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Modification of the Natural Soil for Environmental Governance

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Organobentonites have been widely used to treat with polluted water in environmental applications. We use natural soil instead of organobentonites to sorb pollutants in waste water, remove organic matters of landfill leachate and control infiltration of landfill leachate. The soil was modified by octadecyl trimethyl ammonium chloride. This modified soil had effect on adsorbing pollutants in polluted water and landfill leachate, but it was equivalent to natural soil on antiseepage. So it was not applicable in antiseepage project and could be promote use in the sewage treatment.

Key Words: Modified soil, Cation exchange, Octadecyl trimethyl ammonium chloride, Landfill leachate, Sewage seepage.

INTRODUCTION

With the development of economic, environmental pollution is getting worse. Industrial waste water and domestic water is basically directly discharged without treatments, that is seriously harm to the environment. Sanitary landfill is also widely used method to dispose of municipal solid waste at home and abroad, but the resulting landfill leachate is a difficult problem. Leachate is toxic organic wastewater of high concentration. If it is not handled properly, it will cause serious secondary pollution of surface water, groundwater and soil, that has a huge threat to ecosystem and human health.

Organobentonites have been widely used to deal with polluted water in environmental applications[1]. The modified soil treated with environment will have low cost, simple preparation, a variety of modification and high efficiency removal of many contaminants. So it is an important research and has a development value. As we all know, the soil contains silica, metal oxides, clay minerals and other substances. The surface of clay minerals in the soil exits a large number of hydrophilic inorganic exchangeable cations, that results in adsorbing a thin water layer of mineral soil surface. This water layer of clay minerals in the soil causes greater resistance for the adsorption of hydrophobic organic compounds. By ion exchange, we added modifiers to exchange inorganic cation out of the pre-existing clay minerals, making it to hydrophobic organic clay minerals, so we could study effectiveness of the modified soil to remove sewage and the main pollutants in landfill leachate and feasibility of controlling infiltration of landfill leachate.

In this paper, the soil was modified by placing cationic surfactant octadecyl trimethyl ammonium chloride by cation exchange in order to see adsorption of organic matter and the possibilities of anti-seepage[2].

EXPERIMENTAL

The used soil is from middle earth of the eastern suburbs of Jinan. It should be air dried, crushed and passed through 1.47 mm sieve before using. Octadecyl trimethyl ammonium chloride used is AR grade chemical. Landfill leachate is from a landfill in Jinan. We use magnetic stirring electric heated unit, JJ-2 force electric mixer, SHE-D (III) circulating water pumps, ZK-82B vacuum drying oven, HACH DR/890 COD digestion instrument/colourimeter and atomic absorption spectrophotometer to make experiments.

Determination of soil cation exchange capacity: We weighed soil (1.0 g) in 30 mL centrifuge tubes. A solution of calcium chloride (0.1 mol L^{-1}) was used to replace exchangeable cations in soil with Ca^{2+}. Then $BaCl_2$ solution (0.1 mol L^{-1}) was to substitute for Ca^{2+}. The concentration of replaced Ca^{2+} was measured by atomic absorption spectrophotometer. Then we calculated cation exchange capacity of the soil samples.

Preparation of modified soil: A certain amount of soil samples was placed in a beaker, then the same cation exchange capacity as soil of cationic surfactant was added to samples. Then it was placed in 60 ºC water bath pot for stirring for 2 h, cooled down to room temperature and filtered separated. Solid was washed repeatedly with distilled water for 4 to 5 times to remove chlorine ions. Then it was filtered, dried, crushed and passed through 1.47 mm sieve. So 1.0 cation exchange capacity modified soil was acquired.

Sorption of organic pollutants in polluted water: Modified soil (about 0.5 g) and polluted water (25 mL) were added in a 250 mL Erlenmeyer flask flask. Cap was tightly. Then it was put aside for 24 h and filtered. COD of the filtrate was measured to analysis.

Treatment of landfill leachate: Since COD of the taking landfill leachate was 500 mg L^{-1}, it was diluted 20-fold with distilled water as water samples to be processed. Water samples (25 mL) were pipetted in 150 mL Erlenmeyer flask to be added a certain amount of modified soil. Then it was put aside and filtered. The supernatant of COD and chromaticity was measured[3].

Test of seepage performance: We used soil column experiments to study the performance of impermeable of modified soil. Experimental setup was shown in Fig. 1. The dried and crushed modified soil (3.0 g) was used to fill the column. The height of impermeable layer was 1 cm. After installation of column, the upper layer of impermeable layer was added landfill leachate. A certain negative pressure was to increase flow rate of leakage fluid. When the leakage liquid passed through impermeable layer, samples were regularly obtained. Then we monitored concentration of organic pollutants in exudate by spectrophotometry[4].

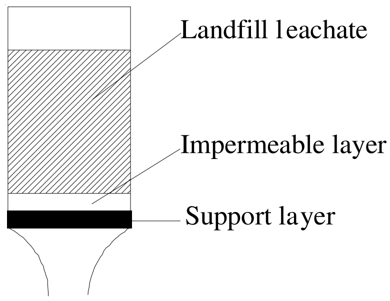

Fig. 1. Experiment equipments of soil column

RESULTS AND DISCUSSION

Capacity of adsorption in polluted water: Previous experiments showed 0.5 g and 1.0 cation exchange capacity modified soil had best adsorption of organic pollutants. So we used 1.0 cation exchange capacity modified soil to compare with the natural soil. Soil was used recyclic order, then combined with water several times, at last we observed the change of COD. Fig. 2 showed that the COD of modified soil firstly increased, then decreased and finally stabilized. The reduction of COD was about 57.44 mg L^{-1}. The changes in the decontamination of original soil was relatively simple, firstly increased and then decreased to stabilization. Compared with natural soil, COD was 27.44 mg L^{-1} lower. From the COD values, detergency of modified soil was much higher than the natural soil.

Modifiers on the adsorption of pollutants led on "distribution" of pollutants in the modified soil. The organic chain of modifier exchanged with inorganic ion of the soil and then was adsorbed at the surface of the soil. The interaction of organic chain made chains squeeze together to form large organic phase, that increased distribution of water pollutants in the modified soil. Through the distribution, some pollutants such as aliphatic compounds, were adsorbed by such organic clay minerals. As a result of high adsorption, the organic layer was no longer pure alkyl organic phase. It was composed of original organic phase and adsorbed alkyl aliphatic compounds. That enhanced the ability of adsorption to pollutants in water[5].

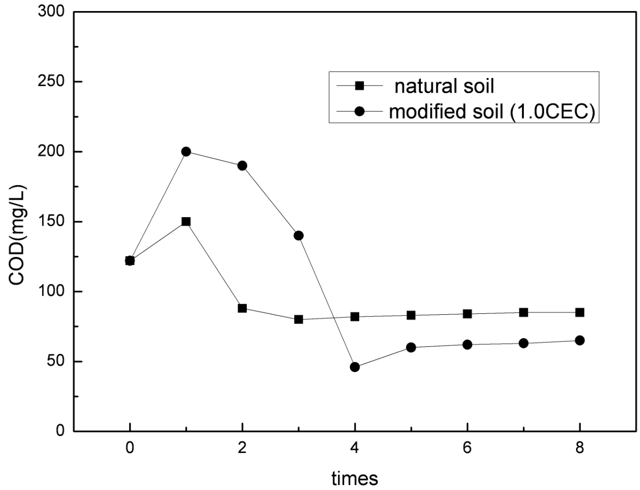

Fig. 2. COD of filtrate after modified soil and natural soil treated with polluted water

However, in the early use of the natural soil, COD values increased slightly, which was caused by some impurities in the soil dissolved in water. Then COD values decreased, because the soil contained very little humus (humus was active substances to adsorb organic pollutants). So soil adsorbed pollutants in sewage by physical adsorption. But humus was little and physical adsorption was weak, it was far less than the chemical adsorption of modified soil. Therefore decontamination capability of modified soil was much higher than natural soil.

Effect of treating with landfill leachate: Experiments had determined the temperature was 25 ºC, the amount of soil was 1.0 g, pH was natural, oscillation time was 40 min, velocity was 140 r/min. Firstly soil was put aside for 1 h, then it would be deal with landfill leachate. In Table-1, removal efficiency of modified soil was 2.5 times than natural soil, at the same time decolourization was also 1.77 times than natural soil. Modified soil worked well in treating with landfill leachate.

TABLE-1
COMPARISON OF TREATMENT BETWEEN MODIFIED SOIL AND NATURAL SOIL

Items	Removal efficiency of COD (%)	Decolourization (%)
Natural soil	22.5	35.2
Modified soil	56.4	62.3

Adsorption and decolourization of modified soil had a good effect. That was because layer space of modified soil increased than natural soil in Fig. 3. Bragg equation as follows:

$$\lambda = 2d \sin\theta \quad (1)$$

In eqn. 1, interplanar spacing d is inversely proportional to angle of diffraction θ. Layer spacing of soil decreases with increasing 2θ. Fig. 3 presents layer spacing of modified soil is larger than natural soil.

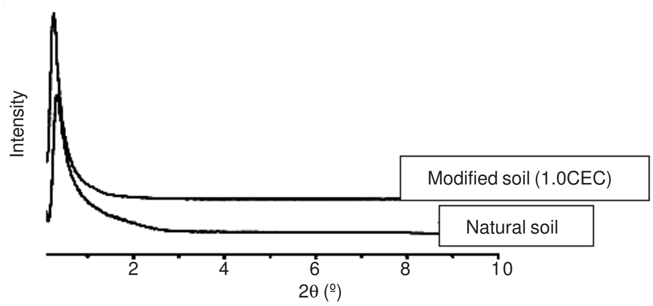

Fig. 3. GIX-ray diffraction pattern of modified soil and natural soil

The organic cations of octadecyl trimethyl ammonium chloride came into the layered structure of soil, exchanging with layers of inorganic cation and forming ionic based organic compounds. Then the layer spacing was greater, ionic exchange was more and adsorption was larger. So adsorption properties of modified soil improved and organic pollutants which displayed colour in landfill leachate reduced greatly.

Impermeable effect of modified soil. In order to investigate impermeable effect of modified soil, the concentration of exudate was 15 mg L^{-1}. It respectively passed through impermeable layer prepared by modified soil and natural soil. Then we measured the concentration of exudate. The results were shown in Fig. 4. Chart basically had the same trend. It is suggested that the modified soil had no effect in anti-seepage of landfill leachate.

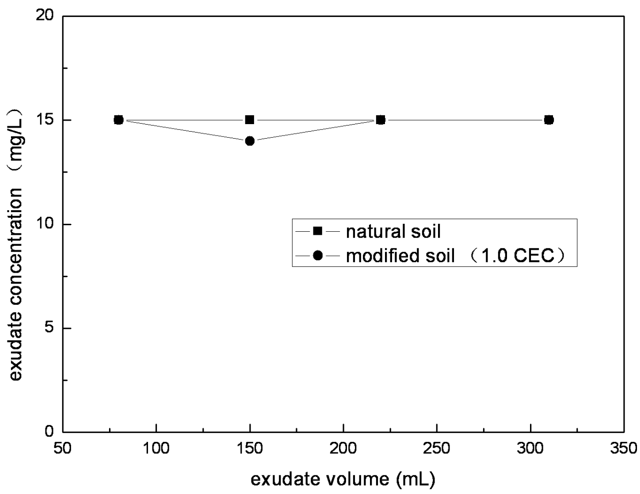

Fig. 4. Anti-seepage effect of modified soil

Conclusion

When soil was used as carrier, modifiers were loaded on the soil by exchanging with hydrophilic inorganic soil cation in the soil, forming oil-modified soil to adsorb pollutants. Experiments showed that modied soil played a role in removing pollutants in waste water and landfill leachate, but it had no effect on anti- seepage. Therefore, this modified soil could be used as purifying agent to deal with polluted water and it could not be applied to the anti-seepage project.

In the later experiments, we would try to use all kinds of cationic surfactant to modify soil to look for breakouts on seepage performance.

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