Trace Elemental Analysis of Rice Samples from Kidney Effected Area Using EDXRF Technique

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Abstract: *Rice 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 P, S, Cl ,K, Ca, Mn, Fe, Cu, Zn, Se are identified and compared with NIST-1515(apple leaf). The impact of each element on human physiology and CKD is analysed.*

Keywords: Rice, CKD, EDXRF, Trace elements

1. Introduction

Kidneys are the two bean shaped organs 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 due to gradual and usually permanent loss of kidney function over time, which may take 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 kidney diseases. High prevalence of chronic kidney disease (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 of these identifiable causes.

Uddanam is a lush green region in the 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 19.0167^0 N, 84.6833^0E. It has an average elevation of 41 meters (137 feet) above the sea level.

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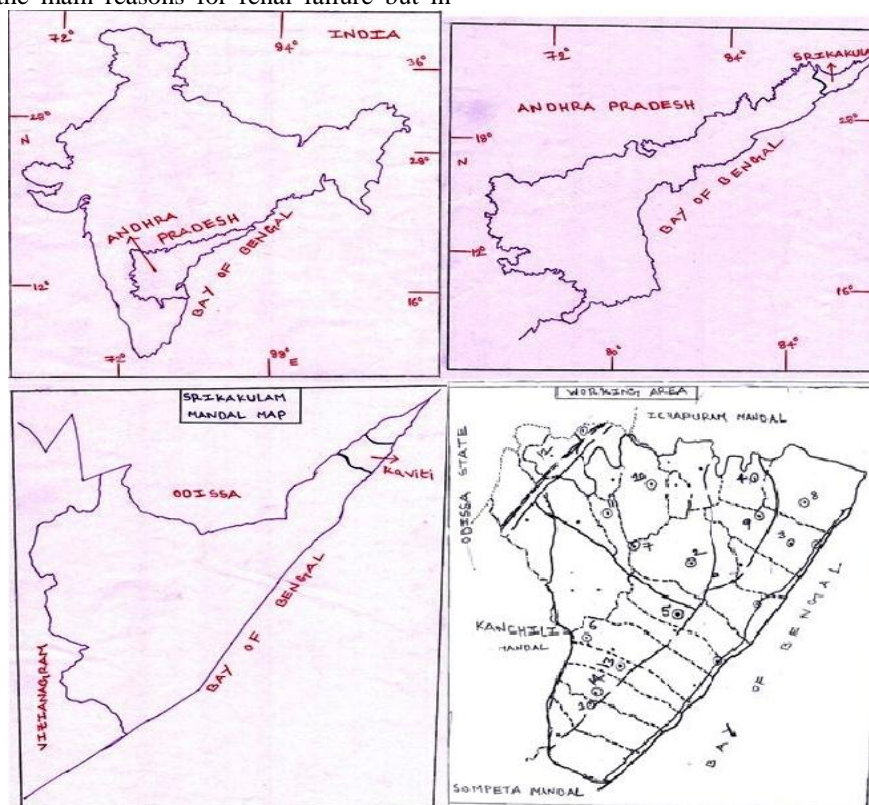

Figure 1: Geographical location of the sampling villages

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. Rice samples were collected from 14 villages of Kaviti area 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 .Higher prevalence of CKD is reported in Kaviti area.

2.2 Sample Preparation

The samples were collected from yield crop directly from the farmer field. The samples were collected on the same day. The samples were washed 2D-water removes the wastage and dried at 60^0C for one hour. The samples Were homogenized in an agate mortar. The well homogenized powder samples were made into pellets of 13 mm diameter at EDXRF laboratory using KBR pelletiser.0.2g of powdered samples were made into pellets

Table 1: CKD prevalence areas

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

2.3 Experimental Procedure

Rice pellet samples are analyzed by Energy dispersive X-Ray Fluorescence (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 [1]. Now a days composition analysis by measuring fluorescence spectra has become a routine technique utilized 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 $Z \geq 11$ (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 also 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 rice samples are estimated using nEXT software.

In the EDXRF experiment, the trace elements P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, Se are identified. The element potassium (K) is of importance in the human body along with sodium. 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 found to be low in all rice samples.

Table2: The average concentrations of P, S, Cl, K, Ca With Standard deviation ($\pm$)

S.No	Village	P	S	Cl	K	Ca
1	Balli Puttuga	4603.53±329.60	787.79±54.20	603.49±42.4	3596.82±118.48	441.01±26.58
2	Kaviti	3707.12±181.48	815.88±19.47	663.6±21.1	3521.14±95.89	439.67±42.57
3	Kapasa Kuddi	2156.01±20.48	976.02±19.31	579	2455.67±29.43	298.77±14.77
4	D.Gonapa Puttuga	1323.95±77.53	854.76±71.21	579	2279.7±77.50	212.52±19.91
5	Bejji Puttuga	3769.46±149.10	790.93±29.15	579	3290.23±70.23	393.05±23.07
6	Lolla Puttuga	3691.18±149.10	877.09±52.16	676.86±26.94	3588.14±131.41	440.21±57.81
7	Tottidi Puttuga	3710.24±185.49	766.41±45.09	579	3165.31±59.46	428.05±30.54
8	Synasiputtuga	973.66±72.07	824.69±82.78	579	1686.08±60.77	184.44±6.47
9	Byreddlaputtuga	1001.45±133.49	941.84±28.25	579	1969.32±47.40	175.67±23.19
10	Rajapuram	997.79±82.13	891.58±18.39	579	2107.72±51.60	176.22±21.03
11	kamalaiputtuga	1119.5±57.41	1138.39±59.16	579	1810.87±37.35	146.72±16.94
12	Khojjiria	1366.62±75.83	726.88±82.80	510.2±119.16	2208.17±55.42	222.08±15.58
13	Varakha	3953.82±197.03	801.69±117.14	654.43±56.54	3647.11±114.49	388.05±59.74
14	Kusampuram	3878±211.36	826.7±56.54	579	3430.44±138.59	400.33±33.99

Table 3: The average concentrations of Mn, Fe, Cu ,Zn, Se With Standard deviation ($\pm$) .

S.No	Village	Mn	Fe	Cu	Zn	Se
1	Balli Puttuga	32.08±2.01	73.22±2.01	5.09±0.25	23.03±2.61	0.17±0.08
2	Kaviti	29.83±0.62	55.63±4.34	4.38±1.32	20.38±0.99	0.61±0.53
3	Kapasa Kuddi	21.57±2.75	48.48±0.88	5.59±0.75	23.54±0.75	0.2±0.09
4	D.Gonapa Puttuga	6.39±0.73	45.82±11.85	4.33±1.31	11.13±1.23	1.42±1.13
5	Bejji Puttuga	35.17±1.81	44.61±0.44	4.93±0.64	18.83±0.93	0.12
6	Lolla Puttuga	23.11±1.05	99.18±27.71	4.09±0.49	23.12±0.81	0.91±0.76
7	Tottidi Puttuga	31.67±0.67	48.87±0.96	5.07±1.32	21.55±1.72	0.43±0.28
8	Synasiputtuga	11.91±1.20	73.03±18.39	4.15±0.05	15.21±1.71	0.88±0.60
9	Byreddlaputtuga	7.26±1.45	37.71±4.85	4.51±1.03	14.47±0.52	0.37±0.24
10	Rajapuram	8.39±0.66	36.43±2.30	5.38±0.83	11.6±0.31	0.46±0.45

11	kamalaiputtuga	11.39±0.85	39.12±3.56	7.69±0.36	20.56±1.03	0.12
12	Khojjiria	12.66±2.14	54.07±3.29	6.34±0.80	16.21±0.74	0.33±0.28
13	Varakha	33.33±1.36	46.6±2.96	5.05±0.67	20.05±1.42	0.15±0.05
14	Kusampuram	32±2.27	51.1±8.73	4.59±0.94	19.3±1.40	0.59±0.66

In rice samples, calcium is very low in all villages with respect to standard. Low level calcium in blood is called hypocalcaemia which can be caused by hyperparathyroidism by kidney failure, by low levels of plasma magnesium (hypo magnesia) (or) by failure to get adequate amounts of calcium (or) vitamin-D in the diet.

Oxidative stress and inflammation play a major role in the progression of renal damage in chronic kidney disease (CKD). Mn is a potent anti – oxidant and cofactors of the enzyme MnSOD, which is the main anti-oxidant enzyme in the mitochondria, responsible for protecting the cell from reactive oxygen species (ROS) by scavenging mitochondrial superoxide's. Mn is very low in the villages D.Gonapa Puttuga, Synasi Puttuga, Byreddla Puttuga, Rajapuram, Kamalai Puttuga, Khojjiria villages.

Iron in Lolla puttuga Rice sample high with respect to standard remaining all villages Rice samples Low abundance. In CKD, the anemia that develops is frequently complex. The primary cause is adequate in production of erythroprotein by the diseased kidney [2]. Decreasing protein intake reduces iron intake and depletes iron stores. Absorption of iron from the gastro intestinal tract may also decrease [3]. Thus multiple factors can contribute to adequate in total body iron stores in patients with CKD, the condition is known as "absolute iron deficiency" [4].

Plasma cu was higher in the Diabetes Mellitus (DM) group when compared to the non-DM control groups. Serum Urea was a positive independent determinant of plasma Zn concentration. These findings demonstrate an alteration in the distribution of Zn of patients with CKD independently of the presence of DM. Also the status of cu seems not influenced by CKD, but only by the metabolic derangements associated with diabetes [5]. In Kapasakuddi village rice sample level the standard. In Kamalai puttuga village, Khojjiria village Rice samples above the standard reference value.

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 anti-oxidant that reduces free radicals [6]. Zinc is Low in the D.Gona Puttuga, Rajapuram village Rice samples. Remaining other villages high with respect to standard.

Increased serum sulfate levels are a common feature of kidney failure. In end-stage renal disease, sulfate can be removed by hemo dialysis and peritoneal dialysis treatment, but serum sulfate levels are often still elevated [7-9]. Increased serum sulfate concentration results in increased complications with calcium and this may be responsible for the parathyroid stimulation that occurs in chronic renal disease [7-10]. Sulphur is low in all rice samples of all villages.

Chlorine is high in villages Balli Puttuga, Kaviti, Lolla Puttuga, Varakha villages and low in the Khojjiria village. Chloride makes up about 0.15% of a person's body weight and is essential for maintaining acid-base electrolyte and fluids balance in the body. Hyperchloremia is an electrolyte imbalance and is indicated by a high level of chloride in the blood. Kidneys control the levels of chloride in blood.

The main regulator of intestinal phosphorus absorption is 1, 25 – di hydroxyl vitamin D (calcitriol) acting through the Na-phosphate co-transporter, NPT 2b in the intestinal epithelial cells [11]. A physiologic plasma phosphorus level of 3-4.5 mg/dl is maintained chiefly through renal clearance about 900 mg of phosphorous is excreted daily in the urine about 90% of plasma phosphates are filtered in the glomerulus and 80 – 97% of the filtered load is reabsorbed mostly in the proximal tubule, no phosphorus is secreted tubule cells [11]. Phosphorus is very high in Balli Puttuga, Kaviti, Kapasa Kuddi, Bejji Puttuga, Lolla Puttuga, Tottidi Puttuga, Varakha, Kusumpuram villages and in remaining all villages phosphorus is less than the strandard.

In patients with chronic renal failure (CRF), Se concentration in blood components is usually lower compared with healthy controls. Plasma Se – depended GSH – PX, one of the five known forms of the enzyme, is synthesized primarily in the kidneys and it is reduced in CKD patients, proportional to the progression of the disease. A significant decrease in GSH-PX activity resulting in increased oxidative stress (OS) is accompanied by wide spread Se deficiency [12]. In all villages rice samples Se is high concentration with respect to standard.
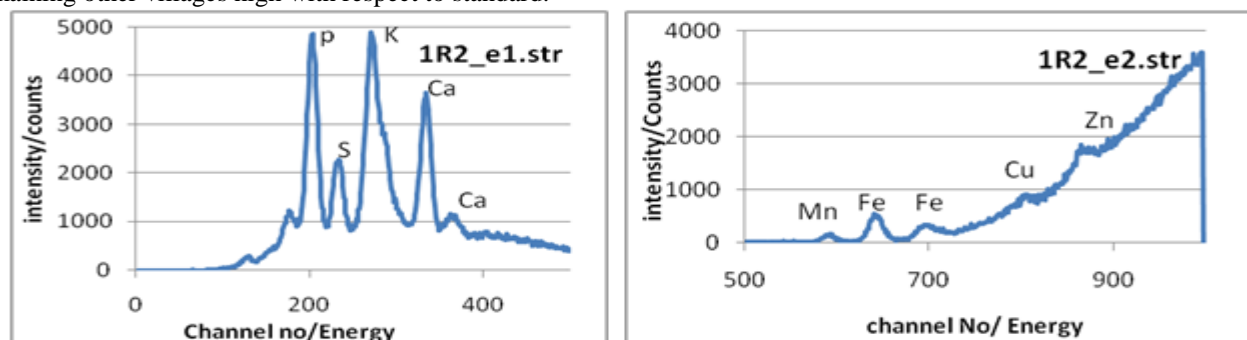

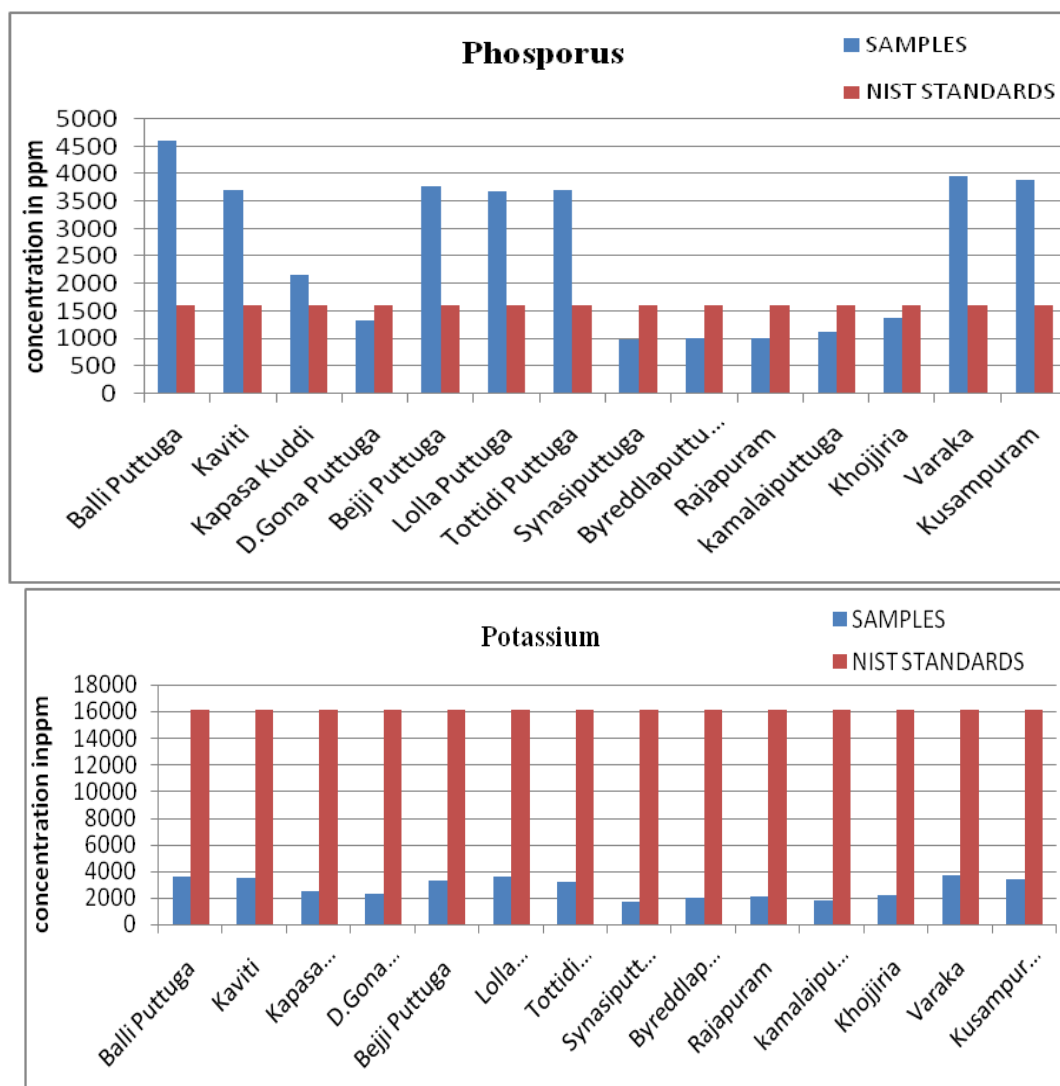**Figure 2:** EDXRF spectrums of Kaviti area sample

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Figure 3: Plots of Phosphorus and Potassium in studied rice samples

4. Conclusion

Rice samples collected from the Uddanam area were analyzed for their element concentration using EDXRF technique. The accuracy of the results obtained was evaluated using NIST apple leaf-1515 standard. In total ten (10) elemental concentrations have been determined. The elemental concentration of S, K, Ca, Mn is below the standard values. The elements P, Cu, Zn, Cl vary in between upper and lower with respect to standard. Iron is low in all villages except in Lolla Puttuga village. Ca is very low significant in all village rice samples. These alterations in rice minerals may be a cause of high CKD prevalence in these area, hence further evaluation is required to substantiate our inference

5. Acknowledgements

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