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Water Characteristics of Dibrugarh Town Protection Drain : its impact on Aquatic Organisms and Human Health

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ABSTRACT

Water pollution is a serious problem in India, as about 70 percent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities such as irrigation and industrial needs. The existing DTP drain for a length of about 22.40 km to drain out sewage water of the urban areas of Dibrugarh Town in Assam (NE India) from Paltan Bazar in the north east to Larua-Jamirah in the south west was studied for the present investigation. The physico-chemical characteristics of water with degradable changes were observed. It is marked by decrease in dissolve O2; total alkalinity; shifting down of freshwater and presence of fewer nutrients for aquatic organisms. Primary production of the drain was also less affected by poor sewage system and solid waste management. Sewage effluents cause substantial reduction in the fish food organisms and consequent reduction in fish fauna. The air all along the drain spreads foul odour of the sewage water vis-à-vis pollutants affected fish inhibited in the drain are often consumed by the poor has become a threat to their general health.

Keywords: DTP Drain, Sewage System, Aquatic Organism, Physico-Chemical Characteristics.

I. INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow so also there is the demand for more water of high quality for domestic purposes and economic activities. Abstraction of water for domestic use, agricultural activity, industrial production etc. not only deteriorates water quality and quantity but also simultaneously affects the aquatic organisms and eventually it affects the human health by minimizing the availability of safe water for human consumption [1].

The aquatic environment with its water quality is considered to be the main factor controlling the state of health and disease of aquatic organisms. The availability of water and its physic-chemical as well as biological composition determines the ability of aquatic environments to sustain healthy ecosystem. Deterioration occurs when a toxic product is added to the aquatic life that adversely affects its ability to dispose it off. In developing countries, only a small proportion of waste water produced by severed communities is treated. Therefore, the quality of water needs to be evaluated thoroughly to set up the baseline information for proper health of the inhabitants.

Open sewage and poor drainage systems are a major threat to the human settlement around the globe. In our country, the majority of urban settlements still have no adequate facilities for disposing the wastes generated. There are several reasons to reconsider the present urban water and waste water policy including limitations of a conventional sanitary system, better understanding of nature and its principles gained during last decades, and the goal of society to achieve sustainable development [2]. Heavily populated areas are still facing increasing problem and carrying the risk of infectious diseases. There are several factors to consider when determining the opportunities for and constraints on the safe use, treatment and disposal of drainage water. Information and data desired at the site of drainage, water production include i) rate of drainage water production per unit area ii) concentration of chemical constituents of health concern and iii) the rates of mass emission.

The present study was conducted in DTP Drain in Town areas of Dibrugarh from June 2012 to August 2013, selecting six different sites, where maximum pollutants are being continuously discharged either from domestic or from industrial establishment to study the physico-chemical characteristics of the waste water in three different seasons [Summer, winter and rainy] and assessing their impact on aquatic organisms including fishes, thereby, predicting the possible impact on general health of the poor masses surviving on catching and consuming fishes inhibited in the polluted water of the drain.

II. METHODS AND MATERIAL

2.1 Study Area

Dibrugarh is located between Lat. N 27°05’38” to 27°42’30”; Long. E 94°33’46” to 95°29’08” and at an altitude of 108m above MSL. The district occupies an area of 3,381 square kilometres. Prior to 1956, several small drains exist in order to drain out rain and sewage water till those finally discharged in to the mighty Brahmaputra River. But the massive Assam Earthquake of 1950, led to a major alteration of the course of Brahmaputra by tilting and shallowing up of the river bed, causing massive erosion of a large chunk of the town. To protect the town from the threat of Brahmaputra erosion, a 8.62km long dyke called, ‘Dibrugarh Town Protection (DTP) Dyke’ was constructed in 1955-1956, running from Maijan in the east to Mohanaghat in the west. Parallel to the dyke, a 6.0 Km long nala called, ‘*Dibrugarh Town Protection Drain*’ (DTP) drain was constructed to empty rain and sewage water of the urban areas of Dibrugarh Town and agricultural effluents especially from the teagardens, as there are tea gardens all around Dibrugarh Town unabatedly use toxic substances like pesticides and woodicites. Unabated encroachment, dumping garbage in drain and lack of maintenance has affected proper functioning of the drain. Houses, shops, places of worship and even schools have come up on the edge of the drain despite the fact that it is illegal to construct any structure within 10 feet on either sides of the system. Glimpses of the obstructed flow of water during lean period, levees of urban debris on the recession of peak flood and dumping of pollutants in market place are the alarming factors of the DTP drain (Figs. 2 - 5). The communities living along the drain in certain localities use polluted water extensively for domestic purposes without prior treatment and draws water from shallow wells. This is surely a great concern to the public health.

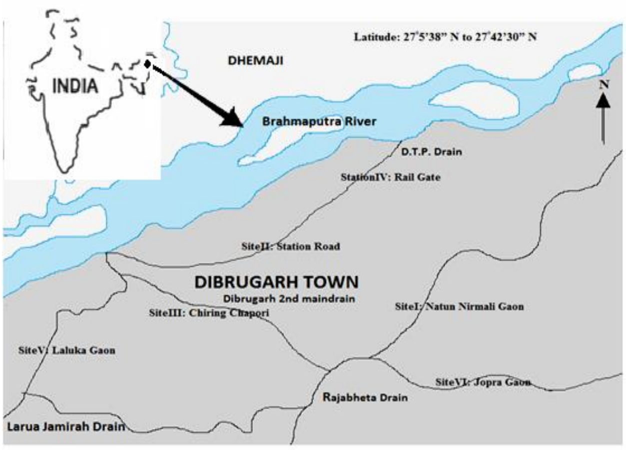

Figure 1. Map showing sampling sites of DTP Drain, Dibrugarh

2.2 Sample Collection and Analysis

The samples were collected from six different sites and stored in clean separate polythene bottles and acidified immediately with nitric acid to lower the pH to 2.0 and brought to the laboratory for detailed physico-chemical analysis. The parameters like pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and conductivity were determined by Elico Digital Meter which gives direct values. A mercury filled centigrade thermometer calibrated from -10 to 100°C was used for temperature measurements on the site directly. Turbidity was determined by using Sacchi Disk method [3]. Modified Winkler’s method was followed for the analysis of Dissolve Oxygen and Dissolve Carbon Dioxide [4]. The alkalinity of water sample was determined through titration against standard acid solution using indicators like phenolphthalein and methyl orange. The physico-chemical parameters were determined according to the standard methods for the examination of water and wastewater [5].

III. RESULT AND DISCUSSION

The results of physico-chemical parameters of water are given in Table 1. Based on the results obtained, the temperature was observed to fluctuate between 19.6-31.5°C (Table 1). The lowest value 19.6°C was found in Site-I during January and highest value 31.5°C in Site-IV during April. In general, biological treatment activity accelerates in warm temperatures and slowed down in cold condition, but extreme hot or cold can stop treatment processes altogether. Therefore, some systems are less effective during cold weather and some may not be appropriate for very cold climates. Hot water, for example, which is a by-product of many manufacturing processes, can be a pollutant. When discharged in large quantities, it can raise the temperature of receiving portions of the nalas locally and disrupt the natural balance of aquatic life. In cold temperature, the viscosity of waste water increases, thereby, decreases the efficiency of settling the suspended solids. Pressure drop increases in the operation of filtration units again because of the resistance that the higher viscosity offer [6]. High temperature discharges can disrupt the natural habitat in surface water by encouraging the growth of algae and aquatic plants that would not be abundant normally. Temperature effects are felt on several accounts like, the metabolic rate of aquatic animals, rates of development, timing and success of reproduction, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and disease. Life cycles of aquatic organisms are often related to changes in temperature. However, during the study, the water temperature was found to be within the permissive level as per WHO limit, except in Site-I, where the temperature was found to be reduced extensively during the winter seasons. Substantial variations in pH were recorded throughout the three different seasons in the selected six sites. The average values recorded were always fluctuates between the pH range of 5.7-7.6. The lowest pH value of 5.7 was recorded in Site-I during July and highest pH value of 7.6 was recorded in Site-IV during April. The pH in the Site (I, III and V) was not found within the WHO guideline levels for waste water (Table 1). Notably, pH usually has no direct impact on consumer organisms. The pH of an aquatic ecosystem is important because it is closely linked to biological productivity. Although, the tolerance of individual species varies with pH value and a value between 6.0 and 8.0 usually indicate good water quality. Natural acidity gets affected in rainwater by the dissolution of atmospheric carbon dioxide (CO_2). If pH is above 7.0, this will indicate that water is probably hard and contains calcium and magnesium [7]. During rainy season (July-August), the waste water pH was found to decrease extensively to become acidic. Low pH often induces the growth of water hyacinth (*Eichhornia crassipes*). When not controlled, water hyacinth grows in the entire drain, dramatically impedes the water flow, prevents sunlight from reaching native aquatic plants and starves the water with less oxygen, leading to fish mortality. The stagnant water of the drain becomes a primary habitat for mosquito breeding; the classic vectors of many fatal diseases, and particularly help breeding a species of snail, known to host a parasitic flatworm, causing *schistosomiasis*.

By observing colour or appearance of waste water, the quality can be judged, as quality varies with the age of wastewater, normally determined qualitatively by its colour and odour. Fresh wastewater is a light brownish-grey colour. The colour of wastewater changes sequentially from grey to dark grey and ultimately to black as the travel time in collection system and more anaerobic conditions develop. Unfortunately, during the study, the Sites I, III and V were found to contain black coloured water, stalls as a direct threat to the life of aquatic organisms and human health (Table 1).

In the Site (I, II, III and V) the odour of the drains was not at all within the permissive level (Table 1). The air all along the drain spreads foul odour of the sewage water vis-à-vis pollutants affected fish inhibited in the drain are often consumed by the poor has become a great threat to their general health. In wastewater, odour are of major concern, especially to those who reside in close proximity with the drains, as it is generated by gases produced by decomposition of organic matter or by substances remains suspended in the wastewater. Freshly discharged waste water is normally odourless. The most characteristic odour of stale or septic wastewater is that of hydrogen sulphide (H_2S), produced by anaerobic microorganisms that reduces sulphate to sulphide.

In all the selected sites, only turbid wastewater was noticed (Table 1). Such conditions of the drains clearly give an indication that large amount of solids remains in suspended mode for a long period of time. High turbidity can have a negative impact on submerged aquatic vegetation, benthic organisms and the ability of juvenile fishes to catch prey. High turbidity affects submerged plants by preventing sufficient light from reaching them for photosynthesis, may significantly increase the water temperature. Water temperature needs to remain fairly constant so aquatic fauna can survive. However, clear water also may not always indicate healthy water condition. Sometimes clear water indicates very high acidic conditions. That's why the Sites (I, III and V) due to their acidic compositions indicate less turbidity in comparison to others.

Conductivity value of 954.34 µs/cm was recorded highest in Site-IV in April and lowest value 250.34µs/cm in Site-I in December. Electrical conductivity in overall is found to be below the WHO permissive level in all the sites except Site-IV (Table 1). The conductivity is related to the concentration of ionized substances present in the water sample. Most of the inorganic substances dissolved in water forming cations and anions which conduct electricity. Conductivity values depend on the nature of the various ions present in the water sample, their relative concentrations, and the ionic strength. Therefore, conductivity value could be a rough estimate of the dissolved mineral content in the water samples [8]. Conductivity of wastewater is a direct function of its Total Dissolve Solids (TDS) and temperature. TDS was found to be positively correlated with temperature and conductivity. The highest value of 1243.67 mg/mL was recorded in Site-IV in May and the lowest value 420.9 mg/mL in Site-I in December. These values were high when compared with WHO guidelines of 500-1000 mg/L (Table 1).

Total Suspended Solids (TSS) value of 1853.2 mg/mL was recorded highest in Site-IV in May and lowest value 429.8 mg/mL in Site-I in February (Table 1).

TSS increases significantly with the increase in conductivity, TDS and water temperature. Impacts to aquatic life from excessive suspended sediment can be divided into two types: effects resulting from sedimentation; and effects that occur in the water column. The effects of excessive suspended sediment on sensitive aquatic organisms, such as fish and aquatic invertebrates can be summarized by the following types of modes of action:

i) direct effects to the physiology or behaviour (e.g. damage to gill tissue, escape/avoidance)
ii) prevention of successful growth or reproduction (e.g. egg smothering);
iii) modification of movement or migration; and
iv) habitat degradation

During the study substantial changes in DO were recorded for the respective three seasons. The lowest value 1.13 mg/L followed by 2.45 mg/L and 2.57 mg/L were recorded in Site-IV, VI and II during summer when water temperature reached about 23-34°C and the highest value 6.2 mg/L was recorded in Site-I during rainy seasons (Table 1). High levels were observed when the drain surface was covered partially with water hyacinth. Depletion of DO was probably due to the dead root fragments from water hyacinth and leaking of organic matter into the waste water. The DO content however was not found to be under the permissive level as per WHO guidelines in Site-II, IV and VI respectively. The amount of dissolved oxygen depends highly on temperature and somewhat on atmospheric pressure. Periods of decreased availability of DO usually occur during summer months when water temperature and biological activity are at their peak (during the growing season). Oxygen requirements are particularly important at increased temperature, since biological processes such as respiration increase and ambient concentrations of DO decrease. Due to the relationship between oxygen saturation and water temperature, the availability of oxygen can become reduced by the warming of water. A balanced and diverse aquatic ecosystem depends on the availability of a minimum level of dissolved oxygen (DO) at any given time. It is well established that low DO levels can have lethal and chronic (e.g. behavioural or physiological changes) impacts on aquatic organisms, especially fish, with early life stages usually being the most sensitive.

Source of free CO_2 in sewage water is either aerobic or anaerobic, produced due to the decomposition of organic matter. Substantial changes in DCO_2 were observed throughout the study. Maximum value 8.74 mg/L was recorded in Site-I during rainy season when the pH was substantially decreased and minimum value 2.45 mg/L was recorded in Site-IV during summer (Table 1). Maximum concentration of DCO_2 was observed in the drainage water with pH less than 7.0. Dissolved CO_2 concentration of the water decreases with an increase in pH. The concentration of DCO_2 and carbonic acid in water has a marked effect on fish, especially on their migration.

The solubility of various substances directly depends on the levels of alkalinity. The lowest value of 110.27 mg/L was observed in Site-I during August and highest value

326.96 mg/L was recorded in Site-IV during May (Table 1). However, there was a reduction in total alkalinity indicated in most of the selected sites including Site (I, III and V). This high quality of alkalinity can be explained as a result of increased effluent discharges (Fig. 5).

Table 1: Average values of physico-chemical parameters for the six sites in different seasons

Sl No.	Parameters	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-VI	WHO *level
1	pH	5.7 ± 0.4	6.4 ± 0.3	5.92 ± 0.1	7.34 ± 0.3	5.96 ± 0.2	6.59 ± 0.1	6 – 8
2	Water Temp. °C	21.87 ± 2.9	25.38 ± 2.4	22.05 ± 1.3	29.60 ± 2.9	22.35 ± 2.1	26.32 ± 1.2	20 – 35
3	Appearance	Greyish, Less Turbid	Blackish, Highly Turbid	Light Brown, Turbid	Blackish, Highly Turbid	Light Brown, Turbid	Blackish, Turbid	—
4	Odour	Odourless	Unpleasant	Unpleasant	Unpleasant	Unpleasant	Unpleasant	—
5	Conductivity µs/cms)	254.34 ± 20.4	707.33 ± 40.5	345.34 ± 20.9	954.34 ± 80.5	356.94 ± 30.4	743.67 ± 30.4	750 - 2500
6	TDS (mg/mL)	403.89 ± 30.2	1023.45 ± 101	435.45 ± 20.4	1356.34 ± 120.3	654.34 ± 86.4	987.34 ± 92.3	500 -1000
7	TSS (mg/mL)	532.2 ± 20.3	1034.5 ± 60.4	756.02 ± 30.3	1734 ± 140.5	542.67 ± 67.4	887.76 ± 80.6	—
8	DO (mg/L)	5.87 ± 0.3	2.89 ± 0.2	4.98 ± 0.5	1.29 ± 0.1	4.24 ± 0.5	2.67 ± 0.1	4.0
9	DCO2 (mg/L)	8.5 ± 0.4	4.6 ± 0.5	7.49 ± 1.3	2.68 ± 0.6	7.11 ± 0.1	3.74 ± 0.3	—
10	Total Alkalinity (mg/L)	115.23 ± 2.3	210.5 ± 1.2	145 ± 3	324.5 ± 1.5	156.89 ± 1.2	230.40 ± 4.2	—

The present study of physico-chemical characteristics of water provides valuable information about the quality of water in the DTP Drain. The results from the present study clearly indicated that water from Sites-II, IV and VI are highly polluted as they contain high levels of turbidity, TDS, TSS, DO, DCO_2, the total alkalinity values were not within the prescribed limits of WHO (Table 1). They release foul odour to its surroundings aggravates the situation further. However water at Sites I, II and V were seem to be less polluted on a comparative basis, even though, the water was not suitable for drinking purpose as they contain low pH, conductivity, TDS, TSS and total alkalinity following WHO guidelines [9]. Hence, before making them suitable for human consumption, these waters need conventional treatment including disinfection.

Figure 3. Luxuriant growth of mosquito larvae on shallower part of the drain

Figure 2. Impediment in the drainage system

Figure 4. Left out of debris after the peak flood

Figure 5. Dumping of household wastes nearby central market place

IV. CONCLUSION

The overall results indicated poor water quality all along the drainage system as the water maintains high level of turbidity, TDS, TSS, DO, $DCO_2$and total alkalinity. The water quality exceeds the tolerable level of water for domestic consumption prescribed by the World Health Organization (WHO). Water drawn through shallow hand borings along the course of the DTP Drain are also contaminated. Fishing and consumption of fishes from DTP drain is harmful, the carcinogens the water carries simply inhibits in the stomach and fleshes of fishes. Additionally, the polluted water is the breeding ground of mosquitoes and snails. These organisms are the vectors of many diseases.

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