NUCLEAR METHODOLOGY TO STUDY KIDNEY ANOMALIES

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ABSTRACT

To study kidney anomalies induced by intake of natural uranium, γ-ray spectroscopy was applied to investigated the elements present in Beagles dogs urine sample and neutron activation analysis (NAA) was applied to determine the concentration of Sodium, Chlorine and Potassium present in these samples. The results from NAA have been compared with the conventional clinical analysis and they were consistent.

I. INTRODUCTION

Toxicological studies show that most of the uranium absorbed by the ingestion in the human system is retained in different body organs and then is excreted, partially, through urine. The amounts of the non-excreted uranium accumulated in these organs, particularly in the kidneys, could cause lesions. This paper reports the application of the nuclear methodologies: γ-spectroscopy and neutron activation analysis (NAA) to identify and to determine the concentration of elements present in the biological urine samples from dogs doped with natural uranium. These results make possible to obtain the maximum of information for a detailed study of kidney malfunction.

II. EXPERIMENTAL PROCEDURE

For this investigation, urine samples of Beagles were used. These animals were chosen because 90% of their physiological characteristics are similar to those in humans [1]. The experiments were performed at the facilities of the UNITOX laboratory from the Universidade Santo Amaro (UNISA). Four male Beagles dogs were housed in individual bails at controlled room temperature. They were fed daily with dog chow doped with uranyl nitrate at a concentration of 100 ppm, except the control animal. This procedure was performed during 5 months: the uranium ingestion started after weaning (~60 days) and continued in the animal maturity. After the 5 Th month these animals were sacrificed.

During all the experiment the following procedure has been carried out:

(i) daily control and measurements of the ingested food;
(ii) daily control and measurements of the animal weight;
(iii) collect of biological material (urine, feces and blood).

Particularly, the biological samples of urine were collected weekly and analyzed by using γ-ray spectroscopy technique. Through this systematic analysis it was possible to observe if there was any variation of the elements present in the urine samples and using neutron activation analysis (NAA) it was possible to quantify any alteration. Besides the urine sample of all animals (control and doped) were submitted monthly to biochemical test (Creatine and Urea) in order to identify renal failure associated with uranium toxicological effects.

III. INSTRUMENTATION AND IRRADIATION

For NAA, a GMX2020 hyperpure Ge detector (Canberra) connected to a S-100 multichannel analyser (Canberra) and to a PC computer was used to measure the induced gammma-ray activity. This procedure was made to identify and quantify the radioactive nuclides ^{38}Cl ($T_{1/2}$=37.29 min, Eγ =1642.0 keV), ^{42}K ($T_{1/2}$=12.52h, Eγ =1524.70 keV),^{24}Na ($T_{1/2}$=15h, Eγ =1368.4 keV). To

determine the concentration of the elements CL, K and Na, in the urine sample, aliquots of 100 μl of the sample were pipetted onto 1cm^2 pieces of Whatman N° 40 filter paper, that were sealed in polyethylene bags. As standards, convenient aliquots of standard solutions of Na, Cl, and K were prepared in a similar way as the samples. Samples and standards were irradiated for 15 minute in the IEA – R1m reactor of IPEN/SP, in a thermal neutron flux of 10^{13} n/cm^{2}s. After irradiation, the sample and standard were gamma-counted for 10 minutes and the area of the select gamma-ray peaks were obtained by using the VISPECT program [2]. The concentration of the elements was obtained using the comparative neutron activation analysis. For γ-ray spectroscopy, the irradiation and counting time were 1 minute and 1 hour, respectively and the spectrum were investigated using the IDF program [3]

Theses analysis were performed for the control and doped animals.

IV. RESULTS AND DISCUSSION

The urine elements investigation using γ-ray spectroscopy was performed weakly during all experiments and besides the presence of the elements chlorine, sodium and potassium only uranium was also identified.

In Table I, the quantitative results of urine sediment using NAA are presented and compared with the conventional clinical analysis. Considering that the results agreed better than 15% for most of the samples, the NAA data were used to check if the concentration of the elements Cl, Na and K in the urine samples are within the normal range. These results are shown in figs. 1, 2 and 3.

TABLE 1. Concentration of Sodium, Potassium and Chlorine in the Urine Sample of the Control Animal by NAA and by the Conventional Analysis.

NAA mg/ml	Selective electrode mg/ml	NAA mg/ml	Selective electrode mg/ml	NAA mg/ml	Selective electrode mg/ml
Na		K		Cl	
2.68 ±0.14	2.67±0.29	2.78 ±0.01	2.89±0.35	5.00±0.07	6.31±0.47
1.36±0.01	1.29±0.10	1.53±0.01	1.45±0.11	2.16±0.04	2.03±0.31
2.13±0.01	1.76±0.21	1.41±0.46	1.37±0.10	4.57±0.07	3.99±0.56
3.63±0.01	2.90±0.35	4.38±0.54	4.09±0.31	5.13±007	4.98±0.61
3.05±0.01	2.73±0.33	2.86±0.01	2.70±0.20	3.82±0.08	4.01±0.39
2.68±0.01	2.32±0.28	1.29±0.05	1.29±0.10	1.67±0.04	3.09±0.47
3.58±0.05	3.33±0.27	4.35±0.08	3.93±0.30	4.86±0.06	5.29±0.80
3.78±0.05	3.66±0.16	4.54±0.08	4.48±0.34	5.52±0.07	5.82±0.41
2.15±0.01	2.14±0.12	4.62±0.0.5	4.57±0.34	3.85±0.05	2.87±0.42
1.89±0.01	1.89±0.18	3.47±0.16	2.93±0.22	2.76±0.05	2.83±0.21
1.86±0.03	2.41±0.26	4.25±0.38	6.98±0.52	3.09±0.07	3.22±0.28

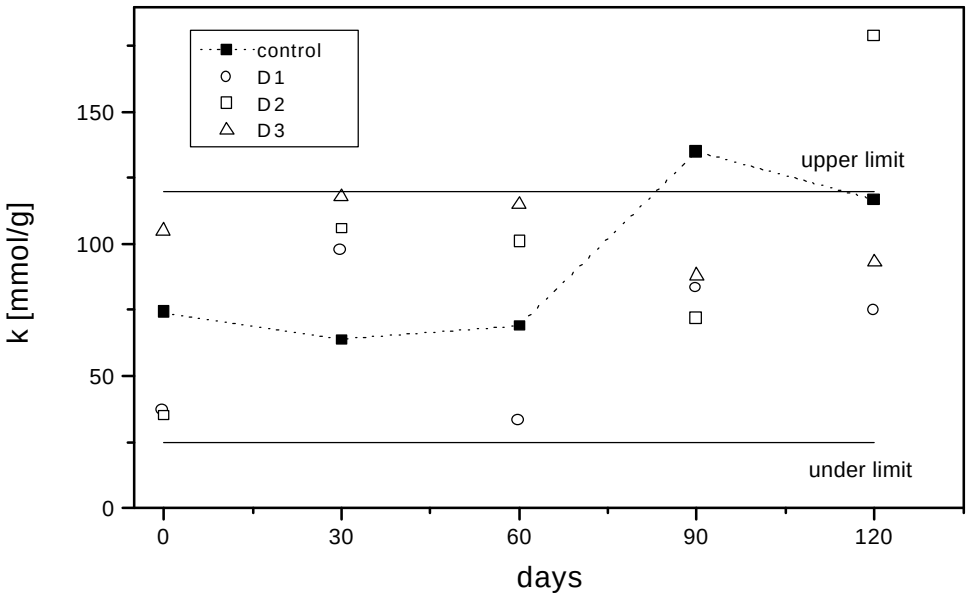

Figure 1. Behavior of the Element Potassium, in the Urine Sample of the Control and Doped Dogs (D1, D2 and D3).

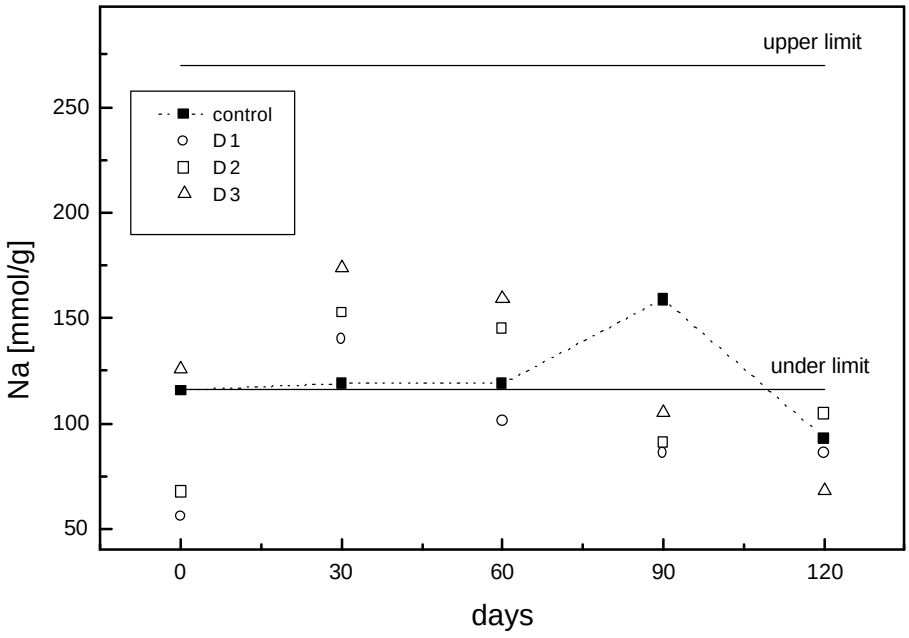

Figure 2. Behavior of the Element Sodium the Urine Sample of the Control and Doped Dogs (D1, D2 and D3).

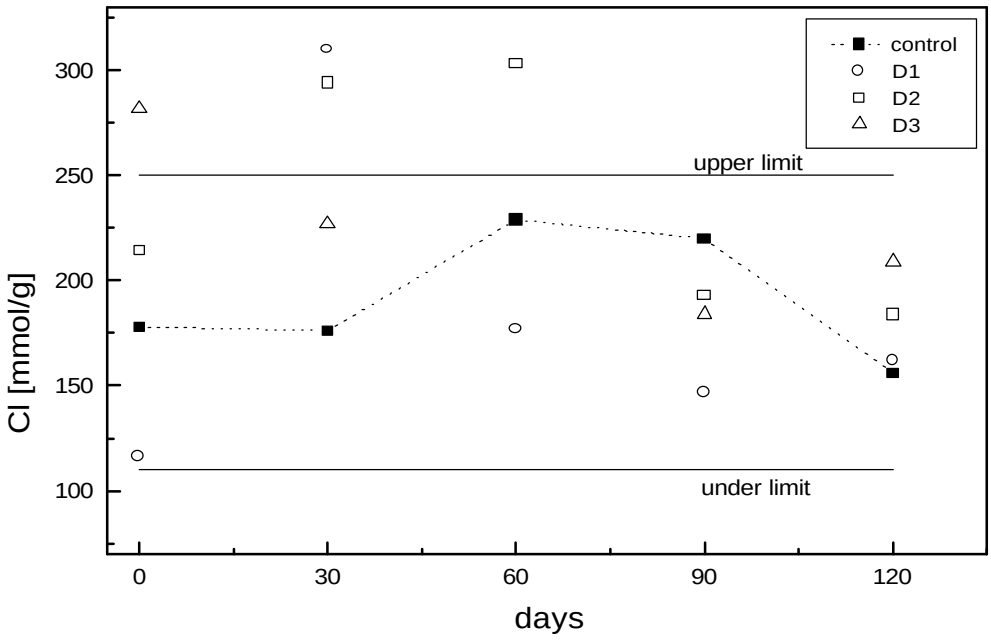

Figure 3. Behavior of the Element Chlorine in the Urine Sample of the Control and Doped Dogs (D1, D2 and D3).

Biochemical tests in urine were also performed in order to determine the concentration of creatine and urea, related to the uranium ingestion, and the results are presented in figs. 4 and 5, respectively.

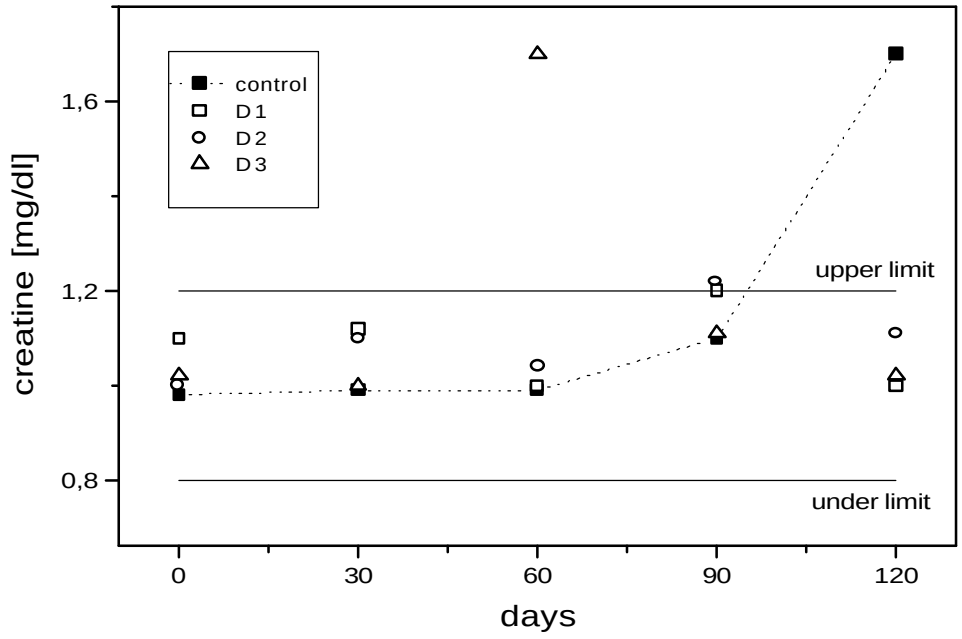

Figure 4. Behavior of Creatine in Urine Samples Related to the Uranium Ingestion.

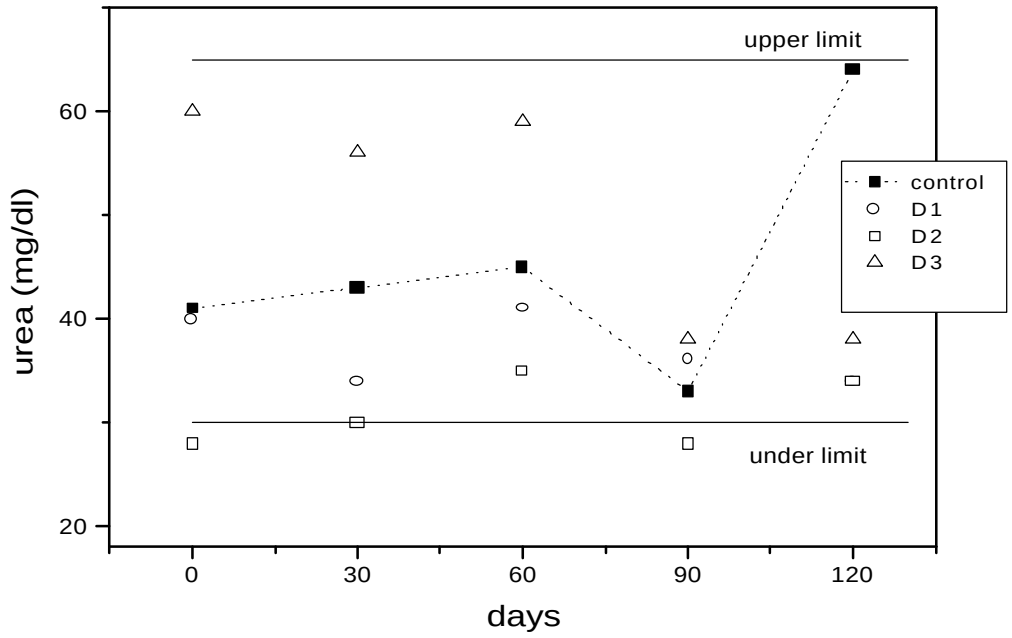

Figure 5. Behavior of Area in Urine Samples Related to the Uranium Ingestion.

The results of the nuclear analysis were correlated with the biochemical tests but it was not possible to identify any renal failure associated with uranium toxicological effects in the animals doped with uranyl nitrate at a concentration of 100 ppm.

Regarding the use of NAA to perform urine analysis we could point out the following advantages:it is an alternative method for diagnose of kidney anomalies;
use of small quantities (~100 μl) in comparison with the conventional clinical analysis (~3ml); it permits simultaneous evaluation of chlorine, sodium and potassium concentrations in urine samples, which is not always possible in the conventional analysis; low activity (0.1 μCi), what reduces the radiation exposure during the handling process of the active material. Due to the short time irradiation and short half-life, associated to the measured radioisotopes (^{38}Cl, ^{24}Na and ^{42}K), there is no residual activity in the urine sample after 48 hours.

Regarding the disadvantages of using this nuclear method, two points must be considered: the need of technician experienced with radiological protection to perform the analysis and the necessity of a nuclear reactor; however, a small size prototype of neutron irradiator for clinical analysis is being developed, so that it can be used outside the reactor premises.

REFERENCES

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[2] Piccot, D., Private Communication, IPEN, 1989.
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