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HEAVY METAL ANALYSIS IN WATER, FISH AND VEGETATIVE SAMPLES OF LAKHA-BANJARA LAKE, SAGAR, MADHYA PRADESH, INDIA

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ABSTRACT

The present study was conducted to assess the risk to human health by heavy metals (Pb, Cd, As) through the intake of locally caught fishes and grown vegetables from sewage fed lake water on agricultural land. Heavy metal (Pb, Cd, As) concentration in water, fish and vegetative samples were analyzed from Lakha-Banjara lake, Sagar, Madhya Pradesh, India in the pre monsoon season (May-June-2013). Heavy metal concentration in all samples were found in order Cd > Pb > As. Fish samples (*Labeo rohita*), Eggplant (*Solanum melonjena*) and Cow Pea (*Vigna unguicilata*) were collected from the lake surroundings and analyzed for heavy metal contents. The water samples were containing larger quantities of heavy metals and due to use of their water for irrigation and cultivation there metals are accumulated into the tissues of vegetables. The vegetative samples also showed concentration above permissible limits (WHO/FAO standard).The presence of such concentration of Pb, Cd and As in fishes and vegetables as well as water is a serious matter of concern and potential risk for human exposure to such heavy metals by eating these vegetables, fishes or even drinking such water. The present study suggests that the waste water irrigation led to accumulation of heavy metals in food stuff causing potential health risk.

Key Words : Bioaccumulation, Human health, Lakha-Banjara Lake, Sagar, Heavy metal concentration, Fish, Egg-plant, Cow-pea

INTRODUCTION

The administrative district of Sagar is located in the central part of Madhya Pradesh, India with a population of 2,378,295 (census 2013) **(Fig. 1)**. People in Sagar and around Sagar mostly depend on agriculture and animal husbandry which requires a lot of water.[1-4] The growing problem of water scarcity has significant negative influence on economic development, human livelihood and environmental quality throughout the world. Rapid urbanization and industrialization releases enormous volume of waste water which is increasingly utilized as a vulnerable resource for irrigation in urban and pre-urban agriculture.[5-7] Waste water may contain various heavy metals including Cu, Pb, As, Cd, Ni, Mg, Zn, Cr and Fe depending upon the type of activity it is associated with. Continuous irrigation of agricultural land with sewage and industrial waste water may cause heavy metal accumulation in soil and vegetable.[8] The incorporation of heavy metal ions into the biological system can have middle term and long term health risk.[9,10] Since, Sagar city has a centrally located lake known as Lakha-Banjara lake and all the sewage and waste water are directly disposed into it which may cause the bio-accumulation of these heavy metals into the fish tissue and the animals drinking this water.[11] The same water is also used for irrigation purposes resulting in the accumulation of these heavy metals into the vegetables.

Irrigation of agricultural land with treated and untreated sewage waste water led to the accumulation of heavy metals in soil, vegetable and cereals. Variation in the heavy metal concentration between the test vegetable and cereal crops reflects the differences in uptake capabilities and their further translocation to the edible portion of plants. Concentration of Cd and Pb found above national and international limits in vegetable and fishes i.e. WHO (World Health

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Organization) and FAO (Food And Agriculture Organization) limits.[12-14] The metal pollution index and health risk index of heavy metal also suggested that Cd and Pb contamination in samples had potential risk for human health due to consumption of plants, vegetable grown at waste water irrigated site.[15] The fishes caught from lakes are also contaminated with heavy metals due accumulation of metal from lake water.[16]

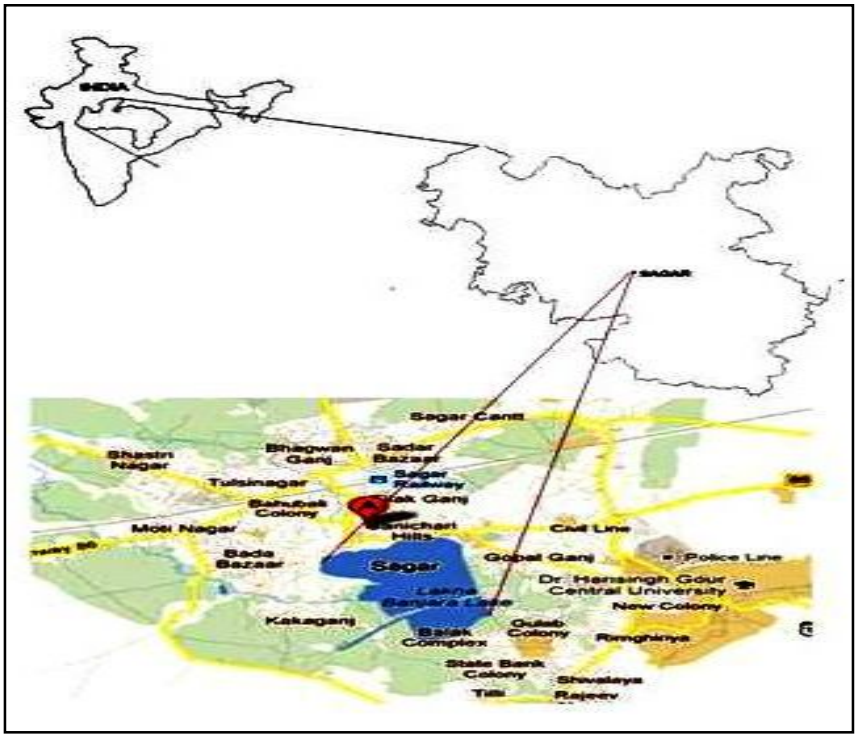

Fig. 1 : Map of Sagar district of Madhya Pradesh, India

AIMS AND OBJECTIVES

The present study have revealed that heavy metal concentration in soil and water above the normal concentration inhibits the growth of plant and fishes and also becomes causal agent of diseases.[17] The people of Sagar have a potential health risk utilizing the vegetable, animal by-product and fish as well as the water of lake.[18]

MATERIAL AND METHODS

Apparatus

A Perkin Elmer Optima 7300V family ICP-OES spectrophotometer, Systronics 2700UV-Vis double Beam spectrophotometer is used for analysis of concentration of heavy metal and Systronics Digital pH meter model 665 was used for pH measurement.

Reagents and solutions

All the chemicals used were of analytical reagent grade purchased from Merck India Ltd. Acid washed glassware analytical grade reagents and double distilled deionized water was used throughout the experiments. The stock solution and environment sample were kept in a pre acid (8M HNO_3) treated polypropylene bottles. The standard stock solution of Lead, Cadmium and Arsenic were prepared from Titrasol (1g/L). The working solutions were freshly prepared by diluting an appropriate aliquot of the stock solution.

Study sites

The study was conducted around the centrally located Lakha-Banjara lake of Sagar city (Latitude- 23°83` N, Longitude- 78°71` E and 1758 feet above sea level), during May-June 2013.

Water sampling

Both lake water and waste water sample from drainage, used for irrigation and drinking purposes were collected in pre acid washed polypropylene bottles and 2.5 ml conc. HNO_3 were added in the water sample to avoid microbial activities. The water samples were

then boiled or evaporated upto one-fourth of original volume. The samples were then kept in a refrigerator for further analysis.[19-21]

Plant sampling

All the major vegetables and cereal crops grown in experimental area either for home consumption or sale were collected. The vegetables viz. Cow pea (*Vigna unguicilata*) and Egg plant (*Solanum melonjena*) are collected from nearby fields around the lake. After collection sample were cleaned with deionized distilled water, weighed, stored in pre cleaned plastic bags, kept frozen in refrigerator. [19-21]

Preparation of analyte of vegetative samples

The collected vegetables were air dried. After removing the extra water from vegetables, the sample were cut into small pieces and kept in an oven to complete dry until constant weight. The dried sample were finely grounded into powder and kept at room temperature. The powder is then placed into a digestion flask and ultra pure HNO_3 and H_2O_2 (1:1 V/V) was added. The digestion flask were treated to 130°C until dissolution, diluted with distil water and analyzed for heavy metal.[19-21]

Fish sampling

Three fish samples (*Labeo rohita*) were collected at three different regions of Lakha Banjara Lake viz. (a). Near Duffrin hospital, (b). Ranipura and (c). Chakraghat with the help of local fisherman. The sizes of the fish collected were varied between 15 cm, 16.4 cm and 18.2 cm and their age were from 6 month to 1 year. After collection, samples were cleaned with deionized distilled water, weighed, stored in pre cleaned plastic bags, kept frozen in refrigerator.[19-21]

Preparation of analyte of fish samples

All the fishes were dissected to separate organs viz. gills, muscles, kidney and liver using scalpels with steel blades and plastic forceps. The muscles were cut into small pieces with Teflon tipped scissor. The separated organs were put into Petri-dish to dry in oven at 120 °C until reaching a constant weight. These organs were putted in digestion flask and ultra pure HNO_3 and H_2O_2 (1:1 V/V) were added. The digestion flask were treated to 130°C until dissolution, diluted with distil water and analyzed for heavy metal. The digested sample aliquots were analyzed for heavy metals directly using ICP-OES with respect to absorbance of standard lead, cadmium and arsenic solutions.[22-24]

RESULTS AND DISCUSSION

ICP-OES was applied for the determination of concentration of heavy metals viz. Pb, Cd and As in the evaporated water sample and digested samples of vegetables viz. Cow pea (*Vigna unguicilata*) and egg plant (*Solanum melonjena*) and sample of fishes (*Labeo rohita*) **(Table 1)**. The result of toxic metal analysis of lake water and waste water from drainage are shown in **Table 2**. The heavy metal concentration level in water was found in the order Cd > Pb > As. The concentration of toxic metal in fresh lake water is lower than waste water of drainage. The result of toxic metal analysis by UV-Vis spectrophotometer of clean water and drainage water shown in **(Table 3)**.

The result for heavy metal analysis of different organs of the fish viz. muscles, gills, kidney and liver of all three fishes are shown in **Table 4**. The result of heavy metal analysis shows that the heavy metal concentration level of gills and muscles are lower than liver and kidney. The orders of concentration level of heavy metal in organs are as : Kidney > Liver > Gills > Muscles. And the heavy metal concentration in different organs was in the order Cd > Pb > As. This concentration is arises due to dwelling of fish in such contaminated water where concentration of heavy metal is above permissible limit. The result also concluded that fish sample obtain from Ranipura and Chakraghat have higher concentration of toxic metal than sample obtain from Duffrin Hospital area. This is due to large disposal of sewage and local industrial waste in such area, which contain highly contaminated with heavy toxic metal. The orders of concentration level of heavy metal in sites are as: Ranipura > Chakraghat > Duffrin Hospital area. The analyses of same heavy metal in vegetative samples are shown in **Table 5**. It also shows that concentration of Cd is higher than Pb and As. The order of concentration level is as: Cd > Pb > As this concentration arises due to irrigation of vegetable field by contaminated waste water as discuss above it had concentration of heavy metal above permissible limit. The result of vegetative and fish sample are showing the bio-

accumulation of the heavy metal and are equally distributed. The metals come from sewage and waste disposal to water sources in lake and drainage water. Then it is accumulated to fishes dwelling in these contaminated water and in vegetable irrigated by these contaminated water.

Table 1 : Permissible limit of heavy metal ion in environmental sample

Samples	Lead (µg/L)		Cadmium (µg/L)		Arsenic (µg/L)	
	WHO	FAO	WHO	FAO	WHO	FAO
Fresh water	0.05	0.05	0.5	1.0	0.1	0.1
Fish	0.05	0.05	0.5	0.5	0.01	0.1
Cow-pea	0.05	0.05	0.5	0.5	0.01	0.1
Egg-plant	0.05	0.05	0.5	0.5	0.01	0.1

Table 2 : Determination of Pb(II), Cd(II) and As(II) in water samples (ICP-OES)

Metal ions	Clean water (µg/L)	Waste-water (µg/L)
Pb(II)	0.000032	0.0463
Cd(II)	0.000056	0.249
As(II)	0.000002	0.017

Table 3 : Determination of Pb(II), Cd(II) and As(II) in water samples (UV-V spectrophotometer)

Metal ions	Clean water (µg/L)	Waste-water (µg/L)
Pb(II)	0.00032	0.0402
Cd(II)	0.00056	0.236
As(II)	0.00002	0.020

Table 4 : Determination of Pb(II), Cd(II) and As(II) in fish muscle, gills, liver and Kidney

Fish-I (Duffrin hospital)				
Metal ions	Muscle (µg/g)	Gills (µg/g)	Liver (µg/g)	Kidney (µg/g)
Pb(II)	0.044	0.090	0.037	0.039
Cd(II)	0.189	0.197	0.198	0.216
As(II)	0.0015	0.004	0.007	0.009
Fish-II (Ranipura)				
Pb(II)	0.036	0.055	0.035	0.045
Cd(II)	0.230	0.210	0.203	0.253
As(II)	0.0017	0.006	0.006	0.004
Fish-III (Chakraghat)				
Pb(II)	0.019	0.012	0.031	0.041
Cd(II)	0.210	0.193	0.201	0.246
As(II)	0.0013	0.004	0.005	0.010

Table 5 : Determination of Pb(II), Cd(II) and As(II) in vegetable samples (Cowpea and Egg-plant)

Vegetative sample of Ranipura		
Metal ions	**Cowpea (µg/g)**	**Egg-plant (µg/g)**
Pb(II)	0.056	0.041
Cd(II)	0.172	0.205
As(II)	0.002	0.005
Vegetative Sample of Chakra-ghat		
Metal ions	**Cowpea (µg/g)**	**Egg-plant (µg/g)**
Pb(II)	0.058	0.051
Cd(II)	0.192	0.235
As(II)	0.002	0.005

CONCLUSION

The environmental pollution through heavy metal ions is the current world growing problem. The discharge of heavy metal ions as a by-product of various human activities are accompanied with large scale water and soil pollutions. In this paper toxic metal (Pb, Cd, As) concentration in water i.e. lake water and waste water from drainage, vegetative samples viz. Cow pea (*Vigna unguicilata*) and Egg plant (*Solanum melonjena*) and different organs of fishes (*Labeo rohita*) viz. muscles, gills, kidney and liver were analyzed. The result shows that drainage water and lake water have highest heavy toxic metal ion concentration. The interpretation of such results concluded that bio-accumulation of toxic metal ions from water to biotic system is at a constant and uniform level. Consumption of these food stuffs and such contaminated water with elevated level of heavy toxic metal ion concentrations may lead to high level of accumulation in the body causing related health disorders.

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