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Chromium Toxicity in Soil around Tannery Area, Hazaribagh, Dhaka, Bangladesh, and its Impacts on Environment as well as Human Health

Md. Joynal Abedin
Accelerator Facilities Division
Atomic Energy Center Dhaka
Post Box: 164, 4 Kazi Nazrul Islam Avenue, Dhaka-1000, Bangladesh

Shirin Akter
Chemistry Division
Atomic Energy Center Dhaka,
Post Box: 164, 4 Kazi Nazrul Islam Avenue, Dhaka-1000, Bangladesh

Sk. Abdul Kader Arafin
Dept. of Natural Sciences
Daffadil International University,
Dhaka-1207, Bangladesh.

Abstract-- The depletion of the soil nutrients and its effect on productivity is a major concern in today's world. The major pathway of the elements to the human body is the foodstuffs that are the agricultural products. So from the point of view, for environmental safety assessment and health care, it is necessary to have the information on the levels of both toxic and essential elements in soil and foodstuff. Chromium excess in soil of tannery area has already become a problem in Bangladesh and this could happen for other trace elements. The projected value of Chromium is 60 µg/gm (Soil-7 of IAEA), our experimental value is 62.7 µg/gm. The data acquisition setup for PIXE is calibrated using 2.5 MeV proton beam in the current range of 20 nA. Twenty different samples are collected from tannery area, prepared as pellet, irradiated and analyzed. Average 17 different elements are detected in each sample. In this research paper, only Chromium values are presented. Remarkable high concentrations of Cr, more than 3000 µg/gm, are found in 5 of 20 samples, which are toxic for soil nutrition. To ensure the deficiency or excess as well as toxicity level, the information on elemental analysis of soil of tannery area is essential.

Key words: PIXE, Analytical techniques, Toxicity, [Si(Li)], MAESTRO-32, DAN-32.

INTRODUCTION

The global concerns of environmental changes with the industrialization and agricultural developments have become an important issue. Elemental analysis of biological, environmental and agricultural materials is an essential factor due to their vital role in human health and diseases.

In recent years the study of both major and trace elements in soil has assumed increasing importance because of their involvement in hormones, vitamins, protein, DNA and RNA synthesis. Any fluctuation like deficiency or excess in their normal level in living cells may lead to physiological disorders causing various diseases like hypertension, dental caries, goiter, cancer, heart disease, gallstones, obesity, osteoporosis, osteomalacia, arthritis, anemia, etc. The modernized IBA experimental facilities available in the Accelerator Laboratory of Atomic Energy Centre, Dhaka have been used for the research works, from sample preparation to data analysis. Microprocessor Controlled Freeze Drying System (Flexi-Dry), Oven (0 – 220 ^{0} C), Mortar Grinding Machine, Microbalance and Hydraulic Pellet Maker have been used for sample drying, powder making, measurement and pellet making respectively. The experimental set-up with new scattering chamber and the [Si(Li)] detector along with the associated circuitry has been used for the PIXE experiments. The soil samples were collected from the surrounding area of Hazaribag Tannery. The pellets have been irradiated by using 2.5 MeV proton beam. The software MAESTRO-32 interface with DAN-32 has been used for data acquisition and analysis. The calibration and standardization of PIXE setup has been done using X-ray source, and IAEA standard [CuS_x (thin), Soil-7 (thick)].

MATERIAL AND METHODS

Sampling and sample preparation

For Chromium contamination level measurement, 20 different samples were collected from different places around Hazaribag tannery area, Dhaka. All samples were taken from 30 cm depth of surface. The soil samples were dried in an oven at 70° C to make them moisture free. Then 0.20 gm dried soil powder were pressed by hydraulic pellet maker. Each pellet was made 7 mm dia and 1.0 mm thickness in size. The pellets were mounted on 35 mm slide frames with adhesive tape and preserved in desiccators until setting them on the wheel and set inside the scattering chamber for irradiation.

Experiment and data acquisition

At a time 13 different sample slides, a quartz and two standard samples were set with the wheeler and set it in the scattering chamber. Achieving the required vacuum, the samples were irradiated by the proton beam of 2.5 MeV with a beam current of 10 to 15 nA. The data acquisitions were done with the well established PIXE technique and by the use of the [Si(Li)] detector (Model: SL30165). Detector window material is Beryllium; thickness .025 mm, active diameter 6.2 mm and active area is 30 mm^2. The detector depletion and bias voltage are (-)100 V dc and (-)700 V dc respectively. Quad bias supply unit model: 710 (ORTEC, 0 -1000 V) is used. 170 µm of Mylar absorber has been used to safe the detector from high level of X-rays. The spectroscopy amplifier model: 671 and MCB model: 919E (ETHERNIM) are used in data acquisition setup. Charges are collected by Faraday Cup, set behind the sample wheeler and connected through a copper spring. MAESTRO-32 software is used for data acquisition.

Particle induced x-ray emission technique

Atomic fluorescence based 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. When charged particles with sufficient energy hit 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.

Impacts of Chromium

Chromium is widely distributed throughout the human body in low concentrations without special concentration in any known tissue or organ, and that these levels decline with age. Human stillborn and infant tissues carry higher chromium concentrations than those of adults [1]. Substantial variation in human liver and kidney chromium levels have been observed in different geographical regions[5], presumably as a reflection of regional differences in environmental chromium intakes.

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 [4]. The results indicated that isolated chromium deficiency in man causes glucose intolerance, inability to utilize glucose for energy, neuropathy with normal insulin levels, and no impairment of insulin action on amino acid uptake and FFA release. The claim that chromium acts as cofactor for insulin can therefore also be applied to two insulin-responsive steps in animo acid metabolism which are independent of the action of insulin on glucose utilization [1].

The total chromium concentration in µg/g dry weight ranged from 2.16 and 1.83 in oysters and egg yolk, respectively, to 0.02 and 0.06 in cane sugar and grits, respectively. It has been calculated that a daily intake varying from 20 to 500 µg chromium, depending on the chemical nature of chromium in individual foods, would be needed to compensate for a urinary loss of 5 µg Cr/day [4]. Hexavalent chromium 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 [1]. Chronic exposure to chromate dust has been correlated with increased incidence of lung cancer [10], and oral administration of 50 ppm of chromate has been associated with growth depression and liver and kidney damage [1]. Deficiency and excess of Chromium is playing the important roles in human health as well as environmental degradation.

RESULTS AND DISCUSSION

Twenty different soil samples of Hazaribag tannery area, Dhaka have been irradiated by the 2.5 MeV proton beam of current range 10 - 15 nA. For each sample, 10 µC charges has been collected through Faraday Cup. The spectrum data files are analyzed using GUPIX (DAN-32) Software and the Chromium concentration are shown in the table 1.

Table: 1 Chromium concentration found within different soil samples of Hazaribag tannery area, Dhaka.

Sample, Hazaribag	Experimental Value (µg/gm)	Value of IAEA Soil-7 (µg/gm)	Experimental Value of IAEA Soil-7 (µg/gm)
Soil-1	73.10	60	62.7
Soil-2	68.50	-	-
Soil-3	97.70	-	-
Soil-4	75.00	-	-
Soil-5	99.40	-	-
Soil-6	147.60	-	-
Soil-7	38.20	-	-
Soil-8	51.70	-	-
Soil-9	5115.00	-	-
Soil-10	300.10	-	-
Soil-11	111.00	-	-
Soil-12	85.20	-	-
Soil-13	136.00	-	-
Soil-14	3526.40	-	-
Soil-15	106.50	-	-
Soil-16	4202.40	-	-
Soil-17	119.20	-	-
Soil-18	105.70	-	-
Soil-19	4520.50	-	-
Soil-20	3979.00	-	-

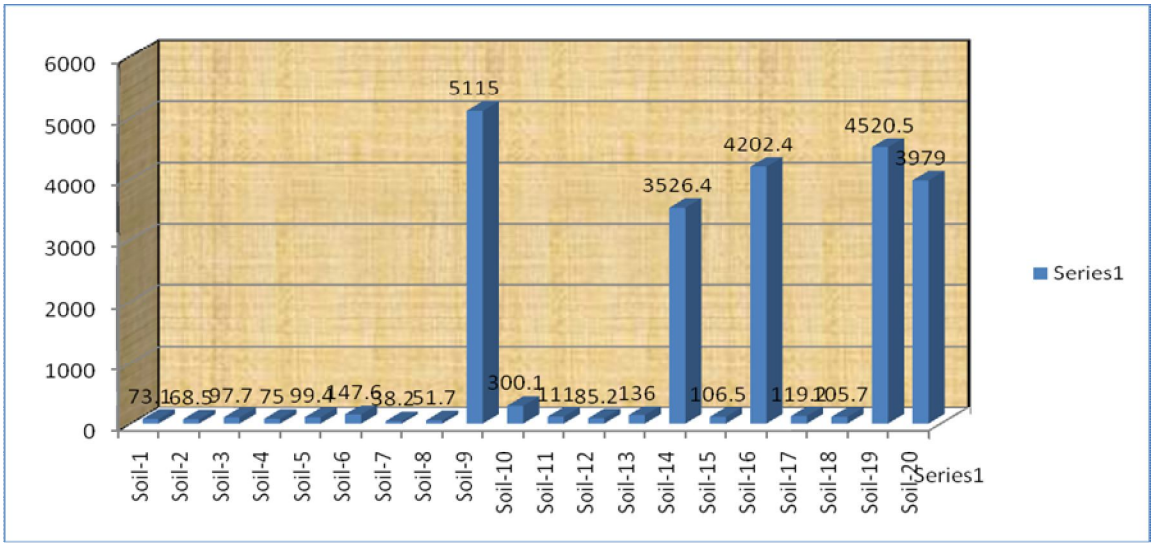

Fig. 1 Graphical presentation of Cr distribution in soil samples of Hazaribag area, Dhaka.

The Chromium solutions are used in tannery industries for leather processing purposes. Liquid wastages from the tanneries are poured into the drain without any type of treatment. These liquid wastages are spreading around the areas due to poor drainage system. According to the concentrations found in experiments, five of twenty samples those are collected from the nearest area of the drain where the liquid wastes are poured, contain a high value of Chromium, more than 3000 µg/gm and is harmful for environment as well as human beings. The comparison figure of Chromium with the reference values of IAEA soil-7 are shown in the table to ensure its toxicity.

CONCLUSION

The present study suggests that the soils around the Hazaribag tannery area highly polluted by Chromium contamination that may deteriorate the environment and may pose threat to human health. Pre-treatment should be taken on tannery wastes disposal and further analysis should be done. Such study will provide sufficient knowledge to evaluate the significance of the problem related to especially environment as well as human beings.

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