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Heavy Metals Content in Soil Sample Collected from Narayanganj Industrial Area, Bangladesh Using Proton Induced X-ray Emission

S. Akter[1,*], R. Khatun[1], M. M. Ahasan[2], M. F. Uddin[2], H. M. Jamil[2], A. N. Monika[2], M. A. Rahman[2], M. Rahman[3], R. P. Das[2], R. A. Sharmin[2]

[1]Medical Physics Division, Atomic Energy Centre, Dhaka, Bangladesh
[2]Institute of Nuclear Medical Physics, AERE, Savar, Dhaka, Bangladesh
[3]Accelerator Facilities Division, Atomic Energy Centre, Dhaka, Bangladesh

Abstract Soil samples were collected from two different steel industries of Narayanganj District, Bangladesh. The samples were then dried, made fine powder and the pellets have been made for irradiation by 2.2 MeV proton beams of current ranges from 10 to 15 nA. Ion Beam Analyzing (IBA) technique Proton Induced X-ray Emission (PIXE) was used for sample irradiation. Data acquisition has been done using MAESTRO-32 software and the data files are analyzed using GUPIX/DAN-32. Elements to be found in the studied samples are: K, Ca, Cr, Mn, Fe, Co, Ni, Cu and Pd. Heavy metal with higher concentration was found in the study area and the concentration of heavy metal decreases with depth. The main objective of the research work is to explore and identify heavy elements presence in soil samples affected by the industrial area for human health.

Keywords Toxic elements, PIXE

1. Introduction

Steel industry is an established and growing industry in Bangladesh. The industry has emerged as a major contributor to the national economy. According to the experts, the growth of steel industry in Bangladesh is mainly induced by the rapid expansion of the country's shipbuilding and real estate sector, as well as the major investments in various infrastructure projects throughout the country [1]. But the unplanned industrialization of a city area are continuously discharging their waste in the public places which pollute soil, water, air and thereby pollute crops and vegetables. A huge number of industries are built in and around Narayanganj district. Heavy metal from these industries or other sources carries significant amounts of toxic heavy metals such as Co, Ni, Cu, Zn and Pd which contaminates the soil as well as effect in environmental pollution. The aim of the research is to explore the effect of heavy metal pollutants for better survival of individual [2].

* Corresponding author:
shirin_apece@yahoo.com (S. Akter)
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2. Methodology

2.1. The Study Area

Soil samples listed in Table 1 were collected from two steel industries in Narayanganj District (Fig. 1). Narayanganj is the oldest District of Bangladesh. It is also a center of business and industry, especially the jute trade and processing plants, and the textile sector of the country. The area of current Narayanganj District is about 684.37 Sq Km. the weather is fairly moderate and the summer and winter are in the interval in the region. The average temperature of the district is 17.5° F. The amount of the annual average rainfall is 183 cm. The Geo position of the district is between 23°34’ to 24°15' North Latitude and between 90°27' to 90°59' East Longitude [3].

2.2. Sample Collection and Preparation

Soil samples were collected at different locations (near chimney, at a distance of 20 and 60 ft from chimney surface (top soil) and lower (subsoil)) from two different steel industries of Narayanganj district. Each sample was properly leveled and kept on the drying oven (“Memmert Schutzart DIN 40050 – IP 20” at temperature of 60℃) for about two week in individual petri-dish. The samples were made dry in such a way that it contains no aqua which was obtained by recording the mass of the sample with a micro balance. The samples were grinded with an Agate Mortal Pester into fine powder. In order to avoid the cross contamination pester, pliers and other related equipment were also cleaned with acetone after grinding each sample. Then the samples of 0.7 mm were made by Hydraulic Pellet Maker.

Table 1. Soil samples collected from two steel industries of Narayanganj District

Sample Location & Sample ID	Near Chimney; (Depth: Upper)	20 ft from Chimney; (Depth: Upper)	20 ft from Chimney; (Depth: 10 inch.)	60 ft from Chimney; (Depth: Upper)	60 ft from Chimney; (Depth: 10 inch)
Indurstry-1	PX 101	PX 102	PX 103	PX 104	PX 105
Indurstry-2	PX 201	PX 202	PX 203	PX 204	PX 205

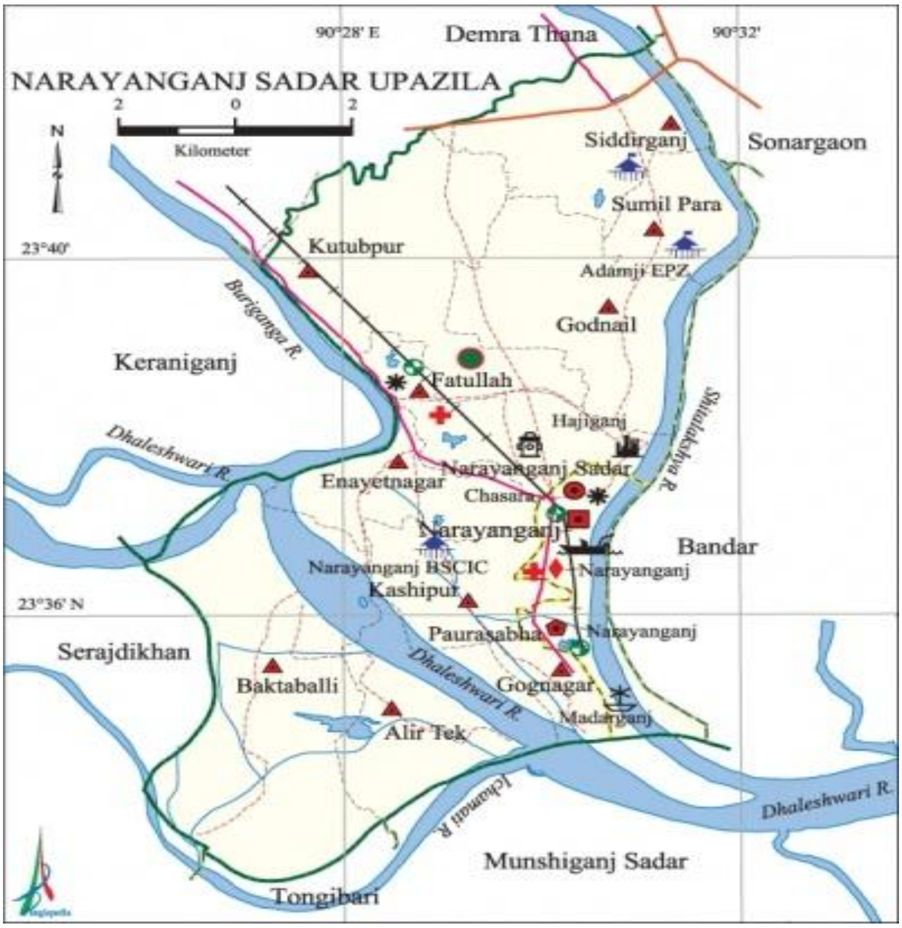

Figure 1. Narayanganj District, Bangladesh

2.3. Analysis of Samples

The experiments were done with 2.2 MeV proton beam with beam current of 10 nA produced from the 3 MV Van de Graaff Accelerators at Atomic Energy Centre, Dhaka, Bangladesh Atomic Energy Commission [4]. In PIXE, the characteristic X-rays emitted from the sample were detected using a 30 mm^2 Si(Li) detector (Model: SL30165) and associated electronic setup. The PIXE analysis provides high Z elements and gives the accurate concentration of the most of the elements present in the samples with high accuracy [5]. In the PIXE technique, MAESTRO software was used to collect the X-ray emission spectrum and for analyzing PIXE spectra, GUPIX with DAN32 interfacing software were used [6].

3. Results and Discussions

The pollution of soil by heavy metal due to several types of industries has now become a global issue. Steel and iron industries are the most important source of soil pollution. The elements that were found in the studied samples are K, Ca, Cr, Mn, Fe, Co, Ni, Cu and Pd which are listed in Table 2 and Table 3 for Industry 1 and Industry 2 respectively. Table 4 shows the Comparison of Elemental constituents of soil (in ppm) with IAEA Soil-7.

Table 2. Elemental concentration (in ppm) for Industry-1

Element	PX 101	PX 102	PX 103	PX 104	PX 105
K	2950	1285	1350	4770	4817
Ca	6082	2383	2422	6537	7501
Cr	375	27	22	162	126
Mn	2619	128	245	2489	1343
Fe	139166	6115	5221	244106	140509
Co	90	77	60	50	85
Ni	136	49	49	93	47
Cu	740	---	---	641	279
Pb	920	811	523	519	222

Table 3. Elemental concentration (in ppm) for Industry-2

Element	PX 201	PX 202	PX 203	PX 204	PX 205
K	1788	1640	1832	1490	1522
Ca	5122	4102	5211	4005	3086
Cr	255	191	233	100	95
Mn	2004	1568	1455	1568	1655
Fe	23586	188938	20111	158978	15663
Co	100	105	90	90	85
Ni	132	120	100	95	125
Cu	130	150	99	120	82
Pb	589	500	129	123	110

Table 4. Comparison of Elemental constituents of soil (in ppm) with IAEA Soil-7

Element	Certified value	Measured value
K	12100	10925
Ca	163000	174153
Zn	104	112.51
Fe	25700	3000
Co	8.9	10.05
Rb	51	65.23

Lead (Pb): The amount of lead found in study ranged from 110-920 ppm with the mean value of 445 ppm. The Mean Detection Level (MDL) varies between 249-510 ppm. The percentage of error varies between 15-23.6%. The reason for the high lead content is due to the industries present in these areas.

Copper (Cu): The copper content in the studied soil ranged from 82-740 ppm with the mean concentration of 224 ppm. Copper is usually in the soil within the range of 0-250 ppm [7]. The mean concentration, Percentage of Error and the Mean Detection Level (MDL) of the study is listed in Table 5.

Table 5. The mean concentration, range of error and range of MDL of the samples

Elments	Mean of Con. (ppm)	Range of Conc.	Range of Error (%)	Range of MDL (ppm)
K	2344	1285-4817	0.54-1.44	19-30
Ca	4645	2383-7501	0.47-1.25	23-45
Cr	159	22-315	1.56-18.08	8-35
Mn	1507	128-2619	0.33-8.33	12-57
Fe	94239	5221-244106	0.12-0.58	14-186
Co	83	50-105	21.23-33.2	72-757
Ni	95	47-136	25.2-31.7	18-139
Cu	224	82-740	1.55-22.43	54-115
Pb	445	110-920	15-23.6	249-510

Nickle (Ni): Nickle has been observed to have the average 95 ppm within the range of 47-136 ppm. It can be shown from Table 6 that a study observed the Ni content of 21.3 ppm. The experimental result is approximately 2-3 times higher than the reference value [10]. Comparison of elemental concentration of soil sample of different countries like Romania, United States, New Zealand, Lebanon with the present study are shown in Table 6. Pie diagram of the mean concentration of all the samples is shown in Fig. 2.

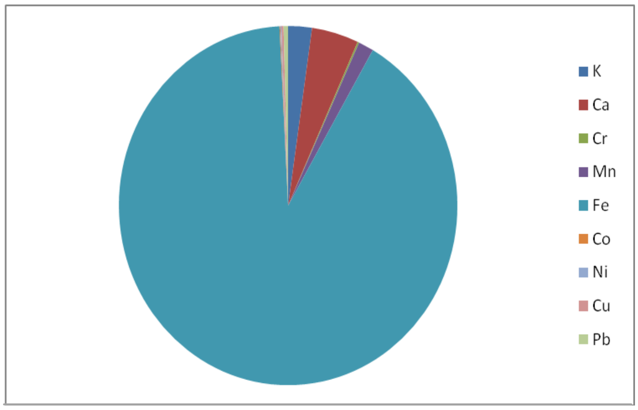

Figure 2. Pie diagram of the mean concentration of elements (in ppm)

Cobalt (Co): The present study shows Co concentration is 83 ppm within the range of 50-105 ppm. The range of error varies between 21-33% and MDL 72-757 ppm.

Table 6. Comparison of elemental concentration of soil sample of different countries with the present study

K	Ca	Cr	Mn	Fe	Co	Ni	Cu	Pb	Reference Study
37000	1200	--	70	46000	--	-	52	--	[8]
15000	24000	54	550	26000	--	19	25	--	[9]
2976	371	80.7	129	32274	--	21.3	31.3	--	[10]
--	--	--	--	--	--	156	98	25	[11]
2344	4645	159	1507	94239	83	95	224	445	Present Study

4. Conclusions

Higher metal concentration such as lead, iron, nickle, copper, cobalt was found in the study area and the concentration was higher than the background level. Metal concentration in the industrial area was higher than other area. It was observed that most of the heavy metal with high concentration was found from the top soil of the studied area and the concentration of heavy metal is decreases with depth. Constant monitoring of heavy metal pollution caused by different types of industries is needed to reduce such type soil as well as environmental pollution.

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