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Research Paper

Evaluation of Littoral Sediment of a Tropical Fish Pond of Bhopal, Bharat

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Abstract: Present work aimed to study the physico-chemical characteristics of littoral sediment of Piplani pond of Bhopal City, mainly used for integrated fish farming. The physico-chemical characteristics of the sediment sample like electrical conductivity, loss on ignition, calcium, magnesium, chloride, total phosphorus, organic carbon, and organic matter have been analyzed from August, 2013 to September, 2013. Composite sediment samples were collected monthly from three sites (S1, S2, and S3) of the Piplani Pond of Bhopal. The sediment samples were collected and brought to the laboratory, processed, and analyzed. Average range of sediment pH was 6.4-6.5 units; electrical conductivity was 861-879 µS/cm; Total Alkalinity was 48-60 mg/gm; Chloride was 35 mg/gm; Calcium 100-120 mg/gm; Magnesium was 24-60 mg/gm; Nitrogen was 0.74-0.78 mg/gm; Total phosphorus was 0.40-0.43 mg/gm; Sodium was 0.238-0.28 mg/gm; and Potassium was 0.34-0.38 mg/gm in the Piplani pond. The percentage range of Organic matter and Organic carbon was recorded between 11%-12% and 6%-7% respectively. The result of the present investigation indicates that the sediment of the Piplani pond is organically rich. The pond receives a high amount of organic material from its surrounding areas in the form of solid waste, domestic waste, waste of sewage canals, etc.

Keywords: Physico-chemical Parameters, Littoral Sediment, Trophic Status, Piplani pond.

Introduction:

Ponds are very important features of the urban ecosystem. They provide valuable habitats for the plants and animals, moderate hydrological cycles, influence microclimate, enhance the aesthetic beauty of the landscape, and extend many recreational opportunities to humankind (Ramesh and Krishnaiah, 2013). Sediment is the loose, sand, clay, silt, and having other soil particles that inhabit the bottom of a water body (Davies and Abowei, 2009). Sediment performs a very important role in the dynamics of pollutants in the aquatic environment (Sona *et al.*, 2020). Therefore, evaluating the quality of water and sediments in aquatic environments is of great importance nowadays.

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Sediment is a usual and fundamental component of the aquatic system and plays an important role in the ecological, geomorphologic, and hydrological functioning of the water body (Khushboo, 2019). Sediment is a habitat and major nutrient source for aquatic organisms. Aquatic sediments are derived from and composed of the natural physical, chemical along biological components normally associated with their watersheds.

Anthropogenic activities cause the changes in quality of sediment. Suspended sediment absorbs pollutants from the water column and settles into the bottom. The condition of the pond bottoms and the exchange of substances between soil and water can be strongly influenced water quality (Boyd, 1995). Sediments form a natural buffer and filter system in the material cycles of waters. Sediment in ponds is an important habitat as well as the main nutrient source for aquatic organisms. On the other hand, the pond soil plays an important role in the balance of an aquaculture system and consequently on the growth and survival of aquatic organisms (Ahmed, 2004). Furthermore, sediments have an impact on the ecological quality because of their quality, their quantity, or both (Stronkhorst *et al.*, 2004).

Littoral sediment often displays considerable spatial heterogeneity in their topography, sediment structure, and sediment composition resulting in corresponding heterogeneity in their associated biological composition (JNCC, 2004). The structure of the sediments in the intertribal zone plays a major role in the distribution of the organisms that live in or on them (Atabatele *et al.*, 2005; and Ikomi *et al.*, 2005). Sediment is also the major site for organic matter decomposition which is largely carried out by bacteria. (Singare *et al.*, 2011). The continuous accumulation of pollutants due to biological and geochemical mechanisms, and causes toxic effects on sediment-dwelling organisms and fish, resulting in decreased survival, reduced growth, or impaired reproduction, and lowered species diversity (Praveena *et al.*, 2007 and Singare *et al*., 2011).

Several works have been carried out on the physico-chemical and biological characteristics of the Piplani pond, but there is no published record available pertaining to its sediment. Therefore, the present investigation was carried out to study the physico-chemical characteristics of littoral sediments of this aquaculture pond of the Piplani area of Bhopal.

Materials and Methods

Study Area: The Piplani pond is also called as Sarangpani Pond. It is a perennial water body located in the Betwa River basin (Figure 1 & 2). The whole Bhopal division of Bhopal district is also located in the Betwa River basin. It lies between latitude 23º12'13.23" N and longitude 77°25'18.31"E at an elevation of 1601ft. This pond is mainly used for fish culture. Due to the mixing of organically enriched effluents from catchment the quality of the water body has degraded. Few Dhobi Ghats (Laundry washing sites are established) along the periphery of the pond. Apart from this, large quantities of domestic wastes from the surroundings are also added to the pond. Most of the time the pond is covered with green algal blooms mainly of Cyanobacteria. The study was conducted at three sampling sites, which were: Site 1 (S1) was selected at the fish landing point, Site 2 (S2) was adjacent to the Park, and Site 3 (S3) near the Dhobi Ghat (Figure 1). Sediment samples were collected from each site once in the first week of every month in triplicate.

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Sediment sampling and analysis: Sediment samples were collected by using the Peterson Grab sediment sampler at a depth of 1 meter and packed in air-tight polythene bags and transported to the laboratory for further analysis. All the sediment samples were air-dried, grinded, and sieved through the 2 mm sieve because sediments contain a large amount of coarse material (debris, rock, shells, wood), that may interfere in the analysis. The analysis was carried out on dry samples. Different physico-chemical parameters were analyzed on air-dry samples. Physico-chemical analysis of the collected sediments samples was done following the standard methods given in Jackson (1973), Page *et al.*, (1982), NEERI (1998), Saxena (1998), and APHA (2012).

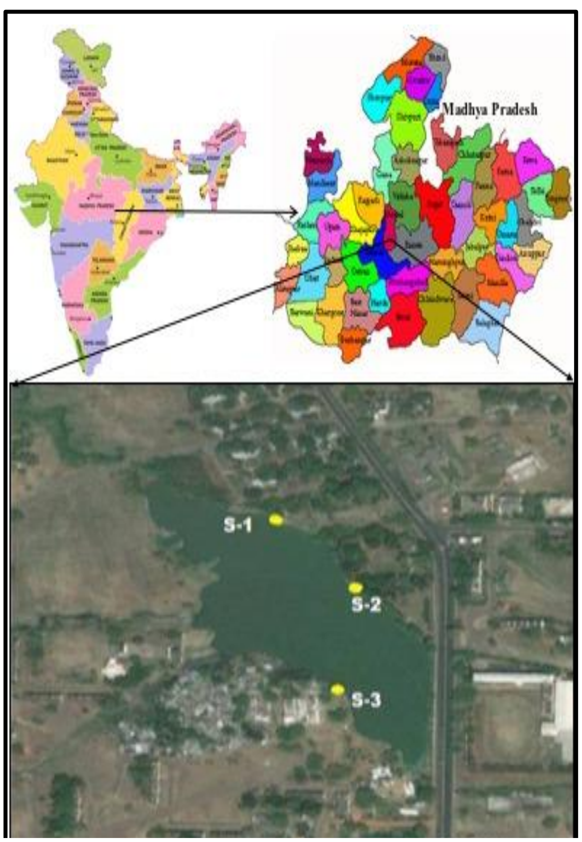

Figure 1: Location of sampling sites in Piplani Pond, Bhopal

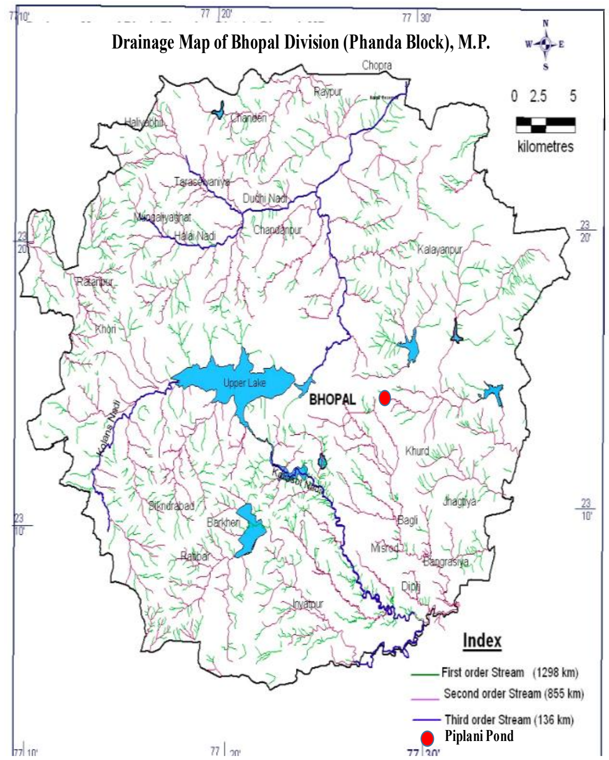

Figure 2: Location of Piplani Pond in its drainage Map (Map Source: Joshi, 2016)

Results and Discussion

The ecological condition of a fish pond is highly influenced by its sediment properties. Natural processes responsible for the formation of bottom sediments can be altered by anthropogenic activities (IAEA, 2003). The sediment status represents an important issue of a freshwater ecosystem, as it is in interconnection with the water mass and several communities of aquatic organisms (pelagic and benthic) that are dependent on each other, as well as on their environmental conditions. Physico-chemical properties of sediment samples of the Piplani Pond are presented in Table 1.

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Table 1: Physico-chemical properties of sediment of the Piplani Pond

Parameters	Site-1	Site-2	Site-3
Color of the Sediment	Grayish Black	Grayish black	Grayish black
Loss on ignition (%)	4	2	2
pH Units	6.5	6.4	6.5
Conductivity (µS/cm)	878	879	861
Total Alkalinity (mg/gm)	56	48	60
Chloride (mg/gm)	35	35	35
Calcium (mg/gm)	120	100	100
Magnesium (mg/gm)	24	48	60
Nitrogen (mg/gm)	0.74	0.74	0.78
Total phosphorus (mg/gm)	0.42	0.43	0.40
Sodium (mg/gm)	0.25	0.228	0.238
Potassium (mg/gm)	0.38	0.34	0.364
Organic matter (%)	12	11	12
Organic carbon (%)	7	6	6

Color of the Sediment: The color of the sediment of any aquatic habitat reflects the ratio of organic material. Physical properties especially the color of littoral sediments reflect the bottom tropic profile of the pond waters. The dark color of sediment indicated a higher percentage of organic material with a maximum percentage of clay. During the present study color of the dried sediment sample was observed grayish-black at all the sites due to the mixing of decomposed plants materials.

Loss on ignition (LOI): Loss-on-ignition analysis of Quaternary lake sediments provides an inexpensive and easy way to investigatepast environmental changes.Loss on ignition analysis of pond sediments provides an inexpensive and easy way to investigate past environmental changes (Shuman, 2003). The percentage weight lost on ignition gives a crude measure of the organic content of the sediment. Generally, percentage loss on ignition values shows an inverse relationship with percentage dry weight values. During the present study period, the average loss on ignition showed the lowest value 2% each at site-2 and site-3 while the highest value was recorded at site-1 (4%) (Table 1). Less loss on ignition at site-2 & 3 may be due to the high percentage of sand in the sediment sample while the high loss on ignition at site-1 can be attributed to high clay content in the sample.

Hydrogen ion concentration (pH): pH of the soil is one of the most important factors for maintaining pond productivity since it controls most of the chemical reactions in the pond environment (Adhikari, 2003). Measurement of surface sediment pH allows the soil acidity to be determined (Clifford, 1992). In addition, pH measurement is also essential (together with pH_2S) in estimating the concentrations of ionic and non-ionic forms of H_2S (Bower, 1978). In the Piplani pond, the pH value of littoral sediment ranged from 6.4 units to 6.5 units (Table 1 & Fig. 3). Similar findings for soil pH (6.43 units to 6.9 units) of sediments of Upper and Lower basins of Bhoj Wetland, Bhopal was reported by Wanganeo *et al.,* 2011. In the Piplani pond, pH values were recorded slightly acidic at all sites may be due to continuous discharge of effluents (sewage and solid wastes) from surrounding areas. Low pH can reduce the availability of key nutrients in the water and lower pond fertility (Adhikari, 2003). A lower

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concentration of pH can be toxic for the benthic organism and may affect the bottom feeder fishes. The acidic pH of the sediment of the Piplani pond reflects its higher trophic status and high decomposition of organic materials in the mud water interface. The neutral soil pH range (6.5 units to 8.0 units) of the Piplani area of Bhopal has also been documented by the agriculture department. The optimal pH range for sustainable aquatic life especially for fishes is pH 6.5-8.2 units (Murdock *et al.*, 2001).

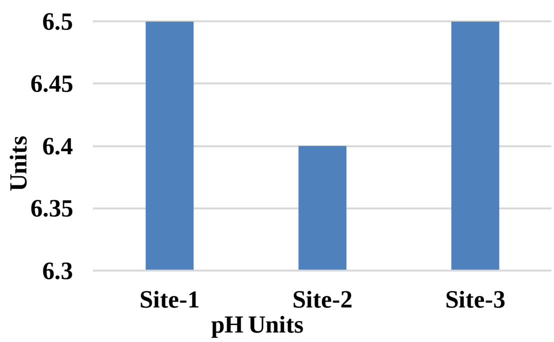

Figure 3: Site wise variation in pH in sediment of Piplani pond

Electrical Conductivity (EC): Electrical conductivity mainly depends on the nature and dissolved concentration of salts ions in the water or sediment of any water body. During the present study electrical conductivity varies between 861 µS/cm to 878 µS/cm (Table 1 & Fig. 4). High conductivity value in the Piplani pond was recorded at site 1. Site-1 has high anthropogenic activities in comparison to the other sampling sites. Deposition and decomposition of organically rich material were also observed at site 1. High conductivity value could be due to high ionic concentration, effluents, and their decomposition on the littoral sediment (Yadav *et al.*, 2013). The high conductivity value recorded from the littoral sediment could be attributed to the high amount of dissolved solids and salt ions coming from domestic raw waters (Raina *et el.*, 2013). Das (2000) reported that the changes in electrical conductivity were associated with the release or depletion of soluble ions in the soil water system. The slight fluctuations in electrical conductivity values at different sites of the Piplani pond may be due to the utilization of ionic minerals by the producer community i.e. phytoplankton and aquatic vegetation (Kumari *et al.*, 2019).

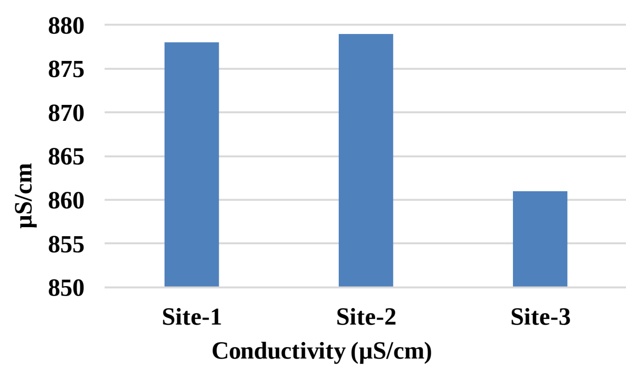

Figure 4: Site wise variation in Conductivity in sediment of Piplani pond

Total Alkalinity (TA): Total alkalinity (TA) helps to determine the buffering capacity of a water body (Egleston *et al.*, 2010) and its presence in littoral sediment is due to the function of carbonate, bicarbonate, and hydroxide content (Dallas and Day 2004). In the sediment of Piplani Pond, TA ranged from 22 mg/gm (at site 2) to 28 mg/gm (at site 3) (Table 1 and Figure 5). Low TA is recorded due to the acidic pH values at all the sites due to the presence of Sulphur dioxide (SO_2). Acid deposition influences mainly the pH of freshwater due to high anthropogenic pressure (Neal, 2018).Ultimately, acidic pH and low alkalinity can create stress for bottom feeder's fishes. Boyd *et al.,* (1994) also reported a similar amount of alkalinity (20-35 ppm) in several fish ponds. On the other hand, Ahmed (2004) reported that soil alkalinity range of 20-28 ppm is suitable for aquaculture practices. According to Spence (1964), littoral sediment (having an alkalinity range of 16 ppm to 60 ppm) of Piplani pond is moderately rich in terms of nutrients.

Chloride (Cl): Chloride is not usually considered a pollutant of concern in freshwater. Sources of chloride in urban water bodies include industrial and municipal wastewaters, agricultural wastes, and deicing salt. No significant difference in chloride content was recorded in the littoral sediment of the Piplani pond and but the bottom was saline on the basis of observed electrical conductivity. The chloride content of littoral sediment depicted similar average values of 35mg/gm (Table 1 and Figure 5) at all the sites may be due to higher organic load and anthropogenic pressure from the respective catchment (Raina *et al.,* 2013). However, chloride from anthropogenic sources is increasingly identified as a significant pollutant of freshwater water bodies (Kauschal *et al.,* 2005).

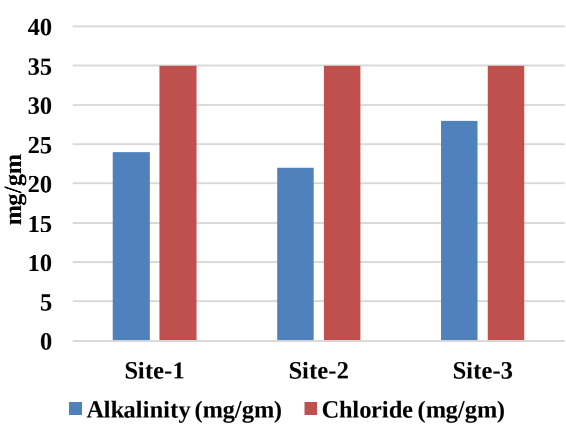

Figure 5: Site wise variation in Alkalinity and Chloride in sediment of Piplani pond

Calcium (Ca^{2+}): Calcium compounds occur naturally in surface water, and their concentrations are determined mainly by the carbonate balance (Galczynska *et al.,* 2013). Calcium is an important nutrient for every aquatic organism mainly used for the formation of sheath and skeletons. In the sediment of Piplani Pond, the minimum calcium recorded was 100 mg/gm (at sites 2 & 3) whereas, the maximum was 120 mg/gm (at site 1) (Table 1 and Figure 6). Calcium compounds occur naturally in a water body, and their concentrations are determined mainly by the carbonate balance (Galczynska *et al.,* 2013), but the addition of sewage waste might also be responsible for the increase in the amount of calcium (Verma *et al.,* 2012). Ohle (1934) reported that a water body having a calcium concentration of more than 25 ppm is to be considered organically rich. Kumar (2014) also documented a similar range of calcium in the bottom waters of Piplani pond and reported pond waters as organically rich.

Magnesium (Mg^{2+}): Magnesium (Mg) compounds occur naturally in surface water, and their concentrations are determined mainly by the carbonate balance (Galczynska *et al.,* 2013). Magnesium is an important part of the sediment and is found frequently in association with iron compounds. Magnesium is a vital micronutrient for both plants and animals (Balasurami, 2006). Average magnesium values of sediment in Piplani Pond vary from 24 mg/gm (at site-1) to 60 mg/gm (at site-3) (Table 1 and Figure 6). High magnesium concentration in sediment especially at site-3 may be attributed due to the mixing of domestic drainage and deposition of organic wastes over the sediments. According to Szyperek (2005), the solubility of magnesium in the ponds is determined by the degree of contamination with biogenic compounds also.

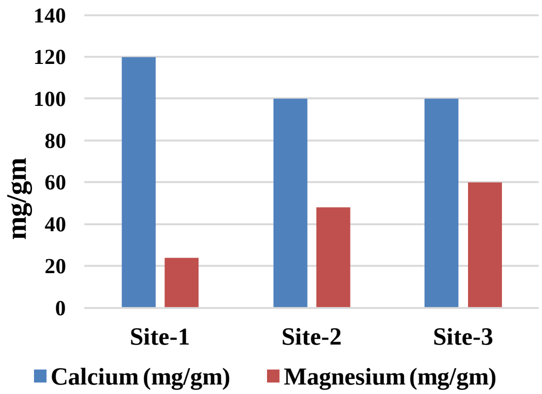

Figure 6: Site wise variation in Calcium and Magnesium in sediment of Piplani pond

Nitrogen: Nitrogen is one of the important elements directly influencing the productivity of a fish pond (Sinha, 1990 and Sarma, 2019). Available nitrogen from the sediment in the Piplani pond was recorded in the range of 0.74 mg/gm to 0.78 mg/gm (Table 1 and Figure 7). Waterbody can be categorized as productive if available nitrogen in the soil and water is around 0.25-0.50 mg/gm (Sinha, 1990). According to Rath (1993), the range of available nitrogen 0.5-0.75 mg/gm of soil is relatively more favorable for pond productivity. High levels of nitrate can lead to eutrophication, which increases algae growth and ultimately reduces dissolved oxygen levels in the water (Murdoch *et al.*, 2001). Kumar (2014) and Kumar *et al.*, (2020) also reported the eutrophic nature of the Piplani pond due to high anthropogenic pressure and a higher range of nitrate-nitrogen in the bottom waters due to the mixing of surface runoff and domestic wastewaters in the pond.

Total Phosphorus (P): Phosphorus (P) entering a wetland or stream is typically present in both organic and inorganic forms, and particulate and dissolved forms (Reddy et al., 2005). During the present investigation, the average values of total phosphorus ranged from a minimum value of 0.40 mg/gm at site-3 and a maximum value of 0.43 mg/gm at site-2 (Table 1 and Figure 7). Generally, in acid soil, P is fixed in association with amorphic and poorly crystalline forms of iron (Fe) and aluminum (Al). This P availability generally is greatest in soils and sediments where pH is slightly acidic to neutral (Reddy *et al.*, 2010). A higher concentration of phosphate can lead to eutrophication, which increases algae growth and ultimately reduces dissolved oxygen levels in the mud-water interface (Murdoch *et al.*, 2001). According to Wetzel (1975), a water body having a phosphorus range of 0.03 to 0.1 and above to be considered eutrophic in nature. Also, the areas of the water bodies, which are directly affected by domestic drainage water have been observed richer in phosphate due to detergent (Wakeel and Wahby, 1970; and Taha *et al.*, 2004). Kumar *et al.* (2020) also reported Piplani pond as eutrophic in nature.

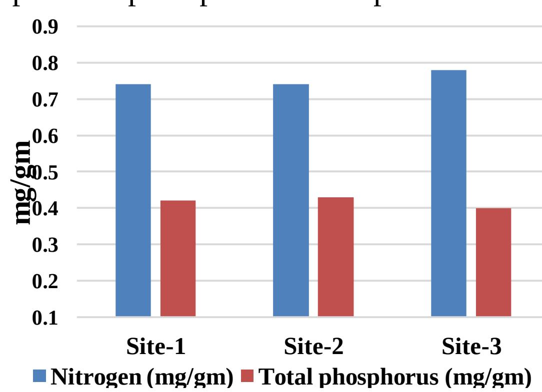

Figure 7: Variation in Nitrogen and Total Phosphorus in sediment of Piplani pond

Sodium (Na^+): Sodium is an important mineral abundantly found in the water

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body's soil. Average sodium ion concentration in the littoral sediment of the Piplani pond varies from 0.25 mg/gm to 0.238 mg/gm at all the sites (Table 1 and Figure 8). The maximum concentration of sodium at site-3 was attributed to the input from sewage channels while minimum concentration was documented at the central zone at site-2. A higher concentration of sodium at the sewage-contaminated site has also been recorded by Kumar (2014) in Hathaikheda Reservoir, Lower Lake of Bhopal. Raina *et al*., (2013) also documented a high amount of sodium at the confluence of the sewage channel and Samrat Ashok Sagar in Bhopal.

Potassium (K): Potassium is an essential micronutrient for plant growth (Mengel,2007) also plays an important role in enhancing productivity in fish farming ponds. Potassium ion concentration in the Piplani pond ranged from 0.34 mg/gm (at site-2) to 0.38 mg/gm (at site-1) (Table 1 and Figure 8). Higher concentration of potassium at site-1 attributed to the input from anthropogenic activities. Higher values of potassium due to anthropogenic pressure have also been recorded by Kumar (2014) in several water bodies of the Bhopal district.

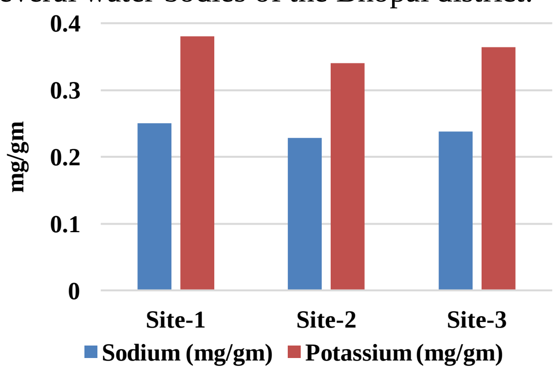

Figure 8: Site wise variation in Sodium and Potassium in sediment of Piplani pond

Organic Carbon: Organic carbon is the most imperative factor determining the fertility status of the soil. During the present study, the organic carbon in the sediment of the Piplani pond recorded the lowest concentration of 6 % at sites- 2 & 3 and the highest of 7% at site-1 (Table 1 and Figure 9). A good amount of organic carbon content at all the sites showed the higher fertility of the littoral sediment of the Piplani pond. Adeyemo *et al.,* (2008) reported that the organic carbon has its origin either from organic matter from natural sources such as plant materials deposited in sediments or anthropogenic inputs to aquatic systems. The generally low organic matter content is thought to be due to its rapid decomposition and microbial activities in the littoral zone.

Organic Matter: Soil organic matter not only influences the various physicochemical properties of bottom sediment releasing different nutrients in a more available form in the aquatic environment but also controls the oxidation reaction, an important property of the entire aquatic ecosystem (Das, 2001). The mean values of the organic matter showed the lowest value at site-2 (11%) and highest at site-1 & 3 (12%) (Table 1 and Figure 9). The presence of organic matter at all the sites may be attributed due to the allochthones inputs of sewage and other wastes (which may be rich in carbon) entering into the pond waters. Organic carbon of pond bottom soil is recommended to be 1.0%-3.0% (Boyd *et al.*, 2002) which is essential for the growth of benthic organisms and microbial activity in pond bottom (Xinglong and Boyd, 2006). Murugesan (2002) also reported >3% content of organic carbon from a productive reservoir of Tamil Nadu.The productivity of bottom feeder fishes depends upon the good quality of organically rich bottom soils (Banerjee and Chattopadhyay, 2002).

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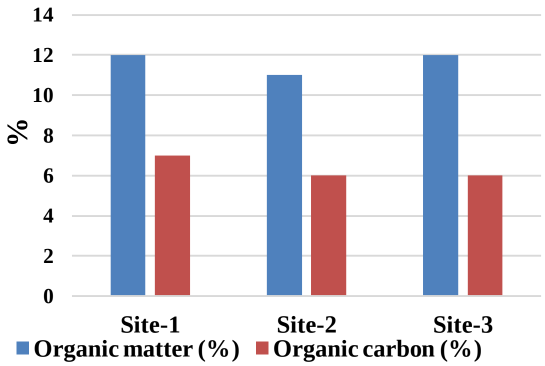

Figure 9: Site-wise variation in Organic matter and Organic carbon in sediment of Piplani pond

Conclusion: The main objective of the present study was to generate basic information about the littoral sediment quality of the Piplani pond of Bhopal. Cations like calcium, magnesium, sodium, and potassium, and the anions like chloride, carbonate, account for most of the dissolved solids in inland water bodies and can directly or indirectly influence the overall productivity of a water body. The chemical composition of soil and water influences the overall fish production in pond waters. The obtained results reveal that most of the analyzed parameters had a uniform distribution of all the sites with very little variation. The present investigation indicates that the sediment of the pond gets affected by several anthropogenic activities and eutrophication of the pond waters.

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