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HEAVY METAL IN WATER AND SOIL OF BYRAMANGALA AND HAROBELE COMMAND AREAS OF ARKAVATHI PERI URBAN AREAS OF BANGALORE CITY

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ABSTRACT

Arkavathi, a tributary of river Cauvery is facing a threat from urbanisation and industrialization since the last few decades. The concentration of heavy metals in surface and ground water and in the soil has been assessed. The water samples were collected from borewells in 5 villages each in both command areas. The seven heavy metals namely Cd, Cr, Pb, Cu, Fe and Zn were analysed. Nickel exceeds the permissible limits in all the surface and ground water samples from both the command areas. Similarly, Iron and Cadmium in Byramangala. Nickel, Iron and Cadmium in Harobele were found to exceed the permissible limits. Lead was found to be above the permissible limit in ground water sample of Chowkahalli village in Harobele command area, while was found to be absent in all the ground water samples of Byramangala command area. Zinc was found to be present but within the permissible limit in all the ground water samples and was absent in ground water sample of Igolhalli village of Harobele command area. Iron in all the ground water samples of Byramangala command area was found to be above the permissible limit, while it was found to exceed the limit in only ground water sample of Bendagudu village in Harobele command area. Chromium was found to exceed the permissible limits in all the ground water samples of both the command areas. Consequently, the order of heavy metals mean concentrations in soils in the soil samples of Byramangala command areas was found to be in the order- Fe >Ni > Zn > Cu> Pb> Cr >Cd, similarly, in Harobele command area the heavy metals were found in the order-Fe >Zn > Ni > Cu> Pb>Cd>Cr.

KEY WORDS : Heavy Metal, Bangalore, Command Areas

INTRODUCTION

Cities are important driving forces in environmental trends as a consequence of the increase in urban population in developing countries, also with various anthropogenic activities that brings lots of change in cities (Marcotullio *et al.*, 2008). The urban population of the world has grown rapidly from 751 million in 1950 to 4.2 billion in 2018. The world recently hit a level of 50% urbanization and the United Nations predicts that the share of urban population will increase to 60% over the next 30 years (UN DESA 2018). This increase in urban population results in rapid growth of urbanization and industrial development, land use land cover change and simultaneously with change in people lifestyle resulted in a poor management of sewage and industrial effluents. Which creates generation of waste water on large scale leads to immense demand for the fresh water (Intizar *et al.*, 2001). That encouraged the utilization of sewage wastewater for irrigation. The use of domestic sewage in farming is becoming prevalent as demand of water is increasing (Najam and Kaur, 2016). Irrigation with sewage became a common practice in arid and semiarid regions, where it was abundantly available (Mekki *et al.*, 2013). The changes in land use of upstream catchment area determine the characteristics of both quantity as well as quality of inflowing water. Quite a number of seasonal rivers have become perennial due to continuous influx of sewage and effluents in urban fringe. Accumulation of trace elements at high concentration in plants growing in polluted environment can lead to serious risk to human health upon consumption (Voutsa *et al.*, 1996). Further, the heavy metals such as cadmium (Cd), Chromium (Cr) and lead (Pb) can have carcinogenic effect (Trichopoulos, 1997).

Soil is a complex system with chemical, biological, physical, geological reactions varying over time and space. Soil forms the central medium for the transportation of heavy metals from the vegetation to humans (Nicholson *et al.*, 2003). Soil is considered as one of the major environmental compartment functioning as a sink for trace elements released by anthropogenic activities (Senesil *et al.*, 1999). Also, depending on type of crops irrigated repeatedly with contaminated water over a period of time (Rapheal and Adebayo, 2011; Balkhair and Ashraf, 2106). The use of waste water has both positive and negative impact on soil and crops as well. In order to make the beneficial usage of sewage it is necessary to adopt scientific approaches such as treating sewage at primary level before used for irrigation to avoid short and long-term environmental risks (Panaskar and Pawar, 2011). The heavy metals remain much longer in soil compared to other parts of the biosphere-air or water (Lasat, 2002; Song *et al.*, 2004). Sewage has significant impact on both soil characteristics and productivity of crops, which may improve the physiochemical characteristics of soil. Some physicochemical properties of soils such as pH and Organic carbon (OC) are important parameters which control the accumulation and the availability of heavy metals in the soil environment (Krishna and Govil, 2007). Domestic wastewater contains essential plant nutrients such as N, P, K and micronutrients which are beneficial for plants growth (Najam and Kaur, 2016). Besides the beneficial plant macro- and micronutrients and organic matter, sewage sludges and composted urban refuses, contain a wide and variable range of potentially harmful trace elements based on the composition of sewage having varying concentration of trace elements (Alloway and Jackson, 1991).

Hence the present study has been undertaken to assess the heavy metals in surface and ground water and the soils in peri-urban regions of Bengaluru, where farmers are using contaminated water for irrigation in Arkavathi river basin.

MATERIALS AND METHODS

Study area

The study area includes Byramangala and Harobele command areas of Arkavathi river basin. River Arkavathi apart from receiving the sewage through its tributary Vrushabhavathi, which receives untreated or partially treated sewage and industrial effluents from the Bangalore city. Bidadi, Kumbalagodu and Harohalli Industrial areas lies in peri-urban areas of catchment area, which discharge partially treated effluents. To assess the heavy metals in water and soils villages coming within 5 km on either side of river is considered. For soil, agricultural fields with different crops were considered.

Sample collection and analysis

Water samples collection and analysis

Ground water samples were collected from Byramangala and Harobele command area of Arkavathi River. A total of five samples were collected from Byramangala, Chowkahalli,

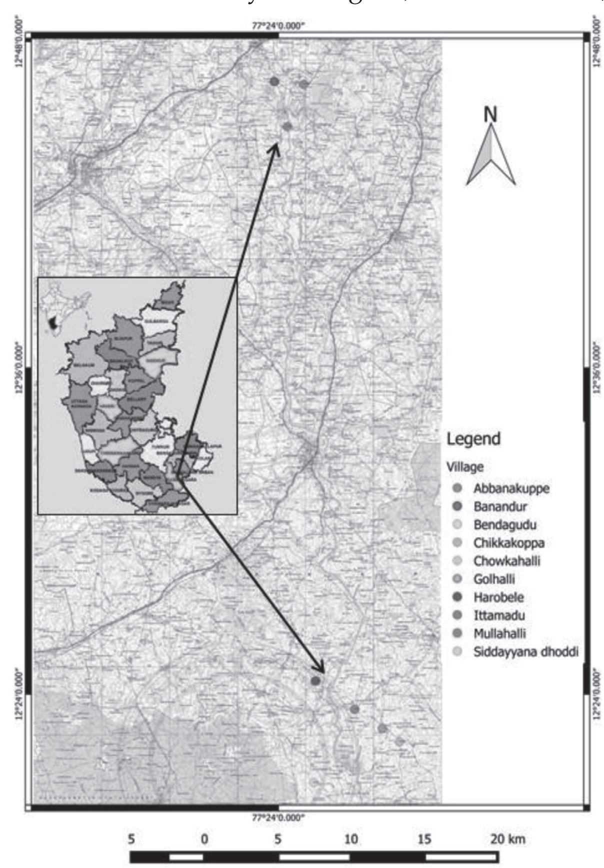

Fig. 1. Water and soil sampling locations at Byramangala and Harobele command area.

Ittamadu, Siddhayyanadhoddi and Kanchugaranahalli villages in Byramangala command area, while Harobele command area included Bendagudu, Mulhalli, Igolhalli, Chikkakoppa and Harobele villages. Similarly surface water sample were collected at outlet from each reservoir. The samples were collected in plastic bottles in early morning and were analysed using APHA (2012) methods for seven heavy metals.

Soil sample collection and analysis

The farmers were predominantly growing crops such as Ragi, Sugarcane, Mulberry, Banana, Napier grass, Paddy, Areca nut and Coconut plantations. Accordingly soil samples were collected in all the crops grown in the region. The composite soil samples were collected using core-cutter. The soil samples were homogeneously mixed, dried, crushed gently and grounded then, sieved and analysed for seven heavy metals (GOI, 2011, Motsara and Roy, 2008).

RESULTS AND DISCUSSION

Heavy metals in Surface Water

Copper was not detected in both reservoirs samples (Table 1). The Chromium, lead and zinc concentration was found to be below the permissible level in both the reservoirs. Nickel was present in both the reservoirs above the permissible limit and, maximum value was found in Harobele reservoir. Similarly, Cadmium was present in both the reservoirs above the permissible limits, and maximum value was found in Harobele reservoir.

Overall, the Harobele reservoir recorded higher level of zinc, lead, cadmium and nickel concentration than that of Byramanagala reservoir. In Byramangala reservoir the heavy metals occurred in the order Fe>Ni>Cr>Cd>Zn>Pb. Similarly, in Harobele reservoir the heavy metals occurred in the order Zn>Fe>Ni>Cd>Pb>Cr, where copper was not detectable in samples from both the reservoirs.

Heavy metals in ground water

The results of heavy metals analysed in ground water samples are given in Fig 2. Cadmium was present in all ground water samples which exceeds the permissible limits, and maximum was found in Siddhayyanadhoddi village of Byramangala command area. Also, Iron was present in all the groundwater samples which exceeds the permissible limit in all the ground water samples of Byramangala and of Bendagudu village in Harobele command area. Maximum concentration of Iron was found in the ground water sample of Siddhayyanadhoddi village in the Byramangala command area.

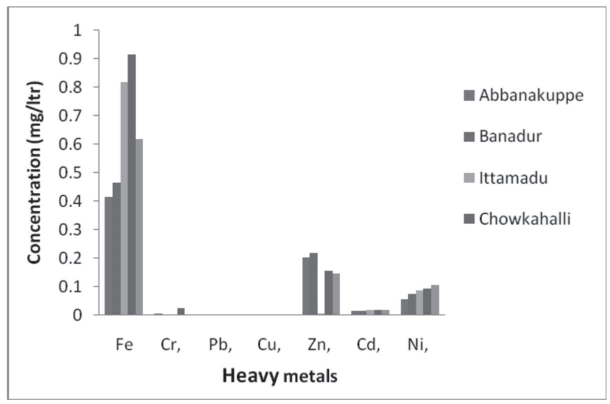

Fig. 2. Heavy metal concentration in ground water samples at Byramangala Command area

The chromium occurred in all samples which are within the permissible limit except in Chowkahalli and Ittamadu villages in Byramangala command area where chromium was not detected. Zinc occurred in all ground water samples, which are within the permissible limit and was not detectable in Igolhalli village. Similarly, lead was detected in only groundwater samples of Mulhalli and Igolhalli village. In Mulhalli village, lead was maximum exceeding the permissible limit.

Nickel was present in all ground water samples, which exceeds the permissible limit and, maximum value was found in Chikkakoppa village of Harobele command area. Similarly, Cadmium was

Table 1. Heavy metal concentration in Byramangala and Harobele reservoirs

Samples	Fe, mg/L	Cr, mg/L	Pb, mg/L	Cu, mg/L	Zn, mg/L	Ni, mg/L	Cd, mg/L
Byramangala reservoir	4.4176	0.0205	0.0041	ND	0.0102	0.0909	0.014
Harobele reservoir	0.4141	0.0025	0.0043	ND	1.315	0.1176	15
IS 10500 limits	0.3	0.05	0.01	0.05-1.5	5-15	0.02	0.003

present in all the ground water samples, which exceeds permissible limits, and maximum was found in ground water of Kanchugarana halli village of Byramangala command area. Overall, heavy metals concentration except zinc was found to be higher in ground water samples in the Harobele command area.

Heavy metals in ground water of Byramangala command area are in the order Fe>Zn>Ni>Cd>Cr and Pb was not detectable, while in the Harobele command area the heavy metals occurred in the order Fe>Ni>Zn>Cd>Pb>Cr and Cu was not detectable. Overall, the ground water in the Byramangala command area has more concentration of heavy metals than the ground water in the Harobele command area except for lead and nickel. The reason is clearly evident as there is continuous influx of sewage and partially treated effluent into the Vrishabhavathi river which is major inlet of the reservoir. The heavy metal such as cadmium contamination occurs due to effluents from the extensive use of cadmium in electroplating industries. Other sources include paints used as pigments and paints, further the use of fertilizers, detergents, refined petroleum products containing cadmium as an impurity can contribute the cadmium to the environment. Similarly, the lead which is used in solders, bearings, cable covers,

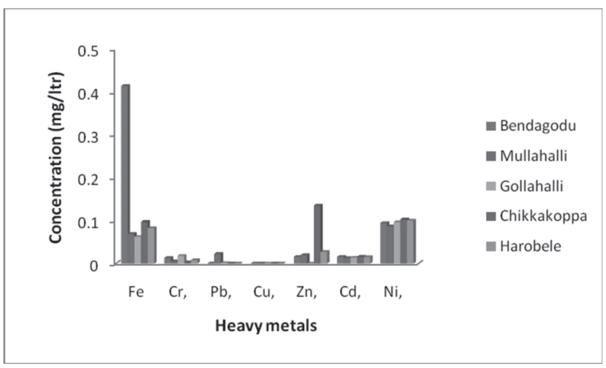

Fig. 3. Heavy metal concentration in ground water samples at Harobele Command area

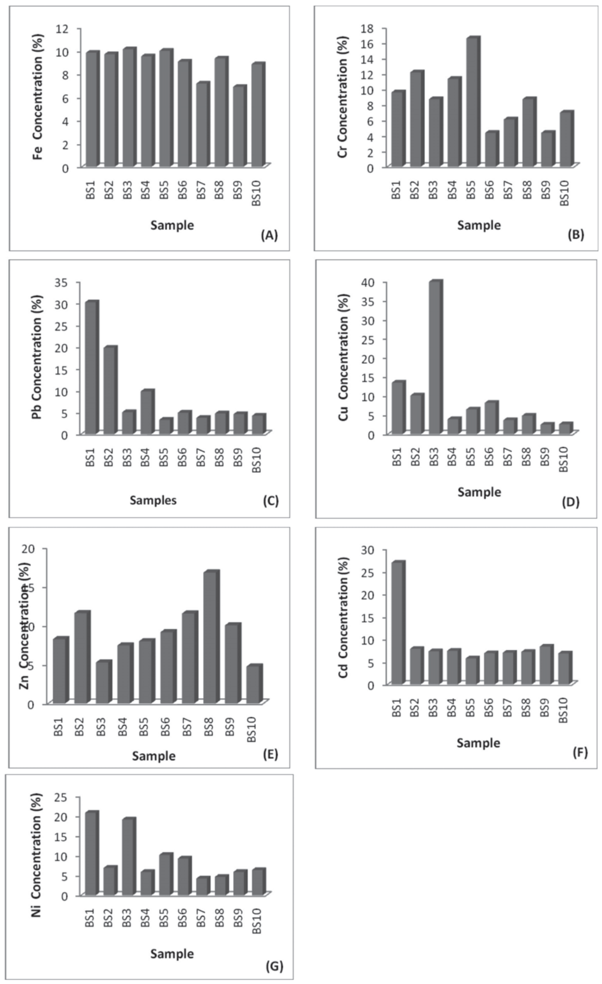

Fig. 4. Crop wise percent heavy metal in soil at Byramangala and Harobele command area

Table 2. Crop wise percent of heavy metal Concentration in soils of Byramangala and Harobele command area

Sample	Crops	Fe	Cr	Pb	Cu	Zn	Cd	Ni
BS1	*Coconus nucifera*	10	10	30	13	8	27	21
BS2	*Saccharum officarum*	10	12	20	10	12	8	7
BS3	*Eleus ecoracana*	10	9	5	40	5	7	19
BS4	*Morus rubra*	10	11	10	4	7	7	6
BS5	*Musa paradisca*	10	17	3	6	8	6	10
HS6	*Coconus nucifera*	9	4	5	8	9	7	9
HS7	*Musa paradisca*	7	6	4	4	12	7	4
HS8	*Eleusine coracana*	9	9	5	5	17	7	5
HS9	*Morus rubra*	7	4	5	2	10	8	6
HS10	*Oryza sativa*	9	7	4	3	5	7	6

Note: BS1-Abbanakuppe, BS2-Banadur, BS3-Ittamadu, BS4-Chowkahalli, BS5- Harobele.
HS1-Bendagodu, HS2-Mullahalli, HS3-Gollahalli, HS4-Chikkakoppa, HS5-Harobele

ammunition, plumbing, pigments, pipes (PVC), in ceramics and dishwares. The possibility of lead more in Harobele ground water could be due to dissolution of old lead plumbing and plumbing fixtures. Also, lead enters the water bodies from Bidadi industrial area and Harobele smelter units. Higher nickel, in the samples would be due to leaching from metals of pipes and fittings, apart from dissolution from nickel ore-bearing rocks.

The order of heavy metals mean concentrations in soils in all six soil samples of Byramangala command areas was found to be in the order-Fe >Ni>Zn> Cu> Pb> Cr >Cd, similarly, in Harobele command area the heavy metals were found in the order-Fe >Zn > Ni > Cu> Pb>Cd>Cr. The mean concentrations of Chromium (2.67 mg/kg) observed in the present study were lesser than concentrations reported in Varanasi, India (5.37 mg/kg) (Sharma *et al.,* 2007). The mean concentration of Copper is found to be (22.7 mg/kg) which were relatively closer to the value observed in Varanasi, India (10.95–28.58 mg/kg) (Sharma *et al.,* 2007). The mean concentration of Nickel is found to be (45.81 mg/kg) which were relatively higher than the value observed in Varanasi, India (10.95–28.58 mg/kg) (Sharma *et al.,* 2007). Maximum concentration of iron in ragi, Chromium in banana plantation, Lead in areca and coconut field, Copper in ragi, Cadmium in areca and coconut field and Nickel in areca and coconut fields were observed in Byramangala command area.

Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways (Bassey *et al.,* 2014).

Heavy metals at minute levels present in natural water, air, dusts, soils and sediments play an vital role in human life (Govil and Krishna, 2001). Heavy metals in soil reacts with humic acid and form complexes which helps the pollutents to migrate faster in the soil (Saether *et al.,* 1997). Of the heavy metals analysed zinc, iron, copper, and nickel, are one of the essential micronutrients required for both plants and animals at lower concentration. While heavy metals such as lead, cadmium and chromium cause various diseases and disorders even in relatively lower concentrations. The accumulation of heavy metals in organisms leading to bio-magnification and causing health effects when bio-transferred. In the Byramangala command area the untreated reservoir water is extensively used for irrigation purposes by pumping of water directly to the agricultural fields. Sometimes the reservoir water is diluted where it is used along with borewell water (Shakeri *et al.,* 2009).

Elevated iron levels in water cause stains in laundry, imparts objectionable tastes and colours to the foods. Iron has natural geological sources which are amplified due to anthropogenic activities. Ingestion of lead can affect the gastrointestinal tract, kidney and central nervous system, development of brain in the infants, mental deterioration in children. Cadmium is a major threat to human health, its accumulation leading to Kidney dysfunction. The heavy metals find their way into the surface waters and the ground water by various means. They find their way into the water supply through heavy metals leaching. Hence precautionary measures to be taken to see that the Byramangala reservoir water is subjected to prior treatment before irrigating the Crop fields. If the heavy metals are drawn into the soil-plant-animal continously then their removal is not easy and since the curative strategies are expensive (Rattan *et al.,* 2002). Crops raised on the metal-contaminated soils accumulate metals in quantities excessive enough to cause clinical problems both to animals and human beings consuming these metal rich plants (Tiller, 1986). Hence vegetable and fruits which are consumed directly, have to be avoided from growing in untreated water.

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