Environmental Geology (1995) 26: 64–67

T. Jie · L. Nianfeng

Some problems of ecological environmental geology in arid and semiarid areas of China

Received: 20 September 1994 / Accepted: 28 December 1994

Abstract Arid and semiarid areas are widely distributed in China but rich in natural resources. Because of the arid climate, complex geological conditions, and human activities, some problems of ecological environmental geology occur, such as lack of water resources, desertification, salinization, and biogeochemical endemic diseases, etc. These problems occur in fragile regions of the environment, seriously restricting the developing of the national economy and causing harm to human health. Ecological environmental geology is a new developing science in China. Through the research of ecological environmental geology and with the help of research results of the western plain of the Tarim Basin in Xingjing, we propose a comprehensive administrative measure of ecological geological environment on the basis of rational utilization of water resources, and it can be used to improve the ecological environment of arid and semiarid areas.

Key words Arid · Semiarid · Ecological environmental geology · Comprehensive administration

General situation of ecological environmental geology in arid and semiarid areas of China

China is one of the countries in the world in which arid and semiarid areas are widely distributed and geological conditions are very complex (Fig. 1). From the west end of the Big Xingan Mountain in the northeast of China to the northwest frontier, this area is a long narrow belt 4000 km long and 600 km wide located between north latitude 35° and 50° and the east longitude 75° and 125° (Shuji 1989). It rinks up the arid areas in the former Soviet Union and in Mongolia, forming an arid zone in the middle Asia in latitudinal direction.

There are rich natural resources of water, soil, and living things and abundant sunlight and heat that benefit growing plants. According to statistical data, the cultivated area is 3,789,000 ha and the uncultivated area is 10,675,000 ha. The grassland is 100,082,000 ha and the forest is 3,042,000 ha (Shuji 1989). There are also abundant mineral resources, such as salt, asbestos, barite, some metals—Ni, Pu, Nb, Ta, etc.,—and oil, natural gas, and coal. There are rich oil reserves under the desert in Taklamkan and its reserves exceed the total amount of Kuwait.

The agriculture of this area relies on irrigation. Secondary salinization is very serious affecting about 60%–80% of the total cultivated land (Guangzhong 1985). The desert is a typical natural landscape in this area and is widely distributed from east to west, totaling about 730,000 km^2. These areas lack good drinking water but saline water, bitter water, and high flourine water are widely distributed. In addition to serious pollution, the biogeochemical endemic diseases are threatening human health.

In the past 30 years, because large increases in population and irrational development of water, soil, and biotic resources, the ecological balance has been violated. This has not only affected the economic development but will seriously endanger human life in the future. However, arid and semiarid areas in China have great advantages in environment and resources and have great potentialities in developing the economy. Thus, studying and solving the problems of ecological environmental geology have important theoretical value and practical significance.

Lack of water resources

The arid areas in China were formed due to air currents on the earth, the distribution of land and sea and latitudinal geological structures of China, and as a result of the

T. Jie (✉) · L. Niangfeng
Division of Ecological Environmental Geology,
Department of Hydrogeology and Engineering Geology,
Changchun University of Earth Sciences, Changchun,
Jilin, P. R. China

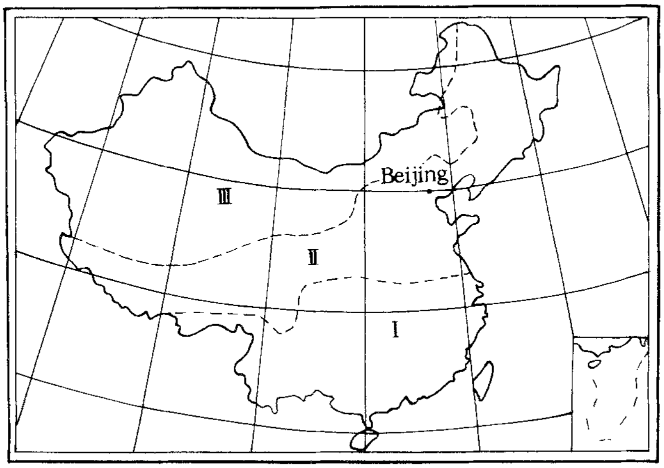

Fig. 1 Climatic zones in China: I, moist zone; II, transition zone; III, arid and semiarid zone

reaction among the climate, geography, and geological structure in this area.

The aridity in this area is related directly to the amount of water resources and precipitation. The precipitation in arid areas is reduced from east to west. For example, the precipitation is approximately 200 mm in the east of Inner Mongolia, 15–180 mm in the Caidamu Basin, and 10–17 mm in the Tarim Basin (Shuji 1989).

Aridity and lack of water are natural phenomena, but significant quantities of water are wasted by improper human activities. All this results in even more serious water shortage. River water diversion, reservoir building, and a large amount of irrigation cause the increase of water evaporation (water and soil surface) and leakage. Limited surface water decreases on the upper and middle reaches or even dries up, but abundant groundwater resources have not been sufficiently developed.

Desertification

Desertification is a special geological and geomorphic landscape in arid and semiarid areas. It is a great enemy of human survival and has characteristics of quick development, great harm, and is irreversible.

Owing to the great increase of population, lack of water resources, and destruction of biological resources by humans, the desertification rate becomes faster. Deserts of the world are expanding at the rate of 60,000 km^2 yr^{-1} (Geping 1989) desertified lands amount to 45,600,000 km^2 (Nianfeng and Jie 1991). Sixty-four countries are facing desertification and two thirds of them are in Asia.

Desertification is very serious in China: areas have increased 39,000 km^2 for 30 years, from 137,000 km^2 in the 1950s to 176,000 km^2 in the 1980s, with an average of 1300 km^2 yr^{-1} (Wenkang 1986). According to the United Nations calculation, by the year 2000 desertification will have caused a great disaster in the world if it keeps on expanding at the present speed.

Desertification occurs mainly in the environment of aridity, winds denuding the land surface, and abundant sand. Its speed of development may be increased by human activities. For example, the average runoff of the Tarim river in the 1950s was about 5,000,000,000 m^3 yr^{-1}, but now is no more than 300,000,000 m^3 yr^{-1} in downstream reaches because of the diversion of river water, the decrease of water resources, or even drying up (Nianfeng and Jie 1992). This has caused the diminution of the grassland and forest belt and resulted in desert encroachment in the area. Deserts may submerge fields, decrease cultivated areas, reduce fertility of soils, submerge roads, stop traffic, pollute the environment, and harm human health. The total loss to desertification is about 0.5 billion Yuan per year in China (Nianfeng and Jie 1991).

Desertification is irreversible, but it can be prevented. As long as we develop and make rational use of water resources, plant trees, and set up ecological protective screens, desertification can be controlled.

Secondary Salinization

Secondary salinization is a worldwide problem of ecological environmental geology. About 55% of the total world land is distributed in the arid and semiarid areas, where, typically, irrigated agriculture is developed (Guangzhong 1985). Secondary salinization is a very serious problem in China also. It has characteristics of wide distribution, quick development, and great harm. Salinized soil is mainly distributed in large irrigated areas and is about 50%–60% of the irrigation area (Guangzhong 1985).

The main reasons for secondary salinization are irrational irrigation, imperfect diversion, and discharge of water works. The groundwater level is raised during the diversion and irrigation processes and exceeds the critical depth of evaporation. Because of the constant evaporation of groundwater, salt in groundwater is greatly accumulated at the surface (Peck 1975). Destruction of forests and grassland for cultivation and the diminishing of vegetation cause the change of evapotranspiration into ground surface evaporation. This is another important reason for secondary salinization. Economic damage due to secondary salinization is very great. For example, the damage in the Kashi plain of Xinjiang has amounted to about 1.9 billion Yuan for 30 years (Nianfeng and Jie 1992).

Controlling the groundwater level and degree of mineralization in irrigated areas and increasing the vegetation cover are effective measures to prevent and cure salinization.

Biogeochemical endemic disease

Abundant salt and some trace elements are accumulated in the surface water or groundwater in a specified geological and geochemical environment. It may cause serious

Table 1 Average content (ppm) of chemical constituents in water samples in Jashi disease area

	n	Na	Ca	Mg	SO_4	Sr	Zn	Mn
River	15	213.75	225.16	77.75	782.94	2.8132	0.0085	0.0145
Reservoir	3	640.98	359.83	152.28	1559.94	3.8666	0.0057	0.0130
Well	30	133.64	113.22	40.67	433.35	2.7108	0.2176	0.0658

spread of some biogeochemical endemic diseases. $MgSO_4$ is the most harmful among the salts, and it can cause digestive system disorders and diarrhea in humans or animals. Flourine has the widest distribution and the highest content among the trace elements, and sometimes As, Se, Sr can also be accumulated. When people drink this kind of water, they may suffer from some endemic diseases.

Endemic fluorosis is the most widespread and serious problem. Arsenism has been discovered in Inner Mongolia and Xinjiang province in recent years. Arsenic content is about 0.01–1.86 mg l^{-1} in groundwater in arsenism areas (Nianfeng 1991). We are studying the relations among the arsenic species [As(III), As(V)], arsenic methylation, and arsenism. In addition, Jashi disease, endemic sterility, is another special biogeochemical endemic disease. The content of $MgSO_4$ is high and Na, K, Sr are also abundant in the drinking water in disease areas, but Zn and Mn are obviously lower (Table 1) (Nianfeng and Jie 1992). When people change drinking water or migrate to another place with good water, this disease can be alleviated and they are no longer sterile.

The spread of biogeochemical endemic disease is a major problem worldwide. Our research has been conducted on geochemistry and human health for a long time and much progress has been made.

Comprehensive protection and harnessing of the ecological geological environment

Drought, salinization, desertification, and endemic diseases are major problems of the ecological geological environment in the arid and semiarid areas. They take place among the same ecological environmental system and interact on one other. These problems are serious in the fragile regions of the ecological geological environment.

A weakened ecological environment has been maintained by limited water resources. Once the water resources crisis occurs, the ecological system will be damaged or even destroyed. The grabbing of biotic resources by mankind may cause some natural disasters.

Men have struggled against natural calamities for a long time, but the consequence is usually protection of the small ecological environment but damage or sacrifice of the big ecological environment.

Ecological environmental geology, adopting the newest theories of environmental geology, environmental ecology, environmental chemistry, environmental medicine, environmental sociology, and the principles of information theory and systematic engineering, and applying modern computer techniques, allows systematic study and the comprehensive harnessing of the ecological environ-

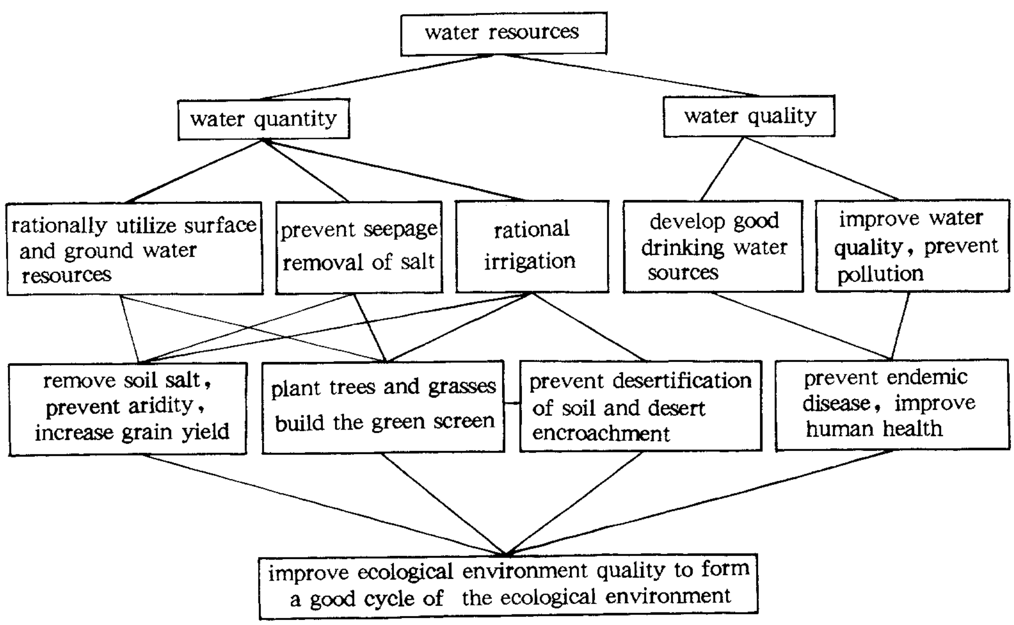

Fig. 2 Measures for comprehensive administration of ecological environment in the western plain of Tarim Basin in Xinjiang

ment being considered as a big system, so that the greatest economic, social, and environmental benefit can be gained with less investment. This is the practical value of ecological environmental geology.

The ecological environment in arid and semiarid areas is complicated and differs from place to place, and there is not a uniform study and administration model. Taking the ecological environment in the western plain of the Tarim Basin in Xinjiang as an example, we propose a comprehensive administrative strategy (Fig. 2) (Nianfeng and Jie 1992). From Fig. 2 we can see that we must pay great attention to the key factor of water resources in arid and semiarid areas. On the basis of rational development, synthetical utilization, and scientific administration of water resources, we can further adjust the proportion of farming, forestry, and animal husbandry and determine the growth rate of the population and the scope of economic development in terms of the quantity of water resources. We must also persist in comprehensive administration of ecological environmental measures, such as building grasslands, and planting trees, so that ecological environmental quality can be improved.

References

Geping Q (1989) Environmental problems and countermeasure in China. Beijing: China Environmental Science Publishing House. pp 342–344

Guangzhong S (1985) Secondary salinization of irrigated land in arid and semiarid region and its preventive management. J Plain Dev 3:1–4

Jianyou S and Guangrong D (1989) Harm of desert. J Arid Land Geogr Vol. 12(1):43–47

Nianfeng L (1991) Medical environmental geochemistry. China Changchun City: Jilin Science and Technology Publishing House. 177–200

Nianfeng L and Jie T (1991) The desertification hazard and its protection and remediation strategies in western Tarim Basin of China. Proceedings of Beijing International Geological Hazards Symposium, pp 473–479

Nianfeng L and Jie T (1992) Comprehensive study of ecoenvironmental geology in the western plain of the Tarim Basin in Xinjiang. China Changchun City: Jilin University Publishing House. pp 122–239

Peck AJ (1975) Development and reclamation of secondary salinity. Australia Brisbane City University of Queensland Press. pp 301–317

Shuji W (1989) Arid land geography research to our country in restrospect and the tasks ahead. J. Arid Geography, Vol. 12(4): 1–9

Wenkang H (1986) Ecological balance and the environment strategy of Xinjiang. J Arid Zone Re Vol. 12(2):14–20

Zhenda Z, Zheng W, and Shu L (1980) Introduction of desert in China. Beijing: Science Publishing House. 84 pp