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Elemental Profile Studies of some Soil Samples using Particle Induced X-Ray Emission (PIXE) Technique

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ABSTRACT

In this work Proton-Induced X-ray Emission (PIXE) technique has been employed for the determination of elemental concentration of soil samples. PIXE analyses have been carried out using a 2.5 MeV proton beam generated with the aid of the 3 MV tandem accelerator of the Institute Nuclear Science and Technology, Atomic Energy Research Establishment, Savar, Dhaka. The X-ray and particle spectra were processed using MAESTRO software and GUPIX software. The elements identified in the soil samples using PIXE were K: 6040.33, Ca: 2018.07, Ti: 3826.5, V: 188, Cr: 1472.22, Mn: 482.37, Fe: 33330.17, Co: 738.47, Ni: 480.95, Cu: 464.42 and Zn: 2144.93 ppm respectively. The legitimacy of the method was done by analyzing Standard Reference Material IAEA soil standard 2586 and found to be compatible. PIXE is a multi element systematic technique used for the determination of major, minor and trace elements in the range of parts per million (ppm).

PACs: 29.20.-c

Keywords: PIXE, micro-nutrients, macro-nutrients

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INTRODUCTION

Elements are the basic building blocks of biology. Out of 100 elements 16 are necessary for plants to complete their life cycle. Natural Nutrient Sources are Air, Water and Soil. Water

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is a source of hydrogen and oxygen and may supply some secondary and micronutrients. Three of the 16 (carbon, hydrogen, and oxygen) are provided to plants through photosynthesis. The other primary plants food elements, macro-nutrients are: N, P, K, Ca and secondary plants food elements, are: Mg, S, B, Mn, Cu, Zn, Fe, Mo and Cl. These 13 are usually present as part of larger chemical compounds, but are generally able to divide into charged particles called ions which are used by growing plants.
Soil is the most important things for plant growth because it gives most primary and secondary nutrients and some micronutrients to the plants. Some soils, particularly sands, can be deficient in several elements, either because they have been depleted by plants or because they have been leached out by rain and irrigation (http://msucares.com/crops/soils/mgfertility.html).

EXPERIMENTAL

Sampling and Sample Preparation

The soil samples were collected from three locations of Dhaka districts (Banani shapon, Tazgaon Shapon, North Kamar para Shapon) and three locations of Comilla districts (Moynamoti Cantonment, Khristan Kabar, Kalakochua) in Bangladesh. The collected soils were dried in an oven at a temperature of 60^0 C for about 10 hours to make the samples water free. After cooling the samples to the room temperature in the desiccators the weights were taken. The process of heating, cooling and weighing was repeated until a constant weight is shown by the balance which is a confirmation of zero water content. In this experiment we have made the pellets of diameter 0.7 mm at 120-130 kg/cm^2 pressure. For every sample two pellets were made. The samples were prepared at the Accelerator Facilities Division of Atomic Energy Center, Dhaka.

Experimental System

Concentration measurements of elements were made with proton beam energy of 2.5 MeV obtained from the 3 MV Tandem Accelerators at the Institute of Nuclear Science and Technology, Atomic Energy Research Establishment, Savar, Dhaka. In case of PIXE measurements the characteristic X-rays emitted from the sample upon bombardment with 3 MeV proton beam were detected using a 30 mm^2 Si(Li) detector SL30165 and associated electronic setup for routine analysis. The detector resolution was 165 eV at 5.9 keV. The count rate was reduced using a 170 μm thick Mylar absorber. The dead time of the measurements was generally less than 5%. A 200 μg/cm^2 gold diffuser foil was used to homogenize the beam onto the target samples and current was in the range of 5-10 nA. The PIXE analysis provides high Z elements such as S, Cl, K, Ca, Fe, Cu, Zn, Ga, Br, Ru, Pb etc. and gives the accurate concentration of the most of the elements present in the samples with high accuracy (Johanson, *etel* 1988). In PIXE technique MAESTRO software was used to save the X-ray emission spectrum.

Data Analysis

Data were analyzed using GUPIX with DAN32 interfacing software (Murray, *etel*) that can simply, automatically and quickly fit the PIXE spectra to obtain the elemental concentrations. Elemental concentration calculation of each element C_Z is based on the following equation: (Campbel, *etel* 1993)

$$C_Z = \frac{Y}{Y_t Q \varepsilon T H}$$

Where Y_t is the X-ray theoretical intensity (i.e. the yield per micro-Coulomb of charge per unit concentration per steradian), Y is the x-ray experimental intensity or yield, Q is the measured proton beam charge, ε is the efficiency of the detector and T is the transmission through any filter or absorbers between the target and the detector. H is an instrumental constant equivalent to the product of the geometrical solid angle of the x-ray detector and any systematic normalization factor present in the charge integration system.

RESULTS AND DISCUSSIONS

The validity of this method is done by analyzing IAEA soil standard 2586. Elemental concentration (in ppm) of soil standard reference material 2586 is listed in Table 1.

Table 1 Elemental concentration (in ppm) of soil standard reference material 2586.

Element	Recommended Value	Measured Value
K	9760 ± 180	4821.9
Ca	22180 ± 540	20089.8
Ti	6050 ± 660	8284.2
V	160	268.6
Cr	301 ± 45	363.7
Mn	1000 ± 18	604.9
Fe	51610 ± 890	49260.5
Co	35	772.3
Ni	75	203.1
Cu	81	37.3
Zn	352 ± 16	297.0
Pb	432 ± 17	498.9

The Elemental concentration of the studied soil samples obtained 3MV Tandem Accelerator is summarizes in table 2.

Table 2 Elemental concentrations (in ppm) of soil samples using PIXE.

Sample ID	K	Ca	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
C-1	5110	3225	4181	278.9	68.82	381.1	18869	342	144.7	956.6	5024
C-2	7090	4069	3812	105.4	4532	1083	38509	979.9	1136	46.59	104.7
C-3	6458	1590	3632	202	182.2	284.2	35463	808	130.9	44.82	45.1
D-1	7371	1040	4297	113.4	3726	708.4	48729	1183	1088	141.4	60.76
D-2	4972	936.4	3394	208.4	180.5	238.4	28639	461.6	223.9	1257	6105
D-3	5241	1248	3643	225.7	143.8	199.1	29772	656.3	162.2	340.1	1530
Average	6040.33	2018.07	3826.5	188.97	1472.22	482.37	3330.17	738.47	480.95	464.42	2144.93

Potassium is essential for plant growth. The primary function may be related to plant metabolism. Respiration increases when potassium is deficient. Potassium is known to be essential for protein synthesis and enzyme activation (http://msucares.com/crops/soils/mgfertility.html). The average K observed in this study is 6040.33 ppm varying within 4972 ppm to 7371 ppm. The percentage of errors varies between 2.56 to 2.98% and the MDL range is 249 to 302 thus providing relatively in the K element.

The average concentration of Ca in the present soil study is 2018.07 ppm varying within 936.4 ppm to 4069 ppm. The percentage of errors varies between 2.86 to 10.23 % and the MDL range is 160 to 206.

The concentration of Ti in the present soil study is 3826.5 ppm varying within 3394 ppm to 4297 ppm. The concentration of V in the present soil study is 188.97 ppm varying within 105.4 ppm to 278.9 ppm. In this study the concentration of Cr is 1472.22 ppm varying within 68.82 ppm to 4532 ppm. The percentage of errors varies between 1.23 to 45.59 % and the MDL range is 59.3 to 79.4.

The concentration of Mn in the present soil study is 482.37 ppm varying within 199.1ppm to 1083 ppm. The percentage of errors varies between 5.38 to 22.12 % and the MDL range is 83.1 to 127.

The concentration of Fe in the present soil study is 33330.17 ppm varying within 18869 ppm to 48729 ppm. The percentage of errors varies between 0.24 to .51 % and the MDL range is 69.1 to 103.

In this research work, the concentration of Cu in is 464.42 ppm varying within 44.82 ppm to 1257 ppm. The percentage of errors varies between 2.84 to 59.07 % and the MDL range is 25.7 to 53.9. It is an important enzyme activator found mostly in the chloroplasts of leaves.

The concentration of Co in the present soil study is 738.47 ppm varying within 342 ppm to 1183 ppm. The concentration of Ni in the present soil study is 480.95 ppm varying within 144.7 ppm to 1136 ppm. The percentage of errors varies between 3.28 to 17.75 % and the MDL range is 23.2 to 59.7. For the activation of ureas, Ni is crucial elements. In lower plants, Nickel activates several enzymes involved in a variety of processes, and can substitute for Zinc and Iron as a cofactor in some enzymes (Barker, *etel* 2010).

In this study the range of Zn concentrations is found 2144.93 ppm varying within of 45.1 ppm to 5024 ppm. The percentage of errors varies between 0.86 - 46.31% and the MDL range is 22.7-53.3. The comparison of the present research with others studies are given in Table 3.

Table 3 Comparison of the elemental concentrations (ppm) in soil samples of present research with others Studies.

Elements	Present Research	Studies from Japan (Bolormaa, *etel* 2007)	Studies from Romania (Ene, *etel* 2010)	Studies from Bangladesh (Rahman, *etel* 2012)
K	6040	884	37000	----
Ca	2018	16220	12000	----
Mn	482	219	700	339
Fe	33330	21040	46000	30404
Ni	480	---	---	48.1
Cu	464	---	52	60
Zn	2144	---	130	209

CONCLUSIONS

Plants are entirely dependent on soil for water, minerals and nutrients. Soil is figuratively and literally the foundation for life on Earth. In the present study eleven elements are found in the soil samples. Among them six elements (K, Ca, Mn, Fe, Co, Ni, Cu, Zn) are essential for plants growth. Co, Ni, V may be required by some plants, but at very low concentrations. The other (Ti, Cr) elements are non-nutrients and are not essential to plant growth. Except Cr, no toxic elements such as As, Cd, Pb etc were detected. This works presents a groundwork revise for further future work.

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REFERENCES

Allen V. Barker, D. J. Pilbeam, Handbook of plant nutrition, CRC Press, ISBN 978-0-8247-5904-9, pp. 4, Retrieved 17 August, 2010.

Antoaneta Ene, Ion V. Popescu, Claudia Stihi, Anca Gheboianu, Ana Pantelica, Carmelia Petre, “PIXE analysis of multielemental samples”, Rom. Journ. Phys., 55:7–8, pp.806–814, 2010.

http://msucares.com/crops/soils/mgfertility.html

J. L. Campbel, D. Higuchi, J. A. Maxwell, W. J. Teesdale, “Quantitative PIXE microanalysis of thick specimen”, Nucl. Instr. and Meth, B 77, pp.95-109, 1993.

James Murray, Geoff Grime, “Identification of elements in proteins by microPIXE (Proton Induced X-ray Emission)”.

Oyuntsetseg Bolormaa, Jamsranjav Baasansuren, Katsunori Kawasaki, Makiko Watanabe, Toshiyyuki Hattori, “Total elemental composition analysis of soil samples using the PIXE technique”, Nuclear Instruments and Methods in Physics Research B 262, pp.385-390, 2007.

S. A. E. Johanson, J. L. Campbell, “PIXE: A Novel Technique for Elemental Analysis”, Willey, Chichester, 1988.

Syed Hafizur Rahman, Dilara Khanam, Tanveer Mehedi Adyel, Mohammad Shahidul Islam, Mohammad Aminul Ahasan, Mohammad Ahedul Akbar, “Assessment of heavy metal concentration of Agricutural soil around Dhaka Export Zone (DEPZ)”, Bangladesh: Implication of seasonal variation and Indices”, Appl. Sci. 2012, 2, pp.584-601; doi: 10.3390/app2030584, 2012.