Selenium Deficiency and Endemic Heart Failure in China: A Case Study of Biogeochemistry for Human Health

A PECULIAR DISEASE

In 1937, a terrible disease of heart failure was reported in some rural areas in Heilongjiang, a far northeastern province of China. Women and children were its primary victims. The disease frequently occurred without warning and led to the death of a large number of people. The major symptom of the disease was myocardial necrosis, which led to acute hypoxia, vomiting, and finally death in several hours. Preliminary investigations were conducted in the late 1930s and 1940s but biotic infecting agents could not be identified. The peculiar disease was then named after the county, Keshan, where the first cases of death from the disease were reported. Since then, Keshan disease was found in another 12 provinces across China between the 1940s–60s. About eight million people lived in the affected areas in the country during that period of time, and thousands of people died of Keshan disease every year. The disease was so severe that a special government office was established to coordinate the nationwide efforts against the disease in the 1950s.

In the 1950s and 60s, large-scale epidemiological investigations were launched in the provinces affected by Keshan disease, including Heilongjiang, Jilin, Liaoning, Hebei, Shandong, Henan, Inner Mongolia, Shanxi, Shaanxi, Gansu, Sichuan, Yunnan, and Tibet.

A variety of biotic or abiotic factors, such as indoor carbon monoxides, nitrite in drinking water, parasites, fungi or bacteria in the local diet, etc., were considered during the investigations. The campaigns did not prove any of the factors related to the incidence of Keshan disease with convincing evidence. However, the nationwide investigations demonstrated that Keshan disease occurred within a geographic belt stretching from the northeast to the southwest of China. In some places, the affected and unaffected areas had clear boundaries. It was not uncommon to see two adjacent villages differing in disease status substantially and constantly for decades. Through the field investigations, the possibility that Keshan disease was an infectious one was excluded. The striking spatial distribution of Keshan disease implied that there could be some geographic or geological factors causing the disease. In fact, the local villagers whose families had lived in the affected areas for generations insisted that the disease was caused by the local “soil and water.” A number of medical researchers started looking in a new direction, the geochemical environment. In 1966, Dr. Haijiang Cai, one of the pioneer medical researchers studying Keshan disease in China, declared “We must team up with the geologists who are interested in the medical issues.”

THE WUYUR RIVER WATERSHED Prototype

In the winter of 1967, a group of eight young scientists from the Institute of Geochemistry, Chinese Academy of Sciences, were organized to respond to the call of the medical researchers. Realizing that the major challenge for the Keshan disease study was how to explain the peculiar spatial distribution of the disease, the new team oriented their focus on the geochemical patterns of the areas affected by Keshan disease. To implement their research strategy, the team selected Keshan County in Heilongjiang Province, the origin of Keshan disease, as their first study area. By teaming up with the local medical doctors, this group conducted a thorough field survey by literally walking across the entire county in 1968. They visited almost all the villages in the county, obtaining information on the incidence of Keshan disease as well the local environmental conditions. Soil and drinking water samples were collected from each of the villages for chemical analysis. The investigation resulted in a map of multiyear cumulative deaths from Keshan disease, with the chemical composition of the drinking water and soils at the village level described for the county. The map demonstrated an interesting pattern of Keshan disease in its geographic distribution in the county. The villages heavily affected by Keshan disease were mostly located in the central part of the county with hilly terrain; in contrast, the villages located along the river valleys along the northern or southern edge of the county had few cases reported during the previous decades. Field investigations indicated the topographic and soil conditions in the central part of the county were favorable for leaching, a geochemical process leading to a loss of dissolved salts or elements from the soils. The observation was supported by the results from the chemical analysis of the soil and water samples. The mineral contents in the drinking water samples collected from the affected villages were significantly lower than those from the unaffected villages. A hypothesis emerged from the investigations that Keshan disease could be caused by a deficit of a chemical or chemicals that are essential for human health and exist in soluble or leachable forms in the soils (1).

To test the hypothesis, the field investigation was expanded from Keshan County to the Wuyur River watershed in 1969–1970, within which Keshan County was located. Wuyur River is an interior river with a length of about 300 km. The river begins in Beian County in the foothills of the Xiao-Xinganling Mountains; flows to the southwest across Kedong, Keshan, Yian, Fuyu, and Lindian counties; and finally ends in the low-lying plains in Durbat County (Fig. 1). As an interior river, the Wuyur River doesn’t have a coastal outlet; this implied to the researchers that the chemical elements could be transported only within the watershed. If some elements were lost in the soils of the upper stream, they should accumulate in the soils downstream. The Wuyur River watershed provided an ideal domain to test the hypothesis of the relationship between Keshan disease and geochemical leaching. If the areas affected by Keshan disease were characterized with losses of certain soluble elements, it would be very interesting to find out the incidence of Keshan disease in the areas where these elements were deposited downstream.

To complement the investigation of the Wuyur River watershed, the research team was enhanced by involving more medical researchers from the Harbin Medical University, the Institutes of Endemic Diseases of Heilongjiang, and the Institute of Labor and Food Health in the Chinese Academy of Medical Sciences. During the coupled epidemiological and geochemical survey, historical incidence data for Keshan disease were collected and verified at the commune (a cluster of villages)