DISTRIBUTION OF TRACE METALS IN DRINKING WATER OF SOME RURAL HABITATIONS IN WESTERN UTTAR PRADESH, INDIA AND THEIR SUITABILITY FOR DRINKING PURPOSE

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Abstract: A study was conducted to assess the distribution of manganese, copper zinc and iron in drinking water in some part of western Uttar Pradesh. Ground water in the study area is neutral to moderately in nature. It was observed that the ground water in the study area is having higher concentration of iron and zinc which is vulnerable to drink. Iron was much higher than the acceptable limit in approximately 59% of water sample as per guide line of (WHO) However, the concentration of zinc were permissible limit but it was much higher than acceptable limit as per EPA guideline. The concentration of copper and manganese was within the limit. The suitability of ground water for drinking purpose were examined using WHO and EPA classification, which indicate that ground water, was unsuitable for drinking purpose in few location.

Keywords: Trace metals, Drinking water, Manganese, Copper, Zinc, Iron

INTRODUCTION

Ground water is a main source of drinking water in developing world (Datta, P.S. 2005). In rural and small communities, ground water is only source of drinking water (Cantere , 1987). About 95% of rural population living in India depends upon ground water for domestic use (Mohair et al, 2002). Water pollution is a serious problem in India as almost 70% of its surface water and growing number of its ground water resources are already contaminated by biological, organic and inorganic pollutants (Sangu and Sharma, 1987 and Rao and Mamtha 2004). Recently it has been reported that more than 33% country ground water resources are unfit for consumption (Times of India, 2010). The main source of ground water contamination is animal waste, industrial effluents, fertilizer, herbicide, insecticide and fungicide. When these applied to crop land and mix in soil, same residue remains in the soil, after plant uptake and may leach in the ground water. Pollution of water is increasing steadily due to rapid population growth, industrial proliferations, urbanizations, increasing living standard and water spheres of human activities. (Ramkrishnan, C.K. *et al*., 2009 and Nageswera Rao *et al*., 2007). Modern agriculture practices (fertilizer and pesticide application in the field) have adversely effected the environment *e.g.*, ground water contamination with heavy metal. Due to economic region, fertilizers are usually not sufficiently purified during the process of manufacturing, and it contained several impurities, among them heavy metals (Table-1). Fertilizer like super phosphate contains the highest concentration of Cd, Co, Cu, and Zn as impurities. Copper sulphate and iron sulphate have the highest content of Pb and Ni (Eugnia *et al.*, 1995).

The behavior of trace metals in ground water is complicated and occurs due to biogeochemical process (WHO, 1993). A number of trace elements are important for the growth and development in the body for example, Zn is essential dietary element and its deficiency causes hypogonadism (Whitten et al, 2004). Trace metals, such as Cu and Zn are necessary in low concentration for all living organism while excess concentration of these elements is harmfull (Merian, 1991).

MATERIAL AND METHOD

Study area

For the study of the problem different villages around the kali east river in Meerut district were selected. Meerut is situated on the Delhi- Dehradun highway and geographically it is located at 29^0 04' N latitude, 77^0 42' E longitude and at an altitude of 237 meter above the mean sea level. The climate of this region is subtropical characterized with extreme summer as well as winter. The maximum temperature between 43 to 45 ^{0}C is common during summer while low temperature of 3 ^{0}C accompanied by frost may be experienced in December to January. The winters are cool; frost generally occurs at the end of December and may continue till the end of January. There is a long variation in rainfall distribution in this region about 80-90 % of rain fall is received during July to September.

Water sample analysis

The samples were collected after the extraction of water either from privately owned manually operated hand-pumps or from electricity operated bore-wells. The water was left to run from the sampling source for 4–6 min to pump out the volume of water standing in the casing before taking the final sample. Then samples were collected in pre-cleaned, sterilized polyethylene bottles of l litre capacity. The samples were taken by holding the bottle at the bottom to avoid any contamination and were analyzed just after the sampling. All the samples were stored in a portable Ice box and transported to the laboratory within 5 hour and stored at low temperature. Ground water samplings were analyzed cationic composition in ground waste. The concentration of manganese, copper, zinc and iron was determined by atomic absorption spectrometer (Parkin-Elmer Made 3110). Analytical grade (AR) chemicals and double glass distilled water were used to prepare the reagents. The analysis of various anionic composition were performed according to APHA, 1998 and APHA–AWWA–WPCF(1994).

Table 1. Metal ion accumulation in underground water in left and right hand side villages of near Kali east river.

S.No.	Name of Villages	Manganese	Copper	Zinc	Iron
1.	Satguru Nagar	ND	.0016	.004	.020
2.	Nagali	.006	.001	ND	.030
3.	Mehalka	.004	.006	.012	.020
4.	Kheri	.042	.009	.081	.189
5.	Mohammadpur	.098	.005	.942	.320
6.	Daurala	.34	.018	.342	4.72
7.	Iklauta	.12	.004	.148	.520
8.	Dhanju	.034	.001	.418	1.18
9.	Ajohata	.190	.031	.078	.165
10.	Dedwa	.283	.145	1.86	5.25
11	Jalalpur	.205	.03	1.54	.510
12.	Jalalpur	.185	.03	1.32	1.21
13.	Ulday Pur	.132	.02	1.43	1.81
14.	Ulday Pur	.131	.02	1.40	1.24
15.	Mathana	.110	.05	.560	1.45
16.	Khanauda	.146	.04	.022	.180
17.	Chalera	.018	.02	.118	.110
18.	Aurangabad	.099	.03	.198	1.65
19.	Aurangabad	.078	.009	.178	.150
20.	Senni	.148	.001	.017	1.82
21.	Rali	.100	.03	.042	.620
22.	GeshuPur	.420	.04	.134	3.52
23.	Kajipur	.220	.01	.121	1.25
24.	Gokul Pur	.142	.03	1.18	1.38
25.	Jai Bhim Nagar	.810	.04	7.18	2.62
26.	Jai Bhim Nagar	.721	.02	4.18	1.85
27.	Alipur	.102	.008	.089	.550
28.	Kohal	.100	.05	3.20	1.60
29.	Ataria	ND	.01	.280	1.62
30.	Itola	.056	.03	1.12	.940
31.	Ajrana	.048	.01	.450	.120
32.	Kudha	.094	.001	.480	10.28

Table 2. Heavy metal contents (average) in fertilizers commonly used in the study area. (Pathak *et al.*, 2002)

Fertilizer	Heavy metal (mg kg^- fertilizer)					
	Cu	Zn	Mn	Mo	Cd	Pb
Single super phosphate	26	115	150	3.3	187	609
Diammonium Phosphate	-	-	-	109	188	-
Muriate of potash	3	3	8	0.2	14	88
Ca-ammonium nitrate	0.2	6	11	-	6	200
Urea	0.4	0.5	0.5	0.2	1	4
Ammonium Sulphate	0.5	0.5	70	0.1	-	-
Triple super Phosphate	7	75	200	0.1	-	-
Ammonium Phosphate	3	80	160	2	-	-
Complex fertilizer	22	276	-	-	6	128
Rock Phosphate	100	200	0.5	-	-	-

RESULT AND DISCUSSION

Manganese occurs mainly in the form of maganese and mangniferrous oxide in ground water. It is obvious from the data (table 1) that the manganese was available in maximum samples and ranged varied from 0.006 to 0.81 mg/l. The manganese concentration was within the permissible limit in all the samples, in the study area. The maximum allowable concentration and the permissible concentration of manganese in drinking water are 0.5 and 1.0 mg/l, respectively, according to WHO, (1984) and ISI, (1983). Manganese is one of the most abundant metals in the earth's crust and usually occurs with iron. Edmunds and Smedley (2000). Edmunds (2000) suggested that manganese could be released by incongruent reactions from silicate or oxide minerals and emerged as potential residence-time indicators. Besides, some elements as redox-sensitive and local chemical conditions could affect their availability and mobility in groundwater. (Zachara *et al.*, 1995, Kedziorek *et al.*, 1998 and Davis *et al.*, 2000).

Copper was available in each sample from villages which varied from 0.001 to 0.14 mg/l. The concentration of copper was within permissible limit. The permissible limit of copper is (2mg/l) as per recommendation of WHO, (2004) and (2011). High concentration of copper in some samples in the study area might be due to interior copper plumbing. (USPEA, 1991). Copper is essential micronutrient, but its high concentration causes physiological effect in human being. Water containing 3mg/l was associated with gastrointestinal disturbance in adults (Pizarro et al 1999). Excess copper in human body is toxic and causes hypertension and produces pathological changes in brain tissues. However, excessive ingestion of copper is responsible for specific diseases of bone (Krishnamurthy and Pushpa, 1995)

Zinc concentration in ground water varied from 0.004 to 7.18 mg/l in the study area. The maximum allowable concentration and the permissible concentration of zinc in drinking water are 10 and 5.0 mg/l respectively, according to ISI (1981). The concentration of zinc is within the permissible limit in all samples. However, according to the guideline of EPA, approximately 59% water samples showed higher concentration than permissible limit. The permissible limit of zinc in drinking water is 1.5 mg/l according EPA guideline. Zinc occurs as a natural mineral in most of the drinking water. It is an essentially dietary nutrients and beneficial human health (Vallce, 1957). However, excess zinc concentration creates aesthetic effect (metallic taste in the water). In this study area, intensive agricultural activities high uses of fertilizers and micronutrients may be a major source of high concentration of zinc in groundwater. Similar results were reported by Rajmohan and Elango (2005) in groundwater of South India. In some samples, high concentration of zinc may be due to leaching of zinc from piping and fitting (Nriagu, C. 1980).

Zinc is nutritionally essential elements which is necessary for growth and is involved in several physiological functions. Nevertheless, at higher concentration, zinc can be toxic to the organism. It is also plays an important role in protein synthesis. Zinc is a metal which shows fairly low concentration in surface water, which is due to its restricted mobility from the place of rock weathering or from the natural sources (BIS, 1998).

Iron contamination in drinking water in the study area ranged between 0.02 to 10.28 mg/l. The maximum allowable concentration of iron in drinking water is 1.5 mg/l according to WHO, (2004) and (2011). As per ISI, the permissible limit of iron in drinking water is 0.3 mg/l. In the study area, 18 samples out of 32 samples showed higher concentration according to WHO standard and 22 samples showed, the concentration of iron more than permissible limit (BIS, 1995). It seems to be of high content of iron in 56% of samples and water can be used other than drinking purpose. The high concentration of iron in some samples might be due to a lot of iron industries, effluent of paper mills, sugar mills dumped in kali east river without any treatment. Another reason for its contamination may be due to rainwater percolating through soil and rocks dissolves minerals containing iron and hold this in solution. These iron rich water recharge surface water and aquifers that inevitably serve as drinking water sources (Colter and Mahler 2006). The higher concentration of iron in hand pump and tube wells water might be due to soil origin and age old corroded iron pipes. (Borah *et al*. 2009).

During the course of investigation, there are number of major and minor industries which discharge their effluents in leaked open channels, sewerage line from city and villages also dump their solid and liquid wastes to the kali east river which pollute the river and water resources around the study area. In the study area the major ion concentration were higher than that of ground water observed in the rest of the region. This may be due to continuous withdrawal of groundwater for drinking through bore-wells which leads to river water intrusion in the ground water.

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