5A). *Typha domininges* biomass production had the highest below ground biomass record of 1.72 ± 0.1 kgDWm⁻² and highest above ground biomass of 1.78 ± 0.27 kgDWm⁻². Above ground biomass accounted for 57% of the total biomass while the below ground biomass accounted for 43% of the total biomass (Fig. 5B).

Tables 3: Plants biomass

A: *Cyperus Papyrus*

	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (kgDWm ⁻²)	2.3 ± 0.1	1.83 ± 0.3	1.59 ± 0.3	1.4 ± 0.2	1.78 ± 0.39
Culm (kgDWm ⁻²)	1.13 ± 0.1	1.05 ± 0.2	0.94 ± 0.4	1.03 ± 0.2	1.04 ± 0.08
Umbel (kgDWm ⁻²)	1.85 ± 0.3	1.69 ± 0.4	1.18 ± 0.4	1.18 ± 0.1	1.48 ± 0.35
Total (kgDWm ⁻²)	5.28 ± 1.09	4.57 ± 0.42	3.71 ± 0.33	3.61 ± 0.19	4.3 ± 0.79

B: *Phragmites australis*

	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (kgDWm ⁻²)	1.58 ± 0.1	1.63 ± 0.1	1.29 ± 0.1	1.24 ± 0.3	1.44 ± 0.19
Stalk (kgDWm ⁻²)	1.18 ± 0.2	1.01 ± 0.4	0.68 ± 0.3	0.65 ± 0.3	0.88 ± 0.26
Leaves (kgDWm ⁻²)	1.90 ± 0.2	1.44 ± 0.3	1.24 ± 0.3	1.10 ± 0.4	1.42 ± 0.35
Total (kgDWm ⁻²)	4.66 ± 0.51	4.08 ± 0.6	3.21 ± 0.5	2.99 ± 0.1	3.74 ± 0.50

C: *Typha domingensis*

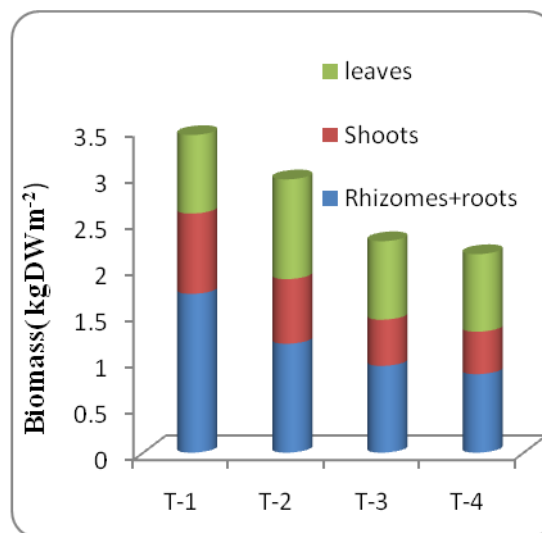
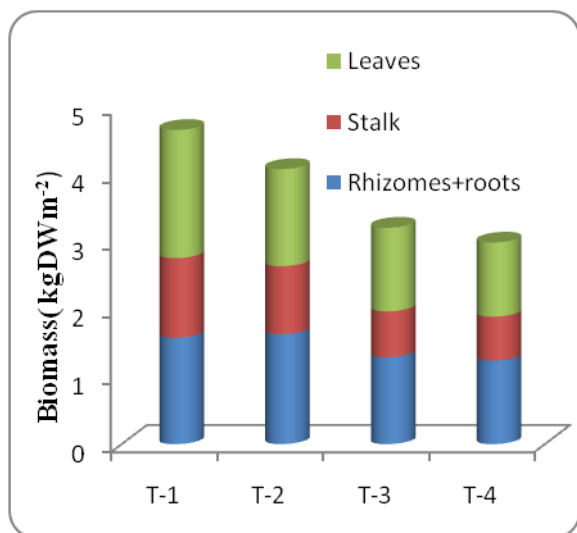
	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (kgDWm ⁻²)	1.72±0.1	1.18±0.3	0.94±0.2	0.85±0.1	1.17±0.4
Shoot (kgDWm ⁻²)	0.87±0.	0.7±0.3	0.5±0.1	0.46±0.2	0.63±0.19
Leaves (kgDWm ⁻²)	0.85±0.	1.08±0.2	0.85±0.2	0.84±0.3	0.91±0.12
Total (kgDWm ⁻²)	3.44±0.5	2.96±0.34	2.29±0.2	2.15±0.3	2.71±0.6

D: Plants biomass as a function of below/above ground plant parts at different transects

	T-1		T-2		T-3		T-4	
	BG	AG	BG	AG	BG	AG	BG	AG
Papyrus	2.3±0.1	2.98±0.5	1.83±0.3	2.74±0.4	1.59±0.3	2.12±0.1	1.4±0.2	2.21±0.11
AG/BG	1.3		1.5		1.33		1.58	
Typha	1.72±0.1	1.72±0.0	1.18±0.3	1.78	0.94±0.2	1.35±0.2	0.85±0.1	1.3±0.13
AG/BG	1.0		1.51		1.44		1.53	
Phragmites	1.58±0.1	3.08±0.3	1.63±0.1	2.45±0.3	1.29±0.1	1.92±0.4	1.24±0.3	1.75±0.2
AG/BG	1.94		1.5		1.49		1.41	

Units: kgDWm⁻²

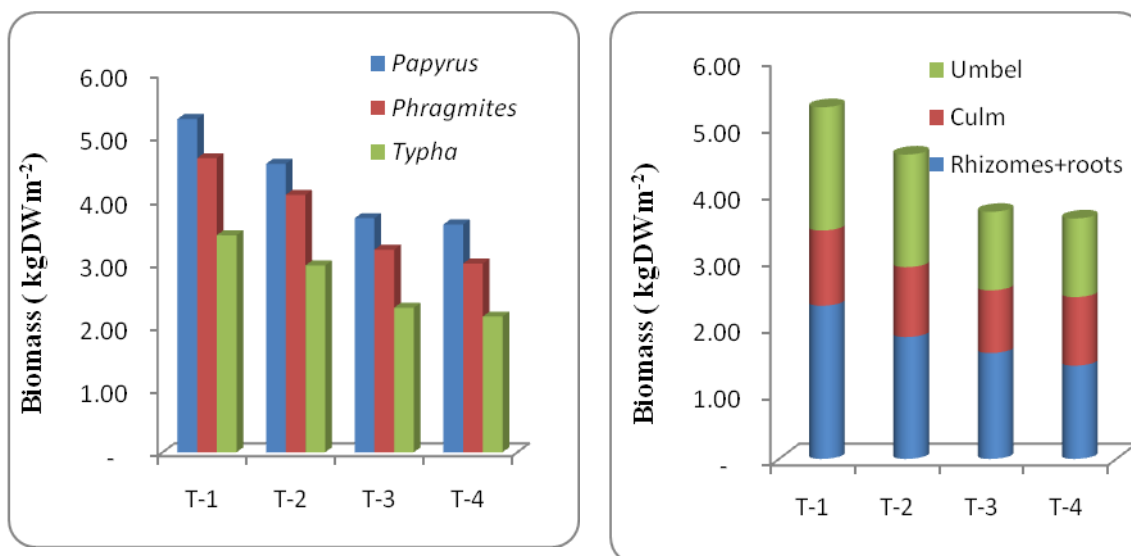
BG- Below ground organs AG- Above ground organs T-1, 2, 3, 4 = transects sampled



A: *Phragmites australis*

B: *Typha domingensis*

Figure 4: Biomass for all plants and *Cyperus Papyrus*



A: All plants compared

B: *Cyperus papyrus*Fig. 5: *Phragmites* and *Typha* biomass

3.4 Nitrogen content in plants

Table 4 A-D shows the results of the nitrogen content in plant parts, which are further illustrated by Figures 6A and B to 7A and B.

Tables 4: Plants nitrogen content

A: <i>Cyperus papyrus</i>					
	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (%DW)	0.85±0.3	0.83±0.2	0.75±0.1	1.03±0.1	0.87±0.12
Culm (%DW)	1.14±0.2	1.12±0.3	1.08±0.2	1.03±0.5	1.09±0.05
Umbel (%DW)	1.70±0.3	1.5±0.5	1.33±0.3	1.34±0.2	1.47±0.30
Total (%DW)	3.69±0.4	3.45±0.3	3.16±0.18	3.4±0.22	3.35±0.22
B: <i>Phragmites australis</i>					
	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (%DW)	0.98±0.4	0.95±0.2	0.9±0.3	0.80±0.4	0.91±0.08
Stalk (%DW)	1.25±0.4	1.23±0.2	1.12±0.2	1.09±0.2	1.17±0.10
Leaves (%DW)	1.78±0.1	1.65±0.1	1.42±0.5	1.33±0.3	1.55±0.40
Total (%DW)	4.66±2.0	4.08±0.4	3.21±0.3	2.99±0.2	3.63±0.70
C: <i>Typha domingensis</i>					
	T-1	T-2	T-3	T-4	Average
Rhizomes+roots (%DW)	0.88±0.2	0.9±0.2	0.75±0.1	0.9±0.1	0.86±0.50
Shoot (%DW)	1.2±0.2	1.15±0.1	1.1±0.3	1.05±0.3	1.13±0.06
Leaves (%DW)	1.73±0.1	1.52±0.1	1.35±0.4	1.34±0.3	1.49±0.18
Total (%DW)	3.44±0.74	2.96±0.54	2.29±0.64	2.15±0.61	3.47±0.45

D: Plants nitrogen content as a function of below/above ground plant organs

	T-1		T-2		T-3		T-4	
	BG	AG	BG	AG	BG	AG	BG	AG
<i>Papyrus</i>	0.85±0.3	2.84±0.4	0.83±0.2	2.62±0.27	0.75±0.1	2.41±0.18	1.03±0.1	2.37±0.22
<i>Typha</i>	0.88±0.2	2.93±0.4	0.9±0.2	2.67±0.26	0.75±0.1	2.45±0.2	0.9±0.1	2.39±0.2
<i>Phragmites</i>	0.98±0.4	3.03±0.38	0.95±0.2	2.88±0.3	0.9±0.3	2.54±0.21	0.8±0.4	2.42±0.17

BG- Below ground organs **AG-** Above ground organs

The total nitrogen content varied in different plants for all the three species (Table 4 A-D). Figure 6A shows that for a given transect, the plant nitrogen content was highest in *Papyrus*, followed by *Phragmites*, but *Typha* had the lowest nitrogen content. Senzia [30] who experimented on constructed wetland system treating domestic wastewater observed that *Phragmites* had higher nitrogen content compared to *Typha*, due to higher accumulation of ammonia nitrogen observed in *Phragmites* than in *Typha*. Plant nitrogen content was higher in above ground organs than in below ground organs for all the plant species (Figures 6B, 7A and 7B) probably because these organs can be inflorescence and are responsible for the photosynthetic activities. Furthermore the higher above ground nitrogen content can as well be attributed by the relatively higher biomass production. Denny [31] reported that young plants possesses higher above ground biomass than old ones while older plants possesses higher below ground biomass than younger ones. These can be due to inflorescence (young plants) and storage of food (old ones). Differences in nutrient composition in plants are likely due to translocation. Nutrients stored by plants are to be translocated to the metabolically active sites when environmental conditions are optimal for

growth [31]. This being the case, plants recycles nutrients from the old organs to the new ones (metabolically active) for growth. From these findings, nutrients removal from a given wetland when the composition and density of plants are known can be established.

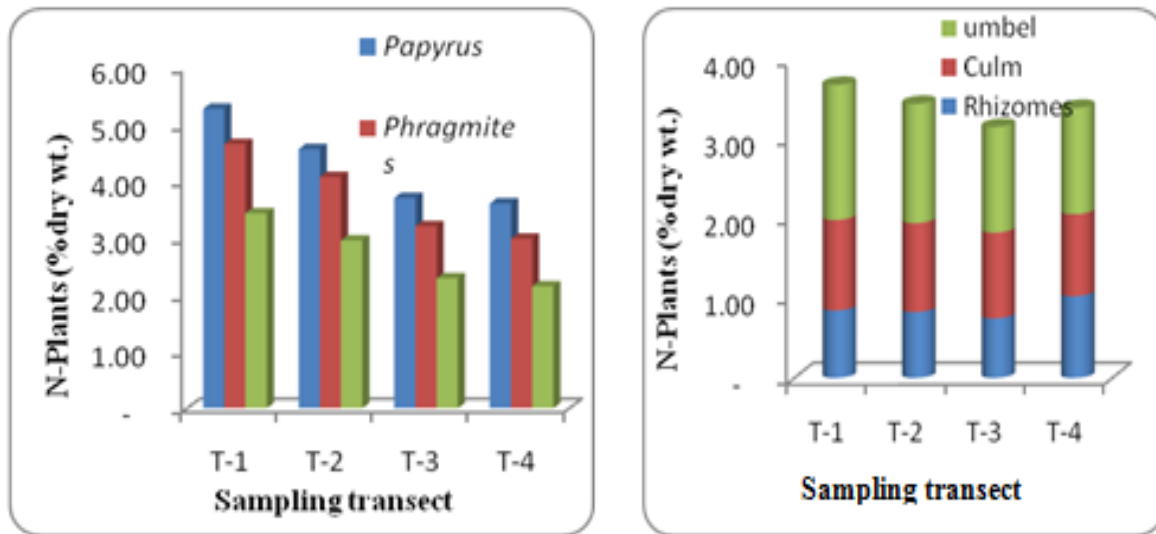
3.5 Estimation of nitrogen content of the wetland plants

Plants nitrogen content determination was estimated by the application of the plants biomass (DWm^{-2}) and nitrogen content (%DW) data, respectively. After the plants biomass content (in $kgDWm^{-2}$) and the plants nitrogen content (in %DW) were determined, the final plants nitrogen content was determined (in gm^{-2}) as a product of biomass and nitrogen content. Table 5 shows the *Papyrus*, *Phragmites* and *Typha* biomass and nitrogen content in above ground and below ground biomass. *Papyrus* has the highest biomass content of $2.52 kg DW/m^2$, but *Typha* had the least biomass content of $1.53 kg DW/m^2$. The nitrogen content in plant biomass was higher in above ground than below ground for all plants. The mean plants nitrogen content found was to be $67.88 gNm^{-2}$.

Table 5: Plants nitrogen content

	Biomass ($KgDWm^{-2}$)			Nitrogen content (%DW)			Nitrogen content (gm^{-2})		
	AG	BG	Total	AG	BG	Total	AG	BG	Total
<i>Papyrus</i>	2.52±0.5	1.78±0.3	4.3±0.4	2.48±0.2	0.87±0.1	3.35±0.2	62.49	15.49	77.98
<i>Phragmites</i>	2.3±0.38	1.44±0.1	3.74±0.2	2.72±0.5	0.91±0.2	3.63±0.7	62.56	13.10	75.66
<i>Typha</i>	1.53±0.2	1.17±0.4	2.7±0.55	2.61±0.2	0.86±0.1	3.47±0.6	39.93	10.06	49.99
Average	2.12±0.5	1.46±0.3	3.58±0.8	2.60±0.1	0.88±0.0	3.48±0.1	55.0	12.88	67.88

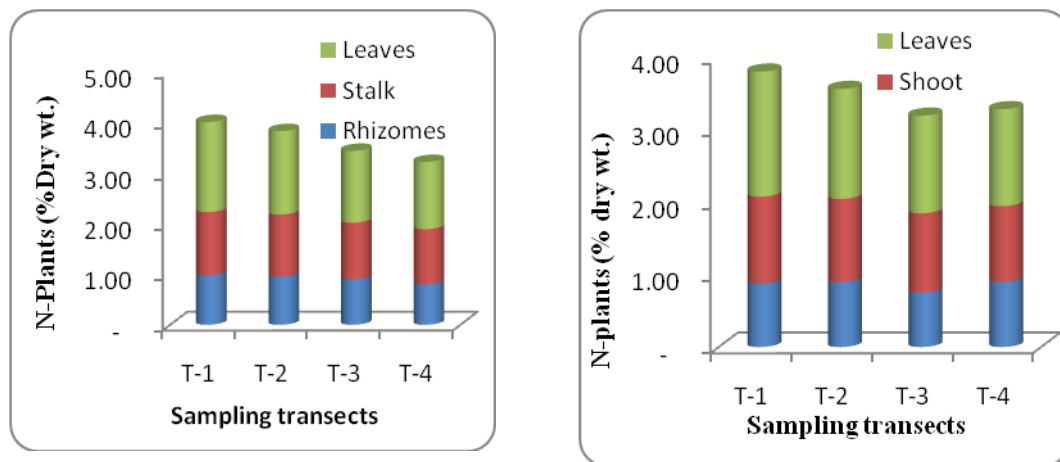
AG= above ground organs **BG=** below ground



A: All species compared

B: *Cyperus papyrus*

Figure 6: Nitrogen content for *Cyperus papyrus* and for all species being compared



A: *Phragmites australis*

B: *Typha domingensis*

Figure 7: *Phragmites* and *Typha* nitrogen content

4. CONCLUSIONS

From the results of this research work, the following conclusions are made;

- (a) Dominant plant species were *Cyperus papyrus*, *Typha domingensis*, *Phragmites australis*, *Thelpteris interrupta*, *Echinochloa pyramidalis*, *Cyperus articulatus*, *Chara* spp., *Eichhornia crassipes* “water hyacinth” and *Azola* spp., which accounted for more than 50% of all the species recorded are an indication of a typical wetland habitat. Furthermore lack of colonizing woody and/or other early succession species suggests that the wetland is stable with respect to vegetal cover. Hence for sustainable wetland functioning while maintaining ecological and biodiversity quality; nutrients load reduction from the non-point source, creation and maintenance of buffer zones and wetland’s participatory monitoring over its functionality are to be practiced.

- (b) *Cyperus papyrus*, *Typha domingensis* and *Phragmites australis* were the most dominant species in the wetland. *Cyperus papyrus* had higher biomass content than the rest of the species followed by *Phragmites*, but *Typha* had the least biomass content.

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