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Impacts of Low Flows on Heavy Metal concentrations in Turag River Bangladesh

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Abstract
Water flow is a vital requirement of a river to secure ecological health status. We investigated the low flow of Turag River and its effect on the heavy metals concentration. Generally, the water of the river flowed very less from January to May. The reverse result was found from June to October. Keeping in mind this fact, eight different heavy metals were statistically analyzed. We observed that during low flow season five heavy metals surpass the standard limit for irrigation. Considering irrigation standard, the order of contamination level was: Mn > Cd > Pb > Fe > Cr > Ni > Zn > Cu in low flow season. Therefore, it is necessary to maintain moderate flow in the river system.

Key words: Heavy metals concentration, High flow, Low flow, Turag river

Introduction

Low flows in rivers are an important characteristic that occur in humid climates on a seasonal basis (Finlayson *et al*., 2009). Nowadays, contamination level of the river is going to be worst due to reduction of water flow. Turag river is one of the key peripheral rivers situated in the northern side of the Dhaka city, Bangladesh. Its flow is the main source of water into the Buriganga, particularly during the dry period (Kamal *et al*., 1999, Alam *et al*., 2007). Moreover, water of this river is necessary for irrigation especially in low flow season.

Suburbanization and industrialization near the river bank has generated large-scale use of metals (Kaye *et al*., 2006). The heavy metals are making water so much polluted that it surpassed the standard limit. It is very harmful, toxic and poisonous even in ppb (parts per billion) range. The Turag has been declared as ecologically critical area (ECA) by the Department of Environment (DoE) on September 2009. After that a large number of studies on water quality assessment of the river have been published. This research is the continuation of the previous researchers.

Due to gradual reduction of water flow the natural purification of polluted water in itself is never fast (Rahman *et al*., 2013). During the last decades, the low flow characteristics (both quantity and quality) of the river changed significantly (Khan, 2004). Since the industries beside the Turag river are continuously discharging their effluents in the river, it is difficult for the river to minimize those due to low flow characteristic. Therefore, the values of metal concentration are continuously changing at an alarming rate. Earlier papers (Mahfuza *et al*., 2012; Siddique and Akter, 2012; Banu *et al*., 2013; Mokaddes *et al*., 2013; Mandal *et al*., 2014; Mobin *et al*., 2014; Biswas *et al*. 2015; Ahmed *et al*., 2016; Sikder *et al*., 2016) determined the metal concentration taking single aspect (only dry period or only a month) in consideration. They did not consider the water flow rate in that sampling period. Consequently, they could not find out the impact of river flow on it which might give an overall projection of the metal pollution.

Keeping in mind this fact, eight different heavy metals: chromium (Cr), cadmium (Cd), lead (Pb), iron (Fe), copper (Cu), nickel (Ni), manganese (Mn) and zinc (Zn) were statistically analyzed for one year to find out the impact of low flow on heavy metals concentration. Viewing the impact and the deviation of concentration, easy and optimal solutions could be suggested for mitigating the pollution level of the subjected metals.

Study area

This paper considered the study along a 4 km long strip of Turag river (Fig 1) starting from Tongi Bridge following the river parallel to the Ashulia road. The average width of the river along this section is 20-25 meters, average depth during wet season is 4-5 meters and during dry season 2-4 meters. The longitude and latitude of sampling sites are given in Table 1.

Table 1. Longitude and latitude of sampling sites

Name of the Location	Longitude	Latitude
Tongi Bridge	90^{0}24´3.389´´ E	23^{0}52´54.65´´ N
World Estema Field	90^{0}23´32.51´´ E	23^{0}53´11.09´´ N
Kamarpara Bridge	90^{0}23´23.43´´ E	23^{0}53´29.61´´ N
Adjacent to Beximco	90^{0}23´10.51´´ E	23^{0}53´50.08´´ N

Methods

The samples were collected for one year which started from November, 2016 and terminates in October, 2017. Twenty eight samples were collected in each month from four sites (02 samples from each bank and 03 samples from the middle of the river) (Fig 1).

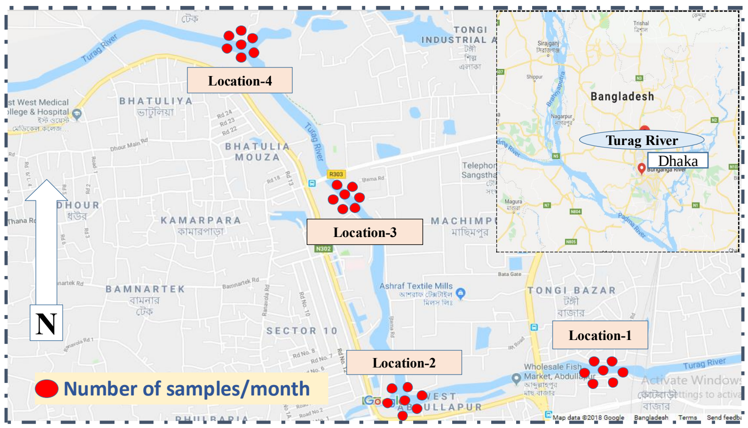

Fig. 1 Location of study area and sampling sites of Turag river

Therefore, total 336 (28×12) samples were collected. Plastic bottles of 500 ml were used for collecting samples. Prior to collection, the bottles were cleaned by detergent solution and then it was treated with 5% HNO3 overnight and finally washed with de-ionized water followed by repeated washing with sample water so as to avoid contamination. All the samples were taken with grab sampling. After sampling, the bottles were kept air tight and labeled properly for identification. The samples were transferred to the laboratory of Atomic Energy Research Establishment (AERE), Dhaka, Bangladesh as soon as possible. Samples were properly labeled and preserve at -20 0C to preclude the risk of hydrolysis and oxidation. Atomic Absorption Spectroscopy (AAS) was used to find out the concentration of heavy metals in the water. Water Flow was provided by Bangladesh Water Development Board (BWDB). MATLAB is used to project the impact of low flow on metals concentration.

Results and Discussion

Over the year the water flow was not stable. From January to May (low flow period) it was lesser and June to October (high flow period) it was higher consistently in all four sites (Fig 2). Monsoon-type rainfall increase the flow rate and absence of rainfall reduce it. Thus the contamination level does not stand same over the year. Since heavy metals discharge from several industries/factories into the river never diminishes due to the absence of neutralizing process. Thus the river water became critically polluted. Monthly variation shown in figures clearly reveals this state and depicts the gravest situation of pollution especially during low flow. The average concentration of chromium was 3.198 ppm in low flow but in high flow it was 0.492 ppm (Table 2 and 3). The result validates the increasing trends of chromium concentration during low flow. In low flow seasons the presence of chromium was six thousand times more than the standard for drinking. For irrigation it was two hundred times more than the standard. But in high flow the concentration was reduced significantly. It was 51% less than the standard value for irrigation though it was not acceptable for drinking (Table 4).

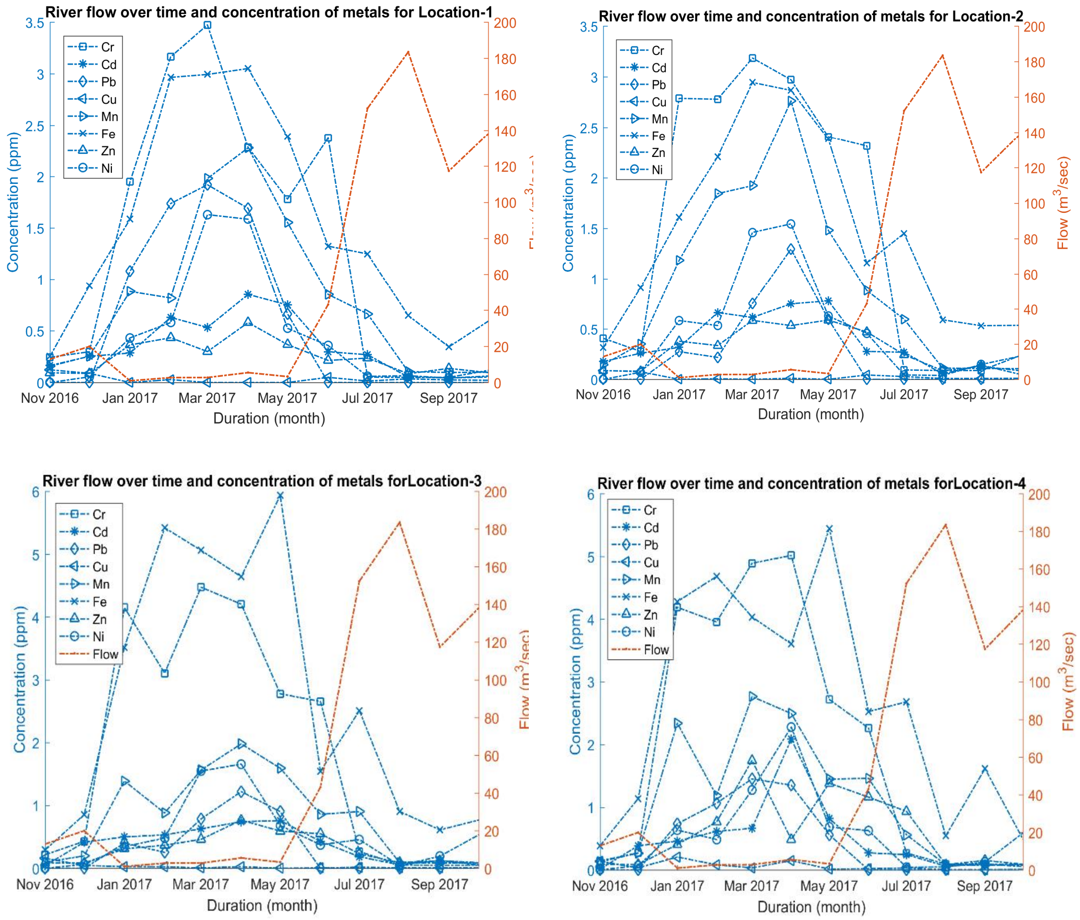

Fig. 2. Impact of river flow on chromium, cadmium, lead, copper, manganese, iron, zinc and nickel concentrations of four sites both in low flow (Jan-May) and high flow (Jun-Oct) seasons.

The experimental result indicates that the average concentration of cadmium was 0.640 ppm in low flow but in high flow it was 0.147 ppm (Table 2 & 3). Basing on the percentage of result we found cadmium is the most contaminated metals in the river. During low flow the presence of cadmium was twelve thousand times more than the standard value for drinking. For irrigation it was one thousand time more than the standard. In high flow the concentration was reduced significantly (Table 4). Even though it was not within the standard limit for drinking and irrigation. But, the definite trend in low flow comes into extreme level and it seems to be reverse in high flow.

Table 2. Heavy metals concentration during low flow of Turag river in 2017.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Average**
Low Flow	0.960 m^3/s	2.733 m^3/s	2.761 m^3/s	5.460 m^3/s	3.266 m^3/s	
Metals			**Concentration**			
Cr (ppm)	2.764	3.320	3.837	3.691	2.380	3.198
Cd (ppm)	0.303	0.528	0.601	1.066	0.703	0.640
Pb (ppm)	0.573	0.736	1.170	1.373	0.637	0.898
Cu (ppm)	0.048	0.049	0.037	0.050	0.005	0.037
Mn (ppm)	1.199	1.344	1.859	1.974	1.382	1.552
Fe (ppm)	2.180	3.733	3.717	3.770	3.593	3.399
Zn (ppm)	0.512	0.724	0.751	0.878	0.683	0.709
Ni (ppm)	0.374	0.819	1.126	1.498	0.815	0.926

Table 3. Heavy metals concentration during high flow of Turag River in 2017

Month	Jun	Jul	Aug	Sep	Oct	Average
High Flow	43.07 m^3/s	152.31m^3/s	183.48m^3/s	117.37m^3/s	138.16m^3/s	
Metals			**Concentration**			
Cr (ppm)	2.129	0.152	0.053	0.051	0.077	0.492
Cd (ppm)	0.344	0.204	0.055	0.076	0.054	0.147
Pb (ppm)	0.006	0	0	0	0	0.001
Cu (ppm)	0.026	0.022	0.014	0.012	0.014	0.018
Mn (ppm)	0.985	0.496	0.094	0.091	0.094	0.352
Fe (ppm)	2.184	1.719	0.469	0.683	0.503	1.112
Zn (ppm)	0.536	0.287	0.086	0.109	0.089	0.221
Ni (ppm)	0.385	0.083	0.038	0.076	0.037	0.124

The average concentration of Lead was 0.898 ppm in low flow season but in high flow it was 0.001 ppm when the water was flowing more than 43.07 m3/s (Table 2 and 3). During low flow season the deviation of concentration was almost two thousand times more than the standard for drinking. For irrigation it was seven hundred times more than the standard. But in high flow season it was 97% and 99% less than the standard value for drinking and irrigation respectively (Table 4). This indicates that Lead concentration in Turag river is harmful for drinking and irrigation only during low flow.

Table 4. Deviation (%) of heavy metals comparing with standard value according to ECR, 97

Metals (ppm)	Standard, ECR 97		Tested result of metals concentration		Deviation (%) during low flow		Deviation (%) during high Flow	
	Drinking	Irrigation	Low flow (Jan-May)	High flow (Jun-Oct)	Drinking	Irrigation	Drinking	Irrigation
Cr	0.05	1.0	3.198	0.492	+ 6298%	+ 220%	+ 886%	-51%
Cd	0.005	0.05	0.640	0.147	+ 12718%	+ 1182%	+ 2843%	+ 194%
Pb	0.05	0.1	0.898	0.001	+ 1697%	+ 798%	-97%	-99%
Cu	1.0	3.0	0.037	0.018	- 96%	- 99%	-98%	-99%
Mn	0.1	0.1	1.552	0.352	+ 1452%	+ 1452%	+ 252%	+ 252%
Fe	0.3-1.0	0.5	3.399	1.112	+ 240%	+ 580%	+ 11%	+ 122%
Zn	5.0	10.0	0.709	0.221	- 86%	- 93%	-95%	-98%
Ni	0.1	1.0	0.926	0.124	+ 827%	- 7%	+ 24%	-87%

An exceptional result was detected in case of copper. Over the year, the copper concentrations in these four sites were almost similar in low flow and high flow season. The experimental values were less than the standard for Bangladesh (Table 4) and the deviation was almost similar both in low and high flow seasons.

The average concentration of manganese was found 1.552 and 0.352 ppm in low and high flow season respectively (Table 2 & 3). Though in low flow season the deviation was one thousand times more than standard, in high flow season when water flow was increasing 43.07 to 183.48 m3/s, the concentration was running-down and reaching into allowable limit. Means that low flow has a significant impact on manganese concentration.

The concentration of iron in low flow season was found 3.399 ppm. While the river flow was increasing 43.07 to 183.48 m3/s during high flow, the metal concentration was reducing up to 1.112 ppm. On the other hand, deviation from the standard in high flow season was 11% and 122% more than standard for drinking and irrigation respectively. Whereas, it increases (240% & 580%) with the decrease of flow rate.

All the values of zinc were lower than Bangladesh standard for both drinking and irrigation (Table 4). But a trend was observed. The concentration of low flow season was higher than the concentration of high flow season.

Turag river water gets polluted through direct industrial discharge containing high scale of nickel. The concentration of nickel was 0.926 ppm and 0.124 ppm in low and high flow seasons respectively (Table 2 & 3). In high flow season the experimental value was below the Bangladesh standard for irrigation but higher than the standard for drinking. The deviation shown in Table 4 depicts that low flow has remarkable impact on nickel concentration. When the low flow was in the river significant amount of nickel was present in the river.

Conclusions

The river with natural water flow can maintain a good healthy environment for its stakeholders. In this paper we measured the concentration of heavy metals (Cr, Cd, Pb, Cu, Mn, Fe, Zn, Ni) both in low and high flow seasons. Finally we observed that the low flow of the river has remarkable impact on Mn, Cr, Cd, Pb, and Fe concentrations. Due to reduction of river flow from January to May, the concentration of these heavy metals exceeded the standard limit up to thousand times. But during high flow from June to October, these heavy metals concentrations lies within the national standard. Considering drinking standard the order of contamination level of the heavy metals are: Cd > Cr > Pb > Mn > Ni > Fe > Zn > Cu in low flow season. For irrigation the order of contamination level of the heavy metals are: Mn > Cd > Pb > Fe > Cr > Ni > Zn > Cu.

Generally river water is not directly used for drinking purpose, but due to tremendous demand for water and huge pressure on ground water, river could be an option in case of emergency. Moreover, this research concluded that Turag river water should not use for irrigation during low flow season. So, the government and the community should seriously ponder over taking effective actions in this regard.

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