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Investigation of Trace Element Concentration in the Water of the Ganges River By PIXE

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Abstract: ***Some heavy metals such as Magnesium, Calcium, Zinc and Iron, Copper which are very important in daily life functioning, but could become toxic beyond their required concentrations. It is quite difficult to measure the concentration of these metals lower than ppm level in aqueous environment. To investigate lower than ppm level(nanogram) Proton Induced X-ray Emission (PIXE) technique provide adequate, accurate and very fast for simultaneous investigation of trace element. PIXE is well known and useful technique, which is based on emission of characteristics X-ray for find out qualitative and quantitative analysis of various samples. The technique is useful for studying the samples containing wide range of concentration.The aim of present study is to find out the concentration levels of trace elements into the Ganga water near the bank and mid water of the Ganga River. Our studies observed that trace element Sc, Ti, Cr, Mn, Fe, Co, Ni, Cu V, and Zn present in the Ganga River.***
Keywords: Trace Element, Toxic Element, PXE, Characteristics X-ray, Pre-concentration

I. INTRODUCTION

India is a country of river and population near the Ganga River is densely populated approximately 37 per cent of India's population. It is also a life-support system for the people of India. The Ganga has been India's river of faith, devotion and worship and also India's National River. The Ganga River, is a lifeline for millions, is used for drinking, power generation, irrigation, fish production, and religious pilgrimages etc.

Studies has been reported that no concentration of metal elements or any metal is being safe, because long term exposure to low concentration is equally harmful like high concentration [1].The actual knowledge of concentration is important because element is the main source of mineral for both human and animal .In order to make the proper planning to tackle the alarming situation of pollution, for this purposes systematic study is needed at each city level. Our aim was to study the in what amount trace element concentration in the Ganga water. For this purpose PIXE technique has been chosen. Proton Induced X-ray Emission (PIXE) is a characteristics X-ray emission technique, which is the non-destructive, simultaneous multi-elemental analysis, very fast and can be used for solid, liquid or aerosol filter samples. PIXE is well known and useful technique, which is based on emission of characteristics X-ray for find out qualitative and quantitative analysis of various samples. The X-ray spectrum is generated by energetic protons exciting and ionizing the inner shell electrons in the present sample's atoms. The expulsion of these inner shell electrons results in the production of characteristics X-rays. The number of X-rays emitted is proportional to the mass of that corresponding element in the sample being analyzed. The generation of X-rays in a sample is very strongly influenced by the bombarding proton. The probability of X-ray production depends upon both the total number of incident protons (beam current) and the proton energy (MeV).These factors must be accurately known for quantitative analysis. Concentration (C_Z) of an element is given as [7] and determined by

$$C_z = \frac{Y_m}{[Y_t\{HQ\varepsilon T\}]}$$

Where Y_m and Y_t are measured and theoretical x-ray yield respectively q is the real charge collected by faraday cup, ε is the intrinsic efficiency of the detector and T is the transmission of x-ray through any medium present between source and detector.

II. SAMPLE COLLECTION

The water samples were collected from bank of River and middle of the river. The Ganga river water sample collected from the different bank (Ghat) of Allahabad (India) and Varanasi city, water sample under study chosen such a way that Ganga entering before Allahabad city and Ganga meeting before Yamuna and after the meeting of Ganga ,which is called Holy Triveni Sangam,in Varanasi different banks were chosen. Samples were collected in propylene bottle, which were cleaned by1N nitric acid and

distilled water. Our study was undertaken along a 160 km stretch of the Ganges River from the Kaushambi district (U.P.India) to Varanasi district. Samples were collected from the Rivers Ganga and Yamuna in Allahabad and and Varanasi at the following sites: Fatepur Ghat, Prayag Ghat, Qila Ghta,Triveni Sangam,Gadhwa Ghat ,Assi Ghat ,Janki Ghat and Rajghat.

III. TARGET PREPARATION BY NADDTC FOR PROTON IRRADIATION

A methodology is given in details [6] for simultaneous detection of several trace elements in aqueous sample .Targets are chemically prepared by preconcentration of the metals. The preconcentration is an operation (process) in which micro components are transferred from the sample of larger mass into the sample of smaller mass, so that the concentration of the micro components is increased. Samples were prepared by adding10 ml of saturated NaDDTC(Sodium Diethyldithio Carbamate ,$C_5H_{10}NaS_2H_2O$) solution in 200ml of water to precipitate the trace metal content present in sample as their respective stable complexes [Van Grieken1982], then steering the solution about 20 minute by magnetic steering to form precipitation of trace metal after that precipitates were filter out by vacuum filtration unit on Nucleopore filter paper of diameter 25 mm and pore size 0.4µm.NaDDTC agent used in fresh water by adding a amount of different element and the recovery efficiency was measured at Cyclotron Facility PU by [ShivcharanVermaet.et.al] and found that
V(2.03%),Co(68.58%),Ni(55.09%),Zn(44.87%),As(0.74%),Cd(42.46%) and the rest recovery efficiency taken from [Cecchi et.al 1990b] for the element S,Cl,K,Ca,Sc,Fe,Cu,Se(80%) Ti,Cr(50%).

(a) (b) (c)

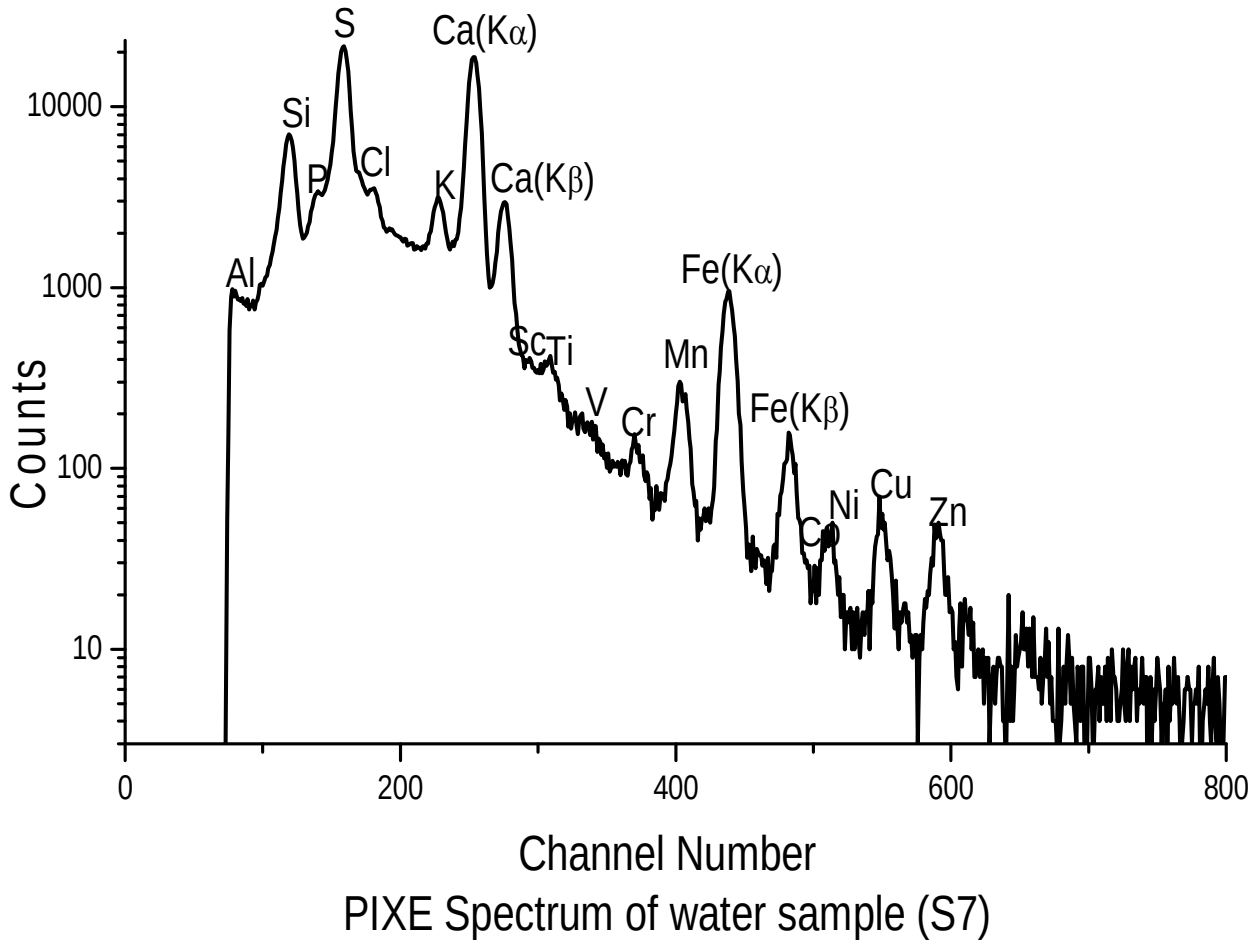
Figure (a) shows filtration unit,(b) target before irradiation and (c) target after irradiation

IV. EXPERIMENTAL DETAILS

PIXE method was used for the determination of the concentrations of the trace heavy metals. Targets were bombarded by a proton beam generated by a 2.7 MeV Cyclotron facility available at the Department of Physics, Panjab University, Chandigarh (India). A collimated proton beam of energy 2.7 MeV having 3-7 nA beam current was used for these measurements. The X-ray yield was measured with and without aluminium absorber, using a planar HPGe detector with Be window of thickness of 25µm having energy resolution of 160 eV at 5.9 KeV. Beam current monitored by collection of charges on a Faraday cup.The efficiency and energy calibration were carried out using standard radioactive sources. The X-ray data was collected using MCA and saved in the hard-disk for off-line analysis. The obtained PIXE spectra were analysed and converted into elemental concentrations of the samples by using the software package GUPIXWIN [7]. The elemental analysis depends on the inner-shell ionization process, measurement of the X-ray yield of the samples and target preparation technique.

V. RESULTS

The results obtained from the trace and toxic metal analysis in the water samples of the Ganga Rivers are expressed in µg/L (Microgram per Liter) i.e ppb throughout the analysis. During the entire sites of study, maximum concentration of all nine metals in the Ganga Rivers observed are as: Scandium (1.36 µg/L), Vanadium (0.44 µg/L), Chromium (0.63µg/L), Copper (1.54 µg/L), Cobalt (0.67 µg/L), Magnese (3.96 µg/L), Nickel (1.44 µg/L), Zinc(1.28 µg/L) and Iron (43.90 µg/L).PIXE spectrum of a water sample and table of concentration shown.



PIXE Spectrum of water sample (S7)

Table: Concentration of water samples in ppb (µg/L)

Element	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
P	76.09	76.93	200.64	85.05	216.13	60.59	63.30	244.74	9.41	149.44	16.67
S	83.57	179.57	308.24	177.08	524.60	636.49	350.49	1219	107.94	274.31	1834
Cl	9.10	17.55	42.07	17.21	48.95	44.54	14.69	18.28	6.23	15.04	27.28
K	15.40	11.13	25.85	28.10	12.76	13.75	8.33	5.75	5.30	7.01	7.35
Ca	17.44	66.50	75.61	63.18	29.16	81.42	87.90	24.20	21.76	17.04	42.59
Sc	0.31	0.44	1.36	0.70	0.73	0.23	0.49	0.44	0.11	0.40	BDL
Ti	1.02	1.32	4.09	4.52	1.55	0.29	0.80	1.67	0.69	0.33	1.87
V	0.07	0.02	0.44	0.24	0.10	BDL	0.08	0.17	0.05	BDL	BDL
Cr	0.54	0.35	0.50	0.57	0.63	0.30	0.52	0.51	0.40	0.21	0.34
Mn	0.52	0.78	3.96	2.00	0.90	1.27	2.21	0.33	1.32	0.36	9.03
Fe	12.53	12.04	43.90	32.43	12.89	8.42	10.46	6.51	7.76	5.54	13.76
Co	0.09	0.48	0.67	0.60	0.24	0.29	0.41	0.12	0.12	0.16	0.32
Ni	0.55	0.74	0.84	0.72	0.58	0.82	0.66	0.78	0.51	1.44	0.95
Cu	1.05	1.54	1.07	1.38	0.73	1.21	0.91	1.23	0.91	1.30	1.58
Zn	0.40	0.78	0.53	1.23	0.56	1.10	1.28	1.16	0.52	0.96	1.43

BDL is below detection limit

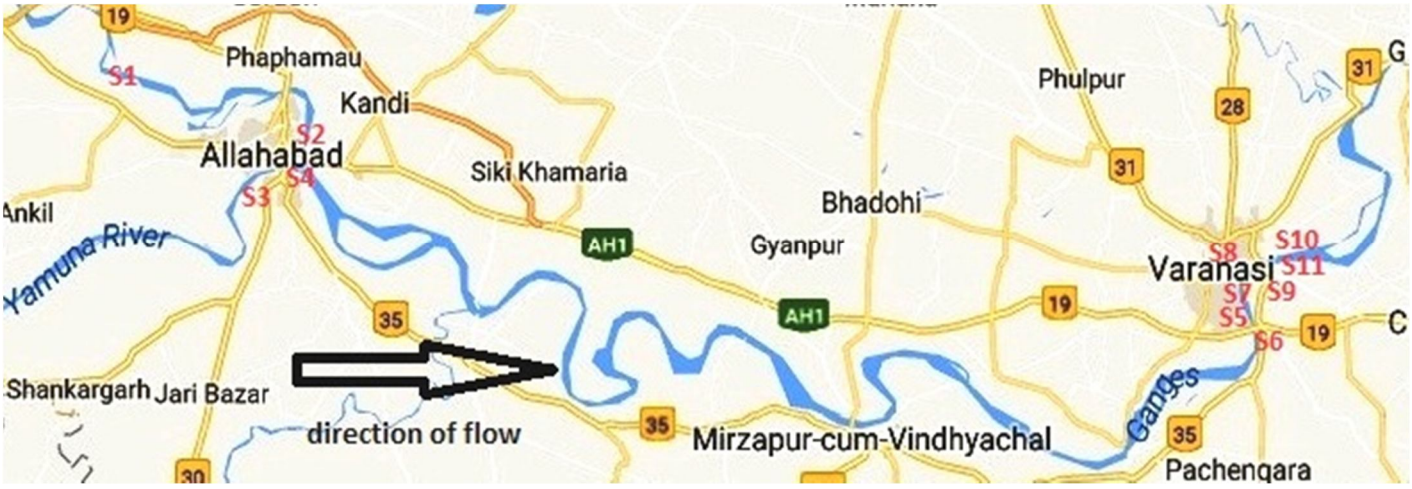


Photo courtesy: Google map (https://www.google.co.in/maps/)

Sampling sites: S1: Fathepur Ghat (Alld); S2: Prayag (Alld.); S3: Qila Ghat(Alld); S4: Triveni Sangm(Alld) ; S5: Gadhwa Ghat (Vns) ; S6: Gadhwa Ghat M* (Vns); S7: Assi Ghat(Vns); S8: Janki Ghat(Vns); S9: Janki Ghat M*(Vns); S10: RajGhat(Vns); S11: RajGhat M*(Vns).
Alld; Allahabad; Vns; Varanasi, M*: mid area in the River;

VI. DISCUSSIONS

Water Sample preparation technique plays an important role in the whole analytical procedure. The accuracy and reproducibility of the measurements depends on the chosen sample preparation technique. The concentrations of various elements of interest in the samples are given in above table. The overall errors in the measured concentration vales for various elements have been estimated to be in the range of 5-10%.our results are compared with Status of Trace and Toxic Metals in Indian Rivers [Government of India, May2014] and it was found that concentration of Cr,Cu,Ni,Fe, and Zn lie within range of minimum and maximum after monsoon season[9] .

VII. CONCLUSION

Compared to the established Indian drinking water standard [IS 10500: 2012] concentration of all trace elements are below. But continuous exposure of these elements can be harmful as given in [1]. River bank showed higher trace element concentrations than mid area of the Ganga River.

VIII. ACKNOWLEDGEMENT

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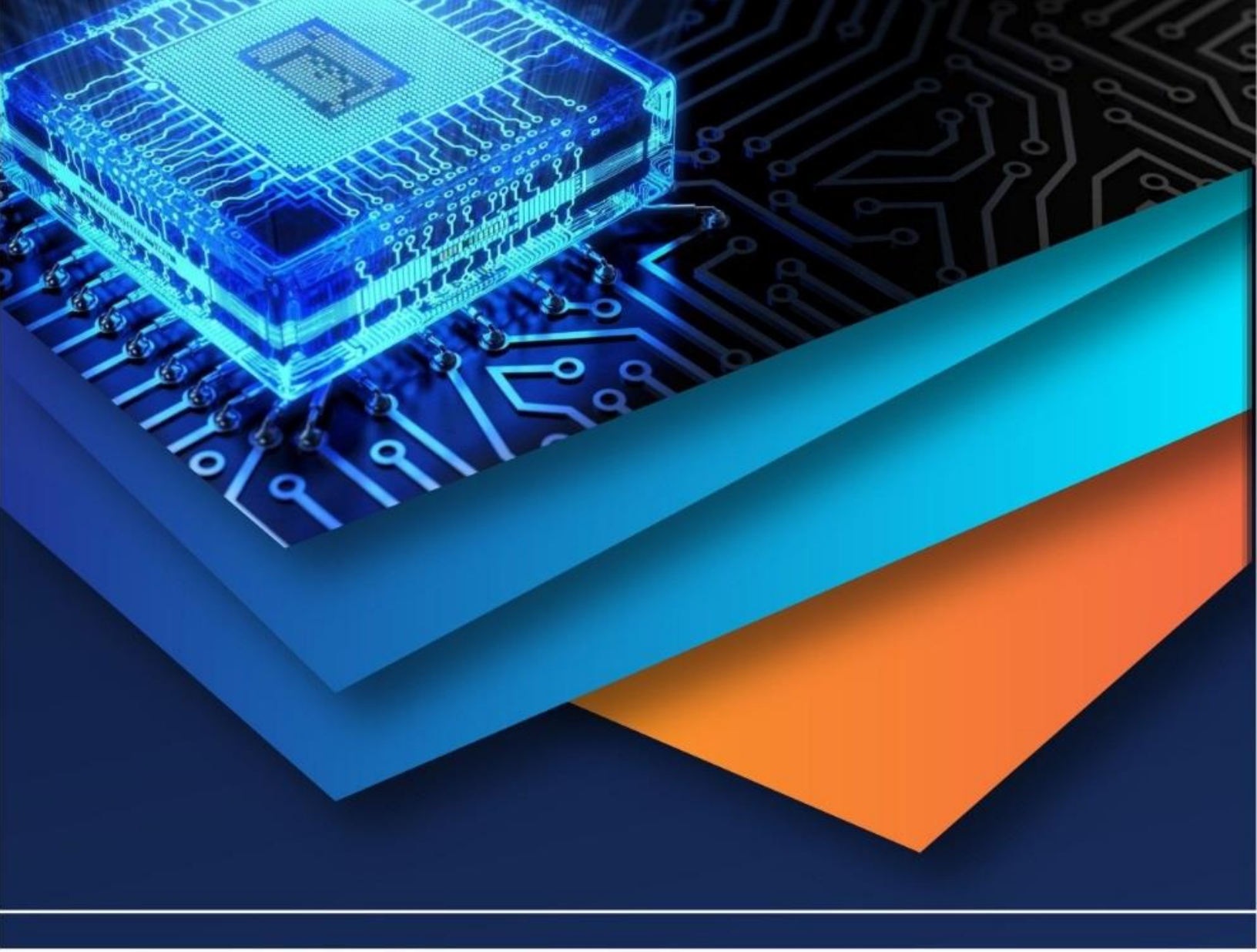

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