Arsenic (As)

In a nutshell

Arsenic is a widely-occurring metalloid element. It is a human poison which was formerly used in pesticides and wood preservatives. After chronic human exposure, e.g. from contaminated groundwater, arsenic can also produce skin lesions, nerve damage, anemia, and cancer of skin, lung and urinary bladder.

Phosphate rock used to make phosphate mineral fertilizers can contain arsenic. Use of low-arsenic sources for fertilizer production would help reduce arsenic exposure and thus human health risks.

What is arsenic?

Arsenic is a naturally occurring metalloid element which is widely distributed in the earth's crust. Arsenic cannot be destroyed in the environment; it can only change its chemical form. In the environment, it combines with oxygen, chlorine, and sulphur to form inorganic arsenic compounds. In animals and plants, it combines with carbon and hydrogen to form organic arsenic compounds.

Contamination from different sources

More than 30 arsenic containing compounds were used in the past as herbicides, insecticides and rodenticides, and wood preservatives; some of them are still registered and applied in some countries. In the EU, use of arsenic-containing pesticides and biocides is severely restricted.

Arsenic in soil can come from both natural and man-made sources. Atmospheric pollution from industrial processes and from application of phosphate fertilizers appear to be major contributors to the anthropogenic arsenic deposition in agricultural soils. The arsenic content of fertilizers depends on its concentration in the rock phosphate used for their manufacture. Elevated concentrations of arsenic in soils (compared to background values) have also been reported following the application of sewage sludge. It was estimated that in the UK in the 1980s, about 2.5 tonnes of arsenic per year was added to the agricultural land by use of sludge, compared to 6.1 tonnes from phosphate fertilizers. Since arsenic can be taken up by some plants such as rice and ferns, increased levels in soil can result in increased levels in animal feed and in food.

Human health effects and dietary exposure

Arsenic has been recognised and used as a human poison for millenia. Dioscorides, a Greek physician in the court of the Roman Emperor Nero, described arsenic as a poison in the first century. Its ideal properties for poisoning included its lack of color, odor or taste when mixed in food or drink, the symptoms of poisoning which resemble bacterial food poisoning, and its ubiquitous distribution in nature, which made it readily available. Arsenic-contaminated beer (from contaminated grain) resulted in 6000 poisonings and approximately 71 deaths in Northern England in 1900. Arsenic poisoning can be treated with dimercaprol, the first rationally developed chelating agent, which bind arsenic tenaciously and hastens its excretion in the urine.

Prolonged low-level dietary arsenic exposure can lead to skin lesions, peripheral neuropathy, and anemia, and to cancer of skin, lung and urinary bladder.

Such effects were seen after large-scale chronic arsenic poisoning by environmental water contamination in Bangladesh, where international efforts were mounted to provide better water supplies by digging deeper wells into aquifers. Many of these wells ended up tapping water from geological formations naturally high in arsenic. As a result, many thousands of people were poisoned via drinking water, crops irrigated with contaminated water, and food prepared with contaminated water. Arsenic-contaminated groundwater is a threat to public health in a number of countries worldwide.

Total arsenic levels are higher in fish and seafood commodities than in most other foods, but in these products, the arsenic is mainly organic. Unlike inorganic arsenic, organic forms are rapidly excreted so do not accumulate, and are much less toxic.

The major dietary sources of exposure to the more toxic inorganic arsenic are rice and rice derived products, cereals and cereal products (typically wheat-based), certain vegetables, fruit and fruit juices, shellfish, seaweeds, water, and other non-alcoholic and alcoholic beverages.

In Europe, mean dietary exposure to inorganic arsenic is about 0.2-1.4 µg/kg b.w./day in infants, toddlers and other children, and 0.1-0.4 µg/kg b.w./day in adults. The main exposure sources are drinking water, grain-based processed products (e.g. wheat bread, rice, milk and dairy products), food for special dietary uses, bottled water, coffee and beer, rice grains and rice-based products, fish and vegetables (especially algae). In adults, adolescents and children, exposure to inorganic arsenic was mainly from wheat bread and rolls. In infants and toddlers, exposure was mainly from rice, milk and dairy products.

In Spain, highly exposed consumers are estimated to have daily intake of inorganic arsenic of about 5-18 µg, mainly from rice (63%) then vegetables and fruit (31%) and fresh fish (6%).

The US Environmental Protection Agency EPA Reference Dose (RfD) (i.e. safe exposure level) for inorganic arsenic is 0.3 µg/kg/day. The Joint Food and Agricultural Organization/World Health Organization (FAO/WHO) Expert Committee on Food Additives (JECFA) and the European Food Safety Authority (EFSA) could not identify a safe level of chronic exposure to inorganic arsenic. They concluded that it may increase risk of cancers of the skin, lung and bladder by 0.5-1% at 2-7 µg/kg/day (WHO 2011) or 0.3–8 µg/kg bw/day (EFSA 2009).

The only foods for which Codex Alimentarius has established arsenic Maximum Levels (Codex 2016) are

- Edible fats and oils 0.1 mg/kg
- Fat spreads and blended spreads 0.1 mg/kg
- Natural mineral waters 0.01 mg/kg
- Rice, husked 0.35 mg/kg
- Rice, polished 0.2 mg/kg

The focus on rice and water reflects the known high exposure from these sources.

Potential solutions

It is clear that arsenic in food is highly undesirable, and exposure should be kept as low as reasonably achievable. Reducing levels of arsenic in phosphate-based mineral fertilizers would reduce dietary exposure. There is currently no feasible technology for removing arsenic from phosphate-based mineral fertilizers, so the only solution would be to select low-arsenic sources for fertilizer production.

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