The Status and Disaster Losses of Seawater Intrusion in Kiaochow Bay Region

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Abstract: By analyzing the history about seawater intrusion of the Dagu river estuary, Baisha river estuary, Yang river estuary and Xin'an region, we study the seawater intrusion in Kiaochow Bay region. With the content of Cl^- 200mg/L, 250mg/L, 300mg/L in groundwater as main index, we divide Kiaochow Bay region into four parts: non-seawater intrusion region, the slight one, the more serious one and the severe one. And we can conclude that the most serious seawater intrusion region is the river estuary, it will be gradually less serious in backland and two banks of rivers. We estimate the direct economic of the seawater intrusion region.

1 INTRODUCTION

Human long-term remaking nature and developing economy, destroyed the natural environment of relative balance(Cao B X, 1995). Excessive exploitation of water resources makes the situation of the water resources and ecological environment is becoming more and more serious. Almost all coastal areas are densely populated areas. A large amount of water demand has caused great pressure on groundwater resources, and excessive exploitation of groundwater has become more serious. In Europe, there are at least 100 areas affected by seawater intrusion effect(Scheidleger A, 2004); such as the Netherlands, have the enough fresh water resources from the river and the atmosphere, but more than 20 wells forced to close by the action of seawater intrusion in the past few decades(Freedman V and Ibaraki M, 2002; Stuyfzand P J et al, 2004).

Kiaochow Bay is the mother Gulf of Qingdao, is located in the south of Shandong Peninsula, also known as the Jiaoao. There are the Nanjiao River, Dagu River and other rivers flow into the Kiaochow Bay. The seawater intrusion of Kiaochow Bay region originated in the 1970´s, which has been developed for several decades, and the scale of invasion has been increasing(Luan X M et al, 2009).

2 DEFINITION OF SEAWATER INTRUSION

Xue Yuqun gives the definition of seawater intrusion from the perspective of its mechanism and evolution(Xue Y Q et al, 1992): if the groundwater was pumped more than recharged it, when the groundwater head of the coastal zone decreases to below the head of the sea water, the interface between salt water and fresh water is going to be pushed to the land until a new balance is formed, that is the seawater intrusion. Wang Bingchen gives the definition of seawater intrusion from the angle of influence(Wang B C, 1995): seawater intrusion is a natural phenomenon due to the decline of the groundwater level in land caused seawater intruding to the aquifer in the coastal areas. Jiang Jiali analysed seawater intrusion from the angle of inducement(Jiang J L, 2002): in the coastal areas, over exploitation of groundwater leads to groundwater depth decline, then the dynamic balance of salt water and fresh water was destroyed, that the groundwater is directly invaded by the sea water.

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3 RESEARCH AREAS AND METHODS

3.1 Research Area

Shandong province and Qingdao city carried out the strategy of protection and development surrounding the Kiaochow Bay Region. Within all variety of geological hazards which exist in Kiaochow Bay region, seawater intrusion is of the largest scale, the most influential and the most serious hazard losses. Therefore, study area includes the West of Shinan District, the old port area, the West of Sifang District, Hongdao area, Shaohai of Jiaozhou city, Huangdao eastern regional area, that the total area is about 500km^2.

3.2 Research Methods

We get the newest seawater intrusion data of the content of Cl^- and other chemical composition in groundwater, which corresponds to a hydrological year's. With the different content of Cl^- as main standard of the seawater intrusion degree, we divided Kiaochow Bay region into serious parts. We evaluated the disaster loss of seawater intrusion by the mathematical methods.

4 TYPICAL SEAWATER INTRUSION AREA

The seawater intrusion of Kiaochow Bay coastal areas began in the 1970's, and the start time and the process of development are different in the different shore section, the interannual change and the influence factors are different also, and take prevention measures of seawater intrusion also varies. Typical seawater intrusion area includes four shore section of Dagu River downstream, Baisha River downstream, Yang River downstream and Huangdao Xin´an area.

4.1 Downstream of the Dagu River

In the downstream area of Dagu river has large distribution of salt water. Its marine silt sediment layer has been extended to Lancun of Jimo North. Since 1981 developed the groundwater of Dagu River downstream to supply the Qingdao city, Ligezhuang area has formed groundwater drawdown funnel about 100km^2, and the lowest groundwater level -8.18m in the center, caused seawater intrusion gradually in the southern and southeastern. At the same time, because the poor management of Nanzhuang Dongfeng gate in the downstream of the Dagu River, resulting the seawater traced back to Hejiazhuang village, and distance estuary up to 12km. Because of groundwater level is lower, seawater intrusion is very favorable, resulting in groundwater quality deteriorated significantly along both banks of the river, compared to 1988 and 1981, the front of seawater intrusion carried about 750m, the effect area is 3km^2. After 1990, with the water conveyance project from the Yellow River to Qingdao city, the amount of groundwater exploitation reduced, and precipitation increased than the 1980s, the high water period of funnel does not occur again after 1994. In 1997, the engineering of underground seepage prevention curtain wall has constructed in Xiaomawan, salt water not to expand. overall, the Cl^- concentration and salinity have downward trend. During the extremely dry years of 2002, downstream of the Dagu River seawater intrusion area did not change much due to take measures in advance. After 2004 and 2005 years, the groundwater has supplied, seawater intrusion trend slowed down significantly, groundwater quality has the signs of recovery. But near the Ligezhuang area of seawater intrusion, the exploitation area of groundwater is mining, the water supply capacity is reducing, so that residents using water is difficult.

4.2 Downstream of the Baisha River

Baisha downstream is the groundwater source area near Qingdao city. Its aquifer is the alluvium and diluvium of the Baisha River, and has excellent quality water in the 1960s. In the 1970s, groundwater overexploitation, underground water level gradually decreased, that caused seawater intrusion. In 1984, it has formed groundwater drawdown funnel about 25km^2, and the lowest groundwater level -9m in the center. So it became the earliest and most harmful area of seawater intrusion in Qingdao city. In the middle of the 1980's, the seawater intrusion area reached 8.5km^2. Until 1985, under the influence of the ninth Typhoon, the seawater intrusion has eased, and then continued to develop slowly. It is the abundance of groundwater in 1990, the groundwater funnel were pacified, and groundwater exploitation amount is reduced, to compensate the groundwater, seawater intrusion area stepped back a little. It is extremely dry year in 2002, seawater intrusion increased, some villages disaster is very serious, such as Qianhaixi village is completely surrounded by salt water, near

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the little water can be drunk. As the vegetable planting base of Qingdao, seawater intrusion caused vegetable cannot grow, that yield 70%, grain also significantly cuts or even, a large number of wells scrapped.

4.3 Downstream of the Yanghe River

The groundwater exploitation in downstream of the Yanghe River based on agricultural water supply, and the area is five small river estuary (also known as the "five river estuary "). Seawater along the river upstream, caused seawater intrusion, the intrusion area has occurred large area of grain production and wells scrapped phenomenon.

4.4 Downstream of the Xin'an River

Seawayer intrusion area is located in Xin'anhe River downstream estuary, and the distance to the coast nearest less than 500m. Because of the mining amount greatly exceeds the natural recharge in the 1980s, the water level drops quickly, the lowest water level elevation is -3m, leads to seawater intrusion. Since the beginning of 1986, the distances of seawater intrusion is 600m or so. The amount of the mining is reduced gradually until the total is stopped.in 1986 ~1995 years, At present, there are some phenomena such as land salinization, farmland damage, rural water use difficult and so on. Now surface water is the main supply source, the trend of the intrusion of sea water has been contained.

5 DISTRIBUTION CHARACTERISTICS OF SEAWATER INTRUSION

5.1 Status Survey

Seawater intrusion is affected by human factors, is due to the over exploitation of groundwater, saltwater and freshwater interface changed, seawater intrusion into freshwater aquifers, form the disaster. So the range and distribution of seawater intrusion is in constant change. Through the investigation of the current situation of the seawater intrusion in a hydrological year, we can get the latest data of intrusion.

A total of 544 groundwater samples were collected. In the sample collection process, we also investigate the water intake point information, such as the landscape, environment, mining methods and others.

Samples were collected by successive encryption sampling method, a total of three times. First, 220 groundwater samples were collected in the region, according to the results of laboratory tests to understand the overall situation of water quality. Then according to the distribution of Cl^- content, in the distribution of the 200mg/L, 250mg/L and 300mg/L boundary lines are encrypted 200 samples. Finally, according to the results of the previous two analysis, we selected the key and the typical section to collect 124 samples. So there are two purposes. One is to fill some of the sampling area by the supplementary sampling in the study area. Two is a better analysis of the characteristics about the current situation of seawater intrusion through the targeted encryption.

5.2 Status Characteristics

According to the results of Cl^-, we used the Excel software and Surfer software to generate the equivalent line automatically. Isoline map and MapGIS map were corrected, and the Cl^- content said in a location map.

With the content of Cl^- 200mg/L、250mg/L、300mg/L in groundwater as main index we divide Kiaochow Bay region into four parts: non-seawater intrusion region, the slight one, the more serious one and the severe one. And we can conclude that the most serious seawater intrusion region is the river estuary of Dagu river, Baisha river and Yang river and Xin'an region of Huang island, it will be gradually less serious in backland and two banks of rivers.

5.3 Seawater Intrusion Area

The invasion area was low, the ground elevation is generally less than 10m. The formation is the Quaternary sedimentary layer. According to the different geographical position, from the coastline to the Cl^- concentration of 250mg/L, we can get the area ratio of the affected area of the seawater intrusion.

Dagu River downstream region of seawater intrusion affected area is the largest, accounting for main intrusion zone 46%. Followed by Baisha downstream, the Yanghe River downstream area, and the area of seawater intrusion in Huangdao area is the smallest, which accounts for 9% of the main invasion area. The area of seawater intrusion is

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related to the regional hydrogeology, groundwater utilization and exploitation.

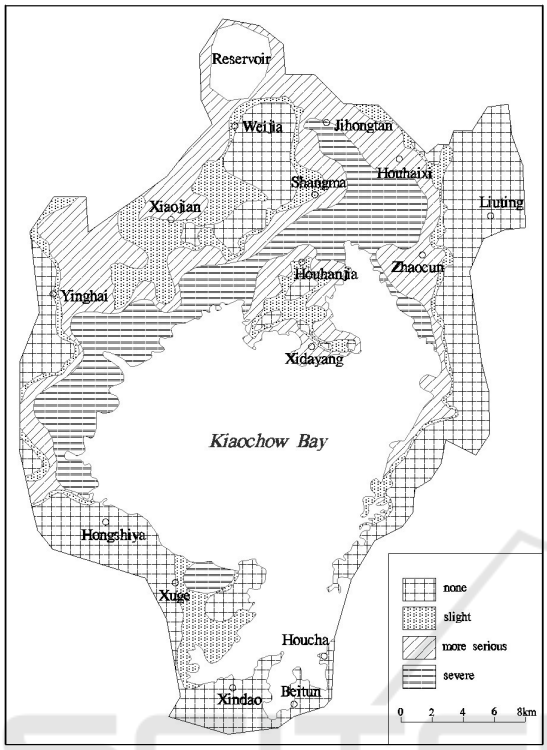

Figure 1: Distribution of seawater intrusion area in the Kiaochow Bay region.

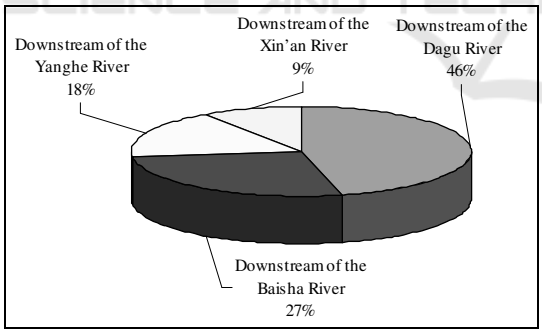

Figure 2: Percentage of major seawater intrusion area.

6 LOSS OF SEAWATER INTRUSION DISASTER

The seawater intrusion is a geological disaster of slow degeneration, which has a wide distribution area, which is often not easy to cause people's attention, but the economic loss caused by it is huge (Li P et al, 2004). The seawater intrusion area of Kiaochow Bay is mainly in the farmland and vegetable planting area, the seawater intrusion has destroyed the underground fresh water resources, which has brought the extremely disadvantageous influence to the agricultural production. Due to differences in lots of different soil texture and cultivated species, it is difficult to accurately calculate the seawater intrusion disaster loss. But according to the value of agricultural production caused by seawater intrusion, agricultural production was more than 15% in the concentration of Cl^- at 250mg/L~300mg/L area, and agricultural production was more than 35% in the concentration of Cl^- higher than 300mg/L area.

In the Kiaochow Bay region, the concentration of Cl^- at 250mg/L~300mg/L area is 114.5km^2, and the concentration of Cl^- higher than 300mg/L area is 73.5km^2. The normal agricultural output of Kiaochow Bay coastal areas is 4.5 million yuan/km^2.

Then in the area of the concentration Cl^- at 250mg/L~300mg/L, agricultural production loss:

114.5km^2 × 4.5 million yuan/km^2 ×15%=77.29 million yuan

And in the area of the concentration Cl^- higher than 300mg/L, agricultural production loss:

73.5km^2 × 4.5 million yuan/km^2 × 35%=115.76 million yuan

The sum of these two is the total disaster loss, that is to estimate the direct economic losses caused by seawater intrusion in the Kiaochow Bay region every year, about 193.05 million yuan.

7 CONCLUSIONS

With the content of Cl^- 200mg/L、250mg/L、300mg/L in groundwater as main index, we divide Kiaochow Bay region into four parts: non-seawater intrusion region, the slight one, the more serious one and the severe one. And we can conclude that the most serious seawater intrusion region is the river estuary, it will be gradually less serious in backland and two banks of rivers.

We have evaluated the economic damage caused by the seawater intrusion in the Kiaochow Bay region, which is 193.05 million yuan every year.

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APPENDIX

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