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A survey of natural uranium concentrations in drinking water supplies in Iran

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ABSTRACT

Background: Measurement of back ground concentration of uranium in drinking water is very important for many reasons, specially, for human health. The uranium concentration in drinking water in many counties is a matter of concern for clinical and radioactive poisoning.
Materials and Methods: The uranium concentration in drinking water is determined using laser flourimatric uranium analyzer. For this purpose after sampling, sample handling and sample preserving, sample preparation and treatment for reduction of organic matter, the concentration of uranium is measured.
Results: To determine the uranium concentrations in drinking water in Iran, nearly 200 water samples were collected from all sources supplying drinking water in 21 provincial centres in the country. The wells were found to be the main source for drinking water. Uranium in the samples was measured by a laser fluorimetry technique. According to results, the concentration values found in the wells ranged from 1.0 to 10.90 μgL^{-1}, while nearly 95 percent of the cities had uranium concentrations in the wells at less than 4.70 μgL^{-1}. Surface waters showed uranium concentrations in the range of 0.75 to 2.58 μgL^{-1}. The daily intake of uranium from drinking water was estimated to range from 2.04 to 21.80 μgd^{-1}, with the mean value of 5.44 μgd^{-1}.
Conclusion: Highest uranium mean concentration of 10.9 μgL^{-1} was found in Ardabil area where more studies should be done in that province in the future. *Iran. J. Radiat. Res., 2003; 1(3): 139 - 142*

Key words: *Uranium, drinking water, surface waters, wells, intake, provincial centres, Iran.*

INTRODUCTION

Uranium, the heaviest naturally occurring element, is widespread in nature, occurring in granites and various other mineral deposits. This element exists in nature in the +2, +3, +4, +5, and +6 valence states, the most prevalent form being the hexavalent form, commonly associated with oxygen as the uranyl ion, UO2. Natural uranium is a mixture of three isotopes, including ^{238}U (99.285%), ^{235}U (0.71%), and ^{234}U(0.0054%). These radionuclides decay by alpha particle emission. They possess very long half-lives (4.7×10^{9} years for the most abundant isotope of natural uranium, namely ^{238}U), which results in very low specific activity for natural uranium. This property makes natural uranium to be considered as a heavy metal with chemical toxicity rather than a radiological hazard, with the kidney as specific target organ (Hursh and Spoor 1973).

Uranium in the environment components originates from several sources, including leaching from natural deposits, release in mill tailings, emissions from nuclear industry and the combustion of coal and other fuels (Dresen *et al.* 1982; Cothern and Lappenbusch 1983, Essien *et al.* 1985, Tadmor 1986), as well as the use of the phosphate fertilizers containing significant concentrations of uranium (Spalding and Sackett 1972). This element enters the human body through ingestion of water and diet components, as well as inhalation. According to data available,

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drinking water may contribute significantly to total uranium intake. The U.S. Environmental Protection Agency has reported that the mean contribution of uranium from drinking water to total intake is 31.1% U.S. EPA (1990, 1991)

In Iran, the drinking water is supplied from both ground and surface water sources, with the former being the main source in most parts of the country. In a national survey of radioactivity in drinking water supplies in Iran, during 1994-95, natural uranium concentrations in water sources in large and densely populated cities namely, provincial centres, were also measured. The results of the measurements are presented in this paper.

MATERIALS AND METHODS

Sampling

Total of nearly 200 water samples from all existing sources supplying drinking water, including wells, springs, and rivers, in 21 cities were collected for this study. In the case of the wells, as sources with potentially higher uranium concentration, all the wells existing in the region of interest, or at least 50% of the wells in the regions with large number of wells, were examined. Each water sample was collected in a 1L polyethylene bottle rinsed with deionised and test water. The sample was acidified to PH less than 2 with concentrated nitric acid according to EPA instructions (Krieger76). For each water source sampled an information sheet was completed.

Uranium measurement

Water samples were analysed for natural uranium contents by laser-induced flourimetry technique, using Scintrex UA-3 Uranium Analyser. Simple chemical treatments of the samples and fluorescence measurement of uranium in final solution, by the standard addition method, were carried out according to procedure recommended by the instrument manufacturer. (Robbins et al 1985) The uranium measurement sensitivity by the applied instrument is 0.05 μgL^{-1}. The measurement accuracy is ±15% for uranium concentration above 1 μgL^{-1}.

RESULTS AND DISCUSSION

The uranium concentrations in drinking water sources sampled in 21 provincial centres of the country are shown in table 1.

The number of population, nature of water sources and contribution of each to drinking water supply, in each city are also indicated in the table. As shown in the table, the wells are the main source supplying drinking water in the majority of cities studied in this work. In only 6 cities, the rivers contribute from 15 to 100% to drinking water supply. In Tehran, the most populated city of the country, the contribution of the rivers to drinking water supply is greater than that of the wells only in the years with appropriate rainfall. According to data in the table, the uranium concentrations in the wells of the cities studied ranges from 1.03 μgL^{-1} (in Sanandaj) to 10.90 μgL^{-1} (in Ardabil). Ninety five percent of the cities have, however, uranium concentrations in the wells less than 4.70 μgL^{-1}. In a recent and more comprehensive study for determining uranium concentrations in the wells of Ardabil city, it was found again that the concentration values ranges from 5 to 17μgL^{-1}, with the mean value of nearly 10 μgL^{-1}. There is a lake in this city, called Shourabil, with uranium concentration of nearly 18 μgL^{-1}. The water of this lake is not used for drinking water or other domestic uses. Ardabil is also a province with numerous hot springs, used by local people and tourists for medical purposes. The uranium concentrations in these springs were also measured in this study. The results have shown very low uranium concentrations in these springs, ranging from 0.33 to 0.74 μgL^{-1}, which are much lower than the concentration values found in the wells of the Ardabil (5-17 μgL^{-1}). The uranium concentrations in surface waters, as expected, are relatively low and in the range of 0.75 to 2.58 μgL^{-1}, with the mean value of 1.35 μgL^{-1}.

Table 1. Concentrations of uranium in domestic water supplies in the provincial centers in Iran.

City (province)	Populations (In millions)	Water source	Portion used for drinking (in percent)	Uranium concentrations (µg/L)
Ahvaz (Khouzestan)	0.885	Rivers	100	2.58 ± 0.12
Ardabil (Ardabil)	0.341	Wells	100	10.90± 0.56
Bandar Abbas (Hormozgan)	0.298	Wells	20	4.71 ± 4.27
		Rivers	80	0.90 ± 0.01
Eelam (Eelam)	0.126	Springs	60	1.70 ± 0.64
		Wells	40	2.32 ± 0.29
Esfehan (Esfehan)	1.405	Rivers	50	1.37 ± 0.01
		Wells	50	3.90 ± 1.54
Hamadan (Hamadan)	0.401	Wells	75	3.55 ± 1.28
Kerman (Kerman)	0.385	Wells	100	2.32 ± 0.67
Kermanshah (Kermanshah)	0.693	Springs	15	1.26 ± 0.24
		Wells	85	1.47 ± 0.51
Khoram Abad (Lorestan)	0.273	Springs	80	1.24 ± 0.22
		Wells	20	1.81 ± 0.01
Mashhad (Khorasan)	1.887	Springs	20	3.00 ± 0.01
		Wells	80	4.09 ± 1.79
Oroomiyeh (West Azarbaijan)	0.435	Rivers	30	1.42 ± 0.01
		Wells	70	2.30 ± 0.78
Rasht (Gilan)	0.418	Wells	80	1.75 ± 1.61
Sanandaj (Kordestan)	0.278	Springs	5	0.84 ± 0.20
		Wells	95	1.03 ± 0.01
Sari (Mazandaran)	0.196	Wells	100	2.31 ± 0.25
Semnan (Semnan)	0.098	Wells	85	3.07 ± 0.58
		Springs	15	2.67 ± 0.01
Shahrekord (Bakhtiari)	0.100	Wells	100	1.27 ± 0.61
Shiraz (Fars)	1.050	Wells	100	3.17 ± 0.84
Tabriz (East Azarbaijan)	1.191	Rivers	15	0.75 ± 0.01
		Wells	85	3.53 ± 2.91
Tehran (Tehran)	6.759	Rivers	60	1.09 ± 0.34
		Wells	40	2.61 ± 0.75
Yazd (Yazd)	0.327	Wells	100	3.48 ± 0.95
Zanjan (Zanjan)	0.286	Wells	100	2.07 ± 0.78

According to data of this study, the uranium concentrations in drinking water supplies in Iran are in the range of the values reported for many of the other countries. The mean uranium concentration of 2.55 μgL^{-1} of drinking water in 978 sites in the United States in the 1980s has been reported by the USEPA (USEPA 1990, 1991). According to a survey of 130 cities in Ontario city in Canada, during 1990-95, the mean of the average uranium concentrations in treated drinking water was 0.40 μgL^{-1}, and ranged from <0.05 to 4.21 μgL^{-1} (OMEE 1996). In another survey of 322 wells in the Kitigan Zibi First Nation Community in Quebec in Canada, uranium was detected at levels ranging from 0.01 to 1481 μgL^{-1}, with the mean value of 5.1 μgL^{-1} (Moore *et al.*1996) Of course, the maximum uranium concentration value in Quebec City is very high and far from that in Iran. A number of studies have detected much lower uranium concentrations in drinking water. The concentration value reported for New York City ranges from 0.03 to 0.08 μgL^{-1} **(**Fisenne and Welford 1986). The mean uranium concentration in drinking water supplies in five Japanese cities was found to be 0.9 ngL^{-1} (Nozaki *et al.* 1970). Based on uranium concentration values found in drinking water supplies in each city, the daily intake of uranium from drinking water for an adult consuming 2 Ld^{-1} was calculated to be from 2.04 to 21.80 μgd^{-1}, with the mean value of nearly 5.44 μgd^{-1}. At present, there is no specific concentration limit for uranium in drinking water in Iran. Compared to latest U.S.EPA drinking water standard of 30 μgL^{-1} for uranium (U.S.EPA 2000[a]), the concentration values in drinking water supplies in Iran are considered to be acceptable for public health.

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