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Research Paper

Deleterious Concentrations of Heavy Metals in Ground Water Along River Musi, Telangana State, India

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An attempt is made to accentuate the accumulation of heavy metals in ground water on the peripherals of river Musi from the eastern part of Hyderabad urban to Valigonda village to a length of about 70kms. The heavy metals like Al, As, Co, Cr, Cu, Zn, Pb, Ni, Mn are determined from ground water to assess the water quality. High concentration of heavy metals to their standard limits threatening the sustainability of animal, plant and human life. The source of heavy metals in ground water along Musi River is due to indiscriminate discharge of industrial effluents and domestic sewage, and being carried along the river far off places from the source. The slow movement of water in the river leads to accumulate and precipitate the heavy metals both vertically and moves laterally. The untreated and or partially treated waste water used for irrigation is expected to have adverse impacts on local and shallow aquifers, which makes the ground water in the vicinity unsuitable for domestic, drinking and irrigation purposes. There is an urgent need to handle the problem with a suitable plan and strategy. Excessive plantation along the river banks may solve to some extent the seriousness of the problem. Bio-remediation in the surface water bodies may check the depletion of aquifers.

Keywords: Heavy metals, Water quality, aquifers, River Musi, Bio-remediation

Introduction

Hyderabad is the fifth largest metropolitan cities in India, and it has diverse cultures entangled and cultivated on the banks of river Musi with a population of 13 million. It has grown to the present state with a very rapid pace from Qutubshahi rulers to modern era with monuments, hills, forests and surface water bodies along with industries (Srisailam Gogula and Sunder Kumar Koli 2016).

The rive Musi is a tributary to mighty river Krishna flowing from the heart of the city and separating into Hyderabad and Secunderabad

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twin cities. The river Musi originates in Ananthagiri Hills of Ranga Reddy district 90 kms to the west of the city of Hyderabad and confluences to river Krishna at Wadapally of Nalgonda district on eastern part of the state and it travels to a stretch of around 170 Kms. The water is used for drinking and around one lakh hectares land is cultivated at the downstream of Musi River during the monsoon periods.

The water in the river Musi flows from laterites of deccan traps to over the plains of granites and attained purity and medicinal properties. This water brings good name and fame to the Hyderabad city over the centuries. Today, that innocuous water became very dangerous and toxic with color and odor. Rapid urbanization and industrialization around the city of Hyderabad polluted the surface water bodies and damaged to beyond measures. The river receives large amounts of untreated sewage from industrial, domestic disposal dumping caused the water to contaminate to the extreme toxic levels. Hundreds of farmers on the banks of Musi cultivate various crops, on hundreds of acres of land, thanks to perennial availability of water. Farmers bother very little if the water they use for cultivation is untreated polluted water of the river or the secondary treated water let out from sewage treatment plant (STP) abutting River Musi in city.

Incidentally, in case of river Musi, the areas irrigated by waste water and ground water coexist next to each other, this means the quality of ground water in the local aquifers deteorates year after year, especially the salinity of water being on the rise.

Location

The present area of investigation forms part of toposheet no. 56K/11 and 56K/15 and is bounded by $78^0$35’30"E to $78^0$57’35’E longitudes and $17^0$18’30"N to $17^0$28’30"N latitudes (Figure 1) and covers an area of 570 square kilometers. The topography is rugged with undulations consisting of structural and residual hills. The highest elevation is 505mts and the lowest is 326mts, with a general slope to the eastern side.

The agricultural practices in these areas dependent on ground water from where the river Musi flowing. The present catchment area consists of 10 major, 15 medium and around 50 small scale surface water bodies. In turn these surface water bodies are filled and or attached to the river Musi. The investigation is mainly concentrated on the downstream area to affirm the status of ground water.

Geology and Drainage

The present area is part of peninsular gneissic complex of south India of lower Proterozoic era. Peninsular gneisses and granites of archaean age are the oldest rocks exposed in the area. The dominant type of rocks intruded by closepet granites and dolorite dykes. Dharwars comprising of amphibolite gneisses, schist and quantizes occur as narrow bands within the granites. Feldspar and quartz veins occur as intrusive bodies in the granites (Figure 2). There are two types of granites exposed in the vicinity namely pink and gray. Gray ones are medium to fine grained with less porosity and permeability, where in the pink granites are medium to coarse grained fractured, fissured and sufficiently permeable to accommodate the ground water. The weathering in the area is intense and pronounced, leading to develop secondary porosity and increasing the percolation capacity.

Figure 1: Location Map of the Study Area (SOI Toposheet No. 56K/11 and 56K/15)

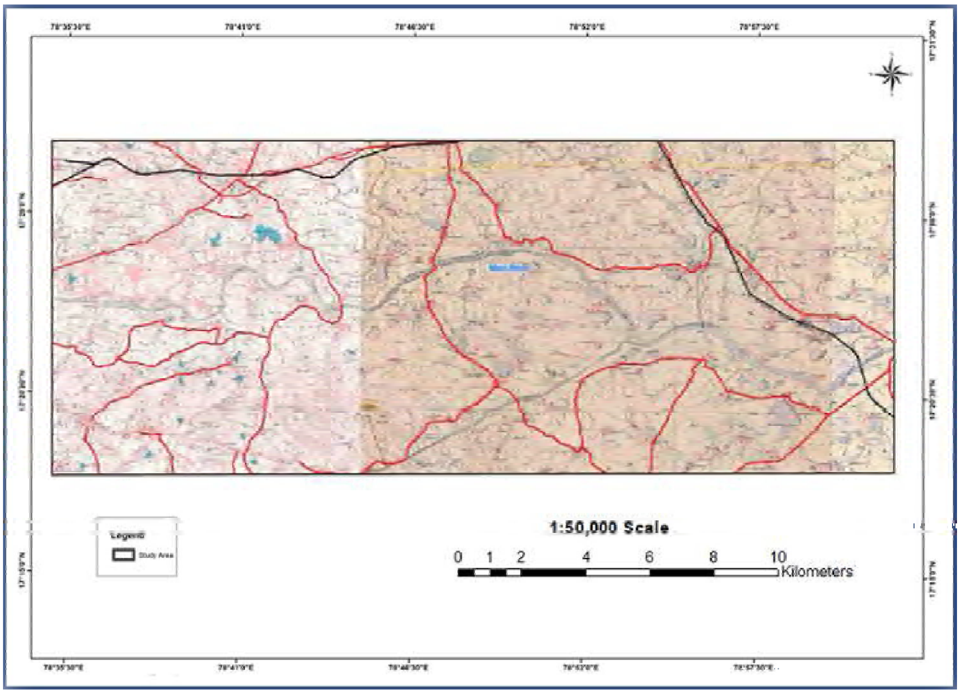
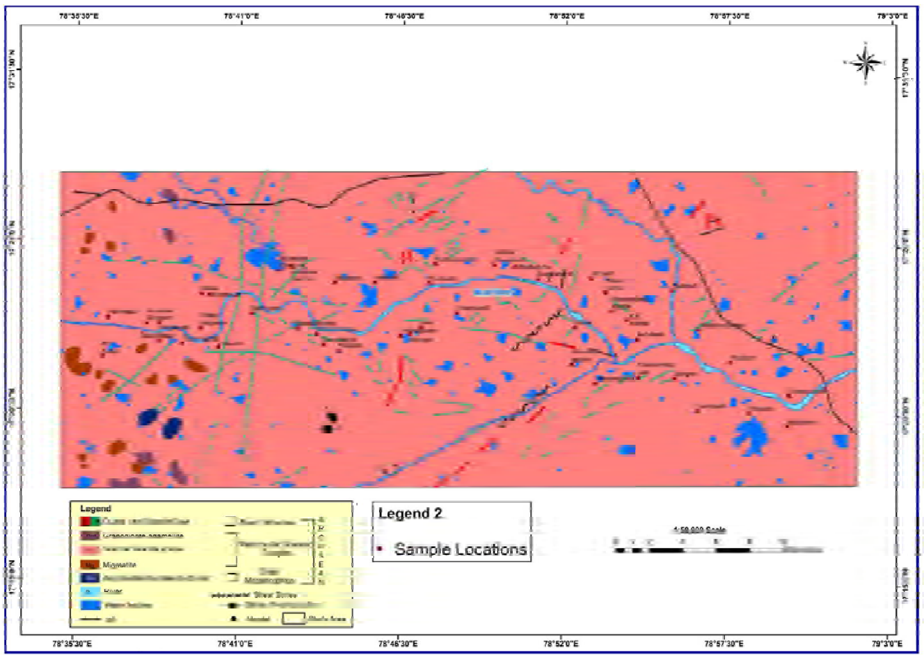


Figure 2: Geology and Sample Locations Map of the Study Area



Source: GSI,2002

The drainage in the area is dendriitc to subdendritic, because of rugged topography long continued drainage pattern is not developed. The drainage density is more and three to four stream orders are found. There are no profound lineaments are noticed in the area, and majority are only inferred type.

Sample Collection and Analyses

Ground water samples collected along the river Musi from the east of Hyderabad city Peerzadiguda to Valigonda village (Yadadri Bhuvanagiri District) to a length of 50 kms, covering both north and south banks. Sampling is being carried out about 500mts to one kilometer away from the river. This kind of water sampling may help to demarcate the extent of pollution from river Musi. Most of the water samples collected are from the village water supply bore wells and their locations are shown in Figure 2. The depths of the bore wells varying from 200 to 300 ft and a few are beyond 500fts. The water from these bore wells is not used for drinking purposes, but used for other activities, like gardening, washing and cleaning.

The ground water samples collected in one liter polythene containers and the pH is determined in the field only. The water were analyzed for heavy metal along with Electrical Conductivity, Total dissolved solids using ICP MS. Instrument reproducibility is checked with repetition of analyses along with prescribed standard methods. The heavy metals analyzed are Al, As, Co, Cr, Cu, Zn, Ni, Mn and the results are shown in Table 1.

Table 1: Elemental Concentrations in Ground Water of River Musi (North part of the River Musi)

Sample No.	Location Names	pH	Al	As	Co	Cr	Cu	Mn	Ni	Zn
1	Parvatapur	10.44	22.16	ND	ND	ND	5.01	29.21	ND	46.99
2	KachwaniSingaram	11.02	39.40	ND	ND	ND	ND	ND	8.05	ND
3	Mutialguda	11.02	29.47	ND	ND	5.84	ND	ND	ND	59.43
4	Pratap Singaram	10.36	9.85	ND	13.62	4.97	ND	ND	13.37	ND
5	Makta	11.25	25.40	ND	6.12	ND	ND	0.64	ND	32.14
6	Korremula	10.06	22.73	ND	9.68	ND	4.27	238.68	14.65	58.95
7	Edulabad Cherruvu	11.13	4.91	ND	ND	5.56	ND	ND	ND	32.47
8	Edulabad Junction	10.90	14.11	ND	ND	ND	ND	ND	0.24	29.10
9	Madaram	10.14	13.43	ND	6.26	ND	ND	ND	ND	27.25
10	Yenkirala	10.10	24.20	ND	ND	ND	1.34	ND	ND	ND
11	Rudravelli	10.41	12.97	ND	ND	ND	ND	12.81	ND	ND
12	Raghavapuram	10.61	52.97	ND	2.05	ND	ND	1.09	ND	13.98
13	Chinna Ravulapalli	10.24	25.61	ND	ND	5.94	ND	0.61	ND	ND
14	Bhattuguda	10.24	22.18	6.66	14.61	2.75	ND	0.87	11.49	1217.14
15	Gurraladandi	10.27	17.25	5.14	8.86	ND	ND	ND	ND	168.07

Table 1 (Cont.)

Sample No.	Location Names	pH	Al	As	Co	Cr	Cu	Mn	Ni	Zn
16	Jampalli	11.02	31.50	10.51	9.15	ND	ND	ND	15.88	23.61
17	Mission thanda	11.10	19.12	ND	6.89	ND	ND	ND	ND	ND
18	Pocharlabodu thanda	10.83	27.68	6.75	ND	ND	0.84	ND	8.74	53.29
19	K.K thanda	10.39	30.28	ND	ND	ND	ND	ND	ND	53.67
20	Suryapalli	10.29	13.65	ND	ND	ND	6.86	ND	ND	ND
21	Bollapalli	8.88	9.90	8.46	ND	ND	ND	ND	ND	42.21
22	Chaitanyapuram	10.32	12.07	4.53	ND	ND	ND	ND	6.69	23.81
23	Poddatur	10.59	8.88	3.17	ND	3.21	ND	ND	ND	ND
24	Lingarajupalli	10.34	12.61	ND	4.53	ND	ND	ND	10.45	2436
25	R K Nagar	10.21	28.48	9.78	4.53	ND	ND	42.41	8.05	1296.21
26	Thimmaiguda	10.89	16.74	ND	ND	ND	ND	ND	ND	151.49
27	Qutubullapur	11.00	85.90	ND	ND	ND	ND	ND	8.77	36.79
28	Gaurelli	10.51	21.00	ND	ND	ND	ND	511.41	7.32	39.89
29	Bacharam	10.50	17.17	9.53	9.57	ND	1.34	4.71	3.68	83.23
30	Bandaravirala	10.41	32.54	5.72	ND	2.19	ND	266.76	14.86	1704.02
31	Chinnaravirala	10.85	20.77	9.36	ND	ND	ND	ND	ND	166.72
32	Guvvalegila	10.78	20.67	ND	ND	ND	ND	ND	ND	78.15
33	Pillaipalli	10.35	13.52	ND	ND	4.05	ND	11.54	10.93	75.48
34	Peddagudem	10.19	6.66	ND	ND	ND	ND	2.99	8.62	103.70
35	Alinagar	11.15	12.59	ND	ND	ND	ND	ND	16.29	ND
36	Jolur	10.21	16.85	9.90	11.42	ND	7.74	ND	16.45	61.58
37	Khapraipalli	10.45	9.86	ND	8.99	ND	ND	1.11	ND	21.49
38	Peddaravulapalli	10.70	49.49	ND	11.78	ND	ND	ND	ND	40.36
39	Indral	10.59	11.22	ND	2.89	ND	17.32	2.98	ND	78.66
40	Shivareddy gudem	10.31	24.15	ND	11.13	ND	ND	138.35	ND	274.94
41	Wankamamidi	10.75	11.83	ND	ND	ND	ND	ND	ND	40.81
42	Dharmareddy palli	10.32	35.93	ND	9.11	ND	ND	ND	10.11	35.73
43	Sangem	10.18	22.92	ND	1.35	4.82	ND	ND	15.91	42.44
44	Varkatpalli	10.12	47.97	3.21	ND	ND	ND	1.90	ND	43.45
45	Gokaram	10.16	23.56	ND	2.79	ND	ND	94.53	ND	287.04
46	Jalukaluva	10.49	24.18	ND	ND	ND	ND	ND	ND	31.50

Sources of Heavy Metals in Ground Water

Pollution of ground water from hazardous metals and minerals can arise from naturals as well anthropogenic sources. Natural sources are seepage of metallic elements through leaching of rocks and minerals in to water, volcanic activity, forest fires etc (Hill K, 2018). Pollution can also be arise from the partitioning of polluting elements (in clay minerals), between sedimentary rocks and their precursor sediments and water (Rashmi Verma and Pratima Dwivedi 2013), along with rapid industrialization consumerist life style. Pollution of ground water occurs both at the levels of industrial products and the end use of products and run off.

There are hundreds of industries like large scale; small scale and even cottage type are advocated on up land and catmint areas of river Musi. Industries like mining, leather, lead acid batteries, E-waste ceramics, bangle industry, electroplating, paints, incineration and fuel combustion and along with pharmaceuticals are the group of industries responsible for the Musi river water pollution. These industries were never felt to discharge their effluents after treatment and for many years they were not provided sewage treatment plant (STP).One group of factors that may be detrimental to all organisms within urban ecosystems is metal contaminants, which get deposited in soil and sludge.

Results and Dicussion

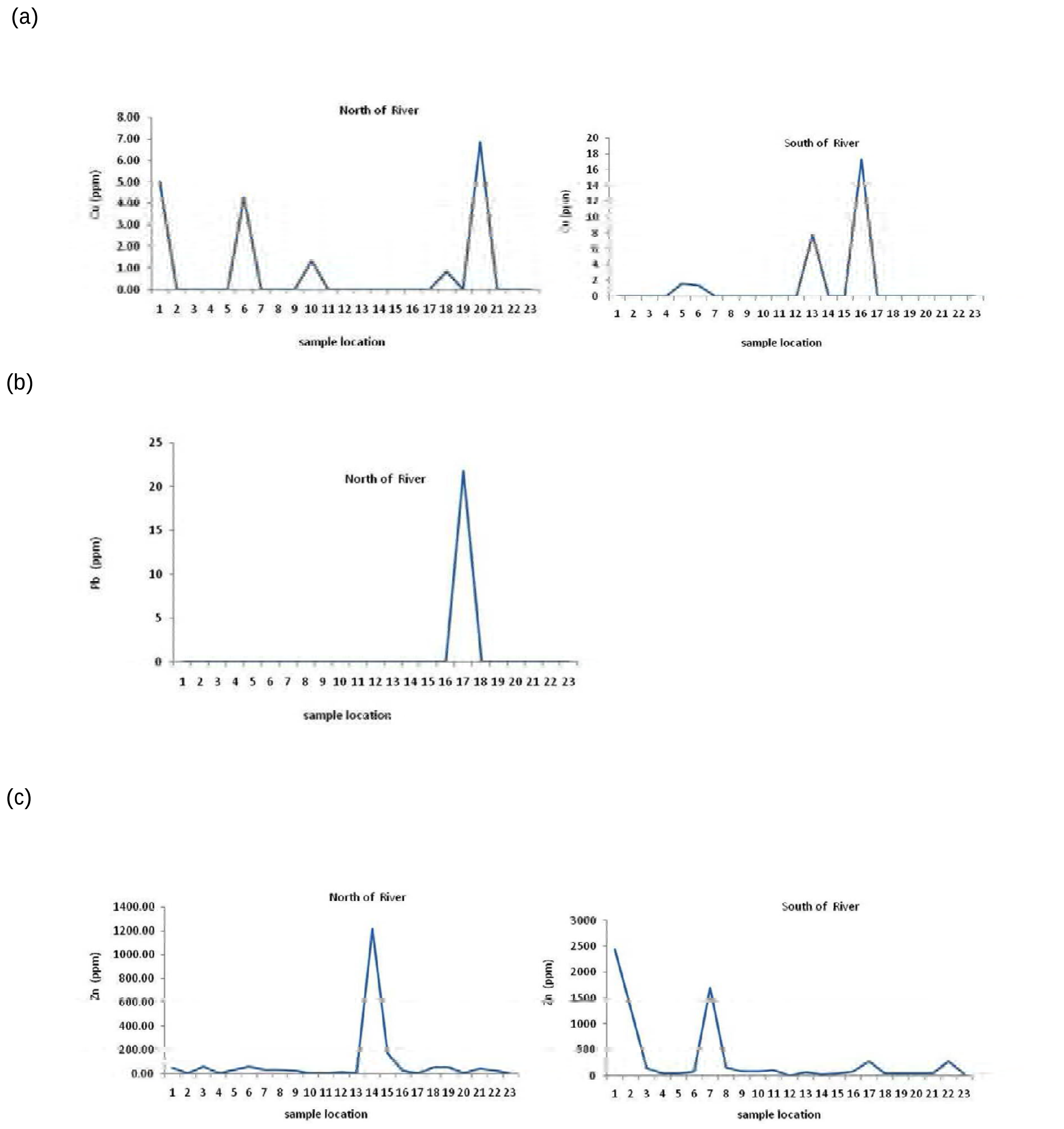
The heavy metals refers to any metal and metalloid element that has a relatively high density ranging from 3.5 to 7.0 g/cm and is toxic or poisonous at low concentrations, includes Cadmium (Cd), arsenic(As), chromium (Cr), zinc (Zn), nickel (Ni), copper (Cu) and lead (Pb). Although "heavy metals" is a general term defined in the literature, it is widely documented and frequently applied to the wide spread pollutants of soils and water bodies (Ravindra K Gautham et al 2014). These metals are found widely in the earth's crust and are non-biodegradable in nature. They enter into the human body via air, water and food. A small number have an essential role in the metabolism of humans and animals in trace amounts but their higher concentration may cause toxicity and health hazards. The hazardous nature of heavy metals has been recognized because of their bio accumulative nature in biotic systems. They can enter into the environment through mining activities, industrial discharge and from household applications, into nearby bodies of water (Samba shiva Rao et al.,2017).

The distribution of Cu, Pb and Zn in the study area is a serious matter to discuss, because these are primary metallic elements found in soil and water. The abnormal concentrations noticed in the water samples collected in the area. The use of copper is increasing world over and ends up more and more in the environment. Rivers are depositing sludge on their banks that is contaminated with copper, due to the disposal of copper-containing wastewater and will ends up in soil. When copper ends up in soil it strongly attaches to organic matter and minerals. As a result it does not travel very far after release and it hardly ever enters groundwater. In surface water copper can travel great distances, either suspended on sludge particles or as free ions.

Copper particles are released into atmosphere by windblown dust, volcanic eruptions and atmospheric sources, primarily Cu smeltes and ore processing. The fate of elemental copper in water is complex and influenced by pH and dissolved oxygen (Gebvekidam Mebratu and Samuel Zarabruket al.2011). The lowest copper content is found at Pocharlabodu Thanda is 0.84 ppm and the highest is at Indriyal village is 17.32 ppm (Table 1a, b). Majority of places copper is not detected in ground water samples may be due to elevated levels of dissolved oxygen in water (Figure 3a).

Lead (Pb) is found to be only in two locations i.e. Yenkirala and Mission Thanda villages with

Figure 3: Distribution Map of Cu, Pb and Zn in the Study Area



15.59 and 21.74 ppm respectively in the northern regions of the river Musi (Table 1). Lead being least mobile element in water. The industrial effluents discharged in to river Musi might have segregated and precipitated in the in the upstream portion on the north of river (Figure 3b). Lead can end up in water and soils through corrosion of leaded pipelines in a water transporting system and through corrosion of leaded paints. It cannot be broken down; it can only convert to other forms.

The accumulation of Zinc (Figure 3c) is more at Bandaravirala (1704 ppm), Lingarajupalli (2436 ppm) villages is very abnormal to its admissible limits. Naturally Zinc must be low concentrations in surface and ground waters because of its restricted mobility.Mining and metallurgical processing of zinc ores and its industrial application are the major sources of zinc in the air, soil and water. It also comes from the burning of coal.

Aluminum can be selectively leached from rock and soil to enter any source of water apart from its artificial sources. Aluminum quickly forms insoluble compounds and becomes practically safe for plants and animals (Bulanova NU et al 2001 and Olga Momot et.al 2005). Under the action of acid rains, Al can pass to the ionic state and react with biological objects changing them or surpassing their function. The minimum and maximum concentration of Al in ground water is found to be 4.91ppm and 52.97ppm (Table 1). The high Al concentration is found at the stream confluence points (Figure 4a).

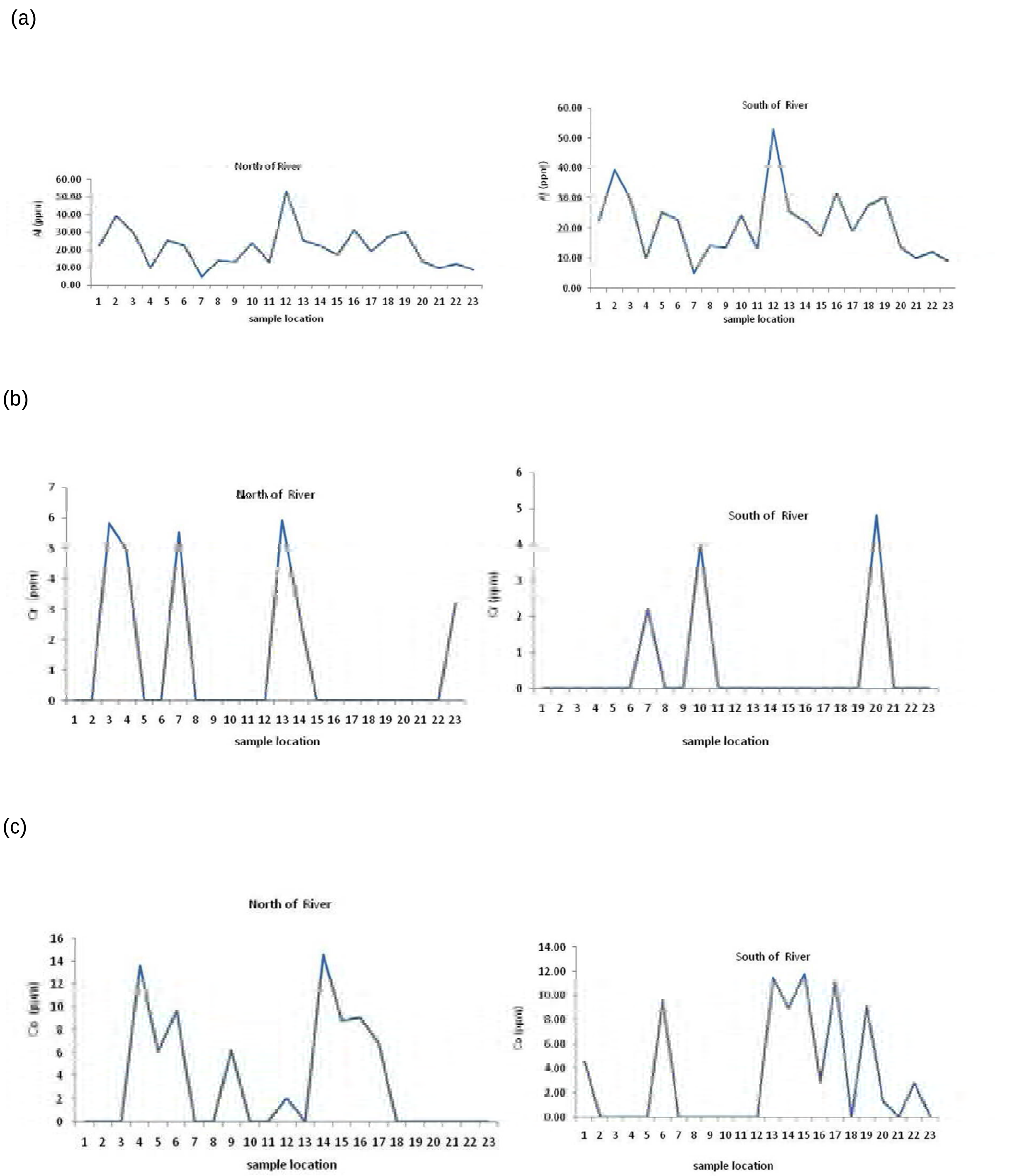
Most of the chromium in air will eventually settle and end up in waters or soils. Chromium in soils strongly attaches to soil particles and as a result it will not move towards groundwater. In water chromium will absorb on sediment and become immobile (Baralkiewicz D et al (1999)). The highest and lowest concentration of Cr is 2.19 to 5. 49 ppm respectively and the cr is not detected in many groundwater samples (Figure 4b).

Only a small part of the chromium that ends up in water will eventually dissolve. In water, chromium occurs in two oxidation states, +3and +6. Under salt water conditions with a pH of approximately 8, cation Cr^{+4} may also be present. Oxidized chromium, Cr+6, under the form of anionic compounds is found in its unstable form mainly in the upper layers of the water. In many waters, chromium in suspension constitutes 34-65 % of the overall chromium. Concentrations of chromium above 100 μg 1-1 are rarely encountered, mainly in industrial regions (Dojlido J.R., Best G.A. 1993).

Cobalt cannot be destroyed once it has entered the environment. It may react with other particles or adsorb on soil particles or water sediments. Cobalt will only mobilize under acidic conditions, but ultimately most cobalt will end up in soils and sediments. The occurrence of cobalt in soils is to a large extent determined by bedrock. Its concentrations in the solutions of various soils oscillates from 1.35 to 14.67 ppm (Table 1), and is generally greater in the salted soils of a warm dry climate. An increased amount of cobalt occurs, as well, as a result of industrial pollution (Figure 4c). Cobalt occurs in the surface waters in small concentrations, most often of from several to several-score μg 1-1 (Turekian K. K. Scott M. 1994).

Soils that contain very low amounts of cobalt may grow plants that have a deficiency of cobalt. When animals graze on these grounds they

Figure 4: Distribution Map of Al, Cr and Co in the Study Area



suffer from lack of cobalt, which is essential for them.

The accumulation of Ni in ground water samples is presented in Table 1 and Figure 5a.

The minimum and maximum content of Ni is varying from 0.24 to 16.45ppm respectively. The high concentration of Ni is noticed at Mission Thanda and Jolur villages with more than 16ppm, Sangem and Jampally are also found with high concentrations of Ni.

The larger part of all nickel compounds that are released to the environment will adsorb to sediment or soil particles and become immobile as a result. In acidic ground however, nickel is bound to become more mobile and it will often rinse out to the groundwater. In natural water environments, nickel concentration is generally small, because it mainly occurs in a colloidal form and is subject to rapid sorption by loamy minerals and hydroxides of iron and manganese in bottom sediments (Dojlido J. R. 1995). Nickel is easily accumulated in the biological environment, particularly in the phytoplankton or other aquatic plants.

The distribution of Manganese in Musi area is shown in Figure 5b, and the data is presented in Table.I. The minimum and maximum are 0.61 and 511.1ppm respectively. Gaurelli (511.41ppm), Bandavaripally (266.76ppm) and Koremla (238.68ppm) are the abnormal concentrations noticed.

Manganese is a very common compound that can be found everywhere on earth. Manganese is one out of three toxic essential trace elements. Manganese is a mineral that naturally occurs in rocks and soil and may also be present due to underground pollution sources. Manganese is seldom found alone in a water supply. Chemically it can be considered a close relative of iron since it occurs in much the same forms as iron. When manganese is present in water, it is every bit as annoying as iron, perhaps even more so. In low concentrations it produces extremely objectionable stains on everything with which it comes in contact. Manganese is present most frequently as a manganese ion (Mn^{++}) in water. Salts of man-ganese are generally more soluble in acid than in alkaline water (Loranger et al., 1996).

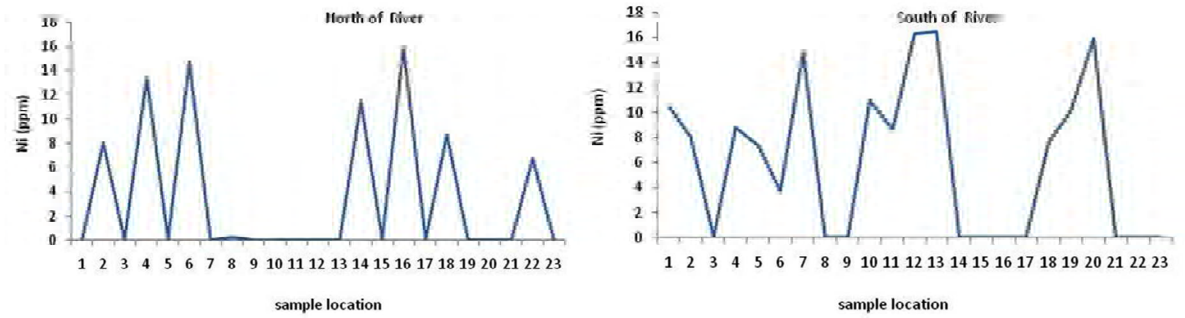
Arsenic is the most toxic and dangerous element found in the groundwater. Its distribution is presented in Figure 5c and data is shown in Table 1. The lowest and highest concentrations are 3.17 to 10.51ppm respectively. High As concentration is found mainly in the southern part of the river. Julur and R.K nagar in the southern area and Jampally in the northern area represented with very high values of As.

Arsenic is a component that is extremely hard to convert to water-soluble or volatile products (S. Murcott et,al, 2012). The fact that arsenic is naturally a fairly a mobile component, basically means that large concentrations are not likely to appear on one specific site (Garelick H,et,al 2008) .This is a good thing, but the negative site to it is that arsenic pollution becomes a wider issue because it easily spreads. Arsenic cannot be mobilized easily when it is immobile (R.Tuli et.al 2010). Due to human activities, mainly through mining and smelting, naturally immobile arsenics have also mobilized and can now be found on many more places than where they existed naturally (shiva shanker et al 2014).

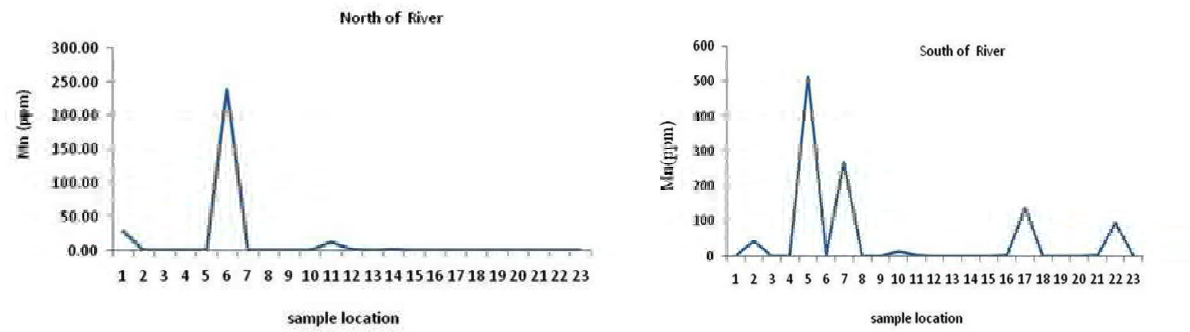
Arsenic is mainly emitted by the copper producing industries, but also during lead and zinc production and in agriculture. It cannot be destroyed once it has entered the environment, so that the amounts that we add can spread and cause health effects to humans and animals on many locations on earth.

Figure 5: Distribution Map of Ni, Mn and As in the Study Area

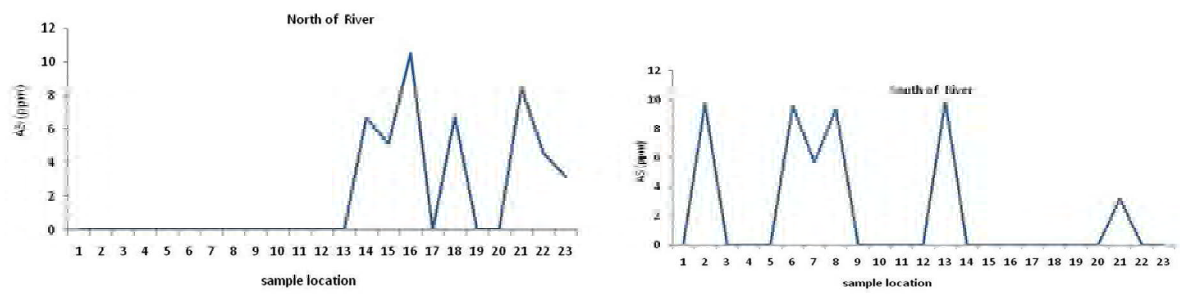
(a)



(b)



(c)
(c)



Conclusion

The toxic concentrations of heavy metals in ground water adjoining musi river villages posing a great treat to the land animal and man. All these heavy metals analyzed are in the abnormal levels, depending on the mobility adsorption over sediments at some places could not detect, therefore, the accumulation of heavy metals mostly isolated where the river water is stagnate or in slow flow.The highly polluted water seeps in to ground and contaminate the underground aquifers that sustain the water table. Chemicals present in the polluted river water also seep into the water table and changes its texture. Wastewater has been in use for cultivation in peri-urban Hyderabad for a little over four decades now. The untreated waste water used for irrigation is expected to have adverse impacts on local aquifers, which makes the local ground water unsuitable for domestic, drinking and irrigation purposes. The problem is only compounded during the monsoon season, as percolation is higher.

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