STATUS OF HEAVY METAL IN THE PERIPHERAL RIVERS AROUND DHAKA CITY

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Abstract: Buriganga, Balu, Shitalakhya, Turag and Tongi Canal are the peripheral channels around Dhaka City receive large quantity of untreated sewage, industrial liquid and municipal waste everyday leading to serious surface water contamination. This study focuses on the status of heavy metal in those peripheral rivers and canals. Five different parameters, Cd, Cr, Ni, Pb and Zn are considered for statistical analysis. The average values of the parameters for the dry season were taken for comparison with the Bangladesh standards. The presence of excess amount of heavy metals including Cd, Cr, Pb, Ni and Zn confirms the chemical contamination of water. Concentrations of Cd, Cr, Ni and Zn from the selected rivers water reveal that those remain below the allowable limits to discharge into public sewer, inland water and irrigated land. The concentration of lead (Pb) is found higher than the allowable limits and may be harmful for all the three cases. Concentrations of the selected heavy metals are higher than Bangladesh standards for drinking water in most of the cases.

Keywords: Water quality, heavy metal, peripheral rivers, pollution, standard.

INTRODUCTION

Population of Greater Dhaka Metropolitan area is about 12.6 million with an estimated growth rate of 4.2% per annum that labeled the city as a mega city [1-3]. Large population poses huge pressure on water supply system and causes tremendous water crisis every year. Ground water is the main source of water and excessive amount of withdrawal of groundwater is lowering the water table every day. Unplanned urbanization, economic development as well as gigantic population growth are the main reasons for ever increasing water deficit. The Dhaka Water Supply and Sewerage Authority (DWASA) are only entrusted with supply of piped water in the Dhaka Metropolitan and its adjacent area. The present water supply coverage is 75%, out of which 87% is derived from groundwater sources using a network of 573 Deep Tube-wells (DTW). The remaining 13% of the water is derived from surface water bodies comprising the peripheral rivers around Dhaka City [Fig. 1] which is treated by water treatment plants before entering the distribution system. Due to the expansion of the city water demand is also increasing and in order to meet the ever increasing demand there might be one potential solution which is the conjunctive use of groundwater and surface water in order to maintain the balance between anthropogenic demand and water's natural availability for usage and recharge [3-6].

Although Bangladesh is a riverine country and Dhaka City is surrounded by rivers in its periphery, improper river water quality does not allow its convenient use. The surface water along these peripheral rivers is known to be highly polluted due to municipal and industrial untreated wastewater that discharged into these rivers [2,3,7,8]. Water of the surrounding rivers and canals has already exceeded the standard limits of many water quality parameters because of the discharge of huge amount of untreated wastes. Proper treatment of water of peripheral rivers around Dhaka city might be a possible option of surface water supply. For this purpose an assessment has been made on the status of water quality considering presence of heavy metal in water.

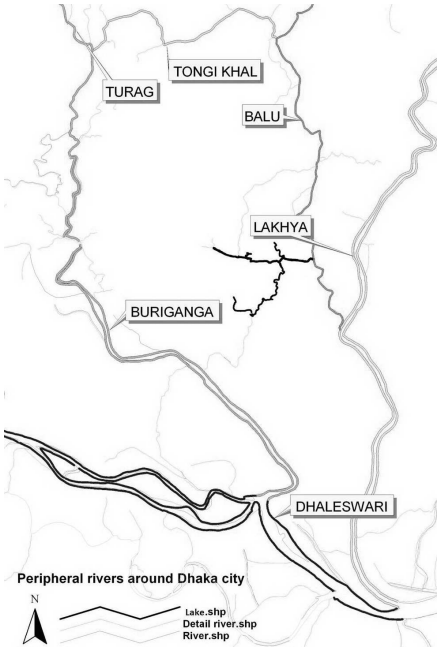

Figure 1: Peripheral Rivers around Dhaka City

METHODOLOGY

The study was initiated by introducing a rational methodology in which water sample is tested with respect to the presence of heavy metal in peripheral river water. For this purpose water samples were collected from five peripheral rivers to analyze water quality. Five water quality parameters (Cd, Cr, Ni, Pb, Zn) has been set for this particular study. Environmental quality standards for those parameters are shown in table 1. As a preliminary step for initiating the study, a map of the study area showing Greater Dhaka and the peripheral rivers was first developed with the aid of existing GIS themes on Rivers and canals.

Table 1: Environmental Quality Standards (EQS) for Drinking Water, Discharge in Inland Surface Water, Public Sewer and Irrigated Land [9]

Water Quality Parameters	Unit	Bangladesh Standard for Drinking Water	Discharge in Inland Water	Discharge Into Public Sewer	Discharge on Irrigated Land
Cadmium (Cd)	mg/l	0.005	0.5	0.05	0.05
Chromium(Cr)	mg/l	0.05	0.5	1.0	1.0
Lead (Pb)	mg/l	0.05	0.1	1.0	0.1
Nickel (Ni)	mg/l	0.1	1.0	2.0	1.0
Zinc (Zn)	mg/l	5.0	5.0	10.0	10.0

VARIATION OF RIVER WATER QUALITY PARAMETER

Water quality of the selected rivers and canals has been assessed keeping attention on the drinking standard as well as on discharge in inland water, public sewer, irrigated land etc mentioned in environmental conservation rules 1997 [9]. Although the analysis has iterated the term peripheral rivers around Dhaka city innumerable times, there are very few data of the river reaches located in the north i.e. Tongi Khal. The inflow and out flow of Tongi Khal is completely controlled by Turag and Balu river. Therefore, the term peripheral rivers is justified in the sense that water quality of Tongi Khal would not be superior to, rather equivalent to or worse than that of the Turag and Balu river. Water quality observed in different measurements in the river system has been illustrated in the following sections. The analysis presented in this paper is based on the collected river water quality data (before 2010) and recently tested data (year 2010) in BUET laboratory. The previous year data have been collected from different sources [10-14]. To get the worst condition of the river, the water qualities of rivers have been analyzed only for dry

seasons when the rivers flow below their average discharge level.

Variation of Cadmium (Cd) over Time

Cadmium is a metal found in natural deposits as ores containing other elements. [15]. Naturally a very large amount of cadmium is released into the environment through human activities, such as manufacturing. Health effects that can be caused by cadmium are: Diarrhoea, stomach pains and severe vomiting, Bone fracture, Reproductive failure and possibly even infertility, Damage to the central nervous system, Damage to the immune system, Psychological disorders, Possibly DNA damage or cancer development. [16]. Although cadmium occurs naturally in rivers, as for humans, too much can damage wild animals and plants. Cadmium in the dissolved form is potentially quite toxic to aquatic life. Again river water highly polluted with cadmium can contaminate surrounding land through irrigation. Changes of Cadmium concentration in peripheral rivers around Dhaka city in dry seasons from 1997 till 2010 (Table 2) indicates that maximum cadmium concentration in the peripheral rivers was in 1998 and minimum in 2006. Again in 2009 there is a rise of cadmium concentration in the peripheral river water. In this case no specific trend is observed as cadmium concentration is varying in river water from 1998 to 2010. During 1998 the values were 0.03mg/l, 0.08 mg/l, 0.07 mg/l, 0.08 mg/l at Buriganga, Balu, Turag, Shitalakhya respectively. All these values are extremely higher than Bangladesh standard for drinking water, discharge into public sewer and discharge on irrigated land but less than the limits for discharge in inland water. In the recent year 2010 cadmium concentration is less than the limits of standards for discharge into public sewer, inland water and irrigated land. Considering all the values found in the peripheral river water it can be said that cadmium is not harmful for discharge into public sewer, inland water and irrigated land.

With respect to drinking purposes in most of the cases Cadmium values are much higher than Bangladesh standards for drinking water. Generally river water is not directly used for drinking purposes but due to tremendous demand for water and huge pressure on ground water body, river water could be an option in case of emergency. Proper treatment can reduce heavy metal from water and can make water drinkable. In our country Saidabad water treatment plant is mainly responsible for large volume of river water treatment process and they use rapid sand filtration system which only allows a small portion of removal of cadmium from water.

Table 2: Variation of Cd concentration in peripheral rivers over time

Year	Unit	Buriganga	Balu	Turag	Tongi khal	Shitalakhya
1997	mg/l	0.014	0.006	0.018	0	0.006
1998	mg/l	0.03	0.08	0.07	0	0.08
2006	mg/l	0	0.0012	0	0	0.0013
2009	mg/l	0.01	0.01	0.01	0.01	0.01
2010	mg/l	0.018	0.015	0	0	0

Variation of Chromium (Cr) over Time

Chromium (VI) is known to cause various health effects. The health hazards associated with exposure to chromium are dependent on its oxidation state. The metal form (chromium as it exists in this product) is of low toxicity. The hexavalent form is toxic. Adverse effects of the hexavalent form on the skin may include ulcerations, dermatitis, and allergic skin reactions. [16]. Drinking chromium contaminated water may cause sever health problem.

The variation of Chromium is analyzed from the year 1994 to 2010 (Table 3). The highest value of Chromium is found in 2010 in Balu river which is 0.73 mg/l. This value is lower than Bangladesh standards for discharge into public sewer, discharge in inland water and discharge on irrigated land. For all the observed year Chromium concentrations are much less than Bangladesh standard value for discharge into public sewer, discharge in inland water and discharge on irrigated land. Chromium concentration is considered not harmful for the above purposes.
But for most of the cases the concentration of Chromium is much higher than Bangladesh standards for drinking water. Considering drinking purposes peripheral river water is not suitable for drinking because of high concentration of chromium. The possible methods of removal of chromium from water are ion exchange and activated carbon method. In context of our country, water treatment plant use conventional methods for treating water. Therefore amount of chromium removal from river water is not significant.

Table 3: Variation of Cr concentration in peripheral rivers

Year	Unit	Buriganga	Balu	Turag	Tongi khal	Shitalakhya
1994	mg/l	0.27	0.13	0.11	0.008	0.27
1998	mg/l	0.1	0.13	0.01	0	0.1
2004	mg/l	0	0.003	0.006	0.002	0.001
2006	mg/l	0	0.002	0	0	0.001
2009	mg/l	0.02	0.022	0.011	0.015	0.013
2010	mg/l	0.167	0.73	0.025	0.01	0.005

Variation of Nickel (Ni) over Time

Nickel may end up in water from both point and non-point sources. Nickel is directly emitted from various industries through discharge on surface water. It is applied in alloys for treatment of heavy metal polluted surface water, in nickel-cadmium batteries as a catalyzer and as a pigment. [16]. Nickel is a dietary requirement for many organisms, but may be toxic in larger doses. Nickel tetra carbonyl is water insoluble, but is toxic and carcinogenic. For the cases of nickel concentration only three years data are available (Table 4) and based on these it has been found that nickel concentration in 1998 in both buriganga and turag river is 0.1 mg/l which is equivalent to Bangladesh standard for drinking water and much lower than standard for discharge into public sewer, irrigated land and inland water. In the recent years Ni concentration remains lower for all the three purposes except for drinking purposes. These standards indicated that nickel concentration in Peripheral River water might not be dangerous for discharge into inland water, public sewer and irrigated land but this water might not be suitable as drinking water. Nickel may be removed from water by means of active carbon adsorption and coagulation methods.

Table 4: Variation of Ni concentration in peripheral rivers over time

Year	Unit	Buriganga	Balu	Turag	Tongi khal	Shitalakhya
1998	mg/l	0.1	0.01	0.1	0	0.005
2009	mg/l	0.007	0.008	0.007	0.006	0.007
2010	mg/l	0.089	0.035	0.01	0.005	0.005

Variation of Lead (Pb) over Time

Exposure to low levels of lead over an extended period of time can have severe effects. [17]. Lead in drinking water can cause a variety of adverse health effects. In babies and children, exposure to lead in drinking water above the action level can result in delays in physical and mental development, along with slight deficits in attention span and learning abilities. In adults, it can cause increases in blood pressure. Adults who drink this water over many years could develop kidney problems or high blood pressure.

Lead concentration in 1997, 1998 and 2006 (Table 5) shows that at almost all the selected rivers are higher in concentration than the Bangladesh standards for drinking Water and standards for discharge in inland water and irrigated land, but lower than discharge into public sewer. In the recent time 2010, Pb concentration found in Buriganga and Balu river is higher than Bangladesh standards for discharge in inland water (0.1 mg/l) and irrigated land (0.1 mg/l). These standards indicated that Pb concentration in peripheral River will probably be harmful for discharging in inland water and irrigated land. Mainly domestic and industrial sewage cause high Pb in water of peripheral Rivers around Dhaka city.

Table 5: Variation of Pb concentration in peripheral rivers

Year	Unit	Buriganga	Balu	Turag	Tongi khal	Shitalakhya
1997	mg/l	0.47	0.04	0.394	0.05	0.074
1998	mg/l	0.1	0.34	0.31	0.05	0.23
2004	mg/l	0.27	0.003	0.006	0.05	0.004
2006	mg/l	0.23	0.04	0.36	0.05	0.12
2009	mg/l	0.02	0.025	0.016	0.023	0.022
2010	mg/l	0.224	0.216	0.04	0.018	0.038

Variation of Zinc (Zn) over Time

Drinking water contains certain amounts of zinc, which may be higher when it is stored in metal tanks. Industrial sources or toxic waste sites may cause the zinc amounts in drinking water to reach levels that can cause health problems. The highest Concentration of Zn was found in Buriganga River in 1997 and 2005 (Table 6). The values are 4.6mg/l and 4.57 mg/l respectively. These Values are lower than Bangladesh standards for drinking water, discharge in inland water, discharge into public sewer and discharge on irrigated land. From the table it has been found that the rest of the values are satisfactorily lower than Bangladesh standard for drinking water, discharge into public sewer, in inland land, on irrigated land. The concentration of Zn will not be a threat for discharge in inland water, public sewer and irrigated land.

Table 6: Variation of Zn concentration in peripheral rivers

Year	Unit	Buriganga	Balu	Turag	Tongi khal	Shitalakhya
1997	mg/l	4.6	3	2	0	2.996
1998	mg/l	1.226	0.9	0.7	0	3.55
2005	mg/l	4.57	2.93	2.02	0	3
2009	mg/l	0.237	0.062	0.169	0.088	0.402
2010	mg/l	1.103	0.156	2.055	0.156	0.106

POLLUTION STATUS OF PERIPHERAL RIVERS

Peripheral rivers around Dhaka have been greatly changed with rapid urbanization and industrialization. This rapid urbanization process has not taken place in a formal and planned manner. Industries are polluting the rivers, canals and wetlands over the years in and around the city to such an extent that surface water turned pitch black in several spots. Pollution has set in on the Buriganga, Shitalakhya and Balu rivers and made it almost impossible to treat the water. Industry generates liquid and solid waste, most of the human excreta directly goes down the rivers through underground sewer. Waste from these industries is connected with the sewerage system that directly goes into the rivers around the city. The quality of water in peripheral rivers around Dhaka city has deteriorated significantly during the last few years. Especially in the dry period, the situation is alarming due to the uncontrolled disposal of untreated domestic and industrial sewage to the rivers. Water of the surrounding rivers and lakes has already exceeded the standard limits of many water quality parameters. Moreover, the presence of excess amount of heavy metals including Cd, Cr, Pb, Ni, Zn confirms the chemical contamination of water.

CONCLUSIONS

Water crisis is one of the critical problems in Dhaka city. This problem is not a new one and it cannot be solved overnight. There is a good option to use the water of the peripheral rivers around Dhaka. The storage volume and flow of these rivers are not insignificant. But the question is the water quality. In this paper an analysis has been done on the present condition of heavy metal in peripheral river water. The higher concentration of lead indicates that peripheral river water is not well enough to discharge into inland water, public sewer and irrigated land. This is mainly because of the discharge of municipal waste water and effluent from the industries established in unplanned way near the river side. But considering other heavy metal (Cd, Cr, Ni, Zn) water quality of peripheral rivers is well enough for discharge into inland water, public sewer and irrigated land. The concentration of heavy metals in river water are extremely higher than Bangladesh standard for drinking water. As water crisis is a major concern of modern life, use of treated surface water may be an alternative source to meet the water demand in the city. After

treating in plant before entering the distribution system the concentration of heavy metal can be minimized and water can be used for drinking purposes. In Bangladesh water treatment plants use conventional methods to purify water and removal efficiency of heavy metal is very low. Therefore further modern methods such as slow sand filtration would be a good option to improve river water quality as it can minimize considerable amount of heavy metal in water.

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