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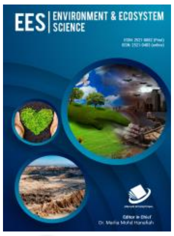

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RESEARCH ARTICLE

STUDY OF THE PHYTODIVERSITY ALONG ANTORUN RESERVOIR,

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ABSTRACT

The Antorun river is a flowing river situated at Onipanu village, along Ogbomoso-Iresaapa road, Nigeria. It was constructed primarily for irrigation purpose through the Nigerian-Canadian vegetation project and is under scrutiny for other purposes such as hydroelectric project, recreation, fishing and research. This study aimed at evaluating and documenting the species richness and diversity of the non-woody angiosperms along the reservoir.1m² quadrats were placed randomly at both rainy and dry seasons to sample non-woody angiosperms along upper (site A), middle (sites B and C) and lower (site D) courses which extend to about 1 km. A total of 1526 non-woody individual plants belonging to 28 genera and 13 families were identified in the study area. 22 of the plants were medicinal while others were forage plants. The family Asteraceae had the highest number of individuals (878) representing 9 species, with *Tridax procumbens* being the most frequent (11.3%). The importance Value Index (IVI) of the species in the study ranged between 1.1 and 44. Sampling point B recorded the highest diversity with Simpson's index of 0.822 and Shannon-Wienner's index of 1.849. The upper course of the reservoir was richest while the lower course was the poorest in species diversity and the commonest plant species in the study area was *Emilia sonchifolia*. Some woody species present in the study area were also identified and recorded. Information about plant diversity in this study area is useful in evaluating the potential impact of proposed developmental activities on the environment.

KEYWORDS

Phytodiversity, wetland, Antorun, Environmental Impact, species richness.

1. INTRODUCTION

1.1 Background Information

Wetlands are important sites for biological conservation because they support a rich biodiversity and present high productivity [1]. At present in Nigeria, the destruction of natural habitats occurs continuously; a pace which results into the depletion of the country's biodiversity. According to a report by the researchers, about 48 species of animals and 431 species of plants are endangered in Nigeria, of which 16 species of mammals and 20 species of plants are endemic [2].

In the aquatic ecosystem, the phytoplanktons are the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell fish and fin-fish [3]. The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers [4]. The researchers reported that plankton communities serve as bases for food chain that supports the biological integrity of the water body [5,6].

The researchers referred to wetlands as general sinks for sediments and that wetlands which are connected to adjacent aquatic ecosystems (e.g. rivers, estuaries) may trap more sediment as compared to wetlands that lack such connectivity [7]. Wetland contributes to a healthy environment, such as; water retention at dry periods, flood mitigation, trapping of suspended solid and attached nutrients [8]. Wetlands may be sources of organic Carbon, and Nitrogen, (Mitsch and to aquatic ecosystems 1,9]. Wetlands are distinguished by three primary components: hydrology, soils and vegetation. Wetland hydrology is the driving force that, determines the soil development, the assemblage of plants and animals that inhabit the site and the type and intensity of biochemical processes [10].

The researchers conducted a research on planktonic diversity in krishnagiri reservoir in India in which they discovered that *Scenedemus sp, Rediastrum duplex, Bacillaria sp., Cymbella leptoceros, Gamphonema sp., Meloxira sp., Navicula cyplocephala, N. cospidala, N. viridula, Nitchia obtusa, Pinnularia sp., Chleriva sp., Oscillatoria currices* and *O. limosa* were dominant during the monsoon [11]. The wide distribution, spatial abundance of phytoplankton diversity are dependent upon the user of the underground and surface water quality and diversity and its abundance were said to be due to the dilution factors performed in the sampling stations and enhanced by the physical and chemical variability in coordination with seasonal and spatial variations.

The researchers carried out a similar study in Ethiopia, in which vegetation samples were collected from the field with special attention paid on the general habitat, topography, growth form and abundance of the plants [12]. From their study, a total of 71 species of vascular plants were recorded which belong to 44 families and 62 genera in which the most frequent species in the reservoir area were *Croton macrostachyus* (23.1%), *Dombeya torrid* (15.4%), and *Combretum adengonium* (12.3%). The most frequently encountered species in the downstream area were *Maytenus senegalensis* and *Carissa spinarum* (8.27% each), followed by *Dombeya torrida* (12.3%).

The researchers conducted a research on diversity and variability of aquatic macrophytes in Ikpa river in Ikot Ebom, Nigeria; in which the modified method of flora collection by other researchers were used [13,14]. The results of their study indicated that 286 individual plants comprising 35 species, 27 genera and 17 families were encountered. ANOVA result showed that all the months were insignificantly different at the probability level of 0.05 ($F = 3.07$; $P = 0.0113$). The monthly variations of aquatic macrophyte species and the highest occurrence was observed in *Dissotis erecta* (11.385%) while *Panicum subalbidum* occurred least (only 2 times).

The researchers carried out studies on baseline studies of the flora biodiversity of a proposed crude oil exploration field in Edo State, Nigeria during both wet and dry seasons. Identification of vegetation at the various observation points along the transect was carried out to species level, documented and characterized using $100m^2$ form of quadrat [15]. One hundred and twelve plant species belonging to 102 genera and 58 families were encountered in the study. Medicinal plants made up 39% of the total plant species, weeds 26% edible fruits, food crops, oil crops and fiber crop 31% while timber trees made up 4% of the total.

1.2 Justification of the Study

According to the researchers, many dams were built in Nigeria during the twentieth century following geotechnical and hydrologic studies; but with minimal pre-project ecological studies. Neither the values nor the vulnerabilities of the river ecosystems are generally appreciated before such constructions were undertaken [12]. Many of the major dams were situated in remote locations and were implemented with limited public interest and environmental consequences since they were undertaken before comprehensive environmental impact analysis were conducted. Ecological attributes were often neglected, and pre-dam ecological conditions were rarely inventoried [12]. The current use and management of water and wetland resources is dominated by the construction of large dams to store much of the available water for hydropower irrigation and urban water supply. This practice which serves to exacerbate the climate variability and change impacts has often left too little for maintaining the traditional wetland function downstream and caused significant stream flow regime change in most of the major wetlands in Nigeria, UNEP (2007) alerts that globally, wetlands have been reduced by 50%, while the other researchers estimated that one-third of all endangered species are dependent on wetlands[16,17,18].

Information obtained from the officials of NABDA has it that, the Antorun dam was newly completed and on it, information on aquatic resources was yet to be documented [19]. Though, there is an ongoing research on the study of the aquatic animals, there is need to study and document the available plant species. With the results of such a study at hand, saving the plants biodiversity activities becomes practicable. Such human activities include river or water impoundment; waste water discharges; over exploitation of the plant animal resources. A search into the literature has also shown no empirical data readily available on the biodiversity of wetlands around Antorun reservoir.

This study shall therefore be beneficial because its outcome can have the potential to provide information on the variety of life forms in the location prior to planning further developmental projects there. This step is important in order to determine at the onset, the potential impacts such developmental projects could have on biodiversity. It will also enable one to know what biological species would be at the receiving end of such impacts; as well as its possible implications on the environment in future. The researchers has pointed out, "Realizing the cumulative impact of our activities and learning how we can conduct the human enterprises within nature's regenerative capacity is essential" [20]. Thus, whether one views development from the economic or environmental perspective, one should realize that we are all dependent on biodiversity. Its survival is therefore very central to our survival. So, sustainable development is the key issue for consideration at all times. This study is therefore, necessary in order to ensure documentation of the various plant species available near the Antorun reservoir (which was a proposed site for rural electricity generation) and this shall in turn serve as guide for policy making, planning and for proper conservation so as to sustain life.

Wetland plants, both vascular and nonvascular exist in sufficient richness to provide clear and robust signals of human disturbance. They have been used effectively to distinguish environmental stressors including hydrologic alterations, nutrient enrichment, and other types of human disturbance [21-24]. This study is further justifiable by the fact that Vegetation is useful to evaluate wetland integrity as they are found in all wetlands. Plants are primarily immobile and as such they reflect the temporal, spatial, chemical, physical, and biological dynamics of a system; they can indicate any long-term, chronic stress it undergoes [24]. This study sought to dwell on the aforementioned facts to evaluate the status of the study site with respect to angiosperm biodiversity, past anthropogenic influences on plant diversity and recommend means for future developmental efforts.

1.3 Aim and Objectives

The aim of this study was to evaluate the status of the flora around Antorun reservoir with respect to its non-woody angiosperm diversity.

The objective of the study was to investigate and document the floristic composition at the upstream, midpoint area and the downstream of the reservoir being proposed for electricity generation. This effort is therefore a necessary and important one as an integral part of the Environmental Impact Assessment of the location. In order to achieve the aim of this study, the following objectives have been defined:

(i) To enumerate the variety of angiosperm species in the study area;

(ii) To document the biological species richness around Antorun reservoir with respect to its angiosperm diversity;

(iii) To calculate the relative abundance of the different non-woody angiosperm species making up the flora richness of the study area;

(iv) To compute some forest ecological indices on the flora of the study area with a view to documenting the species distribution along the reservoir.

(v) To identify and record the woody species present in the study area.

2. MATERIALS AND METHODS

2.1 The study Area

Study of angiosperm plant diversity was conducted along Antorun stream and its reservoir which is located at Onipanu village, along Ogbomoso-Iresaapa road, Oyo State, Nigeria. The study area covers the upper, middle and lower courses of the stream spanning a length of about 1.5km. and the sampling points spanned a distance of about 40m on either sides of the stream. (Figure 1).

2.1.1 The Antorun stream and reservoir

The Antorun stream is a flowing stream, which takes its source from Antorun a village, near Onipaanu village northwest of Ogbomoso. The vegetation is that of a transition between forest and savannah, with a dam that was constructed by the federal government of Nigeria. The construction was fully completed in 2012 by the Ogun-Osun River Basin Development Authority, which has its headquarters in Abeokuta and under the Federal Ministry of Water resources [19]. The geographical location of the dam is on latitude 08° 06 .63', Longitude 04° 18.520′ and latitude 08° 06.571'; longitude 04° 18.573′ at 354 m above sea level with an average depth of 8.42 m [19]. The dam was primarily constructed for vegetation through irrigation and for some other purposes such as; hydroelectric power project for aesthetic purposes, for recreation and relaxation. It was also meant to serve, as a means of livelihood through fishing, sporting, picnicking and for research purpose [19].

Antorun stream and reservoir is enriched with diverse organisms; as it is home to a variety of economically important fauna and flora. There are three main genera and four species of fish identified so far based on catch record of the local fishermen. These species are Tilapia (*Oreochromis* *niloticus*), mud catfish (*Clarias gariepinus*, *Clarias isheriensis*) and the African Pike (*Hepsetus odoe*). These fishes are of economic importance, most especially to the local folks as they constitute a fair percentage of their protein intake and also to researchers due to some identified uniqueness presented by the African Pike (*Hepsetus odoe*) [19].

At Antorun reservoir, there are important flora and fauna species that make up the dam environment such that a balance of nature is maintained. These include wild plants species such as *Eichornia crassipes* (water hyacinth), *Elodea densa*, green algae, some species of water birds, wild rabbits, water snakes, monitor lizards and squirrels [19]. Availability of these animal species may be seasonal as dry season often exposes some, thereby forcing them into hiding or seasonal displacement. It has not been ascertained which of these animals is the most abundant but reports from local hunters has it that grasscutters (*Thryonomis swinderianus*) constitute most of the catch [19].

The whole of the study area was divided into five study sites or plots A, B, C, D and E. sampling point A was an open field located at the upland area of the dam, which had various farming activities. The site also had some streamlets which sources of water to the study area were (Plate 3.1). Sampling point B was at the middle course of the stream on the south eastern part of the reservoir, also devoid of the trees due to some form of farming activities. This site also had a recreational facility in form of a hut (Plates 3.2 and 3.3). Sampling point C was on the north western part of the reservoir (Plate 3.4). Sampling point D was a downstream location southeast of the dam; with its characteristics swampy and fairly shaded nature due to presence of much water and availability of some trees (Plate 3.5). The sampling point E was at the extreme end of the study area, further south western location to the reservoir, across the main bridge along Ogbomoso-Iresaapa road. The location was characterized by large and medium size trees of various species including bamboos.

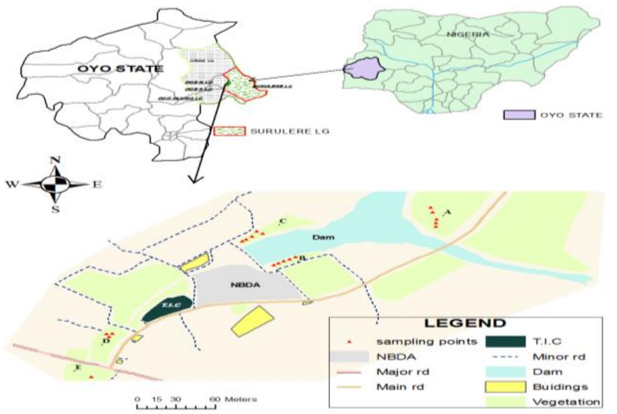

Figure 1: The Map of the Study Area, Showing the Sampling Points.

2.1.2 Vegetation

The vegetation of the study area is savanna woodland, being within the transition zone between the southern guinea zone and the drier northern Nigeria savanna. This ecological zone is generally made up of a mixture of various species of trees, shrubs, herbs and grasses. It is worthy of note that the vegetation of the Antorun stream bank, an average of 40 meters on either side, have been substantially altered by clearing to extend the banks (Plate 6). Other notable places in connection with the study are shown in plates 1 to 10.

2.2 Sampling points and Sampling Technique

The survey of aquatic and wetland plants associated with Antorun dam was undertaken during the tail end of the rainy season in November 2013. The sampling sites were chosen according to the dominant vegetation to represent all aquatic community types. In each plot, five quadrats of 1m^2 were randomly positioned along a transect to sample the non-woody angiosperms around the water (Figure 1). At each sampling point, the easting, northing and altitude were determined in five different positions by means of GPS equipment. The mean values for these readings were then calculated.

2.3 Vegetation Data Collection

The total number of quadrats throughout the study area was recorded. From each quadrat, the species richness was noted, and the names of all the non-woody plant species recorded. The abundance of each species per quadrat was also recorded.

2.4 Plant Specimen Collection and Identification

Voucher specimens of plants were collected from the study area, allotted collection numbers, pressed and dried for keep at the LAUTECH herbarium Ogbomoso (LHO). Many of the plants of the plants were identified on the field but some were taken to the Herbarium of Forestry Research Institute of Nigeria (FRIN) Ibadan for authentication. The plants found on site E were mainly *Tithonia diversifolia*.

Plate 1: Sparse Savanna Vegetation of the Study Area

Plate 2: Upper and Middle Courses of Antorun Reservoir Viewed from Top of the Dam.

Plate 3: Lower Course of Antorun Reservoir Showing the Excess Water Outlet

Plate 4: Onipaanu Village, the Settlement Near the Study Area

Plate 5: Administrative Block of the National Biotechnology Development Agency (NBDA) near the Study Area.

Plate 6: One of the streamlets in site A supplying water to the study area.

Plate 7: The study site B with a recreation facility.

Plate 8: Part of the study site B located at the south eastern area of the reservoir.

Plate 9: The sampling point C of the study area.

Plate 10: The sampling point D of the study area

2.5 Determination of Some Ecological Indices in the Study Area

2.5.1 Frequency, density and importance value index

Frequency of each plant species was calculated by dividing the number of quadrats in which a species occured by the total number of all quadrats. This was carried out during the tail end of the rainy season.

Also during the rainy season, the density of each plant species was determined by counting the number of individuals of the species in a quadrat and summing up the total for all quadrats and dividing it by the total number of quadrats (in m^2) studied. The importance value index (IVI) of each plant species during rainy season was determined for all the plant species found along Antorun reservoir by summing up the relative frequency and relative density.

2.5.2 Measurement of Alpha Diversity

Each of the five study plots A-E was taken as a study site. For each site, species richness was calculated as the total number of species encountered. Evenness or heterogeneity was determined as the distribution of individuals among the species in the site.

As a measure of species richness and community evenness, the following two ecological indices of diversity were computed for each study site.

(i) Simpson's Index of Diversity

This index was calculated using the formula according to the researchers as follows [25]:

$$Is = \frac{1 - \sum n\,(n-1)}{N\,(N-1)}$$

Where n = total number of plants of a particular species
N = the total number of plants of all species

(ii) Shannon - Wiener Index, which is given as follows [26]:

$$H = -\sum Pi\,(\ln Pi)$$

Where P*i* = the proportion of each species in the site.
Other measures of alpha diversity which were computed for each study area include the following:

a) Evenness (E) according to the researchers [26]:

$$E = \frac{H}{\ln S}$$

Where H =Shannon-Wiener index for a site
S = total number of species in the site.
The mean of the five study sites was determined for the study area.

b) Frequency (f): the study area was taken as a unit for this purpose.

The number of all the quadrats laid, was noted and frequency of each species calculated as;

$$f = \frac{\text{Number of quadrats in which a species occurred}}{\text{Total number of quadrats}}$$

c) Density (d): the density of each plant species was calculated as number of individuals per m^2 area of the study location.

d) Importance value index for each species was computed in accordance with the method of [27]. This is defined by the following formula: RF + RD = IVI

Where RF is the relative frequency of each species encountered and,
RD is the relative density of each species found.

Species richness as described by Aremu [28] was estimated as follows:

$$d = \frac{S - 1}{\ln N}$$

Where d= Species Richness, S is the total number of species and N is the total number of individuals of all species.

2.5.3 Measurement of Beta Diversity

Data from the five-sampling points A, B, C, D and E was compared for their similarity / homogeneity or otherwise. The following two similarity indices were employed for this purpose;

a) The modified form of Sorensen's Similarity Index (i.e. Morisita-Horn Index) as presented by the researchers was used to compute the similarity between pairs of sampling points in the study area 29].

$$C_{MH} = \frac{2\sum(a_i \times b_i)}{(d_a + d_b) \times (N_a \times N_b)}$$

Where
N_a = the total number of individuals at site A
N_b = the total number of individuals at site Bt
a_i = the number of individuals in the *i*th species in A
b_i = the number of individuals in the *i*th species in B

$$d_a = \frac{\sum a_i^2}{N_a^2}$$

$$d_b = \frac{\sum b_i^2}{N_b^2}$$

b) Peterson's homogeneity index (P) was used to compare the homogeneity of pairs of sampling points [30].

$$P = 1 - 0.5 \sum | a_i - b_i |$$

Where a = the proportion of species i in sample A
b= the proportion of species i in sample B

2.6. Identification of Woody Species

The tree species in each sampling point were also noted along with other non-woody species that were not encountered in the sampling quadrats.

3. RESULTS AND DISCUSSIONS

3.1 GPS Information about the Sampling Sites

Table 1 shows the mean GPS readings on each of the five-sampling points A TO E. Location A had its easting (d°), northing, and altitude (m) values ranging from 4.3150 to 4.3149 d°, 8.1116 to 8.1126 and 351 to 357 respectively with their respective mean values being 4.3149, 8.1120 and 355m

In location B, the easting (d°), northing (d°) and altitude (m) respectively ranged between 4.3100 to 4.3104, 8.1096 to 8.1099 and 354 to 359, the respective mean being 4.3102, 8.1097 and 356m. In location C, the easting (d°), northing (d°) and altitude (m) respectively ranged between 4.3091 to 4.3094, 8.1111 to 8.1113 and 358 to 361 with their respective mean values being 4.3149 (d°), 8.1120 (d°) and 355 (m). In location D, the easting (d°), northing (d°) and altitude (m) respectively ranged between 4.3049 to 4.3051, 8.1056 to 8.1057 and 351 to 352 with their respective mean values being 4.3050 (d°), 8.1057 (d°) and 351 (m) (Table 1).
From this study, the species richness of the study area was documented. All the non-woody angiosperm species encountered were identified to species level at the herbarium section of the Forest Research Institute of Nigeria (FRIN) in Ibadan. The plants were enumerated based on their species, genera and families. Some of the plants encountered were documented in photographs.

Table 1: GPS – Locations and Elevations of the Sample Sites

Sample site	The mean GPS reading		
	Easting (d°)	Northing (d°)	Altitude (m)
A	4.3149	8.1120	355
B	4.3102	8.1097	356
C	4.3092	8.1113	359
D	4.3050	8.1057	351
E	4.3043	8.1029	349

3.2 Species Richness and Community Evenness of the Study Area

Table 2 shows the non-woody angiosperm species composition and abundance in the study area. A total of 28 plant species belonging to 28 genera and 13 families were encountered. Out of the families, Asteraceae recorded 9 species; Poaceae (4); Papilionaceae (4) and Euphorbiaceae (2); while the other nine families had one species each. In terms of number of individuals, the notable families were Asteraceae represented by 878; Poaceae, by 321; Papilionaceae, by 82 and Euphorbiaceae, by 71 out of a total of 1526 individuals.

The results of relative abundance of each of the 28-plant species encountered in the study area are also presented in Table 1. *Emilia sonchifolia* (family Asteraceae), recorded the highest (35.26%), followed by *Imperata cylindrica* (family Poaceae) with 14.81% and then *Alternanthera sessilis* (family Amaranthaceae) (9.17 %), *Calopogonium mucunoides* (Papilionaceae) (5.05 %), *Andropogon gayanus* (Poaceae) (4.52 %) and *Chromolaena odorata* (Asteraceae) (3.60 %). Among the least abundant species were *Cassia rotundifolia* (Caesalpiniaceae), *Crotalaria retusa* (Papilionaceae), *Elusine indica* (Poaceae), *Phyllanthus amarus* (Euphorbiaceae) and *Spigelia anthelmia* (Loganiaceae) with relative abundance value of 0.07 % each (Table 2).

3.3 Species Frequency, Density and Importance Value Index (IVI)

Percentage frequency, Relative frequency, density and Relative density for each of the plant species are shown in Table 3. The Table also presents the importance value index (IVI) for each species. *Tridax procumbens* was the most frequent species (55%). Among the plants with the least frequency were *Cassia rotundifolia*, *Commelina erecta*, and *Mimosa pigra*, each with a value of 11.0 %. It can also be observed in the entries in Table 2, that *Emilia sonchifolia* was the most densely populated species in this study area (30/m^2). Following this was *Imperata cylindrica* (13/m^2), and next in line was *Tridax procumbense* (10/m^2) and *Alternanthera sessilis* (8/m2). Also, in the Table, *Emilia sonchifolia* can be observed to have recorded the highest value of IVI of 44%. The few other species having high values of IVI were; *T. procumbense* (22) *Imperata cylindrica* (21) *Andropogon gayanus*

(14.6), *Calopogonium Mucunoides* (11.7), *Chromolaena odorata* (10.4) and *Alternanthera sessilis* (7.8) (Table 3).

3.4 Results of Alpha Diversity of the Sampling Points

As a measure of community evenness, the diversity of four of the five sampling points calculated with Simpson's Diversity Index and Shannon-Wiener Index are presented in Table 4. In terms of species composition, the result indicated that, site A was the richest with the value of 80.95, followed by site C (72.95), and B (58.2) while site D had the least value of 43.2. Also, in this Table, the Simpson's index for site B revealed high diversity value of 0.822 followed by sites D and C which had 0.624 and 0.607 values respectively. Moreover, site A recorded the least diversity value of 0.654 with respect to Shannon-Wienner's index. The index was not calculated for site E because the location was practically filled up with a single non-woody plant species i.e. *Tithonia diversifolia*.

3.5 Results of Beta-Diversity for the Study Area with Respect To Non-woody Angiosperm Species.

As a measure of homogeneity of pairs of study sites, the results of beta diversity calculated using Morisita-Horn and Peterson's indices are presented in Table 4. Sites A, B had the highest similarity of 0.642 i.e. (the most similar sites), site B, C (0.098), site C, D (0.068). Both sites B, D and A, D have the least similarity value of 0.038 (Table 5). The Peterson similarity index values obtained for the sites as follows: Sites A, C (0.819), sites B, C (0.771), sites A, B (0.541), sites B, D (0.277), sites C, D (0.093) and A, D (0.11). Peterson's index indicated that sites A, C was the most similar pair of sites while sites C, D indicated the least similar pair of sites.

Table 2: Species Composition and Abundance of the Study Area

Species	Family	Abundance	Relative Abundance
1. *Andropogon gayanus* kunth	*Poaceae*	69 (A , B)	4.52
2. *Ageratum conyzoides* L.	*Asteraceae*	31 (B , D)	2.03
3. *Alternanthera sessilis* (L.) R. Br. ex DC	*Amaranthaceae*	140 (D)	9.17
4. *Aspilia Africana* (Pers) C.D. Adams	*Asteraceae*	13 (B , C)	0.85
5. *Calopogonium muconoides*	*Papilionaceae*	77 (B,C,D)	5.05
6. *Cajanus cajan* (L) Millsp.	*Papilionaceae*	2 (B)	0.13
7. *Cassia rotundifolia* Pers.	*Caesalpiniaceae*	1 (C)	0.07
8. *Chromolaena odorata* (L) King and Robinson	*asteraceae*	55 (B,C)	3.60
9. *Commelina erecta* Linn.	*Commelinaceae*	5 (B)	0.32
10. *Crotalaria retusa* (L).	*Papilionaceae*	1 (C)	0.07
11. *Desmodium ramossissimum* G. Don	*Papilionaceae*	2 (B)	0.13
12. *Elusine indica* (L.) Gaertn	*Poaceae*	1 (A)	0.07
13. *Erigeron floribundus* Kunth sch. Beep	*Asteraceae*	26 (D)	1.70
14. *Emilia sonchifolia (Linn.) DC*	*Asteraceae*	538 (A,B)	35.26
15. *Euphorbia hirta* L.	*Euphorbiaceae*	70 (B)	4.59
16. *Hyptis suaveolens* Poit (T)	*Lamiaceae*	3 (C)	0.19
17. *Imperata cylindrica* P. Beauv.	*Poaceae*	226 (A , C)	14.81
18. *Mimosa pigra* Linn.	*Mimosacea*	10 (D)	0.70
19. *Oldenlandia herbacea* (L). Roxb.	*Rubiaceae*	2 (B)	0.13
20. *Passiflora foetida* Linn.	*Passifloraceae*	2 (B)	0.13
21. *Pennisetum polystachion* (L.) Schult.	*Poaceae*	25 (A,B,C , D)	1.64
22. *phyllanthus amarus* Schum.andThonn.	*Euphorbiaceae*	1(B)	0.07
23. *Senecio biafrae* Oliv. Hiern	*Asteraceae*	3 (D)	0.19
24. *Sida acuta* Burm.F	*Melvaceae*	10 (B)	0.70
25. *Spigelia anthelmia* L.	*Loganiaceae*	1 (C)	0.07
26. *Tithonia rotundiflora* (Helms.)	*Asteraceae*	23 (A)	1.51
27. *Tridax procumbens* Linn.	*Asteraceae*	171 (A,B,C,D)	11.21
28. Vernonia pauciflora Less.	*Asteraceae*	18 (A)	1.18
Total		1526	100.00

(Alphabets in parentheses show the sampling sites in which each plant was encountered).

Table 3: Frequency, Density and Importance Value Index (IVI) of the Species encountered during the Studies

S/N	Species	Freq	Density	R.F (%)	R.D (%)	IVI
1.	*Andropogon gayanus kunth*	50.0	3.8	10.3	4.3	14.6
2.	*Ageratum conyzoides*	22.0	1.7	4.5	1.9	6.4
3.	*Althernanthera sessilis*	5.0	7.8	1.0	8.8	9.8
4.	*Aspilia africana*	16.0	0.7	3.3	0.8	4.1
5.	*Calopogonium mucunoides*	33.0	4.3	6.8	4.9	11.7
6.	*Cajanus cajan*	5.0	0.1	1.0	0.1	1.1
7.	*Cassia rotundefolia*	11.0	0.05	2.3	0.1	2.4
8.	*Chromolaena odorata*	33.0	3.0	6.8	3.6	10.4
9.	*Commelina erecta*	11.0	0.27	2.3	0.3	2.6
10.	*Crotalaria retusa*	5.0	0.05	1.0	0.1	1.1
11.	*Desmodium ramosissimum*	5.0	0.1	1.0	0.1	1.1
12.	*Elusine indica*	5.0	2.1	1.0	0.1	1.1
13.	*Erigeron floribundus*	16.0	1.4	3.3	1.7	5
14.	*Emilia sonchifolia*	44.0	30	9.1	35	44
15.	*Euphorbia hirta*	5.0	4	1.0	4.6	5.6
16.	*Hyptis suaveolens*	16.0	0.2	3.3	0.2	3.5
17.	*Imperata cylindrica*	27.0	13	5.6	15	21
18.	*Mimosa pigra*	11.0	0.6	2.3	0.7	3
19.	*Oldenlandia herbacea*	5.0	0.1	1.0	0.1	1.1
20.	*Passiflora foetida*	5.0	0.1	1.0	0.1	1.1
21.	*Pennisetum polystachion*	38.0	1.4	7.8	1.6	9.4
22.	*phyllanthus amarus*	5.0	0.2	1.0	0.2	1.2
23.	*Senecio biafrae*	5.0	0.2	1.0	0.2	1.2
24.	*Sida acuta*	16.0	0.6	3.3	0.7	4
25.	*Spigelia anthelmia*	5.0	1	1.0	0.1	1.1
26.	*Tithonia rotundefolia*	27.0	1.3	5.6	1.5	7.1
27.	*Tridax procumbens*	55.0	9.5	11.3	11	22
28.	*Vernonia pauciflora*	5.0	1	1.0	1.2	2.2
	TOTAL	486	88.6	100	100	

R.F = Relative Frequency; IVI is the sum of relative frequency and relative density

Table 4: Alpha diversity of the sampling points with respect to non-woody angiosperm species

Sites	Simpson's index (SI)	Shannon-wienner's index (H)	Species richness (D)	Eveness (E)
A	0.293	0.654	80.95	0.105
B	0.822	1.849	58.2	0.314
C	0.607	1.191	72.95	0.195
D	0.624	1.346	43.2	0.246

Table 5: Similarity matrix of beta diversity values between pairs of study sites based on Morisita-Horn's index of diversity

	A	B	C	D
A	1			
B	0.642 (0.541)	1		
C	0.030 (0.8I9)	0.098 (0.771)	1	
D	0.038 (0.110)	0.038 (0.277)	0.068 (0.093)	1

The values in parenthesis are those of Peterson's diversity indices.

3.6 Woody Species encountered

The woody plant species encountered in the study area were mainly tree seedlings, shrubs and small trees. Only few large trees were observed (Table 6). A total of 29 woody species were found. The two most widely distributed of the species were *Daniellia oliveri* and *Vitex doniana* (Table 6). Only one wetland macrophyte was identified in the study area i.e. *Nymphaea lotus* of the family Nymphaeaceae (Plate 11)

Table 6: The woody plant species (trees and shrubs) observed along Antorun stream in Abule Onipanu, Ogbomoso.

S/N	Species Name	Yoruba Name	Family name	Status/Size	Location
1	*Albizia adianthifolia*	Ayunre	Fabaceae	Tree seedlings	B
2	*Anacardium occidentale*	Kaju	Anacardiaceae	Small trees	B; D.
3	*Annona senegalensis*	Igi abo	Annonaceae	Tree seedling	C
4	*Anthocleista djalonensis*	Shapo	Loganiaceae	Tree seedling	C
5	*Bambusa spp*	Oparun	Poaceae	Large trees	D; E
6	*Bridelia ferriginea*	Ira elegun	Phyllanthaceae	Medium size tree	C
7	*Bridelia micrantha*	Ira	Phyllanthaceae	Small and medium size trees	C.; D
8	*Danielia oliveri*	Iya	Fabaceae	Small trees	B; C; E; D; A
9	*Elaeis guineensis*	Ope	Palmae	Medium size trees	D; E
10	*Ficus elastic*		Moraceae	Small tree	D
11	*Ficus sur*	Opoto	Moraceae	Small tree	D
12	*Glyphaea brevis*	Atoori	Malvaceae	shrub	D
13	*Gmelina arborea*	Igi isana	Verbenaceae	Small tree	C.
14	*Hymenocardia acida*	Orupa	Phyllanthaceae	Small trees	C; A.
15	*Lonchocarpus sericeus*	Ipapo	Fabaceae	Tree seedling	C
16	*Mangifera indica*	Mangoro	Anacardiaceae	Medium size trees	C; D.
17	*Parkia biglobosa*	Igba	Fabaceae	Large tree	E
18	*Piliostigma thonningii*	Abafe	Fabaceae	Small trees	C
19	*Psidium guajava*	Gorofa	Myrtaceae	Small tree	D
20	*Pterocarpus erinaceus*	Igi ara	Fabaceae	Small tree	D
21	*Sarcocephalus latifolius*	Egbesi	Rubiaceae	Small tree	C
22	*Securidaca longepedunculata*	Ipeta	Polygalaceae	Tree seedling	B
23	*Securinega virosa*	Iranje	Phyllanthaceae	shrub	B; C.
24	*Senna siamea*	Kasia	Fabaceae	Medium size tree	E
25	*Spathodea campanulata*	Igi oruru	Bignoniaceae	Tree seedling	C
26	*Tectona grandis*	Gedu	Lamiaceae	Small trees	C; D;
27	*Terminalia glaucescens*	Idi	Combretaceae	Medium size trees	C; D;
28	*Vitellaria paradoxa*	Emi	Sapotaceae	Small tree	C
29	*Vitex doniana*	Oori	Lamiaceae	Small and medium size trees	C; E; D; A;

Plate 11: Morphology of *Nymphaea lotus,* the Aquatic Macrophyte Found in the Reservoir.

3.7 Discussion

A total of 1528 individual plants belonging to 28 species, 28 genera and 13 families were identified as non-woody angiosperms along the Antorun stream. The plant species' distribution indicated that the family *Asteraceae* had the highest individuals (878) in nine species, followed by the family the *Poaceae* which was represented by 321 in 4 species; Amaranthaceae 140 in one species; *Papilionaceae* 82 in four species and *Euphorbiaceae* had 71 in two species. Among these plants encountered were grasses, shrubs, medicinal and leguminous plants which are of great benefit to humans and grazing animals. In the study of vegetation in a proposed field of crude oil exploration, Akinnibosun and Omatsola, (2011) equally found medicinal plants making up 39% of the total plant species, weeds 26%, edible fruits, food crops, oil crops and fibre crop 31% while timber trees made up 4% of the total 112 plant species encountered by them. Although the present study area was less diverse in species composition than that of the researchers [15]. The plant species encountered are of various potential uses and applications (Figure 2).

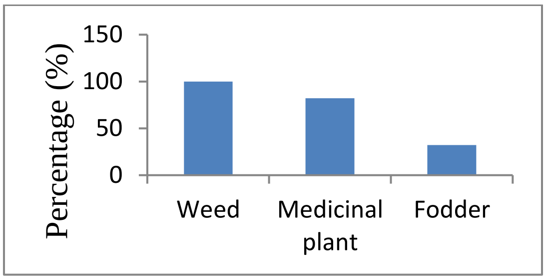

Figure 2: The Frequency of the Different Utility-Based Categories of Plants.

Generally, all the study sites had family Poaceae and Asteraceae present in them, but Papilionaceae was absent in site A, Asteraceae was absent in C, and Lamiaceae in A and D. Meanwhile, family Euphorbiaceae and Passifloraceae were present only in B. Site A had a total of 3 families, site B had a total of 10; site C, a total of 7 and site D, a total of 9 families. Asteraceae are believed to be favoured by their great diversity of life-form, wind and human dispersal and their diversity of native habitats, but their high number among agricultural weeds seems to be more related to the large number of species within the family [31]. The researchers reported similar observations in an oil palm plantation in Ghana where they found that *Chromolaena odorata, Aspillia africana* and *Melanthera scandens* and grasses such as *Panicum maximum, Imperata cylindrica* and *Digitaria horizontalis* were dominant in both young and old plantations[32].

The two most dominant weed families encountered in this study were Poaceae and Asteraceae (Tables 2 and 3). The results of relative frequency of species (Table 2) indicates that *Tridax procumbens* was the most frequent species (11.3%) followed by *Andropogon. gayanus* (10.2%) which is then followed by *Emilia sonchifol*ia (9.1 %), in that order (Table 2). The other notable species include *Pennisetum polystachion* with a value of (7.8 %) *Chromolaena odorata* and *Calopogonium mucunoides* which both recorded a value of 6.8% each. The dominance of Asteraceae followed by Poaceae may suggest near savanna vegetation. The low frequency of *Chromolaena odorata* may be as a result of burning as the researchers reported that regular burning of grassland and savannah reduces the establishment of both the Asian–West African and the southern African biotypes of *Chromolaena odorata* [33]. Also, natural forests are not usually invaded by *Chromolaena odorata* due to its high light requirements, but, forest degradation allows the weed to establish, suppressing the recruitment of trees [34]. Thus, Forest gaps that naturally develop through tree-fall are colonized rapidly by *Chromolaena odorata*.

The Other plant species probably had lower frequencies due to several environmental factors. The researchers reported that several theories have been proposed to explain why some species are rare and others are common. Rare species have a low frequency over habitat patches and consequently a limited contribution to community assembly process. Several factors may restrict species geographical distribution, which range from lack of propagules (dispersal limitation) and unsuitable habitat (niche limitation) such as a derelict quarry site. Several other biotic and abiotic factors have been noted as agents of species ecological amplitude. These concomitantly amount to some degree of ecological succession causing direct changes in plant species abundance in terms of frequency of occurrence and density. Also, subsequent high mortality of seedlings and self-thinning of older plants occur [35].

The importance value indices (IVI) of the species in this study are generally low, ranging between 1.1 and 44 (Table 3). The researchers equally reported similar values of IVI in young plantation in which, *Chromolaena odorata* was the most dominant species with IVI value of 17.13 followed by other notable species such as *Aspilia africana* (13.19), *Melanthera scandens* (11.17), *Mallotus oppositifolius* (7.08) and *Digitaria horizontalis* (5.52). In the mature plantation, Essandoh *et al.* (2011) reported IVI for *Chromolaena odorata* as (14.19), *Aspillia africana* (8.71) and *Melanthera scandens* (8.11) as dominant species [31]. Other notable species reported by them were *Imperata cylindrica* (7.76), *Panicum maximum* (7.52) and *Cyperus rotundus* (7.11). Low IVI values could be due to the sharing of resource spaces to minimize interactions among the species and to facilitate access to resources [36]. Also, the low IVI values could be due to many different species with few individuals representing each [36].

The results of alpha diversity of the sampling points showed similar trends with regard to Simpson's and Shannon-Wienner's indices (Table 4). The sampling point B recorded the highest diversity with Simpson's index of 0.822 and Shannon-Wienner's index of 1.849, while sampling point A showed the lowest diversity with 0.293 and 0.654 respectively. One expects the calculated values of species richness to follow similar pattern with species diversity, but these are at variance with regard to the study. The sampling point A with the least indices of diversity recorded the highest value of species richness (80.95) while sampling point B with the highest indices of diversity recorded a low value of species richness (58.2). With regards to evenness, sampling points B and A recorded the highest and the lowest values respectively among the four locations. This means that the most diverse sampling point (B) also was the one with the highest value of evenness. In a related studies conducted by the researchers in Shasha, Ala and Omo Forest Reserves, Species evenness results (E) followed the same pattern as Shannon index (H') [37].

Site A with the lowest value of evenness shows, that individuals in the species were not evenly distributed. As in most plants, weed seeds is very vital in the life cycle of annual or perennial weed species that reproduce through seed alone [38]. Thus the quality and quantity of weed seeds in the soil bank determines the weed situation in a given farm land. Weed seed bank has been described as the reservoir of viable weed seeds that are present on the soil surface and scattered in the soil profile. It can also be defined as the place where weed seeds remain until germination. Weed seed banks are actually the sole source of future weed populations. The study Site A is mainly dominated by weeds or grasses in the family Poaceae, followed by members of the family Asteraceae. Thus, site A, is made up of only two families. This type of vegetation makes the site tend towards savanna vegetation with fewer species (low diversity) but with the presence of high number of individual plants in family Asteraceae, which is a medicinal plant and fodder plant (i.e. lower evenness). Other plant species may be represented by few individuals as a result of biotic and abiotic factors. The researchers reported that the abiotic factors in primary successional environments are also seen in the prevalence of wind dispersed propagules whose distribution is controlled by environmental factors after the seeds have been released from the seed source [39].

The highest values of Simpson's and Shannon-Wienner's indices in sampling point B are evident by its highest species in family Asteraceae (4), Papilionaceae (3), Euphorbiaceae (2) Poaceae (2), Malvacea (1), Lamiacea (1) and Rubiaceae (1). The Site B has a high number of species but a reduction in the number of individual in each species. The site is therefore more diverse and more evenly distributed but with relatively low species richness (Table 3). The site is rich with sufficient number of medicinal plants and livestock feed which may be as a result of the possibility that it has little human exploitation. The researchers reported that the abundance and rarity of a plant species especially those of great economic value, is a function of the intensity and pattern of exploitation which the forest is generally subjected to [40].

Site C recorded the highest number of species in the families Poaceae, Asteraceae and Papilionaceae which had (2) species each. The least number of species were found in family Lamiaceae, Loganiaceae. In terms of number of individuals in each, family Poaceae had the largest number, majorly represented by *Imperata cylindrica* (225), the next family in line was Asteraceae, mostly represented by *Tridax procumbens* with (114) plants and Papilionaceae, represented by *calopogonium. mucunoides*. The high amount in Poaceae probably made a source of feed for grazing animals. This plant abundance might have been triggered by burning. The researchers described *I. cylindrical* as a rhizomatous and aggressive plant which may reproduce by seed following human disturbance [41]. Burning also appears to induce its flowering, but the seeds are mostly sterile [41]. However, the persistence and aggressiveness of *Imperata cylindrica* rhizomes is the main mechanism of survival and spread, and its resilience makes it difficult to control. The vegetation of the site is savannah in nature as. *I. cylindrica* has been known to be widespread in the savannahs [41].

Site D recorded the highest number of species in family Asteraceae (5), while the least family were in; Amaranthaceae, Pappillionaceae, and Mimosaceae with one species each. Moreover, the number of individuals was highest in the family Amaranthaceae, mainly represented by *A. sessilis* (140), and followed by Asteraceae, represented by *A. conyzoides* (31) stands and Poaceae which was represented by *A.gayanus* with 26 plants. The abundance of *A. sessilis* an emergent weed in site D is an indication of a swampy condition. The researchers reported that it is because of the varied habitat types and high levels of precipitation in parts of West Africa that there is a large diversity of aquatic plant species in the region[42]. Water logging plays an important role in determining plant distribution in terrestrial communities , since the consequences to plants may be fatal *A. sessilis* prefers places with constant or periodically high humidity but may however tolerate extremely dry conditions. It often grows in mixed association with several other aquatic species and the plant spreads by seeds, which are wind-and water-dispersed, and by rooting at stem nodes[43,44].

Poaceae, like Amaranthaceae and to a lesser extent Euphorbiaceae, are characterized by nitrophilia and the C4 photosynthesis [45]. These physiological traits are advantageous in man-made habitats, under conditions of fertilization and/or irrigation. According to the researchers, families with predominant abiotic dispersal (such as Amaranthaceae or Euphorbiaceae) have higher proportions of agricultural weeds. Their agricultural importance may be related to human dispersal. Furthermore, all these families possess a large number of herbaceous, short-lived species, well adapted to disturbance [46]. Other plants may have been suppressed as a result of canopy-shade by higher plants of the site. The researchers reported of seedling establishment in open canopies such that an open canopy may favour germination and seedling establishment through increased solar radiation. Likewise, the existence and population density of a plant species in a tract of a rainforest is a function of the availability of its seeds or propagules and the existence of favourable micro-climate for the seed germination and growth [46].

The results of non-woody plant species diversity around Antorun reservoir indicate that there were few species with large numbers of individuals and many species with few numbers of individual. Thus, the study area was less even but species rich. The researchers made similar observation in his study [37]. In this study area Abundance of *A. sessilis*, an invasive weed is eminent in the near future. Many upland plants are identified as highly invasive. They have been introduced at various points in time for agricultural reasons or accidentally. This is the case of *Chromolaena odorata* L., *Echinochloa colona Calopogonium mucunoides*, *Rottboellia cochinchinensis* Lour. W. Clayton and *Mimosa* spp., which have become a threat to rice and maize fields where their manual control is almost impossible [30]. Plants such as *I. cylindrica* and *C. odorata* are to be greatly monitored [30]. The allelopathic properties of the *C. odorata* aid it in gaining dominance in vegetation, and in replacing other aggressive invaders such as *Lantana camara* L. (Verbenaceae) and *Imperata cylindrica* Beauv (Poaceae) [47].

The results of Morista-horn's index between pairs of study sites in Table 4 indicate that sites A and B had the closest similarity (0.642), site B and C (0.098) being dissimilar, much as sites C and D (0.068), with low values of similarities. The most dissimilar sites were B and D and A and D both with 0.038 with respect to this index. The fact that site B, D and A, D have the same value of Morista-horn's index suggests that the sites A and B are alike or cluster as indicated by the high similarity value of 0.642. The Peterson similarity index revealed that site A,C (0.819) were the most similar sites, followed by sites B,C (0.771), then came sites A,B (0.541) and lastly, sites B,D (0.277).

The woody plant species encountered in the study area were mainly tree seedlings, shrubs and small trees. Only few large trees were observed (Table 3). A total of 29 woody species were found. The two most widely distributed of the species were *Daniellia oliveri* and *Vitex doniana* (Table 6).

4. CONCLUSION

The efforts made in this study were to achieve ecosystem goals. The non-woody angiosperms along Antorun reservoir that have been documented in this study included 28 species of plants in 28 genera and 13 families. The plants are all weeds, out of which 22 of them are medicinal, and 10 are forage plants. The weed and medicinal plants have the highest percentages of utility, with the fodder plant being the least (Figure 2).

Members of the family *Asteraceae* were the most abundant *with Emilia sonchifolia* occurring most but less distributed among the sites while, the least abundant plants are *Cassia rotundifolia*, *Crotalaria retusa, Elusine indica, Phyllanthus amarus,* and *Spigelia anthelmia*. The area in general is dominated by family Asteraceae, Poaceae and Euphorbiaceae in descending order of abundance. And these families are known to be constituted of medicinal, forage and leguminous plants.

In conclusion, all the plant species identified and enumerated in the study area were observed to be beneficial to the community, in terms of medicinal usage, and livestock feeds. Thus, the plants obtained in this study are of economic importance to the people of the community. This result obtained will be useful to planners, environmentalists and policy makers for the purpose of proper management of the site and for environmental evaluation report**.**

Based on the results obtained from the study, some contributions have been made to knowledge as follows:

(a). The non-woody plant species richness at the vicinity of Antorun stream are being documented for the first time, and these include twenty-eight species in twenty-eight genera and 13 families.

(b) The abundance of each of the non-woody angiosperm species found along the reservoir, have been determined and reported.

(c) The homogeneity/heterogeneity indices of representative locations along Antorun reservoir have been computed.

(d) The basic ecological information with regard to non-woody Angiosperm biodiversity of Antorun stream, being proposed for generation of hydro-electricity has been reported, and this can be found useful in evaluating the impact of the proposed development on the environment.

A number of economic tree species were encountered in the study area. These include *Anacardium occidentale* (oil and fruit), *Daniellia oliveri* (timber), *Elaeis guineensis* (oil), *Gmelina arborea* (fuelwood, timber and pulpwood), *Mangifera indica* (fruit), *Pterocarpus erinaceus* (timber), *Vitellaria paradoxa* (oil and fuelwood), *Senna siamea* (timber), *Lonchocarpus sericeus* (timber) and *Tectona grandis* (timber).

A few of the woody species identified, that are known to be ethnomedicinally valuable and which have been found to be potential raw materials for chemical/drug industries are *Annona senegalensis*, *Mangifera indica*, *Sarcocephalus latifolius*, *Securidaca longepedunculata*, *Senna siamea*, and *Spathodea campanulata*. It is however regrettable that most of the species only occurred in the study area as seedlings and small trees/shrubs. The land has been intensely worked and many trees felled for various reasons including farming, lumbering and fuelwood collection.

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