Study on Soil Physical and Chemical Properties of the Yellow River Wetland in Baotou

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Abstract

Taking the soil of the Yellow River wetland in Baotou as the research object, soil samples (0-10cm, 10-20cm, 20-40cm, 40-60cm 4 soil layers) were collected in 5 different types of sample plots, and the physical and chemical properties of soil and their correlation were analyzed. The results show that: (1) with the increase of soil depth, the soil bulk density increases first and then decreases in vertical distribution, and the surface layer is smaller than the middle and lower layers; Soil total porosity, capillary porosity, soil water content and capillary maximum water holding capacity show a trend of decreasing first and then increasing. (2) the contents of soil organic matter, all N, all P, quick P and quick K show obvious accumulation on the surface,with the increase of soil depth, the contents of all K show a decreasing trend, and the distribution law of total K is different； the total amount of salt showed a decreasing trend, and the total amount of salt showed a surface accumulation； the change law of PH value is not obvious .(3) Soil bulk density, porosity, water content, organic matter, PH and other physical and chemical factors have significant correlation ($p < 0.05$), of which soil bulk density has extremely significant negative correlation with soil water content ($p < 0.01$), and soil water content has extremely significant positive correlation with total p and available p ($p < 0.01$), etc.

Keywords

Baotou, The Yellow River wetland, Physical and chemical properties of soil.

1. Introduction

Wetland is a multi-functional transitional ecosystem with unique hydrological, soil, vegetation and biological characteristics between terrestrial ecosystem and aquatic ecosystem. It has important resources, environment and ecological benefits, and plays a very important role in protecting ecological environment and biodiversity, maintaining ecological balance and regulating climate. It is called "kidney of the earth" and "biological gene" [1-2]. Wetland soil is the initial place for wetland to obtain chemical substances and the medium of biogeochemical cycle. The physical and chemical properties of soil can not only reflect the structure, water storage capacity and fertility of wetland soil, but also affect the growth of wetland vegetation, which is related to the formation and succession of wetland environment along the river [3]. However, due to excessive reclamation by human beings, the natural wetland area is continuously decreasing, the flood control function of regulation and storage is declining, the biodiversity is decreasing, and the soil quality is declining [4]. Taking the soil of the Yellow River wetland in Baotou as the research object, this paper analyzes the physical and chemical properties of different wetland types and the correlation between the physical and chemical properties of soil, aiming at providing scientific basis for improving the ecological function of the Yellow River wetland in Baotou and having important guiding significance for the rational utilization and protection of the Yellow River wetland in Baotou.

2. Materials and Methods

2.1 Survey of Research Area

The Yellow River wetland in Baotou is located in the south of Baotou City, Inner Mongolia. It reaches Balihuan in the east, Bayangole in the west, Ordos City in the south and the Yellow River Levee in the north 2km. Geographical coordinates are 109 25' 51 "to 111 1' 36" east longitude, 40 14' 39 "to 40 33' 20" north latitude, with a total area of 29000 hm2, accounting for 81.4% of the city's wetland area, distributed along 220km of the Yellow River flowing through the city's territory[5]. The Yellow River wetland in Baotou is located in semi-arid grassland zone, with typical continental monsoon climate, belonging to wetland plain under Yellow River alluvial. The average annual precipitation is 307.4mm, the annual evaporation on the water surface is 2342mm, the average annual temperature is 8.5℃, and the frost-free period is 148 days[6]. The main landform is the wetland plain under the Yellow River alluvial, with landscape types such as water area, swamp, shrub and grassland. The soil types are mainly meadow soil, saline soil and aeolian sandy soil. The surface water mainly comes from the Yellow River water, followed by atmospheric precipitation and groundwater. The groundwater level is relatively high and the soil humidity is high and alkaline[7].

2.2 Sample Site Setting and Sample Collection

According to the hydrological characteristics and vegetation distribution types of the Yellow River wetland in Baotou, five standard plots with fixed community characteristics were set up. According to the actual situation, three 50cm×50cm quadrats are set up for each plot, with a total of 15 quadrats. At the same time, samples are taken at different depths of 0-10cm, 10-20cm, 20-40cm and 40-60cm in the vertical direction respectively, and the samples are taken back to the laboratory for measuring the basic physical and chemical properties of soil. The time for field investigation and sample collection is May 2017. See Table 1 for the basic survey of monitoring sample plots.

Table 1 Basic survey of monitoring sample plots

Name of sample plot	Number	Latitude and longitude	Soil PH
Seasonal waterlogged marsh wetland in Zhaojun Island	YD01	109°38 ′43 ″E 40°32 ′41.1″N	alkaline
Perennial waterlogged marsh wetland in Zhaojun Island	YD02	109°40 ′38 ″E 40°31 ′25″N	strong alkaline
Seasonal waterlogged wetland in the Xiaobai River	YD03	109°46 ′55″E 40°32 ′37″N	strong alkaline
Perennial waterlogged wetland in the Four rivers of sand	YD04	109°52 ′53 ″E 40°31 ′32″N	alkaline
Perennial waterlogged wetland in Zhanggai Camp	YD05	109°05 ′109 ″E 40°31 ′37″N	alkaline

2.3 Determination Method

Soil total porosity, capillary porosity, capillary maximum water holding capacity and soil bulk density are determined by circular knife method. Soil moisture content was determined by drying method. Soil organic matter was determined by potassium dichromate method. The total nitrogen in soil was determined by high Kjeldahl method. Total phosphorus in soil was determined by molybdenum antimony spectrophotometry. Total potassium in soil was determined by hydrofluoric acid-perchloric acid digestion and atomic absorption spectrometry. Soil available phosphorus was extracted by sodium chloride carbonate solution and determined by spectrophotometer colorimetric method. Soil available potassium was extracted by ammonium acetate solution and determined by atomic absorption spectrometry. Soil PH was measured by potentiometry. The total salt content of soil was determined by drying method. See soil agrochemical analysis for the above determination method[8].

2.4 Data Processing

Data processing and mapping are carried out by Excel software, and statistical analysis and correlation analysis are carried out by SPSS 20.0 analysis software.

3. Results and Analysis

3.1 Physical Properties of Soil

3.1.1 Variation Characteristics of Soil Bulk Density and Porosity in Different Wetland Types

As can be seen from Figs. 1A-1C, the average soil bulk density is 1.15-1.74g/cm^3, the average total porosity is 34.21-56.73%, and the average capillary porosity is 33.50-55.14%. Generally speaking, with the increase of soil depth, the soil bulk density first increases and then decreases in vertical distribution, and the surface bulk density is lower than the lower layer. The total porosity and capillary porosity of soil decreased first and then increased. As the surface layer of soil is mostly sandy soil, the soil is relatively loose and its bulk density is small. The middle and lower layers are mostly clay, with compact soil, large soil volume, large total porosity and large capillary porosity. Sediment deposition will accompany the soil layer, which will lead to a decrease in the bulk density of the underlying soil, indicating that uneven deposition of sediment may change the natural vertical distribution of wetland soil bulk density.

There was significant difference in soil bulk density under the same soil layer of different wetland types ($P < 0.05$), indicating that the soil texture had changed. The soil bulk density of the five plots in 0-20cm is 1.42g/cm^3, 1.63g/cm^3, 1.37g/cm^3, 1.24g/cm^3, 1.31g/cm^3, respectively. Their total porosity is 44.61%, 37.26%, 49.02%, 52.55%, 52.20%, respectively. Clay has the largest bulk density, followed by sandy soil and loam is the smallest. This shows that the better the structure, the smaller the bulk density and the greater the porosity. Due to human interference, the soil bulk density in seasonal ponding state is smaller than that in perennial ponding state, with appropriate porosity and good structure (e.g. YD01 and YD02), which indicates that the soil in perennial ponding state has poor structure and the soil in seasonal ponding state has good structure. The order of soil bulk density of different wetland types from high to low is YD02 (1.65 g/cm^3) > YD01, YD03 (1.40 g/cm^3) > YD05 (1.37 g/cm^3) > YD04 (1.36 g/cm^3).

3.1.2 Variation Characteristics of Soil Water Content and Capillary Maximum Capacity in Different Wetland Types

As can be seen from Fig. 1D, the average soil water content is 17.24-36.06%. The sampling time of soil samples in this study is May. The soil water content in seasonal ponding state is unsaturated water content, so the soil water content in perennial ponding state is greater than that in seasonal ponding state. Generally speaking, with the increase of soil depth, the vertical distribution of soil water content shows a trend of decreasing first and then increasing, and the maximum value mostly appears at the bottom of the soil profile. The reason for this change is, on the one hand, the evaporation of soil surface water is large, the infiltration of water body is strong, the evaporation of middle and lower layers of soil is small, the soil is mostly clay, which has good water retention, resulting in the increase of soil water content. On the other hand, the different micro-geomorphic features of different wetland types and the influence of human activities will lead to different changes of soil water content in different lands. The soil water content of different wetland types is significantly different ($P < 0.05$). the order of soil water content of different wetland types from high to low is yd04 (32.27%) > YD05 (29.66%) > YD03 (24.66%) > YD01 (24.39%) > YD02 (19.82%). it can be seen that the soil water content of most perennial waterlogged states is greater than that of seasonal waterlogged states.

As can be seen from Fig. 1E, the average maximum water holding capacity of the capillary is 19.28-44.45%. Except YD04, the maximum water holding capacity of other sample plots decreased first and then increased. The difference of soil maximum water holding capacity among different wetland types is significant ($P < 0.05$). the order of soil maximum water holding capacity of different wetland types from high to low is YD05 (35.40%) > YD04 (35.27%) > YD03 (32.40%) > YD01 (32.23%) > YD02 (22.43%). on the whole, the capillary maximum water holding capacity under perennial water accumulation is larger than that under seasonal water accumulation, and the soil water holding capacity and water storage capacity under perennial water accumulation are better.

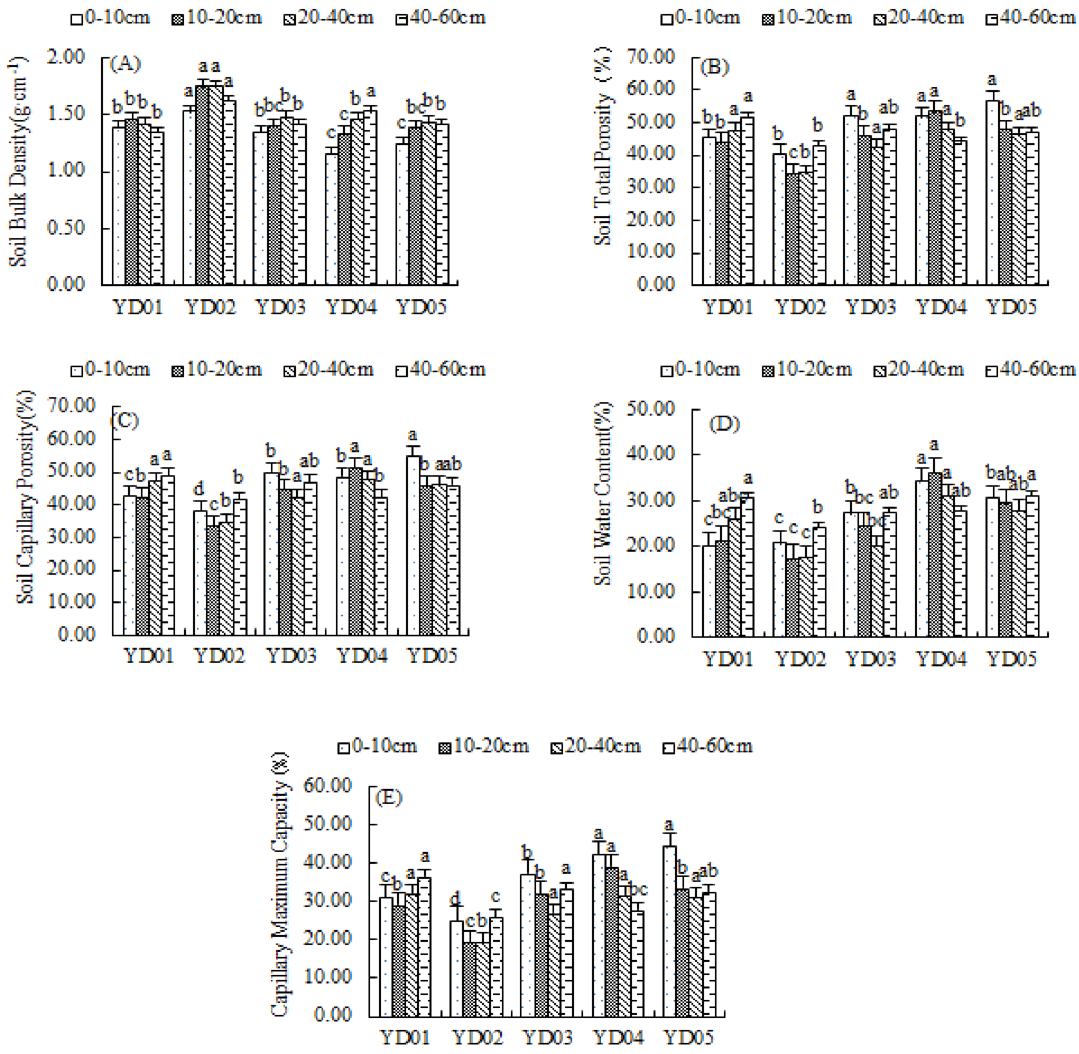

Fig.1 Variation characteristics of soil physical properties in different wetland types

3.2 Chemical Properties of Soil

3.2.1 Variation Characteristics of Soil Organic Matter and Nutrient Elements in Different Wetland Types

As can be seen from Fig. 2A, the average content of soil organic matter is 2.41-23.61g/kg. Generally speaking, organic matter is obviously aggregated on the surface layer, which is obviously larger than the middle and lower layers. Apparent accumulation of organic matter is obvious. The organic matter content of different wetland types is significantly different ($P < 0.05$). the order of the organic matter content of different wetland types from high to low is YD02 (15.96 g/kg) > YD04 (11.23 g/kg) > YD05 (10.57 g/kg) > YD01 (8.35 g/kg) > YD03 (5.90 g/kg). it can be seen that the organic matter content of perennial stagnant water is significantly higher than that of seasonal stagnant water.

As can be seen from Fig. 2B-2F, the average total N content is 0.23-0.84g/kg, the average total P content is 0.55-1.63g/kg, the average total K content is 19.78-26.95g/kg, the average available P content is 0.71-125.54mg/kg, and the average available K content is 44.91-133.79mg/kg. On the whole, the contents of total N, total P, available P and available K show a distribution pattern of high and low, and the phenomenon of aggregation is obvious. This research result is consistent with that of Shan Guilian et al. [9] and Shao Xinqing et al. [10]. The variation law of total K content is different.

The contents of total N, total P, total K, available P and available K in different wetland types were significantly different ($P < 0.05$). The order of total N content in different wetland types from high to low is YD04 (0.49 g/kg) > YD02 (0.47 g/kg) > YD01 (0.38 g/kg) > YD05 (0.37 g/kg) > YD03 (0.33 g/kg). The order of total P content from high to low is YD04 (0.97 g/kg) > YD01 (0.68 g/kg) > YD05 (0.63 g/kg) > YD02 (0.62 g/kg) > YD03 (0.61 g/kg). The order of total K content from high to low is YD02 (24.70 g/kg) > YD05 (22.20 g/kg) > YD01 (21.68 g/kg) > YD03 (21.30 g/kg) > YD04 (21.10 g/kg). The contents of total N and P in perennial stagnant water are higher than those in seasonal stagnant water.

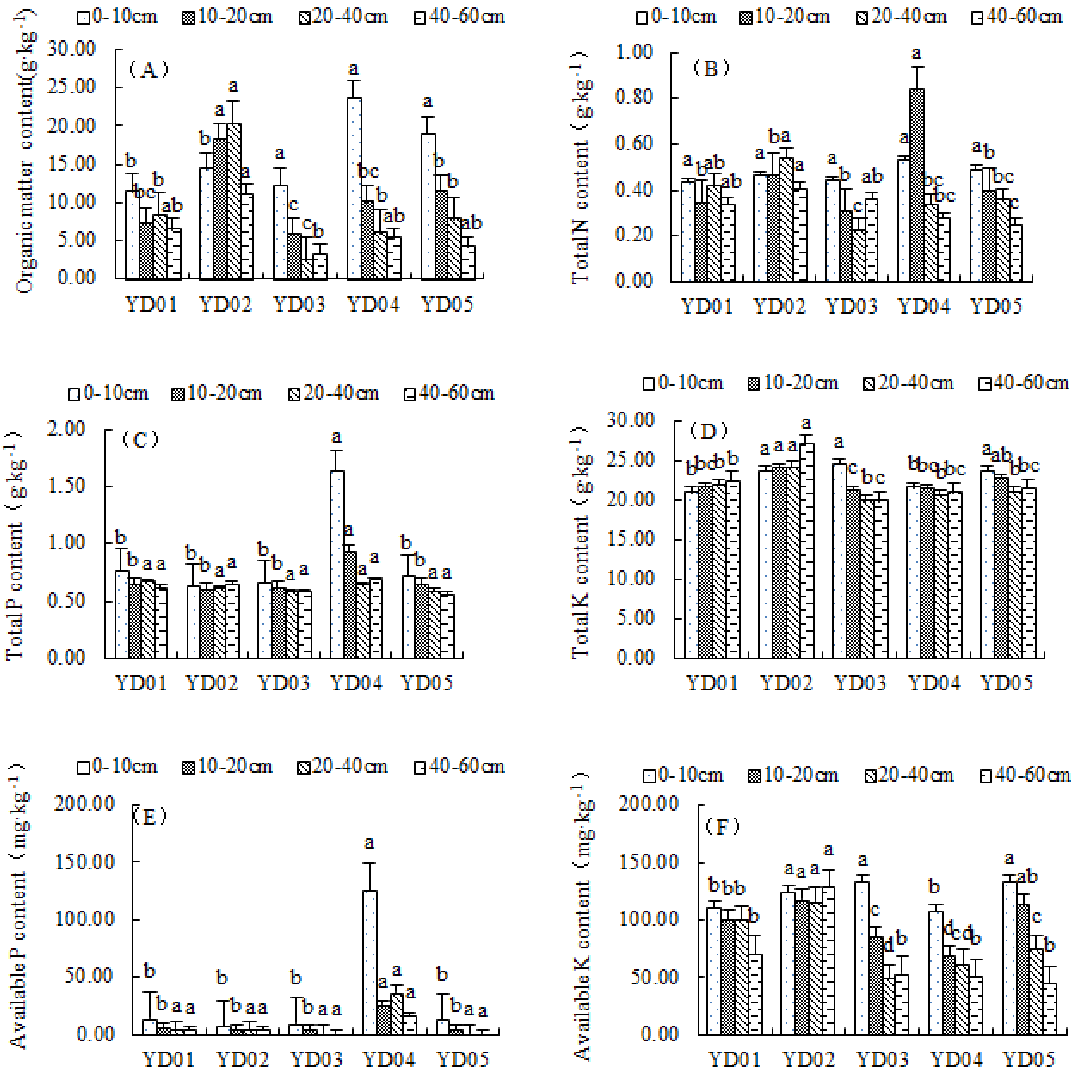

Fig.2 Changes of soil organic matter and nutrient elements in different wetland types

3.2.2 Variation Characteristics of Soil PH and Total Salt Content in Different Wetland Types

As can be seen from Fig. 3A, the PH value is between 7.77 and 9.17, and the PH value of each layer of soil is greater than 7. the soil in the study area belongs to alkaline soil. On the whole, the change rule of PH value is not obvious. There is no significant difference in the PH values of different wetland types ($P < 0.05$). the order of PH values of different wetland types from high to low is YD03 (9.02) > YD02 (8.60) > YD01 (8.44) > YD05 (8.19) > YD04 (7.94). it can be seen that the PH value of seasonal waterlogging is higher than that of perennial waterlogging.

As can be seen from Fig. 3B, the average total salt content is 1.06-26.11g/kg. Overall, with the increase of soil depth, the total salt content shows a decreasing trend, and the total salt content shows the characteristics of surface aggregation. The total salt content of different wetland types is significantly different ($P < 0.05$). the order of total salt content of different wetland types from high to low is YD01 (18.82 g/kg) > YD03 (3.99 g/kg) > YD05 (3.10 g/kg) > YD02 (2.50 g/kg) > YD04 (1.54 g/kg). it can be seen that the total salt content of seasonal water accumulation is greater than that of perennial water accumulation. The total salt content of YD01 is 7, 4, 12 and 6 times higher than that of YD02, YD03, YD04 and YD05, which indicates that the soil salinization of YD01 is serious.

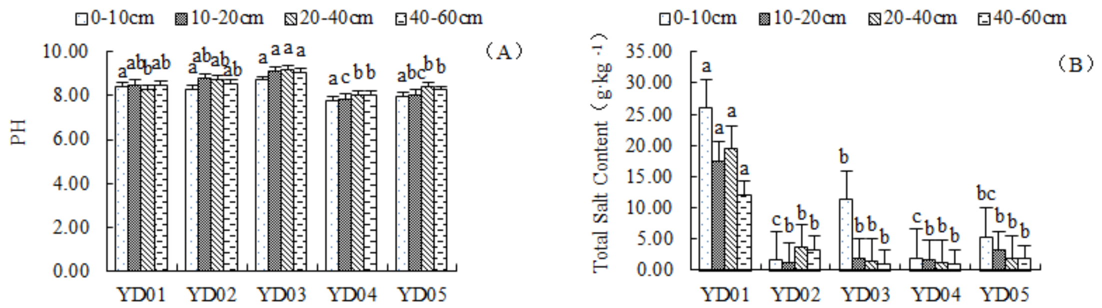

Fig.3 Changes of soil PH and total salt content in different wetland types

3.3 Correlation Analysis of Soil Physical and Chemical Properties

From Table 2, it can be seen that soil bulk density has a very significant negative correlation with soil water content ($P < 0.01$), with total porosity, capillary porosity and capillary maximum water holding capacity ($P < 0.01$), and with total P and available P ($P < 0.05$). Soil water content has extremely significant positive correlation with total porosity, capillary porosity and capillary maximum water holding capacity ($P < 0.01$), and extremely significant positive correlation with total P and available P ($P < 0.01$); Total porosity has a very significant positive correlation with capillary porosity and capillary maximum water holding capacity ($P < 0.01$). Capillary porosity has a very significant positive correlation with capillary maximum water holding capacity ($P < 0.01$). The maximum capillary water holding capacity has a significant positive correlation with total P and available P ($P < 0.05$). Organic matter has a very significant positive correlation with total N and available K ($P < 0.01$), and a significant positive correlation with total P, total K and available P ($P < 0.05$); There was a very significant positive correlation between total P and available P ($P < 0.01$). There was a very significant positive correlation between total K and available K ($P < 0.01$). PH has significant negative correlation with soil water content, total porosity, capillary porosity and capillary maximum water holding capacity ($P < 0.05$), and has significant negative correlation with total P and available P ($P < 0.05$). The correlation analysis shows that soil water content, organic matter and PH play an important role in soil physical and chemical properties.

Table 2 Correlation analysis of Soil Physical and Chemical Properties

Parameter	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	1												
X2	-.742**	1											
X3	-.917**	.841**	1										
X4	-.883**	.847**	.994**	1									
X5	-.956**	.826**	.979**	.968**	1								
X6	0.018	-0.086	-0.095	-0.103	0.047	1							
X7	-0.13	0.242	0.185	0.191	0.239	.592**	1						
X8	-.549*	.451*	0.36	0.312	.498*	.549*	.460*	1					
X9	0.371	-0.238	-0.213	-0.182	-0.22	.557*	0.289	-0.083	1				
X10	-.499*	.465*	0.32	0.273	.450*	.496*	0.315	.957**	-0.141	1			
X11	0.083	-0.313	-0.093	-0.094	-0.03	.762**	0.398	0.167	.778**	0.077	1		
X12	-0.177	-0.229	0.127	0.09	0.105	-0.028	-0.007	-0.028	-0.015	-0.13	0.289	1	
X13	0.438	-.656**	-.461*	-.450*	-.489*	-0.348	-0.427	-.542*	-0.032	-.541*	-0.1	0.013	1

Note: "+"means positive correlation and "-"means negative correlation; * and * * indicate the significance at the levels of 0.05 and 0.01 respectively. X1 represents soil bulk density, X2 represents soil water content, X3 represents total porosity, X4 represents capillary porosity, X5 represents maximum capillary water capacity, X6 represents organic matter content, X7 represents total N content, X8 represents total P content, X9 represents total K content, X10 represents available P content, X11 represents available K content, X12 represents total salt content, and X13 represents PH value.

4. Conclusion

(1) Soil bulk density, soil water content, total porosity, capillary porosity and capillary maximum water holding capacity of different wetland types are significantly different ($P < 0.05$). Generally speaking, with the increase of soil depth, soil bulk density increases first and then decreases, while total porosity and capillary porosity decrease first and then increase. Perennial waterlogged soil has large volume, small porosity and poor structure, while seasonal waterlogged soil has small bulk density, large porosity and good structure. The soil water content and capillary maximum water holding capacity show a trend of decreasing at first and then increasing. The soil water content and capillary maximum water holding capacity under perennial ponding condition are larger than those under seasonal ponding condition. The study found that the soil structure in the state of standing water all the year round will be destroyed, which is not conducive to the permeability and water retention of the soil, and is not conducive to the growth of wetland plant communities and the activity of microorganisms.

(2) The contents of soil organic matter, total N, total P, total K, available P and available K in different wetland types were significantly different ($P < 0.05$). In the vertical distribution, organic matter, total N, total P, available P and available K content are obviously aggregated, and the variation law of total K content is different. The contents of organic matter, total N and total P in perennial ponding state are higher than those in seasonal ponding state. In recent years, due to a large number of reclamation of farmland around Baotou Yellow River wetland by human activities, the consumption of soil nutrients is serious and the soil fertility is reduced.

(3) The total salt content of different wetland types was significantly different ($P < 0.05$). Generally speaking, the change rule of PH value is not obvious, and the PH value in seasonal water accumulation state is greater than that in perennial water accumulation state. The total salt content showed a decreasing trend, and the total salt content showed the feature of surface aggregation. The total salt content in seasonal ponding was greater than that in perennial ponding. The total salt content of YD01 is 7,4,12,6 times higher than that of YD02, YD03, YD04 and YD05, which indicates that the soil salinization of YD01 is serious. Soil salinization has a certain inhibitory effect on plant growth, so more saline-alkali tolerant plants should be introduced to improve the salinization degree of Baotou Yellow River wetland soil, thus improving the physical and chemical properties of the soil in the region and protecting the ecological environment of the wetland.

(4) Through correlation analysis, it can be seen that the correlation between soil bulk density, porosity, water content, organic matter, PH and other physical and chemical factors is significant ($P < 0.05$), of which the soil water content has a very significant positive correlation with total P and available P ($P < 0.01$), the organic matter has a very significant positive correlation with total N and available P ($P < 0.01$), and has a significant positive correlation with total P, total K and available P ($P < 0.05$). PH has significant negative correlation with soil water content, total porosity, capillary porosity and capillary maximum water holding capacity ($P < 0.05$), and has significant negative correlation with total P and available P ($P < 0.05$). Studies have found that soil water content, organic matter and PH play an important role in soil physical and chemical properties. In the rational use and protection of soil, Baotou Yellow River wetland can improve the composition and properties of litter by increasing species diversity, promote its rapid decomposition, continuously increase the content of organic matter in soil, and improve the physical and chemical properties of soil.

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