JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Nov. 2013. Vol. **7**(Spl. Edn.), p. 809-812

Characters of Saline-alkali Soil in Western Jilin and biological Treatment

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(Received: 27 September 2013; accepted: 04 November 2013)

Saline-alkali soil is widely distributed in western Jilin, which is a important province of crop producers of China. Land salinization will cause serious damage to agriculture and engineering. This thesis took field investigation on western Jilin and did some laboratory test of soil sample collected in Zhenlai country of Jilin province. The result showed that: soil samples were carbonate saline-alkali soil, the moisture content of soil samples were higher with the increasing of depth, pH and soluble salt content were lower with the increasing of depth, the influence depth of evaporation was 30cm in the research area. Sulfur- oxidizing bacteria treatment mechanism was discussed. The research can provide theoretical basis of prevention and treatment of saline-alkali soil in western Jilin.

Key words: Saline-alkali soil, Land salinization, Western Jilin, Biological treatment, sulfur-oxidizing bacteria.

Western Jilin province is one of typical seasonal frozen soil distribution area of northeast in China, which has massive saline-alkali soil. It has severe cold winter and torrid summer in western Jilin, the annual precipitation is low and rainy season is June to August, otherwise, spring and autumn are dry and windiness. Because of the strong evaporation effect of earth's surface, salinity in soil easily gathered on surface and formed into saline soil. Furthermore, the water migration during freezing process in winter brought the salinity to freezing front, and when spring came, salinity accumulated once more due to the evaporation of surface, this process aggravated the salinity degree of soil. Soil salinization would not only bring serious harm to agricultural production, but also lead to some damage to engineering project such as frost heave and differential settlement of highways. Therefore, for the purpose of controlling the increasing soil salinization trend, it would have theoretical and practical significance of researching the characters saline-alkali soil western Jilin.

This research took the soil samples from Zhenlai of Jilin province, and did a serious laboratory test of soil samples, studied the characters saline-alkali soil and discussed the treatment measure, provided theoretical basis of preventing the soil salinization of western Jilin.

MATERIALS AND METHODS

Soil samples were taken from Zhenlai country of Jilin province during spring. 8 samples were collected with the depth of 0cm, 10cm, 20cm, 30cm, 40cm, 50cm, 70cm and 100cm. According the phenomenon of field, the earth surface was dry and showed grey-white because of the massive

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crystals of soluble salt, the soil underground were wet and black-brown or gray.

Granulometric composition and physical properties of soil samples

Granulometric composition and basic physical properties were shown in Table 1.

According to Table 1, all 8 samples were low liquid limit clay, most particle diameters were distributed in the range of 0.005-0.075mm. The soil natural densities were 1.6-1.72g/cm3 and had unobvious variation with the increasing of depth. Natural moisture content were markedly increasing with the increasing of depth during the limits of 0-30cm; but beneath 30cm, natural moisture content changes little with the increasing of depth. This result caused by dry and windiness weather of spring, the evaporation reduced the moisture content of soil which closed to surface, and the soil weren't effected beneath the influence depth of evaporation. The relationship between natural moisture content and depth is shown in Figure 1.

Salinity composition and chemical properties of soil samples

Chemical properties analysis is a significant part of soil basic characters study, this research took soluble salt content test, pH test, organic content test and cation exchange capacity(CEC) test. Soluble salt refers to the salinity which can easily dissolved in water, which include all kinds of chloride, water-soluble sulfate and water-soluble carbonate. Total soluble salt content and each kind of salinity composition had been tested during the research. The results are shown in Table 2.

According to Table 2, pH of 8 soil samples were high than 7, it means soil samples were all alkalinity. The variation of pH with increasing of depth is shown in Figure 2, pH was lower on the surface due to the effect of rainwash; during the limits of 0-30cm, pH was higher with the increasing of depth, the alkalinity of soil were getting enhanced; beneath the depth of 30cm, pH was lower with the increasing of depth, the alkalinity of soil were getting reduced.

Besides, according to the test of salinity of soil samples, the major soluble salt were Na^+ and HCO_3, some total soluble salt content of samples were higher than 0.3%. Therefore, the soil of research area can be named as carbonate saline-alkali soil. The relation of total soluble salt content and depth were shown in Fig. 3, according to Figure 3, the main regulation of soluble salt content is getting lower with the increasing of depth, but this trend is obvious during the limits of 0-30cm, not so obvious beneath the depth of 30cm. It also caused by evaporation of the spring, the salt migrated to surface with the ground water, hence there's more salification in the soil which close to surface. It means the influence depth of evaporation was 30cm in the research area.

RESULTS AND DISCUSSIONS

Advances of improving saline-alkali soil

According the research above, western Jilin has a certain amount of carbonate saline-alkali soil. Jilin Province is one of the most important grain-producing areas, saline-alkali soil is harmful to grain and crop growth and would cause some serious engineering problems. For this reason, the

Table 1. Basic physical properties of soil samples

Depth of soil samples/cm	Density /g/cm^3	Particles mass fraction /%			Nature Moisture content/ %	Liquid limit moisture content/%	Plastic limit moisture content/%	Ip
		Sand 2-0.075mm	Silt 0.075-0.005mm	Clay <0.005				
0	1.6	33.32	59.74	7.01	1.87	28	20	8
10	1.71	17.48	54.67	27.82	12.62	23.12	14.62	8.5
20	1.7	14.74	59.66	25.6	18.17	25.1	16.4	8.7
30	1.72	21.19	60.92	17.88	21.98	29.8	18.9	18.6
40	1.72	30.33	52.48	17.23	19.06	28	17	11
50	1.6	29.06	54.5	16.44	16.65	27.1	17.6	9.5
70	1.68	33.6	48.43	18.08	19.33	25.7	15.2	10.5
100	1.72	25.72	58.89	15.43	21.91	26.3	16	10.3

Table 2. Basic chemical properties of soil samples

Depth of soil samples/ cm	Total soluble salt content/%	Soluble salt component content/%							Organic matter content/	pH	CEC content /mmol/ 100g
		Na^+	K^+	Ca^+	Mg^+	SO_4^{2-}	Cl^-	HCO_3^-			
0	0.516	2.79	0.16	0.37	0.5	0.1	2.3	1.44	0.97	7.7	9.19
10	0.374	2.69	0.15	0.3	0.08	0.20	1.85	2.37	0.7	8.2	13.68
20	0.286	3.15	0.11	0.19	0.7	0.21	1.1	1.93	0.73	8.3	14.21
30	0.157	1.38	0.1	0.19	0.78	0.63	0.55	1.41	0.56	8.3	11.46
40	0.115	0.92	0.09	0.13	0.42	0.29	0.45	1.05	0.23	8.1	8.72
50	0.08	0.7	0.02	0.17	0.36	0.32	0.45	0.8	0.29	8	9.55
70	0.089	0.56	0.01	0.1	0.24	0.21	0.02	0.74	0.32	7.6	7.91
100	0.06	0.5	0.01	0.18	0.24	0.21	0.05	0.7	0.27	7.7	10.23

treatment to saline-alkali soil of western Jilin is necessary and urgent. Jilin province started the land consolidation and rehabilitation project at 2008, used diversion irrigation and planting paddy field to improve saline-alkali soil and looked forward to increasing the grain output. But many headrace channels were frost heaving damaged during winter, led to some problems to management and using of channels. So it have to find another safe and clean treatment way.

Because of the metabolism of microorganism produces massive organic acid, it can neutralization the alkalinity of saline-alkali soil. Some special microorganism such as sulfur-oxidizing bacteria can also oxidize elemental sulfur and sulfide and produce sulfuric acid, reduce the pH of soil and improve the solubleness of soil mineral substance, provide more nutrient to crops. Bossuyt. H[1] had reported the microorganism could promote the soil aggregate formed, soil which treated by fungicide was loosen and had lower volume-weight, capillary holes of soil were cut off and non-capillary holes increased, leaching salt process was accelerated and salinization were conducted. This chapter aims to the method of using sulfur-oxidizing bacteria to improve saline-alkali soil.

Improving the saline-alkali soil with sulfur-oxidizing bacteria

Sulfur-oxidizing bacteria is a kind of chemoautotrophy bacteria, which widely distributed in soil, fresh water, salt water, hot spring and sulfur mine. It can oxidize hydrogen sulfide and other sulfide into elemental sulfur, sulfide is

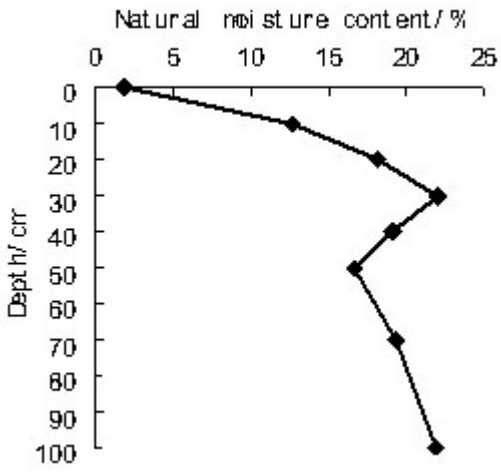

Fig. 1. Relationship between natural moisture content and depth

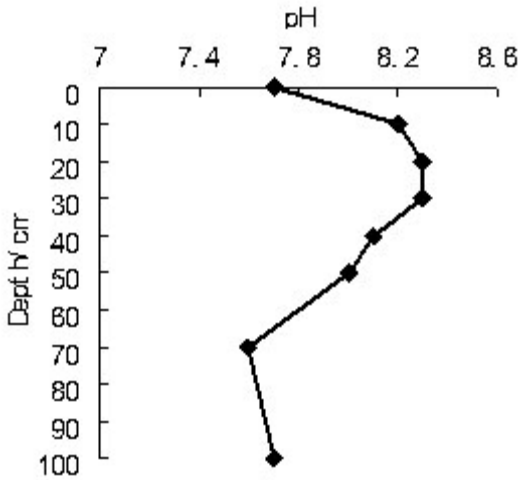

Fig. 2. Relationship between pH and depth

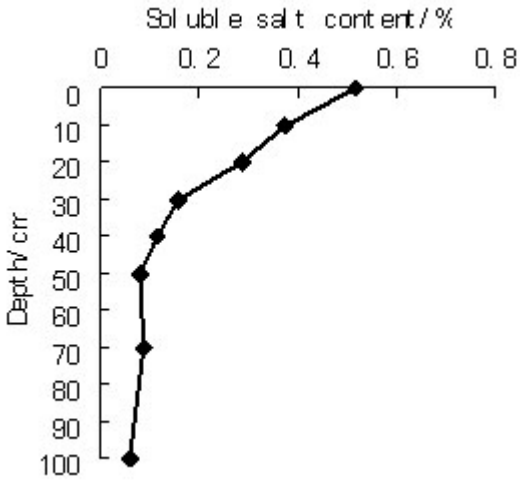

Fig. 3. Relationship between soluble salt content and depth

electron donor and oxygen is electron acceptor[2], the reaction equations are as Eq. (1) and (2):

$$2H_2S + O_2 \xrightarrow{\text{Sulfur-oxidizing bacteria}} 2S_2 + 2H_2O \quad ...(1)$$

$$H_2S + 2O_2 \xrightarrow{\text{Sulfur-oxidizing bacteria}} H_2SO_4 \quad ...(2)$$

Sulfur-oxidizing bacteria can also oxidize elemental sulfur into energy which needed by cell growth and metabolism, the oxidative product is sulfuric acid[3], and more soluble sulfate gathering in the water. The biochemical reaction equation is as Eq. (3):

$$2S + 3O_2 + 2H_2O \xrightarrow{\text{Sulfur-oxidizing bacteria}} 2H_2SO_4 \quad ...(3)$$

During the biochemical reaction, sulfur-oxidizing bacteria produce sulfuric acid and take the neutralization reaction to OH in the soil, the reaction can lower the pH of soil. Zhang Jing[4] had done some laboratory test using sulfur- oxidizing bacteria to improve dredger fill and well results were obtained. This method can be used in western Jilin, and this is the author of next step research direction.

CONCLUSIONS

1. Carbonate saline-alkali soil was distributed in western Jilin, it would cause some serious problems.
2. Moisture content of soil samples were higher with the increasing of depth, pH and soluble salt content were lower with the increasing of depth, the influence depth of evaporation was 30cm in Zhenlai area.
3. Sulfur- oxidizing bacteria can lower the pH of soil, this method can be used in western Jilin.

ACKNOWLEDGMENTS

This work was supported by the International Cooperation Project of the Natural Science Foundation (grant number: 40911120044), Natural Science Foundation of China (grant number: 40672180, 41372267, 41302247), and the Doctoral Program Foundation of Higher Education of China (grant number: 20120061110054).

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