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HEAVY METALS ASSESSMENT IN CORRELATION WITH PHYSICO-CHEMICAL PROPERTIES OF DRINKING WATER IN JHUNJHUNU DISTRICT OF NORTHERN RAJASTHAN, INDIA

Sudhir Mittal[1*], Asha Rani[2] , Rohit Mehra[3]

[1]*Department of Physics, Baba Farid College, Deon, Bathinda-151002, Punjab, India*
[2]*Department of Physics, Dev Samaj College for Women, Ferozepur-152002, Punjab, India*
[3]*Department of Physics, Dr. B.R.Ambedkar National Institute of Technology, Jalandhar-144011, India*

ABSTRACT

In the present communication, analysis of various heavy metal (Cr, Fe, Cu, Zn, As, Se, Cd, Pb and Th) concentrations in 10 drinking water samples collected from the diverse locations from different depths of Jhunjhunu district of Rajasthan, India has been carried out by using high resolution inductively coupled plasma mass spectroscopy (HR-ICP-MS) technique. The water samples were taken from hand pumps and tube wells. The measured concentrations of Cr, Fe, Cu, Zn, As, Se, Cd, Pb and Th varies from 4.31 to 25.22 µg l^{-1}, 23.37 to 1074.47 µg l^{-1}, 0.71 to 9.73 µg l^{-1}, 1.35 to 677.6 µg l^{-1}, 0.57 to 3.78 µg l^{-1}, 3.32 to 11.36 µg l^{-1}, 0.06 to 1.86 µg l^{-1}, 1.23 to 27.54 µg l^{-1}, 0.89 to 5.34 µg l^{-1} with the mean value of 10 µg l^{-1}, 399 µg l^{-1}, 3 µg l^{-1}, 223 µg l^{-1}, 2 µg l^{-1}, 6µg l^{-1}, 1 µg l^{-1}, 10 µg l^{-1} and 2 µg l^{-1} respectively. 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. The concentration of above mentioned heavy metals in all the investigated water samples lies within the safe limit as approved by USEPA (2011). According to WHO (2008) recommended limit the heavy metal concentrations of all investigated water samples lies below than the permissible limit except from Fe, Se and Pb. 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*:*Health Hazards, HR-ICP-MS, Physico-Chemical properties, Protection Agencies and Radiological and Chemical Risk.

1. 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 Jhunjhunu 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 measurement of heavy metal concentration in water sample of Jhunjhunu district of Northern Rajasthan, India assumes significance. Such study 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. However literature survey shows no attempt has been made towards the measurement of heavy metal concentration in water of Jhunjhunu district of Northern Rajasthan, India. In the present study, heavy metal concentration in water from Jhunjhunu district of Marwar region of Northern Rajasthan, India has been investigated systematically.

2. GEOLOGY OF THE AREA

Rajasthan is located in North West of India. It lies between 23°30´ and 30°11´ north latitude and 69°29´ and 78°17´ east longitude. Figure 1 shows the geographic location of Rajasthan in India, as well as the location of the sampling sites.

Jhunjhunu district is situated in Northern part of Rajasthan. It lies between 27°38´ and 28°31´ North latitude and 75°02´ and 76°06´ longitude. It is bounded by Churu and Sikar districts of Rajasthan in North-West, South-West and South-East and Hisar and Mahendragarh districts of Haryana in North-East. The South and North-East part of Jhunjhunu district is covered by Alwar group of rocks. Aravali hills are also present in some areas of this district. Mainly Desertic and sand Dunes soils are found in this district. Out of three copper producing belts in India, the Khetri copper belt is located in this district. The minerals commonly found in this district are copper, iron, cobalt, limestone, granite and marble.

III MATERIALS AND METHODS

3.1 Sample Collection and Preparation

In order to measure the heavy metal concentration, 10 drinking water samples were collected from the various different locations of Jhunjhunu 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.

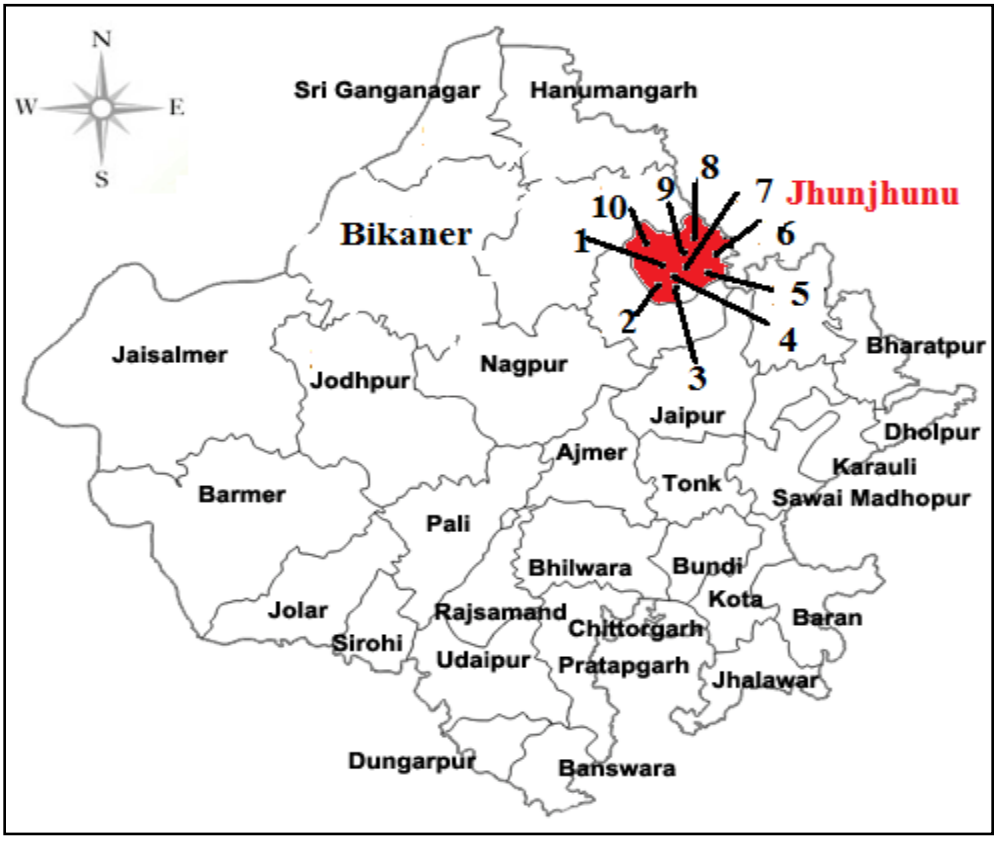

Fig. 1 The map showing the sample locations of Jhunjhunu District

3.2 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).

3.3 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 Jhunjhunu district of Northern Rajasthan, India are tabulated in table1.

Table1. The concentration of different heavy mates in groundwater samples from some areas of Jhunjhunu District.

Sr. No.	Sample Location (Village)	Source	Depth (m)	$^{52}Cr_{24}$	$^{57}Fe_{26}$	$^{63}Cu_{29}$	$^{66}Zn_{30}$	$^{75}As_{33}$	$^{77}Se_{34}$	$^{111}Cd_{48}$	$^{208}Pb_{82}$	$^{232}Th_{90}$
	Jhunjhunu											
1	Jhunjhunu	Tube well	76	24.79	270.7	2.35	135.17	2.21	5.29	1.72	27.54	2.88
2	Nawalgarh	Tube well	122	25.22	23.37	0.92	1.35	1.06	5.44	0.06	1.23	1.15
3	Borki	Hand Pump	30	5.20	309.1	1.24	630.96	0.57	3.32	0.62	7.34	0.89
4	Badagav	Tube well	91	4.31	204.5	1.20	18.96	2.21	3.91	0.14	2.73	1.60
5	Khetri	Hand Pump	21	6.05	512.1	2.48	407.87	1.13	8.54	0.38	4.05	1.33
6	Singhana	Tube well	183	5.26	526.6	3.68	271.00	3.78	11.36	0.44	5.86	2.01
7	Sultana	Tube well	91	4.94	146.5	0.71	11.57	1.51	3.99	0.75	14.29	1.21
8	Mandrela	Tube well	91	7.94	190.1	3.34	14.93	2.44	9.14	0.26	4.61	1.90
9	Chidawa	Tube well	61	10.39	102.0	1.45	58.18	2.53	4.72	0.28	5.15	1.01
10	Dhandhuri	Hand Pump	61	8.57	1704	9.73	677.60	1.90	6.90	1.85	25.96	5.34
	Range		**21-183**	**4.32-25.22**	**23.37-1704**	**0.71-9.73**	**1.35-677.60**	**0.57-3.78**	**3.32-11.36**	**0.14-1.85**	**1.23-27.54**	**0.89-5.34**
	Average		**83**	**10**	**399**	**3**	**223**	**2**	**6**	**1**	**10**	**2**

From which it can be seen that the heavy metal concentration in drinking water samples varies from 4.32 to 25.22 μg l^{-1} (Cr), 23.37 to 1704 μg l^{-1} (Fe), 0.71 to 9.73 μg l^{-1} (Cu), 1.35 to 677.60 μg l^{-1} (Zn), 0.57 to 3.78 μg l^{-1} (As), 3.32 to 11.36 μg l^{-1} (Se), 0.14 to 1.85 μg l^{-1} (Cd), 1.23 to 27.54 μg l^{-1} (Pb) and 0.89 to 5.34 μg l^{-1} (Th) with the mean value of 10 μg l^{-1}, 399 μg l^{-1}, 3 μg l^{-1}, 233 μg l^{-1}, 2 μg l^{-1}, 6 μg l^{-1}, 1 μg l^{-1}, 10 μg l^{-1} and 2 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}, 10 μg l^{-1}, 100 μg l^{-1}, 300 μg l^{-1}, 5000 μg l^{-1} and 15 μg l^{-1} of Cu, Cd, Se, As, Cr, Fe, Zn and Pb 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 Cu, Cd, Se, As, Cr, Fe, Zn and Pb in drinking water samples are 1000 μg l^{-1}, 5 μg l^{-1}, 10 μg l^{-1}, 50 μg l^{-1}, 50 μg l^{-1}, 300 μg l^{-1}, 5000 μg l^{-1} and 5 μg l^{-1}, respectively as set by WHO (2008) [9]. The observed values of the concentration of all the heavy metals in our investigated water samples are well below the allowed maximum contamination limit as approved by USEPA except (S1, Lead concentration 27.54 μg l^{-1} and S10 Lead concentration 25.96 μg l^{-1}. The concentration of iron in all drinking water samples is found to be well below the allowed maximum contamination limit as recommended by WHO and USEPA except sample (S3=Iron concentration 309.1 μg l^{-1}, S5=Iron concentration 512.1 μg l^{-1}, S6=Iron concentration 526.6 μg l^{-1} and S10=Iron concentration 1704 μg l^{-1}). The content of Se in one drinking water samples has been found to be well below the allowed maximum contamination limit as recommended by WHO except sample (S6, selenium concentration 11.36 μg l^{-1}) . The measured value of lead in 30% water samples is found to be higher than the safe limit as set by WHO (S6, lead concentration 5.86 μg l^{-1}; S7, lead concentration 14.29 μg l^{-1} and S9, lead concentration 5.15 μg l^{-1}).

Table 2. Physico-Chemical properties at various locations in Jhunjhunu district of Northern region of Rajasthan.

Sr. No	Sample Location (Village)	TDS (mg l^{-1})	Conductance $m\Omega^{-1}$	pH
	Jhunjhunu			
1	Jhunjhunu	1050	1.57	8.03
2	Nawalgarh	325	1.54	7.82
3	Borki	**150**	1.2	8.22
4	Badagav	300	1.18	8.06
5	Khetri	710	1.67	7.01
6	Singhana	1010	2.51	7.03
7	Sultana	240	1.27	7.31

8	Mandrela	1155	2.85	7.16
9	Chidawa	350	1.10	7.31
10	Dhandhuri	945	2.40	8.14
	Range	**150-1155**	**1.10-2.85**	**7.01-8.22**
	Average	**623**	**2**	**8**

The high concentration of heavy metal has been found in Jhunjhunu 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 lignite, gypsum, clay and limestone 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 150 to 1155 mg l^{-1} with the mean value of 623 mg l^{-1}. The value of TDS in all water samples were found well below than the recommended permissible limit 1000 mg l^{-1} as set by WHO (2008) except (Jhunjhunu and Mendrela). A good positive correlation of Se, Cu and Cr with TDS has been found.

The conductance of drinking water samples ranges from 1.10 to 2.85 $m\Omega^{-1}$ with mean value of 2 $m\Omega^{-1}$ as shown in table 2. The measure value of conductance in 3 water samples were found more than the recommended MCL of 2 $m\Omega^{-1}$ as given by WHO (1971) [10]. High values of TDS and conductance may be due to the heavy metals dissolved in investigated water samples.

From table 2 it is clearly seen that the pH of drinking water samples ranges from 7.01 to 8.22 with the mean value of 8.00. 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) except four samples as shown in table 2. 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 some selected regions of Rajasthan are higher than the safe limit recommended by WHO (2011) and USEPA (2011). The conductance of 20% and TDS in three 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 Cr with TDS in studied water samples has been observed. Except four sampling site the observed pH value in all drinking water samples are found within the MCL limit as approved by WHO. The overall result shows that heavy metal concentration in six 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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