SCIENTIFIC NOTE

A RECONNAISSANCE SURVEY OF Cd CONTENT IN KIDNEY STONES OF IRAQI PATIENTS

Urinary calculi or kidney stones are deposited chemicals formed through several incompletely understood physico-chemical processes. The chemical constituents of most urinary calculi are oxalates, phosphates, urates, carbonates, cystines and xanthines. The major constituents of the calculi are well known; calcium being a major cationic constituent. However, trace element composition of these stones is less known and only a few papers dealt with trace element determination in urinary calculi so far (Eusebio and Elliot, 1967, Donev *et al*., 1977, Meyer and Agino, 1977, Levinson *et al*., 1978, Lin *et al*., 1985, Wandt and Pougnet, 1986, Pougnet *et al*., 1987 and Wandt and Underhill, 1988).

Cadmium is a relatively rare metal in nature, but its concentration in the natural environment can be significantly enhanced due to several industrial, agricultural or other human activity products (Table 1). Phosphate fertilizers are known to contain high concentrations of Cd, most of it is absorbed by the plant and eventually enters the food chain (Hutton, 1983). Sewage is also known to contain anomalous values of Cd, which, if not treated properly, can enter the natural water systems or soil and finally into the food chain (Davies, 1980). Some industrial activities, including mining and smelting of Cd-bearing ores, can also cause Cd-pollution problems to the surrounding environment (Cannon and Anderson, 1971 and Hanya, 1971).

Cadmium is known to be among the hazardous heavy metals in the natural environment and can be accumulated in the human body in variable concentrations. It is highly concentrated in the kidney; where about 50% of the Cd content in the human body is found (Khalid, 1980). The pathological impact of Cd accumulation in the human body is manifested in several ways (Yasumura *et al*., 1980). It is a well known carcinogenic metal (Furst, 1971) and was suggested to cause hypertension (Perry, 1971), as well as disintegration of bones (Hanya, 1971).

Highly variable concentrations of Cd were reported in kidney stones, ranging from 1.3 ppm to 392.8 ppm (Donev *et al*., 1977). Lower values were reported by Levinson *et al*. (1978) who gave concentrations ranging from 0.03 ppm to 0.3 ppm (mean values). The highest concentrations were found in kidney stones of struvite composition, whereas the lowest concentrations were found in those of whewellite and uric acid compositions. The role of Cd in the crystallization of Ca-oxalates is not well understood. However, Eusebio and Elliot (1967) found that Cd is among the metals that enhance crystallization of Ca-oxalate. It was shown to have relatively low effect on the solubility of the Ca-oxalate crystals (Elliot and Eusebio, 1967).

To the best of our knowledge, this is the first time Cd is analysed in kidney stones of Iraqi patients. Twenty four samples of kidney stones, extracted by surgical means, were obtained from Iraqi patients ranging in age from 6 to 70 years, and included 17 males and 7 females. The composition of the stones was investigated by X-ray diffraction, and Cd was analysed by atomic absorption spectrophotometry following total digestion by Aqua Regia. The weight of the analysed samples ranged from 0.1 gm to 1.6 gm. The total amount of each sample was digested and made to 25 ml solution. Consequently the detection limit varied from 0.1 ppm in the concentration 1 gm/ 25 ml. to 1 ppm in the 0.1 gm/ 25 ml concentration.

Table 1: Cadmium content in some natural materials and products

Earth crust	0.2 ppm	Vinogradov (1959)
Sea-water	0.1 ppb	
Fresh-water	3 ppb	
Basalts	0.22 ppm	Turekian and Wedepohl (1961)
Granites	0.13 ppm	
Shale	0.3 ppm	
Carbonates	0.035 ppm	
Deep-sea clay	0.42 ppm	
Phosphorites (Iraq)	57 – 73 ppm	Al-Qaraghuli (1983)
Soil (uncontaminated)	0.5 ppm	Hawkes and Webb (1962)
Soil (contaminated)	3 ppm	Hanya (1971)
Phosphate fertilizers (Iraq)	9 – 20 ppm	Al-Qaraghuli (1987)
Rice (grown on contaminated soil, Japan)	2 ppm	Hanya (1971)
Normal sewage sludge	50ppm	D.O.E. (1977)
Sewage sludge (England and Wales)	60 – 1500 ppm	Davies (1980)
Human kidney	446 – 1470 ppm	Yasumura *et al.*(1980)
Human liver	50 ppm	
Human bone	4 ppm	
Human heart	0.01 – 0.03 ppm	

The results of the analysis are given in Table 2. Fourteen of the samples are of Ca-oxalate composition, six urates, one mixed urate and oxalate and one mixed oxalate and cystine. The composition of two of the samples was not identified and they appear to be a mixture of more than two phases.

Cadmium was detected in 5 samples only. The concentration in the remaining samples was below the detection limits, which are dependent on the sample weight and concentration of the metal in the analysed solution. In this way, about 60% of the stones with non-detectable Cd contain less than 1 ppm Cd and about 40% of these stones contain less than 0.1 ppm Cd. The Cd content in kidney stones of the Iraqi patients is within the lower ranges of the values reported by Donev *et al.* (1977), but within the limits reported by Levinson *et al.* (1978).

Three of the positively detected samples are composed of monohydrated calcium oxalate (whewellite) with a mean Cd content of 3.7 ppm. One sample, composed of a mixture of whewellite and uric acid, contained 3.4 ppm and one sample, composed of uric acid only contained 2.2 ppm Cd.

Table 2: Cadmium content in the samples of kidney stones (present study)

Sample no.	Sex	Age (yr.)	Weight (gm)	Composition	Cd (ppm)
1	M	57	0.112	uric acid	<1.0
2	M	64	0.182	uric acid	<0.9
3	F	40	0.545	uric acid	<0.6
4	M	60	1.605	not identified	<0.05
5	F	12	0.217	Ca-oxalate hyd.	<0.9
6	M	47	0.032	Ca-oxalate hyd.	<1.1
7	F	37	0.135	Ca-oxalate hyd.	<0.9
8	M	6	0.882	Ca-oxalate hyd.	<0.2
9	M	60	0.456	not identified	<0.6
10	M	?	0.255	Ca-oxalate hyd.	<0.8
11	F	65	0.096	Ca-oxalate hyd.	<1.0
12	M	38	0.448	Ca-oxalate hyd.	3.6
13	M	27	0.116	Ca-oxalate hyd.	6.36
14	M	45	1.471	Ca-oxalate hyd.	1.20
15	M	53	0.476	Ca-oxalate hyd. and uric acid	3.40
16	M	60	1.223	uric acid	<0.1
17	F	70	0.238	uric acid	2.20
18	F	50	0.953	uric acid	<0.1
19	M	35	0.356	Ca-oxalate hyd.	<0.7
20	F	54	0.425	Ca-oxalate hyd.	<0.7
21	M	35	0.257	Ca-oxalate hyd.	<0.8
22	M	50	1.164	Ca-oxalate hyd.	<0.1
23	M	60	0.279	Ca-oxalate hyd.	<0.8
24	M	42	0.929	Ca-oxalate hyd. and L-Cystine	<0.2

Note: Detection limit in the concentration range 0.1 gm/ 25 ml is 1 ppm and in the concentration range 1 gm/ 25 ml is 0.1 ppm.

No definite relation between sex or age with Cd concentration was confirmed in the analysed samples, probably due the relatively small number of samples with detectable Cd concentrations. However, Cd in 24% of the male populations (4 samples) was detectable with a mean value of 3.6 ppm and in 14% of the female population (1 sample) was detectable with 2.2 ppm. All the remaining samples (males and females) were with less than 1 ppm Cd.

The stone of the youngest patient with detectable Cd (27 years male) contained the highest Cd concentration of 6.4 ppm, whereas, the lowest detectable Cd concentration was found in the stone of 45 years old male patient. The mean Cd content in the stones of patients less than 40 years old (2 samples) is about 5 ppm, whereas the mean Cd content in the stones of patients more than 40 years old (3 samples) is 2.2 ppm. The composition factor is also illustrated in the results; 21% of the oxalate stones contained detectable (more than 1 ppm) Cd in contrast to 17% of the urate stones. The tendency towards higher Cd concentrations in the former may be explained by the affinity of Cd^{2+} for Ca^{2+} in natural compounds. However, the present results do not show clear or definite trends and any conclusions based on them are speculative in view of the small number of samples with detectable Cd concentrations.

On the other hand, Cd concentrations detected in the kidney stones of the present study are much lower than Cd concentration reported in the human kidney it self of (446 – 1470) ppm range values (Yasumura *et al*., 1980) which show the incompatible biochemical behavior of these two Cd-collectors in the human body. Two explanations may be suggested here, one is that cadmium prefers organic complexes within kidney tissues over the inorganic precipitation in the kidney stones. The other way to explain this controversy is the age of both Cd depo-centers; the kidney being much older than the stone and hence have more time to accumulate Cd while filtering the blood.

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