Boron (B) and water

Boron and water: reaction mechanisms, environmental impact and health effects

Seawater contains approximately 4-5 ppm boron. River water generally contains only 10 ppb. In seaweed 8-15 ppm and in mussels 4-5 ppm (dry mass) of boron was found.
Boron dissolved in water occurs as $B(OH)_3$ (aq) or $B(OH)_4^-$ (aq).

In what way and in what form does boron react with water?

Under normal circumstances boron does not react with water. However, for boron compounds may be the case. For example, the boron trifluoride ethyl ether complex reacts with water, forming diethyl ether BF_3, and releasing some highly flammable gases. A number of boron compounds, such as boron tri iodide, are hydrolysed in water.

Solubility of boron and boron compounds

Boron salts are generally well water soluble. Boric acid has a water solubility of 57 g/L, borax of 25.2 g/L, and boron trioxide of 22 g/L. Boron trifluoride is the least water soluble boron compound, with a water solubility of 2.4 g/L.
Some boron compounds, such as boron nitrite are completely water insoluble.

Why is boron present in water?

The most abundant minerals containing boron are kernite, borax, ulexite and colemanite. It can also be found in slate and in loam rich rock formations. Air-tight soil contains boron concentrations of between 5 and 80 ppm. Boron rich places, such as fumaroles, contain boric acid, borates and boron minerals. The degree of binding to clay minerals is mainly pH-dependent. Boron is released from rocks and soils through weathering, and subsequently ends up in water.
In industry the pure element is rarely used, except for metal boride production, or to improve aluminum conductivity. Metal borides are processed to for instance turbines, rocket power, containers for high-temperature reactions, and electrodes. The hardness of steel is enhanced by adding boron.
Sodium perborate is applied as a bleach in detergents. This eventually forms borate, which directly damages water plants. Borates are applied as water softeners. Other boron compounds are applied in glass, glass fibre, ceramic and email production. Glass is more solid and heat resistant when boron is added, and glass fibres are applied as insulation. Boron compounds may also be found in cleansing agents, batteries, illegal preservatives, and eye drops.
The most important compounds in this respect are borax, boron oxide and boric acid. Boric acid and borax are added to fertilizers and pesticides in large amounts. The element is also present in impregnation and wood preservatives. it is applied as an abrasive as boron carbide and boron nitrite.
Boron has a special function in a polymer matrix. It is applied to regulate nuclear reactors as a cooling agent in dangerous situations. It also absorbs neutrons in the reactor core.
Boron often ends up in soil and groundwater through domestic landfills, when these are inadequately sealed. It serves as a typical indicator compound that indicates the presence of other hazardous substances.

What are the environmental effects of boron in water?

Boron is a dietary requirement for a number of organisms, and it plays an important role in mitosis. This applies to green algae, and some higher plant species. Boron deficiencies cause growth problems and difficulties in sugar mobilization. The boron compound that is absorbed most is boric acid. Plants contain 30-75 ppm of boron (dry mass). The toxic mechanism starts at concentrations exceeding 100 ppm. This may decrease crop yield. Grass species tolerate relatively high boron concentrations, but pine species are particularly susceptible. However, trees do require large amounts of boron compared to other plant species. A tolerable boron concentration in soils is approximately 25 ppm.
High boron concentrations in water may be toxic to fish species, regarding concentrations of 10-300 mg/L. For water plants mainly borate is hazardous.
Boron is not a dietary requirement for vertebrates.
Boric acid is mildly water hazardous, but boron halogens are strongly water hazardous. Boron is averagely mobile and is transformed slowly. It may therefore spread rapidly through water.
Boron consists of two stable and fourteen instable isotopes.

What are the health effects of boron in water?

The human body contains approximately 0.7 ppm of boron, an element that is not considered a dietary requirement. Still, we absorb this element from food stuffs, because it is a dietary requirement for plants. Daily intake is approximately 2 mg. The amount of boron present in fruits and vegetables is below the toxicity boundary.
At a daily intake of over 5 g of boric acid the human body is clearly negatively influenced, causing nausea, vomiting, diarrhoea and blood clotting. Amounts over 20 g are life threatening. Boric acid irritates the skin and eyes. Skin contact with boron trifluoride may cause corrosion.
A possible correlation exists between the amount of boron in soils and drinking water, and the occurrence of arthritis among people.
Both boric acid and borax are applied in medicine in certain amounts. Neutron absorbing characteristics of boron are applied in brain tumour treatment (boron neutron capture therapy).

Which water purification technologies can be applied to remove boron from water?

Boron naturally occurs mainly as boric acid and as boric acid salts. Boric acid can be removed by ion exchangers, but very slowly, because of its resemblance to silicate.

Literature and the other elements and their interaction with water

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