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Degradation of Microbes for the Crude Oil Contaminants

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Abstract: Production and storage-transportation of crude oil can not only give rise to soil pollution but also destroy ecological environment. Degradation of microbes for oily soil was studied with the instrument, Geofina Hydrocarbon Meter (GHM), by experimental analysis qualitatively and quantitatively in the paper. Analytical result showed that the crude oil could be considerably degraded by eating-oil microbes in oily soil and the number of eating-oil microbes increased while the working hours of oil-well rising. As a result, contaminated oil could be degraded more quickly by a lot of eating-oil microbes in the soil. At the same time, the degradation rate of contaminated oil increased gradually as the time went on. In addition, amount of gaseous component in the oily soil samples increased with degraded time and the microbes could selectively consume contaminated oil strongly, so biodegradation might alleviate the degree of contamination and destruction to the soil and environment in the process of oil production at oilfield. The law of oily soil degraded by microbes was investigated and some useful conclusions were drawn in the paper.

Key words: Microbes; Crude oil; Contaminants; Degradation; Experimental analysis

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In the course, such as oil exploitation, storage, transportation, processing and production and so on, the cases of crude oil falling and leakage often happen. The crude oil entering into soil of the earth's surface results in environment pollution [1~3]. The petroleum pollution for soil may destroy structure and function of ecosystem, which not only makes the comprehensive fertility of soil decline but influences growing of plants. It is more awful that organic contamination in soil may harm human health by biological accumulation and enlargement action of natural food chain [4,5]. Many organic contaminants in petroleum can result in various diseases, for instance, cancer, malformation and gene mutation, to human beings, so the research of degradation for crude oil contaminants is of important significance [6,7].

At present, the method of biological degradation is considered as a better way in the world. Microbes can degrade organic contaminants in soil. The process of biological method is simpler than other ones and expense is lower. In addition, its effect is better and it can't produce additional pollution. So some scholars in the world begin to study the method of biological degradation according to the characteristics of oilfield soil in different areas [8,9]. Biological method to resolve soil contamination will be a significant direction of technology for environmental protection in the future. In China, the soil environments of most oilfields are suitable for applying biological method. Taking soil contaminants of the First Production Factory at Daqing Oilfield for example, the experiment for oily soil biodegradation were finished and the characteristics of microbes degra-

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dation for crude oil was analyzed qualitatively and quantitatively, utilizing technology of thermo-evaporation gas chromatograph. Moreover, the law of oily soil degraded by microbes was investigated and some useful conclusions were drawn in the paper.

1 Experimental Samples and Analysis Method

1.1 Experimental Samples

Experimental samples were collected from oil-well area that was far away from the site of human activity. Sample 1 was collected from the place where oil-wells had being worked for 15 years. There were more eating-oil microbes selected and domesticated by the nature in the oily soil near oil-wells with longer working history. Sample 2 was gained from the area where oil-wells had being worked for two years. The basic data of the soil samples is listed in Table 1.

1.2 Experimental Method

Microbes have good capability of adaptation for the natural environment. The degradation degree of petroleum hydrocarbon is related to the species and amount of microbes, petroleum composition and the environmental parameters influencing biochemical action. Temperature of 10 ~40 degrees centigrade is the optimal condition for microbe reproduction, so experiment was carried on under the condition of room temperature (about 25 degrees centigrade) and natural moisture environment. At first, put sample (100g) triturated into particle size (1mm) into clean transparent glass column, then add cool water boiled to the samples and make sample just immerse in water. The amount of water is decided by sample absorption degree. This experiment should be carried on in the laboratory without light and wind. Experimental time was set for five days, ten days and fifteen days respectively. In addition, the disturbance coming from man should be avoided in the process of experiment.

Table 1 Basic data of the soil samples

Samples	Density (g/cm^3)	Porosity (%)	pH	Water content (%)	Weight loss (%)	Electric conductivity ($\mu s/cm$)
I	2.014	3.3	8.75	1.38	4.92	91.6
II	2.054	3.7	9.40	3.06	2.34	94.9

The main instrument used in analytical experiment was large-scale Geofina Hydrocarbon Meter (GHM) made in Norway GEOLAB. Three GHM detectors were all FID types. The exit pressure of high pure hydrogen was 0.26MPa, and the constant pressure of air compressor was set to 0.6MPa. The carrier gas was helium whose exit pressure was 0.4MPa and the pressure ahead of column was 0.06MPa. Chromatographic column was OV-1032d quartz capillary column with the length of 25 meters. Velocity of helium going through the chromatographic column was 0.85ml/min. Sample injection, detector and auxiliary part of the instrument was set to the same temperatures (300 degrees centigrade).

Initial temperature of quantitative analysis was 220 degrees centigrade, then increase temperature to 300 degrees centigrade at the rate of 40 degrees centigrade per minute and keep it for two minutes. Organic components of petroleum in soil were volatilized from samples. The products of thermo-evaporation were carried by carrier gas to FID C and FID A respectively, then they were detected quantitatively and qualitatively. The ratio of gas distribution between FID C and FID A was 30 : 1. The temperature of chromatographic oven was initially set at 30 degrees centigrade. Then it was raised at the rate of 4 degrees centigrade per minute to 300 degrees centigrade and keep it for 20 minutes until the experiment was finished. By the above experiment, the quantitative and qualitative data of biodegradation for oily soil were obtained in order to calculate the amount and composition of oily organic matters in the samples.

2 Experimental Results and Discussions

Degraded rate and degraded amount were got by experimental data analysis in the process of mi-

crobe degradation for oily soil. The characteristics of relative degraded rate for samples was shown as Fig. 1. The numerical value in Fig.1 had been normalized. Because there were more eating-oil microbes in sample 1 than those in sample 2, the relative degraded rate for organic matter during 5 days was much higher than that of sample 2. In addition, with microbe degradation continuing, the velocity of degradation of the two samples became faster and faster and their relative degraded rate also became higher and higher. The result showed that the more eating-oil microbes, the faster microbe degradation for oily soil. In other words, oily soil around oil wells with longer production history had more eating-oil microbes, so the degraded degree of contaminated oil was increased obviously.

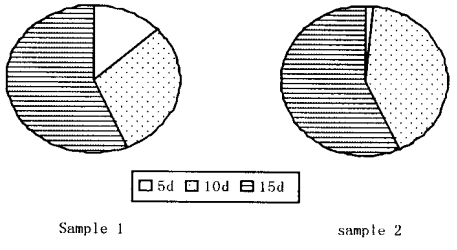

Fig.1 Relative degradation rate of oily soils in different time

The quantitatively analytical result of oil amount with time changing in soil samples was shown as Fig. 2, which shows the quantity of contaminated oil was very different in two samples. The initial amount of organic matter in sample 1 (0.358mg/g) was obviously higher than those in sample 2 (0.056mg/g). Sample 1 came from the district where oil wells had longer production history, so the contaminated oil had been accumulated continually, which resulted in the amount of organic matter in sample 1 were more. Whereas, sample 2 came from the district where oil wells had shorter production history, so the amount of organic matter in sample 2 was lower. Fig.2 also showed the amount of organic matter in two samples all decreased with the microbe degradation getting on, which meant microbe degradation for organic matter became strong with time going on. There really were eating-oil microbes in the soil around oil well and they could degrade petroleum in soil. Certain composition of petroleum was selectively consumed, therefore the degree of destruction of contaminated oil for soil and environment was alleviated in the nature.

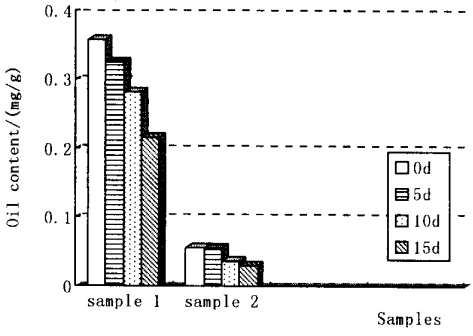

Fig.2 Biodegraded characteristics of soil organic matter quantitatively

The qualitatively analytical result for organic matter in sample could be demonstrated by the percentage content of gaseous and non-gaseous components at normal temperature. The qualitatively analytical characteristics for microbe degradation for organic matter in soil was shown as Fig.3.

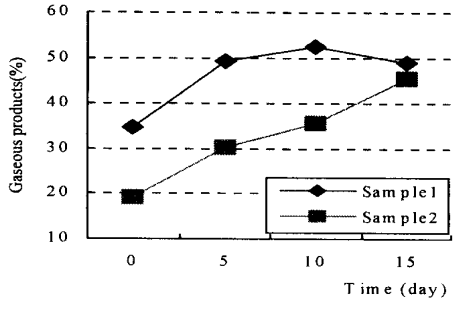

Fig.3 Biodegraded characteristics of soil organic matter qualitatively

The component contents of gaseous hydrocarbons in sample 1 were always higher than sample 2 during the process of microbe degradation for 15 days (Fig. 3). The gaseous contents of the samples increased with the time of degradation going on, however the gaseous contents of sample 1 decreased on the fifteenth day. Main reasons could be as follows: on the one hand, microbe degradation for soil organic matter was

of selectivity. Hydrocarbon compounds with medium long carbon chain were preferentially degraded, however, gaseous hydrocarbon molecules and heavy components were left. As a result, the content of light hydrocarbons increased in samples. On the other hand, the phenomenon might be related to the methane produced in the process of microbe degradation. Qualitative analysis also confirmed that microbes had really stronger degradation and consumed action for crude oil.

3 Conclusion

Analytical results for sample of oily soil demonstrates: there exist eating-oil microbes in oily soil near around oil-well and microbes could considerably degrade petroleum dropped and leaked in soil, which could decrease petroleum destruction for soil and pollution for environment. The longer the well history was, the more the eating-oil microbes were in the soil near wells. As a result, contaminated oil could be degraded quickly. More contaminated oil was accumulated with history of oil-well longer, so the amount of organic matter in oily soil increased obviously. The relative degraded rate of contaminated oil was increased gradually as the time went on. Amount of gaseous component increased with degradation carried on in the oily sample. The microbes could selectively consume contaminated oils strongly. The study on microbe degradation for oily soil was of practical value for environmental protection and important significance for the continuable development of economy in the district of oilfield.

References

[1] Zhang Xingru (张兴儒), Zhang Shiquan (张士权). Exploiting Construction and Environmental Influence of Petroleum Field [M]. Beijing: Petroleum Industry Press, 1998. 129-148.

[2] Xia Lijiang (夏立江), Wang Hongkang (王宏康). Soil Pollution and its Precaution-Treatment [M]. Shanghai: East China University of Science and Technology Press, 1997. 135-143.

[3] Al-Hassan J M, Afzal M, Rao C V N. Petroleum Hydrocarbon Pollution in Sharks in the Arabian Gulf [J]. Bullellin of Environment Contam mate. Toxicol, 2000, 65: 391-398.

[4] Li Tianjie (李天杰), Gong Shiguo (宫世国), Pan Genxing (潘根兴). Soil environment-precaution-treatment and entironment protection of soil [M]. Beijing: Higher Education Press, 1996. 92-101.

[5] Ren Lei (任磊), Huang Yanlin (黄延林). Petroleum pollution of soil [J]. Environment Protection in Agriculture (农业环境保护), 2000, 19 (6): 360-363.

[6] Li Peijun (李培军), Tai Peidong (台培东), Guo Shuhai (郭书海), et al. Two phases boiremediation of oil contaminated soil from Liaohe oilfield [J]. Environmental Science (环境科学), 2003, 24 (3): 74-78.

[7] Genouw G, Naeyer F, Meenen P. Degradation of oil sludge by land farming a case study at the Ghent harbour [J]. Biodegredation, 1994, 5: 37-46.

[8] Scherrer D. Biodegradation of crude oil in experimentally polluted clayey and sandy mangrove soil [J]. Oil & Chemical Pollutition, 1990, 6: 163-176.

[9] Scott T W, Brker G W, Cook R C. Biodegradation of hydrocarbon contaminated soils at crude oil production sites in west [Z]. Texes and New Mexico: SPE, 1993.