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DISTRIBUTION OF TRACE METALS IN STORM WATER RUNOFF IN THE INDUSTRIAL AREAS OF GREATER GUWAHATI OF ASSAM, INDIA

MRIDUL BURAGOHAIN[*], YAMIN HASSAN[a] and HARI PRASAD SARMA[b]

Department of Chemistry, Lakhimpur Girls' College, NORTH LAKHIMPUR (Assam) India
[a]Department of Chemistry, Assam Down Town University, Dispur, GUWAHATI – 06 (Assam) INDIA
[b]Department of Environmental Science, Gauhati University, GUWAHATI – 14 (Assam) INDIA

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ABSTRACT

The focus of this research was upon consequences of urban stormwater runoff with respect to copper, zinc, manganese, iron, cadmium, lead and nickel in the industrial areas of Greater Guwahati, which is the largest urban area of Assam, India. The water samples were collected from twenty four different sites. The metals were analysed by using Atomic Absorption Spectrometer, Perkin Elmer AA 200 model. Copper and zinc content of strom water was found to be within the guideline value of WHO. Statistical analyses of the data reveal that the distribution of various trace metals in the study area is widely off normal with significant positive kurtosis and skewness. The metal concentration of strom water in the study area follows the trend Fe > Pb > Cu > Mn > Ni > Zn > Cd. Top priority should be given to frequent monitoring of the status of strom water.

Key words: Copper, Zinc, Manganese, Iron, Cadmium, Lead, Nickel, Storm-water, Industrial areas, Guwahati.

INTRODUCTION

Water quality of storm-water runoff was soon identified as being a concern as important as water quantity. Urban stormwater is harmful to the environment because of the effects it has on the water quality and water quantity of receiving waters[1]. As urbanization increases and the amount of permeable land cover decreases, the ability for rainwater to dissipate into the ground through deep infiltration and shallow infiltration considerably decreases[2]. Because of the numerous dissolved contaminants in stormwater, urban runoff dramatically increases stream water conductivity and contamination as both point source and non-point source contributions to receiving water bodies[3]. High concentrations of conductive substances in runoff may shock organisms in the receiving waters[4]. Knowledge of the concentration and distribution pattern of trace metals in strom water can play an important role in estimating the sources of runoff water pollution, especially in the industrial areas of Greater Guwahati, which is the largest urban area of Assam, India. The primary objective of this study is to present a statistically meaningful storm-water quality database on trace metal contamination with special reference to copper, zinc, manganese, iron, cadmium, lead and nickel so that purpose-orientated water assessments and predictions can be made in the study area.

Available online at www.sadgurupublications.com
[*]Author for correspondence; E-mail: mbg_2007@rediffmail.com; Mo.: +91-94353-89548

EXPERIMENTAL

Profile of the study area

The study area (Fig. 1), from Jorabat to Byrnihat along the National Highway-40, the gateway to Guwahati and North East India is a commercial area with heavy traffic activities round the clock. Besides heavy traffic these areas witnesses various industrial activities starting from coke processing industry to cement manufacturing industry including alloy industry, brick manufacturing industry, food processing industries, cold drinks manufacturing unit, medicine manufacturing unit.

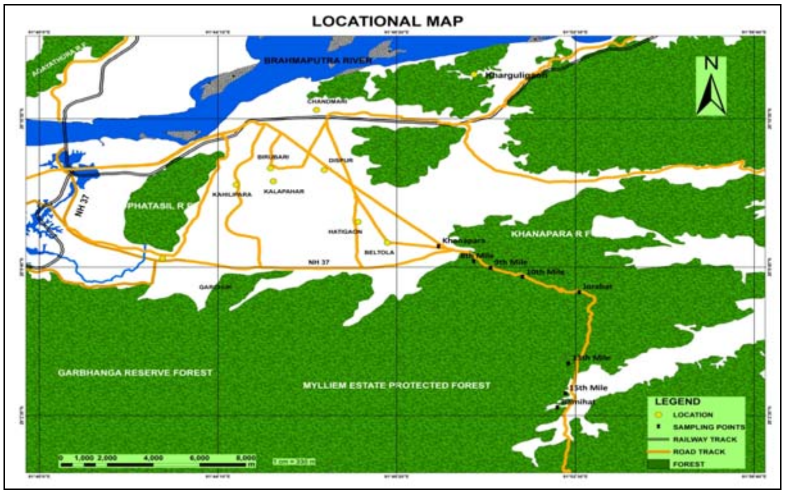

Fig. 1: Location map of Greater Guwahati, Assam (from Jorabat to Byrnihat)

Sampling information

Separate water samples were selected by random selection and compiled together in clean and sterile one-litre polythene cans to set a representative sample and stored in an ice box. Samples were protected from direct sun light during transportation. Water samples were collected during March, 2012 to February, 2013 as given in Table 1.

Table 1: Physical location of sampling stations in the study area

Sample No.	Sampling location	Geographical location	
		North (N)	East (E)
A_1	Khanapara	$26^0\ 7^/\ 14.1^{//}$	$91^0\ 49^/\ 18.5^{//}$
A_2		$26^0\ 7^/\ 7.0^{//}$	$91^0\ 49^/\ 12.3^{//}$
A_3		$26^0\ 7^/\ 2.5^{//}$	$91^0\ 49^/\ 5.1^{//}$
B_1	8^{th} mile	$26^0\ 6^/\ 48.5^{//}$	$91^0\ 50^/\ 8.0^{//}$
B_2		$26^0\ 6^/\ 43.0^{//}$	$91^0\ 50^/\ 19.6^{//}$
B_3		$26^0\ 6^/\ 40.7^{//}$	$91^0\ 50^/\ 26.0^{//}$
C_1	9^{th} mile (Covers Baridua & Hastinapur, Ghy-23)	$26^0\ 6^/\ 37.5^{//}$	$91^0\ 50^/\ 31.3^{//}$
C_2		$26^0\ 6^/\ 31.4^{//}$	$91^0\ 50^/\ 43.0^{//}$
C_3		$26^0\ 6^/\ 25.8^{//}$	$91^0\ 50^/\ 56.7^{//}$

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Sample No.	Sampling location	Geographical location	
		North (N)	East (E)
D_1	10th mile (Amerigog,Ghy-23)	$26^0\ 6^/\ 22.6^{//}$	$91^0\ 51^/\ 16.0^{//}$
D_2		$26^0\ 6^/\ 14.3^{//}$	$91^0\ 51^/\ 23.7^{//}$
D_3		$26^0\ 6^/\ 5.9^{//}$	$91^0\ 51^/\ 52.5^{//}$
E_1	Jorabat	$26^0\ 5^/\ 56.7^{//}$	$91^0\ 52^/\ 35.4^{//}$
E_2		$26^0\ 5^/\ 43.4^{//}$	$91^0\ 52^/\ 44.7^{//}$
E_3		$26^0\ 5^/\ 26.7^{//}$	$91^0\ 52^/\ 53.5^{//}$
F_1	13th mile	$26^0\ 4^/\ 33.9^{//}$	$91^0\ 52^/\ 32.2^{//}$
F_2		$26^0\ 4^/\ 20.2^{//}$	$91^0\ 52^/\ 37.2^{//}$
F_3		$26^0\ 4^/\ 14.7^{//}$	$91^0\ 52^/\ 41.8^{//}$
G_1	15th mile	$26^0\ 3^/\ 5.8^{//}$	$91^0\ 52^/\ 46.3^{//}$
G_2		$26^0\ 3^/\ 3.2^{//}$	$91^0\ 52^/\ 49.0^{//}$
G_3		$26^0\ 2^/\ 56.2^{//}$	$91^0\ 52^/\ 51.5^{//}$
H_1	Byrnihat	$26^0\ 2^/\ 42.2^{//}$	$91^0\ 52^/\ 53.9^{//}$
H_2		$26^0\ 2^/\ 35.6^{//}$	$91^0\ 52^/\ 56.0^{//}$
H_3		$26^0\ 2^/\ 12.8^{//}$	$91^0\ 52^/\ 58.3^{//}$

Analysis

The concentrations of copper, zinc, manganese, iron, cadmium, lead and nickel were analysed by using Atomic Absorption Spectrometer (Perkin Elmer AA-analyst 200) with Flow Injection Analyze Mercury Hydride Generation System (Model-FIAS-100) as per the standard procedures[5]. All the reagents and standards (analytical grade, purchased from Merck, India) were prepared freshly at the time of analysis. A blank was analyzed between elements specific standard readings to verify baseline stability of the instrument.The experimental findings and statistical analysis of the experimental data are summarized in Tables 2 and 3.

Table 2: Metal content in stromwater of Greater Guwahati at 24 different stations

Sample No	Cu (mg/L)	Zn (mg/L)	Mn (mg/L)	Fe (mg/L)	Cd (mg/L)	Pb (mg/L)	Ni (mg/L)
A_1	0.40	0.19	0.11	17.26	BDL	0.73	0.01
A_2	BDL	0.31	BDL	0.24	BDL	0.11	0.03
A_3	BDL	0.21	0.08	0.11	BDL	0.05	0.01
B_1	1.26	0.47	BDL	1.80	0.04	2.15	0.02
B_2	0.35	0.44	0.06	19.74	BDL	0.41	0.01
B_3	0.11	0.35	0.09	2.01	BDL	0.42	0.02
C_1	0.26	0.35	0.12	1.90	0.08	0.09	0.01
C_2	0.21	0.34	BDL	1.86	BDL	0.06	0.02
C_3	0.02	0.36	BDL	1.01	BDL	0.06	0.02

Cont…

Sample No	Cu (mg/L)	Zn (mg/L)	Mn (mg/L)	Fe (mg/L)	Cd (mg/L)	Pb (mg/L)	Ni (mg/L)
D_1	0.01	0.26	0.08	1.30	BDL	0.08	0.01
D_2	BDL	0.45	BDL	0.98	BDL	1.33	0.02
D_3	BDL	0.41	0.10	1.10	0.04	0.04	0.02
E_1	0.20	0.61	BDL	1.34	BDL	0.05	0.10
E_2	0.02	0.22	BDL	0.89	0.09	0.61	0.30
E_3	BDL	0.51	0.06	0.21	BDL	0.08	0.40
F_1	0.20	0.18	0.08	2.90	0.11	0.05	0.80
F_2	0.01	0.25	0.01	1.30	BDL	0.08	0.10
F_3	0.21	0.06	BDL	18.53	BDL	0.31	0.02
G_1	0.02	0.07	0.03	4.17	BDL	0.09	0.01
G_2	0.04	0.47	0.05	6.21	0.04	0.04	0.02
G_3	BDL	0.25	0.01	0.85	0.04	0.05	0.01
H_1	BDL	0.22	0.10	0.79	0.03	0.11	0.02
H_2	0.02	0.46	0.94	2.70	0.03	0.12	0.30
H_3	BDL	0.16	0.14	1.70	0.04	0.07	0.02

Table 3: Comparison of statistical data of different metals in the study area

Statistics	Cu	Zn	Mn	Fe	Cd	Pb	Ni
Minimum	BDL	0.06	BDL	0.11	BDL	0.11	0.01
Maximum	1.26	0.61	0.94	26.21	0.11	2.15	0.80
Average	0.18	0.33	0.15	4.85	0.05	1.10	0.46
Median	0.11	0.31	0.09	1.75	0.04	0.98	0.22
Kurtosis	11.65	0.02	11.91	2.28	1.17	0.20	6.29
Skewness	3.16	0.56	3.21	1.92	1.43	0.29	2.59

RESULTS AND DISCUSSION

Copper (Cu)

The study revealed that concentration of Cu varied from BDL to 1.26 mg/L. Study revealed that all the samples analysed were within the safe limit of WHO (1.5 mg/L). Cu enters the water system through mineral dissolution, industrial effluents, because of its use as algaecide and insecticide and through corrosion of Cu-alloy water distribution pipes. It may occur in simple ionic form or in one of many complexes with groups, such as cyanides, chlorides, ammonia or organic ligands[6]. Cu may be dissolved from water pipes and plumbing fixtures, especially by water whose pH is below 7.

Zinc (Zn)

The observed values of concentration for Zn content in the water samples ranges from 0.06 to 0.61 mg/L. Analysis showed that 100% samples of the total collection had Zn concentration below the permissible limit of WHO/BIS (5.0 mg/L) which means the water of the region is safe in terms of Zn. Zn is found naturally in many rock-forming minerals like zinc blende wurzite, smithsonite and hemimorphite. It also may be present in industrial discharges. Zn has lots of use like galvanization of steel, preparation of negative plates in electric batteries, vulcanization of rubber, wood preservatives and antiseptics and in rat and mouse poison (Zn-phosphide).Very low amount of the Zn may cause loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Zn-shortages can even cause birth defects. However large amount of Zn can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia, damage of the pancreas and disturb the protein metabolism, cause arteriosclerosis and respiratory disorder[7].

Manganese (Mn)

The observed values of concentration for Mn content in the water samples ranges from BDL to 0.94 mg/L. Analysis showed that 100% samples of the total collection had Mn concentration below the permissible limit of WHO/BIS (0.5 mg/L). Mn is a very reactive element, found in nature and used extensively in industry for the manufacture of glass, ceramics, batteries, paints, varnishes, inks, dyes and fireworks[8]. The deficiency of Mn may cause improper growth, disrupt the nervous system and interfere with reproductive system[9]. At high concentrations in water it will cause an unpleasant taste, deposits on food during cooking, stains on sanitary ware, discolouration of laundry, deposits on plumbing fittings and cooking utensils, and will foster the growth of micro-organisms in water supply systems.

Iron (Fe)

Analysis of water samples of the study area showed that concentration of Fe varied from 0.11 to 19.74 mg/L. Study revealed that 87.5 % the samples analysed were within the safe limit of WHO (0.3 mg/L). The Fe content of the area may cause bacterial activity (redort diseases) but it has no adverse effect in agricultural plants[9]. The presence of these “iron bacteria” which derive their energy from the oxidation of Fe (II) to Fe (III) can also cause a rotten egg odour in the water and sheen on the water surface and in the process deposit a slimy coating on the piping. Fe is contained in a number of biological significant proteins as haemoglobin and cytochromes. Although Fe has got little concern as a health hazard but is still considered as a nuisance in excessive quantities. Long time consumption of strom water with a high concentration of Fe can lead to liver diseases (hemosiderosis). Fe deficiency caused anemia. It has also been reported that children have been known to develop Fe toxicity by higher Fe intake symtomized by fatigue, anorexia, dizziness, nausea, vomiting, headache, weight loss, shortness of breath and possibly a graying colour to the skin. High concentration of Fe in water is not suitable for processing of food, beverages, ice, dyeing, bleaching and many other items. Water with high concentration of the Fe when used in preparation of tea and coffee, interacts with tanning giving a black inky appearance with a metallic taste[10]. So, protective measures should be taken to control the problems of Fe in waters of the study area.

Cadmium (Cd)

The observed values of concentration for Cd content in the water samples ranges from BDL to 0.11 mg/L. The experimental data reveals that Cd content of strom water at 37 % of the sampling sites exceeds the guideline value as set by BIS/ICMR (0.01 mg/L). Cd is released into the environment from mining and metal processing operations, burning fuels, making and using phosphate fertilizers, and disposing of metal products[11]. Cd is used for electroplating and for pigments used in paint, printing ink, and plastics. It is also used extensively as a stabilizer for PVC plastic and in electrical batteries and fluorescent and video tubes.

Lead (Pb)

Analysis of water samples of the study area showed that concentration of Pb varied from 0.11 to 2.15 mg/L. Study revealed that 29 % of the samples analysed were within the safe limit of WHO (0.2 mg/L).

The toxicity effects of Pb in humans include nausea, abdominal pains, uncomfortable body movement, state of unconsciousness ultimately producing coma and death[12]. Moderate to low levels of exposure may result in hearing loss; inhibit growth, learning disabilities, cramps, irritability, fatigue, vomiting, constipation, sleep disorder, poor appetite, and trouble sleeping. The strom water quality can have a great impact on the Pb level of water. If the water is soft or corrosive, this type of water can accelerate the leaching of Pb and other metals from household plumbing and water fixtures. The signs of this type of problem would include: around basins, metallic or bitter taste to the water especially in the mornings and frequent leaks/evidence of corrosion of the household plumbing[13]. The Pb content of water in the study area needs urgent attention and regular monitoring of the strom water is very essential in the study area.

Nickel (Ni)

Analysis of water samples of the study area showed that concentration of Ni varied from 0.01 to 0.80 mg/L. It has been observed that Ni content of strom water 25 % of the sampling sites exceeds the maximum permissible limit of 0.02 mg/L as set by WHO. The highest Ni value (0.80 mg/L) was recorded at sampling points $F_{1.}$ The most common type of reaction to Ni exposure is a skin rash at the site of contact. Skin contact with metallic or soluble Ni compounds can produce allergic dermatitis[14].

CONCLUSION

Statistical observations on copper, zinc, manganese, iron, cadmium, lead and nickel in strom waters of the industrial areas of Greater Guwahati, Assam show that all these metals exhibit a non-uniform distribution having significant positive kurtosis and skewness value point towards sharp trace metals distribution with a long right tail. Comparing the water content of trace metals with the recommended maximum values for drinking purposes, it is found that a sizeable number of strom water samples contain iron, cadmium, lead and nickel at an alert level which are due to the industrial run-off through the rivers. Increased urbanization and industrialization are to blame for an increased level of these contaminants in the water sources. The concentrations of copper, zinc and manganese in the strom water of the area are either low or moderate and within the guideline values of WHO. Keeping in view of the unusually high concentrations of the harmful metals at some of the sampling sites, it is concluded that regular monitoring of water sources should be ensured by the concerned authorities to prevent the outbreak of water borne diseases in the area.

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