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Soil Quality Analysis in Newly Increased Cultivated Land

Zhe Liu^{1, 2, 3, 4}, Huanyuan Wang^{1, 2, 3, 4, *}

¹Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an 710075, China

²Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an 710075, China

³Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xi'an 710075, China

⁴Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China

*Corresponding author e-mail: liuzhe168@126.com

Abstract. In order to explore soil physical-chemical properties and water quality in Bailiang town, Heyang county of Shaanxi Province, the soil physical-chemical properties of newly increased cultivated land, the water heavy metal contents of chromium, copper, zinc, arsenic, selenium, cadmium, mercury and lead of Yellow River water and groundwater in the project area were measured. The results showed that the pH value, total salt content and heavy metal content of the Yellow River and groundwater were all in line with the farmland irrigation water quality Standard, which could guarantee irrigation use. The type of soil in the 0~30 cm was sandy loam, the bulk density of 0~30 cm soil layer was 1.52 g cm^{-3} , and the saturated hydraulic conductivity was 229.41 cm d^{-1} , which could meet the needs of planting soil quality requirements, but sandy loam soil with large saturated water conductivity was easy to leak water and fertilizer. Meanwhile, the content of exchangeable calcium of 0~30 cm soil layer was in a very rich state ($38.6\sim90.1 \text{ cmol kg}^{-1}$), and the content of available potassium ($36\sim128 \text{ mg kg}^{-1}$) and effective boron ($0.56\sim0.89 \text{ mg kg}^{-1}$) were moderate, the content of organic matter ($1.06\sim2.65 \text{ g kg}^{-1}$), total nitrogen ($0.18\sim0.33 \text{ g kg}^{-1}$), available phosphorus ($3.2\sim8.4 \text{ mg kg}^{-1}$) and available silicon content ($41.0\sim68.6 \text{ mg kg}^{-1}$) were in a state of lack. These results indicate that the organic fertilizer, green manure, straw and small amounts of fertilizer could be used to increase the content of organic matter, and other nutrient elements in the cultivated layer. It was recommended to design the loess tillage layer and plow pan layer, which played the role of water retention and fertilizer retention, and was suitable for the growth of aquatic crops.

1. Introduction

Cultivated land quality has important implications for new countryside construction, food security, and eco-civilization. The root of food security lies in the quantity and quality of cultivated land. Facing the increasing pressure on food demand, the number of cultivated lands in China was decreasing, the quality was generally low, and the medium and low areas account for more than 2/3 of the total area. Therefore, there is a lot of room for increasing grain yield by increasing the amount of cultivated land



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and improving the quality of cultivated land [1-2]. To understand soil physical-chemical properties and water quality of cultivated land quality is very important for promoting land remediation and high-standard basic farmland construction, which was essential for sustainable use of cultivated land. At present, the newly cultivated land mainly comes from land reclamation and land development projects, and land reclamation projects linked with the increase and decrease of urban and rural construction land [3-4].

Large quantities of agricultural by-products and animal waste are produced each year in China, in order to reduce the pressure on land-fill sites and conserve natural resources, we should compost these organic wastes and recycle them onto arable land to increase quality of newly increased cultivated land. Application of organic materials such as crop residues, compost and poultry manure are well known environmental practices in soil restoration, maintaining soil organic matter and reclaiming degraded soils [5-6]. The study of different planting patterns was also important for increasing quality of cultivated land and structural evolution, and can be used to systematically identify issues and trends in soil quality and structure as well as nutrient cycling and balance [7-9]. This information is critical for understanding newly increased cultivated land, increasing soil fertility, and developing sustainable agricultural management practices. Thus, the objective of the study was to assess the soil physical-chemical properties and water quality of cultivated land quality, which has important effect on implement the national cultivated land protection system and carry out rural land consolidation work. The result would provide a theoretical basis and technical support to improve the quality of cultivated land and increase crop yields.

2. Materials and methods

2.1. Site description

Heyang County was located in the northeast of Shaanxi Guanzhong plain and the west bank of the Yellow River. The site had a warm temperate semi-arid continental monsoon climate with abundant light and heat resources, less precipitation, distinct dry and wet seasons, and variable climate. The annual mean temperature was 11.5 °C, with an accumulated temperature above 0°C of 4465.7°C, with a frost-free period of 194 days and annual average precipitation of 553 mm. The research project area was located in Bailiang Town, 16.8 kilometers northeast of Heyang County. The terrain was high in the west and low in the east, with an altitude of 430~680 meters (35°18'30"~35°19'22"N, 110°23'31"~110°24'32"E).

2.2. Sampling and measurement methods

Soil sampling followed the principle of random, multi-point, and mixing, which were collected in 2016. According to the depth of the tillage layer, the depth of soil sample collection was set to 0~30 cm. The "S" type point method commonly used in the large-area was adopted for the sampling. According to the "Soil Monitoring Technical Specification HJ/T166-2004", the sampling density was not less than 5 sampling points per 100 hectares, and on this basis, a sampling unit was set for every 6 hectares. According to the data provided by the Heyang County project department, the preliminary planning and construction scale of the project area was more than 80 hectares, which was divided into 13 sampling units, and each of the sampling units collected three soil samples (0~30 cm). After mixing the soil samples, a sample of about 1 kg was taken by the quarter method and stored for testing, for a total of 13. The storage of the samples was carried out in accordance with the standard of "Collection, Treatment and Storage of Soil Samples" (NY/T1121.1-2006), soil samples were air-dried at the testing Laboratory. The basic physical and chemical properties such as soil organic carbon, total nitrogen, available phosphorus, and mechanical composition were tested according to the conventional methods of related books [10-11].

3. Results and analysis

3.1. Water quality analysis in the project area

The groundwater in the project area was low-mineralized freshwater dominated by bicarbonate, the cations were mainly Na, Na-Ca and Na-Mg, and the salinity was between 1.0 and 2.0 g L⁻¹. During the wet season (July to September), the groundwater depth was 0.5~1.0 m. In the dry season (December to March of next year), the groundwater depth was 1.5~2.0 m. The water samples quality characteristics of the Yellow River and groundwater in the project area were shown in Table 1. According to the "Water Quality Standard for Farmland Irrigation" (GB5084-2005), the pH value of water samples in the Yellow River and groundwater was in the range of 7.94 to 8.05, and the total salt content was in the range of 920 to 1250, which were in line with the standards for irrigation water quality. In summary, after the completion of the project, a good water conservancy irrigation and drainage facility could be ensured. The content of heavy metals such as chromium, copper, zinc, arsenic, cadmium, lead and mercury of water samples in the project area were in line with water quality standards, and could meet the irrigation requirements.

Table 1. Water quality properties of project area

Index	Yellow River	Groundwater	Water Quality Standard GB 5084-2005
pH	8.05	7.94	5.5~8.5
Total Salt (mg L ⁻¹)	1250	920	≤2000
Chromium (mg L ⁻¹)	0.004ND	0.006ND	≤0.1
Copper (mg L ⁻¹)	0.05ND	0.05ND	≤0.5
Zinc (mg L ⁻¹)	0.05ND	0.05ND	≤2
Arsenic (mg L ⁻¹)	0.0018	0.0003ND	≤0.05
Selenium (mg L ⁻¹)	0.001	0.00058	≤0.02
Cadmium (mg L ⁻¹)	0.006	0.006	≤0.01
Lead (mg L ⁻¹)	0.01ND	0.01ND	≤0.2
Mercury (mg L ⁻¹)	0.00004	0.00005	≤0.001

3.2. Soil physical properties in the project area

The physical indicators of soil samples in the project area were conducted in an indoor laboratory, which were shown in Table 2. From Table 2, the type of soil in the 0~30 cm was sandy loam. The pH value of the soil ranged from 7.99 to 8.50, which was weakly alkaline (pH 7.5~8.5), could suitable for aquatic crop growth. For the soil of newly increased cultivated land, in order to meet the suitable pH requirements of the slightly acidic to neutral soil for high-yield aquatic crops, the pH value could be appropriately reduced by the later fertilization management and cultivation measures. The bulk density of 0~30 cm soil layer in the project area was 1.52 g cm⁻³ and the saturated hydraulic conductivity was 229.41 cm d⁻¹. Sandy loam soil with large saturated water conductivity was easy to leak water and fertilizer. According to the soil condition of 0~30 cm soil layer and the growth demand of rice and rape in the project area, the measure of soil mass organic reconstruction was recommended to artificially design the loess tillage layer with a bulk density of 1.2~1.3 g cm⁻³, and then design a plow pan with a weight of 1.6~1.7 g cm⁻³, which played the role of water retention and fertilizer retention, and was suitable for the growth of aquatic crops.

Table 2. Soil physical properties of the project area

Depth (cm)	Statistic	Grain diameters (%)			Texture (USDA)	pH	BD (g cm^{-3})	Saturated Hydraulic Conductivity (cm d^{-1})
		Clay	silt	sand				
0~30	Minimum value	1.46	24.58	35.65	Sandy loam soil	7.99	1.51	241.28
	Maximum value	6.93	62.89	68.49		8.50	1.53	244.98
	mean value	3.49	42.47	54.04		8.29	1.52	229.41

3.3. Soil nutrient properties in the project area

According to China's soil nutrient grading standards, the content of exchangeable calcium of 0~30 cm soil layer was in a very rich state ($38.6\sim90.1 \text{ cmol kg}^{-1}$), the content of available potassium ($36\sim128 \text{ mg kg}^{-1}$) and effective boron ($0.56\sim0.89 \text{ mg kg}^{-1}$) were moderate, at the same time the content of organic matter ($1.06\sim2.65 \text{ g kg}^{-1}$), total nitrogen ($0.18\sim0.33 \text{ g kg}^{-1}$), available phosphorus ($3.2\sim8.4 \text{ mg kg}^{-1}$) and available silicon content ($41.0\sim68.6 \text{ mg kg}^{-1}$) were in a state of lack of extreme deficiency. The management measures for the later stage of fertilization in the newly increased cultivated land should be strengthened. The content of organic matter, nitrogen, phosphorus and silicon of the cultivated layer could be improved by adding organic fertilizer, green manure, straw and small amounts of fertilizer. Before the planting of rice and rapeseed, the base fertilizer should be applied. During the planting process, the fertilizer should be scientifically proportioned according to the fertilizer requirement of the crop to improve the fertility of the soil and meet the high yield of crop growth.

Table 3. Soil nutrient properties of the project area

Depth (cm)	Statistic	Organic Matter (g kg^{-1})	Total Nitrogen (g kg^{-1})	Available Phosphorus (mg kg^{-1})	Available Potassium (mg kg^{-1})	Effective Boron (mg kg^{-1})	Available Silicon (mg kg^{-1})	Exchangeable Calcium (cmol kg^{-1})
0~30	Minimum value	1.06	0.18	3.2	36	0.56	41.0	38.6
	Maximum value	2.65	0.33	8.4	128	0.89	68.6	90.1
	mean value	1.97	0.24	5.4	79	0.72	57.7	62.5

4. Conclusion

The pH value, total salt content and heavy metal content of the Yellow River and groundwater in Bailiang Town, Heyang County, Shaanxi Province were all in line with the Farmland Irrigation Water Quality Standard, which could guarantee irrigation use. The 0~30 cm soil layer in the project area was sandy loam soil, the pH value range was 7.99~8.50, the average bulk density was 1.52 g cm^{-3} , the saturated hydraulic conductivity was 229.41 cm d^{-1} , and the content of soil exchangeable calcium was in a very rich state, the content of available potassium and effective boron were moderate, at the same time the content of organic matter, total nitrogen, available phosphorus and available silicon content were in a state of lack of extreme deficiency. The measure of soil mass organic reconstruction was recommended to strength the late fertilization management of reconstituted tillage layer. The fertilizer should be scientifically proportioned according to the fertilizer requirement of the crop to improve the soil fertility, and the organic fertilizer, green manure, straw and small amounts of fertilizer could be used to increase the content of organic matter, nitrogen, phosphorus and other trace elements in the cultivated layer. It was recommended to design the loess tillage layer and plow pan layer, which

played the role of water retention and fertilizer retention, and was suitable for the growth of aquatic crops.

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References

- [1] Zhang B B, Kong Xi B, Yun W J, et al, 2015. A review on quality and monitoring of arable land in China [J]. *Journal of China Agricultural University*, 20(2): 216-222.
- [2] Fu G Z, Bai W Q, 2015. Advances and prospects of evaluating cultivated land quality[J]. *Resources Science*, 2015, 37(2): 226-236.
- [3] Chen Y J, Xiao B L, Fang L N, et al, 2011. The Quality Analysis of Cultivated Land in China [J]. *Scientia Agricultura Sinica*, 44(17):3557-3564.
- [4] Du G M, Liu Y S, Yu F R, et al, 2016. Evolution of concepts of cultivated land quality and recognition [J]. *Transactions of the Chinese Society of Agricultural Engineering*, 2016, 32(14):243-249.
- [5] Bronick C J, Lal R, 2005. Soil structure and management: a review [J]. *Geoderma*, 124:3-22.
- [6] Six J, Bossuyt H, Degryze S, et al, 2004. A history of research on the link between (micro)aggregates, soil biota, and soil organic matter dynamics [J]. *Soil & Tillage Research*, 79, 7-31.
- [7] Birkhofer K, Bezemer T, Bloem J, et al, 2008. Long-term organic farming fosters below and aboveground biota: Implications for soil quality, biological control and productivity [J]. *Soil Biol. Biochem.* 40, 2297-2308.
- [8] Qiu X L, Zong L G, Liu Y F, et al, 2015. Effects of different cultivation patterns on soil aggregates and organic carbon fractions [J]. *Environmental Science*, 36(3): 1045-1052.
- [9] Tejada, M, Gonzalez, J L, Martinez-Garcia, et al, 2008. Application of a green manure and green manure composted with beet vinasse on soil restoration: effects on soil properties. *Bioresour. Technol.* 99, 4949-4957
- [10] Bao S D. *Soil and agricultural chemistry analysis*, 2008[M]. Beijing: China Agriculture Press.
- [11] Lu R K. *Analytical methods of soil agricultural chemistry*, 1999[M]. Beijing: China Agriculture Press.