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Eutrophication of Dandaru reservoir in Ibadan, Nigeria in relation to land-use and mechanical desilting

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ABSTRACT

Eutrophication of water bodies is mainly caused by influx of Nitrogen and phosphorus compounds from land-use. Understanding relationship water reservoirs and farmlands will foster management of ecological resources. This study examined the link between eutrophication and land-use at Dandaru reservoir at Agodi, Ibadan, Oyo State and effect (s) of mechanical clean up on the reservoir. The Vegetation, soil of Lawn (L), bush fallow (BF), vegetable farm (VF) and Agodi Gardens (AG), and water quality of Dandaru reservoir in Ibadan were systematically assessed pre- and post-desilting following standard procedures. Forty 0.25 m^2 *quadrats were floristically assessed for Relative importance values (RIV) and Shannon-Weiner index (H`). Three randomly extracted bulked and sub-sampled top soil of each land-use were analysed physiochemically. The reservoir was sampled for phosphate, Organic carbon (TON), nitrate (TN), dissolved oxygen (DO) and pH in three replicates at entry, mid and exit points of the river. Data were analysed using ANOVA at p=0.05. Means statistical differences followed Fisher's LSD. Fifty one plant species were enumerated pre-desilting consisting of 15, 22, 29 and 11 species in L, BF, VF and AG respectively; 22 plants were enumerated post-silting consisting 10, 10, 8 and 8 species in L, BF, VF and AG respectively. legumes ranged in RIVs from 4.217-8.397 in BF and VF. Pre-desilting, VF had highest H` (3.334), while AG had lowest (1.988). Post-desilting, Lawn had highest H` (1.956) while VF had lowest (1.679). P, TOC, TN and pH were significantly different in all land-uses with TN (0.81±0.02g/kg) and TOC (7.83±0.05g/kg) in BF. Phosphorus (0.31±0.03g/kg) was high at AG pre-desilting. Post-desilting, TN (32.90±3.37g/kg) and TOC (2.24±0.04g/kg) were significantly high in lawn. Pre-silting, pH and DO were significantly different at all points, lowest at midpoint (6.73±0.04mg/l and 7.89±0.30mg/l respectively); post-silting, pH (7.87±0.00) and DO (9.54±0.0Img/l) increased at midpoint.The legumes in agricultural lands most likely contributed to eutrophication of Dandaru reservoir. However, desilting offered temporary restoration. Cessation of agricultural activities around Dandaru reservoir with its periodic assessment will prevent eutrophication.*

Keywords: Eutrophication, Dandaru reservoir, desilting, mechanical clean up, agricultural land-use

INTRODUCTION

Land-use is the arrangement, activities and inputs undertaken by people in a certain land cover type to produce, change or maintains it (FAO, 1999). It varies in types and includes activities on the farmland, vegetation types, urbanization type and drainage. Land-use and land management practices have a major impact on natural resources including water, soil, nutrients, plants and animals. Aquatic ecosystems interact with land-use types that surround them, depending on nature and scope of activities (Vitonset, 1997). According to Litke (1999), the impacts of excessive fertilizer use, untreated waste water, effluents and detergents significantly increase nutrient load in lakes and these accelerates eutrophication beyond natural levels bringing about deleterious changes to the natural ecosystem. Eutrophication, defined by OSPAR (2003), as the enrichment of water by nutrients causing an accelerated growth of algae and aquatic plants, produces an undesirable disturbance to the balance of organisms present in the water and the quality of the water. Excessive nutrient loading of aquatic bodies is a most challenging emerging environmental problem in the world (UNEP, 2003, 2009).

Agricultural activities involving use of cover crops, especially, nitrogen fixing legumes cause eutrophication in nearby ecosystems (Galloway *et al.*, 1995). Other ecological consequences of eutrophication are presence of excessive planktonic algae and water weeds (macrophytes), low concentration of dissolved oxygen, blockage of sunlight penetration which affects the submerged plants, low water transparency (high turbidity), harmful odours and disruption of ecosystem functions (Rabalais, 2001). Eutrophication is thus, a prioritized emerging environmental issue (UNEP, 2009) resulting from increasing global nitrogen overload of ecosystem from unregulated urban agriculture and human activities, especially in developing nations.

Research information on land-use can be used to develop solutions for natural resource management such as management of salinity, siltation and water quality of water bodies used for urban development and other utilitarian purposes. For instance, augmented nutrient inputs to inland waters may result from modifications of land-use of watersheds such as controlled deforestation, agricultural practices, industrial development and urbanization when all variables and their dynamics are known. In the case of eutrophication, when the real cause is identified, various methods of mitigation are proposed (UNEP, 2003), like dredging of accumulated sediments, reduction of erosion into the water body, use of mulch to reduce rainfall eroding the soil surface, stoppage of the use of fertilizers on farms located near the reservoir, banning washing and bathing and/ or agricultural watershed management practices to reduce nutrient.

Dandaru reservoir is surrounded by four main land-use types - an extensive open lawn, bush fallow, vegetable farm and Agodi Gardens whose river course empties into the reservoir. The flow of materials into the reservoir from the above sources has become a serious threat to the organisms present in the water body, and its ecosystem services such that the Federal Government included it in desilting projects of Ogun-Oshun River Basin Development Authority. Therefore, studies on the real cause(s) and effects of the eutrophication are needed to prevent re-eutrophication following the planned desilting, of the reservoir and to explore impact and possible sustainability of the co-existence of the agricultural and other land-use types bordering the reservoir.

This study was thus carried out to determine the floristic composition and diversity of the various land-use types, identify the floral species with potential contribution to eutrophication on the reservoir and determine the level of eutrophication of Dandaru reservoir at different points before and after mechanical remediation.

MATERIALS AND METHODS

Study Area

Dandaru reservoir adjoins Agodi Gardens (a public recreation Park) and Oyo State Fisheries Department in Ibadan, Oyo State (Figure 1) on geo-coordinates: N 07^{0}24`; E 003$^0$53`, and geographical elevation of 211 m above sea level. It is 0.18 km^2 (17.04 ha) in size (Google Earth, 2013). The reservoir is an artificial lake created in the 1960s out of a river basin along Dandaru River opposite Oyo State secretariat complex. In terms of drainage, the river drains water from Bashorun and Agodi areas through the Agodi Gardens down to the lake where it stabilizes before being let into Mokola area of Ibadan city. The Reservoir is surrounded by wetland vegetation and other land-use types - the Agodi Gardens, farm lands (bush fallow and vegetable farms), open lawns and two major roads. The climatic condition of the area in terms of rainfall is a humid tropical area with two peaks of rain in June and September.

Figure 1: Locations of land-use types around Dandaru reservoir, Agodi, Ibadan in 2012-2013 (©Google Earth, 2013)

Sampling Techniques

Floristic assessment was carried out in November, 2012 (before mechanical desilting) and February, 2013 (after mechanical desilting). The herbaceous flora of the four identified land-use types were systematically assessed by laying (0.5 x 0.5) m^2 quadrat at 5m intervals along a 50 m long transect in each land use. Enumeration and identification of floral species followed Akobundu and Agyakwa (1998) and Johnson, (1997). Data collected were subjected to density and frequency analyses of Kent and Coker (1992) for calculation of Relative Importance values as used by Olubode *et al.* (2009) where:

$$\text{Relative Important Value (RIV)} = \frac{RF + RD}{2}$$

Where:

$$\text{Density (D)} = \frac{\text{Abundance of species}}{\text{Number of quadrats laid}}$$

$$\text{Frequency (F)} = \frac{\text{No. of occurrence of species}}{\text{Number of quadrats}}$$

Relative frequency (RF) = frequency of each species/ total frequency of all species x100

Relative density (RD) = number of individual of species/ total density of all species x100.

Species diversity indices were computed for species richness, equitability, and evenness following Hammer and Harper (2012) using the statistical software PAST© 2012, Version 2.02. Muiltivariate ordination and classification were employed for summarization of information contents of the floristic data and phytosociology using Detrended Correspondence analysis (DCA) of Hills (2012) for stand ordination with the DECORANA software; and while Two-Way Indicator Species Analyses for classification with TWINSPAN software.

Soil samples were randomly collected at each land-use type from the top (0-15 cm of soil surface) using a soil auger. Soil of each land-use was bulked, separated into three replicates, air-dried, and analysed for physiochemical parameters such as TN, TOC P, K, Ca, Na, pH and soil texture following the standard procedures of A.O.A.C (1984).

Assessment of nutrient composition of Dandaru reservoir

Water samples (1000 ml) were collected from Dandaru reservoir at three different points (entry, midpoint and exit point) in three replicates using specimen bottles for the determination of the biochemical parameters such as Nitrates, Nitrite, phosphate, dissolved oxygen, pH and turbidity using APHA (1995) procedures. Soil nutrients were assessed by sampling three locations in each land-use type in replicates of three and later bulked before sub-sampling for routing laboratory analyses for physicochemical properties of the soils. The procedure followed the methods of A.O.A.C. (2003).

Data Analyses

All data sets from soil and water samples were analysed using statistical procedures for completely randomized design for analysis of variance (ANOVA). Where significant, Fischer's least significance difference was used to separate means at p= 0.05 level of significance.

RESULTS

Before the mechanical desilting, floristic survey indicated 51 herbaceous plant species in 22 families in the four land-types (Tables 1-4). Fifteen (15) plants with high RIV were documented in the Open lawn (Table 1), with *Syndrella nodiflora* having the highest RIV (16.087) while *Alternanthera sessilis, Centrosenma pubescens, Solenostemon monostachyus* and *Acalypha ciliata* had the lowest RIV (1.375). Leguminous species enumerated at the open lawn were *Desmodium scorpirus* (3.385) and *Centrosenma pubescens* (1.375).

Twenty two (22) plants were documented in the Bush fallow. The highest RIV was recorded in *Oldenladia corymbosa* (13.839) while *Zea mays, Waltheria indica, Phyllanthus amarus, Laportea aestuans, Solenostemon monostachyus, Setaria* *longiseta* and *Commelina erecta* had the lowest RIV (1.449). Leguminous plants such as *Centrosenma pubescens*, *Schrankia leptocarpa*, *Calopogonium mucunoides* and *Desmodium scorpirus* were found with moderately high RIV ranging from 4.217 to 8.433 (Table 2). Twenty nine (29) plants species were enumerated in the Vegetable farm with the highest RIV recorded in *Syndrella nodiflora* (14.071) while lowest was found in *Commelina erecta* and *Spigelia anthelmia* (0.997). Leguminous plants such as *Desmodium scorpirus, Centrosenma pubescens and Schrankia leptocarpa* had moderately high RIV, ranging from 3.7 to 8.397 (Table 3). Agodi Garden had 11 plants, with the highest RIV of 27.887 in *Syndrella nodiflora* while the lowest RIV was recorded in *Musa sapientum*, *Aspilia africana*, *Vossia cuspidata* and *Bambusa bvulgaris* (Table 4). The only legume plant found in Agodi Garden with RIV (5.769) was *Schrankia leptocarpa*. Vegetable farm had the highest species diversity (H') (3.334) while the lowest species diversity value (1.988) was recorded in Agodi Garden. Similar trends were observed in Equitability index. Agodi Garden however had the highest dominance (0.179) while the lowest dominance (0.054) was recorded in Vegetable farm (Table 5). The inverse was recorded in Evenness indices for Agodi garden (0.664) and vegetable garden (0.623).

Table 1: Relative importance values of herbaceous plants occurring in an open lawn around Dandaru reservoir in November, 2012.

S \N	Names of Species	Family	RIV
1	*Syndrella nodiflora* Gaertn	Asteraceae	16.087
2	*Peperomia pellucida* (L.) H.B. & K.	Piperaceae	14.713
3	*Panicum maximum* Jacq.	Poaceae	13.968
4	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	12.599
5	*Setaria babata* (Lam.) Kunth	Commelinaceae	11.219
6	*Commelina erecta* L.	Commelinaceae	6.878
7	*Ageratum conyzoides* Linn.	Asteraceae	5.922
8	*Cyathula prostrata* (L.) Blume	Amaranthaceae	4.972
9	*Desmodium scorpirus* (Sw.) Desv.	Fabaceae	3.385
10	*Talinum fruticosum* (L.) Juss.	Portulacaceae	3.173
11	*Laportea aestuans* (Linn.) Chew	Urticaceae	1.587
12	*Alternanthera sessilis* (L.) DC.	Amaranthaceae	1.375
13	*Centrosenma pubescens* Benth	Fabaceae	1.375
14	*Solenostemon monostachyus* (P. Beauv.) Brig.	Lamiaceae	1.375
15	*Acalpha ciliata* Forsk.	Euphorbiaceae	1.375

Table 2: Relative importance values of herbaceous plants occurring in a bush fallow around Dandaru reservoir in November, 2012

S/N	Names of species	Family	RIV
1	*Oldenlandia corymbosa* Linn.	Rubiaceae	13.839
2	*Panicum maximum* Jacq.	Poaceae	12.508
3	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	8.433
4	*Centrosenma pubescens* Benth.	Fabaceae	8.433
5	*Chromolaena odorata* (L.) R.M. King & Robinson	Asteraceae	6.744
6	*Spilanthes filicaulis* (Schum. & Thonn.) C.D. Adams	Asteraceae	5.481
7	*Desmodium scorpiurus* (Sw.) Desv.	Fabaceae	5.481
8	*Ageratum conyzoides* Linn.	Asteraceae	5.231
9	*Schrankia leptocarpa* DC	Fabaceae	5.008
10	*Calopogonum mucunoides* Desv.	Fabaceae	4.217
11	*Mariscus alternifolius* Desv.	Commelinaceae	4.217
12	*Tithonia diversifolia* (Hemsl.) A. Gray	Asteraceae	3.541
13	*Talinum fruticosum* (L.) Juss.	Portulacaceae	2.528
14	*Cissus quadrangularis* L.	Vitaceae	2.528
15	*Zea mays* L.	Poaceae	1.449
16	*Waltheria indica* Linn.	Sterculiaceae	1.449
17	*Phyllanthus amarus* Schum. & Thonn.	Euphorbiaceae	1.449
18	*Laportea aestuans* (Linn.) Chew	Urticaceae	1.449
19	*Solenostemon monostachyus* (P. Beauv.) Brig.	Lamiaceae	1.449
20	*Peperomia pellucida* (L.) H.B. & K.	Piperaceae	1.449
21	*Setaria longiseta* P. Beauv.	Poaceae	1.449
22	*Commelina erecta* L.	Commelinaceae	1.449

Table 3: Relative importance values of herbaceous plants occurring in a Vegetable farm around Dandaru reservoir in November, 2012.

S/N	Names of species	Family	RIV
1	*Syndrella nodiflora* Gaertn	Asteraceae	14.071
2	*Mitracarpus villosus*(Sw.) DC.	Rubiaceae	11.234
3	*Ageratum conyzoides* Linn.	Asteraceae	9.365
4	*Centrosema pubescens* Benth.	Fabaceae	8.397
5	*Desmodium scorpiurus* (Sw.) Desv.	Fabaceae	5.674
6	*Ipomoea eriocarpa* R. Br.	Convolvulaceae	5.674
7	*Panicum repens* Linn.	Poaceae	5.674
8	*Oldenlandia corymbosa* Linn.	Rubiaceae	5.583
9	*Peperomia pellucida* (L.) H.B. & K.	Piperaceae	5.583
10	*Brachiaria deflexa* (Shumach.) Robyns	Poaceae	4.613
11	*Pentodon pentandrus* (Schum. & Thonn.) Vatke	Rubiaceae	4.409
12	*Telfaria occidentalis* Hook. F.	Cucurbitaceae	4.165
13	*Schrankia leptocarpa* D.C.	Fabaceae	3.700
14	*Tridax procumbens* Linn.	Asteraceae	3.479
15	*Brillantasia lamium* (Nees) Benth. Bentham G.	Acanthaceae	3.346
16	*Ipomoea involucrata* P. Beauv.	Convolvulaceae	3.168
17	*Sida acuta* Burm F.	Malvaceae	3.168
18	*Kylinga erecta* Schumach.	Cyperaceae	2.881
19	*Stachytarpheta cayennensis* (L.C. Rich) Schau.	Verbenaceae	2.881
20	*Mariscus alternifolus* Desv.	Cyperaceae	2.526
21	*Aspilia africana* (Pers.) C.D. Adams	Asteraceae	2.349
22	*Kylinga bulbosa* Beauv.	Cyperaceae	2.349
23	*Euphorbia heterophylla* Linn.	Euphorbiaceae	2.349
24	*Spermacoce octodon* (Herper) Lebrun & Stork	Rubiaceae	2.172
25	*Cyathula prostrata* Blume	Amaranthaceae	2.172
26	*Mariscus longibracteatus* Cherm.	Cyperaceae	1.706
27	*Asystasia gangetica* (Linn.) T. Anders	Acanthaceae	1.352
28	*Commelina erecta* L.	Commelinaceae	0.997
29	*Spigelia anthelmia* Linn.	Loganiaceae	0.997

Table 4: Relative importance values of herbaceous plants occurring in Agodi garden around Dandaru reservoir in November, 2012.

S\N	Names of species	Family	RIV
1	*Syndrella nodiflora* Gaertn	Asteraceae	27.885
2	*Paspalum scrobiculatum* L.	Poaceae	14.423
3	*Pupalia lappacea* (L.) Juss.	Amaranthaceae	12.5
4	*Andropogon tectorum* Schum. & Thonn.	Poaceae	9.615
5	*Ageratum conyzoides* Linn.	Asteraceae	9.615
6	*Schrankia Leptocarpa* DC.	Fabaceae	5.769
7	*Mitracarpus villosus* (Sw.) DC	Rubiaceae	5.654
8	*Musa sapientum* L.	Musaceae	2.885
9	*Aspilia africana* (Pers.) C.D. Adams	Asteraceae	2.885
10	*Vossia cuspidata* Griff.	Poaceae	2.885
11	*Bambusa vulgaris* Schrad. Ex J.C. Wend	Gramineae	2.885

Table 5: Diversity of plant species enumerated on four land-use types around Dandaru reservoir in November, 2012

	Land-Use Type			
Diversity	**Lawn**	**Bush fallow**	**Veg. Farm**	**Agodi garden**
Taxa_S	15	22	29	11
Individuals	236	148	365	52
Dominance_D	0.1419	0.09386	0.05378	0.179
Simpson_1-D	0.8581	0.9061	0.9462	0.821
Shannon_H	2.133	2.609	3.334	1.988
Evenness_e^H/S	0.5629	0.6472	0.6232	0.6638

After mechanical desilting, 22 herbaceous plant species were enumerated in 9 families from the four land-use types (Tables 6-9). In the open lawn, 10 plant species were, documented with the highest RIV (39.751) recorded for *Tridax procumbens* while the lowest value (3.253) was recorded in *Stachytarpheta cayennensis, Syndrella nodiflora* and *Tephrosia pedicellata* (Table 6). Legumes enumerated with potential contribution to eutrophication were *Centrosenma pubesens* (6.448) and *Desmodium scorpirus* (16.622). In the bush fallow there were 10 species (Table 7). *Panicum maximum* had the highest RIV (31.373), followed by *Centrosema pubesens* (26.05). Leguminous plant species enumerated were *Desmodium scorpirus, Desmodium tortuosum* and *Calopogonum mucunoides* with RIV (5.322). In the vegetable farm, 8 plants species were enumerated of which *Panicum maximum* also had the highest RIV of 16.729 (Table 8); while the lowest was recorded in *Sida acuta, Panicum repens, Calopogonum mucunoides, Corchorus olitorius* and *Syndrella nodiflora* with RIVs (3.396). Legumes in the ecosystem were *Calopogonum mucunoides* and *Centrosema pubesens* having relatively high RIVs of 3.396 and 10.063 respectively (Table 8). Agodi Garden had 8 plant species with high RIVs with the highest value (23.044) recorded in *Syndrella nodiflora* while the lowest value (5.183) was found in *Paspalum scrobiculatum* and *Cynodon dactylon* (Table 9). Only *Schrankia leptocarpa* was the leguminous plant with high RIV of 18.696. In terms of species diversity (Table 10), Agodi Garden had the highest species richness having 0.8347 while other land-use types were relatively high in species richness with values of 0.832 for open Lawn; bush fallow with 0.7943 and 0.7644 for Vegetable farm. Open lawn had the highest value (1.956) for Shannon-Weiner index; while the lowest was recorded in the vegetable farm (1.679).

Before mechanical desilting, there were significant differences in P, TOC, TN and pH values at $p< 0.05$ level of significance across land-use types (Table 11). However, bush fallow had the highest amount of TOC and TN having (0.81 ± 0.02g/kg) and (7.83 ± 0.05g/kg) respectively. Agodi Garden recorded the highest amount of P having (0.31 ± 0.03g/kg) when compared to other locations. The pH was acidic in all the locations with values ranging from 6.23 - 6.73. Textural class for open lawn, bush fallow and vegetable land were all sandy loamy while Agodi garden had a sandy texture. Meanwhile, other parameters (Ca, K and Na) were not significantly different in all land-use types.

Table 6: Relative importance values of herbaceous plants occurring in an open lawn around Dandaru reservoir in February, 2013

S/N	Names of species	Family	RIV
1	*Tridax procumbens* Linn.	Asteraceae	39.751
2	*Panicum maximum* Jacq.	Poaceae	23.128
3	*Desmodium scorpiurus* (Sw.) Desv.	Fabaceae	16.622
4	*Commelina erecta* L.	Commelinaceae	7.428
5	*Centrosenma pubesens* Benth.	Fabaceae	6.448
6	*Cyathula prostrata* Blume	Amaranthaceae	4.234
7	*Cynodon dactylon* (Linn.) Pers.	Commelinaceae	3.507
8	*Stachytarpheta cayennensis* (L.C. Rich) Schau.	Verbenaceae	3.253
9	*Syndrella nodiflora* Gaertn	Asteraceae	3.253
10	*Tephrosia pedicellata* Bak.	Fabaceae	3.253

Table 7: Relative importance values of herbaceous plants occurring in a bush fallow around Dandaru reservoir in February, 2013

S\N	Names of species	Family	RIV
1	*Panicum maximum* Jacq.	Poaceae	31.373
2	*Centrosenma pubesens* Benth.	Fabaceae	26.05
3	*Desmodium scorpiurus* (Sw.) Desv.	Fabaceae	5.322
4	*Corchorus olitorius* L.	Poaceae	5.322
5	*Desmodium tortuosum* (Sw.) DC.	Fabaceae	5.322
6	*Stachytarpheta cayennensis* (L.C. Rich) Schau.	Verbenaceae	5.322
7	*Panicum repens* Linn.	Poaceae	5.322
8	*Phyllanthus amarus* Schum. & Thonn.	Euphorbiaceae	5.322
9	*Tridax procumbens* Linn.	Asteraceae	5.322
10	*Calopogonum mucunoides* Desv.	Fabaceae	5.322

Table 8: Relative importance value of herbaceous plants occurring in a vegetable farm around Dandaru reservoir in February, 2013

S\N	Names of species	Family	RIV
1	*Panicum maximum* Jacq.	Poaceae	16.729
2	*Centrosema pubesens* Benth.	Fabaceae	10.063
3	*Tridax procumbens* Linn.	Asteraceae	6.729
4	*Sida acuta* Burm. F.	Malvaceae	3.396
5	*Panicum repens* Linn.	Poaceae	3.396
6	*Calopogonum mucunoides* Desv.	Fabaceae	3.396
7	*Corchorus olitorius* L.	Tiliaceae	3.396
8	*Syndrella nodiflora* Gaertn	Asteraceae	3.396

Table 9: Relative importance value of herbaceous plants occurring in Agodi garden in February, 2013

S\N	Names of species	Family	RIV
1	*Syndrella nodiflora* Gaertn	Asteraceae	23.044
2	*Schrankia leptocarpa* DC.	Fabaceae	18.696
3	*Aspilia busei* O. Goffim. & Muschl.	Asteraceae	13.172
4	*Andropogon gayanus* Kunth	Poaceae	13.172
5	*Ageratum conyzoides* Linn.	Asteraceae	8.498
6	*Aspilia africana* (Pers.) C.D. Adams	Asteraceae	5.509
7	*Paspalum scrobiculatum* L.	Poaceae	5.183
8	*Cynodon dactylon* (Linn.) Pers.	Commelinaceae	5.183

Table 10: Diversity of plant species enumerated on four land-use types at Dandaru reservoir in February, 2013

	Land-use types			
Diversity	**Lawn**	**Bush fallow**	**Veg. Farm**	**Agodi garden**
Taxa_S	10	10	8	8
Individuals	51	29	15	52
Dominance_D	0.168	0.2057	0.2356	0.1653
Simpson_1-D	0.832	0.7943	0.7644	0.8347
Shannon_H	1.956	1.845	1.679	1.925
Evenness_e^H/S	0.7068	0.6328	0.7659	0.8566

The spatial projections of stand relationships revealed that there was a clear difference between one land-use type and another (Figure 2). Axis 1 accounted for 78.6% of the variability, while axis 2 accounted for 55.7%. However, Agodi Garden exhibited two different floristic structures, one of which was similar to a small portion of vegetable farm. There was an undefined group with likely unstable floral species which could result from the low vegetation cover occasioned by mechanical remediation (Figure 3). The maize fallow in classification groups 1, 18 and 11 were high in occurrence of weedy leguminous plants relative to other plant species. The trend was also observed in vegetation groups 4, 2 and 9 (Figure 4).

Significant differences were observed in all nutrient parameters except potassium at $p< 0.05$ before the clean-up. The concentrations were generally higher in the reservoir the cleanup. The soil nutrient levels in the vegetable farm were high, with phosphorus having (0.35± 3.77g/kg). However, the highest amount of TOC and TN were observed in the open lawn as 32.90 ± 3.37g/kg and 2.24 ± 0.04g/kg respectively. The bush fallow was higher in calcium (0.16 ± 0.56g/kg) and sodium (3.19 ± 0.64g/kg) compared to other land-use types. The pH of the soil was acidic for open lawn, bush fallow and vegetable farm while Agodi Garden was alkaline having the lowest amount of nutrients (Table 12).

Biochemical properties of water in Dandaru reservoir before clean-up were not significantly different for phosphate, nitrates, nitrite at $p>0.05$. The highest amount of nutrients was observed in at the entry point as 0.033 ± 0.02mg/l, 0.76 ± 0.02mg/l and 0.46 ± 0.01mg/l respectively.

However, in all the locations there were significant differences in the DO and pH. The lowest concentration of DO (7.89 ± 0.30mg/l), was obtained at the midpoint, while the highest concentration of DO was recorded at the entry point (19.29 ± 0.25mg/l) (Table 13). The assessment of the level of transparency (Table 12) showed that the midpoint was lowest (0.06 ± 0.03 m) while the entry point had the highest value (0.20 ± 0.02m) indicating that the water at the entry point was far clearer than in the midpoint.

The biochemical analyses of water in Dandaru reservoir after the mechanical clean up indicated significant differences in the concentrations of all the parameters at $p<0.05$ (Table 14). Phosphate significantly increased in all the locations (entry point, midpoint and exit point) when compared to the previous survey having values of (0.081± 0.03 mg/l, 0.054 ± 0.03 mg/l and 0.021± 0.01 mg/l) respectively. However, nitrate and nitrite concentrations were low with values ranging from 0.06 ± 0.03mg/l – 0.44 ± 0.40 mg/l. The entry point had the lowest amount of DO (3.63 ± 0.02 mg/l) while the highest (9.54 ± 0.01mg/l), was recorded in the midpoint. There was no significant difference in pH as all the land use sites were alkaline in all locations. The turbidity (transparency) level of the reservoir was significantly different in all the locations. The entry point had the highest value (0.80 ± 0.37 m). There was an increased turbidity at the midpoint level with value of (0.14 ± 0.15m) compared to the previous value.

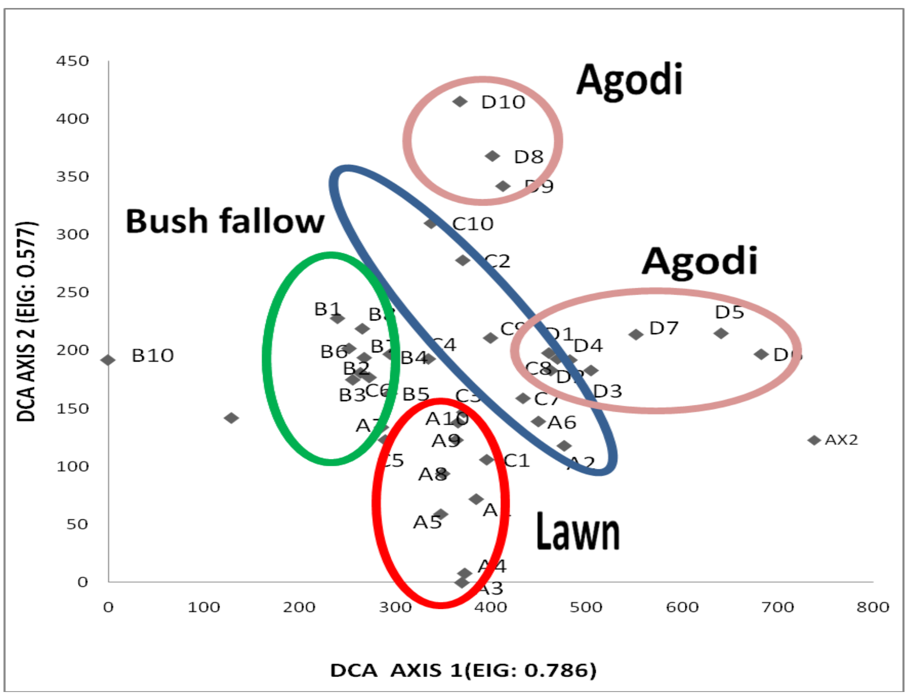

Figure 2: Relationship between the land use types at Dandaru reservoir in Ibadan based on stand ordination in November, 2012

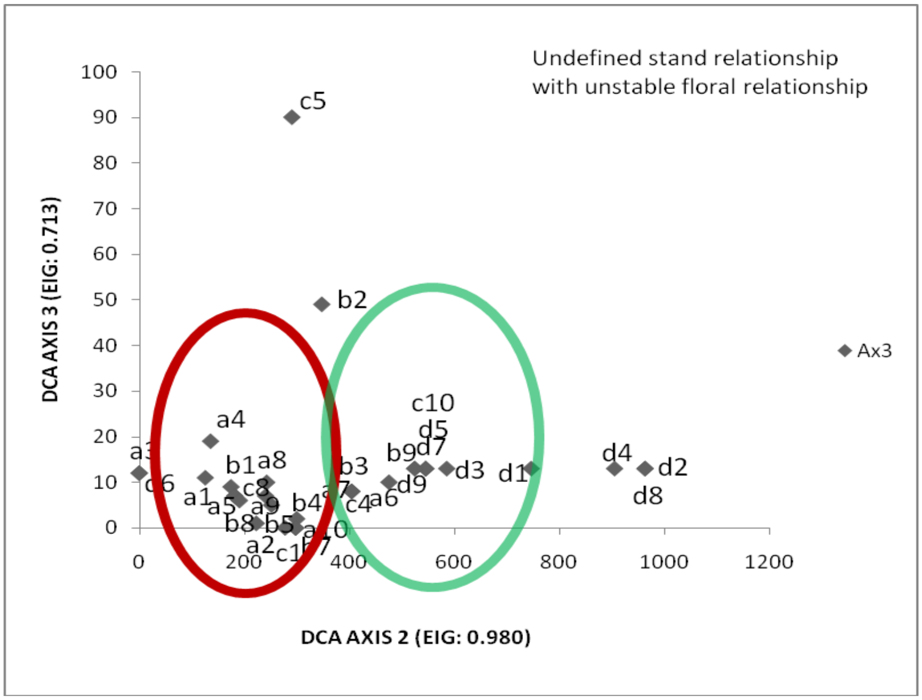

Figure 3: Relationship between land-use types at Dandaru reservoir in Ibadan based on stand ordination in February, 2013

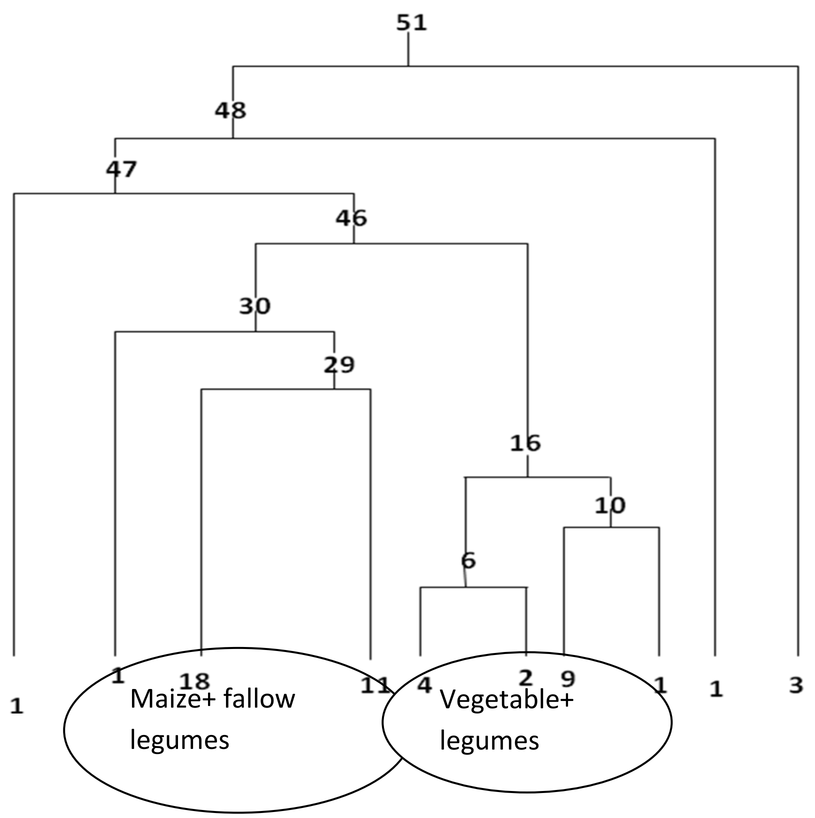

Figure 4: Dendrogram of phytosociology of flora and indicator species of four land-use types in the catchment of Dandaru reservoir, Ibadan in November, 2012

Table 11: Nutrient status of soils of four land-use types around the Dandaru reservoir in November, 2012

Locations	P (g/kg)	TOC (g/kg)	TN (g/kg)	Ca (g/kg)	K (g/kg)	Na (g/kg)	pH	Textural Class
Lawn	0.13 ± 0.03	5.70 ± 0.05	0.60 ± 0.03	0.39 ± 0.003	0.08 ± 0.003	0.05 ± 0.004	6.23 ± 0.04	Sandy Loam
Bush fallow	0.09 ± 0.02	7.83 ± 0.05	0.81 ± 0.02	0.09 ± 0.001	0.10 ± 0.002	0.05 ± 0.002	6.53 ± 0.11	Sandy Loam
Veg. Farm	0.19 ± 0.02	1.07 ± 0.03	0.11 ± 0.02	0.23 ± 0.002	0.07 ± 0.003	0.07 ± 0.002	6.73 ± 0.15	Sandy Loam
Agodi garden	0.31 ± 0.03	3.06 ± 0.02	0.32 ± 0.03	0.19 ± 0.002	0.05 ± 0.002	0.06 ± 0.003	6.70 ± 0.07	Sand
LSD value	0.08	0.004	0.01	ns	ns	Ns	0.08	

ns= not significant ($p > 0.05$)

Table 12: Nutrient status of soils of four land-use types around the Dandaru reservoir in February, 2013

Locations	P (g/kg)	TOC (g/kg)	TN (g/kg)	Ca (g/kg)	K (g/kg)	Na (g/kg)	pH	Textural class
Lawn	0.29 ± 2.06	32.90 ± 3.37	2.24 ± 0.04	0.11 ± 1.12	0.30 ± 0.04	2.50 ± 0.01	6.23 ± 0.36	Sandy loam
Bush fallow	0.34 ± 1.07	21.73 ± 0.64	1.92 ± 0.09	0.16 ± 0.56	0.96 ± 0.24	3.19 ± 0.64	6.23 ± 0.27	Sandy loam
Veg. Farm	0.35 ± 3.77	21.83 ± 0.59	1.95 ± 0.08	0.12 ± 2.86	0.46 ± 0.28	2.92 ± 0.55	6.63 ± 0.04	Sandy loam
Agodi garden	0.26 ± 1.07	6.96 ± 2.42	0.72 ± 0.25	0.07 ± 1.11	0.18 ± 0.01	1.01 ± 0.18	7.29 ± 0.14	Sandy
LSD value	1.65	1.29	0.09	1.05	ns	0.32	0.16	

ns= not significant ($p>0.05$)

Table 13: Biochemical properties of water in Dandaru reservoir, Agodi at different locations in November, 2012

Locations	Phosphate (Mg/L)	Nitrate (Mg/L)	Nitrite (Mg/L)	(DO) (Mg/L)	pH	Turbidity (m)
Entry point	0.033 ± 0.02	0.76 ± 0.02	0.46 ± 0.01	19.29 ± 0.25	7.31 ± 0.04	0.20 ± 0.02
Mid point	0.013 ± 0.003	0.74 ± 0.003	0.45 ± 0.004	7.89 ± 0.30	6.73 ± 0.04	0.06 ± 0.03
Exit point	0.012 ± 0.004	0.75 ± 0.04	0.45 ± 0.03	14.01 ± 008	7.21 ± 0.13	0.11 ± 0.05
LSD Value	ns	Ns	ns	0.271	0.093	0.01

ns= not significant($p > 0.05$)

Table 14: Biochemical Properties of water in Dandaru reservoir, Agodi at different locations in February, 2013

Locations	Phosphate (Mg/L)	Nitrate (Mg/L)	Nitrite (Mg/L)	Dissolved Oxygen (Mg/L)	pH	Turbidity (m)
Entry point	0.081 ± 0.04	0.11 ± 0.06	0.07 ± 0.04	3.63 ± 0.02	7.84 ± 0.10	0.80 ± 0.37
Mid point	0.054 ± 0.04	0.44 ± 0.57	0.27 ± 0.34	9.54 ± 0.01	7.87 ± 0.00	0.14 ± 0.15
Exit point	0.021 ± 0.01	0.12 ± 0.05	0.07 ± 0.03	8.86 ± 0.01	7.78 ± 0.06	0.12 ± 0.22
LSD Value	0.031	0.28	0.16	0.02	Ns	0.01

ns= not significant ($p > 0.05$)

DISCUSSION AND CONCLUSION

The need to produce goods and services and to dispose off the by-products of these activities is an important challenge facing conservation of land resources. The use to which land is usually put sometimes contribute to impoundments, and loss of functions of wetlands and reservoirs located in cities with high concentrations of humans. Of the four land-use types identified in the vicinity of Dandaru reservoir, two which are of core agricultural relevance were found to impact on the water quality of the reservoir based on their floristic composition.

The highest species diversity and richness obtained in the vegetable farm during the pre-mechanical remediation was indicative of human interference, especially noting that the farm was yet to be weeded at the time. The results support the studies of Galloway *et al*., (1995) and Vitousek (1997) which implicated nodulating leguminous plants as contributory factors to eutrophication in lands adjoining water bodies. Eutrophication might have been further caused by fertilizer run-off; erosion of soil particles and other organic matter as reported by Smith *et al*., (1999).

The nutrient status of the soil before the remediation process which showed a high level of TOC and TN in the bush fallow could be due to the intensive cultivation of the land. This agrees with the work of Smith and Schindler (2009) who reported that the amount of nutrients input depend on the types and amount of human activity occurring in the ecosystem.

Increased amount of soil nutrients observed in the second phase of the survey could be due to mechanical disturbance occasioned by the mechanical agitation of the water and sediment by the movement of the bull dozer used causing increased mixing of erstwhile settled elements. The high amount of TOC and TN observed in the open lawn during the post-mechanical remediation could be due to organic waste removed from the reservoir which was dumped in close proximity to the lawn. Pre-silting, the pH of the water in the reservoir was acidic in line with descriptions of impacts of eutrophication on pH in which the water becomes acidic as a result of increased activities of micro flora; whereas the reduced amount of nutrients and alkalinic pH post-silting is expected since the metabolic activities of microflora were excluded with their mechanical removal. The results of dissolved oxygen and turbidity follow similar trends. Murphy

(2002) reported that low concentration of dissolved oxygen was indicative of the decomposition of organic matter by micro-organism leading to oxygen depletion and fish mortality.

The post-mechanical remediation which resulted in a high concentration of dissolved oxygen, alkaline pH and low nitrates and nitrites especially at the midpoint is a good approach to the restoration of the ecosystem. The implication of various land-use types in the catchment of Dandaru reservoir was that the anthropogenic activities are linked to eutrophication and impairment of fundamental use and ecosystem function of the Dandaru reservoir in Agodi, Ibadan. Therefore, this study suggests that all forms of agricultural activities around the Dandaru reservoir should be stopped, and future anthropogenic encroachments should be prevented. Also, periodic assessment of the Dandaru reservoir should be carried out to monitor eutrophication status of the reservoir, and to ensure adequate health of the ecosystem. In the future, wastes from the mechanical clean up of reservoirs should not be dumped on the bank of the reservoir to prevent re-infestation of weeds and re-occurrence of euthrophication,. The debris may be processed offsite into compost for peri-urban agricultural purposes.

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