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Determination of lead, arsenic and selenium in different water resources of Jabalpur by atomic absorption spectrophotometry

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Abstract
Water is an essential for life on the earth. This "Elixir of Life" is facing a severe threat due to pollution. Poor sanitary practices lead to the growth of pathogens as well as exert a pose to an unacceptable waterborne public health risk. Jabalpur is the city surrounded with small and large industries. Also an ordnance factory is located just outskirt of the city which influence the nearby water tributaries get polluted. Thus the present study was done to observe the presence of heavy metals particularly lead, arsenic and selenium. A total of 117 samples were collected from different water sources in Jabalpur city, comprising 20 each from different banks of river Narmada and public taps, 21 from tube wells, 35 from different ponds, 21 from hand pumps. The concentrations of lead, arsenic and selenium were analyzed by Atomic Absorption Spectrophotometer (AAS). The overall concentrations of lead, arsenic and selenium were ranging from 0.097 - 0.450 ppm, 0 - 0.345 ppm and 1.365 - 2.047 ppm, respectively. Almost all the samples were exceeding the maximum permissible limit stated by WHO.

Keywords: Arsenic, atomic absorption spectrophotometer, lead and selenium

1. Introduction
Water plays a significant role in the sound health of every individual and is essential for plant and animal life also. Water contributes in a number of ways to the health, progress and enjoyment of living beings. It is having important functions like universal solvent, thermoregulation of body, maintenance of blood and plasma volumes, cellular osmotic pressure and assist in secretary and excretory functions of body.

Now days, there is a growing concern among public health agencies from both developed and developing countries that with growing urbanization and industrialization, water is getting contaminated with the effluents with presence of heavy metals in the concentration exceeding the maximum permissible limit. This exerts an unacceptable waterborne public health risk. Iron, mercury, cadmium, nickel, cobalt, copper, arsenic, selenium, lead, etc. are important group of environmentally hazardous substances when present above permissible limits [1]. Water bodies contaminated with heavy metals may lead to bioaccumulation in the food chain of the environment [2]. According to WHO (2011), permissible limit for arsenic, lead and selenium is 0.01 ppm. In general, the heavy metals are systemic toxins with specific neurotoxic, nephrotoxic, fetotoxic and teratogenic effects. Heavy metals can directly influence behavior by impairing mental and neurological functions, influencing neurotransmitter production and utilization and alternating numerous metabolic body processes. Systems in which toxic metal elements can impair and dysfunction include the blood and cardiovascular eliminative pathways (Colon, liver, kidneys and skin), endocrine (hormonal), energy production pathways, enzymatic and immune systems [3].

Jabalpur is the third largest city of Madhya Pradesh state. It is an important trade, commerce, industrial, educational and administrative centre of regional and national importance. Good water resources are located around Jabalpur like river Narmada and many ponds, which are sources of animals and human consumption. All these sources receive a large amount of domestic wastes, sewage, agricultural and industrial effluents. An immediate attention was therefore required to determine the presence of heavy metals to assess the quality and potability of water resources of Jabalpur District.

2. Materials and Methods

Approximately 200 ml of water samples were collected in polypropylene bottles from ponds, different banks of river Narmada, hand pumps, tube wells and public taps of Jabalpur city for analysis of heavy metals like Lead, Arsenic and Selenium. Collected samples were stored in refrigerator at 4ºC till further analysis. The details of sample collection are described in table 01.

The materials like nitric acid (concentrated trace metal grade) and water (HPLC grade) were used throughout the course of experiment. Before use, glasswares were cleaned by rinsing once with deionized water and then once more with HPLC grade water. The stock solutions for Pb, As and Se were prepared in 1 liter volumetric flasks and labeled and then distributed into separate transfer beakers.

2.1 Sample analysis

Lead, arsenic and selenium concentrations were determined directly in the acidified filtrates by Atomic Absorption Spectrophotometer (Lab India AA8000). Around 15 to 20 ml sample was taken and measured by a detector to calculate the concentration of that element in the original sample as per standard method for the examination of water and waste water [4].

2.2 Standardization of instrument

2.2.1 Standards

Lead: Lead standard solution (Merck, HC 43285076)
Arsenic: Arsenic standard solution (Merck, HC 42357873)
Selenium: Selenium standard solution (Merck, HC 398599)

2.2.2 Standardization

In all cases, standards and blanks were treated in the same way as the real samples to minimize matrix interferences during analysis. The instrument was warmed up and calibrated. Three different concentrations of standards were used to find out calibration curve. Operating condition of AAS is stated in table 02.

2.3 Statistical analysis

Data gathered from the study were analyzed, using statistical methods of one way ANOVA to find out the level of significance in different sources.

3. Results

The concentrations of lead, arsenic and selenium were analyzed by Atomic Absorption Spectrophotometer in 117 water samples collected from various sources. The overall concentrations of lead, arsenic and selenium were ranging from 0.097 - 0.450 ppm, 0 - 0.345 ppm and 1.365 - 2.047 ppm, respectively.

The concentration of lead in water samples from different banks of river Narmada, ponds, hand pumps, tube wells and public taps water was found in range of 0.097 - 0.354 ppm, 0.105 - 0.418 ppm, 0.101 - 0.450 ppm, 0.105 - 0.418 ppm and 0.109 - 0.450 ppm, respectively.

The concentration of arsenic in water samples from different banks of river Narmada, ponds, hand pumps, tube wells and public taps was found in range of 0 - 0.240 ppm, 0 - 0.101 ppm, 0 - 0.152 ppm, 0 - 0.110 ppm and 0 - 0.345 ppm, respectively.

The concentration of selenium in water samples from different banks of river Narmada, ponds, hand pumps, tube wells and public taps was found in range of 1.365 - 2.137 ppm, 1.206 - 1.950 ppm, 1.450 - 2.047 ppm, 1.587 - 1.915 ppm and 1.541 - 1.990 ppm, respectively, The results are shown in tabular form in table 02.

4. Discussion

Heavy metals are naturally occurring elements with high atomic weight and density at least 5 times greater than that of water. They are dangerous because of bioaccumulation tendency. Various heavy metals like lead (Pb), arsenic (As), selenium (Se), mercury (Hg), chromium (Cr) specially hexavalent chromium, nickel (Ni), barium (Ba), cadmium (Cd), cobalt (Co), vanadium (V), etc are having wide spread application viz. industrial, domestic, agricultural, medical, technological, etc. This may be reason for their distribution in the environment from where they can enter into various water resources as industrial and consumer waste. When agricultural soils are polluted, these metals are taken up by plants and consequently accumulate in their tissues [6] and when animals graze on such contaminated plants and drink from polluted waters, waters also accumulate such metals in their tissues / meat and milk, if lactating [7]. Marine lives that breed in heavy metal polluted water also become contaminated. Human being top consumer in ecosystem is more prone to heavy metal toxicity. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. They are also classified as human carcinogens (known or probable) according to the U.S. Environmental Protection Agency.

The concentration of selenium in different banks of river Narmada, ponds, hand pumps, tube wells and public tap water was found in range of 1.365 - 2.137 ppm, 1.206 - 1.950 ppm, 1.450 - 2.047 ppm, 1.587 - 1.915 ppm and 1.541 - 1.990 ppm, respectively. All the samples analyzed had lead and selenium concentration significantly higher than the maximum permissible limits (0.01 ppm with no relaxation) [8]. In arsenic, it was more than maximum permissible limit (0.01 ppm given by WHO) in 16 (13.67%) samples and higher than acceptable limit in 10 (8.54%) samples, at least one from each source. Statistically source wise, there was no significant variation in case of lead and arsenic but concentration of selenium was significantly high in different banks of river Narmada, hand pumps, and public tap waters in comparison to ponds and tube wells.

Similar study has been conducted by Singh and his coworkers. They studied the concentration of lead in Narmada river, ponds and other water resources in Jabalpur) by using Atomic Absorption Spectrophotometer. Out of 16 target areas (192 samples), 5 were found below detection limit, whereas remaining all 11 target were showed concentration more than maximum permissible limit stated by WHO (2011) [9]. Singh and Chandel did the analytical study of heavy metals of industrial effluents in Jaipur, Rajasthan. The results exhibited that As, Cd, Cr and Pb were not found in any studied wastewater samples, while some of the following heavy metals ranged from : Cu (0.0 - 1.0 mg/L), Fe (0.1 - 0.4 mg/L), Mn (0.0 - 0.4 mg/L), Ni (0.01 - 0.07 mg/L) and Zn (0.68 - 60.84 mg/L). Cu, Fe, Mn and Zn were found above the standard limit recommended by IS: 3307 (1977). However, Ni

was found below the regulated safety values for all studied samples [10]. Dixit and Tiwari estimated the level of water pollution in the Shahpura lake of Bhopal and found that the concentration of the heavy metals in the lake water substantially increased after the religious activities like idol immersion around August and September [11].

5. Conclusion

The results of present study indicated wide spread pollution of different water sources in Jabalpur with various metallic contaminants. This is an alarming situation regarding environment, public and animal health. Therefore, there is an immediate need for preventive and corrective measures to preserve wholesome water.

6. Tables

Table 1: Samples from different water sources

S. No.	Source of water sample	Total No.
1.	Different banks of river Narmada	20
2.	Ponds	35
3.	Hand pumps	21
4.	Tube wells	21
5.	Public taps	20
Total		117

Table 2: Operating condition of Atomic Absorption Spectrophotometer

Element	Pb	As	Se
Wavelength	283.3	193.62	195.81
Slit (nm)	0.7	0.7	0.7
Mode	AA	AA	AA
Flame	Air - Ac	Air – Ac	Air – Ac
Calibration equation	Lin. Cal. Int.	Lin. Cal. Int.	Lin. Cal. Int.
Sample volume (µl)	20	20	20
Lamp	EDL	EDL	EDL
Lamp current (mA)	440	440	440
Standards	01, 03, 05	02, 04, 06	01, 03, 05
Spiked concentration (µg/L)	25	25	25

Table 3: Concentrations of heavy metals in different water resources

S. No.	Source	Pb	As	Se
1	Different banks of river Narmada	0.097 - 0.354	0 - 0.240	1.365 - 2.137
2	Ponds	0.105 - 0.418	0 - 0.101	1.206 - 1.950
3	Hand pumps	0.101 - 0.450	0 - 0.152	1.450 - 2.047
4	Tube wells	0.105 - 0.418	0 - 0.110	1.587 - 1.915
5	Public taps	0.109 - 0.450	0 - 0.345	1.541 - 1.990
Total		0.097 - 0.450	0 - 0.345	1.365 - 2.047

Table 4: Concentrations of heavy metals in different water resources (Statistical Analysis)

S. No.	Source	Pb	As	Se
1.	Different banks of river Narmada	0.03±0.01	0.01±0.02	1.80^{a} ± 0.04
2.	Ponds	0.01±0.00	0.01±0.02	1.69^{b}± 0.03
3.	Hand pumps	0.01±0.01	0.01±0.02	1.81^{a}± 0.03
4.	Tube wells	0.01±0.01	0.01±0.02	1.77^{ab}± 0.02
5.	Public taps	0.02±0.02	0.01±0.02	1.79^{a}±0.03

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