Assessment of Plant Commnunity Structure in a Tropical Wetland Affected by Brick Making—The Case of Sironga Wetland, Kenya

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Abstract

Brick making is one of the major small-scale industries in Sironga which has been expanding due to the growing demand for urban expansion. Due to the increasing population pressure, brick-making is competing for the wetland resources. Sironga wetland is threatened with serious degradation and probable loss of plant diversity. Conversion of this wetland for economic uses such as brick making has resulted in its loss. The objective of the study was to assess the effects of brick making on plant diversity in Sironga wetland. Nyamira County, Kenya. A one metre by one metre quadrat frame was laid down and perpendicularly recorded the percent cover for each species found inside the quadrant plus the percentage area covered by the bare ground litter. From each transect lines "diagonally" detailed vegetation under study was then done. The plant species were recorded and classified into three life-forms; herbs, sedges and grasses. The study revealed that grasses had the highest diversity H = 1.144. Diversity for herbs was H = 0.987 and H = 0.899 for reeds respectively. The study concluded that brick-making activities affected the plant diversity in Sironga wetland. This may be attributed partly to the limited information and awareness campaigns to the surrounding communities on the values and benefits of wetland ecosystem services and the lack of alternative livelihood sources. The study recommends that alternative livelihoods are provided and awareness campaigns on the values and benefits of wetlands to the residents are done by the relevant agencies.

Keywords

Diversity Index, Vegetation Types, Environmental Degradation

1. Introduction

Wetlands are habitats for animal and plant communities and have a vital function in maintaining ecosystem balance. The ecological functions of wetlands include maintaining micro-climate and conserving water reservoirs. Humans depend on wetland resources for their livelihood, thereby modifying the community structure of wetland flora and fauna. One of the anthropogenic activities associated with wetlands in developing countries is brick making. Brick making industry is the oldest industry in the history of mankind. Bricks are extensively used as the main input in construction because of their durability, reliability, low cost and easy availability [1]. In Kenya, bricks are still the preferred building material and hence brick making is a lucrative business and many areas are flouted by informal sectors of brick-making activities [2]. In Sironga wetland located in Nyamira County (Western Kenya), bricks are made using traditional kilns. Brick production in the wetland involves cutting of vegetation and draining the area which impacts directly on wetland biodiversity. Brick-making has immense disturbance potential to cause ecological alterations [3]. Disturbance has been recognized as one of the major factors influencing variations in species diversity [4] [5]. Brick-making activities cause significant disturbances on land [6] that adversely affect vegetation [7]. The disturbances alter the physico-chemical properties and habitats of soil which are likely to influence species diversity [3]. Due to the increasing human population, the demand for bricks for housing within and outside the study area has been increasing which poses a threat to the plant species and diversity. Although production of bricks in the study area has risen in the last decade [8], there is insufficient information on the effects of brick making on plant diversity. This study was undertaken to assess the plant community structure following the rise in brick-making activities within Sironga wetland.

2. Materials and Methods

2.1. Study Area

Sironga wetland is situated in Nyamira sub-location, Western Kenya. It is located at longitudes 34˚45' and 35˚00' East, and latitudes 0˚30' and 0˚45' South. The total area is approximately 899.4 km^2 [8]. The study area has two rainy seasons that is well distributed throughout the year with the long rainy season occurring in December to June and short rain seasons from July to November. Annual rainfall ranges between 1200 mm - 2100 mm per annum. Daily temperatures range between 28.7˚C and 10.1˚C respectively. The average normal temperature is 19.4˚C which is favorable for both agricultural and livestock production [9]. Sironga wetland is an area where most activities of brick making take place and the volume of bricks produced in this area is the highest compared to other wetlands in the County including the neighbouring Nyabomite, Nyabioto and Charachani wetlands.

2.2. Sampling and Data Analysis

An ecological survey study design was adopted in this study. Vegetation foliar cover was determined using the quadrat method. The centre of the study area was established, after which four transect lines were laid down from the centre of the study area. Random quadrat method was used to conduct vegetation sampling where measurement of species composition was carried out. The plot size measured 800 m by 600 m. The exercise was repeated for 15 quadrats. Inside each plot, quadrats of sizes 1 m by 1 m were placed at random. In each plot, all species of plants were identified and recorded, and their percentage cover estimated. The Plant species within the plots were recorded and classified into three life-forms; herbs, sedges and grasses. The species diversity was calculated using the standard diversity index; Shannon diversity index H.

$$\text{Shannon Index}\left(H\right)=\sum_{i=1}^{s}P_i\ln P_i$$

where $P_i = N_i/N$;

And N_i = Sum of individual of a species;

N = Sum of overall species.

3. Results and Discussion

Table 1 shows the plant species that were identified in Sironga wetland during the study. The plants were classified into herbs, sedges/reeds and grasses. A total of 39 plant species were identified: 24 herbs, 8 sedges and 7 grasses. The results showed that the family of *Asteraceae* had the highest number of 8 plant species each followed by *Acanthaceae* with 3 plant species each, *Papilionaceae* with 2 plant species each and *Oxilidaceae*, *Brassicaceae*, *Caryophyllaceae*, *Commelinaceae*, *Menispermaceae*, *Lamiaceae*, *Apocynaceae*, *Cucurbitaceae*, *Dernstaedtiaceae*, *Caesalpiniaceae* with 1 plant species each.

The Shannon entropy index analysis revealed that species diversity for herbs in Sironga Wetland was 0.987, 0.899 and 1.144 for herbs, sedges and grasses respectively. The diversity of all the plant species showed that grasses had the highest diversity followed by herbs and reeds respectively. The dominance of the grasses is assumed to be high because it is fast growing aquatic species of the wetland and therefore when trees/shrubs are cut, the grasses take over fast. Sedges and grasses are also the main peat formers in wetland environments [10] [11] hence dominating the wetland. Though there are some dominant species in Sironga wetland for example S*cirpus debilis* with 10,998 individuals and *Ipomoea acquatica* with 9802 individuals, the diversity is still low. The presence of several species in a disturbed environment is because the species have the ability to live and adapt to the environmental changes [12]. The main causes of biodiversity loss are land use and land cover changes which may lead to the dominance of new invasive species at the expense of native plant species [13] [14]. This supports the findings that the low number of species in Sironga is due to disruption of the ecosystem by activities such as brick making. This supports the

Table 1. Plant diversity in Sironga wetland.

No	Order	Family	Species	No. Counted	P_i	$\ln P_i$	P_i*$\ln P_i$
			HERBS				
1	Asterales	Asteraceae	*Aspillia* spp.	1	0.00008	−9.433	−0.001
2	Asterales	Asteraceae	*Spilanthes mauritania*	1	0.00008	−9.433	−0.001
3	Asterales/compositales	Asteraceae	*Sphaeranthus* spp.	1	0.00008	−9.433	−0.001
4	Asterales/compositales	Asteraceae	*Senecio* spp.	59	0.00457	−5.388	−0.025
5	Asterales/compositales	Asteraceae	*Conyza bonariense*	5	0.00039	−7.849	−0.003
6	Asterales/compositales	Asteraceae	*Blepharis integrifolia*	1	0.00008	−9.433	−0.001
7	Asterales/compositales	Asteraceae	*Dichondra repens*	1107	0.08579	−2.456	−0.211
8	Asterales/compositales	Asteraceae	*Ageratum* spp.	74	0.00573	−5.162	−0.030
9	Caryophyllales	Caryophyllaceae	*Silene garlica*	7	0.00054	−7.524	−0.004
10	Commelinales	Commelinaceae	*Commelina benghalensis*	3	0.00023	−8.377	−0.002
11	Cruciferales	Brassicaceae	*Brassica napus*	2	0.00015	−8.805	−0.001
12	Cucurbitales	Cucurbitaceae	*Momordica foetida*	1	0.00008	−9.433	−0.001
13	Fabales	Papilionaceae	*Trifolium semi-pilosum*	723	0.05603	−2.882	−0.161
14	Fabales	Papilionaceae	*Dolichus* spp.	543	0.04208	−3.168	−0.133
15	Fabales	Caesalpiniaceae	*Cassia didymobtrya*	8	0.00062	−7.386	−0.005
16	Gentianales	Apocynaceae	*Catharantus roseus*	3	0.00023	−8.377	−0.002
17	Geraniales	Oxilidaceae	*Oxalis latifolia*	203	0.01573	−4.152	−0.065
18	Lamiales	Acanthaceae	*Hypoestes forskabili*	46	0.00356	−5.638	−0.020
19	Lamiales	Acanthaceae	*Hypoestes* spp.	200	0.01550	−4.167	−0.065
20	Lamiales	Lamiaceae	*Fuerstia africana*	6	0.00046	−7.684	−0.004
21	Lamiales	Acanthaceae	*Thunbergia annua*	1	0.00008	−9.433	−0.001
22	Polypodiales	Dernstaedtiaceae	*Pteridium aquilinum*	1	0.00008	−9.433	−0.001
23	Ranunculales	Menispermaceae	*Cissampelos pareira*	106	0.00821	−4.802	−0.040
24	Solanales	Convolvulacea	*Ipomoea acquatica*	9802	0.75961	−0.275	−0.209
			Total	**12,904**			**−0.987**
				Shannon entropy index $H = -\sum_1^{24} P_i \ln P_i$			**0.987**
			Sedges: Cyperaceae				
25	Poales		*Scirpus debilis*	10998	0.74939	−0.288	−0.216
26	Poales		*Cyperus digitatus*	196	0.01336	−4.315	−0.058
27	Poales		*Kyallinga* spp.	176	0.01199	−4.431	−0.053
28	Poales		*Cyperus esculentus*	486	0.03312	−3.408	−0.113
29	Poales		*Cyperus* spp.	78	0.00531	−5.238	−0.028
30	Poales		*Cyperus rigidifolia*	739	0.05035	−2.989	−0.150

Continued

31	Poales	*Carex* spp.	1979	0.13485	−2.004	−0.270
32	Poales	*Cyperus rotundus*	24	0.00164	−6.413	−0.011
		Total	**14676**			**−0.899**
			Shannon entropy index $H = -\sum_{1}^{8} P_i \ln P_i$			**0.899**
		Grasses: Poaceae/Graminae				
33	Poales	*Pennisetum clandestinum*	780	0.15479	−1.866	−0.288
34	Poales	*Digitaria scalarum*	3228	0.64060	−0.445	−0.285
35	Poales	*Digitaria velutina*	230	0.04564	−3.087	−0.141
36	Poales	*Sporobulus pyramidalis*	30	0.00595	−5.124	−0.030
37	Poales	*Paspalum* spp.	573	0.11371	−2.174	−0.247
38	Poales	*Eragrostis ciliaensis*	129	0.02560	−3.665	−0.094
39	Poales	*Eragrostis racemosa*	69	0.01369	−4.291	−0.059
		Totals	**5039**			**−1.144**
			Shannon entropy index $H = -\sum_{1}^{7} P_i \ln P_i$			**1.144**

findings that the low number of species in Sironga is due to disruption of the ecosystem by activities such as brick-making, human settlement and deforestation. It implies that Sironga wetland has been degraded as a result of unsustainable exploitation which has affected the diversity of the plant species. Brick-making has led to the destruction of the habitat for both fauna and flora affecting species abundance and species diversity. It can therefore be deduced that the extraction of resources from Sironga wetland has led to low species diversity.

Cyperus spp. was a source of building materials for traditional houses, so was clay. However, with the reduction of grass, it has led to decrease in traditional grass thatched houses. The introduction of brick-making also saw a shift in building materials. Many people started changing from traditional houses made of clay to brick houses. The reduction of *Cyperus* spp. also saw a shift to iron sheets for roofing. Since the inception of brick making in the wetland, reduction of *Cyperus* spp. can be explained by the high demand for the grass to cover the bricks from the effects of direct sunlight, rain and destruction from livestock. A report by [8], made a similar observation of *Cyperus* spp. used to cover bricks when they are spread out to dry to avoid destruction from cattle, sunlight and rainfall. According to [15], a major consumptive practice in Sironga leading to the diminishing of papyrus was due to its multiple usage in building traditional houses and rampant brick making. Habitat alteration/destruction or loss is the greatest threat to plant species. As human population undertake brick-making activities in the wetland, there is disturbance or alteration and loss of many habitats for wild species. Deforestation, draining and reclaiming wetlands and mowing fields for residential or commercial purposes, human settlement, mining are predominant elements of habitat fragmentation which affects species diversity leading habitat destruction [16]. These activities destroy habitats for plants and animal species, isolate communities, therefore, compressing genetic diversity [17]. In Sironga wetland, a number of plant species have declined and may become extinct in the near future. For instance, plant species for *Asteraceae Lamiaceae* and *Solanaceae* are 8, 1, and 1 each respectively. There is a probability of the decline has been affected by harvesting of *Cyperus* spp. and brick making. Findings of this study in relation with other wetlands regionally and internationally, demonstrate that extensive brick making poses a danger of some plants species going into extinction unless measures are taken to preserve the wetland. Despite the fact that very few wetlands are found within Nyamira County, brick making as an economic activity influences plant diversity. The study revealed that brick making in Sironga wetland has contributed to the decline in plant diversity. Low diversity index could also be contributed by other factors such as planting *Eucalyptus Saligna* which contributes to both wetland drainage, which reduces diversity of plants, and loss of plant species. Studies have shown that *Eucalyptus* trees exclude most under growths reducing flora in situ. From the study, it is concluded that encroachment on Sironga wetland through brick making has contributed to the loss of biodiversity. Conservation practices such as use of locally adapted and indigenous tree seedlings should be encouraged so as to sustain the wetland. Grounds, where the production of bricks takes place, should be refilled by planting the suitable tree species to make the ground more stable. Planting bamboo trees should also be encouraged to meet the energy requirements for brick production. Enrichment planting should be carried out for ecological restoration of the degraded area. The Ministry of Environment, Water, Energy, Mining and Natural Resources, NEMA, Forestry Department and the County Government should work together with the County Government and Survey of Kenya Institute of Survey and Mapping to monitor wetlands overtime since it is important to assess its functioning and maintaining the wetland.

4. Conclusion

Encroachment on Sironga wetland through brick making and planting of *Eucalyptus* trees had contributed to the loss of biodiversity. Lack of adequate and appropriate knowledge about the functions and values of wetlands has hindered active management by local communities. The existing policies and legislations on wetlands and strategies aimed at enhancing the wetland functions and values and protecting biodiversity have not been met.

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Conflicts of Interest

The authors declare no conflict of interest.

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