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Studies on the macro-invertebrate community structure, composition with various weed communities in selected ponds of Bihar

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ABSTRACT

The study was designed to assess the quality of three freshwater ponds of district Aurangabad, Bihar, during the period of one year from Dec 2014 to Nov 2015. The three ponds under investigation namely Pond I (Umgaa), Pond II (Ranipokharadeo) & Pond III (Patalganga) have historical and religious value. The study was conducted with respect to the Physico-chemical parameters of pond water including Temperature, pH, TA (Total alkalinity), Free CO2, DO (Dissolved Oxygen), EC (Electrical conductivity), Transparency, and BOD (Biological oxygen demand) by following the standard protocols. The study was also conducted with respect to the Physico-chemical parameters of pond bottom sediments/soil including pH, OC (Organic carbon), N (nitrogen), P (Phosphorus) and K (Potassium) to observe the nutrient status of ponds. The results of the data obtained in various seasons were evaluated and compared for all three selected ponds to quantify overall pond water quality status of the area for its possibility of being utilized as aquaculture. The Relative abundance of Macro-invertebrate species recorded from all the three ponds was also quantified. Since a reciprocal and manifold relationship exists between the macro-invertebrate fauna and macrophytic weed community of the pond ecosystem, the macrophytic weed infestation condition of the pond was also analyzed.

Keywords: *Physico-Chemical Parameters, Pond Water*

1. INTRODUCTION

Water is an important abiotic factor, which has a unique place on the planet as it supports life on earth. The role of water in nature is unique not only for human; but also for the numerous organisms living in the water. 71% of earth surface is covered by water (**CIA, 2008**). Approximately 97% of the world's water is sea water which is salty and only 3% is fresh water. Less than 1% of fresh water is present in ponds, lakes, rivers, dams, etc., which is used by man for consumption and other purposes. Freshwater is a renewable resource of mankind. It may be regarded as "pillar of our civilization". Freshwater has become a scarce commodity due to over-exploitation and pollution **(Ghose and Basu, 1968; Gupta and Shukla, 2006; Patil and Tijare, 2001)**.

The quality of a water of pond refers to all the components of water which support both the survival and optimum growth of the aquatic organism. The physical and chemical quality of water varies according to the basic shape and size, depth, light penetration, precipitation, location, temperature, chemical nature of surrounding soil and dissolved minerals, pH, etc, and the biological components of the habitats depend upon them. If all the physical, chemical and biological parameters are in the optimum condition the balance between these is maintained (**Pratiksha Tambekar *et al*., 2012**). Optimal water quality varies by species and needs to be monitored for optimal growth and survival. Water quality is important in the pond because water quality imbalances can cause stress, poor growth, and mortality of culture species (**Boyd and Tucker, 1998**).

It is only relatively recently, that ponds have been widely recognized as an important freshwater habitat supporting aquatic biodiversity (**Davies *et al*. 2008; Picazo *et al*. 2012; Hassall and Anderson 2015**). Ponds have been found to support higher numbers of rare and uncommon taxa as compared to other freshwater habitats such as lakes and rivers (**Williams *et al*. 2003; Biggs *et al*. 2005; Lukacs *et al*. 2013**). Ponds are globally recognized as being particularly important for macroinvertebrate (**Collinson *et al*., 1995; Oertli *et al*., 2002; Nicolet *et al*., 2004**) and aquatic plant conservation (**Grillas and Roché, 1997; Linton and Goulder, 2000**), contributing highly to freshwater biodiversity at a regional level. It is now well known that freshwater ecosystems are some of the most productive on earth **(Likens 1973**) and it appears that certain types of aquatic macrophytes, e.g., rooted emergent species and floating species, may be the most productive vegetation of all (**Penfound 1956).** Macrophytes include vascular plants, submerged or partly submerged, bryophytes and macroalgae that are visible to the naked eye

(**Hynes 1970; Holmes and Whitton 1977; NERC 1999; Baattrup-Pedersen *et al*., 2006**). Nutrient elements like carbon, nitrogen, phosphorus, and oxygen in abundance lead to eutrophication of ponds, which is not good for a healthy and balanced ecosystem. The problem of aquatic macrophyte infestation is global but is particularly severe in the tropics and subtropics where elevated temperatures favor year round or long growing seasons, respectively (**Holm, *et al*., 1969**). Frequent oxygenation and causing an overflow of the ponds are simple measures which help in getting rid of the excess of nutrients and thus control the algal and macrophytic weed infestation to a certain/ desired level. In India, Bihar also contains a large number of such freshwater ponds, lakes and shallow water areas badly infested with different kinds of macrophytic vegetation. The aquatic weeds significantly deteriorate the ecological status as well as economic value of the ponds. But even, they also rather provide a favorable condition for the growth of macro-invertebrate fauna as a better habitat. A reciprocal and manifold relationship exists between the macro-invertebrate fauna and macrophytic weed community of the pond ecosystem. Such complicated relationship has differently been studied by several authors like **Mclachlan, 1975, Soszka, 1975, Voigts, 1976, Rai and Sharma, 1991** in different types of freshwater ecosystems.

Macro-invertebrates are large enough to be seen with a naked eye and lack a backbone. Macroinvertebrates are ubiquitous and are grouped into feeding groups of shredders, collectors, scrapers, and predators. They may be categorized as Pollution sensitive, moderately pollution sensitive and Pollution tolerant. The taxonomic orders of macro-invertebrates such as Ephermeroptera (E), Plecoptera (P), and Trichoptera (T) are in general three "Pollution sensitive" orders (**Merritt and Cummins, 1996**). The taxonomic orders of macro-invertebrates such as Diptera, Gastropoda, Amphipoda, and Oligochaeta are in general "Pollution tolerant" orders. Macro-invertebrate is an integral link in the stream food chain (**Allan 1995, Merritt and Cummins 1996**). They also aid in the decomposition process by breaking down large organic materials, which are then taken up by microbes and bacteria. This process, known as the "microbial loop", is important for the remineralizing of organic matter (**Allan 1995**). They also show the impacts of habitat loss not detected by traditional water quality assessments and are relatively easy to sample and identify. The understanding of the factors influencing the presence and relative abundance of a macro-invertebrate trait over space and time can prove insight into the functional diversity of the community (**Resh *et al*., 1995, Beche & Resh, 2007**). Biodiversity surveys of aquatic macro-invertebrates and ecological studies in relation to physicochemical characteristics of pond water have been conducted on several Caribbean Islands and few researchers (**Kiran, 2010; Raut *et al*., 2011; Naik *et al*., 2012; Bahekar and There, 2013; Mahajan and Tank, 2013)** in different regions of India. There is no information available in relation to the Physico-chemical characteristics of pond water at Aurangabad, Bihar, India.

Hence the present investigation was undertaken with the following objectives in aquatic freshwater ponds of Aurangabad, Bihar, during the period of one year from Dec 2014 to Nov 2015. (i)To analyze and compare the Physico-chemical analysis of water and sediment in all the three selected freshwater ponds. The observations and analysis of pond water were made every month and that of pond water bottom sediment every 6 months for a period of one year from Dec 2014 to Nov 2015. (ii) To determine the relative abundance of aquatic macro-invertebrates species inhabiting the selected ponds. (iii)To understand the estimated diversity of the chief macrophytic plant species recorded from selected ponds and their intensity of infestations of the pond.

2. MATERIALS AND METHODS

Study Area: Aurangabad district, having three perennial ponds locally known as Pond I (Umgaa), Pond II (Ranipokharadeo) & Pond III (Patalganga).

A sampling of pond water: The surface water samples were collected in clean plastic cans, once a month from three different ponds. Later the data were pooled together and represented as monthly data of the pond. Water temperature was recorded on the spot. The samples for dissolved oxygen were fixed immediately on the field itself.

Samplings of Biota; macro-invertebrate and macrophytes: Samplings of biota i.e. Macro-invertebrate fauna and Macrophytes flora were done following the methods described b**y Welch, 1948.**

Physico-chemical parameters analysis: The analysis of Physico-chemical parameters of the pond water were performed monthly using the standard methods of **Welch, 1948, APHA, 1981 and NEERI, 1986.** Physico-chemical parameters included temperature, pH, total alkalinity, Free CO_2, dissolved oxygen, electrical conductivity, transparency, and biological oxygen demand. Temperature has been long recognized as a major factor in the distribution, abundance, and richness of aquatic organism along the gradients in latitude and altitude (**Vannote *et al*., 1980, Ward 1992**). pH (Potential Hydrogen) is most important in determining the corrosive nature of water. Pond pH varies throughout the day due to respiration and photosynthesis. Electrical conductivity is a numerical expression of the ability of an aqueous solution to carry electric current. Electrical Conductivity is a useful tool to evaluate the purity of water (**Acharya *et al*., 2008**). Transparency of water relates to the depth that light will penetrate water. Transparency of water depends on the number of particles in it and it decreases with the presence of particles that can absorb or scatter light. Carbon dioxide is the end product of organic carbon degradation in almost all aquatic environments and its variation is often a measure of the net ecosystem metabolism of the aquatic system. Alkalinity is a measure of the capacity of water to neutralize the strong acid. Alkalinity is composed primarily of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-), alkalinity acts as a stabilizer for pH. DO is the indispensable need of most organisms. It affects the solubility of nutrients and therefore the periodicity of the aquatic ecosystem (**Wetzel 1983, Fritsh 1907**). BOD is the total amount of dissolved oxygen required by aerobic microorganism for biochemical decomposition of organic matter present in water. BOD has been considered as an important parameter in the aquatic ecosystem to establish the status of pollution.

3. RESULT AND DISCUSSION

The Temperature of water was determined by thermometry method using a simple mercury thermometer. The pH was determined by an electrometric method using pH meter systronics at room temperature (25°C). Total alkalinity in terms of concentration of hydroxide (OH^-), carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions was estimated by a titration method with acid using phenolphthalein and methyl orange as indicators. Free CO_2 was estimated titrimetrically using phenolphthalein as indicator. The

Dissolved oxygen (DO) was estimated titrimetrically by winklers Iodometric method/use of an oxygen meter. The Electrical conductivity (EC) was estimated by electrometry method using a Systronics conductivity meter at room temperature (25°C). Transparency was estimated with a Secchi disk. Biological oxygen demand (BOD) was estimated by incubation of a sample for 5 days at 20ºC and adopting winklers Iodometric method. The pH of soil was estimated by pH meter, Organic carbon by Walkely and Black titration method, Nitrogen by Kjeldahl's method, Phosphorous by Volumetric method and Potassium by Flame photometric method. The monthly value of different Physico-chemical parameters of water samples of three freshwater ponds is presented in Table-1 to 3. The mean value analysis of the readings of soil parameters of three freshwater ponds is presented in Table-4.

Table 1: Monthly Physico- chemical analysis of Pond I (Umgaa)

Month	Air temp (^{0}C)	Water temp. (^{0}C)	pH	DO (mg/L)	Free CO_2 (mg/L)	Total Alkalinity (mg/L)	Conductivity (µmhoscm^{-1})	Transparency (cm)	BOD (mg/L)
Dec 14	19.0	21.0	7.6	6.2	20	255	834	29	11.55
Jan 15	19.5	21.5	7.7	6.1	22	232	1105	28	11.95
Feb 15	21.0	23.5	7.5	6.0	18	247	1209	29	11.25
Mar 15	24.0	25.0	7.6	6.2	21	252	1246	24	12.70
Apr 15	26.0	27.5	7.8	6.8	20	258	1238	23	13.05
May 15	27.5	28.0	7.7	7.8	17	240	1205	24	15.25
Jun 15	30.0	31.5	7.6	7.2	16	210	1135	26	15.05
Jul 15	31.0	32.0	7.6	7.1	20	202	955	27	15.50
Aug 15	32.0	30.5	7.6	6.6	22	214	823	28	14.70
Sep 15	27.5	26.5	7.7	5.8	27	235	834	27	14.25
Oct 15	24.0	26.0	7.5	5.5	29	247	895	29	14.00
Nov 15	21.0	22.5	7.7	6.0	30	228	790	30	14.50

Table 2: Monthly Physico-chemical analysis of Pond II (Ranipokharadeo)

Month	Air temp (^{0}C)	Water temp. (^{0}C)	pH	DO (mg/L)	Free CO_2 (mg/L)	Total Alkalinity (mg/L)	Conductivity (µmhoscm^{-1})	Transparency (cm)	BOD (mg/L)
Dec 14	19.0	20.5	8.1	5.2	25	205	735	31	10.05
Jan 15	19.5	21.0	8.2	5.7	26	195	890	31	10.25
Feb 15	21.0	22.5	8.0	6.1	28	194	905	28	9.75
Mar 15	24.0	24.5	7.9	6.5	26	199	1050	27	9.95
Apr 15	26.0	26.5	7.7.	6.8	23	208	952	26	10.85
May 15	27.5	27.0	7.8	7.4	19	228	982	24	11.65
Jun 15	30.0	29.0	7.8	7.6	15	215	1035	23	11.35
Jul 15	31.0	30.0	7.9	7.1	21	208	955	26	12.40
Aug 15	32.0	30.0	7.9	6.9	24	214	872	27	12.85
Sep 15	27.5	25.5	8.0	6.1	26	225	728	28	12.30
Oct 15	24.0	25.0	8.1	5.8	30	235	894	29	11.95
Nov 15	21.0	22.5	7.9	6.0	29	228	764	30	11.75

Table 3: Monthly Physicochemical analysis of Pond III (Patalganga)

Month	Air temp (^{0}C)	Water temp. (^{0}C)	pH	DO (mg/L)	Free CO_2 (mg/L)	Total Alkalinity (mg/L)	Conductivity (µmhos.cm^{-1})	Transparency (cm)	BOD (mg/L)
Dec 14	19.0	21.5	7.4	6.1	28	240	945	26	8.25
Jan 15	19.5	22.0	7.5	5.7	29	237	895	27	8.00
Feb 15	21.0	23.5	7.6	6.3	26	238	915	29	8.75
Mar 15	24.0	25.0.	7.5	6.8	22	255	1020	28	9.30
Apr 15	26.0	25.5	7.4	7.2	20	246	989	26	9,95
May 15	27.5	26.5	7.6	7.9	18	235	1010	24	10.55
Jun 15	30.0	28.5	7.7	8.2	15	222	1076	23	11.00
Jul 15	31.0	30.0	7.6	7.4	21	245	1058	25	10.95
Aug 15	32.0	31.5	7.5	6.8	23	256	985	27	10.60
Sep 15	27.5	28.0	7.6	6.4	25	251	889	29	10.90
Oct 15	24.0	25.5	7.7	6.0	28	237	912	30	11.25
Nov 15	21.0	23.0	7.7	6.1	29	257	864	31	11.05

Table 4: Soil analysis mean value data of the ponds

Ponds	pH	OC (%)	N (mg Kg^1)	P (mg Kg^1)	K (mgKg^1)
Pond I (Umgaa)	7.2	3.65	282(.28%)	13.35	40.25
Pond II (Ranipokhara-Deo)	7.8	1.95	185(.18%)	9.19	32.45
Pond III (Patalganga)	7.4	3.25	260(.26%)	12.31	54.45

Total 33 species of macro-invertebrate fauna was recorded in pond water among which aquatic insects contained 19 species, 5 species of aquatic annelids, 4 species of molluscs and other phylum species were witnessed. The platyhelminthes is represented by *Rhabdocoela* sp, which are free-living flatworms and are predators of other small invertebrates. The aschelminthes is represented by *Dorylaimida* sp. The only oligochaetes annelid, which was collected from the sediments of all three ponds, appears to belong to genera *Limnodrilus* sp. Definitive identification of these worms requires microscopic examinations of their setae which could not be seen in the photographs. The Arthropods were represented by arachnids, crustaceans, and insects. The insect population is dominating and found distributed mainly in seven orders: Ephemeroptera, Odonata, Hemiptera, Coleptera, Diptera, Plecoptera, Trichoptera. Two species of each Ephemeropterans, odonates and hemipterans genera were observed in the ponds. Odonates nymph prey on small invertebrates (**Merritt et al., 2008**). Coleoptera is represented by five species of beetles. The presence of larval *Laccodytes* sp, *Hydrophilus* sp. indicates that these species are reproducing in this pond. *Tropisternus* sp. possibly has the most widespread distribution of any beetle in a freshwater environment of the Caribbean region**.** Diptera is represented by five species of true flies. The dipteran larva is common in aquatic environments. Two genera of Plecoptera and one genera of Trichoptera were also recorded from the pond. The arachnids were represented by *Eylais tantilla* and *Hydracna skorikowi*. The crustaceans were represented by single *Hemigrapsus* sp.

The macroinvertebrate fauna found amongst the different aquatic plant communities of freshwater ponds can easily be differentiated into two groups depending upon their degree of association with macrophytes. The fauna closely associated with the submerged part of macrophytes are truly associated fauna, viz., *Chaetogaster*, *Tubifex* of annelid, *Hemigrapsus* crustacean of arthropoda and *Pila globosa*, *Lymnae* of molluscs. Others which remain comparatively less associated with macrophytes are generally free moving types, viz., *Dero*, *Limnodrilus* , *Eiseniella* of annelids; *Gyrinus, Berosus, Procladius* of insects and *Gyraulus,.Physa* of molluscs. Their degree of association depends upon different relationships existing between the biology of both the animals and plants. The macrophytic weed infestation condition of the pond was as follows: Pond I (Umgaa) has water area thickly infested with a dense community of submerged plant species having a combination with *Eichhornia*, Lotus, Nymphea & Enhydra at the littoral area. *Eichhornia crassipes* infestation was recorded at a rate of .79 per/m^2. Pond II (Ranipokharadeo) has more or less clear water having a few amounts of submerged plants like *Hydrilla* and *Potamogeton*. Pond III (Patalganga).has submerged plant sp including a few floating *Ipomoea cornea* at one corner (25% area) whose infestation was recorded as 128.54 g/m^2, the other rest corners were occupied with cultivated *Nelumbo nucifera* (Sacred lotus plant), which have aesthetic value.

The population density of associated macro-invertebrate fauna was recorded minimum in the ponds having fewer quantities of submerged and floating plant varieties (Pond II). Such ponds were moderately infested with floating and submerged plant varieties. The pond I & III was comparatively heavily infested with macrophytes and supported favorable conditions for the better development of the invertebrate population. Such observations were also made by several authors like **Fernando (1973), King et al (1988), Roy et al (1980) and Macan (1965**).

4. CONCLUSION

The nutritional status of the three pond soil was found to be in the range of pH 7.2 - 7.8, OC 1.95 - 3.65 %, N 185 - 282 mg Kg^{-1}, P 9.19 - 13.35 mg Kg^{-1} and K 32.45 - 54.45 mg Kg^{-1}. The Physico-chemical parameters of three pond water was found to be in the range of water temperature 20.5- 32.0°C, pH 7.4-8.2, DO 5.2– 8.2 mg/L, free carbon dioxide 15- 30 mg/L, TA 194-258 mg/L, EC 728 – 1246 µmhos cm^{-1}, Transparency 23- 31 cm and BOD 8.00- 15.50 mg/L. The BOD in a different season in the present study indicates pond as a range in moderately polluted. It is also found that the analyzed parameters of water samples were within the permissible limits and are falling under excellent category and hence can be utilized for aquaculture purpose.

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