

Fluoride and fluorosis in Central Europe

Too much of a good thing?

by Fiona Fordyce & Bryony Hope, Edinburgh

Fluoride is one of the most abundant natural substances found on Earth and is a constituent of the rocks, soils, waters, and air that make up our planet. Like several other naturally occurring elements, fluorides can enter the human body via the air we breathe and the food and water in our diets.

Studies carried out in the USA and Europe in the 1950s demonstrated a link between improved dental health and the introduction of fluoridated toothpaste and fluoridated drinking-water to local communities. Scientists are still uncertain whether fluoride is essential to human health, but the mechanisms of dental benefaction are thought to be twofold. Firstly, teeth are formed from the calcium mineral hydroxlyapatite; during the pre-eruptive stage (i.e. during tooth formation in children up to 12 years old) fluoride can enter the mineral lattice forming fluorapatite, which is stronger than hydroxlyapatite. Secondly, fluoride acts as an anti-bacterial agent in the mouth helping to minimise acid attack on teeth.

In contrast to the possible benefits from low intakes of fluoride, health problems (known as fluorosis) associated with too much fluoride have also been widely reported. Fluoride is a powerful calcium-seeking element and can interfere with the calcified structure of bones and teeth in the human body.

Dental fluorosis is an irregular calcification disorder of the enamel-forming cells. Fluorosed enamel is porous, often

stained, and has brown pits. In its more severe form, fluorosed enamel is brittle and prone to erosion and breakage.

“... it is estimated that 25 million people suffer from fluorosis in India alone ...”

Endemic skeletal fluorosis is a chronic metabolic bone and joint disease caused by intake of large amounts of fluoride either through water or, rarely, from foods or the air in endemic areas. The bones of the human body are constantly resorbed and redeposited during a lifetime. Fluoride is a cumulative toxin, which can alter accretion and resorption of bone tissue leading to immobilisation

of the joints. Although skeletal fluorosis commonly affects older people following long years of exposure, crippling forms of the disease are also seen in children in endemic areas.

Fluoride concentrations in the environment are highly variable and are often controlled by particular types of rocks, minerals, or water. For example, endemic dental and skeletal fluorosis has been reported in the East African Rift Valley associated with volcanic rock types and thermal waters. In India and Sri Lanka fluorosis is linked to alkaline groundwaters and in China problems are associated with particular types of coal. It is estimated that 25 million people suffer from fluorosis in India alone. No effective cures are available for either form of fluorosis, however, the diseases are preventable if fluoride intake is controlled. Geoscientists have an important role to play in the identification and amelioration of problems in areas at risk.

One of the major pathways for fluoride to enter the human body is via drinking-water and in response to the potentially harmful effects of the element, the World Health Organisation (WHO) has set a drinking-water quality guideline of 1.5 milligrams per litre. In general, groundwaters contain more fluoride than surface water resources due to greater contact times with fluoride-bearing minerals.

In Central Europe, groundwater resources that exceed the guideline value of 1.5 milligrams per litre are widespread and health effects associated with high fluoride in water have been reported. The BGS is currently involved in a European Union Inco-Copernicus Programme Project (IC15-CT98-0139)

Concentration of fluoride (milligrams per litre)	Possible health effects
Less than 0.5	Dental cavities may occur
0.5 – 1.5	No adverse health effects, cavities decrease
Greater than 1.5	Mottling of teeth and dental fluorosis may occur.
Greater than 3	Association with skeletal fluorosis at higher concentrations

Fluoride concentrations in drinking-water and possible health effects
(From: Guidelines for Drinking Water Quality. 1996. WHO, Geneva)



The brown pitting and staining of teeth indicative of dental fluorosis caused by high dietary fluoride intake.

which aims to improve water quality through reduction of fluoride concentrations in groundwater. The project involves partners from the Netherlands, Moldova, Ukraine, Hungary, and Slovakia.

In rural areas of Moldova, only a quarter of the water supplies satisfy the quality standard for fluoride, which can reach concentrations of 25 milligrams per litre. Initial investigations carried out by the project medical experts in Moldova, suggest that up to 70 per cent of the population in high fluoride areas are suffering from dental fluorosis and skeletal abnormalities. In Ukraine, high concentrations of fluoride in groundwaters are associated with fluorite and phosphate mining. Water containing up to 20 milligrams of fluoride per litre is used for drinking in some areas leading to incidence of fluorosis. Problems in Hungary and Slovakia are less widespread and are mainly associated with industrial contamination, however, waters containing more than two milligrams of fluoride per litre have been reported.

The primary aim of the project is to develop water treatment and fluoride removal technologies based on locally available geological materials such as zeolites. Laboratory tests of various materials are under way and have been scaled up to field trial models for testing in the high fluoride areas of Moldova.

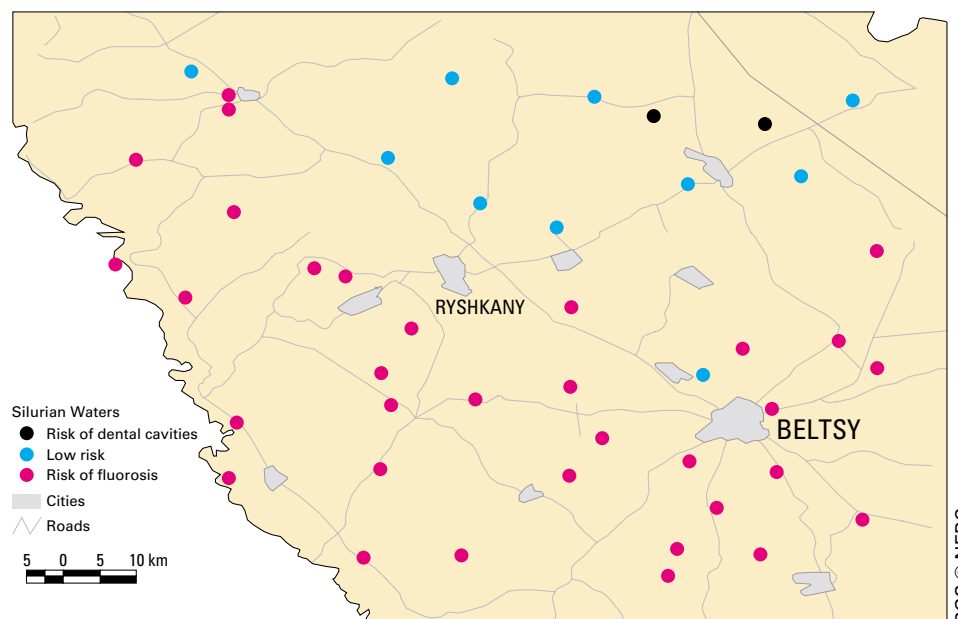
The secondary aim of the project is to develop a computer-based Geographical Information System (GIS) management tool. This will aid the identification of areas where high fluoride waters and fluorosis may be a problem, and hence where the water treatment technology should be targeted.

Geographical Information Systems have become very useful tools in recent years and allow spatial information, normally represented as several different map layers, to be combined and interrogated digitally. The development of the project GIS relies on data collected by the Central European project partners such as water quality parameters, main water supply resources, industrial sources of fluoride, fluorosis prevalence, and centres of population. Each of these factors will form a layer in the GIS and will be categorised according to the likely importance and influence of the factor on the risk of high fluoride waters and fluorosis. The layers will then be combined to produce overall risk assessment maps showing target areas for water treatment where high fluoride waters and fluorosis are likely to be a problem.

By working together in this way, geoscientists, medical scientists, and technologists can aid the identification, management, and amelioration of health problems associated with fluoride.

For further information, contact:

Fiona Fordyce,
Tel: 0131 667 1000
E-mail: fmf@bgs.ac.uk



An example of output from the GIS shows two layers of information for part of Moldova. Centres of population are shown along with the fluoride content of groundwaters from Silurian-age aquifers categorised by fluorosis risk according to the water quality guidelines given in the table (left).