Analysis of the Concentrations of Soil Elements Around Different Manufacturing Garment Areas, Savar

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Abstract:

The Particle Induced X-ray Emission (PIXE) Technique under Powerful Ion beam Analytical (IBA) Technique has been turned to account for the determination of the concentrations of soil elements of different manufacturing garment areas at Savar, Dhaka. The study area was classified into three sub-regions of Savar, Dhaka consisting of (1) Fountain Manufacturing Garment area, (2) Vadail Bazar, and (3) Gonokbari area. The neoteric machineries available in the accelerator Laboratory of Atomic Energy Centre, Dhaka (AECD) have been used for the research works, from sample preparation to data analysis. The proton beam energy 2.2 MeV and the current range 10-15 nA are used in this research. Microbalance, pellet maker etc. have been used for sample preparation. A [Si (Li)] detector associated with other equipments such as amplifier, PC and Smartphones are used for data procurement. The energy of the emitted X-rays indicates the identity of the soil elements and the intensity of the X-rays gives the measurements of the concentrations of the elements existed in the samples. DAN-32 software was used to analyze the collected spectrum data. The detected elements in soil samples and their concentration are Aluminium (3322 to 7299 µg/g), Si (177 to 521 µg/g), Chlorine (87 to 423 µg/g), Potassium (5009 to 7617 µg/g), Calcium (2366 to 5390 µg/g), Scandium (71 to 134 µg/g), Titanium (145 to 3148 µg/g), Vanadium (45 to 135 µg/g), Chromium (48 to 96 µg/g), Manganese (237 to 508 µg/g), Iron (8620 to 14655 µg/g), Nickel (07 to 556 µg/g), Copper (8 to 40 µg/g), Zinc (22 to 90 µg/g), Germanium (7 to 10 µg/g), Selenium (2 to 8 µg/g), Rubidium (84 to 856 µg/g), Strontium (92 to 139 µg/g), Yttrium (5 to 43 µg/g) and Zirconium (287 to 407 µg/g). It is shown that the concentration of Iron is about 34.83% of the total extent comparing to all elements present in the soil samples. This is a horrific signal both for soil and environment. Moreover the presence of Chromium and Titanium, though their concentrations are low, are very detrimental for crops.

Keywords: Trace components, PIXE, Interveinal chlorosis, Eutrophication, Projectile Bremsstrahlung (PB), Secondary Electron Bremsstrahlung (SEB).

I.   Introduction

Soil and water quality are very closely linked and, to a significant extent, soil properties have nine water qualities. As water passes through soil it is filtered and purified which helps to generate clean and wholesome groundwater. This process also includes the removal of nutrients thereby reducing the risk of water **eutrophication** (the process by which water bodies become enriched by nutrients). Soils as a natural resource perform a number of key environmental, social and economic functions [1].

Elemental analysis comprising of physicochemical, biological or environmental origin of any material can provide us a complete view about the intrinsic quality of the material to be used and for attaining and satisfying the desired quality of life.

Significance of some important components of soil is described below:

Iron is an necessary element for enzyme system which brings about oxidation reduction reactions and electron transport chain in the plant, synthesize chlorophyll, maintain the structure of chloroplasts, and enzyme activity, also it regulates respiration, photosynthesis, reduction of nitrates and sulphates, that these reactions are essential to plant development and reproduction. Different plants have two strategies to uptake iron in aerobic conditions. In first strategy trivalent iron (Fe^{3+}) will be converting to solution iron (Fe^{2+}) with phytosiderophores secreted by plant roots. If an adequate amount of iron is not available to plants, iron deficiency (iron chlorosis) will result. Symptoms of iron deficiency appear on the youngest, newest leaves. The area between the leaf veins becomes pale yellow or white (this is called interveinal chlorosis) [2].

Zinc is one of the minerals men should never be without and has such a wide application in human health that everyday should ensure that they obtain enough of this trace element. It is necessary for a healthy immune system, and is also of use in fighting skin problems such as acne, boils and sore throats. It is further needed for cell division, and is needed by the tissue of the hair, nails and skin to be in top form. Zinc is further used in the growth and maintenance of muscles. Children, for normal growth and sexual development also require zinc. It also seems as if zinc helps to control the oil glands, and is also required for the synthesis of protein and collagen – which is great for wound healing and a healthy skin. There is a shortage of zinc in many people's diet, since zinc is destroyed in the milling process and is also lost in cooking. A deficiency will result in an underperformance immune system, open to infections, allegories, night blindness, loss of smell, falling hair, white spots under finger nails, skin problems, sleep disturbances etc. Men with zinc shortage may have a problem with fertility, while women may experience irregular periods. Children with too little zinc may have stunted growth and slow sexual maturity. At the end of spermatogenesis, Zn is highly concentrated in the tail of mature spermatozoa and involved in sperm motility [3].

Iodine in our food is dependent on the iodine found in the ground where the the food is grown, in the food the animals receive, as it influences the iodine content in the fish, meat and eggs we consume. Iodine is used in the product ion of hormones (such as thyroxin) by the thyroid gland, which in turn regulates the conversion of fat to energy, stabilizing our body weight as well as controlling our cholesterol levels. These hormones produced from the iodine are also needed to help form our bones, as well as keeping our skin, nails, hair and teeth in prime condition. Some indication also exists that the iodine is helpful in preventing cancer of the breast and womb. When iodine is deficient the thyroid gland enlarges (referred to as a goiter) to maximize the amount of iodine to be extracted from the blood, and if this problem is not corrected, a shortage of this hormone in the body may lead to contraction, obesity, weakness, mental slowness as well as mental problems. Goiter is now always the cause of iodine deficiency, but can in some cases be caused certain micro-organisms. The consequence of iodine deficiency during pregnancy is impaired synthesis of thyroid hormones by the mother and the foetus [4].

Potassium is an important positive ion in intracellular fluid. A healthy adult needs potassium about 2000 mg/day. When the functions of kidneys remain normal, typical intake of dietary potassium is not toxic. But when the kidneys function poorly, potassium builds up in the blood, creating a condition called hyperkalemia. Potassium builds up in the blood, creating a condition called hyperkalemia. Higher potassium: sodium intakes (determined via urinary excretion rates) have stronger effects on blood pressure and the risk of subsequent cardiovascular disease than either sodium or potassium alone [5].

Calcium plays a very important role in human body. Calcium is essential especially for bones and it makes the teeth and bones strong as well as healthy. It also protects bones and teeth from diseases. Dental caries, bone diseases, hypertension, osteoporosis, osteomalacia etc. diseases attract human body due to the lack of Calcium. The accumulation of carbohydrates in the absence of calcium has also been noted by a number of investigators, and it has been suggested that the role of calcium in this regard is to remove potassium oxalate which presumably interferes with the diastase activity necessary for carbohydrate translocation [6].

Cobalt is required in the manufacture of red blood cells and in preventing anemia. If a normal diet is followed a deficiency is most unlikely. Humans are totally dependent upon their intake of vitamin B_{12} from meat and livers of ruminant animals. Thus, ruminant animals play a vital role in human nutrition as a sole source of vitamin B_{12}. Areas that contain high or low concentrations of Co can have a direct relation to the health of plants, animals and humans in terms of vitamin B_{12} levels [7].

Manganese is one of those humble trace elements so often overlooked, yet essential to health. It enables the body to utilize vitamin C, B1, biotin as well as chorine. It is used in the manufacture of fat, sex hormones and breast milk of females. Manganese is also indicated in stimulating growth of the connective tissue and is also thought to be of importance in brain functioning. Deficiencies are rare but would include poor bone growth, problems with the disks between the vertebrae, birth defects, and problems with blood glucose levels and reduced fertility. Serious deficiency in children can result in paralysis, deafness and blindness. Manganese is not easily absorbed but since small amounts are needed deficiencies is not very general. Mn also plays an essential role in regulation of cellular energy, bone and connective tissue growth, and blood clotting [8].

If large amounts of Copper are present, then Zinc and Vitamin C is reduced in the body, and vice-versa. Copper is required in the formation of hemoglobin, red blood cells as well as bones, while it helps with the formation of elastic as well as collagen – making it necessary for wound healing. Acute Copper poisoning occurs in man when grams of Copper Sulfate are ingested accidentally [9]. A lack of Copper may also lead to increased blood fat levels. It is also necessary for the manufacture of the neurotransmitter noradrenalin as well as for the pigmentation of hair. It can be stored in the body, and daily presence in the diet is therefore not necessary.

Using high quality equipment as mentioned above and modern laboratory facility of AECD, research work can be carried out very carefully. Through the elemental analysis of soil, a standard database may be developed that can play a significant role to improve the environment of our country.

II. Procedure and Methodology

A. *Proton Induced X-ray Emission (PIXE)*

PIXE is a powerful yet non-destructive elemental analysis technique now used routinely by geologists, archaeologists, art conservators and others to help answer questions of provenance, dating and authenticity. When a material is exposed to an ion beam, atomic interactions occur that give off EM radiation of wavelengths in the x-ray part of electromagnetic spectrum specific to an element. PIXE is truly multi-elemental technique and can identify elements from Na whose Z value is 11 (this lower limit is set by inefficiency of the X-ray detectors below Na X-ray) and up through the rest of the periodic table. Applications of this technique are widely ranging and diverse. The AF Laboratory of AECD is routinely being used for the analysis.

The experimental setup used for PIXE analysis is shown in Figure 1. The amount of material exposed to the beam is small. Therefore, most of the yield comes from the part of the proton range were the energy is the highest. The volume analyzed the typical of the order of 1000 d^2 cm^3 (d = beam diameter) for 2 to 3 MeV protons. Accordingly analysis carried out under these conditions implies a high degree of homogeneity of the sample. It was also implicit that standards used to test such analytical methods should be equally homogeneous [10].

In-homogeneities with dimensions of the order of (100 d) μm will have a significant effect on the observed concentrations. Lateral in homogeneities was easily checked by charging the beam position and observing the effect on the scatter of the result [11]. The presence of the depth in homogeneities was checked by charging the proton energy or by using several X-rays or gamma-rays from the same target which have different yield curves.
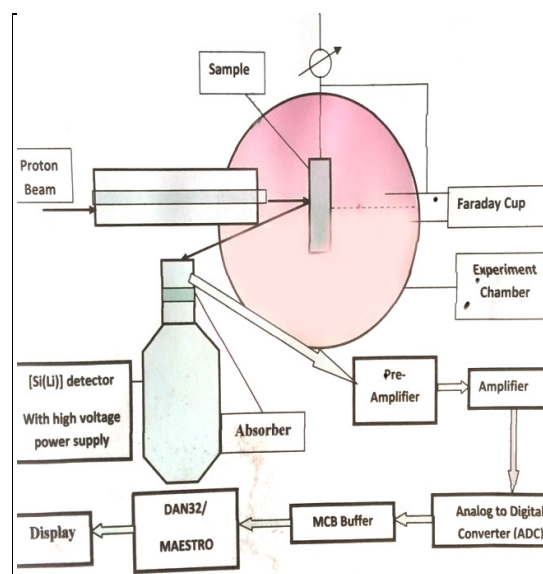

Figure 1: Schematic of PIXE experimental set-up

In our calibration process we mainly followed the H value method described in [12, 13], which is based upon the equation

$$Y(Z, M) = Y_1(Z, M)Q\ C_z T(Z)\ \varepsilon_z\ H$$

Where $Y(Z, M)$ is the measured X-ray yield computed by the fitting program; $Y_1(Z, M)$ is the theoretical X-ray yield per unit beam charge, per unit solid angle and per unit concentration computed from the GUPIX database; Q is the measured beam charge; C_z is the concentration of the element quoted by the manufacturer; $T(Z)$ is the fractional transmission of X-ray through any absorber; ε_z is the intrinsic detector efficiency; H is the product of detector solid angle and any correction factor for the charge measurement. In our case H also includes the effect of improper description of the detector line shape, solid angle, Si crystal thickness; absorber layer thickness etc. It also includes the imperfection in the various database used in GUPIX [14, 15].

B. Sample Preparation and Data Acquisition

The environmental pollution is increasingly becoming a serious problem in Bangladesh for diverse reasons. The unplanned urbanization and industrialization in Bangladesh ave severely affected the environmental components like soil, water and air of big cities and their adjacent areas. Consequently the deterioration of environment and its adverse effect on human health has emerged as a major problem of the country.

The research area of this paper is chosen in different manufacturing garment areas at Savar that are located near Dhaka city. These industries are continually discharging their washes in the open natural canals and sometimes directly into the ground without any treatment, which pollutes the soil.

Three specific locations are selected in the garment areas, Savar for this research. Soil samples have been collected from different depths. The details of sample collection procedure are shown in the table 1.

Table 1: Selected area, depth and quantity of soil sample

Sl No.	Selected Area	Depth (feet)	Quantity of Sample
1	Fountain Manufacturing Garments, Savar	1	2
2	Vadail Bazar, Savar	1	3
3	Gonokbari, Savar	1	3

C. Calculation procedure

PIXE technique identifies the existence of unknown components signing in the. The main objective of the PIXE experiment is to identify the presence of unknown elements signature in X-ray and the quantitative calculation of their concentration from the measured X-ray yields. After the PIXE spectrum was obtained, GUPIX software was used for quantitative analysis of the data. Then we analyzed the spectrums data into concentration of different elements present in the samples using GUPIX software. A typical spectrum of PIXE analysis is shown in fig-2.
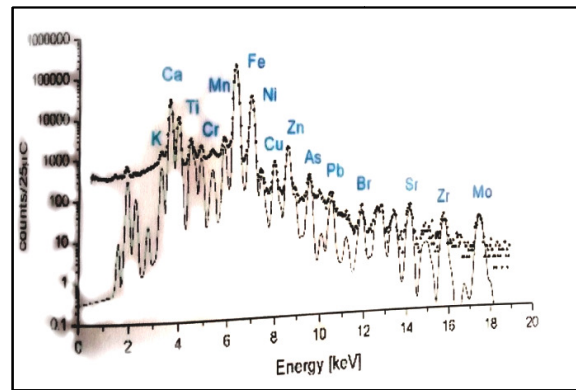

Figure-2: A typical PIXE spectrum of soil elements

Using MAESTRO-32 software with suitable parameters, we can determine both elemental composition, concentration present in the target and unfolding the X-ray spectra. In this experiment, incident beam energy 2.2 MeV with 10 µC irradiation is used. Position of detector, target and the angle made by detector with target must be fixed during experiment, we only need to determine the instrumental constant (H value) against the energy data file, i.e. HED file. Finding the value of instrumental constant "H" is also very important for proper calibration of the PIXE technique [16].

We collected the data of different elements through measuring the peaks from the spectrum saved by MAESTRO-32 software. The spectrum shows the concentration of the element. The collected X-ray spectra were processed off-line with the aid of GUPIX (Guelph PIXE) software package [17] for thin targets.

D. Qualitative analysis

In PIXE analysis, multiple characteristic X-ray lines recognize elements present in the samples. Interference

between X-ray lines of different elements: The primary sources of continuous background for proton excitation are projectile Bremsstrahlung (PB) and the secondary electron Bremsstrahlung (SEB). For proton excitation, continuum background mainly comes from incomplete charge collection and Compton scattering in the detector. It should be noted that the vertical scale of spectra presented here represent the log of the X-ray counts and therefore visually enhances region of low counts as well as the size of background contribution relative to the peak amplitudes.

The inter-element interferences can be occurred either between the K_β signal from element Z and K_α signal from element (Z+1) or (Z+2) or between a particular K-line of a low or medium Z element and a L-line of a high Z element. Mostly encountering interferences include K K_β - Ca K_α, Mn K_β - Fe K_α, Ni K_β - Cu K_α, Br K_β - Ru K_α and As K_α - Pb L_α interferences.

In order to validate the PIXE method, several standards references materials were assumed. The result and the standard deviations of them have accuracy for beam analyses were within several percent (10%).

III. Results

Experimental results of concentrations of elements in PIXE analysis are given below.

Table 1.1: Concentration of the Elements of Soil Sample 1 of Fountain Manufacturing Garments, Savar (1 ft depth)

Z Number	Name of the element	Concentra-tion in µg/g	Limit of detection	Error in %
13	Al	6014.9	6507.4	140.81
14	Si	177	299.3	90.08
17	Cl	87	29.4	12.18
19	K	7617	17.2	0.84
20	Ca	5390	43.2	1.01
21	Sc	134	40.9	13.83
22	Ti	3148	13.2	0.95
23	V	135	32.4	9.49
24	Cr	96	10.2	7.91
25	Mn	508	10.7	11.42
26	Fe	14655	14.9	19.70
28	Ni	556	6.0	23.4
29	Cu	40	4.4	8.94
30	Zn	90	4.6	5.37
32	Ge	10	11.3	58.49

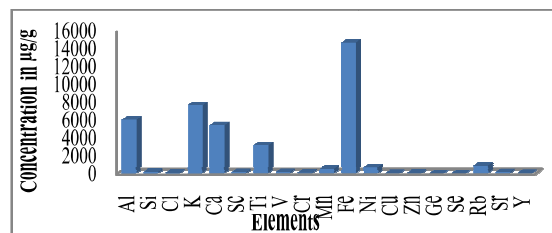| 34 | Se | 2 | 8.1 | 457.78 |
37	Rb	856	33.5	74.48
38	Sr	127	12.8	13.45
39	Y	43	28.3	23.56

Figure 1.1: Bar diagram of concentration of the elements of soil sample 1 of Fountain Manufacturing Garments, Savar (1 ft depth)
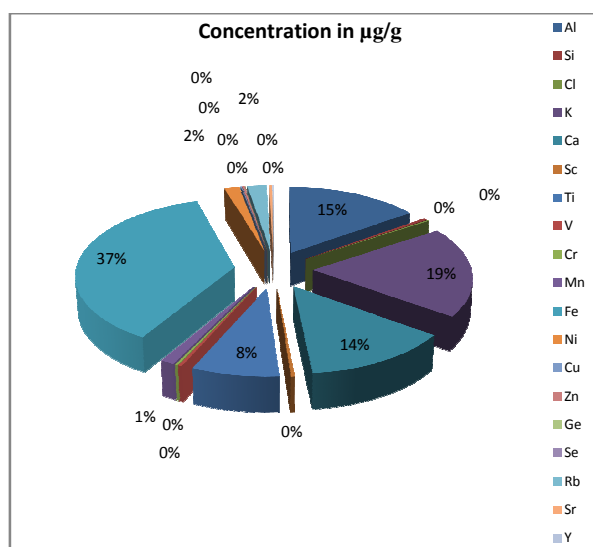

Figure 1.2: Pie chart of concentration of the elements of soil sample 1 of Fountain Manufacturing Garments, Savar (1 ft depth)

Table 1.2: Concentration of the elements of soil sample 2 of Vadail Bazar, Savar (1 ft depth)

Z Number	Name of the Element	Concentra-tion in µg/g	Limit of detection	Error in %
13	Al	3322	4946.7	164.21
14	Si	227	219.6	76.70
17	Cl	423	22.4	30.90
19	K	5380	14.5	0.99
20	Ca	2366	33.6	1.33
21	Sc	71	24.7	15.87
22	Ti	1530	10.7	1.22
23	V	45	20.5	18.64
24	Cr	48	7.6	8.44

25	Mn	237	7.5	2.69
26	Fe	8620	7.9	5.37
28	Ni	7	4.2	12.54
29	Cu	8	3.7	73.87
30	Zn	26	2.8	11.04
32	Ge	7	4.2	41.08
37	Rb	85	10.9	13.35
38	Sr	92	7.5	13.33
39	Y	19	19.1	52.74
40	Zr	407	20.6	7.01

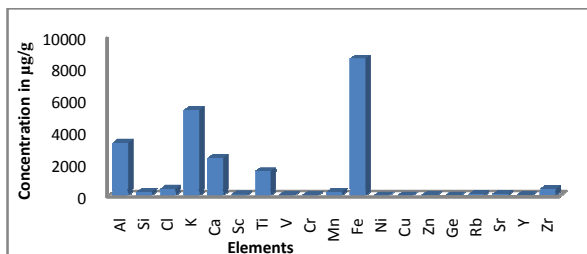| 26	Fe	11187	5.6	1.84
28	Ni	10	6.0	31.15
29	Cu	12	5.2	157.90
30	Zn	22	4.0	13.69
32	Ge	8	5.5	395.89
37	Rb	84	13.6	13.91
38	Sr	139	7.6	10.15
39	Y	5	11.3	219.05
40	Zr	287	21.8	9.44

Figure 1.3: Bar diagram of concentration of the elements of soil sample 2 of Vadail Bazar, Savar (1 ft depth)
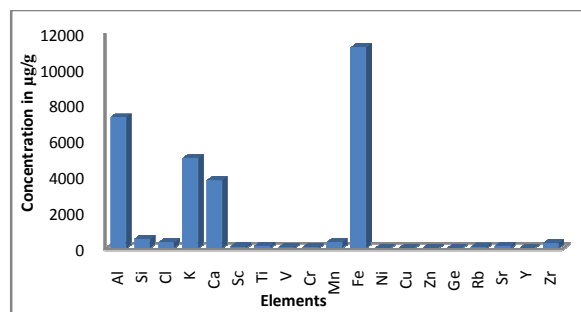

Figure 1.5: Bar diagram of Concentration of the elements of soil sample 3 of Gonokbari, Savar (1 ft depth)
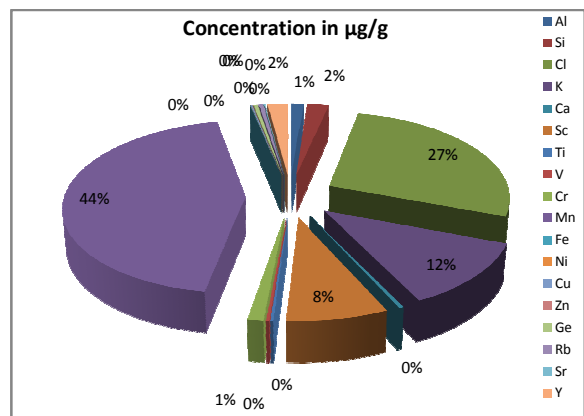

Figure 1.4: Pie chart of concentration of the elements of soil sample 2 of Vadail Bazar, Savar (1 ft depth)
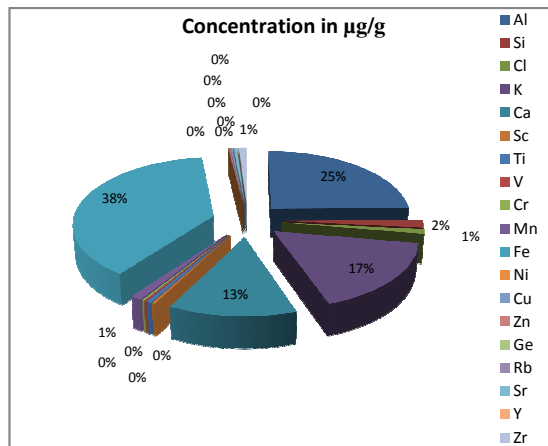

Figure 1.6: Figure Pie chart of Concentration of the elements of soil sample 3 of Gonokbari, Savar (1 ft depth)

Table 1.3: Concentration of the elements of soil sample 3 of Gonokbari, Savar (1 ft depth)

Z Number	Name of the element	Concentration in μg/g	Limit of detection	Error in %
13	Al	7299	4739.5	457.04
14	Si	521	210.9	24.40
17	Cl	331	20.6	7.58
19	K	5009	17.0	1.00
20	Ca	3783	32.9	14.65
21	Sc	97	32.3	12.4
22	Ti	145	11.3	1.24
23	V	59	20.1	7.40
24	Cr	65	7.8	6.60
25	Mn	347	6.9	2.19

IV.   Discussion

It has been shown that the concentration of Iron is the highest among all elements present in the soil samples that are found in this study and the concentration of Iron varies from 8620 to 14655 μg/g.

The concentration range of the minor and trace elements in soils recorded for three different areas are given in above tables. The decreasing order of the concentration of the different elements Fe> K> Al> Ca> Ti> Rb> Ni> Si> Mn> Cl> Zr> Sr> V> Sc> Cr> Zn> Y> Cu> Ge> Se reflects their abundance in the soil of the aforementioned garment areas. .

In terms of sub-regions, the order was sub-region (1) > sub-region (3) > sub-region (2).

The concentration of the different elements determined in the three sites around the garments and especially Fe, K, Al, Ca and Ti were comparable with the relevant data reported in surface soils of Poland [18]. Higher values were observed at these sites for the elements Fe, K, Al, Ca and Ti and lower for the elements Ge and Se.

These findings reflect the impact of the soil and indicate the contamination of the studied area due to accumulation effects connected mainly with the waste transport and disposal but also to the geology background of the region [19].

As it is known the chemical and physical soil properties (pH, CEC, salt content, water, temperature) can influence the migration and mobility of trace elements whereas major elements (e.g., K, Fe and Zn) are regularly applied to the soil in the form of mineral fertilizers [20].

Existence of Chromium (48 to 96 µg/g) and Titanium (145 to 3148 µg/g) in most of the soil sample is an alarming signal for soil pollution in the garment areas, Savar.

We have done the experiments at a fixed proton energy, 2.2 MeV, in Van de Graaff accelerator which may not sufficient to excite "all the elements in the thick target samples. Greater than 2.2 MeV energy of the proton beam is better to excite the elements and isotope present in a sample [21].

We need to reduce the uncertainties or errors in the X-ray spectrum peaks. For this reason, we require a proper selection. Sharper the peaks in the spectrum the better would be the selection. Having the time interval histogram at our disposal, the measurement can be inspected with a more detailed view, where not only the total counts are determined but the time flow is followed as well. If better accuracy is in demand than $\sqrt{N}$ (N = Number of counts), then the time interval histogram approach has the capability to deliver a reduced uncertainty, because of additional time interval information [22].

IV. Conclusion

The PIXE analysis for the identification of the elemental concentrations in biological, medical, and environmental samples has now been a sophisticated technology. It is used for its sensitivity, accuracy, precision, simplicity of thick target.

MAESTRO-32 supported by GUPIX software has been applied for the elemental analysis of thick soil samples in cooperation with the Accelerator Laboratory of Atomic Energy Centre, Dhaka to ensure the quality of life.

The detected elements in soil samples with their concentration range are Aluminium (3322 to 7299 µg/g), Si (177 to 521 µg/g), Chlorine (87 to 423 µg/g), Potassium (5009 to 7617 µg/g), Calcium (2366 to 5390 µg/g), Scandium (71 to 134 µg/g), Titanium (145 to 3148 µg/g), Vanadium (45 to 135 µg/g), Chromium (48 to 96 µg/g), Manganese (237 to 508 µg/g), Iron (8620 to 14655 µg/g), Nickel (07 to 556 µg/g), Copper (8 to 40 µg/g), Zinc (22 to 90 µg/g), Germanium (7 to 10 µg/g), Selenium (2 to 8 µg/g), Rubidium (84 to 856 µg/g), Strontium (92 to 139 µg/g), Yttrium (5 to 43 µg/g) and Zirconium (287 to 407 µg/g).

Toxicant ingredients such as Chromium and Titanium etc. have been found in this research which are detrimental for environment surroundings soils, plants, animals, man etc. Comparing to other analytical techniques, the multi-elemental character of PIXE brings advantage and potentialities to soil science investigators for elemental analysis.

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