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Abundance, diversity and distribution of Macrophytes in lotic wetlands: A case study on Sironga and Kapkatet Wetlands, Kenya

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Abstract

Wetland macrophytes provide important ecological and social-economic values. However, the recent increase in anthropogenic influences has compromised the ecological integrity of most lotic wetlands, which has ultimately threatened their structure and functioning, causing degradation and loss of macrophytes. This study was aimed at assessing the biodiversity, distribution and abundance of macrophytes in Sironga and Kapkatet wetlands with respect to various anthropogenic activities. Sampling was conducted for a period of six months, covering both dry and wet seasons from February – July 2019. Macrophytes were identified using identification keys and diversity indices such as the Shannon-Wiener, Simpson's, and Species evenness were used to determine macrophyte diversities. The numbers of different macrophytes species was enumerated from five randomly sampled line transects along the water ways and another fifteen also randomly distributed on the wetlands on a monthly basis. There were three main lifeforms of aquatic macrophytes found in both Sironga and Kapaktet wetlands namely, emerged, submerged and floating, which were dominated by *Centella asciatica* and Cyperus sp. and the floating macrophytes, *Potamogeton schwenfurthii* dominated Kapaktet wetland. The study found that macrophyte distribution, abundance and biodiversity were highly affected by predominant economic activities resulting to wetland conversion, nutrient influxes and unsustainable exploitation of macrophytes. We recommend a further study focusing on effects of sedimentation resulting from unsustainable agricultural practices on water quality and macrophytes diversity, distribution and abundance, the effects of changing land-use practices and how different environmental agencies can be involved in the advocacy, conservation and management of the riverine wetlands.

Keywords: Lotic Wetlands; Macrophytes; Diversity; Distribution; Abundance

1. INTRODUCTION

On an ecological perspective, wetlands are highly diverse ecosystems which are seasonally or permanently inundated with water. This provides anoxic conditions that support oxygen-free processes, which promote the growth of characteristically distinct wetland vegetation [1]. These plants co-exist in most wetlands, some such as the free floating macrophytes, such as *Pistia stratiotes* and *Eichhornia crassipes* which have a short turnover time being extensively used in constructed wetlands to remove nutrients and heavy metals like Zinc, Nikel, and Cadmium from wastewater [2]. According to the Ramsar convention of 1971, wetlands occur naturally or artificially, lotic or lentic, some are seasonal while others occur permanently [7, 8, 9]. Although wetlands only cover approximately 6% of earth's surface, their immense value is largely underestimated, owing to their multiple ecological and economic uses [3]. Different life forms of wetlands such as the floating-leaved macrophytes are secondary carbon sources which bio-geochemically transfer energy to the decomposers. Additionally, plant surfaces provide habitat for bacterial growth, as well as uptake and storage of the nutrients and aeration of water bodies [4]. Population growth has nonetheless fueled increased utilization of macrophytes threatening different species with total extinction. This is because water quality in these wetlands is highly compromised by pollution, abstraction and wetland conversion which can result into low biodiversity and decreased importance of wetlands with regard to sustenance of life on earth [5].

Due to the recent growth of anthropogenic influence on natural ecosystems, it is difficult to achieve a well-balanced wetland ecosystem without adequate conservation measures which are geared towards restoration of ecosystem integrity, economic and aesthetic values of wetlands. Therefore, maintenance of healthy and diverse wetland ecosystem is crucial to ensure balanced biotic and abiotic interactions [6]. The abundance, occurrence, composition, distribution and biodiversity of aquatic macrophytes depends on many factors, such as availability of solar energy which is converted to organic matter, wetland processes and energy dynamics as well as physico-chemical parameters of the wetland environment [10, 11, 12, 13]. For instance, countries which lie within the tropics have a high abundance, distribution and diversity of aquatic macrophytes probably because of a constant photoperiod and *Papyrus* spp. is among the most dominant and most productive emergent macrophytes in the tropical and subtropical regions [6, 12, 13]. In Kenya, some fringe riverine and lacustrine wetlands are commonly known as "Papyrus wetlands" due to extensive distribution and abundance of different *Papyrus* spp. Despite the important salient characteristics, socio-economic and ecological values of wetlands, there is paucity of information on macrophyte characteristics of most Kenyan wetlands [14]. This study therefore aimed at assessing the distribution, abundance and diversity of macrophytes in Sironga and Kapkatet wetlands which provide water sources to feed influent rivers draining into Lake Victoria.

2. MATERIALS AND METHODS

2.1 Study areas

Sironga (00°30'23"S, 34°54'58" E) and Kapkatet (0°38'32"S, 35°13'21" E) wetlands, are Kenyan highland wetlands located at altitudes of 2,017 and 1,957 meters in Nyamira and Kericho Counties respectively (Fig. 1 & Fig. 2). The two wetlands are approximately 30km apart located in a densely populated region of about 900 people per km2 and the sampling sites were selected based on varied human activities within the Wetlands.

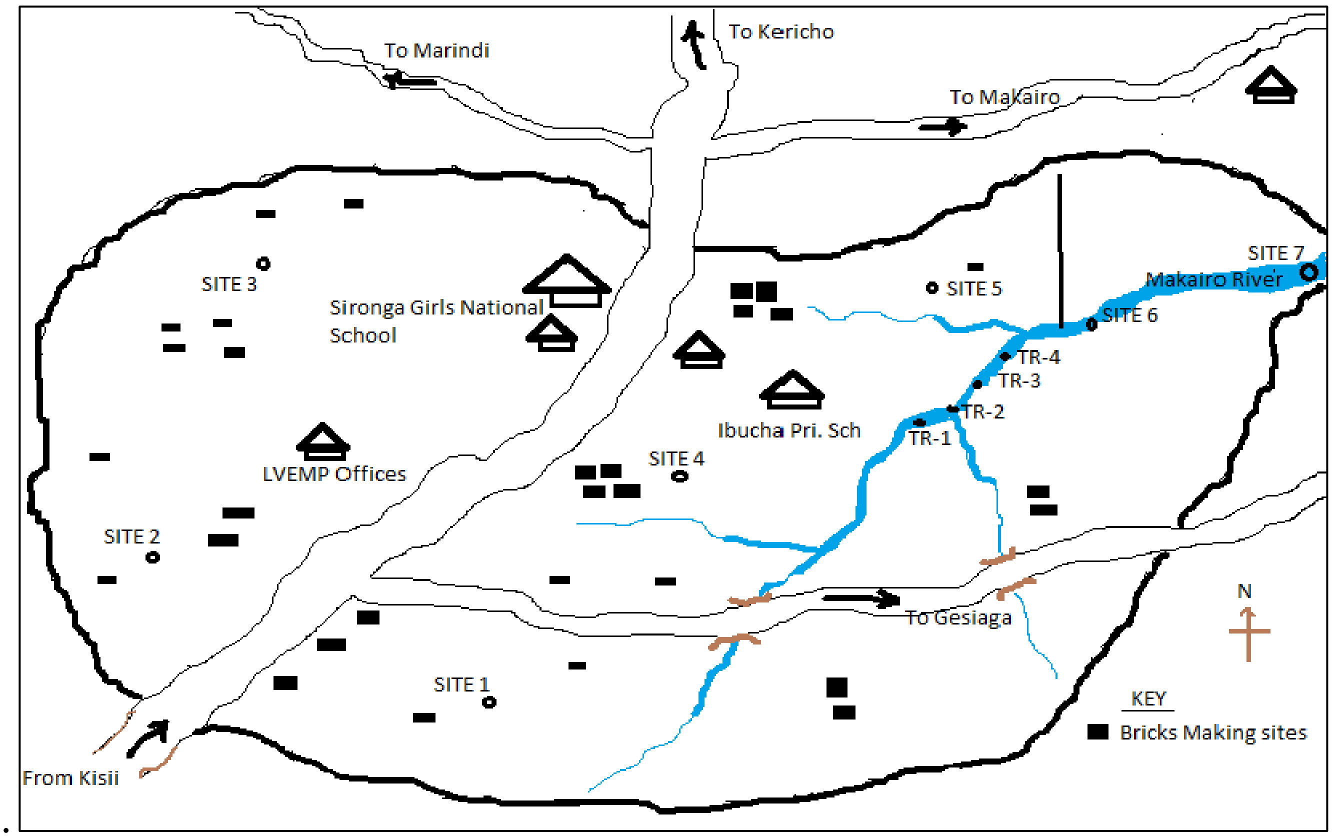

Figure 1: *A sketch Map Showing the Sironga Wetland and some human activities within and around it*

In both wetlands, the sampling sites were selected based on the predominant human activities. For instance site G1 (0.35490S, 0.3454420E) was conspicuously affected by water abstraction for car wash and infrastructural development such as road and building construction, whereas, site T1(00.6008680S, 034.9110120E) was a recipient of the effects of farming activities in the wetland. The predominant economic activity in site W1was brick making and indiginous riparian vegetation had been replaced by exotic *Eucalyptus* spp. On the other hand, site W2 (00.5958400S, 034.9120920E) was mainly used for grazing animals. For Kapkatet wetland, selection of Site S1 (00.6511950S, 035.2089720E) in Kapkatet wetland was premised on the recent increase in agricultural activities, while sites S2 (00.6500930S, 035.2060380E) and S3 were to cover the effects of wetland conversion (into padocking and Eucalyptus plantation) and infrastructural development respectively.

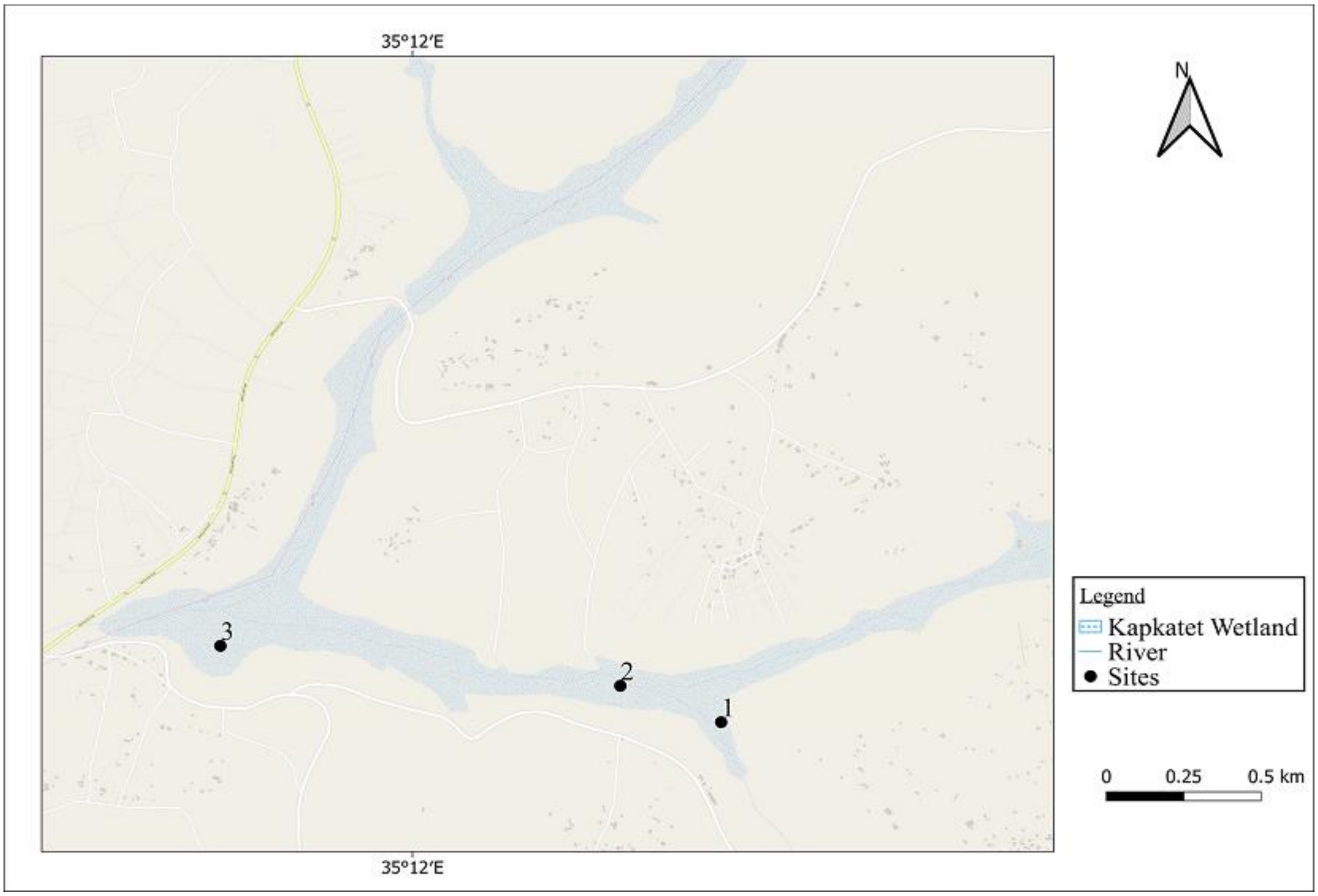

Figure 2: *Map of Kapkatet wetland showing sampling sites in Kericho County*

2.2 Sampling of Macrophytes

A Global Positioning System (model 35c-Garmin) was used to map the randomly selected sampling sites. Various macrophytes were collected from these sites for identification, enumeration and classification. Macrophyte samples from different sampling sites were sampled using 5 by 5m quadrats and 50m long line transects for which all the macrophytes were counted and then the procedure was repeated for the remaining 19 points. From that, 5 and 15 randomly distributed line-transects were used to sample the riparian zone and extensive floodplain respectively on a monthly basis for a period of six months. The different plants were counted and identification of different macrophytes was done to species level through visual observation of plant morphological features, such as flowers, fruits, shoot and rhizomes [14, 15, 16]. The percentage cover of macrophytes was estimated using photographs taken during sampling. The macrophyte plants collected were labeled and stored correctly to avoid damaging plant morphological features such as flowers, fruits and rhizomes which provide a brief description of the habitat.

2.3 Estimation of Biodiversity indices

The study estimated four diversity indices according to [17]: Shannon-Wiener$(H) = \sum - (Pi * ln\, Pi)$, where; **Σ** is the sum of all calculation and $\mathbf{P_i}$ is the fraction of species i in the entire population while Simpson's diversity index: $(\boldsymbol{D}) = \frac{\sum n(n-1)}{N(N-1)}$, where; **n** = number of individuals of each species and **N**, the total number of individuals of all species. Species richness = $\frac{S}{\sqrt{N}}$ where **S** is the number of species and **N** the total number of individuals of all species and species evenness= $(\boldsymbol{E}) = \mathbf{1} - \frac{\boldsymbol{Imin}}{\boldsymbol{Imax - Imin}}$ where **I** is the diversity index and I_{min} and I_{max}, the lowest and highest values of this index for the given number of species.

3. RESULTS

Throughout the study, a total number of 21900 aquatic plants of different categories (emergent, sub- merged, floating and free floating) were collected, consisting of 53 species of macrophytes that were identified from all seven sampling stations (Table 1). The aquatic macrophytes represented 21 families. The highest dominated were *Centella asiatica, Cyperus helferi* and *C. marginatus*, the least dominant was *Kolanchoe densifora. Centella asiatica, Limnophila chinensis,* *Isolepsis fruitans* and *Cyperus* sp. were evenly distributed in all sampling sites. Majority of the species were found in site S1 in Kapkatet wetland and the least were found in site T1 in Sironga wetland. Macrophytes richness changed with time and area. *C. asiatica* recorded higher density in S1 of 1050 followed by W2 with 650 while S3 recorded lower density of 200. *C. helferi* and *C. marginatus* recorded a higher density in S1 of 1100 and 1055 respectively. *Polygonum setosulum, Kolanchoe densiflora, Polygonum* sp., *Teramnus* sp, *Dichrocephala* sp, *Alchemilla* sp, *Osmondia regalis, Dissotis* sp and *Sphaeranthus suaveolens* recorded low densities in all the sampling sites.

Table 1: Macrophytes distribution in Sironga and Kapkatet wetlands

Botanical name	G1	T1	W1	W2	S1	S2	S3
Centella asiatica	300	0	600	650	1050	500	200
Blechum indicum	10	0	12	0	22	0	0
Athyrium filix- femina	15	0	20	0	25	18	0
Aciotis acuminifolia	10	0	50	0	0	0	0
Limnophila chinensis	0	0	150	0	0	0	0
Cyperus helferi	100	0	254	0	1100	450	278
Comarum palustre	0	0	210	150	750	0	0
Cyperus marginatus	100	0	254	0	1055	250	138
Actinoscirpus grossus	0	0	210	150	750	0	0
Colocasia esculenta	0	0	0	0	0	0	150
Cyperus rotundus	0	0	115	150	750	320	0
Panicum virgatum	158	0	0	0	372	120	0
Robus apetalus	0	0	120	0	350	0	0
Ludwiga abyssinica	17	0	0	0	167	0	0
Polygonum setosulum	58	0	0	0	0	0	0
Coelachne Africana	210	0	320	0	0	0	0

Helichrysum forskahlii	0	0	0	0	392	0	0
Crassula granuikii	195	120	155	0	558	215	0
Dissotis senegambieceaesis	0	0	0	0	298	0	0
Sphaeranthus suaveolens	0	45	0	0	0	0	0
Isolepis fruitans	120	95	152	108	225	120	108
Helichrysum globosum	0	0	0	0	165	0	0
Commelina diffusa	0	0	0	0	0	118	0
Plectrathus punctatus	0	0	0	0	258	0	0
Pennisetum clandestinum	0	0	185	0	250	0	0
Melanthera scandens	0	0	0	0	185	0	0
Pellacavindis varocanonica	22	0	0	0	0	0	0
Alchemilla kiwawensis	20	15	0	0	171	62	0
Polygonum nepalense		0			0	66	0
Spermacoce princiae	0	0	0	0	0	51	0
Digitaria abyssinica	121	85	181	175	0	0	0
Tristema mauritianum	7	0	27	15	0	0	0
Poa annua	227	0	315	0	0	0	0
Kolanchoe densiflora	0	0	0	0	17	0	0
Cyphostempm barbuseti	0	0		0	62	0	0
Achyrospermum schimperi	18	0	0	0	75	0	0
Polygonum salicifolium	38	0	0	0	112	0	0
Potamogeton schwenfurthii	26	0	52	0	0	350	0
Spermacoce princiae	0	51	0	0	0	0	0
Kalanchoe desiflora	18	0	0	0	0	0	0
Ageratum conyzoides	38	0	0	0	0	78	0
Microglossa densiflora	0	0	20	0	0	0	0
Polygonum sp.	0	0	30	0	0	0	0
Cyperus dives	0	0	115	85	320	80	50

Teramnus sp.	0	0	0	0	20	0	0
Dichrocephala sp.	0	0	20	0	0	0	0
Oxyanthus sp.	0	260	0	0	0	0	0
Cyperus sp.	0	0	120	75	470	251	185
Commelina sp.	0	0	0	0	0	125	0
Panicum sp.	0	0	0	0	300	0	0
Alchemilla sp.	0	0	0	0	50	0	0
Osmondia regalis	0	0	0	0	92	0	0
Dissotis sp.	0	0	0	0	85	0	0

In Sironga wetland, the macrophytes community were dominated by *C. asiatica* (20.02%), followed by *Digitaria abyssnica* (7.3%) and *Poa annua* (7%). The wetland was dominantly composed of *C. asiatica*. This is more or less stable because the difference in dominance with the next dominance species is large, approximately 13%. Six species namely; *Crassula granukii, Coelachne africana, Poa annua, Digtitaria abyssinica* and *Isolepis fruitans* had percentage composition of above 5% indicating that their distribution was significant while the rest were insignificant (Table 2).

Table 2: Densities of macrophytes in Sironga Wetland.

Botanical name	Range	Mean	SD	Total	% Composition
Ludwiga abyssinica	17	4.25	8.5	17	0.22
Achyrospermum schimperi	18	4.5	9	18	0.23
Kalanchoe desiflora	18	4.5	9	18	0.23
Microglossa densiflora	20	5	10	20	0.26
Dichrocephala sp.	20	5	10	20	0.26
Blechum indicum	12	5.5	6.4	22	0.28
Pellaca vindis varocanonica	22	5.5	11	22	0.28

Polygonum sp.	30	7.5	15	30	0.39
Athyrium filix- femina	20	8.75	10.3	35	0.45
Alchemilla kiwawensis	20	8.75	10.3	35	0.45
Polygonum salicifolium	38	9.5	19	38	0.49
Ageratum conyzoides	38	9.5	19	38	0.49
Sphaeranthus suaveolens	45	11.25	22.5	45	0.58
Tristema mauritianum	27	12.25	11.5	49	0.63
Spermacoce princiae	51	12.75	25.5	51	0.66
Polygonum setosulum	58	14.5	29	58	0.75
Aciotis acuminifolia	50	15	23.8	60	0.77
Potamogeton schwenfurthii	52	19.5	24.8	78	1.01
Robus apetalus	120	30	60	120	1.55
Limnophila chinensis	150	37.5	75	150	1.94
Panicum virgatum	158	39.5	79	158	2.04
Pennisetum clandestinum	185	46.25	92.5	185	2.39
Cyperus sp.	120	48.75	59.2	195	2.52
Cyperus dives	115	50	59	200	2.58
Oxyanthus sp.	260	65	130	260	3.36
Cyperus rotundus	150	66.25	77.8	265	3.42
Cyperus helferi	254	88.5	119.9	354	4.57
Cyperus marginatus	254	88.5	119.9	354	4.57
Comarum palustre	210	90	106.7	360	4.65
Actinoscirpus grossus	210	90	106.7	360	4.65
Crassula granuikii	195	117.5	84.1	470	6.07
Isolepis fruitans	57	118.75	24.4	475	6.13
Coelachne Africana	320	132.5	159.4	530	6.84
Poa annua	315	135.5	160.5	542	7.00
Digitaria abyssinica	96	140.5	45.7	562	7.26
Centella asiatica	650	387.5	301	1550	20.02

In Kapkatet wetland, two species, *C. helferi* and *C. asiatica* were almost co-dominant, implying a relative instability in dominance, while other species such as *C. marginatua* and *C. rotundus* had a relatively high percentage composition. Eight species (*C. marginutus, Cyperus sp., C. rotundus, Crassula granukii, C. asiatica, C. helferi, Actinoscirpus grossus* and *Comarun palustre*) had percentage composition greater than 5% while the remaining species had low abundance of less than 5 % (Table 3). Therefore, the two wetlands exhibited a clear difference in the dominant macrophyte community with Sironga being dominated by *C. asiatica* while Kapkatet wetland was dominated by *C. helferi*. Some macrophytes, such as C. asiatica and P. annua in Sironga wetland, and *C. marginatus* and *C. asiatica* in Kapkatet wetland, showed a high degree of variance in their spatial distributions. There were three lifeforms of aquatic macrophytes found in both Sironga and Kapaktet wetlands namely, emerged, submerged and floating, which were dominated by *C. asciatica* and *Cyperus* sp. There was only one floating macrophytes species in both wetlands, *Potamogeton schwenfurthii*. which was dominant in Kapaktet wetland.

Table 3: Densities of macrophytes within Kapkatet wetland.

Botanical Name	Range	Mean	SD	Total	% Composition
Kolanchoe densiflora	17	5.67	9.81	17	0.12
Teramnus sp.	20	6.67	11.55	20	0.14
Blechum indicum	22	7.33	12.70	22	0.15
Athyrium filix- femina	25	14.33	12.90	43	0.29
Alchemilla sp.	50	16.67	28.87	50	0.34
Spermacoce princiae	51	17.00	29.44	51	0.35
Cyphostempm barbuseti	62	20.67	35.80	62	0.42
Polygonum nepalense	66	22.00	38.11	66	0.45
Achyrospermum schimperi	75	25.00	43.30	75	0.51
Ageratum conyzoides	78	26.00	45.03	78	0.53

Dissotis sp.	85	28.33	49.07	85	0.58
Osmondia regalis	92	30.67	53.12	92	0.62
Polygonum salicifolium	112	37.33	64.66	112	0.76
Commelina diffusa	118	39.33	68.13	118	0.80
Commelina sp.	125	41.67	72.17	125	0.85
Colocasia esculenta	150	50.00	86.60	150	1.01
Helichrysum globosum	165	55.00	95.26	165	1.12
Ludwiga abyssinica	167	55.67	96.42	167	1.13
Melanthera scandens	185	61.67	106.81	185	1.25
Alchemilla kiwawensis	171	77.67	86.57	233	1.58
Pennisetum clandestinum	250	83.33	144.34	250	1.69
Plectrathus punctatus	258	86.00	148.96	258	1.75
Dissotis senegambieceaesis	298	99.33	172.05	298	2.02
Panicum sp.	300	100.00	173.21	300	2.03
Robus apetalus	350	116.67	202.07	350	2.37
Potamogeton schwenfurthii	350	116.67	202.07	350	2.37
Helichrysum forskahlii	392	130.67	226.32	392	2.65
Cyperus dives	50-320	150.00	147.99	450	3.04
Isolepis fruitans	108- 225	151.00	64.37	453	3.07
Panicum virgatum	372	164.00	189.86	492	3.33
Comarum palustre	750	250.00	433.01	750	5.07
Actinoscirpus grossus	750	250.00	433.01	750	5.07
Crassula granuikii	558	257.67	281.44	773	5.23
Cyperus sp.	185-470	302.00	149.19	906	6.13
Cyperus rotundus	750	356.67	376.34	1070	7.24
Cyperus marginatus	138-1055	481.00	500.24	1443	9.76
Centella asiatica	200- 1050	583.33	431.08	1750	11.84
Cyperus helferi	278-1100	609.33	433.55	1828	12.37

Shannon Weiner index (H), Simpson (1-D), Species Evenness and Richness were used in this study. Shannon Weinner ranged from 1.623 site T1 to 2.846 site S1 (Table 4). Shannon Weinner was highest in site S1 by 2.846 and lowest in site T1 by 1.623, Simpson ranged from 0.757 at site T1 to 0.926 in site S1. Simpson was highest in site S1 by 0.926 and lowest in site T1 by 0.757. Species Evenness ranged from 0.600 in site G1 to 0.898 in site S3. Evenness diversity index was highest in site S3 by 0.898 and lowest in site G1 by 0.60. Species richness ranged from 0.726 in site S3 to 2.873 in site S1. Richness diversity was highest in site S1 by 2.873 and lowest in site S3 by 0.726.

Table 4: Macrophytes diversity indices in Sironga and Kapkatet wetlands.

	G1	**T1**	**W1**	**W2**	**S1**	**S2**	**S3**
Taxa (S)	19	7	21	9	27	14	6
Shannon (H)	2.434	1.623	2.698	1.826	2.846	2.137	1.685
Simpson (1-D)	0.888	0.757	0.915	0.778	0.926	0.829	0.800
Evenness	0.600	0.724	0.707	0.690	0.638	0.605	0.898
Richness	2.448	0.927	2.478	1.087	2.873	1.578	0.726

4. DISCUSSION

Lotic wetlands play a crucial role in the stream ecosystems by protecting the stream banks from the impacts of floods and storm waters, removing environmental pollutants and improve the water quality. These wetlands provide habitat for flora and fauna, hence enhancing the biodiversity of streams by supporting different life forms. Although the macrophyte community in both the two wetlands were represented by three biological forms, the emergent species dominated the wetlands while the floating macrophytes only occupied sheltered stream waters of Kapkatet wetland. Only few macrophytes were uniformly distributed across both the wetlands, and the abundance varied considerably based on anthropogenic activities and water quality parameters. Macrophytes diversity and species composition was high in both wetlands. The abundantly distributed macrophytes, such as *Apiaceae, Cyperaceae, Poaceae* and *Cyperus* sp. and the frequently occurring macrophytes, such as Plantaginaceae and Crassulaceae could be considered resilient and well-adapted to the changing wetland environment as a result of increasing anthropogenic activities, while *Blechnaceae, Dyropteridae, Melastomataceae, Commelinaceae, Rosaceae, Melatomataceae, Potamogetanaceae, Onagraceae, Polygonaceae, Asteraceae* and *Rubiaceae* were less abundant and rarely distributed, and could be highly vulnerable to environmental changes. The high abundance of Apiaceae, Cyperaceae, Poaceae and Cyperus sp. was attributed and correlated to high dissolved oxygen, total nitrogen and favourable temperatures at the sites. Four families of macrophytes were distributed in all sites of the Kapkatet wetland, *Apiaceae, Blechnaceae, Plantaginaceae* and *Cyperaceae*.

Macrophytes are highly sensitive to the environmental changes caused by natural and anthropogenic effects. In Sironga wetland, the highest number of macrophytes recorded at site W1 was attributed to exposure to sunlight, clear water and high nutrients level while the lower number recorded at site T1 was attributed to encroachment of the wetland, paddocking and agricultural activities. These activities have led to nearly total loss of a large number of macrophyte species which had been previously observed growing in the wetland. In contrast, the highest number of macrophytes recorded at site S1 in Kapkatet wetland, which would have been due to high levels of total nitrogen and phosphorus, resulting from inorganic fertilizers used in the adjacent farms which are known to promote the growth of aquatic plants. Nevertheless, some species such as *Blechum indicum* were directly lost from the riparian zone of

Sironga wetland as a result of frequent use of pesticides for weeding, since the wetland is located within a high potential agricultural land [18].

However, lower abundance of macrophytes recorded at site S3 can be attributed to high turbidity, which prevents light penetration and consequently slowing the rate of photosynthesis. Both wetlands experienced related anthropogenic influences resulting from activities such as grazing, farming, infrastructural development, and replacement of indigenous vegetation with exotic trees which are known to lower the water table. Indeed, [7] had observed that a decreased water table could be the main reason for the decline in species richness of macrophytes. This is further supported by [19] who reported that decreased water table disturbs the microbial habitat and activity in the surface waters affecting the survival and growth of some macrophyte species. In addition, grazing defoliates the vegetation cover which alters the ecosystem interactions leaving only the most resilient plants. [20] found that paddocking can cause habitat fragmentations and alter the community structure of macrophyte species through disturbance of their ecological niches.

The abundance and dominance of the three families of macrophytes, Apiaceae, Cyperaceae and Poaceae in both wetlands was highly correlated to dissolved oxygen levels, total nitrogen, phosphorous and the prevailing optimum temperatures (unpublished data). Generally, the three families of emergent macrophytes (Apiaceae, Crassulaceae and Cyperaceae) dominated the macrophyte communities due to their competitive ability, which makes them able to survive in both aerobic and anaerobic conditions. [21] found that these species can recycle nutrients hence create energy flows, through microbial loops, which sustains them and various commensals which grow in association with these macrophytes. Their abundance can however be restricted by indiscriminate harvesting for livestock feed reducing the available biomass for primary consumers and decomposers and nutrient sequestration [22]. Consequently, the low abundances of *Blechum indicum, Athyrium filix- femina, Actinoscirpus grossus, Robus apetalus*, and *Colocasia esculenta* species at sites G1 and T1 could be largely attributed to increased human activities and therefore a possible loss of some ecological values of these wetlands. For instance, *Cyperus* species such as *C. rotundus* are important in phytoremediation because they accumulate heavy metals such as Cr, Mn, Fe, Cu, Zn and Pb [8]. Climate change has also exacerbated the effects of anthropogenic activities in the wetlands through by changing the reproduction cycles and growth patterns of macrophytes [23] and macrophyte densities of macrophytes showed a significant relationship with nutrient levels, particularly nitrates, phosphates and dissolved oxygen. Previous researchers such as [24] and [25] consider a high Shannon-Wiener diversity index (H') to be a good indicator of optimal water quality conditions for the survival and growth of macrophytes. In this study, the high macrophytes diversity at S1 (H' = 2.846) in (Table 4), indicates optimum temperature, nutrients availability and light penetration (unpublished data). High temperatures enhance the solubility rates of DO and increase the metabolic processes of the macrophytes. Comparatively, higher macrophyte species diversity was recorded during the rainy season (May, June and July) due to warmer temperatures and nutrients (unpublished data) influxes from overland. The Shannon's index which ranged 1 to 2.5 units indicated eutrophication in most sampling areas of the wetlands during the rainy seasons which was influenced by seasonal nutrient fluctuations. This trend was observed in site S1 which had had the highest species richness of 2.873. The low species richness recorded at S3 (0.726) could be due to poor environmental conditions, such as anoxic conditions which affected plant establishment and growth and the species evenness showing how the individuals are distributed within the wetland were closer to 1. According to [26], values closer to 1 indicate high evenness in the distribution of species. The high species evenness recorded at S3 of 0.898

can be attributed to evenness of the environmental conditions which favored survival of the plants all over the habitat. The low species evenness recorded at G1 of 0.60 indicates a shift to dominance where only few species dominate the station as a response to unfavorable conditions.

5. Conclusion and Recommendations

The diversity, distribution, and abundance of macrophytes was determined by water temperature, dissolved oxygen, TN, TP, TSS and turbidity (unpublished data) in both Sironga and Kapkatet wetlands. Various anthropogenic activities impact negatively and affected water quality and the diversity, distribution, and abundance of macrophytes species in both Sironga and Kapkatet wetlands, which include wetland conversion, poor farming practices, wetland encroachment, deforestation, and unsustainable exploitation of macrophytes which degrade macrophytes and deteriorate water quality. Roads and buildings have been constructed in the wetlands resulting to loss of habitats for growth of macrophytes. Nevertheless, the study has mostly considered taxonomic aspects of macrophytes relating it to abundance, distribution, and biodiversity. However, for effective conservation and management of these lotic wetlands a future related study is needed to focus on: effects of sedimentation resulting from unsustainable agricultural practices on water quality and macrophytes diversity, distribution, and abundance. Effects of changing land-use practices propagated by increased anthropogenic activities on these wetlands and how different environmental agencies can be involved in involved in the advocacy, conservation, and management of the riverine wetlands.

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