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Health Hazards Caused by Heavy Metals and their Physico-Chemical Properties in Water Samples from Jodhpur District of Northern Rajasthan, India

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***Abstract* - High Resolution Inductively coupled plasma mass spectroscopy (HR-ICP-MS) technique has been used to study the concentration of heavy metals (Zn, Cd, Pb, Cu, Mn, Fe, Se, Cr and Th) in drinking water samples collected from 10 different locations of Jodhpur district of Northern Rajasthan, India. The heavy metals have been studied for their health hazards and the concentration is correlated with recommended safe limits as suggested by various protection agencies. Moreover, significant correlation has been observed among the physico-chemical properties of water and heavy metal concentration. The results revel that drinking water contaminated with heavy metals is prone to radiological and chemical threats for inhabitants.**
***Keywords:*HR-ICP-MS, Radiological effects, Physico-chemical analysis, Ground water.**

I.INTRODUCTION

In the 20th century obtaining drinking water has become a serious problem due to the ground water is contaminated by the addition of toxic substance. A number of studies have been conducted in the whole world to determine the concentration of heavy metals in water samples [1-5]. Among heavy metals Zn, As, Cu, Cd and Pb are present throughout the earth crust and are much toxic than other metals. The previous studies reveal that intake of these metals may result chronic damage. From the health point of view the intake of large amount of Zinc can cause anaemia. The intake of Cadmium by food and water can injure the renal, pulmonary, skeletal, testicular and nervous system. Excess of Lead in the human body may lead to cause headache, irritability, abdominal pain and various symptoms related to the nervous system. Large consumption of Arsenic via water may lead to gastrointestinal symptoms, severe disturbances of the cardiovascular and central nervous systems, and eventually death. Large intake of Copper may cause stomach and intestinal distress such as nausea, vomiting, diarrhea and stomach cramps.

In our recent investigation, the activity concentration of natural radionuclides in the soil samples of Jodhpur district of Northern Rajasthan, India was found to be higher than MCL [6]. The concentration of natural radionuclides in soil and water is proportional to heavy metal concentration at particular place. In the target region the main sources of drinking water is mainly tube well. The water obtained from the tube well may be unsafe for drinking purposes and very harmful from the health point of view. Hence measurements of heavy metal concentration in water sample of Jodhpur district of Northern Rajasthan, India have significant importance. These studies will be helpful in determination whether the water of this district can be used for drinking purpose without posing any health hazard to the inhabitants. There is no literature available which is showing that any attempt has been made for the measurement of heavy metal concentration in water of Jodhpur district of Northern Rajasthan, India. In the present study, heavy metal concentration in water from Jodhpur district of Marwar region of Northern Rajasthan, India has been investigated systematically.

II.GEOLOGY OF THE AREA

The studied area lies in the North West part of India. Its location varies between 23°30´ to 30°11´ north latitude and 69°29´ to 78°17´ east longitude. Figure 1 shows the position of Rajasthan with in India; the locations of sampling sites are also marked in it. Jodhpur district covers a major region of Northern Rajasthan. It is extended between 26°00´ to 27°37´ latitude and 72°55´ to 73°55´ longitude. It has common boundary with the five districts. The Bikaner is touching from north, Jaisalmer is in northwest, Barmer is located in South West, Pali in South East and Nagaur is in East-North side. It is basically a hilly region containing Hillocks rocks of Pre-Cambrian to the recent age. The limestone, sandstone and granite commonly found in these rocks. They are enriched with minerals like Jasper, Ball clay and Dolomite. Moreover is a naturally occurring region existing in the womb of Luni-Jawa Plains, Jojri and Sukri rivers.

III.MATERIALS AND METHODS

A.Sample Collection and Preparation

In order to measure the heavy metal concentration, 10

drinking water samples were collected from the various different locations of Jodhpur district of Rajasthan, India on random bases. The samples were collected from tube wells at the various depths. In order to get fresh water, the tube wells were pumped for at least 10 minutes before the samples were taken. 100 ml of water sample was taken from each location and there after filtered by using Whatman filter paper No. 1.

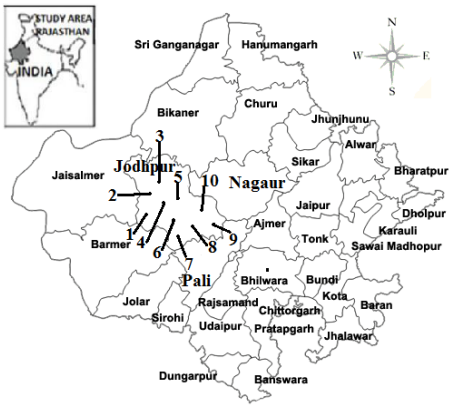

Fig. 1 The map showing the sample locations of Jodhpur District

B.Physico-Chemical Analysis

Half of the filter water for each sample was used for physico-chemical analysis namely pH, conductance and total dissolved solids (TDS) by using pH/EC bench top meter using standard procedures (ALPHA, 1985).

C.HR-ICP-MS Analysis

The heavy metal analysis in half of the water samples was carried out by using high resolution inductively coupled plasma mass spectroscopy (HR-ICP-MS) (Perkin-Elmer Sciex Elan DRC II) technique at National Geophysical Research Institute (NGRI), Hyderabad, India. For heavy metal analysis, NIST 1640a (National Institute of Standards and Technology) was used as a calibration standard and NIST 1643e was used as a reference material. HR-ICP-MS technique takes only 2 to 6 minutes for the analysis of each sample and has excellent precision of about 5% relative standard deviation (RSD). It is a full Multi-elemental technique over a mass range of 3-238 a.m.u. The detail analytical procedure of this method is described by Balaram [7].

IV.RESULTS AND DISCUSSION

The data for various heavy metal concentration (Cr, Fe, Cu, Zn, As, Se, Cd, Pb and Th) in 10 drinking water samples collected from the different locations at different depths of Jodhpur district of Northern Rajasthan, India are tabulated in table1. From which it can be seen that the heavy metal concentration in drinking water samples varies from 3.87 to 23.62 µg l^{-1} (Cr), 75.52 to 3248.94 µg l^{-1} (Fe), 1.06 to 7.03 µg l^{-1} (Cu), 16.76 to 865.57 µg l^{-1}(Zn), 2.29 to 11.18 µg l^{-1} (As), 4.72 to 17.41 µg l^{-1} (Se), 0.07 to 3.55 µg l^{-1} (Cd), 2.71 to 40.60 µg l^{-1} (Pb) and 0.30 to 9.73 (Th) with the mean value of 7.96 µg l^{-1}, 854.75 µg l^{-1}, 3.16 µg l^{-1}, 283.01 µg l^{-1}, 4.75 µg l^{-1}, 9.49 µg l^{-1}, 1.08 µg l^{-1}, 15.94 µg l^{-1} and 2.55 µg l^{-1} respectively. Various protection agencies have recommended the different permissible limits of concentration of heavy metal in drinking water for inhabitants. The US Environmental Protection Agency (USEPA, 2011) has recommended 1300 µg l^{-1}, 5 µg l^{-1}, 50 µg l^{-1}, 50 µg l^{-1} and 100 µg l^{-1} of Cu, Cd, Se, As and Cr respectively in drinking water as a permissible limit. [8]. The concentration of heavy metals in all the investigated drinking water samples lies within the safe limit approved by USEPA. Moreover the safe limits of heavy metal concentration of Fe, Cu, Cd, Se, As, Pb and Zn in drinking water samples are 100 µg l^{-1}, 1000 µg l^{-1}, 5 µg l^{-1}, 10 µg l^{-1}, 50 µg l^{-1}, 5 µg l^{-1} and 5000 µg l^{-1} respectively as set by WHO (2008) [9]. The observed values of the concentration of Cu, Cd and As in our investigated water samples are well below the allowed maximum contamination limit as approved by USEPA. The concentration of iron in all drinking water samples is found to be higher than the safe limit as recommended by WHO except sample S4 (Iron concentration 91.47 µg l^{-1}). The content of Se in 50% drinking water samples has been found to be higher than the permissible limit as recommended by WHO (S1, selenium concentration 10.38 µg l^{-1}; S7, selenium concentration 10.24 µg l^{-1}; S8, selenium concentration 17.41 µg l^{-1}; S9, selenium concentration 14.52 µg l^{-1} and S10, selenium concentration 12.96 µg l^{-1}). The measured value of lead in 60% water samples is found to be higher than the safe limit as set by WHO expect (S4, lead concentration 2.71 µg l^{-1}; S5, lead concentration 4.86 µg l^{-1}; S8, lead concentration 3.94 µg l^{-1} and S10, lead concentration 3.56 µg l^{-1}). The high concentration of heavy metal has been found in Jodhpur district may be due to the geological structure of the district and intensive mining of red marble in this district. Moreover high concentration of heavy metals in drinking water samples may be due to the use of minerals such as jasper, dolomite, limestone, granite, phosphate, which contains high concentration of heavy metals in this district. The concentration of Zn and Cu in present water samples are higher where as Cd and Pb are lower than the reported values for Amritsar district of Punjab [1].

From table 2 it is clear that TDS in drinking water samples ranges from 312.5 to 1230 mg l^{-1} with the mean value of 710.35 mg l^{-1}. The value of TDS in 40% water samples were found more than the recommended permissible limit 100 mg l^{-1} as set by WHO (2008). A good positive correlation of Se, Cu and Fe with TDS has been found.

The conductance of drinking water samples ranges from 0.94 to 3.03 mΩ^{-1} with mean value of 1.98 mΩ^{-1} as shown in table 2. The measure value of conductance in 4 water samples were found more than the recommended MCL of 2 mΩ^{-1} as given by WHO (1971) [10]. High values of TDS and conductance may be due to the heavy metals dissolved in investigated water samples.

TABLE 1 THE CONCENTRATION OF DIFFERENT HEAVY MATES IN GROUNDWATER SAMPLES FROM SOME AREAS OF JODHPUR DISTRICT.

Sr. No.	Sample Location (Village)	Source	Depth (feet)	$^{52}Cr_{24}$	$^{57}Fe_{26}$	$^{63}Cu_{29}$	$^{66}Zn_{30}$	$^{75}As_{33}$	$^{77}Se_{34}$	$^{111}Cd_{48}$	$^{208}Pb_{82}$	$^{232}Th_{90}$
	Jodhpur											
1	Sherguarh	Tube well	400	23.62	1020.01	3.00	345.41	2.38	10.38	3.55	40.60	3.39
2	Kvinda	Tube well	375	5.05	1061.23	5.49	865.57	4.62	7.34	3.27	39.96	1.91
3	Ossian	Tube well	700	6.10	75.52	1.41	81.70	3.01	5.74	0.39	6.86	0.30
4	Tinwari	Tube well	740	5.84	91.47	1.21	16.76	2.61	6.12	0.09	2.71	0.72
5	Mathania	Tube well	650	7.72	103.92	1.06	24.99	2.53	5.46	0.43	4.86	1.01
6	Basni (Jodhpur)	Tube well	350	11.04	209.64	3.10	587.42	11.18	4.72	0.90	17.12	0.70
7	Kakani	Tube well	250	3.87	776.80	3.62	90.86	8.01	10.24	1.04	13.68	4.58
8	Dhangeavas	Tube well	700	5.25	1855.84	2.69	355.79	2.29	17.41	0.20	3.94	2.15
9	Pipar City	Tube well	150	5.87	3248.94	7.03	440.71	7.42	14.52	0.86	26.13	9.73
10	Bilada	Tube well	300	5.25	104.15	3.02	20.92	3.50	12.96	0.07	3.56	1.04
	Range		150-740	3.87-11.04	75.52-3248.94	1.06-7.03	16.76-865.57	2.38-11.18	4.72-17.41	0.07-3.55	2.71-40.60	0.30-9.73
	Average		461.5	7.96	854.75	3.16	283.01	4.75	9.49	1.1	15.94	2.55

TABLE 2 PHYSICO-CHEMICAL PROPERTIES AT VARIOUS LOCATIONS IN JODHPUR DISTRICT OF NORTHERN REGION OF RAJASTHAN.

Sr. No.	Sample Location (Village)	TDS (mg l-1)	Conductance mΩ-1	Ph
	Jodhpur			
1	Sherguarh	409	1.37	8.45
2	Kvinda	708.5	1.75	7.07
3	Ossian	368.5	0.94	7.97
4	Tinwari	330	1.27	7.14
5	Mathania	395	1.35	6.32
6	Basni (Jodhpur)	312.5	1.56	7.33
7	Kakani	1140	2.87	7.54
8	Dhangeavas	1060	2.79	7.25
9	Pipar City	1230	3.03	7.00
10	Bilada	1150	2.86	7.04
	Range	312.5-1230	0.94-3.03	6.32-8.45
	Average	710.35	1.98	7.31

From table 2 it is clearly seen that the pH of drinking water samples ranges from 6.32 to 8.45 with the mean value of 7.31. pH values of all the drinking water samples were found to be below the permissible limit of 7-8.5 as recommended by WHO (1971). Hence the drinking water samples from these regions are unsafe for drinking purpose.

V.CONCLUSION

The measured concentration of heavy metals in water samples from the selected regions of Rajasthan are higher than the safe limit recommended by WHO (2011) and US Environmental Protection Agency (USEPA, 2011). The TDS and conductance of 40% water samples has been found more than the recommended safe limit as given by WHO and a good positive correlation between the concentration of Se, Cu and Fe with TDS in studied water drinking water samples are found within the MCL limit as approved by WHO. The overall result shows that heavy metal concentration in nine drinking water samples cross the MCL as recommended by various protection agencies and therefore unsafe for drinking purposes which is harmful for health point of view.

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