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Cadmium and Zinc Concentrations in the Potable Water of the Eastern Province of Saudi Arabia

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Cadmium is among the most harmful of the heavy elemental pollutants. Its concentration does not exceed 1 mg/L in non-polluted spring water and 5 mg/L in regular drinking stream water. Pollutant cadmium in water may arise from industrial discharges and corrosion of zinc galvanized pipes. The effects of acute cadmium poisoning on humans are very serious. Among them are hypertension, cardiovascular disorders (Ostergard 1977), kidney damage and destruction of red blood cells and testicular tissues (Flick 1971). It is believed that much of the physiological action of cadmium is due to its replacement of zinc in some enzymes thereby impairing its catalytic activity.

Schroeder et al (1967) proved in their studies on rats that the dietary level of zinc can influence susceptibility to cadmium. When the molar ratio of Zn/Cd in drinking water was 1:1, signs of cadmium toxicity were much greater than when a molar ratio of 4:1 was used. They recommended that cadmium toxicity should be studied together with zinc concentration in order to get an accurate picture about the magnitude of its harmful effects.

The World Health Organization (WHO) and United States Public Health Service (USPHS) Standards for drinking water recommend an upper limit concentration of 0.01 mg/L for cadmium and 5 mg/L for zinc.

The Eastern Province of the Kingdom of Saudi Arabia is undergoing extensive industrialization, crude oil exploration, production, processing and exportation. All of these are sources of trace

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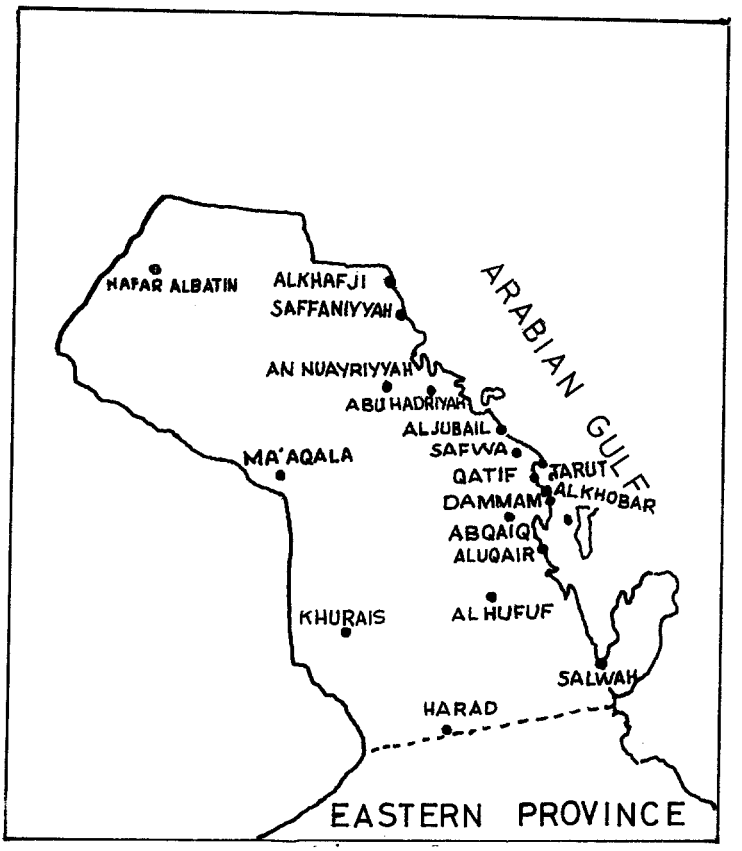

Figure 1. Sampling Areas

heavy metal pollution. It is inhabited by a population where private and public water wells, particularly in the rural areas, are in most cases the major source of potable water. At the present time, a complete network of piped desalinated safe water is under construction and is partly in operation in some urban areas.

This paper deals with the determination of cadmium and zinc concentrations in the potable water of the Eastern Province in order to generate baseline data to enable the medically qualified members of the research team to study the possible relationship between these two ions and cardiovascular morbidity in the population consuming this water.

MATERIALS AND METHODS

In 1983 and 1984 three hundred and seven water samples were collected from the seven major populated areas of the Eastern Province: 40 from Qatif, 50 from Jubail, 52 from Dammam, 149 from Al-Hasa, 5 from Al-Khobar, 6 from Hafer Al-Batin and 5 from Khafji, (Figure 1). All samples were stored at $4^{o}C$ until analyses were performed for cadmium and zinc by flame atomic absorption according to the method of Brown (1968). Analyses were duplicated and cadmium and zinc recoveries were 92 to 95 percent respectively.

RESULTS AND DISCUSSION

Results of cadmium and zinc concentrations in the 307 water sampling sites are recorded in Tables 1, 2 and 3.

Our results in Table 1 indicate that 200 water samples out of 307 ones analyzed for cadmium are below the WHO and USPHS limits for this element. Of the others, 107 samples, or 43.9%, exceed the upper limit while 30 samples, or 11.4%, have cadmium concentrations more than twice as much as the accepted levels.

Table 2 indicates that Dammam has 77%, Jubail 54%, Qatif 63%, and Al Hasa 10% of their sampled water above the recommended cadmium upper limit. The other three areas (Al Khobar, Hafer al-Batin and Khafji) have cadmium concentrations within the accepted standards.

These results may be explained by the fact that Dammam, the capital of the Eastern Province, and Jubail, a city that has witnessed phenomenal industrialization expansion during the past ten years, have both been traditional centers for industry and both have extensive water storage and distribution systems, a possible contributing factor for cadmium pollution. In Qatif, water sources are mainly private wells; the water is distributed through old pipes which are often inflicted by corrosion. Al Hasa, on the other hand, is an important agricultural center.

Table 1. Cadmium concentrations in water sampling loations.

Cd CONC. (mg/L)	No. OF SAMPLES INT.	CUM.	PERCENTAGE INT.	CUM.
0.0020	29	29	9.4	9.4
0.0040	40	69	13.0	22.5
0.0060	44	113	14.3	36.8
0.0080	59	172	19.2	56.0
0.0100	28	200	9.1	65.1
0.0120	26	226	8.5	73.6
0.0140	20	246	6.5	80.1
0.0160	10	256	3.3	83.4
0.0180	11	267	3.6	87.0
0.0200	5	272	1.6	88.6
0.0220	5	277	1.6	90.2
0.0240	4	281	1.3	91.5
0.0260	2	283	0.7	92.2
0.0280	0	283	0.0	92.2
0.0300	2	285	0.7	92.8
0.0320	1	286	0.3	93.2
0.0340	1	287	0.3	93.5
0.0360	1	288	0.3	93.8
0.0380	3	291	1.0	94.8
0.0400	2	293	0.7	95.4
0.0420	1	294	0.3	95.8
0.0440	0	294	0.0	95.8
0.0460	0	294	0.0	95.8
0.0480	3	297	1.0	96.7
0.0500	4	301	1.3	98.0
0.0520	2	303	0.7	98.7
0.0540	0	303	0.0	98.7
0.0560	1	304	0.3	99.0
0.0580	1	305	0.3	99.3
0.0600	1	306	0.3	99.7
0.0620	0	306	0.0	99.7
0.0640	0	306	0.0	99.7
0.0660	0	306	0.0	99.7
0.0680	0	306	0.0	99.7
0.0700	1	307	0.3	100.0
0.0720	0	307	0.0	100.0
0.0740	0	307	0.0	100.0
0.0760	0	307	0.0	100.0

Table 2. Cadmium concentration distribution in different water sampling locations.

Location	Qatif	Jubail	Dammam	Hasa	Khobar	H.Batin	Khafji
Mean Conc.	0.026	0.015	0.012	0.007	0.004	0.003	0.001
Std.Dev	0.019	0.013	0.018	0.003	0.002	0.001	0.002
R.E.S.D.	0.022	0.011	0.007	0.003	0.002	0.001	0.002
S. E. M.	0.003	0.002	0.001	0.000	0.001	0.000	0.001
Maximum	0.060	0.070	0.035	0.021	0.008	0.004	0.004
Minimum	0.003	0.001	0.000	0.000	0.003	0.001	0.000
Samp.size	40*	50	52	149	5	6	5

*One sample missing

Table 3. Zinc concentration distribution in different water sampling locations

Location	Qatif	Jubail	Dammam	Hasa	Khobar	H.Batin	Khafji
Mean Conc.	0.284	0.575	0.862	0.292	0.467	0.162	0.248
Std.Dev.	0.367	0.686	1.439	0.420	0.532	0.206	0.403
R.E.S.D.	0.373	0.611	1.142	0.365	0.559	0.187	0.401
S. E. M.	0.057	0.097	0.200	0.034	0.238	0.084	0.180
Maximum	1.360	3.440	7.300	2.798	1.340	0.566	0.963
Minimum	0.003	0.008	0.011	0.000	0.060	0.016	0.021
Samp.size	40*	50	52	149	5	6	5

*One samle missing

It is the site of many oases with sweet running water. Consequently, samples collected from there have received the least cadmium pollution.

As for zinc concentration in water (Table 3), only two samples have exceeded the upper limit of 5 mg/L and no harmful effects are expected from its presence in the drinking water in the levels indicated.

These results will be more interesting when the study of relationship between cadmium concentration alone and its molar ratio concentration with zinc in drinking water and trends of cardiovascular morbidity in the population consuming this water in each of the seven sampling areas is completed.

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