

Elemental Profile Analysis of Some Traditional Medicinal Plants of Bangladesh Using PIXE Technique

Md. Lokman Hossen^{1,*}, S. M. Azharul Islam¹, Md. Joynal Abedin², Shirin Akter², O. F. Rasel³,
M. Monjur Ahasan², Rajada Khatun², Ashrafun Nahar Monika²

¹Department of Physics, Jahangirnagar University, Savar, Dhaka, Bangladesh

²Accelerator Facilities Division, Atomic Energy Center, Dhaka, Bangladesh

³Physics Discipline, Khulna University, Khulna, Bangladesh

Abstract Bangladesh is the darling child of nature where about 722 medicinal plants are available. Photosynthesis and respiration are two major reactions on which lives on the planet- earth depend. Ions of different metal element have an important role in both the reactions. Few elements are essential to the body as nutrients called minerals. Atoms of different element such as Ca, K, Mn, S, P, Mg, Fe, Si, I, Cd, Ti, V, Sc etc of *Azadiracta indica*, *Aloe vera*, *Justicia adhatoda*, *Geodorum densiflorum*, *Nigella sativa*, *Embllica officinalis* and *Terminallia chebula* were figured out by using PIXE (Proton Induced X-ray Emission). Well dried pelleted samples of these medicinal plants were irradiated with proton beam accelerated with 3 MV Van de Graff accelerator. The emitted X-rays were collected using Lithium-drifted Silicon [Si(Li)] detector. Maestro and GUPIX software were used for data acquisition and analysis.

Keywords Elemental, Medicinal Plant, PIXE, [Si(Li)] Detector, Software, Disease

1. Introduction

Plants have been used in treating human diseases for thousands of years. A medicinal plant is any plant which, in one or more of its organ, contains substances that can be used for therapeutic purposes or which is a precursors for synthesis of useful drugs. Botanist reported that about seven hundred and twenty two types of medicinal plants are available here in Bangladesh. Some 6000 years ago, it appears that people (Neanderthal man) valued herbs as a medicinal plants. Because of their potential impact on human health, medicinal plants really can play an important role in healing and soothing of various diseases. It is told that minerals are important for their curative and poisonous effect on human health and are responsible for the formation of the active chemical constituents present in medicinal plants [1]. Rocks that contain minerals are break into smaller particles due to the weather effect and then become part of the soil. These minerals, content in the soil, are sucked in by all the living plants. These plants are devoured as food stuff by both animals and human beings. The plants absorb much of the essential elements from the soil in which they grow and serve as indicators of the materialization and are in fact used for this purpose

(Avnish, et al., 2010). Heavy metals are the matter of concern in the herbal drugs as certain plants have the tendency to store them from the soil, pol-luted water and atmosphere (Newall et al., 1996, Baker, 1994). All the elements such as various major, minor and trace elements concentration are important for determining effectiveness of medicinal plants in treating various diseases and to understand their pharmacological action.

2. Materials and Methods

2.1. Sampling Area

All the seven medicinal plants, listed in table 1 with local name, scientific name, parts of plants and medicinal use, were collected from Jahangirnagar University campus. Jahangirnagar University is situated almost at the central region of Bangladesh. Geographically, the campus is situated at 30° 16'N latitude and 90° 52'E longitudes, 32 km North West from the Dhaka city. It embraces about 2.8 km² (≈ 697.56 acres) of land with distinct ecological habitats and vegetation types (JU diary 05). The average height of this land is about 11.9 m (≈ 39 ft.) from the mean sea level and its soil is highly acidic with many pebbles and yellowish to reddish in colour. The climate of the campus can be categorized by the hot, rainy, humid summers and dry, cool winter. Temperature is very high in summer, which begins to rise in March and April is found the hottest month with a maximum and minimum temperature of 33.9°C and 23.8°C

* Corresponding author:

russell.juphy@gmail.com (Md. Lokman Hossen)

Published online at <http://journal.sapub.org/jnpp>

Copyright © 2014 Scientific & Academic Publishing. All Rights Reserved

respectively. January is the coldest month with maximum temperature 23.1°C and minimum 14.1°C. Humidity varies between 55-78% (source: Meteorological Dept., Dhaka). Figure 1 represents the sampling area.

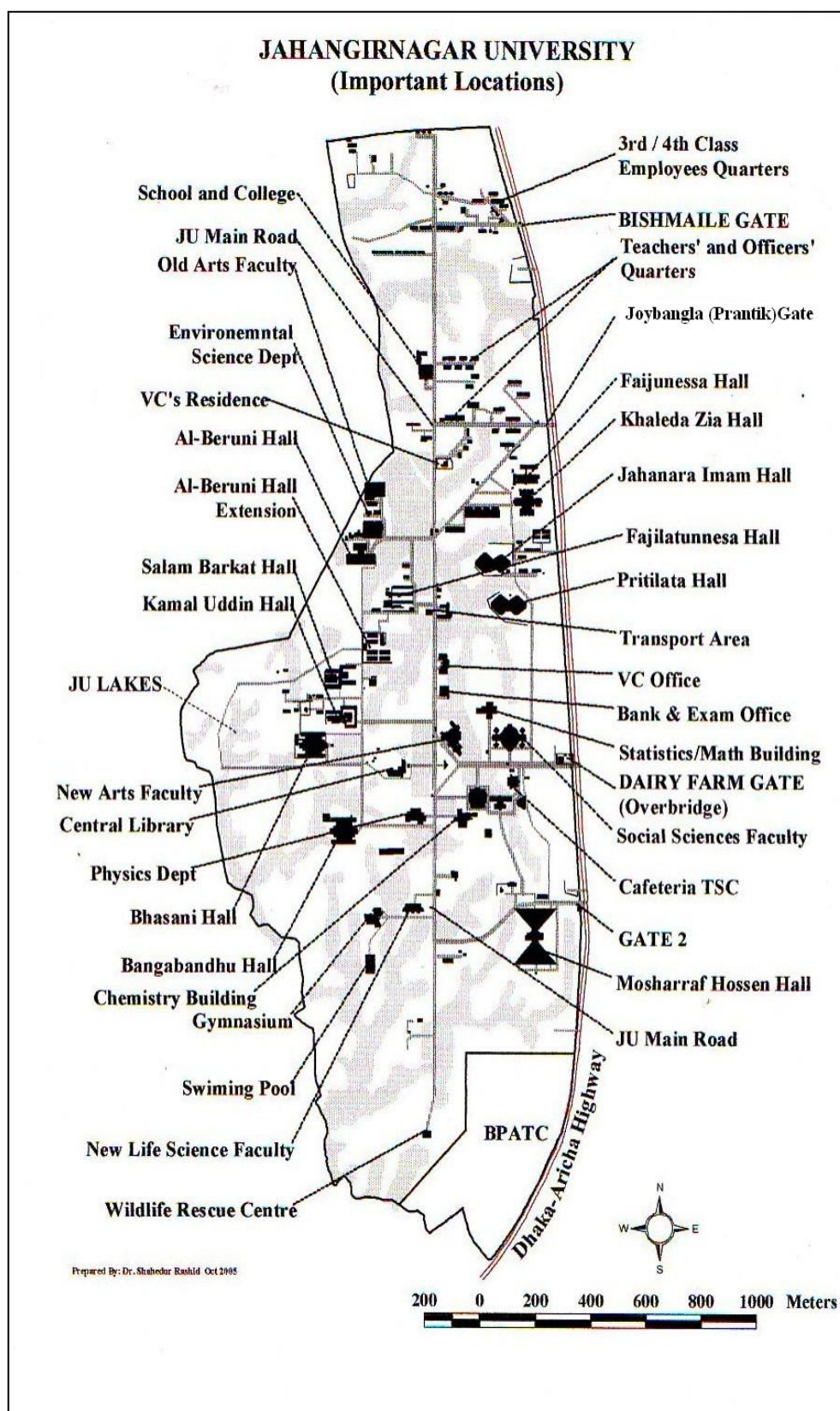


Figure 1. Map of Jahangirnagar University of Bangladesh from Where Medicinal Plant Samples Were Collected

2.2. Sampling Technique

All of the plant samples were washed extensively in distilled water in order to remove superficial dust. The leaf samples were dried at (50-80)°C for 48 hours. The trunk, seed, fruit and bark samples were desiccated in an oven too with temperature of 90°C for about 100 hours. In this work we use “Mettler Schutgart DIN 40050 – IP 20” to dry wet sample. After cooling the samples at the room temperature, their weight was taken. The process of heating, cooling and weighting was repeated until a constant weight was shown by the electronic balanced to confirm that the samples were completely dried and become moisture free. The dried weighted samples were ground into fine powder using a mortar pestle. Three sub-samples of each plant sample were then prepared and pressed into pellets of 7 mm diameter and 2 mm thickness using a table-top hydraulic press (Pressure: 125 kg/cm²).

2.3. PIXE Technique

With the advent of nuclear-based analytical methods in the last 40 years, proton induced X-ray emission (PIXE) has established a role in the elemental analysis of different materials. PIXE is a technique with a diverse array of applications in biology, geology, materials science, and others. PIXE spectrometry is one of the important and widely used analytical techniques at MeV energy accelerators. Sven Johansson and co-workers at the department of Physics, Lund University first developed this technique in the early 1970s [2]. PIXE is based on atomic fluorescence by energetic proton and the analysis is performed by measuring the characteristic x-ray emitted from the samples. PIXE is well adapted to measure major, minor, and trace element in different sample matrices such as biomedical, environmental, agriculture and industrial samples. In the present study the technique has been utilized for analysis of medicinal plant

samples. The importance of PIXE method is quantitative analysis for multi elemental character.

2.4. Sample Irradiation and Data Acquisition

In order to X-ray emission, each of the samples was bombarded in an air tight chamber with 2.5 MeV proton beam at the current intensity of (10-20) nA. The proton beam was accelerated with 3 MV Van de Graff accelerator. The emitted X-rays were detected using a liquid-nitrogen-cooled 30 mm² [Si(Li)] semiconductor detector. The X-ray fluorescence spectra were collected and quantitatively analyzed by the software Maestro and GUPIX respectively. Standard reference materials (SRM) from International Atomic Energy Agency (IAEA) – Apple leaf (1515) and CuS were used for concentration calibration. SRM are the agents with which whether a system is suitable for performing a task or not can be scrutinized. Before performing our study, the energy curve of the samples stated above were compared with the other energy curves of the same materials. The curves were aligned sharply and thus concentration calibration was determined with SRM.

3. Results and Discussion

Among twenty six essential elements Cr, As, Co, Cu, F, I, Fe, Mn, Mo, Ni, Se, Si, Sn, V and Zn are the paradigm of trace elements which are very important for the nutrition of human body and the other essential major elements are C, H, O, N, S, Ca, P, K, Na, Cl and Mg. Different medicinal plants have their definite role for smooth functioning of our body as these plants contain different level of trace elements (C. h. B. Devi et al., 2013). Total nine different elements namely P, S, K, Ca, Sc, Ti, V, Cr and Fe have been detected in all the plants. The elemental concentration in the medicinal plants are given in Table 2.

Table 1. Plant's Local Names, Scientific Names, Parts of the Plants Used and Their Particular Usage in Treating Diseases

Sl. No	Local name	Scientific name	Parts of plants: medicinal use
1	Neem	<i>Azadiracta indica</i>	Trunk: Used as dentifrice, antiarthritic, spermicidal, antifungal, antibacterial etc.
2	Ghritokumari	<i>Aloe vera</i>	Leaf: Used for healing skin wound, burn, scald, blisters, insect bites, rashes, sores, herpes, urticaria, vaginal infections etc.
3	Basok	<i>Justicia adhatoda</i>	Leaf: Used to treat coughs, colds, asthma, fever etc.
4	Shonkho	<i>Geodorum densiflorum</i>	Rhizomes: Used to regulate menstrual cycle in women
5	Kalojira	<i>Nigella sativa</i>	Seed: Used to treat asthma, bronchitis, rheumatism, eczema, boils, to increase milk production in nursing mothers and to promote digestion etc.
6	Amloki	<i>Emblica officinalis</i>	Fruit: Used as immunomodulatory, antiulcer, anticancer actions, protecting aging process, promoting spermatogenesis etc.
7	Horitoki	<i>Terminallia chebula</i>	Fruit: Used in asthma, bile duct disorders, heart disease and related chest pain, high blood pressure, high cholesterol, sexually transmitted diseases (STDs) etc.

Sulphur, potassium and calcium are the mostly tracked out elements available in all the seven medicinal plants. From the experimental concentrations of different element, it can be seen that *Aloe vera* (Ghritokumari) contains maximum concentration of sulphur (127913.2 ppm).

As part of four amino acids, sulphur performs a number of functions in enzyme reactions and protein synthesis. It is necessary for formation of collagen, the protein found in connective tissue in our bodies. S is also present in keratin, which is necessary for the maintenance of the skin, hair, and nails, helping to give strength, shape, and hardness to these protein tissues.

Potassium is very important to almost all the organisms and is necessary in nerve action. Potassium ions can play crucial role in curing renal disorder and diarrhoea [3]. Potassium also act as an activator of some enzymes and coenzymes which are relevant to the normal growth and muscle function. Potassium along with sodium works for helping to maintain the blood pressure by maintaining the body's water balance [4, 5]. This way, potassium works as a protective agent against hypertension. From the results obtained, it is observed that the concentration of potassium ranges from 21443.3 ppm in *Aloe vera* (Ghritokumari) to 1369.7 ppm in *Azadiracta indica* (Neem).

From the data obtained, the concentration of calcium ranging from 61538.9 ppm in *Azadiracta indica* (Neem) to 1926.8 ppm in *Nigella sativa* (Kalojira). For important electrochemical and coordination purpose, calcium is used in cell walls, healthy bones, teeth and blood. Calcium guides the physical condition of the muscles and nerves. For

children, the recommended daily uptake for calcium is between 500 and 1000 mg and for adults 800 mg. It is quite difficult to achieve a calcium level of nearly one percent of the total [6].

Iron is found only in *Azadiracta indica* (Neem) (4570.7 ppm) and *Nigella sativa* (Kalojira) (2561 ppm). The main function of iron is in the transport of oxygen to the tissues (haemoglobin) and is also involved in the processes of cellular respiration. Iron eliminates phlegm and strengthens the function of stomach [6].

Like others, phosphorus is also important element and are seen in all the samples except *Azadiracta indica* (Neem). Phosphorus participates in many body functions enclosing DNA synthesis, energy metabolism, and calcium absorption as well as utilization [7]. The maximum and minimum amount of phosphorus is found in this study is 396844.3 ppm and 917.9 ppm in *Justicia adhatoda* (Basok) and *Nigella sativa* (Kalojira) respectively.

Vanadium acts as the protection system against any harm of tissues. Vanadium salts has a therapeutic efficacy in treating diabetes mellitus [8, 9]. The presence of vanadium in *Azadiracta indica* (Neem), *Nigella sativa* (Kalojira) and *Terminallia chebula* (Horitoki) might be helpful in the treatment of diabetes.

Chromium has an important effect in curing diabetes mellitus as this can be found in pancreas that produces insulin hormone [10-12]. The maximum concentration of chromium is 16774.9 ppm in *Nigella sativa* (Kalojira) and minimum concentration is 686.4 ppm in *Aloe vera* (Ghritokumari).

Table 2. Actuarial Concentrations in (ppm) of the Elements of the Selected Medicinal Plants

Element	<i>Azadiracta indica</i>	<i>Aloe vera</i>	<i>Justicia adhatoda</i>	<i>Geodorum densiflorum</i>	<i>Nigella sativa</i>	<i>Embllica officinalis</i>	<i>Terminallia chebula</i>
P	ND	391318.8 ppm	396844.3 ppm	177522.2 ppm	917.9 ppm	114832.4 ppm	190580.4 ppm
S	242.4 ppm	127913.2 ppm	54132.9 ppm	38466.9 ppm	3906.8 ppm	29974.2 ppm	62758.6 ppm
K	1369.7 ppm	21443.3 ppm	11395.7 ppm	11378.8 ppm	1939.6 ppm	6024.1 ppm	4869 ppm
Ca	61538.9 ppm	20171.1 ppm	15707.4 ppm	39534.7 ppm	1926.8 ppm	2564 ppm	8398.2 ppm
Sc	174126.5 ppm	ND	ND	5329.8 ppm	5478.9 ppm	ND	3712.7 ppm
Ti	11310.1 ppm	2847.5 ppm	ND	ND	4898.2 ppm	ND	4597.1 ppm
V	7673.1 ppm	ND	ND	ND	82760.3 ppm	ND	3289.7 ppm
Cr	1937.9 ppm	686.4 ppm	ND	1405.7 ppm	16774.9 ppm	ND	ND
Fe	4570.7 ppm	ND	ND	ND	2561 ppm	ND	ND
I	ND	36134.6 ppm	64408 ppm	28424.6 ppm	ND	ND	1589.5 ppm

Titanium is found only in three of the samples at a high amount. It is harmless to our body. There is no known biological role for titanium and most of them passes through us without being adsorbed [13].

Iodine is found in four samples which help the thyroid to produce thyroxine and triiodothyronine hormones. These hormones play a major part in regulating processes relating to growth and development of the body and influence the maturation of the reproductive system.

Maximum amount of scandium is present in *Azadiracta indica* (Neem) (174126.5 ppm) and minimum composition (3712.7 ppm) in *Terminallia chebula* (Horitoki). Although a high amount of scandium is present in the samples, it is not toxic and has no biological role in human body [13].

4. Conclusions

PIXE technique was employed to the study of elemental constituents of some traditional medicinal plants generally administered in curing many diseases and ailments in Bangladesh. PIXE measurements were carried out using 2.5 MeV collimated proton beams from the 3 MV Van-de-Graaff accelerator of Atomic Energy Center, Dhaka. Medicinal plants are usually used for treating specific diseases and ailments due to different elements absorbed by different medicinal plants. The medicinal plants analysed so far are being used frequently by the inhabitant of Bangladesh. Among all the plants taken, *Nigella sativa* (Kalojira) is a remedy for all ailments (universal healer). Others are also important for different purposes. Therefore, the results of this study may help the consumers in using them for therapeutic purpose more effectively.

ACKNOWLEDGEMENTS

The authors are highly grateful to all the staffs of the Accelerator Facilities Division of Atomic Energy Centre, Dhaka for providing the necessary facilities required for this study.

REFERENCES

- [1] Rajurkar, N.S., Damame, M.M., Appl. Radiat. Isot. 49 (1998) 773.
- [2] Johanson, S.A.E. and Campbell, J.L, PIXE, A Noble Tech-nique for Elemental Analysis, Wiley, Chichester, 1988.
- [3] Haas, E.M., 2008. http://hkpp.org/general/potassium_health.html.
- [4] Howard, A., 2008. <http://www.free-press-release.com/news/200806/1213863387.html>.
- [5] Hyun, H.J., Sohn, J.H., Ahn, Y.H., Shin, H.C., Koh, J.Y., Yoon, Y.H., 2000. Depletion of intracellular zinc induces macromolecule synthesis- and caspase -dependent apoptosis of cultured retinal cells. Brain. Res., 869 (1-2), 39
- [6] Hyun, H.J., Sohn, J.H., HA, D.W., Ahn, Y.H., KO, H J.Y., Yoon, Y.H., 2001. Depletion of intracellular zinc and copper with TPEN results in apoptosis of cultured human retinal pigment epithelial cells. Invest. Ophthalmol. Vis. Sci., 42 (2), 460.
- [7] <http://naturopathicvermont.com/Minerals.pdf>.
- [8] Sivarajan, V.V., 1994. Balachandran, I., Ayurvedic Drugs and their Plant Sources, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, p. 570.
- [9] Sizer F., Whitney, E., 1999. Nutrition: concepts and contro-versies, 8th edn. Wadsworth. Belmont. Jam Pol L.M., et al., 2001. Age-related eye disease study research group (collective name-AREDS S). A randomized, placebo-controlled, clinical trial of high-dose supplementation with vitamins C and E, beta-carotene and zinc for age-related macular degeneration and vision loss: AREDS report no.8. Arch. Ophthalmol., 119, 1417.
- [10] Jam Pol L.M., et al., 2001. Age-related eye disease study re-search group (collective name-AREDS S). A randomized, pla-cebo-controlled, clinical trial of high-dose supplementation with vitamins C and E, beta-carotene and zinc for age-related macular degeneration and vision loss: AREDS report no.8. Arch. Ophthalmol., 119, 1417.
- [11] Jordan Valley Next Series Operation Manual., 2000., Jordan Valley AR. Inc., Austin.
- [12] Mansour, O.A., El-Sayeh, B.M., Helal, K.O., Faculty Pharm, B., 2000., 38, 165.
- [13] <http://www.lenntech.com/periodic/elements/sc.htm>, 1998-2014.