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Study on rules of dynamic variation of nitrogen in soil after reclaimed water drip irrigation

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ABSTRACT

Reclaimed water belongs to one of makeup waters to be applied to agricultural production, which can not only reduce the quantity of wastewater effluent, but also reduce the quantity in demand of good-quality water, and is key element in utilization of limited water resources. Through field experimental method and taking drip irrigation, the regulation of reclaimed water drip irrigation on dynamic variation of nitrogen in soil was studied in this paper. The results indicate that compared to the contrast treatment, NH₄⁺ – N content in the surface layer increased sharply in the initial period after reclaimed water drip irrigation, and then decreased significantly in the fifth day, and down to the level before irrigation on the ninth day, which was uniform between soil layers. NO₃-N content under all the treatments presented the almost same trend in soil profile: NO₃-N content increased with the soil depth, indicating an obvious tendency of NO₃-N leaching down to lower layers. However, at the depth of 100–150 cm, NO₃-N content began to decrease. When reclaimed water drip irrigation was used for cucumber planting, NO₃-N content in different layers at the ending of the growing period increased by 38.20%, 44.67%, 34.94%, 30.88%, respectively, than that before planting.

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Introduction

Reclaimed water belongs to one of makeup waters to be applied to agricultural production, which can not only reduce the quantity of wastewater effluent, but also reduce the quantity demanded for good-quality water, and is key element in utilization of limited water resources with high efficiency. Yet, contaminating materials in the wastewater have not been fully removed as the result of economic and

technical difficulties. The N and P element, higher salt content, various toxic trace substances and pathogenic agent abounded in reclaimed water possibly become new pollution source which could bring about adverse impact to the quality of soil and crop [1,2].

Reclaimed water belongs to the water resource which is reclaimed from non-conventional water resources such as the effluent discharged from sewage disposal plant, industrial water drainage and domestic wastewater that could be recycled for specific utilization due to acceptable water quality

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after proper treatment [3–6]. Yet, the worldwide scarcity of water resources pushes on reuse of wastewater. It's estimated that water scarcity in China would reach $1.3 \times 10^{10} \text{m}^3$ and the quantity in demand of reclaimed water would reach $7.67 \times 10^{10} \text{m}^3$ in 2030. However, such countries as US, Australia, Israel, Japan and France etc. have already adopted reclaimed water as one of important solutions to alleviate the crisis of water resources. Furthermore, gross amount in demand of reclaimed water in Israel, Australia and Tunis etc. has respectively reached 25%, 11% and 10% total demand of water resources. Whereas reclaimed water is mainly applied to farming irrigation, the Werdbbee Farm in Australia began to apply reclaimed water to irrigation since 1897, and 42% reclaimed water has already been applied to farming irrigation in US, but the irrigation by reclaimed water now is at starting point in China, e.g. Beijing Municipality plans to establish 40,000 hm^2 reclaimed water irrigated area and utilize $3 \times 10^8 \text{m}^3$ reclaimed water in 2010. Along with the increase of reclaimed water irrigation area for 30 years, the safety and environmental impact of which has attracted wide attention [7–13]. The trend of irrigation by reclaimed water is spread worldwide and such countries as US, Australia, India, Israel and former USSR etc. have abounded in successful experience in utilization of poor quality water. But for long time, research fellows have only been focusing on the study of water salinity of irrigation water quality instead of in-depth and systematic study of chemical composition of irrigation water and its impact against physicochemical property of soil. Therefore, many countries recently began to focus on the study of impact from reclaimed water irrigation against soil physicochemical property and reclaimed water utilization approach [14–17].

On the one hand, reclaimed water irrigation can reduce serious non-point source pollution resulted from direct irrigation by wastewater, provide important nutrient to plant growth, promote plant growth and enhance crop yield [18–21]; on the other hand, superfluous nutrients, toxic chemicals and pathogenic agents will simultaneously enter environmental ecosystem along with the irrigation by reclaimed water, which would result in environmental pollution [22,23] and probably imperil human health. Moreover, the nitrogen also is one of key factors [23–25] in water body pollution and eutrophication even though it's one of important elements to make up biomass. Meanwhile, through excessive application of nitrogenous fertilizer and such human activities as unrestricted discharge of domestic sewage etc., massive nitrogen remains in soil after rejection by the crop and which would bring about latent and real environmental pollution [26–28] through volatilization, sprinkling or runoff etc. with composition pattern of $\text{NO}_3^- - \text{N}$ and $\text{NH}_4^+ - \text{N}$. Therefore, the study of nitrogen in soil, especially the dynamic variation of $\text{NO}_3^- - \text{N}$ and $\text{NH}_4^+ - \text{N}$ provides important theory and instruction to prediction and control of agricultural non-point source pollution.

Besides, with such characteristics as keeping watering duration, watering amount and soil moisture range in high control, drip irrigation can adjust soil moisture and nutrient according to soil physical property [29–33], distribution of crop root system and consumptive use of crop, and ensure crop yield with good quality and high yield while reducing agricultural non-point source pollution. The reuse of rural

domestic sewage through drip irrigation will enhance utilization efficiency of such nutrients as nitrogen and phosphorus etc. in reclaimed water, which saves fertilizer, water and increases crop yield while reducing redundant pollutant entering environmental ecosystem, meanwhile it's significant in relief of water resources crisis [34–36], prevention and treatment of agricultural non-point pollution as well as promotion of recycling economy. Under similar conditions, this experiment compares and researches the rules of dynamic variations of nitrogenous agent in soil after drip irrigations by reclaimed water and groundwater with different proportion.

Material & method

Overview of experimental field

The experimental field is entitled “Pilot Zone of Agricultural Non-point Source Pollution Control in Water Source Area at Centerline of South-to-North Diversion Project”, which is jointly established by Geographical Science & Resources Research Institute to Chinese Academy of Sciences and Policy & Engineering Research Center to South-to-North Diversion Project to State Council. The experimental field is located in mountainous area at south part of Maojian District, Shiyan City, Hubei Province, where belongs to subtropical monsoon climatic region with 4 distinctive seasons and enjoys such characteristics as longer wintertime and shorter summertime, faster temperature rise during springtime, continuous precipitation during autumn days, less sleet during wintertime, relatively higher temperature during wintertime with less bitter cold, annual solar radiation of 106.6 kcal/cm^2 , physical radiation of 50.4 kcal/cm^2 , annual average sunshine duration of 1925.8 h, mean annual temperature at $15.3 \text{ }^\circ\text{C}$, extreme minimum temperature at $-14.9 \text{ }^\circ\text{C}$, extreme maximum temperature at $41 \text{ }^\circ\text{C}$, $\geq 10^\circ\text{C}$ annually accumulated temperature of $4936.5 \text{ }^\circ\text{C}$, annual frost-free period for 246 days, mean annual precipitation of 855 mm, great fluctuation in annual rainfall, rainfall during flood period (from May 1st to October 20th) accounted for 58%–62% annual rainfall, which is endowed with great intensity, short duration, limited infiltration and liability to scour and erode ground surface. In addition, the soil in experimental field belongs to yellow-brown soil with unit weight between 1.56 and 1.71 g/cm^3 .

Tentative layout

The experiment was conducted during growing period of cucumber in 2011 from September 20th to December 10th. Ridge planting is applied to the cucumber cultivation with 60 cm-wide ridge shoulder, 15 cm-high ridge height, 140 cm spacing between centerlines of two ridges, 2-row planting in the ridge and 40 cm-wide plant spacing. Diammonium phosphate compound fertilizer is applied to the field with proportion of 20kg/mu before cucumber planting, and composition of irrigated water is classified with 3 marks as T1 (fully irrigated by reclaimed water), T2 (irrigation by water combined with 50% reclaimed water and 50% groundwater) and C (fully irrigated by groundwater), which is detailed in Table 1 below. The 3-classification experiment shall be

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