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A Study on Water Quality and Macrophyte Diversity in Three Wetlands of Sambalpur District, Odisha from Ecosystem Management Perspective

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ABSTRACT

Manmade wetlands provide many services that contribute to human well-being and poverty alleviation. Some groups of people, particularly those living near wetlands, are highly dependent on these services and are directly harmed by their degradation. We assessed overall ecological condition of two lentic and one lotic wetlands present in the periphery of Sambalpur town, Odisha, India. Wetland macrophytes were sampled through 1x1m^2 quadrates and water quality parameters were studied following "Guide manual: water and wastewater analysis" by CPCB and APHA (1998)". In the phytosociological study, 43 species of macrophytes were recorded belonging to 20 families in the 3 study sites. Both the lentic wetlands showed highest diversity indices in postmonsoon period with emergent plants outnumbering free floating and submerged plants. This indicated that the hydrodynamic forces in lentic wetlands were not enough to uproot the emergent plants. The present work showed that macrophytic diversity being negatively correlated by all most all water quality parameters studied indicating considerable anthropogenic impact on these systems. Further PCA biplot showed large positive loadings on component 1 by water conductivity, TSS, TDS, NO_3, and BOD that caused regionalization of three wetlands namely Durgapali pond (Site I), Kanjhuri nalia/ canal (Site II), and Gobindtola canal (Site III) of Sambalpur town indicating differential antropogenic impact as per their need. The study emphasized on immediate management of these wetlands specifically the small lotic wetlands for promoting water health.

Key words: *Lentic, Lotic, Phytosociological, hydrodynamic, Macrophytic diversity*

Introduction

Wetlands, rich in aquatic resources, play a significant role in maintaining rich biodiversity. These are suitable habitats for supporting growth of a variety of aquatic life forms (Hazarika *et al.*, 2012). Ggenerally it sustains diverse aquatic vegetation, also called hydrophytic plants. According to India State of Forest Report, 2019, the country has 62,466 wetlands covering 3.83% of its recorded forest area as recorded by Pardikar., 2020(https://theprint.in/environment/10-more-indian-wetlands-identified-as-crucial-to-global-biodiversity-heres-why-it-matters/357435/). The water bodies like swamps, bogs, marshes, deltas and floodplains of India needs attention as many such areas are currently under threat from encroachment and pollution. Further, increasing urbanisation has significantly reduced the amount of area under wetlands. A rapid assessment undertaken by Wetlands International South Asia (WISA) indicated that nearly 8% of India's wetlands area was likely to be situated within an urban cover (Khandekar ., 2020) (https://thewire.in/environment/world-wetlands-day-ramsar-convention-catchment-water-pollution-urbanisation). She also reported that the states of Uttar Pradesh, Tamil Nadu, West Bengal, Odisha, Andhra Pradesh and Telangana account for over half of all urban wetland area.

Eliska., (2011) opined that variations exist in different macrophytes on the basis of their biomass production, capability to recycle nutrients, and impacts on the rhizosphere by release of oxygen and organic carbon, as well as their capability to serve as a conduit for methane. Studies on macrophytes in wetlands of India are well documented by many authors. Several workers have also discussed the wetland plants of the different districts of Odisha state (Pattnaik *et al*. 1983; Saxena and Brahmam., 1996). But the macrophytic diversity in the inland wetlands, both freshwater and saline, is in general, poorly known.

The depth, density, diversity and types of macrophytes present in a system are indicators of water body health. Where submerged aquatic macrophytes are abundant, they can have a heavy influence on habitat structure, fishability, recreational use and nutrient dynamics. The absence of macrophytes may indicate water quality problem such as excessive turbidity, herbicides or salinization which interfere with plant growth and development. However, an overabundance of macrophytes can result from high nutrient levels and may affect ecosystem health, recreational activities and the aesthetic appeal of the system (National Aquatic Resource Surveys., 2017: https://www.epa.gov/national-aquatic-resource-surveys/indicators-macrophytes)

The distribution, habitat characteristics and biota of the Indian mangroves have been relatively well documented (Gopal and Krishnamurthy, 1993; Selvam, 2003; Kathiresan, 2004) but in the inland wetlands, both freshwater and saline, are in general, poorly known. Very few studies have been reported from all over India. With this background the present work was intended to evaluate overall ecological condition of two lentic and one lotic wetlands present in the periphery of Sambalpur district, Odisha, India.

Materials and Methodology

The present study deals with the investigation of the macrophytic diversity and water quality of three wetlands in the periphery of Sambalpur town,

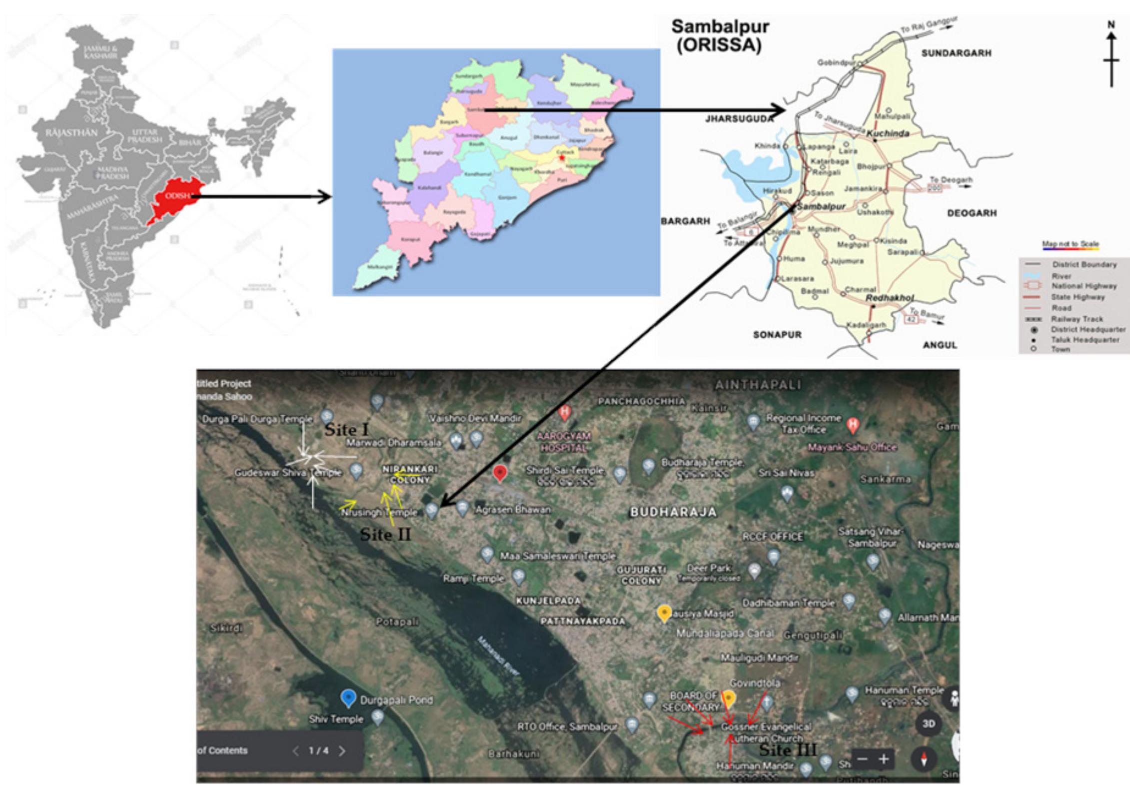

Fig. 1. The study sites

which are Site I (Durgapali small community Pond of nearly 150ft×300ft area), Site II (Kanijhuri Nalia/ Canal originated from Hirakud reservoir), Site III (Gobindtola canal originated from Hirakud reservoir) of Sambalpur town, Odisha respectively. The study was carried out for a period of one year i.e. from January 2018 to December 2018.

Macrophyte sampling

Wetland macrophytes were sampled through a 1x1m^2 quadrate randomly placed at five locations of three study sites (Quadrate Method). Selection of quadrate was based on the wetland use type prevailing in the study site. Data from five study sites were used to get the macrophyte count of the study sites. Macrophytes (floating plants) were collected and were placed in clean water for two days and then the plants were separated and identified following "The Flora of Orissa" 1-4 Vols. by Saxena and Brahmam., (1996). Samples were taken once in pre- monsoon (April, 2018), monsoon (July, 2018) and post- monsoon (November, 2018). Data obtained from different wetlands were subjected to calculate community characteristics as follows.

Frequency was estimated as per Raunkier., (1934),

$$\text{Frequency} = \frac{\text{No. of qudrate of occurrence of species}}{\text{Total no. of qudrate studied}} \times 100$$

Density and Abundance was calculated following Mishra (2012) as:

$$\text{Density} = \frac{\textit{Total no. of individual of a species}}{\textit{Total no. of qudrate studied}}$$

$$\text{Abundance} = \frac{\text{No. of individual of species}}{\text{No. of qudrate of occurrence of species}}$$

Important value index

Important value index (IVI) of each species was calculated by adding relative frequency, relative density and relative abundance of the species (Phillips *et al.,* 1994)

Species diversity

Species diversity ($\bar{H}$) of the herbaceous species was determined following Shannon and

Weiner, (1963) as $=-\Sigma\,(n_i/N)\ ln\,(n_i/N)$

Where n_i=IVI of individual species and N=Total IVI of individual of all species in the area.

Water quality analysis

For water quality analysis random samples of water were collected from three different locations of each wetland in the morning on the same date when macrophytes were collected. Water samples were collected from 50cm depth in each collection sites for analysis of total dissolved solids (TDS), total suspended solids (TSS), pH, conductivity of water, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), Nitrate content of water, Phosphate content of water. All these parameters were studied following "Guide manual: water and wastewater analysis" by CPCB and APHA., (1998)".

Statistical analysis

The data obtained from physicochemical parameters of surface water and diversity index of macrophytes were subjected to multiple correlations by SPSS 16 and PCA with Minitab 19 software.

Results and Discussion

Seasonal variation of macophyte diversity in three wetlands

Table 1: Macrophytes recorded from three wetlands in the periphery of Sambalpur town with their conservation status

A total of 43 species of wetland macrophytes belonging to 20 families were recorded from the study area during the present study (Table 1). The list of macrophytes includes 6 free floating, 8 submerged, 24 emergent, 4 floating leaved, 1 bund macrophytes. The wetland macrophytes include the free floating macrophytes like *Hydrocharis morsus ranae*, *Eichhornia crassipes*, *Azolla pinnata*, *Jussiea repens*, *Pistia stratiotes* etc; submerged macrophytes like *Ottelia alismoides, Egoria densa, Elodea Canadensis, Potamogeton crispus* etc; emergent macrophytes like *Phragmites karka, Bolboschenus glaucus, acorus calamus, Ludwigia adscendens, Agrostis stolonifera* etc; Floating leaved macrophytes *like Nymphoides peltata, potamogeton gramineus, Nymphoides indica, Euryale ferox* etc; and small number of macrophytes growing on the bund. Family poacea was noticed as the abundant family with 5 species, followed by families hydrocharitaceae with 4 species, Onagraceae with 4 species, cyperaceae with 4 species, potamogetonaceae with 4 species, ameranthaceae,

Table 1. Macrophytes recorded from three wetlands in the periphery of Sambalpur town with their conservation status

S.l. No.	Scientific Name	Common Name	Family	Iucn Status	Seasonally Occured	Distribution Patern
1	*Acorus calamus*	sweet flag or	Acoraceae calamus	Least concern	Post Monsoon and Monsoon	Emergent
2	*Agrostis stolonifera*	creeping bentgrass, creeping bent, fiorin, spreading bent, carpet bentgrass or redtop	Poaceae	Least concern	Monsoon	Emergent
3	*Alternanthera philoxeroides*	alligator weed	Amaranthacea	Threatened species	Post Monsoon, Pre monsoon	Emergent
4	*Alternanthera philoxeroides*	alligator weed	Amaranthaceae	Threatened species	Post Monsoon and Pre Monsoon	Emergent
5	*Anthoxanthum odoratum*	sweet vernal grass	Poaceae	Threatened species	Pre Monsoon	Emergent
6	*Apium inundatum*	Lesser Marshwort	Apiaceae	Threatened species	Post Monsoon	Submerged
7	*Azolla pinnata*	mosquitofern, feathered mosquito fern and water velvet.	salviniaceae	Threatened species	Pre Monsoon, and Monsoon	Free floating
8	*Bolboschoenus glaucus*	puruagrass, tuberous bulrush	Cyperaceae	Threatened species	Pre Monsoon	Emergent
9	*Bolboschoenus miritimus*	sea clubrush, osmopolitan bulrush, and bayonet grass.	Cyperaceae	Least concern	Pre Monsoon, Monsoon and Post Monsoon	emergent
10	*Centalla asiatica*	Asiatic pennywort or Gotu kola	Apiaceae	Threatened species	Pre Monsoon	Emergent
11	*Colcasia esulentum*	Taro	Araceae	Threatened species	Pre Monsoon	Emergent
12	*Cyperus distans*	slender cyperus	Cyperacea	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Emergent
13	*Egoria densa planch*	large-flowered waterweed or Brazilian waterweed	Hydrocharita-ceae	Threatened species	Monsoon and post Monsoon	Submerged
14	*Eichhornia crassipes*	water hyacinth	Pontederiacea	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Free floting
15	*Elodea canadensis*	American or Canadian waterweed or pondweed	Hydrochari-taceae	Threatened species	Monsoon and post monsoon	Submerged
16	*Euryale ferox*	fox nut, foxnut, gorgon nut or makhana	Nymphaeaceae	Least concern	Pre Monsoon, Monsoon and Post Monsoon	Floating leaved
17	*Fimbristylis dichotoma*	forked fimbry or eight day grass	Cyperaceae	Threatened species	Pre Monsoon and Monsoon	Emergent
18	*Hydrilla verticillata*	Hydrilla Water Thyme Florida Elodea Indian	Hydrochari-tacea	Threatened species	Post monsoon	Submerged
19	*Hydrocharis morsus-ranae*	common frogbit or European frog's-bit	Hydrocharitacea	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Free floating

Table 1. *Continued ...*

S.l. No.	Scientific Name	Common Name	Family	Iucn Status	Seasonally Occured	Distribution Patern
20	*Hygroryza aristata*	Hygroryza aristata, (Asian watergrass	Poaceae	Not known	Pre Monsoon, Monsoon, Post and Monsoon	Emergent
22	*Imperata cylindrica*	cogongrass, kunai grass, blady grass, cotton wool grass	Poaceae	Critically endengered	Post monsoon	Emergent
23	*Ipomoea aquatica*	water spinach, river spinach, water morning glory, water convolvulus, Chinese spinach, Chinese Watercress, Chinese convolvulus, swamp cabbage	Convolvulaceae	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Emergent
24	*Jussiaea repens*	floating primrose-willow	Onagraceae	Least concern	Post Monsoon	Free Floating
25	*Lemna minor*	duckweed or lesser duckweed	Lemnaceae	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Free floting
26	*Ludwigia adscendens*	water primrose	onagraceae	Threatened species	Pre Monsoon	Emergent
27	*Ludwigia parviflora*	primrose-willow, water-purslane, or water-primrose	onagraceae	Threatened species	Pre Monsoon and Post monsoon	Emergent
28	*Marssilea quadrifolia*	four leaf clover; European waterclover	Marsileaceae	Least concern	Pre Monsoon, Monsoon and Post Monsoon	Emeregent
29	*Myriophyllum sibiricum*	shortspike watermil foil, northern watermilfoil, and Siberian water-milfoil.	Haloragacea	Threatened species	Monsoon	Submerged
30	*Nymphoides indica*	banana plant, robust marshwort, and water snowflake	Menyanthaceae	Threatened species	Pre Monsoon and Monsoon	Floating leaved
31	*Nymphoides peltata*	fringed water lily, yellow floating heart, floating heart, water fringe, entire marshwort	Menyanthaceae	Threatened species	Pre Monsoon	Floating leaved
32	*Ottelia alismoides*	duck-lettuce	Hydrocha-ritaceae	Least concern	Post monsoon and Monsoon	Submerged
33	*Oxystelixa esculentum*	Rosy Milkweed Vine	Apocynaceae	Least concern	Post Monsoon	emergent
34	*Persicaria attenuate*	Watersmart Weed, Hairy Knotweed	Polygonaceae	Threatened species	Pre Monsoon, Monsoon and Post Monsoon	Emergent
35	*Pistia stratiotes*	Pistia stratiotes, is often called water cabbage, water lettuce, Nile cabbage, or shellflower	Araceae	Threatened species	Pre Monsoon, Monsoon, Post and Monsoon	Free floating
36	*Potamogeton crispus*	curled pondweed or curly-leaf pondweed	Potamogeto-naceae	Least concern	Pre Monsoon, Monsoon and Post Monsoon	Submerged

Table 1. *Continued ...*

S.l. No.	Scientific Name	Common Name	Family	Iucn Status	Seasonally Occured	Distribution Patern
37	*Potamogeton gramineus*	various-leaved pondweed, grass-leaved pondweed or grassy pondweed	Potamogeto-naceae	Threatened species	Pre Monsoon	Floating leaved
38	*Potamogeton pectinatas*	sago pondweed or fennel pondweed	Potamoget-onaceae	Least concern	Post Monsoon and Pre Monsoon	Emergent
39	*Potamogeton praelongus*	whitestem pondweed	Potamogeto-naceae	Threatened species	Pre Monsoon	Submerged
40	*Sagittaria latifolia*	Broad leaf arrowhead, duck-potato Indian potato, or wapato.	Alismataceae	Endengered species	Pre Monsoon and Monsoon	Emergent
41	*Sporobolus diander*	dropseeds or sacaton grasses	Poacea	Threatened species	Post Monsoon	Emergent
42	*Tamarix dioica*	lal jhau, urusia, ban jhau, nona-gach, urichiya	Tamaricaceae	Thraetened species	Pre Monsoon, Monsoon and Post Monsoon	Emergent
43	*Trapa natans*	buffalo nut, bat nut, devil pod, ling nut, mustache nut or singhada	Lythraceae	Threatened species	Post Monsoon and Monsoon	Bund

apiacaeae, menyanthaceae, Araceae and acoraceae with 2 species each, Holoragaceae, Polygonaceae, Lemnaceae, Apocynceae, Lythraceae, Salviniaceae, Nymphaceae, Alismataceae, Convolvulaceae and Marsiliaceae with 1 species each.

Out of 17 species of macrophytes recorded from the Durgapali pond, 35.29 % species were present throughout in the site during Pre monsoon, 23.52 % species were present during monsoon, 41.17 % species were present during Post monsoon. Out of the 30 species of wetland macrophytes recorded from the Site II (Kanijhuri Nalia/Canal) , 40 % species were present throughout in the site during Pre monsoon, 20 % species were present during Monsoon, 40 % species were present during Post monsoon. Out of the 28 species of wetland macrophytes recorded from the Site III (Gobindtola canal) , 35.71 % species were present throughout in the site during pre monsoon, 25 % species were present during monsoon, 39.28 % species were present during post monsoon.

Seasonal study of wetland macrophytes in the study area (number of species) based on habitat conditions revealed that maximum number of species (22 species) were noticed during post monsoon, followed by 19 species in pre monsoon and 17 species of macrophytes during monsoon. The study revealed occurrence of more number of macrophyte species during post monsoon.

Water quality in three wetlands

The value of water quality parameters of three sites (taking the average of pre monsoon, monsoon and that of post monsoon) has been demonstrated in Table 1

Table 2: Physico-chemical parameters (Avg ± SEM) of three sites over one year

If compared to surface water quality criteria for different uses (specified by CPCB https://cpcb.nic.in/wqm/Primary_Water_Quality_Criteria.pdf), the DO, BOD of studied sites were not even suitable for bathing purpose (BIS limit was 3-6 mg/litre for DO and 2-3 mg/l for BOD). Discharge of domestic effluents, sewage, and agricultural runoff could have the main cause of unsuitable water qualities for human use in present study. Padmanabha., (2017) observed that the Water Quality Index of lentic ecosystem is higher than the lotic ecosystem in general indicating the water quality of standing water to be deteriorated more than the running water in Mysuru, India. This is in conformity with our findings.

Diversity index of three wetlands in three season indices was observed and represented in table 3. The seasonal index of wetland macrophytes noticed an abundance of free floating and emergent macrophytes during Post monsoon. Emergent and amphibious species were tolerant of high trophic conditions and poor lighting conditions as reported by Pereira *et al*., (2012). The most important factor in the life-history and ecology of aquatic macrophytes is the rainfall and its distribution throughout the year (http:// shodhganga. inflibnet. ac.in /bitstream / 10603 /26753 /5 /05 _ chapter%201.pdf). The highest diversity during postmonsoon in three sites may be due to rainfall, fresh water intrusion and favourable environmental conditions etc. Shannon Wiener index (2.74 ±0.36) indicates poor to moderate pollution status of lake as reported by Biswas *et al*., (2015). On the basis of this finding the diversity index of macrophytes in the present study sites indicate the three sites to be moderate or highly polluted.

Genus diversity is a useful parameter for the comparison of communities under the influence of biotic disturbances or to know the state of succession and stability in the community as stated by Biswas *et a*l., (2015). The present findings of highest diversity during post monsoon are substantiated if compared to the findings of Biswas *et al*., (2015). In the present study emergent aquatic macophytes outnumbered the submerged and free floating species. It is thought that emergent macrophytes are the most particularly productive of all aquatic macrophytes since they make the best use of all three possible states-with their roots in sediments beneath water and their photosynthetic parts in the air (Westlake., 1963). Highest diversity during post monsoon might be attributed to the heavy load of organic matter in sediment as well as in water during post monsoon period.

Multiple correlations (Table 3) indicated that the macrophytic diversity was affected negatively by all most all water quality parameters studied. The dataset was further treated using Principal Component Analysis (PCA) to extract the parameters that are most important in assessing variation in water quality and vegetation diversity. Three Principal Factors were identified as responsible for the data

Table 2. Physico-chemical parameters (Avg ± SEM) of three sites over one year

Water quality parameters	Site I	Site II	Site III
TDS (mg/L)	242.92±31.75	124.17±22.27	128.33± 22.9
TSS(mg/L)	200.583±33.15	100.42±12.2	112.67±29.75
PH	7.121±0.249	6.845±0.216	6.958±0.289
COND (µS/cm)	336.00± 39.225	161.25±22.58	141.83±14.45
DO (mg/L)	3.313±0.298	2.562±0.175	3.612±0.0148
BOD (mg/L)	31.775±3.64	29.38±3.367	28.1±4.593
COD (mg/L)	159.75±8.261	348.74±32.95	419.425±30.14
NO_3 (mg/L)	15.147±2.248	6.453±0.72	2.712±0.125
PO^4 (mg/L)	0.214±0.077	0.225±0.014	0.324±0.069

Table 3. Multiple correlation between different water qualities and diversity of aquatic macrophytes

	Sites	TDS	TSS	pH	Conductivity	DO	BOD	COD	Nitrate	Phosphate	DI
Sites	1										
TDS	-.457**	1									
TSS	-.362*	.917**	1								
pH	-.079	-.464**	-.643**	1							
Conductivity	-.629**	.897**	.834**	-.430**	1						
DO	-.359*	.114	.211	-.450**	.377*	1					
BOD	.115	.777**	.768**	-.623**	.537**	-.223	1				
COD	.603**	.202	.124	-.266	-.111	-.448**	.651**	1			
Nitrate	-.731**	.702**	.572**	.096	.688**	-.111	.319	-.245	1		
Phosphate	.219	.612**	.785**	-.746**	.438**	.013	.836**	.431**	.087	1	
DI	.632**	-.887**	-.812**	.238	-.879**	-.265	-.467**	.122	-.788**	-.359*	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

Table 3. Diversity Indices of aquatic macrophytes in three wetlands during pre monsoon, monsoon, and post monsoon

Sites	Pre Monsoon	Monsoon	PPost Monsoon
Site I (Durgapali Pond)	1.58	1.258	1.788
Site II (Kanjhuri canal)	2.194	1.994	2.374
Site III (Gobindtola canal)	2.172	1.829	2.166

structure explaining 93.57 % of the total variance of the dataset, in which COD (62.09%), BOD (17.79%), and TSS (13.68%) represents total variance of water quality in the present study.

This biplot (Fig: 2) shows that conductivity, TSS, TDS, NO3, conductivity and BOD have large positive loadings on component 1 whereas COD, pH, and DO have large negative loadings on component1 and score plot indicate strong influence of these variables in recognizing the pollution load in three sites.

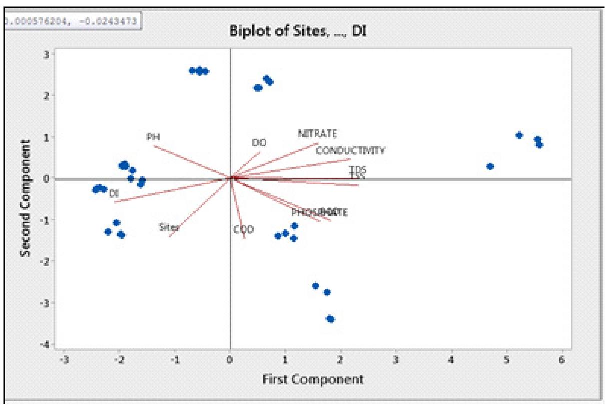

Fig. 3. The PCA Biplot

Conclusion

The study indicated strong influence of water quality on macrophyte diversity and community composition. Further it is affirmed that the small community pond was under strong anthropogenic impact and needs to be protected from over anthropogenic pressure. As such type of wetlands support agricultural activities by providing a source of water for irrigation and livestock and for domestic consumption in most of the places in India, monitoring of these wetlands' water quality and macrophyte diversity are highly essential for the benefit of local poor people.

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