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A study on drilling fluid waste improving desertification soil in Changqing gas field

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ABSTRACT

Changqing gas field is located in semi-desert or semi-desert grassland, arid climate. Waste drilling fluid was produced as a result of gas field development contained high moisture, organic and clay. So, waste drilling fluid could be used to improve the desert. Waste drilling fluids were treated by a fertilizer treatment agent and were used to improve the desert. So, the soil physical and chemical properties are greatly improved, soil organic matter is increased, capillary porosity increased 3.4 times, powder content increased 12.23 times, clay content increased to 1.62% from zero, cation exchange capacity, organic matter, and soluble nitrogen increased two times. Plant high and weight are also increased by 18.24 and 23.44%, respectively. Soil micro-organisms have a substantial increase by 5–6 times, and conducive to the establishment of soil ecosystem and the formation of a virtuous circle.

Keywords: Changqing gas field; Waste drilling fluid; Improving desert

1. Introduction

Changqing gas field is located in desert or semi-desert grassland, arid climate, and fragile environment. Gas field produces a large amount of waste drilling fluid that contains clay and organic matter that are useful for the desert improvement and desert vegetation. A large number of moisture in the waste fluid is the matter lacked in desertification soil. So, the combination of waste fluid treatment and soil improvement is according to the development ideas "science, green and harmonious" in Changqing gas field. And it is to overcome the environment secondary problem of solidification technology of waste fluid [1,2]. At present, solidification technology is used to hardening material such as cement for the main treatment agent as is a common technique, but treatment agent plus large, curable solid high hardness, soil could not be restored, and there was a secondary pollution.

2. Waste drilling fluid feature

Changqing gas field belongs to low pressure and low-permeability gas reservoir. So, low-density polymer mud system is used mainly due to the need to protect the reservoirs, and 4% bentonite, 0.3%

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Table 1
Characteristics of gas field waste drilling fluids

Moisture (%)	90~95
COD (mg/L)	3,000~8,000
Organic matter (g/kg)	6~10
Clay (%)	4~6
Zeta potential (mV)	−30~−40
R (s^2/g)	10^9~10^{10}

CMC, and 0.1–0.3% K-PAM are added in it. So, moisture content is high. Therefore, waste fluid is a kind of stable colloidal system containing clay and organic matter, and water retention effect is good. It is shown in Table 1.

Table 1 shows that ζ potential, sludge specific resistance (R) of waste fluid was high, it was a kind of stable colloidal suspension system. The moisture content, organic matter, and clay content were far higher than desertification soil. Sand substantially free of clay and organic matter was 0.33%.

3. Waste fluid treatment and soil improvement principle

Desertification soil in gas field area is weak alkaline and poor, and also clay and colloidal particles less. To increase the clay and colloidal particles, the content of organic matter is increased and the composition of soil colloid absorbing cation is changed which improved soil permeability that was mainly way for soil improvement [3,4]. As high content of organic matter and clay in waste fluid, waste fluid by the environment friendly treated can be used to improve soil. It can regulate the physical and chemical properties of desertification soil by increasing the water retention ability and fertilizer content. Using fertilizing agent in the waste fluid treatment process [5], one can improve soil ion environment, increase soil organic matter, and colloid ion content. This is not only to achieve the purpose of processing waste fluid to have positive role in the desertification soil improvement.

4. The apparatus, materials, and methods for the experiment

4.1. Experiment apparatus

Laser particle size analyzer (LS13, Beckman Coulter), Zeta potential analyzer (JS94J2 M, Global Hengda), Ion chromatograph (HIC-SP, Shimadzu), and Atomic absorption spectrometer (AA-7000, Shimadzu) were used.

4.2. Experiment materials

Drilling fluid waste: snuff color, moisture 93%, zeta potential −37mv, sludge specific resistance 2.4×10^9 s^2/g; soil conditioner: laboratory-made.

4.3. Experiment methods [6,7]

Soil mechanical composition was measured using a laser particle size analyzer; capillary porosity was measured using the ring knife series analysis method; cation exchange capacity was measured using EDTA-ammonium; organic matter was measured using potassium dichromate volumetric; nitrogen was measured using alkaline hydrolysis distillation; phosphorus was measured using sodium bicarbonate leaching molybdenum blue colorimetric assay; CO^{2-}, HCO^-, SO_4^{2-}, and Cl^- concentration was measured by ion chromatography; Ca^{2+}, Na^+, and K^+ concentrations were measured by atomic absorption spectrophotometry; and bacteria was measured by dilution plate count method.

5. Results and discussion

5.1. Influence of soil physical and chemical properties

Waste fluid treated by fertilizing agent was mixed with desertification soil according to 1:1 or 2:1 proportion [8] which would improve the desertification soil. Analysis and comparison before and after the improvement of soil physical and chemical properties after 60d can be seen in Tables 2 and 3.

Waste fluid treated by fertilizing agent could improve the physical and chemical properties of desertification soil. Capillary porosity increased 3.4 times; powder content increased 12.23 times; clay content increased to 1.62% from zero; and cation exchange capacity, organic matter, and soluble nitrogen increased two times. And the ability of water retention and fertilizer was enhanced. At the same

Table 2
Comparison of soil properties

	Before improvement	After improvement
pH	8.3	7.1
Capillary pore (%)	11	34.2
Powder (%)	1.89	23.12
Clay (%)	0	1.62
CEC (cmol/kg)	2.4	6.3
Organic matter (%)	0.33	0.62
Soluble nitrogen (mg/kg)	4.19	9.27

Table 3
Comparison of soil ions

	Before improvement	After improvement
CO_3^{2-} (g/kg)	0.105	0.105
HCO_3^- (g/kg)	1.117	1.208
Cl^- (g/kg)	2.127	0.941
SO_4^{2-} (g/kg)	0.865	0.264
Ca^{2+} (g/kg)	0.030	0.040
Na^{2+} (mol/g)	2.8	3.1
Alkalify degre (%)	46.6	12.6

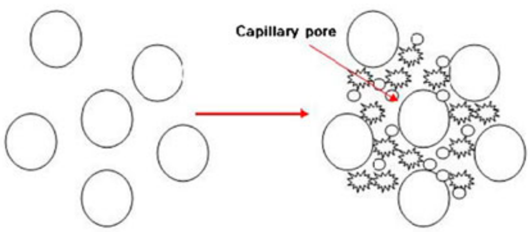

Fig. 1. Soil improvement principle.

time, the reduction of substitutability ion and soil alkalinization in the improved soil could explain that waste fluid adsorbed or replaced the ion of desertification soil, which helped reduce soil salinity-alkalinity (Fig. 1).

5.2. Influence of the water retention

The moisture content of different depth improved soil and desertification soil after 48 h lighting was detected, and it was compared with the moisture content of soil not lighting. It can be seen in Fig. 2.

The moisture content of improved soil by waste fluid was higher than desertification soil (Fig. 2) .And improved soil had good water retention effect, after 48 h lighting, moisture content almost didnot change.

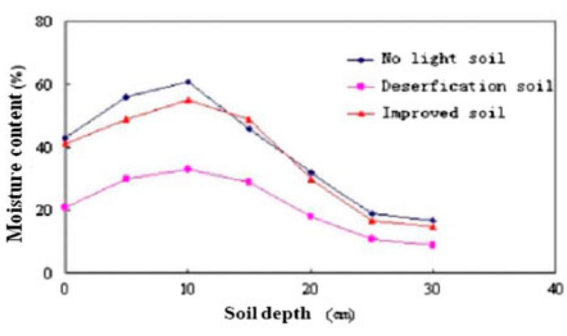

Fig. 2. Comparison of soil water retention.

Table 4
Effects of improved soil on plant growth

	Blank	Improved soil
Plant height (cm)	14.8	17.5
Dry weight (g)	6.4	7.9
N (g/kg)	26.2	11.3
P (g/kg)	1.27	0.09
K (g/kg)	21.0	13.2

Table 5
Quantity of soil micro-organisms

	Soil layer	Organic matter (g/kg)	Micro-organisms (cfu/100 g)
Background value	0~5 cm	3.3	1.83×10^4
	5~10 cm	2.5	1.13×10^4
	10~20 cm	2.2	0.92×10^4
	Average	2.67	1.29×10^4
Improved soil	0~5 cm	6.2	11.01×10^4
	5~10 cm	5.1	8.01×10^4
	10~20 cm	4.8	6.06×10^4
	Average	5.37	8.36×10^4

5.3. Influence of to plant growth

Planted huwei grass in the improved soil, tested analysis huwei grass column high, dry weight and *N*, *P*, *K* content in soil after two months. And compared with the blank control group, in order to determine the plant growth condition and absorbing situation of *N*, *P*, *K*. The results could be seen in Table 4.

The way of waste fluid improving desertification soil could significantly improve the huwei grass growth, and plant height and dry weight increased by 18.24% and 23.44%, respectively. At the same time, it could strengthen *N*, *P*, *K* nutrient uptake of the huwei grass, and *N*, *P*, *K* content in the soil was decreased.

5.4. Influence of the soil micro-organisms

Improved soil by treated waste fluid could provide enough water and organic matter for the growing and breeding of micro-organism. And a large number of microbial breeding was helpful for desert ecological system establishment and circulation. Microbial quantity increased 5~6 times in the improved soil and biological environment was improved that could be seen in Table 5.

6. Conclusion

(1) Waste drilling fluid with the characteristics of high water, organic matter, and clay is a kind

of stable colloidal system; so, it has the ability of water retention and fertilizer which can be used to improve the desertification soil.

(2) Waste fluid treated by fertilizing agent as soil conditioner can improve desertification soil, improve the physical and chemical properties of soil greatly, capillary porosity increased 3.4 times, clay content increased to 1.62% from zero, cation exchange capacity increased two times, and enhance the ability of water retention of soil.

(3) Desertification soil is improved by adding treated waste fluid; organic matter of soil increases two times, plant growth condition is improved, plant height and dry weight increase 18.24% and 23.44%, the quantity of soil microbial also greatly increases 5–6 times, it is helpful for soil ecological system establishment and circulation.

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