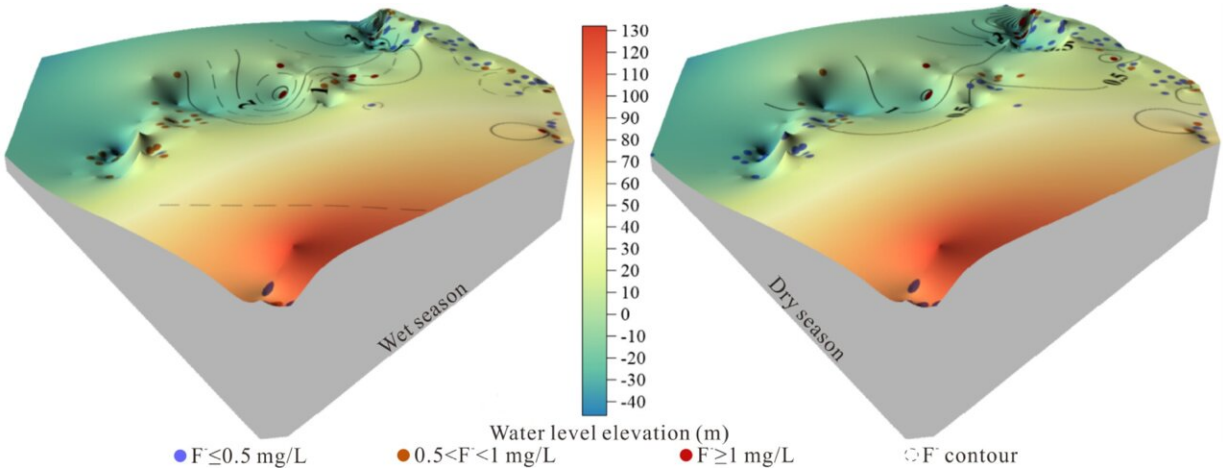
Risk assessment for fluoride in groundwater of Mihe-Weihe River Basin—a region with high fluorine content

July 14 2023



Graphical abstract. Credit: *Frontiers of Environmental Science & Engineering* (2023). DOI: 10.1007/s11783-023-1670-8

Due to the unclear distribution characteristics and causes of fluoride in groundwater of Mihe-Weihe River Basin (China), there is a higher risk for the future development and utilization of groundwater. Based on the systematic sampling and analysis, a team of researchers from Shandong University of Science and Technology studied the distribution features and enrichment mechanism for fluoride in groundwater by the graphic method, hydrogeochemical modeling, the proportionality factor between conventional ions and factor analysis.

Their analysis is published in the journal *Frontiers of Environmental Science & Engineering*.

Fluorine is one of the essential trace elements for human beings and has a positive effect on metabolism, playing a role in preventing diseases. However, long-term overtaking by fluoride can destroy the enzymes needed for vitamin metabolism; fluoride can not only damage our bones but also lead to the degeneration of brain tissue, the kidney and the central nervous system, which is known simply as "fluorosis."

Fluorine can go in the humans by potable water, food and air, but the absorption rate in each medium is different. The fluorine in drinking water can be digested and absorbed by most of the human body, so drinking high-fluorine water is the major cause of "fluorosis."

At present, global water resources are facing an extreme shortage, which has caused shallow groundwater to be gradually exploited as a drinking water source in many countries and regions, especially in the arid and semiarid northern regions of China. Currently, greater than 70% of drinking water is supplied by shallow groundwater. Groundwater plays a vital role in supporting the benign development of the ecosystem and maintaining the basic living security of human beings.

However, with the rapid growth of industry and agriculture, especially the continuous acceleration of urban construction and the continuous improvement of industrialization, the pollution of shallow groundwater is becoming increasingly severe. In particular, the fluorine content in a large area exceeds the standard, which seriously threatens human health.

Therefore, clarifying the distribution features and enrichment mechanism for fluorine in groundwater is the basis for solving drinking water problems in fluorosis-prone areas and is also one of the important tasks for treating endemic fluorosis.

The Mihe-Weihe River Basin is a region with a high fluorine content in the groundwater of Shandong Peninsula in China and is part of the endemic fluorosis area due to long-term overtaking by high-fluorine water. The residents have been severely affected by high-fluorine water for a long time, so it is a key area for the prevention and control of endemic fluorosis in Shandong Province.

The standard (GB17018-1997) for the classification of endemic fluorosis is that the fluorine content is greater than 1.0 mg/L, which indicates a low-incidence area; a fluorine content greater than 2.0 mg/L indicates a moderate incidence area; a fluorine content greater than 4.0 mg/L indicates a severe-incidence area.

Based on the investigation of the fluorine content in drinking water, there were 34585 drinking water sources in the basin, and an average of 6–7 households had one well, of which 562 wells were identified as high-fluorine water sources (high incidence area); these wells led to 550000 victims, accounting for 55.9% of the total population; 238 water wells were identified as moderately diseased water sources (medium-incidence area), accounting for 42.35% of the total number of diseased areas.

Based on the investigation of endemic fluorosis, 4520 children 8–12 years old and 2002 patients had dental fluorosis, with a prevalence rate of 44.3%. There were 36802 adults over 16 years old and 700 patients with skeletal fluorosis, with a prevalence rate of 1.9%. The enrichment of fluoride in groundwater poses a great threat to the survival of local residents and the sustainable development of the economy.

But now there is a lack of research on the migration and enrichment of fluorine in shallow groundwater in the Mihe-Weihe River Basin, as well as the evaluation of environmental quality and human health caused by fluorine pollution. The negative effects of fluorine pollution in shallow groundwater are not clear. The work of Professor Peihe Zhai's team fills

this gap.

In this study, the research team found the groundwater in the Mihe-Weihe River Basin is characterized by high TDS and weak alkalinity, and fluoride concentration in groundwater is generally on the high side, with a large area of medium-fluorine water (0.50 mg/L–1.00 mg/L). High-fluorine water is mainly in the northeast (interfluvial lowlands and alluvial-marine plains), which is HCO_3·Cl-Na- and HCO_3-Na-type water.

In vertical direction, fluoride concentration decreases as the buried depth of groundwater level increases. Fluorine richness in wet season is chiefly controlled by rock weathering and the dissolution of fluorine containing minerals, and the weak alkaline environment, rich in sodium and poor in calcium, is the main reason for fluorine richness in dry season.

Contamination assessment results suggest that groundwater is severely polluted in the northeast of Mihe-Weihe River Basin, and wet season > dry season. There are fewer ecological risks, but the health risks for adults and children should be paid attention to, especially in Weihan and Changyi water source areas during wet season.

The work of preventing fluoride and improving groundwater quality in the Mihe-Weihe River Basin has been developed in a scientific and rational direction, and the methods for exploitation, utilization and management, suitable for the local situation, has become an important research content.

The results of this work can not only provide a scientific basis for the sustainable utilization of local groundwater resources and the improvement of the water quality, but have great guiding significance for the treatment of fluorine pollution in local shallow groundwater and the regional environmental planning.

More information: Xingyue Qu et al, Distribution, enrichment mechanism and risk assessment for fluoride in groundwater: a case study of Mihe-Weihe River Basin, China, *Frontiers of Environmental Science & Engineering* (2023). DOI: 10.1007/s11783-023-1670-8