Bled, Portorož, Slovenia, October – November 2011

BORON IN UNDERGROUND WATER IN THE AREA OF THE CITY OF LJUBLJANA

Renata BREGAR, Matej STEGU

Institute of Public Health of the Republic of Slovenia, Department for Sanitary Chemistry

Grablovičeva 44, 1000 Ljubljana, Slovenia; tel.: +386 1 5205 753, e-mail: renata.bregar@ivz-rs.si

Introduction

Boron is naturally occurring element widely distributed in environment. It is present in compounds in the earth's crust at an average concentration of 8 mg/kg. The most common boron containing ores are borosilicate minerals and especially alkaline earth borates, including borax ($Na4B4O2.10H2O$), kernite ($Na2B4O7.4H2O$), colemanite ($Ca2B6O11.5H2O$) and ulexite ($NaCaB5O9.8H2O$).
In aqueous solution, boron is normally present as boric acid and borate ions, with the dominant form of inorganic boron as undissociated boric acid in natural water systems. Boric acid acts as an electron acceptor (Lewis acid), accepting hydroxide from water to form $(B(OH)4)^-$ ion. In concentrated solutions (>0.1 M boric acid) polymeric species are formed.
The extent of soil adsorption depends on the chemical composition of the soil, pH, salinity, organic matter content, iron and aluminum oxide/hydroxide content and clay content. The adsorption of boron to soils can be variable and range from being fully reversible to irreversible. The greatest adsorption is observed at pH 7.5-9.0 in soils that contain high concentrations of amorphous aluminum and iron oxides and hydroxides.
Elemental boron, its carbides, halides, hydrides, boric acid and borates are widely used in different manufacturing processes and industries. This may result in their release to the environment through various waste streams. Especially boric acid and borates are used in glass manufacture, cleaning and cosmetic products, as pesticides, fertilizers, wood and leather preservatives, flame retardants, etc.

Boron is an essential nutrient for plants but can be toxic for other organisms when is accumulated in high concentrations.

Boron compounds are ubiquitous in the environment and monitoring data indicate that the general population may be exposed to boron compounds via ingestion of food and drinking water and dermal contact with consumer products containing boron compounds, such as soaps, detergents and cosmetics. The greatest exposure to boron for the general population is from food.

The daily intake of boron in a normal diet is about 10 - 20 mg/day, with the main source being fruits and vegetables. An estimated mean human exposure to boron of 14.1 mg/year was reported based on the average drinking water concentration of 25.8 µg/L. Total daily boron intake in normal human diets ranges from 2.1 - 4.3 mg boron/kg body weight/day.

Slovene legislation

According to the regulations for drinking water quality in the Republic of Slovenia the maximum permissible concentration for boron is 1 mg/l.

Experiments

Samples were collected as part of the underground water monitoring program, organized by ARSO (Slovenian Environment Agency), for the area of Ljubljansko polje and Ljubljansko barje.
Within this program there are approximately 16 sampling points in the area of the City of Ljubljana. Samples are taken two times per year (spring and autumn period).

Sampling

Samples from some monitoring boreholes were taken by Grundfoss MP 1 pump used only for underground water sampling, other samples were taken on the pipes.
Samples were stored at 4 ºC in appropriate sample containers and analyzed within 24 hours.

Analytical method

Determination of boron

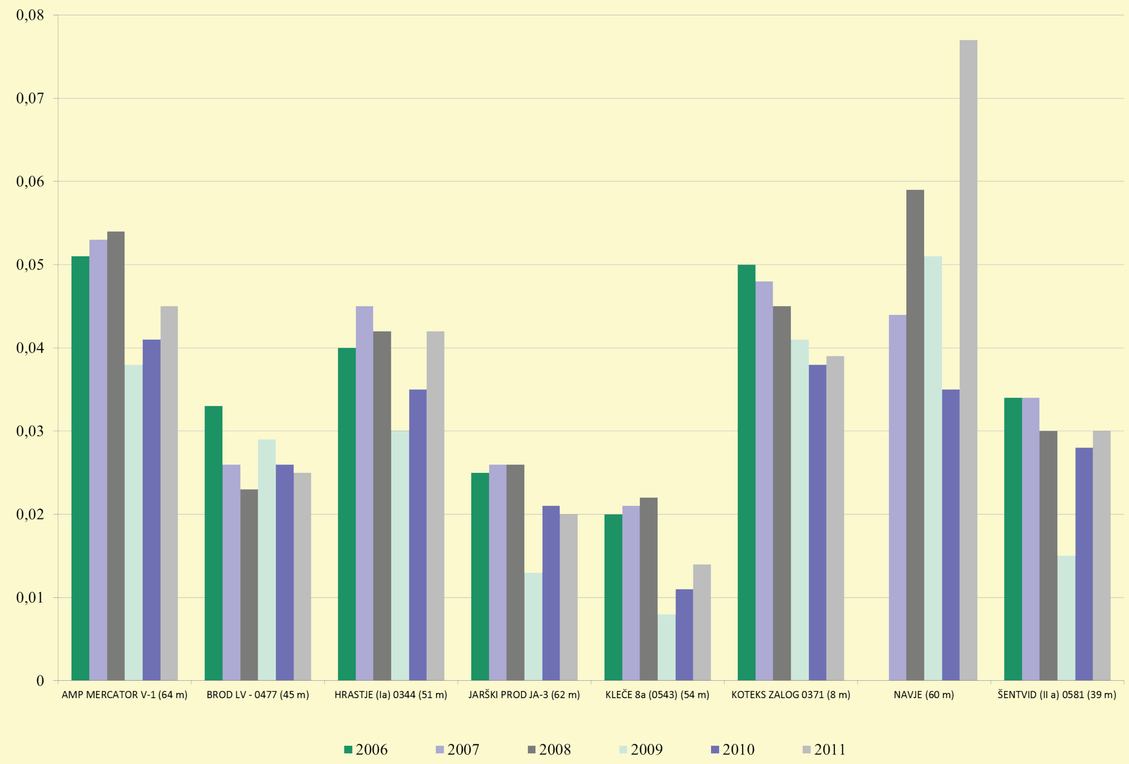
Boron in water can be determined by several methods. Most common are spectrophotometric methods. Spectrophotometric method with azomethine–H is appropriate also for colored samples and samples with non-filterable turbidity.

Apparatus

-Varian CARY 50 (1,5 cm cells)
-membrane filtration device, equipped with membrane filters with a pore size 0,45µm
-ordinary laboratory apparatus

Results

Boron concentrations in major drinking water sources for the city of Ljubljana are presented for the last 6 years.
Concentrations of boron (mg/l) in underground water for the period from 2006 to 2011 in major drinking water wells HRASTJE, KLEČE, ŠENTVID and JARŠKI PROD and monitoring boreholes BROD, KOTEKS, NAVJE and AMP MERCATOR are shown on the chart below.
HRASTJE, KLEČE, ŠENTVID and JARŠKI PROD wells are used as a direct source of drinking water for the capital.



Conclusions

As it is evident from the monitoring results, the concentration of boron in underground water didn`t change significantly in the last six years. Apart from that we are also not able to correlate the boron content with the depth of the well or season of the year.

The average concentration for individual wells ranges from 16 to 53 µg/L and can be attributed solely to natural, geological origin.

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