Trace Elemental Analysis of Soil Samples of Kidney Effected Area Using EDXRF Technique

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Abstract: Soil samples are collected from different villages affected with chronic kidney disease (CKD) in Uddanam area of Srikakulam district, Andhra Pradesh, India. These samples are analyzed using Energy Dispersive X-ray Fluorescence (EDXRF). The trace elements Si, K, Ca, V, Cr, Mn, Fe, Ni, Cu, Zn, As are identified and compared with NIST soil-2587 standard. The impact of each element on human physiology and CKD is analysed.

Key words: Soil, CKD, EDXRF, Trace Elements

INTRODUCTION:

Kidneys are the two bean shaped organs that are located in the back, just under the ribs and on either side of the spine. Kidney plays an important role in the purification of blood and removal of waste from the body. Chronic kidney disease (CKD) occurs when one suffers from gradual and usually permanent loss of kidney function over time which may take from months to years.

Over a decade, a new form of kidney disease of unknown etiology has emerged in the Uddanam area in Srikakulam district, Andhra Pradesh, India. Almost 50% of people are suffering from the kidney disease.

High prevalence of CKD has become an environmental health issue of national concern in India. Hypertension and diabetes are known to be the main reasons for renal failure but in areas with high prevalence of CKD, the majority of patients do not show any identifiable cause.

Uddanam is a lush green region in Srikakulam district of the state of Andhra Pradesh, India (Fig:1), located on the east coast of India with rich coconut and cashew plantations. Geographically Uddanam is located at 19.01670N, 84.68330E. It has an average elevation of 41 meters (137 feet) above the sea level.

In the present work, soil samples are collected from seventeen villages of Uddanam area, made into pellets and are exposed to x-ray beam. Using EDXRF facility available at UGC– DAE CSR Kolkata, trace elemental concentrations are evaluated using standard reference material (SRM).

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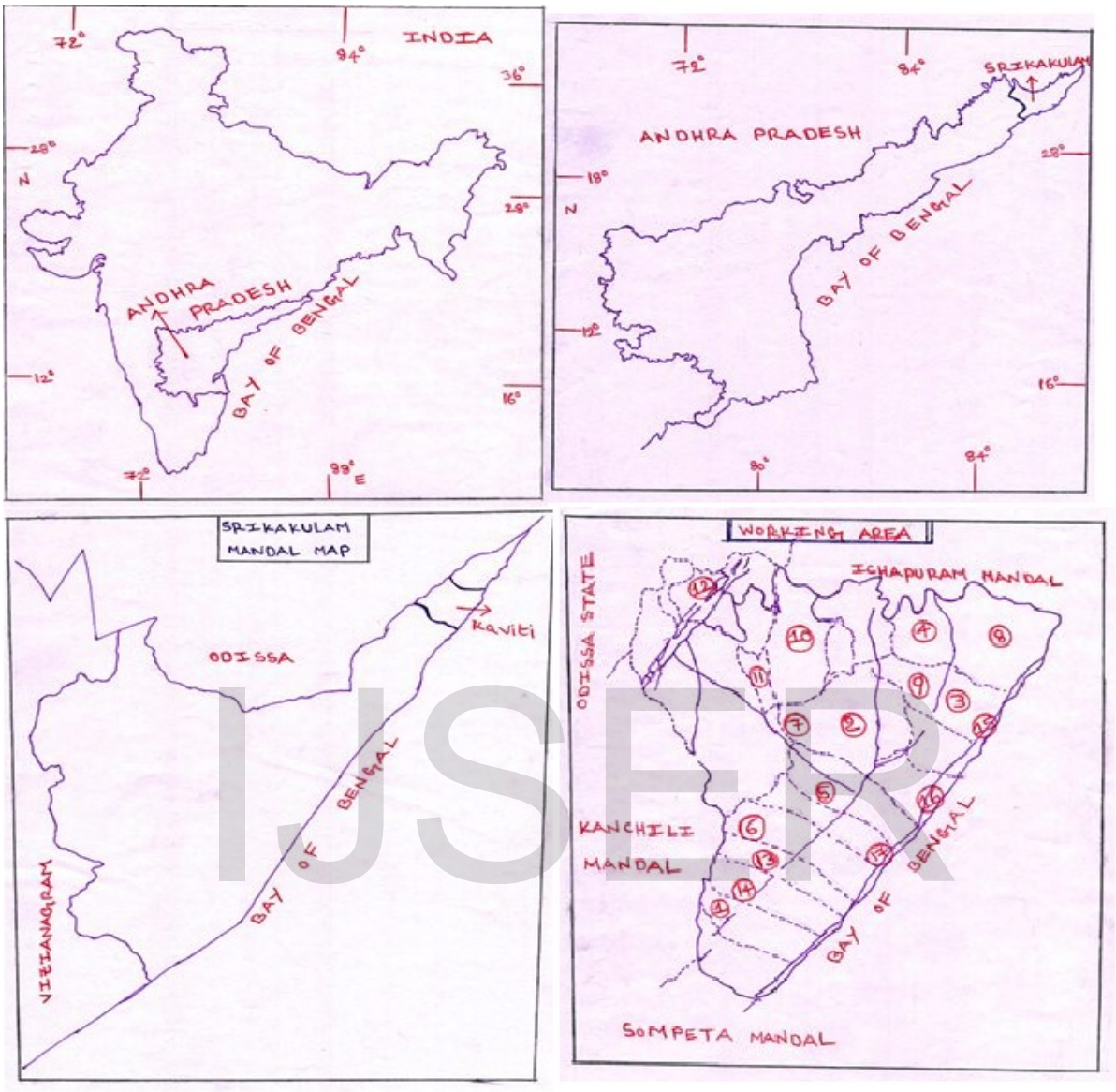

FIG:1 Geographical location of the sampling villages

2. MATERIALS AND METHODS

2.1 STUDY AREA:

Uddanam region consists of four areas, population of each area and number of kidney patients are given in Table 1. Soil samples were collected from 17 villages of Kaviti area for analyses: 1. Balli Puttuga 2. Kaviti 3. Kapasa Kuddi 4.D.Gonapa Puttuga 5. Bejji Puttuga 6. Lolla Puttuga 7. Tottidi Puttuga 8. Synasi Puttuga 9. Byreddala Puttuga 10. Rajapuram 11. Kamalai Puttuga 12. Khojjiria 13. Varakha 14. Kusuma puram 15.CH.Kapaskuddi 16. Kothapalem 17. Peddakarrivanipalem.Higher prevalence of CKD is reported in Kaviti area.

s.no	Area	Total population	No. of kidney patients	Percentage of effected patients
1	Ichchapuram	82,236	1100	1.33
2	Sompeta	79,440	1200	1.51
3	Kanchili	64,125	3200	4.99
4	Kaviti	76,019	4500	5.91

Table: 1 CKD prevalence areas

2.2 SAMPLE PREPARATION:

In each village, soil samples were collected from three points at a depth of 30 cm and in a matrix of 1m×1m and then mixed homogeneously [1,2] and stored in polythene bags. All the samples were collected on the same day. The soils were dried at 600C for one hour and homogenized in an agate mortar. The well homogenized powder samples were made into pellets of 13 mm diameter [3-4] at EDXRF laboratory Using KBr pelletiser. 0.2 g of powdered samples were made into pellets.

2.3 EXPERIMENTAL PROCEDURE:

Soil pellet samples are analyzed by EDXRF at UGC – DAE CSR Kolkata center. X-Ray Fluorescence (XRF) spectrometry has been a technique for elemental analysis for almost 100 years based on Moseley's well known law which relates "characteristic" fluorescence radiation to the atomic number of the emitting atom [5]. Today, composition analysis by measuring fluorescence spectra has become a routine technique used in a vast number of research areas ranging from material science to biomedical science. X-Ray fluorescence analysis is non-destructive and has high precision. It is a multi-elemental method to analyze most elements of the periodic table and more effective for elements with Z ≥11 (i.e Sodium (Na) to Uranium(U)). Moreover, as the fluorescence intensity is proportional to the concentration of an element present in the sample, not only qualitative but also quantitative analysis is possible.

3.RESULTS AND DISCUSSION:

The spectra are collected for sufficiently long time to ensure good counting statistics. During the irradiation of each sample, the total charge collected was noted. The x-ray spectra are recorded with Si(Li) detector. The concentrations of different elements in the soil samples are estimated using nEXT software.

Village	Si	K	Ca	V	Cr	Mn	Fe	Ni	Cu	Zn	As
Balli Puttuga	409730.9±11037.51	6803.12±229.7	227.75±38.52	209.42±30.97	117.16±24.65	1250.03±59.28	30590.51±1285.67	26.49±6.50	39.77±4.16	76.08±6.84	6.98±0.01
Kaviti	407060±4442.96	5096.28±486.21	351.46±128.21	429.22±23.72	91.58±12.02	826.95±83.12	32818.68±780.48	1.99±1.55	29.83±2.38	66.78±6.68	6.95±0.005
Kapasa Kuddi	354050.5±86814.42	5568.05±503.02	92.38±2.5	354.51±40.39	92.36±10.93	519.65±45.88	33860.61±2692.84	7.00	26.94±4.15	58.49±4.95	6.95±0.005
D.Gona Puttuga	398693.6±14820.22	7522.84±777.99	1943.35±447	406.65±3.11	86.1±6.72	650.89±28.63	39305.37±1668.32	17.49	33.69±2.60	110.51±12.71	6.97±0.01
Bejji Puttuga	387976.9±21990.72	3760.81±55.83	113.84±10.86	409.01±93.95	124.95±53.84	685.29±22.27	31569.98±2115.22	15.61±6.27	28.37±2.27	55.30±7.82	6.95±0.01
Lolla Puttuga	401849.3±12486.14	5567.70±530.21	155.25±16.94	409.50±104.56	119.11±8.81	983.48±24.84	36568.75±868.79	21.56±7.25	28.83±3.48	58.55±6.11	6.96±0.02
Tottidi Puttuga	412025.8±26844.07	1757.55±170.63	53.53±2.97	370.27±36.25	111.96±20.51	803.98±56.70	28320.7±1569.05	13.59	30.23±3.73	54.68±1.60	6.94±0.005
Synasi puttuga	370740.9±12839.9	6567.67±391.46	1965.82±180.46	502.87±26.69	125.34±12.42	793.92±48.54	36576.88±1434.52	34.67±6.83	43.05±1.94	79.75±5.45	6.97±0.005
Byreddla puttuga	357367±14207.5	8846.28±205.4	4945.16±369.98	644.54±63.30	144.05±32.64	864.36±51.56	45326.85±1526.16	4.9	33.48±4.22	97.98±19.33	6.95±0.005
Rajapuram	419386.8±5976.98	2279.07±134.73	1.56±0.09	321.75±33.52	82.57±34.76	333.42±6.42	22993.24±623.48	4.51±3.05	32.63±1.89	51.28±9.82	6.96±0.005
Kamalai puttuga	360456.6±20272.51	10830.95±1025.0	1448.28±220.20	205.15±35.22	163.01±54.92	421.01±15.17	37680.8±1814.08	29.93±2.35	37.27±3.77	54.77±12.07	6.99
Khojjiria	348253.2±10124.35	12575.51±1026	2809.33±147.36	128.32±12.78	76.04±12.31	484.12±36.48	29638.65±272.13	18.51±4.85	31.82±1.04	56.07±2.86	7±0.01
Varaka	352414.2±17043.46	5486.95±286.18	78.91±49.48	250.71±23.74	114.68±24.46	1115.59	30417.56±732.13	31.6±5.86	34.34±0.47	50.53±10.33	6.96±0.005
Kusam puram	333981.6±5062.63	7090.80±413.92	461.69±44.74	280.59±8.15	121.88±16.74	1014.76±22.31	41254.06±849.27	30.34±6.06	54.84±4.41	123.95±7.09	6.98±0.02
Ch.kapa sakuddi	373186.3±11711.42	9829.27±610.10	1872.33±224.82	301.52±16.47	96.63±10.45	1261.18±59.44	42761.17±1108.53	36.17±4.38	41.64±4.59	98.49±8.34	6.97±0.01
Kothapalem	384405.4±12889.53	13555.76±351.41	2261.89±495.47	397.02±64.55	76.13±37.20	858.17±9.70	47340.6±1270.14	0	22.12±2.46	73.65±1.09	6.97±0.01
Peddkarrivanipalem	380702.9±72767.16	14854.87±471.88	4402.66±34.14	459.23±29.98	90.99±22.31	936.16±17.11	51404.64±855.45	0	27.17±0.33	74.79±5.20	6.98±0.01

Table 2: *The average concentrations of trace elements in soil samples in ppm (± standard deviation)*

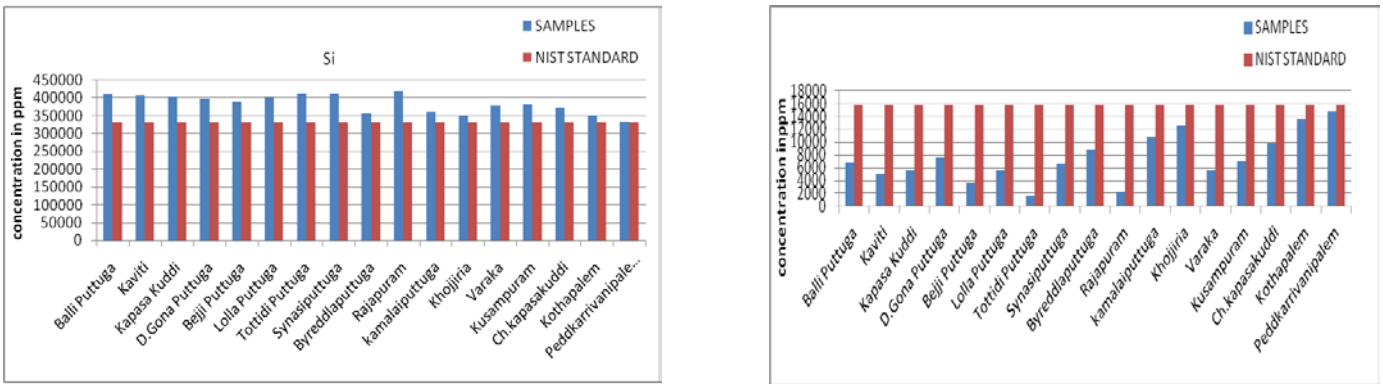

Figure 3: *concentrations of Si and K in soil samples (ppm)*

In the EDXRF experiment, the trace elements Si, K, Ca, V, Cr, Mn, Fe, Ni, Cu, Zn, As are identified. The element potassium (K) has significant importance, along with sodium, as far as human body is concerned; it regulates the water balance and acid-base balance in the blood. Potassium is found within all cells of the body and its levels are controlled by the kidneys. Potassium is formed to be low in all villages, very low in Tottidi Puttuga and Synasi Puttuga villages.

In soil samples, calcium is found to be very low in all villages compared to standard value. Calcium is the most abundant mineral in the human body and is critical to good health. It is not only a component of bones and teeth, but is also essential for blood clotting and necessary for muscle and nerve functions. If the level of calcium in the body becomes too low (Hypocalcaemia). Hypocalcaemia may also result from the consumption of toxic levels of phosphate. Symptoms of severe hypocalcaemia include numbness (or) tingling around the mouth (or) in the feet and hands as well as in muscle spasms in the face, feet and hands. Hypocalcaemia can also result in depression, memory loss (or) hallucinations. Severe hypocalcaemia occurs when free calcium in the blood stream is less than 3 milligrams per deciliter of blood. If hypocalcemia is caused by low serum magnesium levels, the magnesium deficiency must be corrected to effectively treat the hypocalcemia.

Oxidative stress and inflammation play a major role in the progression of renal damage in chronic kidney disease (CKD). Manganese (Mn) is a potent anti-oxidant and cofactors of the enzyme Mn-SOD (superoxide dismutase), which is the main antioxidant enzyme in the mitochondria responsible for protecting the cell from reactive oxygen species (ROS) by scavenging mitochondrial superoxides. Only D.Gonapa puttuga village soil sample, manganese level the standard value.

Iron in soil samples from Lollaputtuga and Synasi puttuga villages level the standard value. In all villages, iron is observed above the standard, except in Rajapuram village. In CKD, the anemia that develops is frequently complex. The primary cause is in adequate in production of erythroproietin by the diseased kidney [6]. Decreasing protein intake reduces iron intake and depletes iron stores. Absorption of iron from the gastro intestinal tract may also decrease [7]. Thus multiple factors can contribute to adequate in total body iron stores in patients with CKD, the condition is known as "absolute iron deficiency" [8].

Plasma copper was higher in the diabetes mellitus group when compared to the non-diabetic control groups. Serum urea was a positive independent determinant of plasma Zn concentration. These findings demonstrate an alteration in the distribution of Zn in patients with CKD independently of the presence of diabetic. Also the status of copper (cu) seems not to be influenced by CKD, but only by the metabolic derangements associated with diabetes [9].In all soil samples, copper is found to be below the standard value.

Zn is low in all soil samples. Zinc is essential for human nutrition as it acts as a structural and functional component of several metallic proteins and participates in cellular metabolism reactions. Zinc is also an antioxidant

that reduces free radicals [10]. Lower serum concentration of zinc have been attributed to reduced food intake and intestinal absorption, uremic toxicity, interaction with calcium and iron, vitamin D deficiency and increased mineral loss during dialysis [11].

Vanadium, a trace element present in the body has several health benefits including improvement of insulin action and protection against diabetes. Vanadium compounds have been tested as potential therapeutic agents in type-I [12-14] and type-II [15-18] diabetes. Vanadium is found to be more in all soil samples compared to NIST standard.

Arsenic level is found to be below the standard in all villages. The arsenic levels in the serum and blood cells correlate with worsening kidney disease, with the development and progression of CKD, which are attributed to arsenic-induced oxidative stress [19].

Silicon is a trace element, comprising less than 0.01% in the human body. In humans, chronic exposure to silica has been associated with mild renal functional abnormalities and major histology changes in the kidneys. Bolton.et al, reported four patients with a history of intense silica exposure and rapidly progressive renal failure and concluded that silicon seems to be responsible for the nephro toxic change. Silicon is found to be high in all villages expect in peddakarivanipalem village.

The accumulation of nickel in the body through exposure can lead to lung fibrosis, cardio-vascular and kidney diseases and the most serious concerns relate to nickels carcinogenic activity [20-21]. The level of nickel is same as the standard in Ch.Kapasakuddi village. Nickel is not detected in kothapalem, peddakarivanipalem.

4.CONCLUSION

Soil samples collected from Uddanam area were analysed for their elemental concentration using EDXRF technique. The accuracy of the results obtained was evaluated using NIST standards. In total, concentrations in Eleven elements have been determined. Fe and V are above the standard reference and Ca, Ni, As, Cu, Zn are below the standard. The elements Si, K, Mn vary in between upper and lower limit with respect to standard. Silicon is very much high in Varakha village. In Byreddalaputtuga Vanadium is found to be very high. Potassium is very low in Synasi puttuga and Tottidi puttuga villages. Nickel is very low in Kaviti and Byreddala puttuga villages .In Kothapalem and Peddakarrivanipalem villages, Ni is not detected. Calcium is not detected in Kapasakuddi, Tottidi Puttuga, Synasi Puttuga, Rajapuram and Varakha villages.

These alterations in soil minerals may be a cause of high CKD prevalence in these area, hence further evaluation is required to substantiate our inference

ACKNOWLEDGEMENT

The authors are thankful to Dr.A.K.Sinha, Director, UGC – DAE CSR Kolkata centre, for granting the necessary permissions and for providing EDXRF facility to carry out this work. Authors also thank Mr.Pandi Srinivas, member of Sewa organistation, for his help during sample collection.

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