Detection of Radionuclides and Heavy Metals in Water Samples in selected regions of Punjab (India)

[1] Amit Kumar, [2]Sunita Rani

Research Scholar, Department of Chemistry, Guru Kashi University, Talwandi Sabo- Bathinda(Punjab), dr.amitarya01@gmail.com
Department of Chemistry, Guru Kashi University, Talwandi Sabo- Bathinda(Punjab).

Abstract: This research examined samples of different water available in Punjab state. Thus, the different water samples are hand pump, municipal water, water from the inside, and nearby thermal plant. Also, this research estimates the biological oxygen demand in different water samples. Mainly the radionuclides and heavy metal concentrations are analyzed. The radionuclides are Uranium and Cesium, and eight heavy metals are concentrated that are, copper (Cu), Chromium (Cr), Manganese (Mn), Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Arsenic (As). ICP-MS (Inductively coupled Plasma Mass Spectroscopy) technique is used for the estimation of radionuclides and heavy metal concentration in different samples. Results show that the Uranium concentration is higher in Guru Nanak Dev Thermal Plant, Bathinda than Talwandi Sabo Power Corporation Limited (Mansa). Uranium is found in the range of 1.10 ppb (in drinking water samples from TSPCL collected 15 km. away from thermal plant) to 79.20 ppb (GNDTP, sewage water). The high values of Uranium concentration can be due to thermal plant establishment or any other reasons in that area like access use of fertilizers and industrialization. Also, the estimated heavy metal values were evaluated and compared with the reported values by the World Health Organization (WHO). Thus, the evaluation shows that retreatment is needed to improve water quality.

Keywords: *Heavy metals, Different water samples, Radionuclides, and Spectroscopy*

DOI: 10.48047/ecb/2023.12.9.210

1. INTRODUCTION

Water is an essential substance to many animals and all that surrounds them. It has been in existence since the origin of the universe itself. Water forms a greater percentage of men's and animals' blood and tissue [1]. Man uses water for the following activities: irrigation, power generation, and domestic activity. There are two sources of water: rain and groundwater. It is found in rivers, wells, lakes, and streams. The activities of humans and natural phenomena constantly pollute the sources of water and affect water quality. [2] Water pollution arises as a result of waste and sewage disposal into the environment and rivers by industries, hospitals, and the use of materials such as fertilizers by farmers. These disposed-of materials often contain radionuclides [3]. The World Bank estimates 21% of communicable diseases, in India, are water related. Of these diseases, diarrhea alone is estimated to have killed over 535,000 Indians in 2004. The major microbial populations found in wastewater treatment systems are bacteria, protozoa, viruses, fungi, algae, and helminths [4]. So estimation of heavy metals and radionuclides is very important. Uranium has been part of our planet's crust since it was formed and is present in variable amounts in its rock, soil, air, and water. Uranium enters our bodies via the air we breathe, the food we eat, and the water we drink. Children are particularly vulnerable to uranium exposure; contact with DU in war zones or groundwater contamination are the most likely exposure scenarios [5]. Moreover, cardiovascular diseases, kidney-related problems, neurocognitive diseases, and cancer are related to the traces of metals such as cadmium (Cd) and chromium (Cr) as reported in epidemiological studies. The Pb is known to delay the physical and mental growth in infants, while Arsenic (As) and mercury (Hg) can cause serious poisoning with skin pathology and cancer and further damage to the kidney and liver, respectively [6]. The determination is needed to remove those heavy metals from the water. So this research provides the estimation of heavy metals and radionuclides from different water samples of Punjab.

2. RELATED WORK

Ajay kumar *et al.* [7] investigated the radon concentration of water samples in different locations from the Udhampur district of Jammu & Kashmir, India, by using RAD7 and Smart RnDuo monitor. In the study about 17.07% of water samples were recorded to display elevated radon concentration above the reference range suggested by the United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR). Two methods were used for analysis; the evaluation revealed good agreement between the values obtained with the two methods. Eugene Pascal Binam Mandeng *et al.* [8] determined the levels of toxic metals in sediment samples from two watersheds in the Abiete-Toko gold district, southern Cameroon. The investigation shows that the Cu and Ni concentrations of site 4 of the Kienke watershed were higher than the standard average values, whereas in the Tchangue watershed, only Ni was higher than the standard average values. Site 4 of the Kienke watershed and the Tchangue watershed were polluted by Ni and might create an adverse effect on the river's ecosystem.Shittu Abdullahi *et al.* [9] examined the heavy metals and radioactivity concentration of drinking water in 24 sample locations collected from Dutse town. The samples were later studied for gross alpha and radioactivity using MPC-2000, a low background alpha and beta detector. The results show that the correlation was improved by removing an outlier which was considered to have weighted the function unduly to significantly reduce the correlation.M. U. Khandaker *et al.* [10] are concerned with the concentrations of natural radionuclides and heavy metals in marine fish (Rastrelliger Kanagurta) collected from the Straits of Malacca since aquatic stock form an important source of the daily diet of the surrounding populace. The results reflect the contribution of additional technologically enhanced naturally occurring radioactive material (TENORM) pollutants, largely expected to be a result of oil and gas waste streams, related to shipping activities, the route being regarded as the second busiest water channel in the world.M. M. Shaban and I. H. Shady [11] assessed the radioactivity of drinking water collected from groundwater wells in El-Beheira governorate, Northwestern of Egypt. Risk assessment due to intake of heavy metals around study areas where hazard quotient and hazard index was less than 1 meaning that no significant risk or systemic toxicity in the exposed population.Sunita Rani [12]in her study of heavy metal contamination of groundwater assesed that in 90 % of the samples studied were having one or more of the heavy metals,Cu, Cd, Se, As and Cr with concentration more than the recommended value.

3. MATERIALS AND METHODS

3.1 Sampling Area

Water samples have been collected from the areas near and far off from the Two different thermal plants one is situated in Punjab (TSPCL, Mansa), and the other in Punjab (GNDTP, Bathinda). Random water samples are collected as drinking water, hand pump water, cooling tower water, sewerage water raw water, and canal water.

3.2 Sample evaluation of heavy metals and radionuclides

The water samples collected were true water samples, that is, free from suspended or particulate materials, properly stored or preserved so that it should be free from any variations in the content of water samples. The concentrations of natural uranium present in the groundwater samples were analyzed by ICP-MS,Model Perkin-Elmer Sciex ELAN DRC II (IIT Roorkee) at the Instrumentation Centre via the standard run and with the respective reference Uranium standards. The results are recorded in ppm and ppb levels.

4. RESULT AND DISCUSSION

In this section, the collected water from different sources is analyzed as Guru Nanak Dev Thermal Plant, Bathinda, and Talwandi Sabo Power corporation limited, Mansa.

4.1 Analysis of Uranium and Cesium Concentration

Table 1: Uranium and Cesium concentration in Guru Nanak Dev Thermal Plant, Bathinda

Sr.No.	Water Source	Uranium concentration (ppb)	Caesium concentration (ppb)
1	Drinking water	5.78 ± 0.05	0.45 ± 0.001
2	Hand pump water	8.67 ± 0.40	0.10 ± 0.001
3	Cooling tower water	7.61 ± 0.44	0.37 ± 0.001
4	Sewage water	79.20 ± 3.71	0.12 ± 0.005
5	Waterworks water (Raw water)	51.60 ± 0.32	0.11 ± 0.005
6	15 Km away from the thermal plant	3.68 ± 0.04	0.65 ± 0.001

Table 2: Uranium and Cesium concentration in Talwandi Sabo Power Corporation Limited, Mansa

Sr.No.	Water Source	Uranium concentration (ppb)	Caesium concentration (ppb)
1	Drinking water	1.36 ± 0.005	0.18±0.005
2	Hand pump water	2.02 ± 0.01	0.12±0.005
3	Cooling tower water	2.36 ±0.02	0.24±0.005
4	Sewage water	2.43 ± 0.01	0.11±0.005
5	Waterworks water (Raw water)	2.40 ± 0.18	0.11 ± 0.001
6	15 Km away from the thermal plant	1.10 ±0.01	0.10±0.005

Table 1 and 2 shows the uranium and caesium concentration of two different places. In Table 1 the Guru Nanak Dev Thermal Plant is considered and in Table 2 the Talwandi Sabo Power Corporation Limited analysis is carried out. Uranium concentration in water for the whole of the studied area ranges from 1.10µg/L (TSPCL) to 79.60µg/L (GNDTP). In drinking water works water (without purification) raw water has 51.60ppb uranium, which is above the permissible unit given by WHO. Hand Pump water has 8.67 ppb of uranium it is safe for drinking purposes. As this purified water either through aqua guard or RO treated water inside thermal plant uranium concentration estimated at 5.78ppb is in the permissible range. But continuous use of this water may cause serious problems to plants and human beings, so necessary treatment of water is required before its use. Results show that the Uranium concentration is higher in Guru Nanak Dev Thermal Plant, Bathinda than in Talwandi Sabo Power Corporation Limited (Mansa). Uranium is found in the range of 1.10 ppb (drinking water sample from TSPCL collected 15 km. away from thermal plant) to 79.20 (GNDTP, sewerage water) The high values of uranium 25 concentration can be due to thermal plant establishment or any other reasons in that area like access use of fertilizers and industrialization.

4.2 Analysis of Heavy metal concentration

Here, heavy metals such as copper (Cu), Chromium (Cr), Manganese (Mn), Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Arsenic (As) are analyzed for two different places.

Table 3: Heavy metal concentration in different water samples from Guru Nanak Dev Thermal Plant, Bathinda

(a)

Sr.No.	Water Source	Cr	Cu	Mn	Pb
1	Drinking	10.47 ± 0.34	28.13 ±2.66	12.63 ± 1.13	6.80 ±.60
2	Hand pump Water	3.46± .17	29.13 ± 1.47	14.97 ± 0.50	8.07 ± .38
3	Cooling Tower Water	4.53± .01	33.67 ± 1.22	24.90 ± 0.81	8.11 ± .20
4	Sewage water	4.65± .16	27.74 ± 1.33	12.55 ± .44	7.32 ± .20
5	Water works water (Raw Water)	4.53 ± 0.01	32.25 ± 0.04	18.93 ± .16	8.30 ± .02
6	15 Km away from thermal plant	7.77 ± 0.34	11.04 ± 0.96	12.9± 6.87	7.18 ± .13

(b)

Sr.No	Water Source	As	Hg	Ni	Cd
1	Drinking Water	7.09 ± .89	17.86 ± 4.32	8.98 ±.35	.16 ± .01
2	Hand pump Water	9.50 ± .72	17.18 ± .83	10.60 ± .49	.16± .01
3	Cooling Tower Water	10.41 ±.40	19.37 ± .80	5.4 ± .24	.28 ± .01
4	Sewerage water	20.57 ± 1.8	7.60 ± .23	2.89± .14	.65 ± .03
5	Water works water (Raw Water)	20.43 ± .05	38.50 ± .12	3.45 ± .005	.59± .01
6	15 Km away from thermal plant	4.78 ± .12	23.99 ± .87	7.87 ± .14	.13 ± .01

Table 3 shows the heavy metal concentration of the Guru Nanak Dev thermal plant. In Table 3(a) the Cr, Cu, Mn, and Pb are given, and in Table 3(b) the values of As, Hg, Ni, and Cd are analyzed. Here, the drinking water has higher heavy metals than the other water samples of the thermal plant.

Table 4: Heavy metal concentration in different water samples from Talwandi Sabo Power Corporation Limited, Mansa

(a)

Sr.No.	Water Source	Cr	Cu	Mn	Pb
1	Drinking Water	7.51	34.07 ±0.21	30.30 ± 0.09	0.00
2	Hand pump Water	4.56 ± .14	51.39 ± 2.06	17.28 ± 0.57	8.40 ± .07
3	Cooling Tower Water	3.37± .08	33.73 ± 1.36	15.29 ± 0.49	7.80 ± .20
4	Sewerage water	10.36± .02	49.66 ± .06	26.09 ± .09	9.30 ± .12
5	Waterworks water (Raw Water)	3.47 ± 0.14	38.45 ± 2.55	16.04 ± .80	8.06 ± .56
6	15 Km away from thermal plant	3.90 ± 0.06	38.68 ± 2.40	24.46± 1.38	9.10 ± .43

(b)

Sr.No.	Water Source	As	Hg	Ni	Cd
1	Drinking Water	2.43	0.01	7.13 ± .02	0.00
2	Hand pump Water	10.97 ± .57	6.29 ± .53	8.53 ± .32	.16± .01
3	Cooling Tower Water	10.74 ±.52	6.29 ± .24	9.3 ± .31	.16 ± .01
4	Sewerage water	12.98 ± 0.09	15.15 ± .10	10.49± .20	.13 ± .005

5	Water works water (Raw Water)	12.14 ± 1.28	15.15 ± .51	5.18 ± .44	.21± .005
6	15 Km away from thermal plant	9.70 ± .77	30.07 ± 2.31	5.13 ± .34	.29 ± .01

Table 4 shows the heavy metal concentration of the different water samples from Talwandi Sabo power corporation limited, Mansa. All the heavy metals are mostly higher in sewerage water. Drinking water also has higher metal values and it affects the human body so severe retreatment is needed.

5. CONCLUSION

In the present study Two thermal plants namely Guru Nanak Dev Thermal Plant, Bathinda and Talwandi Sabo Power Corporation Limited, Mansa are studied. GNDTP and TSPCL are situated in Punjab. The results show that drinking water is best. However, the concentrations from all locations have exceeded the permissible limits by WHO. So further retreatment is needed to improve the quality of the water. In the future the presented research will consider various locations for determination of water quality.

REFERENCES

1. O. O. Galadima, M. D. Ayagi, R. Rebecca, U. Rilwan, and M. A. Dauda, "Analysis and Assessment of Gross Alpha and Beta in Drinking Water of Some Selected Areas of Gashua, Yobe State, Nigeria", Adv Theo Comp Phy, vol. 5 (3), pp. 485 491, 2022.

2. Sunita Mittal and Sangeeta Sharma, "Assessment of drinking ground water quality at Moga, Punjab (India): an overall approach," Journal of Environmental Research and Development, 3 (1), pp. 129-136, 2008.

3. Shittu Abdullahi, Chifu E. Ndikilar, Abdussalam B. Suleiman, and Hafeez Y. Hafeez, "Evaluation of Radioactivity Concentration in Drinking Water Collected from Local Wells and Boreholes of Dutse Town, North West, Nigeria."

4. P. Rajasulochana, and V. Preethy, "Comparison on efficiency of various techniques in treatment of waste and sewage water–a comprehensive review, Resour Efficient Technol, vol. 2 (4), pp. 175–184, 2016.

5. Dhameer A. Mtlak, and Fadhil A. Aumran, "Study of background radiation in soil and water samples from many regions from Al-Fallujah city." In IOP Conference Series: Materials Science and Engineering, vol. 928, no. 7, p. 072130. IOP Publishing, 2020.

6. Silas Verwiyeh Tatah, Michael Sunday Abu, Mgbede Timothy, and Amsa John, "Heavy metals risk assessment of commercial boreholes water within Wukari Town of Taraba State Nigeria", World Journal of Advanced Research and Reviews, vol 14, no. 2, pp. 672-679, 2022.

7. Ajay Kumar, Sumit Sharma, Rohit Mehra, Priya Kanwar, Rosaline Mishra, and Inderpreet Kaur, "Assessment of radon concentration and heavy metal contamination in groundwater of Udhampur district, Jammu & Kashmir, India", Environmental geochemistry and health, vol. 40, pp. 815-831, 2018.

8. Eugene Pascal Binam Mandeng, Louise Marie Bondje Bidjeck, Armel Zacharie Ekoa Bessa, Yvan Demonstel Ntomb, Jacques Wassouo Wadjou, Elvine Paternie Edjengte Doumo, and Lucien Bitom Dieudonné, "Contamination and risk assessment of heavy metals, and uranium of sediments in two watersheds in Abiete-Toko gold district, Southern Cameroon", Heliyon, vol. 5, no. 10, 2019.

9. Shittu Abdullahi, Chifu E. Ndikilar, A. B. Suleiman, and Hafeez Y. Hafeez, "Assessment of heavy metals and radioactivity concentration in drinking water collected from local wells and boreholes of Dutse Town, North West, Nigeria", Journal of Environment Pollution and Human Health, vol. 4, no. 1, pp. 1-8, 2016.

10. M. U. Khandaker, Kh Asaduzzaman, S. M. Nawi, A. R. Usman, Y. M. Amin, E. Daar, D. A. Bradley, H. Ahmed, and A. A. Okhunov, "Assessment of radiation and heavy metals risk due to the dietary intake of marine fishes (Rastrelliger Kanagurta) from the Straits of Malacca", PLoS One, vol. 10, no. 6, pp. e0128790, 2015.

11. M.M. Shaban, and I.H. shady, "Risk Assessment of Radionuclides and Heavy Metals in Ground Water in Selected Water Wells in Northwestern of Egypt", International journal of advanced research (IJAR), pp. 266-275, 2016.

12. Sunita Rani, "Heavy Metals Contamination of Ground Water in Moga (Punjab): An Indexing Approach", International Journal of Engineering, Applied and Management Sciences Paradigms, vol. 54, no. 3, pp. 200-204, 2019.