

Chemical Assessment of Cadmium in the Groundwater of Saharsa District, Bihar

Sandeep Kumar Jha and Ashok Kumar Yadav

University Department of Chemistry

B. N. Mandal University, Madhepura, Bihar, PIN-852113, INDIA

Email - yadavkrashok@yahoo.co.in

Manuscript received online 05 February 2025, accepted on 25 March 2025

Abstract : Now a days water pollution has become one of the most common phenomenon and the consumption of polluted water has become the fate of the people. People are suffering from many types of diseases due to consumption of polluted water and hence to create awareness and to avoid these diseases, regular monitoring of water quality is essential. Present paper reports the result of chemical assessment of cadmium in the groundwater of Saharsa District, Bihar which is situated at latitude 25°35'–26°28' N and longitude 86°18'–86°51' E. All the ten community development blocks of Saharsa district have been selected as sampling sites and from each block two samples either from well or tube well, on the basis of availability of functioning well or tube-well, have been collected for analysis. Thus, all together twenty samples were collected for pre- and post- monsoon seasons respectively in the year 2022. These samples were analyzed. The concentration of Cadmium (Cd) was found to be ranged between 0.046 ppm to 0.073 ppm for pre-monsoon and 0.044 ppm to 0.068 ppm for post-monsoon season, and its average values were between 0.044 ppm to 0.070 ppm. The acceptable and allowable maximum limits prescribed by USPH and WHO respectively are same i.e. 0.01 ppm. Thus all the values are much higher than the maximum limit.

(Keywords : Biochemical Effects, Toxicology and Toxicity, Environmental Levels and Ecological Effects of Cadmium).

Introduction

Cadmium(Cd) as a distinct element was discovered by Stromeyer of Germany in 1817. Owing to the similarity in atomic structure and chemical behaviour, Cd and Zn often occur together in nature. However, while Zn is an essential element, Cd is considered as a toxic

element. They are found together in sulfide deposits. Igneous rocks contain about 0.03 ppm Cd and 80 ppm Zn on an average. These elements are mobilized in the weathering process and find their way into oceans, where their respective concentrations reach to about 0.1 ppb of Cd and 20 ppb of Zn. Soils contain about 4.5 ppm of Cd because of its biogenic enrichment in humid materials. Natural Cd levels in air are about 0.002 µg /m³ although values as high as 0.3 µg/m³ may be found near zinc smelters.

Biochemical Effects, Toxicology and Toxicity:

Cadmium acts as inhibitor of sulphhydryl enzymes. It has also got affinity for other ligands in cells such as hydroxyl, carboxyl phosphatyl cysteinyl and histidyl sidechains of proteins, purines and porphyrin. It can disrupt pathways of oxidative phosphorylation.

Cadmium interacts or competes with other metals such as Cu, Fe and Zn and induces the deficiency symptoms of these essential metals.

Cadmium is highly toxic because of the absence of homeostatic control for this metal in the human body. The general population is exposed to cadmium via ingestion or inhalation. The workers in mining and smelting industries may be occupationally exposed to higher levels of Cd in the body by steady accumulation over a long period. About 1 to 2% of ingested and about 11% of inhaled cadmium is retained in the body and in mammals, the absorption increases which there is deficiency of Ca in the diet. About one-third of the absorbed cadmium is stored in the

kidney, which is the target organ. When excessive amounts of Cd^{2+} are ingested, it replaces Zn^{2+} at key enzyme sites and induce metabolic disorders.

The symptoms of cadmium toxicity produced by enzymatic inhibition include hypertension, respiratory disorders, damage to kidney and liver, aminoaciduria (urinary excretion of aminoacids), hypocalciurea (urinary excretion of excessive Ca), glucosuria (excretion of blood sugar in the urine), proteinuria (urinary excretion of proteins), osteoporosis (decalcification of the skeleton), formation of kidney stones, etc. Carcinogenic and teratogenic effects have also been observed in epidemiological studies on animals.

A disease specifically associated with cadmium poisoning was recognised in Japan. People residing along the banks of Janstsu river in Northern Japan were consuming the rice which was contaminated with cadmium and they were ingesting 100 to 1000 mg of Cd every day. The pollution was due to a nearby mining complex and by the end of 1965, about 100 deaths were reported. The victims accumulated about 500 to 600 mg of Cd in their body over several years of consuming the contaminated rice as their staple food and finally fell fetal due to the so called itai itai (or ouch-ouch) disease. The disease was characterized by kidney malfunction, drop in the phosphate level of the blood serum, loss of minerals from the bones and osteotmalacea (which is characterized by bone fracture and intense pain) or severe osteoporosis. Concentrations of cadmium in the rice grown in polluted areas were found to range from 0.6 to $1\ \mu\text{g}$ per gram.

Environmental Levels and Ecological Effects :

Natural cadmium levels in air are in the range of 0.002 to $0.048\ \mu\text{g}/\text{m}^3$ but near smelters, the value may be as high as $0.3\ \mu\text{g}/\text{m}^3$. The safety level of Cd in drinking water in many countries is 0.01 ppm but many surface waters show higher Cd levels. The maximum permissible

concentration of Cd in water is $5\ \mu\text{g}/\text{g}$ as per the W.H.O. guidelines.

Cadmium in blood reflects current exposure level but cadmium in urine may reflect body burden when the exposure is low. Normal Cd levels are less than 1 mg % in blood.

The main problem with Cd in human nutrition is that the body does not completely excrete whatever Cd is absorbed. The estimated daily intake of Cd in different countries ranges from 25-60 mg /day while the tolerable daily intake (TDI) of cadmium is about 57 to $72\ \mu\text{g}/\text{day}$. Normal cadmium content of rice is about 29 ppb. Cadmium content of sea water varies from 0.05 to $0.12\ \mu\text{g}/\text{g}$.

Cadmium in water at 10 ppm level can kill fishes in one day while at 2 ppm level they will be killed in 10 days. Hardness and salinity of water provides some degree of protection. Amongst the aquatic invertebrates, crustaceans are more sensitive to Cd toxicity as compared to molluscs and polychaetes.

Plants exposed to Cd at toxic levels exhibit "Chlorosis" and reduced growth. Cd in agricultural soils is mainly derived from the Cd present in fertilizers and sewage sludge applied in the crop fields. When grown in cadmium contaminated soils, the roots of corn, oats, soyabeans, tomatoes and alfalfa accumulate highest levels of Cd, whereas the aerial parts of carrot, potato, lettuce and tobacco accumulate highest levels of Cd. Thus, water, food and smoking are the major sources of Cd for general population. Tobacco contains 1 ppm of Cd. Hence the tissues of smokers contain more Cd concentration than non-smokers. On an average, a smoker inhales 0.1 to $0.2\ \mu\text{g}$ of Cd from each cigarette he smokes.

Cadmium may be methylated in the environment. Although the transient formation of methyl cadmium has been inferred under

Table-1
Iron concentration in the groundwater of Saharsa District (Bihar) for pre- and post-monsoon seasons and their average in the year 2022)

Sl. No.	Sampling site	Sample No.	Cd in ppm for pre-monsoon season	Cd in ppm for post-monsoon season	Average value of Cd in ppm for pre and post-monsoon	Maximum and Minimum values of Cd in ppm
1	Nauhatta	TW1	0.059	0.048	0.054	-
2	Nauhatta	TW2	0.056	0.050	0.053	-
3	Sattar Kataiya	W3	0.052	0.044	0.048	-
4	Sattar Kataiya	TW4	0.052	0.046	0.049	-
5	Mahishi	W5	0.058	0.048	0.053	-
6	Mahishi	W6	0.055	0.050	0.052	-
7	Kahra	TW7	0.056	0.044	0.050	-
8	Kahra	TW8	0.058	0.048	0.053	-
9	Sour Bazar	TW9	0.065	0.052	0.060	-
10	Sour Bazar	TW10	0.064	0.056	0.060	-
11	Patarghat	TW11	0.073	0.068	0.070	0.070 (max)
12	Patarghat	TW12	0.072	0.062	0.067	-
13	Sonvarsa	TW13	0.056	0.050	0.053	-
14	Sonvarsa	TW14	0.054	0.048	0.051	-
15	Simri Bakhtiyarpur	TW15	0.048	0.040	0.044	0.044 (min)
16	Simri Bakhtiyarpur	TW16	0.046	0.042	0.044	-
17	Salkhua	TW17	0.052	0.048	0.050	-
18	Salkhua	TW18	0.054	0.046	0.050	-
19	Banma Itahari	TW19	0.056	0.050	0.053	-
20	Banma Itahari	TW20	0.056	0.044	0.050	-

laboratory conditions, it has not been detected in sediments or biota, nor has it been isolated in the natural environment. Cd along with Pb and Hg are considered to be the three major trace elements having the greatest potential environmental hazard. Much greater efforts are needed to control them.

Several researchers¹⁻²⁹ all over the world are working continuously on water quality parameters to aware the people to use safe water for different purposes of domestic uses. Present paper describes the chemical assessment of Cadmium (Cd) contamination in the groundwater of Saharsa District, Bihar which is situated at

latitude 25°35' – 26°28' N and longitude 86°18'– 86°51' E.

Sampling Season: Samples were collected for two seasons namely pre-monsoon (May-June) and post-monsoon (October-November) seasons in the year 2022.

Sampling sites: All the ten community development blocks of Saharsa district have been selected as sampling sites and from each block two samples either from well or tube well, on the basis of availability of functioning well or tube-well, have been collected for analysis. Thus, all together twenty samples were collected. Descriptions of these samples are given in the Table-1

Results and Discussion

The analytical results of cadmium in the groundwater for pre- and post-monsoon seasons have been tabulated in the Table-1. The concentration of Cadmium (Cd) was found to be ranged between 0.046 ppm to 0.073 ppm for pre-monsoon and 0.044 ppm to 0.068 ppm for post-monsoon season, and its average values are 0.044ppm to 0.070 ppm. The acceptable and allowable maximum limits prescribed by USPH and WHO respectively are same i.e. 0.01ppm. Thus, all the values are much higher than the maximum limit.

References:

1. "Subdivision & Blocks | Saharsa District | India". Retrieved 30 March 2022.
2. Arjun Ram et. al., *Applied water science* **11**, 46 (2021).
3. India Water Tool, India Water Tool. In: World Resources Institute, *Columbia Water Center*. (2017).
4. A. K. Biswas & K. Hartley, From evidence to policy in India's groundwater crisis. In *The Diplomat* (2017).
5. R. Suhag, Overview of groundwater in India. New Delhi, India: PRS Legislative Research.
6. Zaveri et al., *Environmental Research Letters*, **11** (2016).
7. Li Peiyue, *Exposure and Health*, 8 3 1-6 (2016).
8. Siebert et al., *Hydrology and Earth System Sciences*, **19**, 1521-1545 (2015).
9. B. Subhadra, *Nature*, 521, 289 (2015).
10. T. Shah, *In Global Water Partnership Technical Committee (TEC) Background Paper No. 19*. Stockholm, Sweden: Global Water Partnership. (2014).
11. World Bank *India groundwater: A valuable but diminishing resource* (2012).
12. D. Han et. al., *Journal of Hydrology*, (2011).
13. Siebert et al., *Hydrology and Earth System Sciences*, **14**, 1863 (2010).
14. Kusum Singh, Raju V. John, Joly Singh and Preeti Parashar; *J. Chemtracks*; **12(1)**, 49 (2010).
15. Jai Prakash Singh, Bijay Singh and Ashok Kumar Yadav; *International Journal of Earth Sciences and Engineering*, **03(02)**, 157 (2010).
16. Madhusudan Pd. Yadav, Ashok Kumar Yadav, Bijay Kumar, Rishikesh Kumar and N. K. Yadav "India"; *J. Chemtracks*, **11(1)**, 31 (2009).
17. K. Rabindra and V. K. Garg, *Environ Monit Assess*, **132**, 33 (2007).
18. Water Resources Department, International Institute for Geo-Information Science and Earth Observation (ITC), Enschede, Neth. Environmental Monitoring and Assessment **129(1-3)**, 115 (2007)
19. P. L. Bishop, *Water Science and Technology* **55** 1-2 (2007).

20. David Brickman, Peter C. Smith, *Marine Pollution Bulletin*, **54**(7), 863 (2007).
21. Anceno, Alfredo J.; Katayama, Hiroyuki; Houpt, Eric R.; Chavalitshewinkoon-Petmitr, Porntip; Chuluun, Buyan; Shipin, Oleg V. *International Journal of Environmental Health Research*, **17**(4), 297 (2007).
22. J. M. Malmaeus, O. M. Karlsson, D. Lindgren, J. Eklund, *J. Water Science and Technology*, **55** (5, Forest Industry Wastewaters VIII), 81 (2007)
23. *Proceedings-Water Quality Technology Conference and Exposition* (2006).
24. Vandenberghe, Veronique; van Griensven, Ann; Vanrolleghem, Peter. *Wastewater Quality Monitoring and Treatment* (2006).
25. *Indian standard specification for Drinking water IS-10500*, (1983).
26. *U. S. Groundwater Survey book S.A 1* (1979).
27. *American Public Health Association book* (1976).
28. *Indian Standard Methods of Sampling and test (Physical and Chemical) of water* (1964).
29. J.D. Hem Study and interpretation of Chemical Characteristics of natural water, *U.S.G.S. water supply paper* (1959).

