Analysis of soil salinization and influence of groundwater depth in the north of Shandong Marine Plain

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Abstract. The present situation of Soil Salinization in the marine plain area of North Shandong Province is classified according to the content of salt, and the influence of groundwater depth on soil salinization is analyzed, it is determined that 5.5-6.0 m before and 3.0-3.5 m after flood season are the "reasonable depth of groundwater".

1. Introduction
Soil Salinization has a great influence on agricultural production in the north of Shandong Province. The soluble salts of soil mainly include neutral salts (sulfate, chloride) and alkaline salts (carbonate, bicarbonate) of sodium, potassium, calcium and magnesium. Salinized soils are further divided into saline (neutral salt) and alkaline (alkaline salt) soils according to the anions in soluble salts.

2. Classification of soil salinization degree
When the content of soluble salt in soil is more than 0.1 mg / 100 mg soil, the plant will be affected. When the content of soluble salt is more than 0.2 mg / 100 mg soil, it will endanger the normal growth of crops. The higher the content of soluble salt in soil, the more serious the damage to crops. The degree of soil salinization in the area depends on the level of salt content, it can be divided into five types: non-salinization (< 0.1 mg / 100mg) , mild salinization (0.1-0.2 mg / 100mg) , moderate salinization (0.2-0.4 mg / 100mg) , severe salinization (0.4-0.6 mg / 100mg) and saline soil (> 0.6 mg / 100mg).

3. Distribution of soil salinization
Soil Salinization in the region can be divided into primary salinization and secondary salinization. The distribution of primary salinization is mainly controlled by landform type and surface lithology, and is mainly distributed in Lowland, lowland and Lowland of Binhai. The quality of groundwater in these areas is poor, the runoff of groundwater is not smooth, the amount of artificial exploitation is small, and the vertical alternation is slow. Under the combined effect of evaporation and capillarity, the salt in the soil accumulates continuously, which results in the salinization of the soil. Secondary Salinization is affected by human factors, mainly in the vicinity of the Yellow River and irrigation channels. Due to the lateral recharge of the river [1-3] , the shallow groundwater has a good recharge condition, but the small amount of exploitation and the large amount of Yellow River irrigation make the groundwater depth less than the capillary rise height of the soil, and the phreatic evaporation is...
strong, the salt content of soil in this area increases constantly, which results in the secondary salinization of soil.

Except for the south of Xiaoqing River, there are salinized soils in the Piedmont Slope Plain and the Yellow River floodplain. The saline-alkali land mainly distributes in the Yellow River Delta Coastal Plain area, the landform type is the alluvial sea deposit plain and the Yellow River Delta Plain area, the ground elevation is less than 10m [4-5].

3.1 Saline soil
It is mainly distributed in the coastal areas of Wudi, Zhanhua, Dongying, Weifang, Dongying, and is mainly caused by seawater immersion. In the saline soil distribution area, the elevation of the ground surface is mostly below 3 meters, the depth of phreatic water is 1-2 meters, the salinity of phreatic water is high, and the influence of seawater immersion, the salt composition chloride accounts for more than 80%, sodium is the main cation, most of the land is bare land, some halophytes grow in some depressions after the accumulation of fresh water during the rainy season, but they will die soon after the rainy season. In the areas far from the sea, the salt content in the phreatic water accumulates on the surface with evaporation due to the flat terrain and poor drainage. The salt content in the 0-20 cm soil layer reaches 0.6% or more, and in some cases 2.0%, forming a large wasteland. Sodium chloride and potassium chloride are dominant in the salt composition, the ratio of Cl⁻/SO₄²⁻ is more than 7, and the salinization type is chloride type. 0-1m soil has high salt content, and there is little difference in salt content between bottom layer and core layer.

3.2 Severe salinization
The severe saline-alkali land in Binhai is mainly distributed in the low-level land around the saline soil and the boundary zone between the low-level land and the gentle slope land. Most of the saline-alkali land is distributed at about 3-4 m above sea level in a strip pattern, and the underground water level is about 2 m deep, the mineralization degree is about 5-10g/L. In addition, Bincheng County in Inland Binzhou, Chen Guan in Dongying and Tang Fang in Gaoqing County are also scattered, mainly due to unreasonable irrigation and farming systems. Due to the high salinity of groundwater, shallow water table and intensive evaporation, the salinity of soil is increased, the salt content of soil surface is 0.4-0.6%, the salt content in soil is mainly K⁺, Na⁺, and the ratio of Cl⁻/SO₄²⁻ is 5.8, it belongs to potassium and sodium chloride salting fluvo-aquic soil (Fig.1., Fig.2.).

![Fig.1. Salt profile of east saline soil in Dingzhuang, Guangrao County](image)
3.3 Moderate salinization
The area is mainly distributed on the gentle slope land around the heavy saline soil, showing narrow
strip shape. In addition to the town of Huimin County Zi Jiao, Binzhou Li ze, Bincheng County,
Gaoqing County Tang Fang Township, there are sporadic distribution. The salt content of soil surface
is 0.2-0.4%, which has seasonal variation. The chemical types of soil salt are mainly chloride type and
sulfate type.

3.4 Mild salinization
The mild salinization mainly concentrates in the low-lying area, the elevation is 6-9m, the phreatic
water depth is less than 2-4m. The cultivation history is long in this area. In addition, there are also
small island-like distribution along the Yellow River, the main chemical type is sulfate-like chloride
type. The surface vegetation is mainly reed and white thatch.

4. Effect of groundwater depth on soil salinization
The influence of groundwater on soil salinization is mainly caused by evaporation. The salt in
groundwater is transported to the surface with groundwater and accumulates continuously. The
evaporation intensity of phreatic water is generally affected by surface evaporation and groundwater
depth, and can be calculated by the following formula:

\[ \varepsilon = \varepsilon_0 e^{-aH} \]  

(1)

\( \varepsilon \) is phreatic evaporation intensity.
\( \varepsilon_0 \) is surface evaporation intensity.
\( a \) is a comprehensive influence coefficient determined by factors other than the depth of
groundwater table and evaporation intensity of water surface.
\( H \) is depth of water level.

The above formula shows that the evaporation intensity of phreatic water decreases exponentially
with the increase of ground water level, and the evaporation amount of phreatic water can be ignored
when the ground water level exceeds a certain depth, the salt content of the groundwater does not
accumulate on the surface with the water.

Previous research results show that the phreatic evaporation intensity varies with the lithology of
vadose zone, the lithology of vadose zone is coarse, the evaporation is strong, the lithology is fine and
the evaporation is weak. The evaporation intensity decreases with the increase of vadose zone
thickness, and the variation can be divided into three stages (Fig.3., Fig.4.).
4.1 Rapidly changing stage
The thickness of unsaturated zone is 1.6 m for silty soil and 2.1 m for clay soil. The evaporation is strong and easy to produce soil salinization. With the thickness of vadose zone increasing, the evaporation is weakened sharply.

4.2 Homogeneously varying segment
The thickness of unsaturated zone is 1.6-3.5 M for silty soil and 2.1-4.0 M for cohesive soil. The evaporation is weak, and the evaporation intensity decreases with the thickness of vadose zone, so soil salinization is not easy to occur.

4.3 Slow-change segment
Below the uniform change section, the evaporation is weak, the evaporation tends to zero, and there is no soil salinization.

4.4 Research results
According to previous studies, the optimal water level burial depth is 4-5 m. On the basis of "optimal water level buried depth" and taking into account factors such as environment and water intake capacity of pumping equipment, it is determined that 5.5-6.0 m before flood season and 3.0-3.5 m after flood season are the "reasonable water level buried depth" of shallow groundwater in the area. The exploitation of shallow groundwater under the condition of "reasonable water level and depth" can maximize the exploitation of groundwater resources and optimize the environmental and economic benefits.
5. Analysis of influencing factors

The formation of soil salinization in the region is mainly influenced by the factors of Hydrology, meteorology, topography, geomorphology, hydrogeological conditions and human engineering activities. However, the main factors driving the evolution of soil salinization in the region are hydrological, hydrogeological conditions and human engineering activities.

5.1 Hydrological and human engineering activities

In order to alleviate the shortage of water resources, Shandong Province has carried out a series of hydraulic engineering construction and completed a relatively perfect network of agricultural irrigation canals. The construction of these hydraulic engineering has greatly changed the hydrological conditions in the region and has a greater impact on soil salinization in the region. The excavation of drainage channels and ditches can improve the drainage conditions in low-lying areas, which can be used to remove soil salinity and alleviate soil salinization. The construction of Plain Reservoir and irrigation by diverting the Yellow River raised the groundwater level, enhanced the evaporation of groundwater and produced secondary salinization.

5.2 Influence of the change of hydrogeological conditions

Under the influence of the long-term overexploitation of shallow groundwater, a series of shallow groundwater drop funnels have been formed in the area, and the velocity of groundwater flow in the funnels is accelerated, which leads to the intrusion of saline water in the north, the increase of the salinity of groundwater and the increase of the salinity of groundwater, the salt content of soil introduced by irrigation also increases correspondingly, which makes the conversion from slight salinization to heavy salinization.

6. Conclusion

Except for the south of Xiaoqing River, there are salinized soils in the Piedmont Slope Plain and the Yellow River floodplain. The saline-alkali land is mainly distributed in the Yellow River Delta Coastal Plain area, the landform types are the alluvial sea deposit plain and the Yellow River Delta Plain area, the ground elevation is less than 10m. Considering factors such as environment and water intake capacity of pumping equipment, it is determined that 5.5-6.0 m before flood season and 3.0-3.5 m after flood season are the "reasonable water depth" of shallow groundwater in the area. The exploitation of shallow groundwater under the condition of "reasonable water depth" can maximize the exploitation of groundwater resources and optimize the environmental and economic benefits.

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