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A STUDY ON SURFACE WATER AND GROUNDWATER NEAR A GARBAGE DISPOSAL SITE IN GUWAHATI, ASSAM, INDIA

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ABSTRACT
The present investigation was carried out to assess the impact of leachate on the groundwater and surface water quality near the unlined open dumping site at Guwahati, Assam. Groundwater and surface water samples have been collected from near the open dump within a radius of 3000m. The physico-chemical characterisation (pH, Alkalinity, Hardness, Free CO_2, Dissolved oxygen, Electrical conductivity and Total dissolved solids) of the groundwater and surface water samples collected from around the open dump has been done. The concentration of trace metals (Mn, Zn, Ni, Cd and Cu) in groundwater and surface water has been studied. Mn and Cd in groundwater have been found to be in higher range than the Maximum permissible limit (MPL) as per WHO and BIS IS: 10500. In surface water, the concentration of Mn has been found to be higher than the MPL specified by WHO and CPCB. Toxic leachate flowing from the base of the dump continuously mixes with the nearby surface water as well as the aquifers neighbouring villages are users of both groundwater and surface water sources thereby causing potential health risk.

KEYWORDS: Open dumping site, Groundwater, Surface water, Leachate, WHO, BIS.

INTRODUCTION
Groundwater has long been considered as one of the purest forms of water available in nature and meets the overall demand of rural and semi-urban people (Mansouri *et al.,* 2012). Among the various reasons, the most important are non-availability of potable surface water and a general belief that groundwater is purer and safer than surface water due to the protective quantities of the soil cover (Shakeri *et al*., 2009). Trace elements are contributed to groundwater from a variety of natural as well as anthropogenic sources. Municipal solid waste disposal sites, primarily open dumping sites can potentially deteriorate the ecology of the surrounding area and pose a serious threat to water resources located in its vicinity. Physical, chemical and microbial processes transfer pollutants from the waste material to the infiltrating water, resulting in a contaminated liquid containing high concentrations of organic and inorganic contaminants. If the leachate is released into the underlying aquifer it forms a complex contaminant plume that fundamentally alters the chemical properties of the aquifer (Jorstad *et al*., 2003). Contamination of groundwater by heavy metals may pose a more serious and continuing health risk to humans and environment (Tripathi and Pandey 2001). Various researchers have worked on groundwater and surface water pollution adjacent to landfill sites in India and outside (Kale *et al*., 2009, D Souza *et al*., 2012; Jhanmani *et al*., 2009; Beyene *et al*., 2011). Some metals present in trace quantity are important for life as it helps and regulates many physiological function of the body. Metals like Zn, Cu, and Fe, which are required for metabolic activity in organisms, while other metals like Cd, Cr and Pb have no known physiological activity; they are proved detrimental beyond a certain limit (Marschner 1995; Bruins *et al*., 2000). The seven years old municipal solid waste open dumping site of Guwahati city (26°06′ 49.3″N 91°40′56.1″E) has been operational since 6th July, 2006. The site is at a distance of 2km from NH 37. The MSW dump is on the fringe area of Deepor beel which is a Ramsar site. The city generates 300 metric tonnes of solid waste per day. The MSW dump in Guwahati contains all sorts of unsorted, unsegregated, non biodegradable and toxic waste of the city. The dump has remained uncovered and no scientific method was adopted in disposal of the waste. There was no liner membrane underneath the waste dump or a leachate collection system to collect the leachate emanated from the base of the dump. The Deepor Beel is reported to provide, directly or indirectly, its natural resources for the livelihood of fourteen indigenous villages (1,200 families) located in its precincts (Roy *et al*., 2011). The Deepor beel supports a number of neighboring villages where people use the beel water for their daily activities like drinking, cooking and washing clothes and utensils.

MATERIAL & METHOD
Groundwater samples were collected from 19 sites during November-December 2012. Sampling stations for groundwater collection were located within a radial distance of 3000m from the source of MSW disposal site. All samples have been collected either from tube wells and dug wells located around the solid waste open dump in the morning hours. Surface water samples were collected from five sites around the municipal solid waste dumping site during the study period. Water samples were collected at a radial distance ranging from (<20m-<3000m) from the source. An uncontaminated site was used as the control site at a distance of 5000m. Water samples have been collected in acid washed 250-ml plastic bottles. The samples were filtered and acidified with nitric acid and preserved at 4^0C until analysis of trace metals. The determinations of trace metals Cd, Cu, Zn, Mn and Ni

were carried out in Atomic absorption spectrophotometer (Thermo fisher iCE 3000 series. Certain physiochemical parameters (pH, dissolved oxygen, free CO_2, total dissolved solids, electrical conductivity, alkalinity, hardness) were analysed for water as per standard procedures (APHA, 2002). Total dissolved solids were determined by the water quality analyser (ELICO water quality analyser PE 138). Data were compared with WHO 1993, BIS IS 10500 1993 and CPCB 1993 for MPL.

RESULT AND DISCUSSION

Groundwater

The water quality parameters in groundwater are given in Table 1.

TABLE 1. Physico-chemical characteristics of groundwater samples (in mg/l)

Sampling stations	pH	Hardness	Alkalinity	Free CO_2	EC	TDS	D.O
S1	7.9	86	110	19.8	266.3	134.5	3.2
S2	7.57	82	95	22.0	220.7	142.7	2.4
S3	7.09	66	50	22.2	287.7	130.0	2.2
S4	7.55	122	130	17.6	220.7	109.9	1.8
S5	7.64	84	75	15.4	248.9	129.1	2.1
S6	7.34	86	90	22.0	261.9	127.2	3.4
S7	7.46	104	65	20.6	242.3	115.1	3.6
S8	7.47	94	90	22.7	217.1	109.0	3.2
S9	7.1	110	85	15.1	262.2	154.0	2.8
S10	7.23	98	115	10.8	245.3	110.2	3.4
S11	7.1	86	85	18.14	322.2	109.12	2.8
S12	7.31	122	120	20.12	412.4	163.1	1.6
S13	7.22	130	95	18.14	283.2	156.2	2.2
S14	7.09	114	105	18.10	276.4	118.3	2.6
S15	7.14	96	65	22.10	246.3	146.28	3.4
S16	7.12	108	115	18.20	252.1	175.3	3.2
S17	7.11	94	80	20.14	296.4	125. 3	2.4
S18	7.52	124	75	12.1	310.5	153.5	2.2
S19	7.44	118	120	16.2	218.2	143.9	1.8
Mean±SD	7.33±0.23	100.73±17.01	92.89±21.87	18.8±3.76	267.93±46.53	134.23±20.14	2.64±0.62

TABLE 2. Level of trace metal concentrations in groundwater samples (ppm)

Sampling stations	Trace metals				
	Mn	Zn	Ni	Cd	Cu
S1	2.165	0.0539	0.0063	0.2035	0.0098
S2	1.891	0.1150	0.0250	0.0019	0.0130
S3	2.412	0.0593	0.0209	0.0480	0.0099
S4	1.812	0.2429	0.0130	0.0340	0.0074
S5	1.792	0.1382	0.0137	0.003	0.0054
S6	2.142	0.1814	0.0293	BDL	0.0087
S7	2.114	0.0679	0.0162	0.0048	0.0057
S8	1.816	0.0985	0.0150	0.0023	0.0134
S9	2.002	0.1155	0.0219	0.0001	0.0029
S10	2.166	0.4619	0.0176	BDL	BDL
S11	1.478	0.4226	0.0132	0.0011	0.0102
S12	2.188	0.0507	0.0143	0.0026	0.0061
S13	1.882	0.0220	0.0226	0.0108	0.0036
S14	1.662	0.0275	0.0132	BDL	0.0065
S15	1.422	0.2407	0.0177	BDL	0.1340
S16	1.664	0.1209	0.0181	BDL	0.0102
S17	1.224	0.0259	0.3792	0.0021	0.0074
S18	1.624	0.0225	0.0198	BDL	0.0013
S19	1.028	0.01194	0.0243	BDL	0.0075
Mean±SD	1.81±0.35	0.130±0.13	0.036±0.08	0.004±0.009	0.016±0.03
SE	0.08	0.02	0.01	0.002	0.006

The groundwater pH ranged from 7.09 to 7.9. As drinking water quality should be in the range of 5 to 9 as according to MPL, the water samples are well within the prescribed range. The results recorded total dissolved solids (109-175.33 mg/l, Hardness (66-130 mg/l), Free CO_2 (12.1-24.4mg/l), Electrical conductivity (217.1-310.5µS), Alkalinity (50-130 mg/l) and Dissolved oxygen (2.02-5.34 mg/l). These values were found within MPL.

The mean concentration of trace metals in groundwater is given in Table 2. The results showed that the overall mean concentration of Zn, Cd and Cu were 0.1304 ppm, 0.0045 ppm and 0.0165 ppm respectively. Ni and Mn showed mean concentrations of 0.0369 ppm and 1.81 ppm respectively. The mean concentrations in the groundwater samples decreased in the sequence of Mn>Zn>Ni>Cu>Cd.

Surface water

To determine the impact of leachate on the surroundings, the surface water samples were analysed for physico-chemical parameters and trace metal. The water quality parameters in surface water have been given in Table 3. The pH of the surface water samples are found in the range of 7.1 to 7.4. This range is within the MPL. The results recorded Hardness (90-150 mg/l), Alkalinity (130-160 mg/l), Free CO_2 (12.4-21.4 mg/l), Electrical conductivity (279-420µS), Total dissolved solids (320.4-440 mg/l).These values are well within the MPL. The total hardness is sometimes useful as an indicator proportionate to the total dissolved solids present, since Ca^{2+},Mg^{2+}, and HCO_3^- often represent the largest part of the total dissolved solids (Lin *et al*., 1996). The dissolved oxygen values are in the range of 0.9-3.2 mg/l. The high level of free CO_2 can be attributed to the heavy inflow of organic waste in the leachate that flows into the surrounding surface water (Kosygin et al., 2007).

TABLE 3. Physico-chemical characteristics of surface water samples (in mg/l) (<20m-<3000m)

Sampling stations	pH	Hardness (mg/l)	Alkalinity (mg/l)	Free CO_2 (mg/l)	EC (µS)	TDS (mg/l)	D.O (mg/l)
S1	7.1	138	130	12.4	345	346.5	1.2
S2	7.4	120	156	14.6	420	320.4	0.9
S3	7.2	112	160	21.4	279	326.6	1.4
S4	7.11	150	154	18.2	250	440	2.2
S5	7.2	90	130	16.8	316	428.4	2.4
Control	7.22	75	90	10.2	312	274	3.2
Mean±SD	7.20±0.12	137±23.28	164±14.76	16.68±3.43	322±65.57	372.38±57.39	5.58±0.64

The concentration of trace metals in surface water has been given in Table 4. The overall mean concentration of Mn, Zn and Ni are 0.725 ppm, 0.231 ppm and 0.035ppm respectively. The mean concentration of Cd and Cu are 0.004 ppm and0.013 ppm respectively. Sample no. S1 collected from within >20m from the dump has been found to have a higher concentration of all the trace metals analysed compared to the other samples. This indicates the gradual inflow of leachate from the dump into the surrounding surface water. The trace metals in surface water are found in the decreasing concentration of Mn>Zn>Ni>Cu>Cd.

TABLE 4: Level of trace metal concentrations in surface water samples (in ppm)

Sampling stations (<20-<3000m)	Trace metals				
	Mn	Zn	Ni	Cd	Cu
S1	1.2982	0.3272	0.1042	0.0075	0.01403
S2	1.7911	0.2952	0.0011	0.0111	0.0372
S3	0.192	0.2912	0.0981	0.0079	0.0052
S4	0.1504	0.3724	0.0012	BDL	0.0142
S5	0.7982	0.2011	0.0019	BDL	0.008
Control	0.1211	0.0016	0.0048	BDL	0.0032
Mean ±SD	0.725± 0.70	0.231±0.07	0.035±0.05	0.004±0.005	0.013±0.01
SE	0.31	0.03	0.02	0.002	0.004

Applicable national and international standards for trace metals in drinking water are presented in Table 5 to determine if the metal concentrations in water samples are found suitable to be used for drinking. In the present investigation, the mean concentration of Mn and Cd has been found to be higher than the MPL for groundwater and surface water. Trace metals (Zn, Cu, Ni) have been found to be within the MPL.

TABLE 5: Comparison of mean trace metal concentration (mg/l) with some national and international water quality standard

Metals	GW	SW	CPCB	WHO	IS:10500
Cadmium	0.004	0.004	2	0.003	0.01
Zinc	0.13	0.23	5	5	15.00
Copper	0.16	0.013	3	2	1.50
Nickel	0.036	0.035	3	0.02	
Manganese	1.81	0.725	2	0.5	0.50

SW=Surface water; GW=Groundwater

WHO (World Health Organization 1993), CPCB (Central pollution control Board 1993), BIS: 10500 (Bureau of Indian standards 1993)

In the present study, Cd and Mn have been found to be higher than the MPL. For Cd, the concentrations in groundwater and surface water are 0.004ppm for both. For Mn, the concentration in groundwater and surface water are 1.81ppm and 0.725 ppm respectively. These metals are toxic in higher concentration and also lead to bioaccumulation through the food chain. Cadmium above the permissible limit can potentially cause nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure along with kidney, liver, bone and blood damage from a lifetime exposure. (Chakrabarty and Sarma, 2010). The IARC has classified cadmium as a human carcinogen (group I) on the basis of sufficient evidence in both humans and experimental animal (IARC 1993). The CPCB (2007) in collaboration with the National Institute of hydrology, India, initiated groundwater quality survey and observed cadmium above the desirable limit in some areas of the country. (Buragohain *et al*., 2010). The lowest concentration of manganese in excess of (0.2 mg/ l) makes water distasteful to drinking with no specific toxic effects (Longe *et al*., 2007). Water containing more than 1mg/l manganese may impart objectionable staining properties on clothes during laundry operations (Eneji *et al*., 2012). Highest mean trace metal concentration was found for manganese (2.614ppm). Many igneous and metamorphic minerals contain divalent manganese as a minor constituent (Chakraborty and Sarma, 2010).The ideal intake amount of copper and zinc is 2 and 4-10mg/day respectively (Chung et al., 2009). Zinc belongs to a group of trace metals, which are essential for the growth of humans, animals and plants and are potentially dangerous for the biosphere when present in high concentrations (Bhagure and Mirgane, 2010). The main sources of pollution are industry and the use of liquid manure, composted materials and agrochemicals such as fertilizers and pesticides in agriculture (Romic and Romic, 2003). The transfer of contamination and its dispersion in the aquifer is a very slow process, and changes in metal concentrations in the upper aquifer layer are not manifested in a short time either. However, the smaller the solum depth, the higher the risk (Romic *et al.,* 1997).

CONCLUSION

The dumping ground is seven years old and it is evident from the study that the groundwater and surface water has accumulated toxic trace metals (Cd and Mn) higher than the MPL and it is a major health risk to the neighboring villages. Contamination of soil and water can lead to bioaccumulation through food chain.

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