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Original Research Paper

Heavy Metal Concentration in Surface and Sub Surface Waters Along Tungabhadra River in Karnataka, India

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ABSTRACT

The occurrence of heavy metals in surface and groundwater samples were measured at 8 sampling points along stretches of Tunga, Bhadra and Tungabhadra rivers of Karnataka. Eighteen surface and 33 groundwater samples were collected and the concentrations of 7 heavy metals (cadmium, nickel, lead, iron, manganese, zinc, copper) were measured using Atomic Absorption Spectrophotometer (AAS). The concentrations of Cd, Ni, Pb and Cu were well below detectable level (BDL) and only Fe, Mn and Zn were detected in both types of water samples. Concentrations of Zn in both the water samples were well within the permissible limit of drinking water standards. The concentration of Fe in 43 and Mn in 33 water samples in the pre-monsoon, and Fe in 31 and Mn in 9 water samples in the post-monsoon seasons exceeded the permissible limit of drinking water standards. The purpose of this study was to identify distribution of the trace metal contaminants in surface and groundwaters along the river stretch, the findings of which would raise significant ecological and public health concerns.

INTRODUCTION

Toxic heavy metals in air, soil and water are global problems that are growing threat to humanity. Metals, a major category of globally distributed pollutants, are natural elements which have been extracted from the earth and harnessed for human, industry and products for millennia. Metals are notable for their wide environmental dispersion, tendency to accumulate in select tissues of human body and plants, and their overall potential to be toxic even at relatively lower levels of exposure. Some metals, such as copper and iron, are essential to life and play irreplaceable roles, for example, the functioning of critical enzyme systems. Other metals are xenobiotics, i.e., they have no useful role in human physiology (and most other living organisms) and, even worse, as in the case of lead and mercury, may be toxic even at trace levels of exposure. Even those metals which are essential, however, have the potential to turn harmful at high levels of exposure, a reflection of a very basic tenet of toxicology **-** the dose makes the poison (Howard 2002).

Tunga and Bhadra rivers are flowing through the densely populated regions and are exposed to maximum anthropogenic exploitation, resulting in regular increase in the degree of pollution. They also receive domestic and agricultural wastes. All these wastes are finally carried to the major river Tungabhadra. Many studies on physicochemical and hydrobiological characteristics of Tunga, Bhadra and Tungabhadra rivers have been carried out (David 1956, Sabhita et al. 1998, Parameswar Naik 1998, Patil 1999, Vanaja 2000, Chandrahas & Varnekar 2001, Gupta & Anupam Sharma 2002, Manjappa 2002**).** These studies emphasized mainly on the physicochemical, biological and heavy metal analysis of river water quality in specific regions of Tunga, Bhadra and Tungabhadra rivers.

However, the present research study deals with the assessment of the heavy metal contamination through the full length of the Tungabhadra river from Gangamula (origin) to the Hospet. The primary objective of the study was to determine the amount of heavy metals present in surface and groundwaters along the Tunga, Bhadra and Tungabhadra rivers stretches of Karnataka.

MATERIALS AND METHODS

The study was carried out in April (pre-monsoon season) and December 2006 (post-monsoon season). Samples were collected from eight different locations along the Tungabhadra river stretch. Starting from the origin place of Tunga and Bhadra river (Gangamula), Shimoga (Tunga river), Bhadravathi (Bhadra river), Kudli (the confluence point of Tunga and Bhadra river), Hairihara, Huvinahadagali and Hospet (Tungabhadra river), a total of 51 samples were collected from both surface and groundwaters (Table 1).

Sample collection: The water samples from tube wells and hand pumps were collected by first running the water for at least 15 minutes so that the sediments, precipitates already formed either on the surface of the well or in the pipelines due to drying of materials, are washed away and prevented from contaminating the samples. Groundwater samples were collected in 2 L labelled polyethylene screw cap containers. Further, to know the pollution load of the river stretch, samples were collected from the midstream at the depth of 1-2 ft and transported to the laboratory.

Sample preparation: Water samples (500 mL) were filtered through Whatman No. 41 (0.45 μm pore size) filter paper for estimation of dissolved heavy metal content. Filtrate and collected water samples (500 mL each) were preserved with 2 mL nitric acid to prevent the precipitation of metals. Both the samples were concentrated ten-folds on a water bath and subjected to nitric acid digestion (Clesceri 1998, Anton Paar 1998) for further analysis.

Sample analysis: Heavy metal analyses were carried out by atomic absorption spectrophotometer (Model: GBC Avanta PM 8 lamps). Average values of three replicates were taken for each determination. The detection limits for Fe, Zn, Cd, Cu, Ni, Pb and Mn were 0.05, 0.008, 0.025, 0.04, 0.06 and 0.000 (mg/L) respectively (Athanasopoulos 2002).

RESULTS AND DISCUSSION

The results of the study are presented in Table 2. In the present study, only Fe, Mn and Zn were detected in surface and groundwater samples, whereas Cd, Ni, Pb and Cu were well below the detection level (BDL) in both surface and groundwater samples.

In pre-monsoon season, concentration of heavy metals like Fe in 15 and Mn in 10 samples, and in post-monsoon season 10 and 3 samples respectively, was found to be high. The values exceeded the permissible limit prescribed by BIS (1998) and WHO (1998) standards for drinking water. In all the samples analysed, cadmium, nickel, lead and copper concentrations were well below detectable level. Concentrations of heavy metals vary seasonally, however, heavy metal concentrations are generally greater during periods when the river flow is low (pre-monsoon months), because the decrease in water volume decreases dilution effects and the decrease in suspended sediment concentrations decreases metal scavenging processes.

The concentration of heavy metals in groundwater samples was found to be high in 28 samples for Fe and in 23 samples for Mn during pre-monsoon season. In post-monsoon season, the concentrations of Fe and Mn were found to be high in 21 and 6 samples respectively. The values exceeded the

Table 1: Surface and groundwater sample details with sample ID code.

S. No.	Sample ID	Sampling point
Surface Waters		
1	R1	Origin place of river Tunga
2	R2	Near Nagathirtha (near Small Bridge)
3	R3	Origin place of river Bhadra
4	R4	Near Nature Camp Bhagavathi
5	R5	Near Babahalli
6	R6	Near Holle belagalu
7	R7	Near Bridge from Pillenagere to Shimoga
8	R8	In Rangappaswamy Temple, Pillenagere
9	R9	In Kudli, Confluence point of Tunga and Bhadra
10	R10	In Siddlepura
11	R11	In Rajanahalli
12	R12	In Halasabalu behind (PC Bavaraju House)
13	R13	Below Bridge near Madalagati
14	R14	Near Forest Nursery Koralahalli
15	R15	In Hale Mudalapura
16	R16	Hulligeramma temple
17	T1	Balagala Kere (Holehonur Road)
18	T2	Puralikere on Road from Pillenagere to Shimoga
Goundwaters		
1	G1	Near Ganesha Temple before Kerekate
2	G2	Infront of Rain gauge station, Kerekate
3	G3	After Kerekate (Sringeri 16kms Stone)
4	G4	Near Forest Check post Kudremukh
5	G5	In RanganthaSwamy Temple Babahalli
6	G6	Near Government School Babahalli
7	G7	Near Maleshappa S/O Lakshmanappa House, Holle belagalu
8	G8	Near Rangappa S/O Kenchappa House, Holle belagalu
9	G9	Roadside near Pillenagere on Shimoga road
10	G10	In Pillenagere.
11	G11	In Eshwarappa House, Tervarachatana halli
12	G12	In Pushpa rice mill, Goudichantanahalli
13	G13	Roadside in Kudli
14	G14	In Siddlepura
15	G15	Roadside in Donnanayakapura
16	G16	In Holle hatti
17	G17	In Rajanahalli near Auto / Bus stand
18	G18	In Ningaiah House
19	G19	Paddy field near main road, Rajanahalli
20	G20	Near Government Fair shop in Halasabalu
21	G21	Near Mohans Miltary Hotel in Kodial Hospet
22	G22	In Margada Durgamma Temple on Harihara-Haveri Road
23	G23	Near Ragavenrda swamy temple,Harihara
24	G24	Near Hulligeramma temple
25	G25	In Hosa Mudalpura
26	G26	Roadside on Hospet to Kustagi Road (Belagum Dhaba)
27	G27	In Dress Camp near Murugan Temple
28	G28	In Amaravathi Canal side bore well
29	G29	In Amaravathi new bore well
30	G30	In Madalagati
31	G31	Roadside in Koralahalli
32	G32	In Forest Nursery Koralahalli
33	G33	Drinking water of Komballi

permissible limit prescribed by BIS (1998) and WHO (1998) for drinking water (Table 3). In all the samples analysed, cadmium, nickel, lead and copper concentrations were found to be well below detectable level.

The iron content in the surface waters ranged from a minimum of 0.28 mg/L at Ra1 to a maximum of 1.5 mg/L at Rh1 and Rh2, during April 2006. In December 2006, it varied from a minimum of 0.118 mg/L at Rb2 to a maximum of 0.830 mg/L at Rh2. In groundwater samples iron content fluctuated from a minimum of 0.10 mg/L at G33 to a maximum of 3.50 mg/L at G14 during premonsoon period. In post-monsoon, it was found from a minimum of 0.070 mg/L at G33 to a maximum of 1.866 mg/L at G1. The BIS acceptable limit for iron is 1.0 mg/L. However, the high concentration of iron may be due to the rock unit, rock-water interaction and nature of the soil (Warrin et al. 1971). Beyond the permissible concentration, iron alters the aesthetic quality of water (Sawant et al. 2000).

According to WHO (1998), the permissible limit for manganese is 0.1 mg/L and excessive limit is 0.5 mg/L. These limits have been established, mainly because of aesthetic and economic considerations rather than physiological hazards. However, manganese is undesirable in domestic water supplies as it causes unpleasant tastes, deposits on food during cooking, stains and discolours laundry and plumbing fix-

Table 2: Heavy metal concentration in water samples in pre and post monsoon seasons (April 2006-December 2006).

Sl No	Sample ID	Cadmium (Cd)	Nickel (Ni)	Lead (Pb)	Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
Heavy metal concentration in surface water samples for pre-monsoon season (April 2006).								
1	Ra1	BDL	BDL	BDL	0.28	BDL	BDL	BDL
2	Ra2	BDL	BDL	BDL	0.30	BDL	BDL	BDL
3	Rb1	BDL	BDL	BDL	0.35	0.01	0.10	BDL
4	Rb2	BDL	BDL	BDL	0.30	BDL	BDL	BDL
5	Rc1	BDL	BDL	BDL	0.61	0.20	0.10	BDL
6	Rc2	BDL	BDL	BDL	0.63	0.18	0.10	BDL
7	T1	BDL	BDL	BDL	0.55	0.10	BDL	BDL
8	Rd1	BDL	BDL	BDL	0.60	0.20	BDL	BDL
9	Rd2	BDL	BDL	BDL	0.50	0.10	BDL	BDL
10	T2	BDL	BDL	BDL	0.50	0.10	BDL	BDL
11	Re1	BDL	BDL	BDL	0.60	0.10	BDL	BDL
12	Re2	BDL	BDL	BDL	0.60	0.10	BDL	BDL
13	Rf1	BDL	BDL	BDL	0.50	BDL	BDL	BDL
14	Rf2	BDL	BDL	BDL	0.40	BDL	BDL	BDL
15	Rg1	BDL	BDL	BDL	0.35	BDL	BDL	BDL
16	Rg2	BDL	BDL	BDL	0.35	BDL	0.15	BDL
17	Rh1	BDL	BDL	BDL	1.50	0.10	0.20	BDL
18	Rh2	BDL	BDL	BDL	1.50	0.10	0.15	BDL
Heavy metal concentration in surface water samples for post-monsoon season (December 2006).								
1	Ra1	BDL	BDL	BDL	0.159	BDL	BDL	BDL
2	Ra2	BDL	BDL	BDL	0.170	BDL	BDL	BDL
3	Rb1	BDL	BDL	BDL	0.180	0.020	BDL	BDL
4	Rb2	BDL	BDL	BDL	0.118	BDL	BDL	BDL
5	Rc1	BDL	BDL	BDL	0.369	0.140	BDL	BDL
6	Rc2	BDL	BDL	BDL	0.380	0.100	BDL	BDL
7	T1	BDL	BDL	BDL	0.320	0.035	BDL	BDL
8	Rd1	BDL	BDL	BDL	0.420	0.150	BDL	BDL
9	Rd2	BDL	BDL	BDL	0.280	BDL	BDL	BDL
10	T2	BDL	BDL	BDL	0.300	0.030	BDL	BDL
11	Re1	BDL	BDL	BDL	0.410	0.035	BDL	BDL
12	Re2	BDL	BDL	BDL	0.430	0.040	BDL	BDL
13	Rf1	BDL	BDL	BDL	0.356	BDL	BDL	BDL
14	Rf2	BDL	BDL	BDL	0.240	BDL	BDL	BDL
15	Rg1	BDL	BDL	BDL	0.180	BDL	BDL	BDL
16	Rg2	BDL	BDL	BDL	0.199	BDL	0.070	BDL
17	Rh1	BDL	BDL	BDL	0.816	BDL	0.181	BDL
18	Rh2	BDL	BDL	BDL	0.830	BDL	BDL	BDL
Heavy metal concentration in groundwater samples for pre-monsoon season (April 2006)								
1	G1	BDL	BDL	BDL	3.200	0.35	0.20	BDL
2	G2	BDL	BDL	BDL	3.100	0.30	0.10	BDL
3	G3	BDL	BDL	BDL	3.000	0.31	0.15	BDL
4	G4	BDL	BDL	BDL	0.400	0.01	BDL	BDL
5	G5	BDL	BDL	BDL	1.000	0.10	0.15	BDL
6	G6	BDL	BDL	BDL	1.100	0.10	0.10	BDL
7	G7	BDL	BDL	BDL	1.100	0.10	0.20	BDL
8	G8	BDL	BDL	BDL	0.550	0.35	1.30	BDL
9	G9	BDL	BDL	BDL	0.650	0.10	BDL	BDL

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10	G10	BDL	BDL	BDL	0.600	0.10	BDL	BDL
11	G11	BDL	BDL	BDL	0.100	BDL	BDL	BDL
12	G12	BDL	BDL	BDL	0.500	0.50	BDL	BDL
13	G13	BDL	BDL	BDL	2.000	0.10	0.20	BDL
14	G14	BDL	BDL	BDL	3.500	0.20	0.10	BDL
15	G15	BDL	BDL	BDL	1.500	0.15	BDL	BDL
16	G16	BDL	BDL	BDL	0.300	0.10	BDL	BDL
17	G17	BDL	BDL	BDL	0.400	BDL	BDL	BDL
18	G18	BDL	BDL	BDL	0.950	0.10	1.50	BDL
19	G19	BDL	BDL	BDL	0.900	0.10	0.15	BDL
20	G20	BDL	BDL	BDL	0.950	0.15	0.15	BDL
21	G21	BDL	BDL	BDL	0.950	0.10	0.10	BDL
22	G22	BDL	BDL	BDL	1.050	0.10	0.05	BDL
23	G23	BDL	BDL	BDL	0.900	0.10	BDL	BDL
24	G24	BDL	BDL	BDL	0.320	BDL	BDL	BDL
25	G25	BDL	BDL	BDL	0.300	BDL	BDL	BDL
26	G26	BDL	BDL	BDL	0.280	0.10	BDL	BDL
27	G27	BDL	BDL	BDL	0.300	BDL	BDL	BDL
28	G28	BDL	BDL	BDL	0.350	0.20	0.50	BDL
29	G29	BDL	BDL	BDL	0.400	BDL	BDL	BDL
30	G30	BDL	BDL	BDL	1.550	0.10	0.10	BDL
31	G31	BDL	BDL	BDL	0.200	BDL	BDL	BDL
32	G32	BDL	BDL	BDL	0.200	BDL	BDL	BDL
33	G33	BDL	BDL	BDL	0.100	BDL	BDL	BDL
Heavy metal concentration in groundwater samples for post-monsoon season (December 2006)								
1	G1	BDL	BDL	BDL	1.866	0.200	0.125	BDL
2	G2	BDL	BDL	BDL	1.765	0.118	BDL	BDL
3	G3	BDL	BDL	BDL	1.800	0.190	BDL	BDL
4	G4	BDL	BDL	BDL	0.208	0.010	BDL	BDL
5	G5	BDL	BDL	BDL	0.593	0.030	BDL	BDL
6	G6	BDL	BDL	BDL	0.612	0.025	BDL	BDL
7	G7	BDL	BDL	BDL	0.627	0.030	0.161	BDL
8	G8	BDL	BDL	BDL	0.374	0.260	0.746	BDL
9	G9	BDL	BDL	BDL	0.478	0.010	BDL	BDL
10	G10	BDL	BDL	BDL	0.462	BDL	BDL	BDL
11	G11	BDL	BDL	BDL	0.070	BDL	BDL	BDL
12	G12	BDL	BDL	BDL	0.382	0.460	BDL	BDL
13	G13	BDL	BDL	BDL	1.080	0.015	BDL	BDL
14	G14	BDL	BDL	BDL	1.199	0.020	0.044	BDL
15	G15	BDL	BDL	BDL	0.800	BDL	BDL	BDL
16	G16	BDL	BDL	BDL	0.780	BDL	BDL	BDL
17	G17	BDL	BDL	BDL	0.280	BDL	BDL	BDL
18	G18	BDL	BDL	BDL	0.260	BDL	BDL	BDL
19	G19	BDL	BDL	BDL	0.512	BDL	0.885	BDL
20	G20	BDL	BDL	BDL	0.500	BDL	BDL	BDL
21	G21	BDL	BDL	BDL	0.530	BDL	BDL	BDL
22	G22	BDL	BDL	BDL	0.550	BDL	BDL	BDL
23	G23	BDL	BDL	BDL	0.580	BDL	BDL	BDL
24	G24	BDL	BDL	BDL	0.630	BDL	BDL	BDL
25	G25	BDL	BDL	BDL	0.180	BDL	BDL	BDL
26	G26	BDL	BDL	BDL	0.163	0.08	BDL	BDL
27	G27	BDL	BDL	BDL	0.160	BDL	BDL	BDL
28	G28	BDL	BDL	BDL	0.178	0.190	0.356	BDL

Table cont.

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29	G29	BDL	BDL	BDL	0.200	BDL	BDL	BDL
30	G30	BDL	BDL	BDL	0.812	BDL	BDL	BDL
31	G31	BDL	BDL	BDL	0.120	BDL	BDL	BDL
32	G32	BDL	BDL	BDL	0.130	BDL	BDL	BDL
33	G33	BDL	BDL	BDL	0.070	BDL	BDL	BDL

Note: BDL - Below Detectable level

Table 3: BIS (1998) and WHO (1998) standards for drinking water.

Sl No.	Parameters	BIS (1998)		WHO (1998)	
		P	E	P	E
1	Copper	0.05	1.50	0.05	1.00
2	Cadmium	0.01	0.01	0.01	0.01
3	Lead	0.05	0.05	0.05	0.05
4	Iron	0.30	1.00	0.30	1.00
5	Zinc	5.00	15.00	-	15.00
6	Manganese	0.10	0.30	0.10	0.30
7	Nickel	-	-	-	-

Note: P = Permissible limit; E = Excessive limit

tures. The manganese content during pre-monsoon season ranged from below detectable level at Ra1, Ra2, Rb2, Rf1, Rf2, Rg1 and Rg2 to a maximum of 0.20 mg/L at Rc1 and Rd1. During the post-monsoon season, the Mn varied from BDL at Ra1, Ra2, Rb2, Rd2, Rf1, Rf2, Rg1, Rg2, Rh1 and Rh2 to a maximum of 0.140 mg/L at Rc1. In groundwater samples, the concentration of manganese fluctuated from BDL at G11, G17, G24, G25, G27, G29, G31, G32 and G33 to a maximum of 0.50 mg/L at G12 during pre-monsoon season. In post-monsoon season, the manganese concentration varied from BDL at G10, G11, G15, G16, G17, G18, G19, G20, G21, G22, G23, G24, G25, G27, G29, G30, G31, G32 and G33 to a maximum of 0.0460 mg/L at G12.

Zinc is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of zinc. Drinking water also 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. Extensive literature on the aquatic toxicity of zinc and especially its toxicity to fishes has been reviewed by Alabaster & Lloyd (1980) and by Spear (1981). Zinc has low toxicity to man but relatively high toxicity to fish.

The zinc content in the present investigation fluctuated from BDL at Ra1, Ra2, Rb2, T1, T2, Rd1, Rd2, Re1, Re2, Rf1, Rf2 and Rg1 to a maximum of 0.20 mg/L at Rh1 during pre-monsoon season. In post-monsoon season the zinc content fluctuated from 0.070 mg/L at Rg2 and 0.181 mg/L at Rh1. The zinc levels in all the stations were well within the standards prescribed by BIS for drinking water. In groundwater samples, the concentration of zinc ranged from BDL at G4, G9, G10, G12, G15, G16, G17, G23, G24, G25, G26, G27, G29, G31, G32 and G33 to a maximum of 1.50 mg/L at G18 during pre-monsoon. In post-monsoon the zinc concentration was measured in G1, G7, G8, G14, G19 and G28.

CONCLUSION

The problem of heavy metal pollution may remain as a legacy of mass industrial activity for many generations and is likely to escalate further in future. In this regard the compilation of past and the present catalogues of heavy metal concentrations is an activity of great importance. Heavy metal pollution is a quickly growing problem for our surface and subsurface water resources. Right now it may not be the biggest pollution problem, but just waiting for it to go away or to solve itself is not going to help. We need to be aware of the problems heavy metals create, so we all, in our own little ways, can contribute to the solutions. Clean water is our step into a clean future. We need to inform people about how heavy metal pollution gets into our environment so they can be more aware of the threats of these pollutants. Immediate attention has also to be devoted to find suitable methods for the recycling and reuse of wastewater. An integrated approach by the environmental engineers, biologists, scientists, and voluntary and Government organizations will certainly help in maintaining a clean and healthy environment.

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