HEAVY METAL TOXICITY IN FISHES OF POLLUTED LAKES OF DHAKA CITY AND ITS IMPACTS ON HUMAN HEALTH

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Abstract

The City of Dhaka is not built up plan wise from the beginning yet till date. The land uses are not following the urbanization rules correctly. Due to the laggings of proper water and air flow and basic treatment of household and industrial utilizing water, some of the major health issues are concerned. This research works is on the focus of heavy metal contamination in fishes of two major lakes in Dhaka city called Dhanmondi Lake and Gulshan Lake. The research is focusing mainly the study on Cr, Cd and Pb concentration in fishes along with other elements. Concentration of Cr is found in ranges of 3.45 µg/gm – 10.25 µg/gm, Cd is 2.17 µg/gm – 9.78 µg/gm and Pb is 1.132 – 7.102 µg/gm. The major element K and Ca with other trace elements are also projected. The data acquisition setup is calibrated using 2.2 MeV proton beam in the current ranges of 5nA to 15nA. The Van-de Graff Accelerator of Atomic Energy Centre, Dhaka has been used for sample irradiation. The IBA technique Proton Induced X-ray Emission (PIXE) has been applied using Si(Li) detector (SL30165) and other ORTEC nuclear electronics. The calibration and standardization of PIXE setup has been done using X-ray source, and IAEA standard CuS_x (thin), Soil-7 (thick).

Keywords: Element, Toxicity, Health, PIXE, MAESTRO-32, GUPIX

Introduction

Due to the density of population and related aspect the city of Dhaka is known as mega city Dhaka. Accordingly, for the better and comfortable life style, so many lakes, ponds, green parks, open places should be available in Dhaka city. Unfortunately, nothing developed in proper way. A few numbers of lakes and ponds are seen in the city and those are not well saved from pollution by receiving liquid household wastages as well as some industrial wastages also.

The particles of toxic metal are generally injected and deposited into the fishes by taking their foods from water and lake sediment. Finally those fishes are sold in daily bazaar and ultimately the people are taking those as food. Our concern is to study the heavy metal toxicity in fishes of Gulshan and Dhanmondi lakes and also their impacts on human health. Trace elements play very important roles in living beings. Any fluctuation like, deficiency or excess of their normal level may lead to physiological disorders in living cells and causing various diseases like hypertension, dental caries, goiter, cancer, heart disease, gallstones, obesity, osteoporosis, osteomalacia, arthritis, anemia, etc [Eric, 1977, Abedin, 2012]. Proton Induced X-ray Emission technique has been used in Van-de Graff Generator Accelerator Laboratory of Atomic Energy Centre, Dhaka for this research works. All other modernized IBA experimental facilities needed for sample preparation to data analysis are available in the VDG. Microprocessor control Freeze Drying system (Flexi-Dry), Oven (30 – 220^0 C), Grinding machine, Electronic balance and Hydraulic Pellet Maker have been used for sample drying, powder making, measurement and pellet making respectively. Ion beam scattering chamber, [Si(Li)] detector along with other circuitries are used for the PIXE experiments. MAESTRO-32 version 6.05 and GUPIX/DAN-32 software have been used for data acquisition and spectrum analysis respectively.

Sampling and pellet making

The fish samples are collected from Gulshan and Dhanmodi lakes, Dhaka, Bangladesh at the winter season of 2014 due to take the advantages of fishing at decreased water level. Local and scientific name of the fishes are Rui(*Labeo rohita),* Pangas(*Pangasius pangasius*), Taki(*Channa punctata),* Baim(*Mastacembelus armatus*), Telapia(*Oreochromis mossambicus),* Koi(*Anabas testudineus),* Tangra(*Mystus vittatus),* Shing(*Heteropneustes fossilis),* Shoal(*Channa striata*) and Puti(*Puntius puntio)*. 10 different fishes are collected from different places of the lakes. For elemental analysis and toxicity determination, middle portion of every fishes are taken as samples for experiments. Separate pots are used for each of the fish sample and dried in a temperature controlled electric oven at 70°

C for several days to make them moisture free. Then the samples ware made fine powder using Mortar (ebonite) grinding pot. A fine powder of 0.025 gm are taken and pressed by hydraulic pellet maker to make 7mm dia and nearly 1mm thick pellets for irradiation. The pellets are mounted on 35mm slide frames with adhesive tape and set them on the sample wheeler inside the IBA scattering chamber for irradiation [Hossen, 2014, Abedin, 2012].

Experiment and data acquisition

At VDG Accelerator Laboratory of AECD, two types of sample wheeler systems are available, one for 16 samples wheeler another for 8 samples wheeler. For these experiments, the first one was used to set 10 different fish sample pellets, quartz and two IAEA-407 reference samples. IAEA-407 reference samples were used to calibration process of concentration measurement. The data acquisition setup has been calibrated and standardization is done using the X-ray source [Abedin, April-2015, Hossen, 2014, Abedin, 2012]. The fish samples were irradiated by the proton beam of 2.2 MeV and the beam current ~15 nA. For each fish sample irradiation, 10 μC charges were collected by the Faraday Cup connected with the sample wheeler by copper spring. As the IAEA standard CuS_x is a thin sample, 5nA beam current was used to irradiate it and 5 μC charge was collected. The X-ray photons emitted from the fish samples are detected and converted into voltage pulses by the [Si(Li)] detector (SL30165) with other associated circuitry. Mylar absorber (170 μm) was used to protect the detector from damage probability by high energetic back scattered protons and also to reduce the X-ray counts to minimize the dead time of the counting system. The spectroscopy amplifier model: 671 and MCB model: 919E (ORTEC) were used in data acquisition setup. MAESTRO-32 software (version: 6.05) was used for data acquisition.

Particle induced X-ray emission technique

Atomic fluorescence based on PIXE spectroscopy is one of the most common and widely used analytical techniques at MeV accelerators and the analysis is performed with characteristic X-rays [Abedin, Mar. - Apr. 2015, Govil, 2001, Johanson, 1988, Debertin, 1988]. When charged particles with sufficient energy hit on a sample, a vacancy in the inner shells of an atom may be created. The probability of creating a vacancy is higher when the velocity of the incoming ions matches the velocity of the inner shell electrons. For MeV ions this probability (cross-section) for ejecting inner shell electrons is quite high. Such a vacancy can be filled in a number of ways and one of the processes may emit X-rays with energy characteristic of that particular atomic number. In the PIXE-technique, these characteristic X-rays are detected by solid state semiconductor detector. An energy dispersive analysis of the detector signals can reveal the identity of different elements present in the sample and, more importantly, by measuring the charge, i.e. the number of incoming particles, the concentrations of the elements can be accurately quantified.

Quality control test and calibration

A quality control test was conducted in the work for the measurement of material concentration using in 3MV Van de Graaff accelerator. Without availability of standard fish sample at Dhaka four standard reference soil samples (of Soil-7) provided by IAEA were irradiated for this purpose. The obtained results of measurements of elemental concentration were compared with the IAEA reference values. Ratios between the reference values and obtained values for the selective materials are shown in Table 1. The ratios of the reference and measured values of the Soil-7 samples using the 3MV VDG accelerator assure us of the system to be reliable for the study. For calibration of the detector we also used the IAEA thick standard Al (99.9%). The obtained result also similar with IAEA provided thick standard shown in Fig 1.

Table 1: Reference value and obtained value of SRM 2586 soil and sample of Soil-7

Standard Soil Samples	Elemental concentration in µg/g										
	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Pb
Reference value	12100	163000	3000	66	60	631	25700	26	11	104	60
Obtained value	13068	135296	3392		74	588	31531			125	

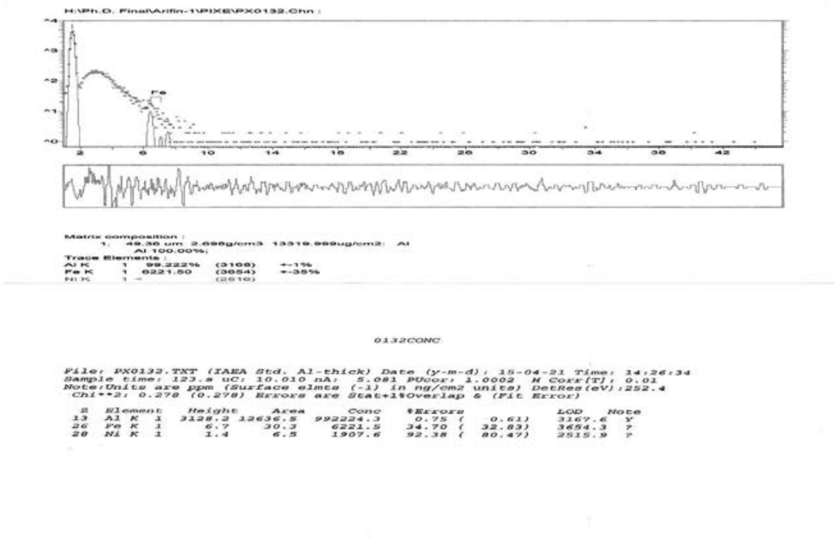

Figure 1: IAEA standard thick Al (purity 99.9%) sample energy spectrum and material concentration

Results and discussion

Ten different fish samples of Gulshan and Dhanmondi Lakes, Dhaka are irradiated by 2.2 MeV proton beam with beam current ~15 nA. The elements with their concentration, average and reference value of IAEA-407 are projected in table-1 and all of the results are shown in the unit of µg/gm. Na, Mg, K and Ca are the matrix and minor constituents and all other detected elements may consider as trace elements of the fish samples. Unfortunately, we could not measure low Z (Z<12) elements like Na and Mg by the [Si(Li)] detector (SL30165) and PIXE experiments, because such low energy X-rays are stopped by the Detector front window.

Table-2 Material concentration in fish samples

Fish /Material	Rui	Pangas	Taki	Baim	Telapia	Koi	Tangra	Shing	Shoal	Puti	Average
Al	7.99	1.99	7.99	1.99	9.97	0.89	5.19	0.82	6.09	1.19	4.411
K	28370	15307	38372	45311	48385	30314	23358	37417	30172	41053	33795.6
Ca	48231	42210	58311	32011	28217	50110	28344	39215	48714	38345	40360.8
V	0	0.91	0	0.91	1.02	0.54	0.11	0.44	0.21	0.1	0.53
Cr	4.22	8.36	6.22	9.36	10.25	7.36	5.25	3.45	7.82	6.05	6.834
Mn	22.19	25.19	20.19	29.19	41.09	31.19	39.19	24.19	22.99	15.19	24.06
Fe	182.85	189.85	136.85	280.85	155.86	127.85	338.05	197.85	99.85	159.05	186.891
Cu	3.1	3.54	3.1	3.54	4.67	2.5	2.98	2.5	2.8	2.08	3.081
Zn	48.55	54.5	48.55	54.5	102.03	39.5	39.59	34.5	42.5	36.59	50.081
Se	7.34	3.15	7.34	3.15	7.46	4	7.47	3.78	7.34	7.47	5.85
Br	63.09	68.19	63.09	68.19	60.09	68.19	71.09	60.34	34.19	76.45	63.291
Rb	4.15	8.15	4.15	8.15	10.1	6.15	4.15	3.15	2.25	4.15	5.455
Sr	79.05	89.65	79.05	89.65	91.6	81.65	15.15	34.65	62.05	53.15	67.565
Cd	2.78	4.17	9.78	2.17	5.19	5.97	8.35	5.97	4.78	7.35	5.651 0.189
I	4.3	5.3	4.3	5.3	3.2	1.5	3.7	0.5	4.3	2.5	3.49
Pb	1.132	5.12	2.132	4.12	2.012	3.22	7.102	5.02	3.092	4.112	3.7062

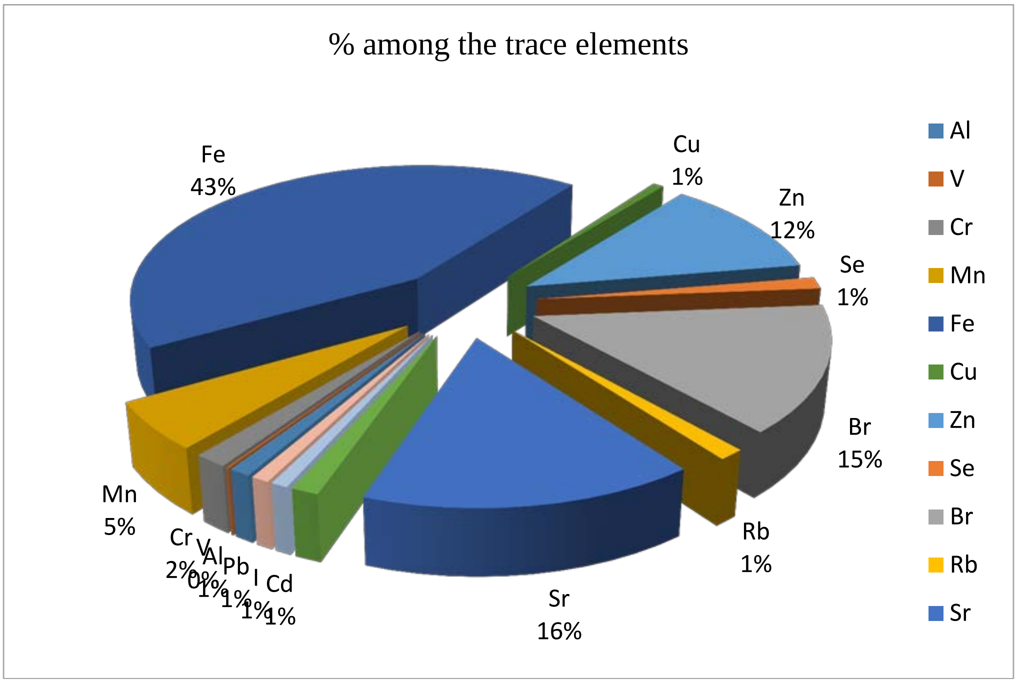

Figure 2: Percentages among the trace elements found in investigated fish samples

Impacts of Cr, Cd and Pb

Hexavalent Cr is much more toxic than trivalent. In fact trivalent Cr has such a low order of toxicity that a wide margin of safety exists between the amounts ordinarily ingested and those likely to induce deleterious effects [Eric, 1977]. Chronic exposure to chromate dust has been correlated with increased incidence of lung cancer [Abedin, April-2015] and oral administration of 50 µg/g of chromate has been associated with growth depression and liver and kidney damage [Eric, 1977]. Deficiency and excess of Chromium is playing the important roles in human health as well as environmental degradation. Chromium deficiency is characterized by impaired growth and longevity in experimental animals and by disturbances in glucose, lipid, and protein metabolism. Severe chromium deficiency in a human subject exhibiting weight loss, peripheral neuropathy, impaired glucose tolerance, and subnormal blood and hair chromium concentrations while on prolonged total parenteral nutrition, and responsive to Chromium therapy, has recently been reported [Abedin, Mar. - Apr. 2015, Abedin, April-2015, Abedin, 2012]. The claim that chromium acts as cofactor for insulin can therefore also be applied to two insulin-responsive steps in amino acid metabolism which are independent of the action of insulin on glucose utilization [Eric, 1977]. The total Chromium concentration is found 3.45 µg/g – 10.25 µg/g, in the average of 6.834 µg/g. The concentration of Cd found in the investigated fish samples found ranges from 2.17 µg/g – 9.78

μg/g, in the average of 5.651 μg/g. Cadmium is virtually absent from the human body at birth and accumulates with age up to about 50 years and the average person not exposed to abnormal amounts of cadmium has a total body burden of 20 – 30 mg, of which one-half to two-thirds occurs in the liver and kidneys [Eric, 1977, Abedin, April-2015, Abedin, 2012].

The amount of Cd inhaled from the air in most circumstances is insignificant compared with that ingested with the food.

Cadmium is toxic to virtually every system in the living being's body, whether ingested, injected, or inhaled. Anemia is a common manifestation of chronic cadmium toxicity in all species, due at least in part to its metabolic antagonism to copper and iron. Changes in the integument characteristic of zinc deficiency can also be induced by cadmium. The toxicity of a particular intake is thus determined by the extent to which the interacting elements are present or absent from the diet. The protective effect of prior administration of zinc against cadmium toxicity has been ascribed to the more rapid accumulation of the hepatic and renal cadmium as metallothionein, especially as such bound Cd is not mobilized during subsequent pregnancy to cause the toxemia and fetal malformations [Eric, 1977].

Biological interest in Pb has centered principally on its properties as a highly toxic cumulative poison in man and animals. In recent years the problem of long-term exposure to increased amounts of Pb in highly urbanized and motorized environments has engaged particular attention. Pb concentrations in the investigated fish samples have shown 1.132 μg/g – 7.102 μg/g, in the average of 3.7062 μg/g. Some of this Pb fallout from the atmosphere can be incorporated into vegetable crops and rainwater [Eric, 1977, Abedin, 2012]. Chronic Pb poisoning is characterized particularly by neurological defects, renal tubular dysfunction, and ariemia. Damage to the central nervous system- causing Pb encephalopathy and neuropathy- is a marked and common feature, especially in children with their low Pb tolerance. For children, chronic Pb poisoning involves physical brain damage with permanent sequelae including behavioral problems, intellectual impairment, and hyperactivity [Eric, 1977]. The World Health Organization gives a provisional tolerable weekly intake of lead by man as 3 mg per person or 0.05 mg/kg body weight [WHO, 1971]. It is pointed out that these intake levels do not apply to infants and children. Efforts to decrease exposure to such readily assimilable forms of lead as atmospheric lead appear to be thoroughly justified by the available evidence.

The concentration of Mercury is not studied in this present study. So the effect of Mercury and related issues are not discussed here.

Conclusion

The present study suggests that the fishes of Dhanmondi lakes and

Gulshan lakes accumulated heavy metal like Cr, Cd and Pb that are consumed daily by the people may pose the threat to their health. To safe the lakes and the fishes as well as the people, no wastages should be poured into the lake-water. A continuous monitoring for material concentration measurement of these sites should be done. Such study will provide sufficient knowledge to evaluate the significance of the problem related to heavy metal deposition, especially environmental effect as well as human beings.

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