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Effects of Solid Waste and Industrial Effluents on Water Quality of Turag River at Konabari Industrial Area, Gazipur, Bangladesh

M. S. Islam, T. R. Tusher, M . Mustafa and S. Mahmud

Department of Environmental Science and Resource Management,
Mawlana Bhashani Science and Technology University, Tangail-1902, Bangladesh

Abstract

The study was conducted to investigate the effects of solid waste and industrial effluents on the water quality of Turag River. Both the upstream and downstream sampled water from the selected points were analyzed for color, odor, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), copper (Cu), cadmium (Cd), iron (Fe), lead (Pb) and zinc (Zn) concentrations. Results of the study showed that the color of water was light to dark black and emitted noxious smell due to the industrial effluents. The upstream water was slightly alkaline with comparatively high DO content while low concentration of other parameters. The water after the solid waste and effluents received points as well as middle and downstream points was slightly alkaline with higher levels of other parameters when compared with upstream point. The minimum and maximum values of pH, EC, TDS, DO and BOD were 7.24-7.61, 425-2277 µS/cm, 239-1349 ppm, 1.22-3.66 ppm and -2.44-0.86 ppm, respectively. The continuous dumping of waste materials resulted in a marked increase in the concentration of metals in the river water varied in the order of Fe > Zn > Pb > Cu > Cd. The study concluded that the downstream water in the river was almost polluted and unsuitable for human consumption and aquaculture purposes.

Keywords: Turag River, Waste, Water quality

Introduction

Water is the most essential requisite that nature provides to sustain life for plants and animals, and also has tremendous role in every mode of human life (Nwankwoala and Nwagbogwu, 2012). Despite its importance, water is the most poorly managed resource in the world (Fakayode, 2005). The existing tendency of industrialization and urbanization may contribute greatly to the poor quality of water through indiscriminate disposal of solid waste, industrial effluents and other toxic wastes which are the major environmental issues posing threats to the existence of human being (Furtado *et al*., 1998; Chindah *et al*., 2004; Ugochukwu, 2004; Emongor *et al*., 2005; Rahman *et al*., 2008). The concentrations of chemical parameters of industrial effluent were above the allowable limits and also tended to accumulate at the downstream area (Fakayode, 2005). Generally municipal solid waste is collected and dumped in a mixed form in an unscientific manner on open waste land or low lying areas even near rivers, ponds and other ecological sensitive regions, which resulting in the pollution of water whereby the quality of the water deteriorates (Sahu, 2007). The waste dump sites virtually become a breeding ground for all kinds of diseases (Sahu, 2007). Solid waste leachate is the greatest threat to groundwater which possesses various chemical and biological contaminants (Bidhendi *et al*., 2010).

Industry is a small user of water in terms of quantity, but has a significant impact on quality (Mukherjee and Nelliyat, 2006). Over three-fourth of fresh water draw by the domestic and industrial sectors, return as domestic sewage and industrial effluents which inevitably end up in surface water bodies or in the groundwater, affecting water quality (Mukherjee and Nelliyat, 2006). Due to lack of properly equipped plants and sanitary dumping sites operated within the required standards, the industrial wastes are released in an adhoc manner to the environment (Satter and Islam, 2005). Presently 10% of waste water generated is being treated; the rest is discharged as it into the water bodies (Satter and Islam, 2005). When the waste stream contains a complex mixture of toxic substances predominantly natural and synthetic organic substances, metals, and trace elements, as well as pathogens from domestic and industrial sectors enter into streams, rivers and other water bodies, they get dissolved or suspended or deposited on the bed resulted in the pollution of water quality (Islam and Tanaka, 2004). Heavy metals such as Cu, Fe, Pb, Mn, Zn), Cd, Co, etc. which are present in water as trace amount, but have significant effect on water environment and thus on human existence (Anonymous, 2004). Contamination of these heavy metals deteriorates the water quality i.e. change the water properties such as pH, EC, TDS, etc. and alter natural processes and natural resource communities, unabated degradation of the aquatic environment poses consequences for fishery resources and their habitats. About 80% of the diseases in developing countries are related to contaminated water and the resulting death toll is as much as 10 million per year (Anonymous, 2004).

Due to rapid growth of textiles, tanneries, pharmaceuticals and other industries in the Konabari, a huge amount of industrial chemicals and wastes are generating daily which are directly discharging into the Turag River. As a result, water used for human consumption, industrial purposes, land irrigation and fish production, is thought to be greatly contaminated by these toxic substances. Both municipal and industrial solid wastes are also dumped on the bank of the Turag River as an open space, which is connected with the river and emits noxious smell. During monsoon, solid wastes are flowed through the river and totally disrupt the water quality of the river. In this regards, the harmful effects of industrial effluents and solid waste on the quality of water need to be checked to ensure water quality, public health and their well-being. Considering the above views in wind the study was conducted to determine the status of the surface water quality including heavy metal concentrations of Turag River at Konabari waste dumping site, and to compare the water quality parameters with the existing standard values.

Materials and Methods

Study Area

The study area was located at the Konabari BSCIC (Bangladesh Small and Cottage Industries Corporation) area at Gazipur district adjacent to the capital city Dhaka of Bangladesh, which is approximately at the latitude of 24.00ºN and longitude 90.34ºE. The elevation of the area was approximately 10 meters and situated beside the Tangail-Gazipur highway. This area is geographically a part of the pleistocene terrace, popularly known as madhupur tract which composed of alluvial soil of the pleistocene period. Such lands are characterized by high, undulated land surface with red soil, criss crossed by flood plains and streams. The Turag River is flowing through the study area. The study area is a unique place where industrial effluents are directly discharged through different channels into the river, and solid wastes are dumped regularly on the bank of the river in an unscientific manner.

Sampling

The water samples were collected from five different points of the Turag River where two samples from upstream (U), two from downstream (D) and one from the middle point (M) at which the river received solid waste (Table 1). Samples were collected in 1 litre plastic bottles at a distance of about 100 meters from each other point to analyse pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD) and heavy metals such as copper (Cu), cadmium (Cd), iron (Fe), lead (Pb) and zinc (Zn). Prior to collect sample, all bottles were washed with distilled water. Before sampling, the bottles were rinsed again three times with the water to be sampled. A 90ml of water sample from each bottle was transferred to 100ml plastic bottle which contained 10ml 2M Hydrochloric acid solution for the analysis of heavy metals. The HCl solution was used to protect water samples from any fungal and other pathogenic attack. After collection, the bottles containing samples were sealed immediately to avoid exposure to air. The samples were taken from the mid-stream and approximately 0.30 meters below the surface. To provide necessary information for each sample such as date of collection, location, time, etc. were recorded in the note book and each sample collected in a plastic bottle was labeled separately with a unique identification number. The water samples for the analysis of DO and BOD were then carefully carried to the laboratory of the Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Tangail-1902, Bangladesh, and the samples for the analysis of heavy metals were transported to the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh-2202, Bangladesh. In the laboratory, the bottles were kept in a clean, cool and dry place before analyzed.

Table 1. Sample collection points in the Turag River at Konabari industrial area

Sampling points	Distance from solid waste dumpsite (m)	Sampling location
U_1	200	Upstream
U_2	100	Upstream
M	0	Middle
D_1	100	Downstream
D_2	200	Downstream

Sample analysis

To analyze the physicochemical properties of water, various standard methods were followed and a number of sophisticated instruments were used. A global positioning system (GPS) was used to measure the elevation of the study area above sea level. Water color was observed by naked eyes and odor was felt with nose. The water pH, EC and TDS were analyzed immediately in the field by using pocket pH, EC and TDS meter, respectively. The DO and BOD of the water samples were determined by Winkler's Iodometric method. The heavy metals, namely Cu, Cd, Iron Fe, Pb and Zn in water, were determined with the help of Atomic Absorption Spectrophotometer (AAS, UNICAM, 969) followed by the method of Clesceri *et al.* (2005). The wavelengths of Cu, Fe, Pb, Zn and Cd were 324.8, 248.3, 217.0, 213.9 and 228.8 nm, respectively. After collection, data were complied and analyzed using Statistical Package for Social Sciences (SPSS) and Microsoft office excel.

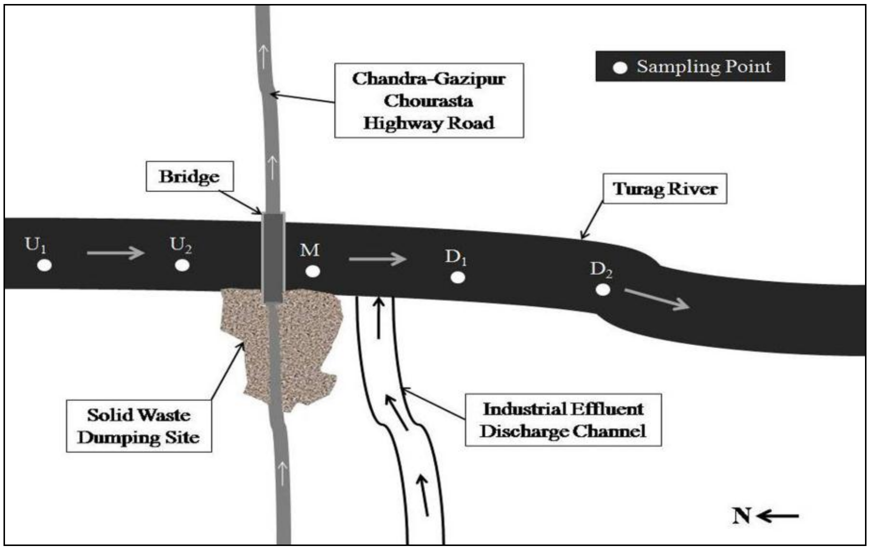

Fig. 1: Layout of the study area with sampling points at Konabari industrial area, Gazipur, Bangladesh

Results and Discussions

The water color of the present study was light to dark black while the phytoplankton enriched dark greenish blue, red or brown color is good for fisheries (Das, 1997). The study investigated bad organic odor of water which emits noxious smell. Therefore, the water was unsuitable not only for aquaculture but also for domestic, industrial, or agricultural purposes. Table 2 and 3 shows water quality parameters of Turag River investigated in this study and comparison of water quality parameters between the present study and the existing standards, respectively.

Table 2. Investigated water quality parameters from various sampling points of the Turag River

Water quality parameters	Sampling points					Mean ± SD	Range
	U_1	U_2	M	D_1	D_2		
pH	7.61	7.35	7.44	7.37	7.24	7.40 ± 0.14	7.24-7.61
EC (µS/cm)	425	429	1068	2277	2166	1273 ± 905.39	425-2277
TDS (ppm)	239	240	609	1349	1306	748.60± 549.78	239-1349
DO (ppm)	2.82	3.66	2.44	1.22	1.67	2.36 ± 0.96	1.22-3.66
BOD (ppm)	-0.86	-2.44	-1.63	-0.81	0.86	-0.98 ± 0.81	-2.44-0.86
Cu (ppm)	0.06	0.05	0.06	0.10	0.06	0.07 ± 0.02	0.05-0.10
Zn (ppm)	0.15	0.08	0.13	0.19	0.13	0.14 ± 0.04	0.08-0.19
Pb (ppm)	0.02	0.01	0.04	0.09	0.07	0.05 ± 0.03	0.01-0.09
Fe (ppm)	2.03	2.81	1.40	3.29	1.58	2.22 ± 0.81	1.40-3.29
Cd (ppm)	0.00	0.00	0.00	0.007	0.001	0.002 ± 0.003	0.00-0.007

Note: U = Upstream point, M = Middle point, D = Downstream point.

Table 3. Comparison of water quality parameters between the present study and the standards

Water quality parameter	Domestic water standard[a]	Drinking water standard[b]	Fish culture standard[c]	Irrigation standard[d]	Present study		
					U	M	D
pH	6.5-8.5	6.5-8.5	6.5-8.0	6.5-8.5	7.48	7.44	7.31
EC (µS/cm)	NA	NA	NA	750	427	1068	2221.5
TDS (ppm)	500	1000	< 400	< 450	239.5	609	1327.5
DO (ppm)	4.0-6.0	NA	5.0	NA	3.24	2.44	1.45
BOD (ppm)	NA	NA	< 5.0	NA	-1.65	-1.63	0.03
Cu (ppm)	1.0	1.0	0.03	0.2	0.06	0.06	0.08
Zn (ppm)	5.5	5.0	< 0.005	2.0	0.12	0.13	0.16
Pb (ppm)	< 0.05	0.05	< 0.02	5.0	0.02	0.04	0.08
Fe (ppm)	< 0.3	NA	< 0.1	5.0	2.42	1.40	2.44
Cd (ppm)	0.01	0.005	0.005	0.01	0.00	0.00	0.004

Note: NA = Not Available, U = Upstream point, M = Middle point, D = Downstream point.
Source: [a] De (2005), [b] ADB (1994), [c] Meade (1998), [d] Ayers and Westcot (1976).

The investigated pH values of five sampling points were ranged from 7.24-7.61 with a mean value of 7.40 (Table 2), which indicated that the water was slightly alkaline. The pH of water samples was within the range of both domestic water (De, 2005) and fish culture standard (Meade, 1998), reflecting its suitability for aquatic life and for all types of water uses. The EC and TDS at different sampling points were ranged from 425-2277 µS/cm and 239-1349 ppm, respectively (Table 2). The EC and TDS of the downstream water were much higher than the upstream. The higher EC and TDS were found at the point D_1, which indicates the greater amount of salts in the water due to dumping of solid waste and discharging of industrial effluents (Irshad *et al*., 2011). The similar phenomenon was reported from the water of the Karnafuli River in Bangladesh by Chowdhury (Chowdhury, 1994). The degree of relationship between EC and TDS of the water samples depicted that the value of TDS is increasing with the increasing of EC value (Fig. 2). Studies of inland fresh waters indicated that streams supporting mixed fisheries have an EC ranged between 150 and 500 µS/cm (Das, 1997). Water that contains more than 1000 ppm of dissolved solids usually contains minerals that give it a distinctive taste or make it unsuitable for human consumption (Irshad *et al*., 2011). As total concentration of dissolved solids in water is a general indication of its suitability for any particular purpose, in this regard, the observed result concluded that the water at the downstream of the river was fully polluted and unsuitable for fish culture and other purposes.

From the result of the investigation, the low levels of DO ranged from 1.22-3.66 ppm were obtained (Table 2), which might be due to the disposal of industrial effluents and solid waste. A few studies on water quality in Bangladesh, undertaken in the Kaliakoir industrial area, north-west of Dhaka city found that the water in the southern reaches of the local wetland, where the industrial effluent entered the system, has no detectable DO (Clemett and Chadwick, 2006). The DO content of the present study was much lower than the standard for domestic water supply and fish culture (Table 3). The result of the study revealed that the value of EC and DO have a significant negative relationship where the level of EC is decreasing with the increasing of the DO contents (Fig. 3). The BOD values of the different sampling points were recorded from -2.44-0.86 ppm. The point M showed relatively higher BOD value than the U_2 which was only 100 m from the point M (Table 2). It might be due to the dumping of solid wastes along the bank of the river. As less than 5 ppm of BOD is generally suitable for fish culture, the BOD values of all samples were below the standard value for fish culture (Table 3). The DO is the amount of oxygen dissolved in water, while the BOD is the amount of oxygen used by the biological organisms during biodegradation. Therefore, when the BOD is high in a water body then the amount of DO is low. The similar result was found in this study where the BOD was decreased with increasing of DO content (Fig. 4).

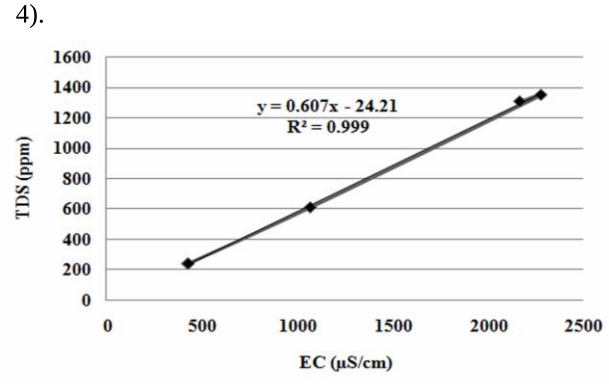

Fig. 2: Correlation between EC and TDS concentrations

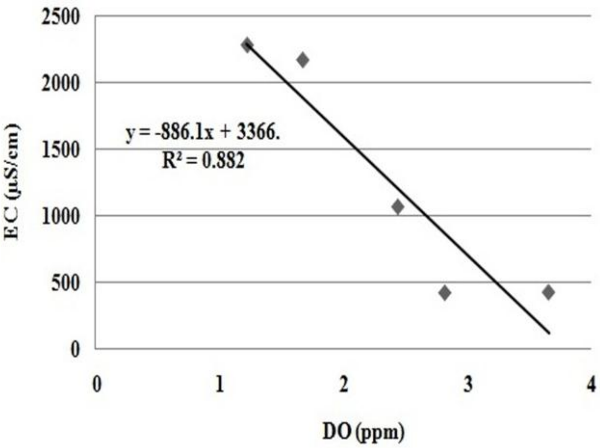

Fig. 3: Correlation between EC and DO concentrations

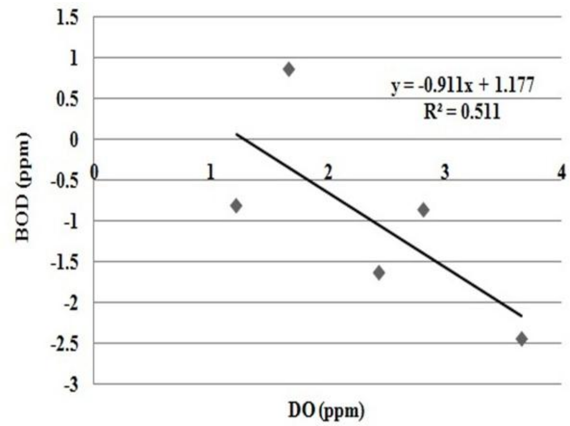

Fig. 4: Correlation between DO and BOD concentrations

In cases of heavy metals sampled, the concentrations of Cu, Pb and Fe were ranged from 0.05-0.10, 0.01-0.09 and 1.40-3.29 ppm, respectively (Table 2). While the average Cu content was lower than that of the standard value of domestic water supplies and fish culture, where the Pb and Fe concentrations exceeding the acceptable limits of domestic water supplies and aquaculture standard (Table 3). The downstream points contained relatively higher concentrations of Pb and Fe than upstream which might be due to disposal of industrial effluents in water. Duval *et al.* (1980) reported that the tannery industries were discharging not only Cr, which was internal to the tanning process, but also significant amounts of Cu, Pb and Zn as well. The Zn concentrations in all samples varied from 0.08-0.19 ppm which was lower than allowable limit for domestic water supplies and irrigation (Tables 2 and 3). The Cd concentrations were ranged from 0.00-0.007 ppm, where the points U_1, U_2 and M showed no Cd in the water; and the point D_1 was rich in Cd (Table 2). Sudhakar *et al.* (1991) conducted an experiment on metal pollution in the river Godavari in India showed that heavy metals in high concentrations at the discharged point and 1 km from the point of discharge and no metal was found in detectable concentration in water before the river receives the effluents. The average Cd content was 0.007 ppm which was higher than the standard value of fish culture.

The results of the study showed that the upstream water was neutral with comparatively high dissolved oxygen, but low values of other parameters. Although the upstream water contained pollutants, the water quality was comparatively good than the water after receiving the solid waste and industrial effluents which was slightly alkaline pH with higher concentration of other parameters, especially downstream point. The results suggested that the solid waste and industrial effluents being discharged into the river have considerable negative effects on the water quality of the river water and as such, the water was not good for human purposes and for other uses. In such conditions, only feasible options that could be followed such as appropriate distance from the surrounding water body should be maintained for waste dumping and dumping site should be properly managed; the industries should be installed effluent treatment plant (ETP) for all the industrial wastes so that they are treated before being dumped into the environment; and appropriate laws and legislations on dumping of industrial waste into the river should be established.

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