Analysis of Influencing Factors of Groundwater Nitrate Nitrogen Driven by Sewage Reuse

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Abstract. Groundwater safety issues directly affect human health and quality of life. Sewage reuse is the main source of nitrate nitrogen pollution. The influencing factors of groundwater nitrate nitrogen must be analyzed to reduce the pollution risk of nitrate nitrogen. Based on the analysis of the literature, the influencing factors are comprehensively analyzed in the process of nitrate-nitrogen migration and transformation, and the influence of natural factors are discussed such as landform characteristics, soil type and soil structure on the migration of nitrate-nitrogen. The impact of human factors such as Nitrogen application, sewage irrigation, land use types and land planting ways are also analyzed, and the research results provide theoretical and scientific basis to support the remediation of groundwater nitrate nitrogen pollution, and can be used as reference.

1. Introduction

In the mid-to-late 1950s, the use of sewage for irrigation is advocated in agriculture; nitrate pollution caused by sewage irrigation in groundwater to become more and more serious. Due to the stable nature and high solubility of nitrate, it is easy to transport with groundwater and become the most common environmental factor of groundwater pollution all over the world. The Tianjin Sewage Irrigation District is one of the earliest sewage irrigation areas in my country. The groundwater medium is mainly clayey sand, which is easily polluted and difficult to restore and adjust.

Urban sewage recycle is considered to be the main way to solve the current shortage of agricultural water sources. It is recognized as a friendly environmental technology by the United Nations Environment Programme and it has been promoted and applied. Due to the high nitrogen content in recycled sewage, there are certain environmental risks during recycling. Long-term and unreasonable sewage irrigation will cause groundwater pollution in the irrigation area. Sewage reuse has a direct impact on the content of nitrate nitrogen in groundwater. The factors that affect the migration and transformation of nitrate nitrogen in groundwater are diverse and complex, mainly including natural factors such as soil geomorphology and hydrogeological conditions. Also includes the impact of human factors such as human activities. Analyzing the influencing factors of groundwater nitrate nitrogen content has important theoretical significance and reference value for promoting the environmental risk research of wastewater reuse in my country.

2. Analysis of Natural Influencing Factors

The research on the migration and transformation mechanism of groundwater nitrate in the unsaturated zone and saturated zone has attracted the attention of many scholars in the world, and it is an important research direction of hydrogeology. The spatial distribution of nitrate nitrogen in groundwater is caused
by its own structural factors and random factors. Factors such as vadose zone, aquifer lithology and groundwater depth have important effects on the vertical distribution of nitrate nitrogen in groundwater. The landform features, soil types, soil structure, and precipitation also can pay more effects on it.

2.1. Landform and soil
Different landform types, soil types and soil structure will affect the transport process of nitrate nitrogen (NO$_3^-$-N) in the aeration zone. The average content of nitrate nitrogen (NO$_3^-$-N) in groundwater in the Bohai Sea Plain area ranges from 7.14 to 10.33 mg L$^{-1}$, while the detected concentration has reached 29.20 mg L$^{-1}$ in hilly areas, the difference is because that the groundwater depth in hilly areas is shallower than that in plain areas, the path and time of surface infiltration are shorter, and it is easier to accumulate large amounts of nitrate nitrogen (NO$_3^-$-N) [1].

The effect of soil types on the vertical transport of nitrate nitrogen can be studied by simulating soil pillars. The results show that the finer the soil particles and the more compact the soil, the weaker the vertical permeability of nitrate nitrogen (NO$_3^-$-N) [2]. Under the condition of water saturation, the vertical migration process of nitrate nitrogen is mainly affected by the soil clay content, with the increase of clay content, the migration speed of nitrate nitrogen will slow down [3].

The larger the soil bulk density, the more clay content in the soil, the lower the nitrate nitrogen (NO$_3^-$-N) migration speed in the soil [4], that is, the longer the infiltration time in the unsaturated zone, and the peak concentration of nitrate nitrogen has a positive and significant correlation with bulk density. Biomass char can significantly reduce the leaching rate of soil ammonium nitrogen and nitrate nitrogen, prolong the leaching time, and reduce the cumulative leaching loss [5].

2.2. Precipitation
The leaching loss of nitrate nitrogen is related with precipitation, and more precipitation leads to large leaching loss. As the precipitation varies with the seasons to a large extent, the total concentration of nitrogen in the infiltrated water also changes accordingly. After the rainy season, the concentration of nitrate nitrogen in groundwater rises sharply, even reaching the highest value. Precipitation and precipitation intensity are the main reasons that determine the leaching and downward migration of nitrate nitrogen in the soil. Precipitation and precipitation intensity are small, and the infiltration and migration speed of nitrate nitrogen is slow.

Nitrate nitrogen usually infiltrates into the groundwater body through the surface or the soil with the water flow. If the groundwater level is deep, the thickness of the vadose zone is larger, which prolongs the time for nitrate nitrogen to enter the groundwater body, and the groundwater body is more difficult to be affected by the external environment and the interference of human activities, the harmful consequences can be avoided by the nitrate nitrogen on the ecological environment [4].

2.3. Deep groundwater
Nitrate in groundwater mainly comes from surface nitrogen pollution sources and enters shallow groundwater through vadose zone with rainfall or irrigation. Nitrogenous compounds will undergo a series of complex physical, biological and chemical reactions during the infiltration process, and finally exists in groundwater with the form of salt nitrogen, and the variation of nitrate nitrogen in groundwater has a certain correlation with the depth of regional groundwater level, the concentration of nitrate nitrogen in groundwater decreases significantly as the depth of groundwater increases [5].

The concentration of nitrate nitrogen (NO$_3^-$-N) is significantly different in groundwater bodies with different groundwater depths. The smaller the groundwater depth of the groundwater body, the looser the soil particles in the unsaturated zone, the more oxygen in the soil layer, and the gradual transition from the reducing environment to the oxidizing environment; coupled with the increase in the amount of organic matter, nitrification is promoted and denitrification is inhibited, nitrogen enters the aquifer in the form of nitrate nitrogen (NO$_3^-$-N) through the nitrification reaction. Since the aquifer is in an oxidizing environment and is close to the soil layer in the unsaturated zone, nitrate nitrogen (NO$_3^-$-N) can be stabilized to exist in it. The thicker the soil layer in the aerated zone, the stronger the compactness
of the soil particles in the upper layer of the aerated zone, and the oxygen required for the nitrification reaction and the electrons required by the nitrifying bacteria will be relatively small, parts of nitrate nitrogen (NO$_3^-$-N) will enter the atmosphere through denitrification.

As the groundwater level drops, the nitrate nitrogen content in the saturated and unsaturated soil layers increases, and the ammonium nitrogen content decreases; the groundwater level rises, the nitrate nitrogen content decreases, and the ammonium nitrogen content increases; the rise and fall of the groundwater level promotes the vertical migration of nitrate in the soil layer; during the rise and fall of the groundwater level, the sandy soil layer is more likely to cause nitrate pollution than the silt soil layer; when precipitation conditions are considered, stable groundwater level is more likely to cause nitrate pollution than rising groundwater level, and rising groundwater level is more likely to cause ammonia nitrogen pollution[6].

2.4. Runoff
Groundwater Runoff conditions have a stronger impact on the transport of nitrate nitrogen and ammonia nitrogen in shallow groundwater. Along the direction of groundwater runoff, the mass concentration of nitrate nitrogen and ammonia nitrogen shows an increasing trend, which has a cumulative effect, and this effect is particularly significant in dry years [7].

The soil prioritious path allows water to penetrate the soil quickly, resulting in a phenomenon of prioritious migration of water and solutes. On the one hand, it shows a high and fluctuating water outflow rate, and on the other hand, it shows a large amount and rapid nitrate nitrogen transport [8].

3. Human factors influence
In addition to natural factors, the factors that affect the migration and transformation of nitrate nitrogen in groundwater are inseparable from the influence of man-made factors, including excessive use of nitrogen fertilizers, irrigation of sewage, and different farming action, which brought about the content difference of nitrate nitrogen.

3.1. Fertilizer use
In recent years, with the improvement of global production technology and people's living quality, a variety of demands for high-quality food crops and massive production have been promoted, and a variety of compound fertilizers have emerged as the times require. As an essential element for plant growth, nitrogen has become an indispensable presence in various fertilizers. However, excessive application of nitrogen fertilizer will cause a large amount of nitrate to accumulate in the soil, nitrogen nutrients and organic and inorganic pollutants have passed through surface runoff to enter the groundwater body, causing pollution to water bodies such as rivers, lakes and streams.

The effect of nitrogen fertilizer concentration on soil nitrate nitrogen content is far greater than irrigation volume and emitter flow. And the nitrogen fertilizer concentration is positively correlated with the soil nitrate nitrogen content, and the irrigation volume and emitter flow are negatively correlated with the soil nitrate nitrogen content [9].

There is a correlation between the concentration of nitrate in groundwater and the amount of nitrogen fertilizer used. Reducing the amount of nitrogen fertilizer used can effectively reduce the accumulation of nitrate nitrogen (NO$_3^-$-N) in the groundwater. Taking the Huanghuaihai Plain as an example, under the wheat and corn cropping conditions, when the use of nitrogen fertilizer does not exceed 273.6 kg hm$^{-2}$, the accumulation of nitrate in groundwater is extremely small; the use of nitrogen fertilizer does not exceed 861.1 kg hm$^{-2}$, the accumulation of nitrate in groundwater will not exceed 50 mg L$^{-1}$. Therefore, based on reducing the amount of nitrogen fertilizer applied, balanced using fertilization can not only increase crop yields and soil nitrogen absorption and utilization, but also promote the good development of plant roots, further form a dense layer of roots, and reduce or even prevent nitrate nitrogen (NO$_3^-$-N) leaching loss.
3.2. Sewage irrigation
Irrigation and precipitation are another way for the leaching of nitrate nitrogen (NO$_3^-$-N) into the groundwater body. In this process, the pollutant sources carrying nitrate nitrogen (NO$_3^-$-N) are mostly livestock manure, industrial residues and domestic sewage. Healthy balance of water bodies and the natural environment is threatened by the dry and wet sedimentation, leaching infiltration, and discharge.

The drip irrigation method makes it easier for a large amount of nitrate nitrogen (NO$_3^-$-N) to enter the deep soil, thereby polluting the groundwater body. Sewage discharge can increase groundwater nitrate pollution. In addition, nitrogen oxides in the atmosphere will sink to the ground through dry and wet conditions, dissolve in various surface waters, and then infiltrate into the groundwater body, resulting groundwater nitrate nitrogen (NO$_3^-$-N) pollution.

3.3. Land use type
The paddy field is saturated, and the groundwater in a reducing environment is conducive to denitrification. Therefore, the content of nitrate nitrogen (NO$_3^-$-N) in the groundwater in the paddy field area is low. Vegetable gardens usually use excessive amounts of nitrogen-containing chemical fertilizers, and due to the relatively low utilization of nitrogen and the large amount of loss in this area, the groundwater bodies are more susceptible to nitrate nitrogen (NO$_3^-$-N) pollution [10]. In addition, small agricultural areas such as vegetable gardens are mainly distributed around cities. Irrigation mostly use the surface water in urban areas which contains excessive nitrogen elements, it will increase the nitrate nitrogen (NO$_3^-$-N) concentration. Because forest land is less affected by human activities, there are fewer nitrate nitrogen (NO$_3^-$-N) sources; the content of groundwater nitrate nitrogen (NO$_3^-$-N) in forest land area is less.

The reason for this phenomenon is the rapid development of urbanization and the accumulation of a large number of laborers, which increases the population density and promotes the degree of industrialization. Eventually, the gradual increase in sewage discharged from life and industry will lead to the nitrate nitrogen (NO$_3^-$-N) pollution in groundwater in urban areas.

3.4. Land planting method
The number of tillage can reduce the leaching amount of nitrate nitrogen (NO$_3^-$-N), and the unturned soil pores are conducive to the leaching movement of nitrate nitrogen (NO$_3^-$-N), and the number of tillage will increase the number of evaporation, making it easier for soil nitrate nitrogen (NO$_3^-$-N) to move upward. Therefore, farming measures will change the soil structure, and then affect the movement of soil water, and ultimately affect the leaching and infiltration of nitrate nitrogen (NO$_3^-$-N).

Due to the differences of land planting methods, the infiltration characteristics of nitrate nitrogen (NO$_3^-$-N) in the soil will show different trends, which are mainly restricted by the two aspects of rainfall irrigation and fertilizer consumption.

According to the different planting conditions of the land, the planting methods are roughly divided into conventional planting areas and intensive planting areas. Intensive agriculture is characterized by high planting degree, high frequency of chemical fertilizer use and large amount of chemical fertilizer, which will increase the loss of nitrogen in agricultural areas and also pose a threat to the safety of groundwater bodies to a large extent. In addition, the serious excessive input of nitrogen fertilizer in the intensive agricultural planting area, which can cause the nitrate nitrogen pollution to the groundwater body, also can cause the nitrate nitrogen concentration in the plant to exceed the standard.

4. Conclusion
This article comprehensively analyzes the influencing factors in the process of groundwater nitrate nitrogen (NO$_3^-$-N) migration and transformation. The natural factors such as landform characteristics, soil type and soil structure were analyzed, and the influence of human factors such as nitrogen fertilizer application, sewage irrigation, land use type, and land planting methods were analyzed. After leaching and infiltration of nitrogen elements, Entering groundwater in the form of nitrate nitrogen (NO$_3^-$-N) is a very complicated process. The rate of nitrate nitrogen (NO$_3^-$-N) infiltrating into the groundwater body
through the vadose zone is difficult to quantify. In addition to denitrification, the natural purification of nitrate nitrogen (NO$_3^-$-N) in groundwater is difficult to repair quickly.

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