Study of Human Milk Composition using PIXE-PIGE Techniques

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Abstract

30 human milk samples collected from the maternity centers of Dhaka city were analyzed using PIXE-PIGE techniques to reveal what types of nutrients are passed from mothers to babies. Wide variation in concentration of different elements was found. Average concentration of different elements found are as, S: 31.49± 13.39, Cl: 395.68± 97.14, K: 1073.09± 256.85, Ca: 788.19± 174.14, Sc: 23.37± 5.00, Fe: 40.02±22.26, Cu: 5.23±1.74, Zn: 39.78±19.93, Br: 9.44±4.67, and Rb: 19.70±5.22 ppm. Wide variation of the elemental concentration is observed. The work is in progress to perform systematic study to evaluate the nutritional status of human milk in Bangladesh.

Introduction

Human milk is the main source of nutrients to babies during the early years of life. Milk formulas, which are the nearest equivalents to human milk, have been established and commercialized. Fruits, vegetables, etc. are also main sources of nutrients. Due to the relatively high cost of human milk substitutes, most nursing mothers of Bangladesh use natural human milk. Even though human milk is the best baby food, an enormously huge number of babies die annually as a result of malnutrition and nutritional deficiencies. Recently some serious environmental problems are encountered in Bangladesh related to the

presence of some toxic elements like arsenic in ground water and lead in air [1]. Physicians have found lead in bloods of some babies in Dhaka Shishu Hospital. Zinc deficiency in arable soil has become a serious problem [2]. Under these circumstances, the high mortality rate of children in Bangladesh has constantly motivated the search for the cause and to find out ways and means to reduce the child mortality rate.

Many trace elements play a very significant role in human life. All trace elements are toxic if ingested or inhaled at sufficiently high levels and for long enough periods [3]. Therefore, determination of the elemental concentration of human milk constituents, natural food items, water, commercially available formula milk, fruits, vegetables, etc. will reveal which kinds of nutrients are passed from mother as well as from other foodstuff to babies.

The objective of the present study is to employ the complementary techniques of PIGE and PIXE, developed at the 3 MV Van de Graaff Accelerator Laboratory of the Atomic Energy Centre, Dhaka (AECD) [4], to determine both the essential and the toxic elements, such as lead, arsenic, fluorine, iron, calcium, zinc, cadmium, selenium, etc., content in human milk with a view to identifying the essential and toxic elements in them.

Experimental

Human milk samples were collected from some of the maternity centers of Dhaka city. Each milk sample was put in specially cleaned polythene bottles. They were immediately frozen and then freeze dried. Pellets were made using a 15 ton Perkin Elmer pellet maker. The pellet samples were irradiated with 2.5 MeV collimated proton beam at a current of about 10 nA from the 3MV Van de Graaff Accelerator of the Atomic Energy Centre, Dhaka, Bangladesh and the emitted X-rays were detected using a Si(Li) detector for external beam PIXE measurements and the total charge collected for each sample was 10 μC. For PIGE measurements (external beam) the pelletized thick samples were bombarded with 3.0 MeV protons at a current of 20 nA and the emitted γ-rays were detected using a HPGe detector. Total collected charge for PIGE measurements was 20 μC. Some samples were analyzed using micro beam PIXE-PIGE set up developed at the 3 MV Single Ended Accelerator at Japan Atomic Energy Research Institute, Takasaki, Japan [5]. The micro beam analysis was

performed with proton energy of 3 MeV at a current of 10 pA. The beam diameter was 1 μm. Total collected charge was 100 nC. The area of the sampled scanned was 957 μm X 957 μm.

Results and discussion

PIXE spectrum collected from human sample is shown in FIG.1. 30 human milk samples were analyzed so far. The concentrations of different elements present in human milk as found in this study are shown in Table I. Average concentration of iron found is 40.02±22.26

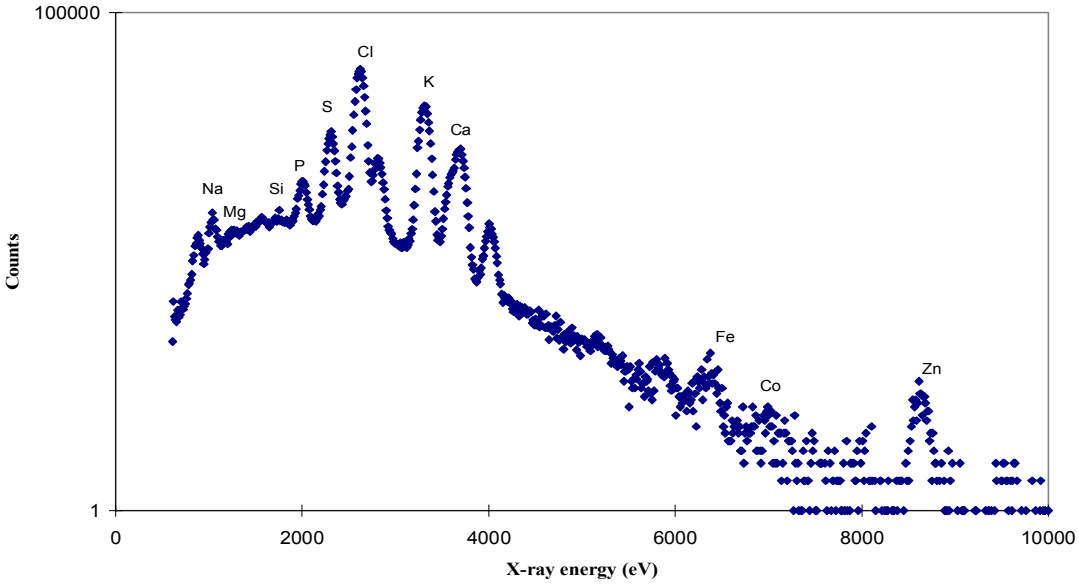

FIG. 1. PIXE Spectra collected from human milk sample.

TABLE-I: ELEMENTAL CONCENTRATION IN HUMAN MILK

Elements	Range (ppm)			Average (ppm)	Standard deviation
S	9.5	-	52.8	31.49	13.39
Cl	266.3	-	508.1	395.68	97.14
K	727.5	-	1518.8	1073.09	256.85
Ca	560.1	-	1172.0	788.19	174.14
Sc	16.0	-	32.3	23.37	5.00
Fe	13.2	-	78.8	40.02	22.26
Cu	2.0	-	7.3	5.23	1.74
Zn	12.7	-	79.1	39.78	19.93
Br	4.5	-	19.8	9.44	4.67
Rb	12.1	-	26.0	19.70	5.22

ppm within the range 13.2 – 78.8 ppm, where as the average calcium content is 788.19±174.14 ppm and in the range of 560.1 to 1172.0 ppm. Average concentration of zinc is found as 39.78±19.93 ppm with in the range of 12.7 -79.1 ppm. The concentration of different elements varies widely from sample to sample.

Examples of the micro beam PIXE-PIGE elemental mapping of Ca, Mg, Fe, Na, Zn, K, S and P were shown in FIG. 2. In general particle size found varies from 10µm X16µm up to 194µmX126µm. Micro beam analysis also shows wide variation in concentration of the elements.

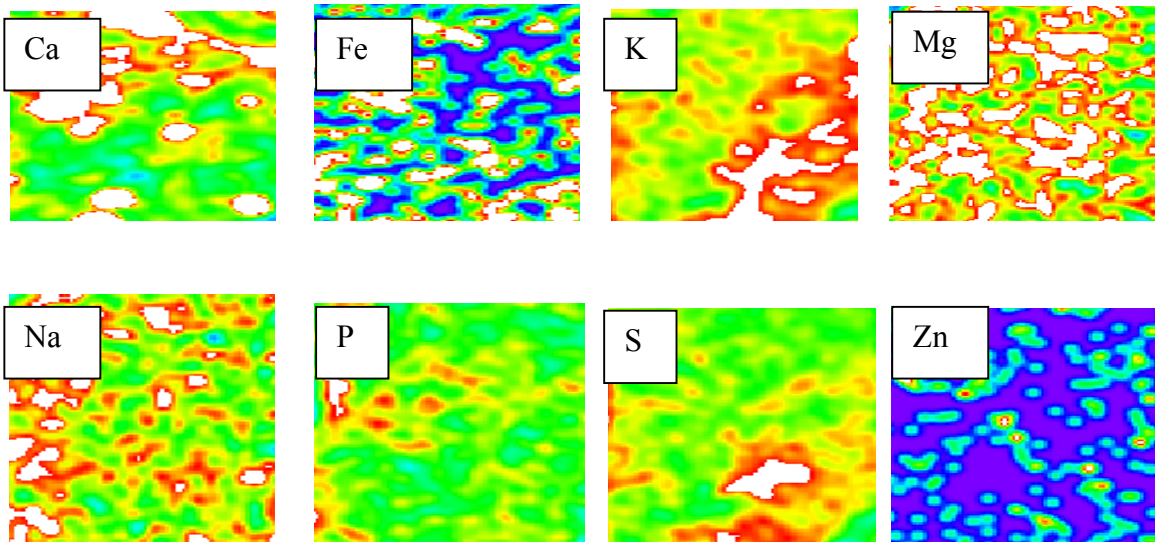

FIG. 2. Examples of proton micro beam images of the elements present in human milk samples.

So far, we have detected the important elements which include Ca, Fe and Zn. We did not detect any toxic element in the samples so far studied. The wide variation of concentration of different elements Fe, Ca, Zn, etc present in the human milk samples indicates the variation of the nutritional status of te mothers in Bangladesh. Systematic study is in progress in this regard.

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