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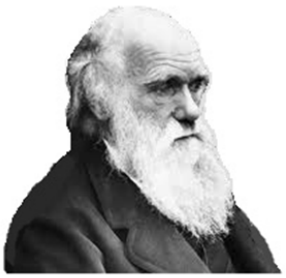

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Motijheel Lake - Victim of Cultural Eutrophication

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ABSTRACT

Destruction of natural water bodies due to cultural eutrophication is a predominant problem in India. Motijheel Lake of Murshidabad district is an environmentally, economically and historically significant water body. However, Anthropogenic activities including unplanned settlements around this lake and its over exploitation have deteriorated its water quality to a great extent. Motijheel Lake acts as a sink for domestic sewage, human and animal excreta. Surface runoffs are discharged into the lake which further adds to the list of pollutants. High phosphate, nitrate and nitrite-Nitrogen and chlorophyll content of the lake categorizes it as hypereutrophic one. Also, the amount of phosphate, nitrite and iron present in Motijheel Lake exceed the permissible limit in drinking water, as prescribed by US Environmental Protection Agency and Bureau of Indian Standards. When the Below Poverty Line residents of the surrounding area consume such water, they become susceptible to various fatal diseases. The low level of Dissolved Oxygen in the lake water signifies huge amount of organic matter deposited in the lake and indicates the lake water to be poor in quality. The high load of coliform bacteria in the lake water further corroborates the deposition of domestic, human and animal wastes. If water with such high concentration of faecal coliform is consumed, it could lead to fatal gastrointestinal and enteric diseases.

***Keywords*:** Eutrophication, Carlson's Trophic State Index, Dissolved Oxygen, Coliform analysis, Motijheel Lake

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1. INTRODUCTION

One of the severe challenges faced by India today is the degradation of water qualities of many of the significant water bodies. For rivers, a natural cleaning process occurs due to the flow of rivers. However, lakes have little scope for natural cleaning. Therefore, the trophic status of environmentally, economically and historically significant lakes is changing, which causes irreversible structural changes in the aquatic ecosystem of the lakes. The shallow, cool and oligotrophic lakes are getting transformed into mesotrophic and further eutrophic lakes. Consequently, there is severe impact on the floral and faunal diversity of these water bodies. Deterioration of the water quality leads to the loss of various economically important species in the aquatic ecosystem [1-3].

Eutrophication is a process, where excess nutrients are added to the water bodies. This addition could be due to natural eutrophication which occurs over a long period of time. However, the trophic structure of a lake could be altered over a short period of time due to various anthropogenic activities. Addition of excess phosphate, nitrate, and nitrite to any water body could be due to Agricultural and Industrial runoffs. Nitrate and phosphate rich fertilizers from the agricultural fields could be deposited into the water bodies or industrial discharges might contain phosphate, nitrate or other heavy metals which are difficult to be degraded. Washing of cloths leads to deposition of detergents and deposition of human or animal excreta also adds various nutrients and phosphate and nitrate compounds [2-5]. Also, excreta contain harmful faecal coliform bacteria which are the causative agent of various diseases. Besides this, there are various unidentified point and non-point sources of pollution which further deposit nutrients and pollutants to the water bodies. When the deposition of nutrient and pollutants at a very high rate exceed the natural ability of the water body to clean itself, we will observe changes in various biochemical and biological parameters of the water body. This phenomenon is known as Cultural eutrophication [2, 6, 7].

There will be severe impact of eutrophication on the biodiversity of the water body. Addition of excess nutrients leads to increase in the population of phytoplanktons and algal blooms could be observed. This covers the surface of the water body and hinders the penetration of sunlight. The algal population often releases toxins which kill various invertebrates and fishes. Most importantly, the increase in the organic matter in the water body leads to high Biological Oxygen Demand (BOD), which depletes the Dissolved Oxygen (DO) of the water body. Due to the scarcity of oxygen other life forms like fishes, invertebrates etc., die, which further increases the organic matter and temperature of the water body. A vicious cycle sets in the water body which further depletes the DO and there is severe loss to the floral and faunal diversity and increase in the population of Detritivores [8-12]. In this study, we have analyzed various biological and biochemical parameters of water of Motijheel Lake and tried to analyze the probable causes behind the deterioration of water qualities.

2. MATERIALS AND METHODS

2. 1. Survey of Motijheel Lake and Surrounding Area

The portion of Motijheel near to the Kala Masjid, Sang-i-dalan, Motijheel primary school adjacent to the Motijheel road was studied. A survey was conducted by collecting information from the residents of the surrounding area. Various sites within this area were used for

collection of water. The results represent a mean observation of the water samples collected from different sites.

2. 2. Estimation of Phosphate, Nitrite, Nitrate and Iron

Phosphate, nitrite, nitrate and iron were measured spectrophotometrically, using a standard calibration curve. Phosphate was measured by Ammonium Molybdate reagent where absorbance of Ammonium molybdophosphoric acid formed was measured at 690 nm. Iron was measured using Ammonium thiocyanate. Formation of iron thiocyanate complex was estimated by measuring absorbance at 430 nm. Nitrite and nitrate was measured using Sulphanilic acid and 1-Naphthylamine. The absorbance of azo-dye was measured at 540 nm.

2. 3. Estimation of Dissolved Oxygen by titration

Dissolved Oxygen was measured by titration using Winkler's method.

2. 4. Estimation of Chlorophyll

Chlorophyll was extracted from the water sample using alkaline acetone. Estimation of chlorophyll concentration was done by measuring the absorbance of supernatant at 750 nm, 665 nm, 663 nm, 630 nm.

2. 5. Coliform Analysis

The concentration of coliform bacteria in the water sample was determined using Lactose broth as the medium and formation of gas bubbles in the Durham's tube. Further the presence of coliform was confirmed by plating the water sample in Eosin Methylene Blue (EMB)-Agar selective Medium.

3. RESULT AND DISCUSSION

We visited the portion of Motijheel Lake near Kala masjid, Sang-i-dalan and Motijheel primary school. This particular area was crowded by unplanned settlements on the sides of Motijheel Lake. We could observe people bathing and washing clothes on this lake and the domestic sewage is also released into the lake (Figure 1 & 2).

The inhabitants of this region belonged to the Below Poverty Line (BPL) category and cannot afford purified drinking water. The water of this lake is used for household chores and consumed, if not used for drinking purposes. The portion of the lake showed shallow water with expose of algal blooms. Floating plants, aquatic weeds and marshy plants covered the entire surface of the lake (Figure 3).

The sides of the lake contained huge deposits of garbage which would eventually run off into the lake. This area is an attraction for the tourists and an amusement park (Motijheel Park) was also constructed, many of the waste products dumped by the tourists find its way into the water of Motijheel lake. Therefore, not only nutrients rich organic matter but also plastics, persistent organic pollutants (POP), faecal coliforms are released into this lake. Also, surface run off containing various pollutants are directly discharged into the lake.

Figure 1. The Motijheel lake water is used for regular household chores.

Figure 2. Human and animal excreta are discharged directly into the lake without prior treatment.

Figure 3. Expanse of algal bloom on the surface of Motijheel Lake. The lake is covered by aquatic weeds, floating plants and marshy plants.

3. 1. Analysis of Biochemical parameters of the water of Motijheel Lake

The main culprits, which change a cool oligotrophic lake into a shallow warm eutrophic lake, are excess quantities of phosphates, nitrites and nitrates. The phosphate, nitrite and nitrate concentration of the lake water is 430 ppb, 1 ppm and 4.56 ppm, respectively, which makes the Motijheel lake Hypereutrophic according to Carlson's Trophic State Index (Table 1) [13].

The concentration of iron present in the lake water is 405 ppb. As the water of this lake is used for domestic consumption several diseases may be caused due to excess concentration of minerals. United State Environmental Protection Agency (USEPA) prescribed the maximum limit of phosphate in drinking water is to be 25 ppb [14]. Consumption of water with 430 ppb of phosphate could lead to digestive problems like diarrhea or constipation, kidney problems, increased risk of osteoporosis and deposition of calcium phosphate in muscles and soft tissues leading to their hardening [15, 16].

USEPA also recommended the maximum level of nitrite and nitrate in consumable water to be 10 ppm and 1 ppm, respectively [14]. Consumption of water with higher concentration of nitrite-nitrogen causes the formation of Methaemoglobin, which lacks the oxygen carrying capacity, causing the veins and skin to appear blue. High nitrite and nitrate intake can also lead to thyroid hypertrophy, diabetes mellitus, cancers of bladder and ovary [17]. Bureau of Indian standards (BIS) prescribed the maximum permissible limit of iron in drinking water to be 300 ppb [18]. Therefore, consumption of water with 405 ppb of iron results in tissue damage, deposition of iron in various organs, liver cirrhosis and bowel cancer [19, 20].

Table 1. Physicochemical parameters determining the trophic class of a lake

Carlson's Trophic State Index						
Trophic Index	Chlorophyll (µg/L)	Phosphate (µg/L)	Secchi Depth (meter)	Nitrate (mg/L)	Nitrite (mg/L)	Trophic Class
<30 - 40	0 - 2.6	0 – 12	>8 – 4	-	-	Oligotrophic
40 – 50	2.6 – 20	12 – 24	4 – 2	0.363	0.02	Mesotrophic
50 – 70	20 – 56	24 – 96	2 - 0.5	0.64	0.07	Eutrophic
70 - 100 +	56 - 155 +	96 - 384+	0.5 - <0.25	2.9	0.1	Hypereutrophic

3. 2. Biological parameters also classifies Motijheel as a Hypereutrophic lake

The chlorophyll content of the water of Motijheel Lake was found to be 118 ppb, which was corroborated by the occurrence of vast expose of algal blooms. The concentration of chlorophyll in the water body definitely categories it as a Hypereutrophic lake. The water was highly turbid and the Secchi depth was found to be around 8.7 cm, again classifying the lake as a Hypereutrophic one. The dissolved oxygen content of the lake was 6 ppm, as measured by Winkler's method. At 8 ºC, the 100% saturation of DO is 11.84 ppm. Therefore, Motijheel lake has 50.66% Dissolved Oxygen saturation, which designates the quality of water to be poor

(Table 2). This further signifies the huge amount of organic matter deposited in the lake both naturally and due to anthropogenic activities.

The deposition of domestic wastes, sewage, human and animal excreta result in contamination of the lake water by various harmful faecal bacteria. We performed Coliform Analysis using both presumptive and confirmatory tests. The faecal coliforms were detected in the water samples collected from the lake and their concentration was estimated to be 1100 coliforms per 100 ml of water (Most Probable Number Index) (Figure 4). Fatal gastrointestinal and enteric diseases would occur if water with such huge concentration of coliform is consumed.

Table 2. Relationship between percentage saturation of DO and quality of water

Dissolved Oxygen Percentage Saturation				
% Saturation of DO	>90 %	89-75 %	74-60 %	<60 %
Quality of Water	Excellent	Good	Fair	Poor

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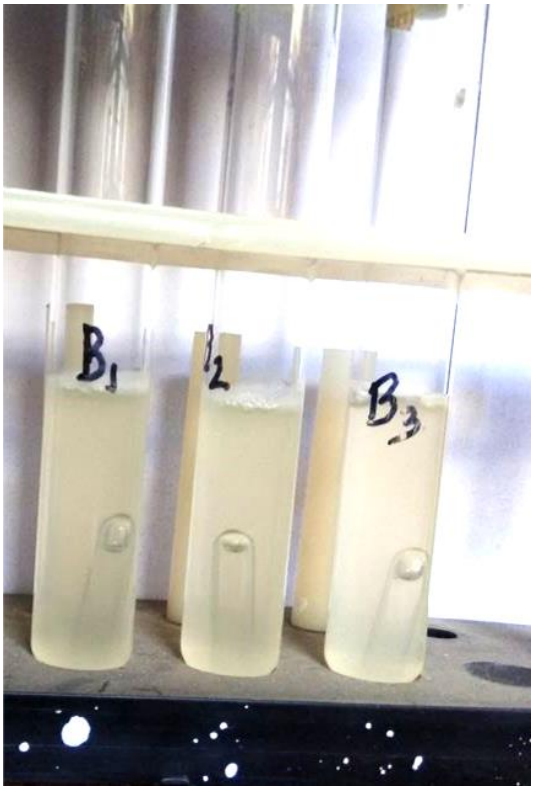
B) 

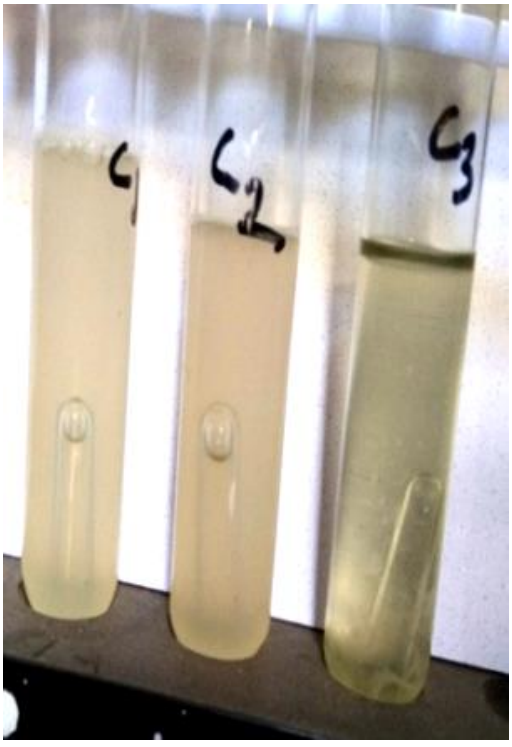
C)  D) 

Figure 6. Presumptive and confirmatory test for Coliform analysis. Panel A-C shows evolution of gas bubbles in Durham's tube at different dilutions of the lake water. Panel D shows coliform colonies with green metallic sheen in EMB-Agar Plates.

4. CONCLUSION

Motijheel Lake is an environmentally, economically and historically significant water body of Murshidabad district. However, unplanned settlements at the site of this water body have led to huge deposition of organic matter into the lake. The current scenario of Motijheel lake depicts the impact of cultural eutrophication on the Biodiversity of a water body leading to irreversible structural changes within the aquatic ecosystem. This study also predicts the potential health hazards which could be encountered by the residents consuming the contaminated water of Motijheel Lake.

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