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GROUNDWATER CONTAMINATION BY HEAVY METALS IN THE INDUSTRIALLY POLLUTED ZONES OF VISAKHAPATNAM METRO CITY, ANDHRA PRADESH, INDIA

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ABSTRACT
With rapid industrialization and ever increasing population there has been a substantial increase in the generation of industrial and urban wastes leading to the contamination of water, air and land resources. Groundwater quality is an important area, to which the attention of scientific community is growing more for its evaluation, protection and sustainable management. Apart from geologic, hydrologic and biological factors that cause the pollution, water quality is also altered by man-induced pollution. Hence the present study is taken up in the industrial parts of Visakhapatnam city. Visakhapatnam is also known as city of destiny with outstanding industrial development with Iron, zinc, steel, petroleum, pharmaceutical, cement, fertilizer, welding industries and a natural major port with huge export and import activities of coal, iron ore, manganese, zipsum, granite, wood and other commercially important chemicals and minerals and good. 25 water samples from tube wells located in industrialized zone of the city were collected for the subsequent laboratory analysis for the determination of heavy metal concentrations in the study area during summer season the year 2011. During the course of present study 24 elements including secondary constituents, heavy metals and trace metals i.e. lithium (Li), beryllium (Be), aluminium (Al), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), arsenic (As), selenium (Sc), rubidium (Rb), lead (Pb), cadmium (Cd), mercury (Hg), Silver (Ag), boron (Ba), cesium (Cs), molybdenum (Mo), strontium (Sr) and uranium (U) and tellurium (Tl) were analyzed on ICP-MS. Beryllium (Be), cesium (Cs) and tellurium (Tl) were found below detectable levels in all the sampling locations. In some locations significant alarming concentrations of arsenic, zinc, iron and mercury were found. Some other biologically active heavy metal concentrations were also found in ground water of the city indicating that Environmental protection programs are needed to eliminate health hazards.

KEYWORDS: Ground water, contamination, chemicals and minerals, elements, health hazards.

INTRODUCTION

Water is essential to people and the largest available source of fresh water lies in underground called groundwater. The immediate effect of industrialization and urbanization generally noticed on the ground water regime of an area, which is most sensitive part of the ecosystem. Generally, contamination of ground water with in a catchment area depends on its land use practice, land disposal of industrial wastes, storage of hazardous chemicals and effluent and infiltration from sewers as well geological formations unique to the aquifer. Groundwater in crystalline terrain generally occurs in environments of a weathered zone at shallow depth these are prone to manmade pollution. On the other hand the contamination of ground water aquifer depends on geographical, topographical and meteorological characteristics and contamination in weathered zone. The groundwater occurs under confined conditions in the weathered mantle and under semi-confined condition in the joints, fractures, etc. The intensity and depth of weathering and the presence of joints, fractures, etc control the occurrence of groundwater. The occurrence may vary from place to place.

The present study area (fig.1) the Visakhapatnam city region comprises of Precambrian meta sediments and intrusive meta igneous bodies (Narasimha Rao 1945). The hill ranges named Kailasa on north, Yarada on south, Narava on west made the city to appear like a amphitheater. These entire hill ranges are composed of granite- sillmanite- biotite geneises locally called as Khondolites (King 1886), charnockites, leptynites. Apart from the meta sediments the study area is also marked my quaternaries such as red sediments, calcium carbonate calcerates, dune sands, beach sands, and economically important black sands. The study area is located between latitude- 17° 30′ 15″ to 18° 11′ 15″ North and longitude- 82° 57′ 37″ to 83° 28′ 12″ East. Visakhapatnam has been notified as one of the most polluted industrial cluster by central pollution control board of India.

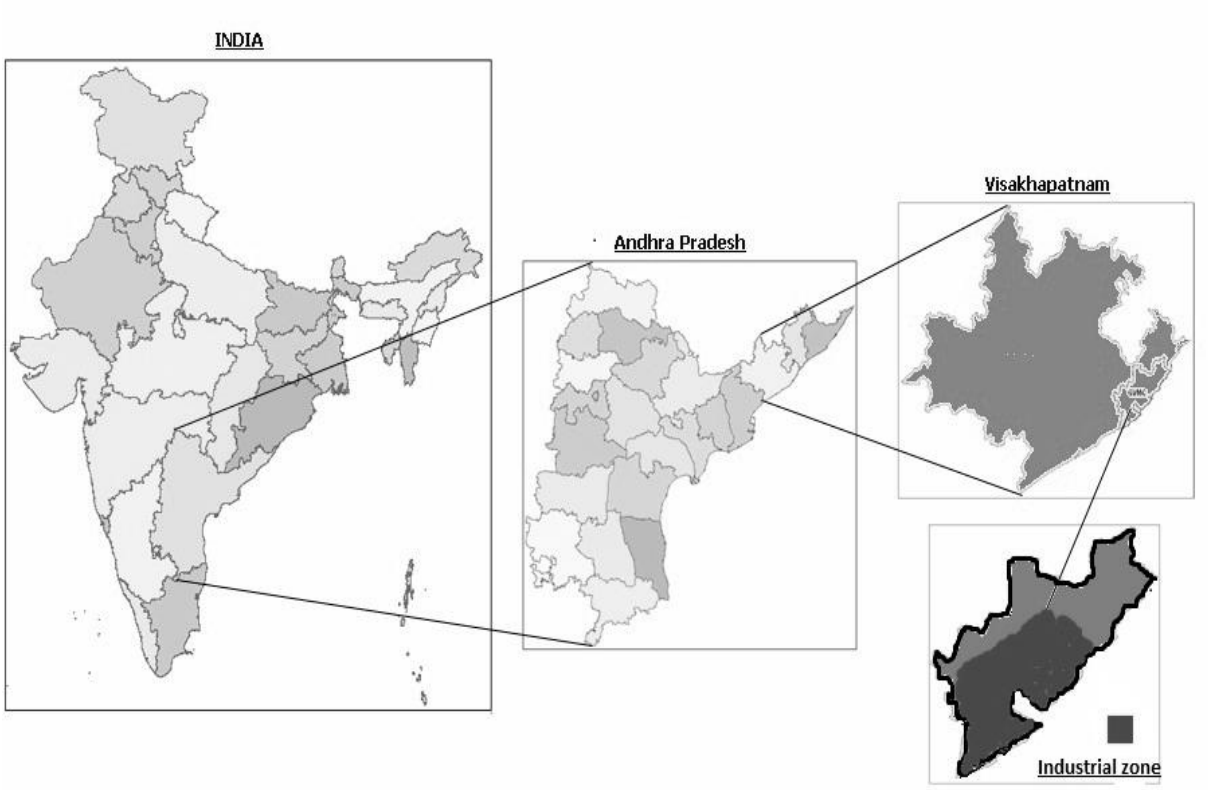

FIGURE 1. Map showing the study area

The tube wells existing in the area are tapping weathered zone. Wide variations occur in tube well depth from 50 to 60 m bgl (below ground level). From the analysis of well data obtained during the field survey, it is revealed that the study area may invariably suffer from severe water shortage. The water levels are at greater depths. However, the water table configurations are similar to that of the land surface, but depth to water table is greater in upland areas. Hence the water resources sector must receive the highest priority for survival and growth of mankind and socio economic development and a healthy eco system of cities.

METHODOLOGY

The study includes collection of data on pollution back drop of the area and collection of ground water samples during summer season of 2011. Twenty five tube well water samples were collected covering the southern industrial part of the study area for the subsequent laboratory analysis, for heavy metals like such as lithium (Li), beryllium (Be), aluminium (Al), vanadium (V), chromium (Cr), manganese (Mn), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), arsenic (As), selenium (Sc), rubidium (Rb), lead (Pb), cadmium (Cd), mercury (Hg), Silver (Ag), boran (Ba), cesium (Cs), molybdenum (Mo), strontium (Sr) and uranium (U) and tellurium (Tl). Using suprapure ® nitric acid, MIBK and APDC analytical grade chemicals the solvent extraction procedure was performed in the pollution testing laboratory in school of environmental sciences, Andhra university, all the sample extracts were subjected to ICP-MS analysis at center for studies on Bay of Bengal, Andhra University.

RESULTS AND DISCUSSION

Any metal (or metalloid) species may be considered a "contaminant" if it occurs where it is unwanted, or in a form or concentration that causes a detrimental human or environmental effect. Particularly heavy metals are being released in to the environment through various manmade sources like vehicular exhaust, metal smelting industry, and leaded petrol, incineration of solid waste, exudates, and residues from metalliferous mines and smelting industries, vapours, fumes, dusts, smoke, mist, fog or smog. Consensus holds that it is impossible to live an environment free of heavy metals. The acceptable and allowable limits for certain heavy metals described by the World Health Organization and Indian standards organization were presented in Table-1. The results obtained by the ICP-MS analysis were presented in Table-2 and 3.

TABLE -1. The essential characteristics for drinking water WHO, IS 10500-1991

World health organization			Indian standards organization 10500-1991		
Characteristic	Acceptable Limit (mg/L)	Allowable Limit (mg/L)	Substance or Characteristic	Requirement/ Desirable limit (mg/L)	Permissible limit in the absence of alternative sources (mg/L)
Iron	0.3	1.0	Iron	0.3	1.0
Manganese	0.1	0.5	Manganese	0.1	0.3
Copper	1.0	1.5	Copper	0.05	1.5
Zinc	5.0	15	Zinc	5	15
Arsenic	-	0.05	Arsenic	0.05	No relaxation
Chromium	0.05	0.05	Chromium	0.05	No relaxation
Lead	0.05	0.10	Lead	0.05	No relaxation
Cadmium	-	0.01	Cadmium	0.01	No relaxation
Mercury	-	-	Mercury	0.001	No relaxation

TABLE -2. Results pertaining to the heavy metal Concentration in ppb at different sampling locations (Li, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga)

Sampling Location	Li	Al	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga
Ramky city	0.5	368.9	3.5	4.2	21.1	328.5	0.3	29.3	151.7	541.7	6.5
Opp V.S organics	0.3	139.8	0.5	1.9	7.1	364.9	0.1	21.7	71.2	162.9	4.5
Colony at R city	0.6	512.2	8.9	30.2	34.7	819.8	0.2	53.6	106.6	1061.1	9.5
Aganampudi	0.2	269.8	13.6	4.1	13.0	163.7	0.2	16.0	78.1	387.3	4.6
Steel plant park	0.2	137.4	6.4	2.8	6.0	611.8	0.1	42.6	114.3	132.3	6.7
Appi konda	0.5	137.5	12.2	1.9	6.0	151.1	0.2	27.4	50.3	196.7	3.2
Gopalreddy nagar	0.3	145.5	9.1	1.6	7.9	132.7	0.2	58.1	49.8	200.5	4.4
Mindi	0.2	166.7	2.0	4.8	11.7	400.4	0.2	62.3	200.4	853.4	8.0
Akkireddypalem	0.2	437.2	10.7	8.3	26.0	412.3	0.4	35.7	115.9	414.0	7.7
Sheelanagar	0.1	176.5	2.7	5.6	11.8	605.1	0.5	184.8	296.1	1096.5	7.7
NAD Junction	4.4	492.5	1.9	3.0	11.7	773.8	0.5	40.1	72.3	192.5	3.3
Jyanapuram	BDL	135.9	29.1	1.5	5.2	358.9	0.1	46.9	81.1	101.1	2.9
Nakkavanipalem	0.1	232.1	5.1	4.5	19.4	319.5	0.2	24.4	82.0	489.9	5.5
Srihari puram	0.8	674.8	2.6	4.8	19.1	415.9	0.2	23.3	44.8	374.2	7.8
Malkapuram	0.2	260.9	1.9	11.1	97.0	322.7	0.2	29.5	166.2	1707.1	11.5
Old post office	0.2	146.4	18.9	2.3	8.5	91.4	0.2	79.3	60.4	264.0	5.1
Desapatrunipalem	0.1	180.4	1.9	3.4	13.8	197.0	0.2	33.7	64.9	257.1	4.4
Lankelapalem	0.4	236.6	1.5	7.9	21.0	609.8	0.3	62.5	93.7	1144.4	13.6
Duvvada	0.1	234.8	1.6	3.1	12.4	331.3	0.3	73.0	108.0	443.7	6.4
Chaitanya nagar	0.1	170.7	9.0	8.1	41.3	318.4	0.2	14.5	78.7	372.4	10.2
Vadlapudi	0.2	167.4	5.9	3.7	10.4	163.1	0.2	97.8	163.2	490.2	6.8
Srinagar colony	0.2	241.6	24.4	4.3	12.5	291.4	0.3	30.1	106.4	205.4	5.5
Autonagar	0.7	556.0	7.8	4.6	14.8	237.5	0.7	42.0	304.9	444.4	11.6
Natayyapalem	0.4	219.9	4.4	8.8	7.4	274.4	0.1	21.2	64.3	193.4	7.6
AVERAGE	0.3	276.8	7.1	5.6	23.1	297.7	0.3	44.3	111.5	532.2	8.0
STD DEV	0.2	164.0	7.3	2.7	24.9	131.1	0.2	27.0	71.9	446.6	3.0

TABLE -3. Results pertaining to the heavy metal concentration in ppb at different sampling location (As, Se, Rb, Sr, Ag, Cd, Ba, Pb,U).

Sampling Location	As	Se	Rb	Sr	Ag	Cd	Ba	Hg	Pb	U
Ramky city	40.1	BDL	1.0	34.6	1.4	3.1	32.6	24.9	75.3	0.1
Opp V.S organics	2.3	BDL	1.2	22.8	3.0	0.8	41.8	1.7	40.4	BDL
Colony at R city	3.3	1.2	1.0	27.5	5.7	1.0	33.9	748.3	64.4	0.9
Aganampudi	1.8	BDL	0.9	26.3	5.9	1.0	21.8	6.1	29.2	0.1
Steel plant park	2.2	0.1	0.3	15.8	0.8	1.7	32.3	5.5	59.1	0.1
Appi konda	2.1	BDL	1.0	13.5	0.4	2.8	15.4	BDL	196.6	0.1
Gopalreddy nagar	6.9	BDL	1.5	40.8	0.6	2.0	21.0	BDL	50.0	BDL
Mindi	7.8	0.2	1.1	33.4	0.9	1.7	51.7	18.7	80.3	BDL
Akkireddypalem	16.7	0.2	2.0	26.6	3.2	2.1	44.9	7.5	61.0	0.1
Sheelanagar	10.5	1.8	1.2	35.8	0.7	0.5	46.8	16.5	49.8	BDL
NAD Junction	12.7	0.3	5.5	234.7	1.2	2.0	21.0	30.5	40.2	0.1
Jyanapuram	2.1	0.3	0.7	7.8	1.3	0.5	13.7	BDL	26.4	BDL
Nakkavanipalem	3.6	0.2	1.6	25.0	3.5	2.1	22.1	BDL	57.7	0.1
Srihari puram	3.0	0.1	1.3	30.6	1.2	1.3	46.3	BDL	45.8	0.2
Malkapuram	7.3	0.1	1.4	60.8	1.4	7.3	78.5	16.1	514.9	0.1
Old post office	4.5	0.6	1.7	27.7	1.0	1.2	19.5	2.9	38.6	BDL
Desapatrunipalem	23.8	0.1	1.9	25.5	0.8	1.3	20.6	15.6	39.9	0.1
Lankelapalem	12.1	0.9	2.1	51.2	1.0	1.5	39.5	BDL	36.8	BDL
Duvvada	3.5	BDL	2.7	22.1	1.2	2.1	20.6	BDL	76.4	BDL
Chaitanya nagar	4.1	0.4	1.6	39.6	7.2	1.5	52.6	11.8	62.9	0.1
Vadlapudi	8.1	0.7	1.9	24.8	0.9	2.8	21.3	BDL	62.8	0.1
Srinagar colony	6.2	0.3	1.7	24.9	0.9	1.2	24.3	6.8	57.4	0.1
Autonagar	7.3	0.5	1.5	48.9	3.7	2.1	48.1	14.2	83.4	0.1
Natayyapalem	4.4	BDL	0.7	37.7	0.8	1.0	26.1	10.2	74.9	0.1
AVERAGE	8.2	0.5	1.6	39.1	2.0	1.9	33.2	58.6	80.2	0.2
STD DEV	8.6	0.5	1.0	43.3	1.9	1.4	15.6	184.1	98.3	0.2

Critical perusal of the results indicated that maximum contaminant level (MCL) for lithium was recorded as 4.4 ppb with an average 0.3 ppb at a standard deviation value of 0.2 ppb. The MCL value for Aluminium was recorded as 674.5 ppb (0.67 mg/L) with an average of 276.8 ppb, with standard deviation of 164.0 ppb. The MCL value for Vanadium was recorded as 29.1 ppb (0.02 mg/L) with an average of 7.1 ppb, with standard deviation of 7.3 ppb. The MCL value for Chromium was recorded as 30.1 ppb (0.03 mg/L) with an average of 5.6 ppb, with standard deviation of 2.7 ppb. The MCL value for Manganese was recorded as 97.0 ppb (0.09 mg/L) with an average of 23.1 ppb, with standard deviation of 24.9 ppb. The MCL value for Iron was recorded as 819.8 ppb (0.81 mg/L) with an average of 297.8 ppb, with standard deviation of 131.1 ppb. The MCL value for Cobalt was recorded as 0.7 ppb (0.0007 mg/L) with an average of 0.3 ppb, with standard deviation of 0.4 ppb. The MCL value for Nickel was recorded as 184.8 ppb (0.18 mg/L) with an average of 44.3 ppb, with standard deviation of 27.0 ppb. The MCL value for copper was recorded as 304.9 ppb (0.30 mg/L) with an average of 111.5 ppb, with standard deviation of 71.9 ppb. The MCL value for Zinc was recorded as 1707.1 ppb (0.17 mg/L) with an average of 532.2 ppb, with standard deviation of 446.6 ppb. The MCL value for Gallium was recorded as 13.6 ppb (0.001 mg/L) with an average of 8.0 ppb, with standard deviation of 3.0 ppb.

The MCL value for Arsenic was recorded as 40.1 ppb (0.04 mg/L) with an average of 8.2 ppb, with standard deviation of 8.6 ppb. The MCL value for selenium was recorded as 1.8 ppb (0.001 mg/L) with an average of 0.5 ppb, with standard deviation of 0.5 ppb. The MCL value for Rubidium was recorded as 2.7 ppb (0.002 mg/L) with an average of 1.6 ppb, with standard deviation of 1.0 ppb. The MCL value for strontium was recorded as 234.8 ppb (0.23 mg/L) with an average of 31.9 ppb, with standard deviation of 43.4 ppb. The MCL value for silver was recorded as 7.2 ppb (0.007 mg/L) with an average of 2.0 ppb, with standard deviation of 1.9 ppb.

The MCL value for cadmium was recorded as 7.3 ppb (0.007 mg/L) with an average of 1.9 ppb, with standard deviation of 1.4 ppb. The MCL value for Boron was recorded as 78.5 ppb (0.07 mg/L) with an average of 32.2 ppb, with standard deviation of 15.6 ppb. The MCL value for mercury was recorded as 748.3ppb (0.74 mg/L) with an average of 58.6 ppb, with standard deviation of 184.1 ppb. The MCL value for Lead was recorded as 514.9 ppb (0.51 mg/L) with an average of 80.2 ppb, with standard deviation of 98.3 ppb. The MCL value for uranium was recorded as 0.9 ppb (0.0009 mg/L) with an average of 0.2 ppb, with standard deviation of 0.2 ppb. Beryllium (Be), cesium (Cs) and tellurium (Tl) were found below detectable levels in all the sampling locations.

CONCLUSIONS

Hydro geologically the area mainly consists of crystalline rocks. In granites and gneisses, groundwater occurs under confined conditions in the weathered zone and semi confined in the areas where joints and fractures are present. Ground water contamination depends on the type of soil media present in the under layers of the earth. A resistivity of factors such as lithology, geomorphology, rain fall, drainage etc. determines the ground water occurrence. It was observed that ground water occurrence, quality and pollution are mainly influenced by land use practice. It is also observed that the ground water quality has identified varying difference at different places due to pollution background and geological set up. Field observations indicate that the sources for pollution of ground water are chemical industries that are situated on the southern and north western side of the city. In the groundwater of the study area secondary constituents and trace metals like Fe, Mn, Cu, Pb, and Cd have been found in excess of the Indian standards organization recommended guideline values due to the impact of industrial effluents. These high values can be deleterious to the health of human beings and thus corrective measures are necessary to prevent increases of chemical parameters in groundwater and to safeguard public health.

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