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STUDY ON HEAVY METAL CONTAMINATION IN GROUND WATER AT OUTER SKIRTS OF KOTA CITY, RAJASTHAN, INDIA

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ABSTRACT

The present study deals with an analysis of heavy metal contamination in 72 numbers of ground water samples drawn from twenty-four different locations selecting six sites from each of the four directions of outer skirts of Kota City of Rajasthan, India, in pre-monsoon period of years 2006 to 2008. At all the selected locations, ground water is used for drinking and domestic purposes. Contamination level of iron, copper, zinc, lead, manganese and chromium were estimated following the standard procedures; atomic absorption spectrophotometrically and data so obtained were compared with the guidelines given in IS 10500 for drinking purpose. Data reveals that in Western, Southern and Northern block, chromium concentration was higher whereas in Southern and Northern block, lead concentration was higher at some locations than the permissible limit.

Key words: Ground water, Heavy metal, Atomic absorption spectrophotometry.

INTRODUCTION

It is an admitted fact that the modern civilization, industrialization, urbanization and increased population have led to fast degradation of our environment and water is the most affected component by these activities. Today, the problem of drinking water has assumed a very complex shape. Attention on water contamination and its management has become a need of hour because of far reaching impact on human health[1]. Ground water is the main source of fulfilling drinking and domestic requirements of most of the population of the world. Ground water may contain heavy metals like iron, copper, zinc, lead, manganese and chromium in such quantities, which are required for better growth of plants and animals but at higher concentrations, these metals may be harmful and than the water become polluted[2]. The heavy metals are non-biodegradable; once, they get into the ground water, they persist for a longer duration[3].

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Many workers have worked out heavy metal contamination in water bodies and there impacts on fauna and flora[4] have bean estimated i.e. trace elements in ground water of Tuppa area, New Nanded, Maharastra. Katatria[5] has reported heavy metals contamination and pollution in Betwa River. Srikanth et al.[6] have published data of Pb, Ca, Ni and Zn contamination of ground water around Hussain Sagar lake, Hyderabad. Ali and Tiwari[7] have made preliminary survey of some toxic metals in the ground waters of Rourkela. Ayyaduri et al.[8] reported mercury pollution in water of Madras city. Khursid et al.[9] have investigated degradation of water quality due to heavy metal pollution in Faridabad District. Reshma and Prakasam[10] evaluated the potability of tube wells of Mayyanad Panchayat of Kerala. Nafees et al.[11] carried out chemical analysis of ground water of outer skirts of Kota city Rajasthan in pre-monsson season. Chanakya and Rao[12] reported impact of industrial effluents on ground water quality of Katten industrial area of Andhra Pradesh.

In view of the high probability of metal contamination in the area due to natural and anthropogenic activities, the present study was undertaken.

EXPERIMENTAL

Materials and methods

Study area

Kota city is centrally located in Hadoti Region. Over the years of industrial development, Kota's name became synonymous with industrial town of Rajasthan as large industrial houses like KSTPS, DCM, Instrumentation Ltd., Chambal Fertilizers Ltd., etc. have their units located at Kota.

Kota has good number of prominent industrial units, good network of railway lines, perennial sources of water and electricity. The Chambal river provides the irrigation, water supply, and electricity to the whole Hadoti Region. It is well connected with all major cities of India by broad gauge railway system. National highway 12 Jaipur to Jabalpur and 76 Shivpuri to Pindwara passes through the city.

In last decade, Kota city has emerged as "Educational City" of India mainly because of its excellence in coaching for entrance examination of national and state level technological institutes for engineering and medical courses. Near about 50-60 thousand students of age group 17-19 years come every year here to sharpen their brains and get through these examinations. Not only for coaching but Kota's name is also known for its "Kota sarees", "Kota stone" and now for Kota's Kachouri and Namkeens.

The district Kota lies between $24^o25'$ and $25^o51'$ North latitudes and $75^o31'$ and $77^o26'$ East longitudes with total area of 5203.94 sq Kms. "Kota City" is located at extreme South of it at $25^o11'$ North latitude and $75^o51'$ East longitude occupying total area of 238.59 sq Kms with average height of 253.30 meters from mean sea level. The only perennial river "Chambal" originating from the hills of Western Madhya Pradesh passes through the district. According to 2001 census, total population of district was 1568525 and according a recent survey, estimated population for 2008 was 1836021. Kota District has Bundi on its West, Sawai Madhopur in the North, Chittorgarh in South West and Jhalawar in the South East and Baran in the East.

The lithological units that constitute the Kota division are mainly those of upper Vindhyan system. The upper Bhander sandstone covers wide areas on the North and parts of Southern sector are mantled by Deccan trap flows. The Eastern parts of the central belt is occupied by the Suket shales, while on the West, there are rock out crops of Kaimur sandstone. Alluvium covers part of the area on the Northeastern parts.

Sampling locations and techniques

To find out heavy metal contamination in ground water of outer skirts of industrial and educational Kota city, water samples were collected from twenty-four different selected sites in per-monsoon period of years 2006, 2007, and 2008. The selection of sampling sites is done to give coverage to the largest area of outer skirts of Kota City in all the four directions, covering estimated points of high probability of ground water pollution. Six villages of prime importance from each direction were selected for study. The bore wells / hand pumps located in residential, commercial, agricultural and industrial area were selected for sampling. Before collecting groundwater samples, the pipeline of bore wells / hand pumps were flushed for a sufficient period of time, so that actual sample can be collected, which represents the true quality of groundwater. The samples were collected as composite samples; at every site, samples were collected from four different points and then mixed together. Sample were collected in pre-cleaned good quality narrow mouth screw-capped polypropylene bottles of two-liter capacity and rinsed thrice with the water to be collected and then filled completely to avoid encroachment of any air bubble. Sample bottles were then screw-caped tightly and brought to the laboratory. The samples were preserved in a refrigerator at 4^oC. Samples were protected from any out side contamination. The analysis of ground water samples was done using procedures of Standard Methods (APHA, 1995)[13] and all analysis were carried out in triplicate.

RESULTS AND DISCUSSION

The findings of present investigation, regarding trace heavy metal contamination in ground water samples collected from various locations at outer skirts of Kota City, Kota during pre-monsoon season of 2006, 2007 and 2008 are presented in Table 1. Comparisons of the data so obtained with limits given for drinking water prescribed by WHO (1993)[14] & BIS (1991)[15] are also reported in Table 1.

Table 1: Water quality data of trace heavy metal analysis at the study sites

Location	Year	Parameters					
		Fe	**Cr**	**Cu**	**Zn**	**Mn**	**Pb**
Maximum permissible limit as per IS 10500		1.00	0.05	1.50	15.00	0.30	0.05
Maximum permissible limit as per WHO		1.00	0.05	2.00	3.00	0.50	0.01
Gangaycha	2006	0.12	ND	0.06	0.09	0.07	ND
	2007	0.16	ND	ND	0.07	0.09	ND
	2008	0.13	ND	0.09	0.11	0.08	ND
Notana	2006	0.09	ND	ND	0.08	ND	ND
	2007	0.15	ND	0.06	0.10	0.06	ND
	2008	0.12	ND	ND	0.07	ND	ND
Rangpur	2006	0.21	0.03	0.08	0.08	0.08	ND
	2007	0.11	0.05	0.06	0.06	0.05	ND
	2008	0.17	0.05	ND	0.09	0.09	ND
Bhim Mandi	2006	0.23	0.07	0.09	0.08	0.07	0.10
	2007	0.15	0.05	0.10	0.06	0.05	0.06
	2008	0.12	0.04	0.07	ND	ND	0.08
Gamach	2006	0.11	ND	ND	0.09	0.08	ND
	2007	0.08	ND	ND	ND	ND	ND
	2008	0.12	ND	0.10	ND	0.10	ND
Tirath	2006	0.08	ND	ND	0.10	ND	ND
	2007	0.12	ND	ND	0.08	0.09	ND
	2008	0.10	ND	ND	ND	ND	ND

Cont…

Location	Year	Parameters					
		Fe	**Cr**	**Cu**	**Zn**	**Mn**	**Pb**
Raipura	2006	0.19	ND	ND	0.09	ND	ND
	2007	0.11	ND	ND	ND	ND	ND
	2008	0.15	ND	ND	0.11	ND	ND
Borkhandi	2006	0.16	ND	0.12	0.15	ND	ND
	2007	0.20	ND	0.10	0.11	ND	ND
	2008	0.25	ND	0.08	0.16	ND	ND
Dhakar Kheri	2006	0.11	ND	ND	0.08	ND	ND
	2007	0.10	ND	ND	0.11	ND	ND
	2008	0.13	ND	ND	0.09	ND	ND
Tather	2006	0.10	ND	ND	0.12	ND	ND
	2007	0.16	ND	ND	0.08	ND	ND
	2008	0.12	ND	ND	0.11	ND	ND
Manpura	2006	0.17	ND	0.07	0.15	ND	ND
	2007	0.13	ND	ND	0.11	ND	ND
	2008	0.15	ND	0.11	0.13	ND	ND
Kaithoon	2006	0.10	ND	ND	0.10	ND	ND
	2007	0.13	ND	0.10	0.08	ND	ND
	2008	0.19	ND	ND	0.11	ND	ND
Ranpur	2006	0.22	ND	0.10	ND	ND	ND
	2007	0.25	ND	0.10	ND	ND	ND
	2008	0.18	ND	ND	0.10	ND	ND
Jagpura	2006	0.29	0.07	0.08	0.13	ND	0.08
	2007	0.18	0.08	0.11	0.11	ND	0.10
	2008	0.15	0.10	0.10	0.14	0.07	0.07
Alaniya	2006	0.17	ND	0.10	ND	0.09	ND
	2007	0.11	ND	ND	0.10	ND	ND
	2008	0.19	ND	0.11	ND	ND	ND

Cont…

Location	Year	Parameters					
		Fe	Cr	Cu	Zn	Mn	Pb
Shankarpura	2006	0.14	ND	ND	0.10	ND	ND
	2007	0.17	ND	ND	0.09	ND	ND
	2008	0.11	ND	0.10	0.10	ND	ND
Dad Devi	2006	0.14	ND	ND	0.10	ND	ND
	2007	0.12	ND	ND	ND	ND	ND
	2008	0.19	ND	ND	0.10	ND	ND
Naya-Gaon	2006	0.21	ND	ND	ND	ND	ND
	2007	0.29	ND	0.10	0.10	ND	ND
	2008	0.17	ND	0.09	0.08	ND	ND
Nanta	2006	0.11	0.21	0.12	0.13	0.31	ND
	2007	0.15	0.16	0.10	0.11	0.34	ND
	2008	0.16	0.29	0.13	0.16	0.38	ND
Ganeshpal	2006	0.11	ND	ND	ND	ND	ND
	2007	0.10	ND	ND	ND	ND	ND
	2008	0.12	ND	ND	ND	ND	ND
Badgaon	2006	0.10	ND	ND	0.10	ND	ND
	2007	0.12	ND	ND	ND	ND	ND
	2008	0.10	ND	ND	ND	ND	ND
Kunhadi	2006	0.11	0.10	0.09	0.11	0.25	ND
	2007	0.14	0.13	0.11	0.10	0.19	ND
	2008	0.10	ND	0.10	0.13	0.18	ND
Balita	2006	0.16	ND	ND	ND	0.22	ND
	2007	0.19	ND	ND	0.10	0.27	ND
	2008	0.12	ND	ND	ND	0.19	ND
Sinta	2006	0.22	0.17	0.12	ND	0.17	ND
	2007	0.17	0.12	0.10	ND	0.13	ND
	2008	0.19	0.15	0.11	0.10	0.19	ND

Iron (Fe)

The weathering of rock and discharge of waste effluents on land are the main source of iron in ground water. Iron migrates as adsorbed to suspended matter, insoluble hydrated iron compounds, complexed to inorganic and organic ligands and also as hydrated ions. Dissolved carbon dioxide, pH and EC of water affect the nature of aqueous iron species

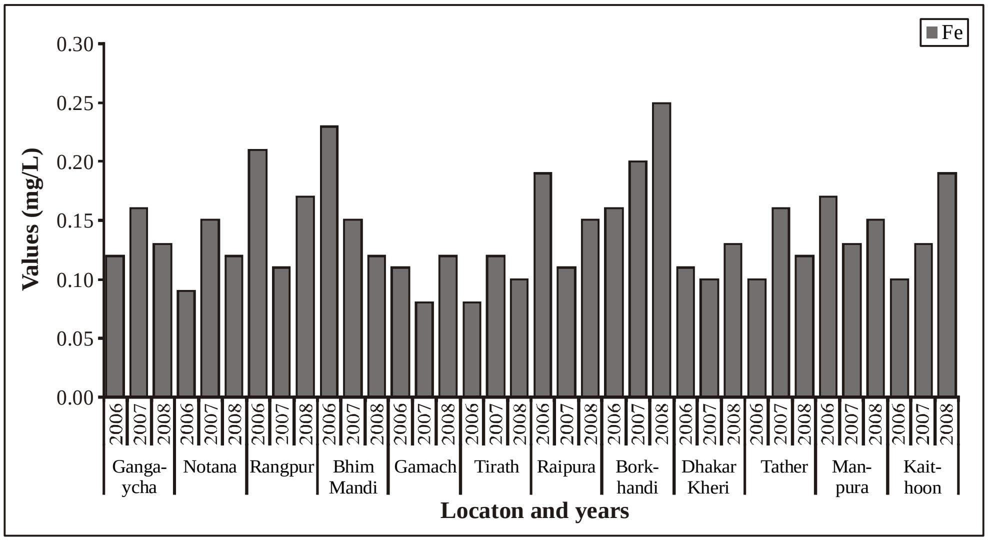

Fig. 1: Iron level in ground water of outer Skirts of Kota city

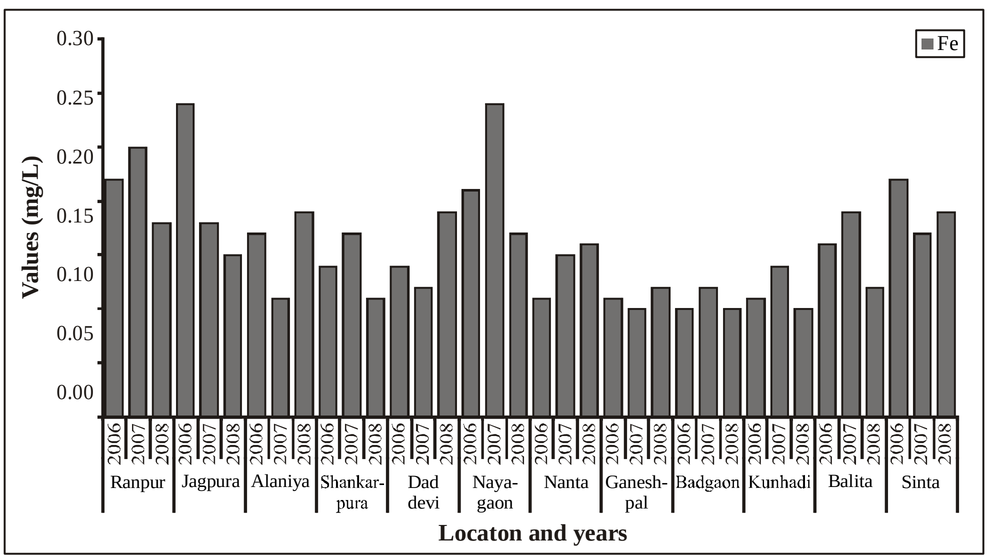

Fig. 2: Iron level in ground water of outer Skirts of Kota city

present in water. Limits in water supplies for potable use have not been laid down from health consideration but due to the fact that iron in water supplies may cause discoloration of clothes, plumbing fixtures and porcelain wares. The "red-rot" disease of water caused by bacterial precipitation of hydrated oxides of ferric iron with consequent unaesthetic appearance to water, clogging of pipes, pitting of pipes and occurrence of foul smells, is due to the presence of relatively high iron in water. Iron in concentration exceeding 1 μg/L also causes astringent taste to water.

The iron concentration in potable water is limited to 0.1 mg/L with upper limit of 0.3 mg/L (WHO, 1993). The BIS has given desirable limit of 0.3 mg/L, which may be extended up to 1.0 mg/L in absence of alternative sources (ISI, 1991). The concentration of iron in ground water of study area ranges from 0.08 to 0.29 mg/L (Figs. 1 and 2). High concentration of iron at various locations causes inky flavor, bitter and astringent taste. Well water containing soluble iron remains clear while pumped out but exposure to air causes precipitation of iron due to oxidation, with a consequence as appearance of rusty color and turbidity. Studies on the iron content[16] have also been reported with high concentration of iron in ground water of Coimbatore, Tamil Nadu along Noyal river, which poses a serious problem in water supplies from bore wells.

Chromium (Cr)

Chromium has been considered as a relative biological and pollution significant element, since it is ubiquitous in nature and most commonly found in the trivalent state. Hexavelent form of chromium is more toxic than trivalent form. The maximum permissible limit of chromium in drinking water is 0.05 mg/L (WHO and BIS). The trivalent form is an essential nutrient for human, required in amounts of 0.05 to 0.20 ppm/day. Generally, the chromium content of drinking water is very low ranging from 0.01 to 0.05 mg/L except for regions with substantial chromium deposits[17]. Chromium is extensively used as tanning agent, catalysts, pigments and in plating industries and hence, it is found in excess quantities in urban area and originates from human activities along with other sources[18]. The chromium concentration in present research ranges from a minimum ND to a maximum 0.29 mg/L. The anthropogenic activities, domestic sewage and wastewater run-off may be the source for indicated chromium. However, study has indicated that the concentration of chromium is below the detection limit in most of the locations, but at some locations, it is detected and the most of values were higher than the permissible limit.

Copper (Cu)

Copper occurs in the earth either in free native state or in the form of its ores depending upon the geographical location and proximity of industry. It is an essential element of human body, but excessive large doses may lead to mucosal irritation, corrosion, widespread capillary damage, hepatic & renal damage and also damage to central nervous system. Copper below 20 µg/L, which can derived from rock weathering, may be found in drinking water. Due to industrial effluent contamination, concentration of copper in ground water may increase. The principal sources of copper in water supplies are corrosion of brass and copper pipe and addition of copper salts during water treatment for algae control. The concentration of copper found in natural waters are not known to have adverse effects on humans, though copper in excess of 1.0 mg/L may impart some taste to water[19] and also enhance corrosion of aluminium and zinc utensils & fittings. Hence, a guideline value of 1 mg/L is recommended by WHO. Toxicity of copper to aquatic life is dependent on the alkalinity of the water. At lower alkalinity, copper is more toxic to aquatic life. The sources of copper that enhance the concentration in groundwater include industrial effluents from electroplating units, textiles, paints and pesticides. The concentration of copper, recorded a maximum 0.13 mg/L in ground water at outer skirts of Kota City, Kota. At most of the locations the content of copper was below the detection limit (0.001 mg/L) of the instrument.

Zinc (Zn)

Zinc is an essential element for both animals & humans and it is necessary for the functioning of various enzyme systems, deficiency of which leads to growth retardation. Low intake of zinc results in retardation of growth, immaturity and anaemia, condition known as "Zinc deficiency syndrome". Symptoms of zinc toxicity in humans include vomiting, dehydration, electrolyte imbalance, abdominal pain, nausea lethargyness, dizziness and lack of muscular coordination. Zinc imparts undesirable bitter astringent taste to water at levels above 5.0 mg/L (WHO, 1993). Water containing zinc at concentrations in excess of 5.0 mg/L may appear opalescent and develop a greasy film on boiling. Toxic concentrations of zinc above recommended value cause adverse effect in the morphology of fish by including cellular breakdown of gills. Zinc deficiency in human body may result in infantilism, impaired wound healing and several other diseases.

Pollution from industrial and agricultural sources to a great extent is responsible for high concentration of zinc in ground water. The concentration of zinc in the study area ranges from ND to 0.16 mg/L. The levels of zinc in the ground water of outer skirts of Kota City, Kota, are safe enough for drinking and other domestic purposes.

Manganese (Mn)

Excess manganese in a diet prevents the use of iron in the regeneration of blood haemoglobin. Large doses of manganese cause apathy, irritability, headaches, insomnia, and weakness of the legs. Psychological symptoms may also develop including impulsive acts, absent-mindedness, hallucinations, aggressiveness, and unaccountable laughter. Finally, a condition similar to Parkinson's disease may develop.

Pollution from industries, leaching from solid waste disposal sites and from coal fly ash disposal sites is the main source of manganese contamination in ground water[20]. The concentration of manganese in the study area ranged from ND to 0.38 mg/L. The maximum permissible limit of manganese as per BIS is 0.30 mg/L and at some locations, values exceed this limit. Hence, the quality of ground water of outer skirts of Kota City, Kota, are suspectable at some locations for drinking and other domestic purposes.

Lead (Pb)

Lead is one of the natural constituents of earth's crust. It is used in the manufacturing of acid accumulators, alkyl lead compounds for gasoline, tetraethyl lead as antiknocking compounds, solder, pigments & paints, roofing material, sulphuric acid, lead arsenite, insecticides, rubber etc. The exposure of lead occurs through air, soil, dust, paint, food and drinking water. It exhibits toxicological symptoms, when route of entry to body is through inhalation, skin absorption and ingestion in drinking water and food in higher concentrations. It has accumulative property in human systems and exhibits some symptoms of acute poisoning, like drowsiness, sluggishness, abdominal disorder, irritability, anemia, and behavioral change (WHO, 1993). Low levels of lead can reduce the activity of enzymes to synthesize hemoglobin resulting in anemia.

Among accumulative metal contaminants, lead represents an exclusive case because of its ubiquitous presence in the environment. Lead poisoning has been recognized as an occupational illness for centuries, and it is linked with both; severe and subtle health damage[21]. Higher concentration of lead in drinking water has adverse effect on central nervous system; blood cell and may cause brain damage. The permissible limit of lead in drinking water is 0.05 mg/L (BIS, 1991). It occurs in drinking water preliminarily from corrosion of lead pipes and solders, especially in area of soft water. Since dissolution of lead required an extended contact time, lead is most likely to be present in tap water after being in the service connection piping and plumbing overnight.

Health effects of lead are generally correlated with blood test levels. Infants and young children absorb ingested lead more readily than do older children and young adults. Lead exposure across a broad range of blood lead level is associated with a continuum of physiological effects, including interference with heme synthesis necessary for formation of red blood cells, anemia, kidney damage, impaired reproductive function, interference with vitamin D metabolism, impaired cognitive performance, delayed neurological and physical development and elevations in blood pressure. The lead content in study area ranged between ND to 0.10 gm/L. At such levels, no lead toxicity problems are to be expected from these water supply and the values are well within limits prescribed for drinking water (BIS, 1991; WHO, 1993) except two locations, and therefore, the ground water of outer skirts of Kota City, Kota, can be safely used as a source of drinking water supplies except two locations i.e.Bhim Mandi and Jugpura.

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