Uranium in foodstuffs, in particular mineral water

Scientific opinion of the Panel on Contaminants in the Food Chain

(Question No EFSA-Q-2007-135)

Adopted on 25 March 2009

This summary, published on 29th May 2009, replaces the earlier version published on 28th April 2009[1].

SUMMARY

The European Food Safety Authority (EFSA) was asked to conduct a risk assessment on uranium at the European level because of the existence of differing regulations and also due to existing gaps in the knowledge base concerning the chronic toxicity of uranium. This opinion focuses on uranium's chemical toxicity, while the radiological risk will be addressed by the Group of Experts established under Article 31 of the European Atomic Energy Community (EURATOM) Treaty under the Directorate-General for Energy and Transport[2].

Uranium (U) is a silvery-white metal occurring in a number of minerals such as uraninite, carnotite and pitchblende. Uranium is also a naturally occurring radioactive element. Several different radioisotopes of uranium occur, showing almost identical physico-chemical characteristics, yet with different radioactive properties. Uranium can be present in water, air, food and feed in varying concentrations through leaching from natural deposits such as soil or rocks, emission from nuclear industry, nuclear weapons, dissolution in fertilizers and combustion of coal and other fuels.

Analytical methods for the determination of uranium in the different matrices are available. Depending on the method, uranium can be measured either as the activity of the radionuclide or as the mass fraction of the isotopes.

In June 2008, the EFSA issued a specific call to selected countries for data on uranium concentrations in individual water and food samples. A total of eight countries (France, Germany, Hungary, Italy, Portugal, Sweden, Switzerland and the UK) sent 9,045 analytical results to EFSA. The number of samples below the limit of detection (LOD) varied considerably across country and food group with 5 % and 27 % in tap and bottled water, 41.3

[1] After adoption of the opinion, EFSA was notified on the following two items: i) the Human Biomonitoring Commission is a commission of the German Federal Environment Agency (UBA) and not of the German Federal Institute for Risk Assessment (BfR). This has been corrected in chapter 8 on page 31, ii) the water data provided by France were erroneously classified as bottled water (sample size: 736), however, the data supplied were both bottled and tap water (sample size: 94 and 642, respectively). As a result, in the revision of the opinion figures have been changed in the following tables: Table 5, 7, 8a, 8b, 9a, 12 and 13, in the respective text related to these tables and in the summary and conclusions. These changes do not change the overall conclusions of the opinion. To avoid confusion, the original version of the opinion has been removed from the website, but is available on request as is a version showing all the changes made.

[2] http://ec.europa.eu/dgs/energy_transport/index_en.htm

% for vegetables and 94.7 % and 100 % for cereals and eggs, respectively. Tap and bottled water had mean concentrations of uranium of slightly above 2 μg/L while soft drinks had concentrations less than half of this. Concentrations in food are less representative since they are reported only from one country and there are few samples in selected categories only. Moreover, occasional high LOD for the analytical method were reported.

Several exposure scenarios were explored for adults in Europe. The first scenario included mean consumption with mean occurrence values as a general situation, a second scenario the 95th percentile consumption with mean occurrence values as a high consumption situation, and a third scenario the mean consumption with 95th percentile occurrence values as a local high contamination situation. Based on these scenarios, the overall lower- and upper-bound uranium exposure estimates varied between 0.05 and 0.28 μg/kg body weight (b.w.) per day. For an average consumer and average occurrence values (first scenario), food contributed about 50 %, while less in the other two scenarios. However, there are uncertainties in the concentrations in food. In an additional fourth scenario including high local contamination situations together with a high consumption, the lower- and upper-bound uranium exposure estimates varied between 0.39 to 0.45 μg/kg b.w. per day. This scenario is, however, unlikely. For infants, the exposure scenario included mean and high consumption of infant formula reconstituted with water containing both average and high levels of uranium. The lower- and upper-bound uranium exposure estimates varied between 0.18 and 1.42 μg/kg b.w. per day, for both bottled and tap water.

Oral bioavailability is limited, and only up to 1-2 % of soluble uranium and 0.2 % of insoluble uranium is absorbed. Almost all uranium that is ingested is cleared by the systemic circulation according to a two-phase process. About one third of the absorbed uranium is retained in the body, initially in the kidney and liver, then redistributed to the skeleton. Terminal half-life of uranium in humans has been estimated to range from 180 to 360 days.

Toxicity of ingested uranium is related to the solubility of the uranium compound; the higher the oral uranium compound solubility is, the greater its toxicity is expected to be. The kidney is recognized as the primary target organ for uranium both in experimental animals and humans. Kidney damage results from the accumulation of uranium in the renal tubular epithelium, where it can cause cell necrosis and atrophy of the tubules, leading to a compromised tubular secretion of organic anions and reabsorption of filtered glucose and amino acids. Besides nephrotoxicity, reproductive and developmental alterations (e.g. decreased pup growth and internal/external malformations), diminished bone growth and neurotoxicity have been documented in animal models but only at higher doses.

The World Health Organization (WHO) has established a tolerable daily intake (TDI) for soluble uranium of 0.6 μg/kg b.w. per day, based on the lowest-observed-adverse-effect-level (LOAEL) for uranium nephrotoxicity of 0.06 mg/kg b.w. per day from a 91-day study in male rats. The Panel on Contaminants in the Food Chain (CONTAM Panel) noted that no new data were identified that would require a revision of this TDI and endorsed it.

Using individual values of participant's weight in the EFSA Concise European Food Consumption Database, the average overall dietary exposure to uranium across European countries was estimated to range from 0.05 to 0.09 μg/kg b.w. per day, assuming lower- and upper-bound scenarios for values below the LOD and between the LOD and the limit of quantification (LOQ), respectively. For high consumers the dietary exposure to uranium was estimated to be between 0.09 and 0.14 μg/kg b.w. per day. These dietary exposure estimates are all well below the TDI of 0.6 μg/kg b.w. per day.

Two specific sub-groups of the population were looked at in more detail. It is considered plausible that some local communities with high uranium concentrations in their water supply can be exposed at the 95th percentile concentration level for a longer period or a lifetime. Normally for chronic exposure it is considered unlikely for such a situation to occur. At the same time there might be high consumers of water among these sub-populations at the 95th percentile consumption level. In such a situation, water could contribute 0.36 μg/kg b.w. per day as a median across the countries studied or a country maximum of 0.51 μg/kg b.w. per day. Contribution from food is not considered likely at the 95th percentile concentration level of uranium at the same time, but more likely at the mean concentration level leading to an exposure of 0.04 μg/kg b.w. per day and possibly 0.07 μg/kg b.w. per day in a high consumption scenario. Thus, also in such a situation the TDI would not be exceeded.

The CONTAM Panel noted that for all exposure scenarios evaluated for infants fed with infant formula reconstituted with water containing uranium, the exposure may be up to 3 times higher than the uranium exposure of adults on the body weight basis. The CONTAM Panel concluded that such exposure in infants should be avoided.

Key words: uranium, tap water, bottled water, public health, infants, dietary exposure, TDI.