Pollution of soil environment by oil exploitation in loess hilly region

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Abstract. This study selected the five typical Wells area as the research object in the town of Li Qu, Baota district, Shaanxi province. The petroleum hydrocarbon content of soil samples collected from 0~10m, 10~30m and 30~50m outside the oil well center was studied and analyzed, the results showed that the well surrounding soil samples of petroleum hydrocarbon concentration in the range of 73-1090 mg/kg, much higher than that of petroleum contaminated soil (500 mg/kg), and petroleum hydrocarbon concentration are radiation pollution radius distribution. According to the standards of oil contaminated soil remediation stipulated by Oklahoma (500mg/kg) and Canada (450mg/kg), the soil around the oil contaminated soil remediation needs to be remediation in different years of production. In addition, due to the specific degradation effect of indigenous microorganisms on petroleum hydrocarbons in the soil, the soil pollution level of the oil Wells in operation is higher than that of the abandoned ones. The soil oil pollution in 2 # and 5 # oil wells is about the critical value in the soil remediation standard.

1. Introduction
In the loess hilly area, the oil storage is large, and the resources are distributed in Yanchang, Ansai, Wuqi, Zhidan and other counties and towns. In recent years, with the expansion of oil development scale, the fragile ecological environment in the loess hilly area has been severely tested, and environmental pollution and ecological damage are increasingly intensified. In the process of oil exploitation, exploration, drilling, oil extraction, oil and gas transportation and other operations will cause certain pollution to the surrounding environment [1]. When oil enters the soil, if there is rainfall and runoff, the oil substances in the soil will cause not only serious pollution to the soil, but also the surrounding plants and groundwater. Due to the low density of oil (829-896kg / m³), strong adhesive force, and strong retention capacity of loess for oil, the maximum detection and migration depth of oil in loess is 30cm, mainly concentrated in the surface layer of 20cm [2,3], which is very important for the growth of crops. Lin [4] et al. showed that the high concentration of petroleum hydrocarbon in the soil will reduce the stem length, density, coverage and biomass of plants. Some components of
petroleum will enter the food chain through volatilization or deposition, which will directly harm human health and affect the reproduction of human beings and organisms. According to the survey data of oil pollution in the soil of Northern Shaanxi, the area of oil polluted soil in Northern Shaanxi is 7.0816 million m², and the content of oil hydrocarbon in the soil is about 5-60 g/kg. It can be seen that the soil oil pollution in Northern Shaanxi is very serious. Oil pollution has attracted the attention of the society and scholars in this area: Li Xiaoli et al. [5] investigated the soil pollution of Yangou and bajiahe oil areas in Yan'an; Zhang Jiayin et al. [6] analyzed the water quality of Yanhe and Qingjianhe River basins; Huang Yanlin et al. [7] investigated and analyzed the sediments of Yanhe and its two tributaries. Their research shows that the soil and rivers in the area are polluted by oil to varying degrees. However, there is still a lack of relevant basic data on the pollution of surrounding soil and plant growth caused by oil exploitation in Northern Shaanxi. In order to find out this point, this paper takes the typical oil well area in Northern Shaanxi as the research object to investigate the oil pollution and its soil physical and chemical characteristics, micro biological characteristics, etc. Through field investigation, sampling and indoor measurement, the distribution characteristics of petroleum hydrocarbons in the soil of the oilfield area are explored, the response of the soil microbial ecosystem to the oil pollution is analyzed, and the stability of the soil ecosystem under different pollution levels is revealed, so as to provide scientific theoretical basis for the evaluation of the soil environmental quality. It provides scientific theoretical basis for soil environmental quality assessment, pollutant discharge and bioremediation and treatment of contaminated soil in this area, so as to maximize the ecological, social and economic benefits of the oil field.

2. Materials and methods

2.1 Overview of the study area
The study area is located in the typical soil area of the Loess Plateau, and the sampling points are respectively in liqu town (36°39′ N, 109°29′ E) and Qiaogou town (36°33′ N, 109°32′ E) of Yan'an City. The average altitude of the study site is about 1089 meters, which belongs to the typical hilly and gully area of the Loess Plateau in Northern Shaanxi. This area belongs to the warm temperate arid and semi-arid continental monsoon climate. The annual average temperature is 8.8 °C, the average temperature in the coldest month (January) is about -7.2 °C, the extreme minimum temperature is -23.6 °C, the average temperature in the hottest month (July) is 22.8 °C, and the extreme maximum temperature is 36.8 °C. The accumulated temperature of ≥10 °C in the whole year is 3268.4 °C, the annual sunshine hours are 2397.3 h, the early frost begins in the first ten days of October, the late frost finally ends in the last ten days of April, and the frost free period is 143-162 days. The annual average rainfall is about 328.4mm, accounting for about 63% of the annual rainfall. It is dry and rainless in spring, hot and humid in summer, dry and waterlogged alternately, cool and rainy in autumn, fast temperature drop, early frost and snow, cold and dry in winter. Natural disasters mainly include drought, frost, rainstorm and hail. The soil is mainly the Yellow loam soil developed on the loess parent material after the black loam soil denudation. The soil fertility is low and the productivity level is low.

2.2 Sample collection
On September 6, 2018, the soil samples for test were collected from the surrounding soil of five typical oil wells of different mining years in lijiu Town, Baota District, Yan'an City. The soil type is Huangmian soil, and the oil well numbers are respectively: 1 #, 2 #, 3 #, 4 #, 5 #. In this study, we took each well pad as the center point and expand to the surrounding area, then selected a representative section of 0-10m, 10-30m and 30-50m outside the center as the sampling area and set up a control area on the waste land without pollution near the well pad. In each sampling area, three samples are randomly selected, and soil samples of 0-30cm soil layer are taken by soil drilling method (s or diagonal 3-5 points). The samples shall be collected in accordance with NY/T-395-2000 technical
code for environmental quality monitoring of farmland soil. After sampling, the samples shall be transported back to the laboratory, root system shall be removed, and the samples shall be sent to the laboratory and stored at 4 °C in dark and low temperature.

2.3 Sample determination and data processing
Petroleum in the soil is extracted with tetrachloroethylene, adsorbed by magnesium silicate, after removing polar substances such as animal and vegetable oil, it is determined by infrared oil detector; refer to HJ 1051-2019 Soil Petroleum Determination infrared spectrophotometry for specific methods.

Microsoft Excel 2016 software was used for data sorting and statistical analysis. ANOVA in SPSS 23.0 was used for one-way ANOVA test of soil indexes in different regions. Duncan and LSD methods were used for multiple comparison (P < 0.05).

3. Results and analysis
3.1 Distribution of oil pollution in soil
It can be seen from Fig. 1 that petroleum hydrocarbons are detected at the soil sampling points around the five oil wells, ranging from 73 to 1090mg / kg, most of which are higher than the critical value of soil oil pollution (500mg / kg) [3]. According to the standard of oil contaminated soil remediation (500mg / kg) stipulated by Oklahoma State of the United States and the standard of oil contaminated soil remediation (450mg / kg) in Canada, the soil around oil wells in different mining years needs to be restored. Among them, 1# old oil well area sampling point pollution is the most serious, more than twice the critical value of soil oil hydrocarbon pollution, which is closely related to the old oil well's past extensive mining method, aging equipment, backward technology, and frequent occurrence of running, emitting, dripping and leaking near the oil well.

In addition, the petroleum hydrocarbon content of the soil around the five oil wells decreases with the increase of distance from the oil wells. Previous studies on the petroleum hydrocarbon content of the soil around the oil wells have found that the basic law of the petroleum hydrocarbon content of the soil around the oil wells is that the farther away from the oil wells, the lower the petroleum hydrocarbon content of the soil, which is consistent with the results of this paper [6]. When the oil production well runs, pours, drips and leaks, the light and water-soluble components in the landing crude oil volatilize and flow to the long-distance transportation with the surface diameter, while the heavy components and the petroleum hydrocarbon components with large coefficient are difficult to carry out the long-distance physical migration, and during the process of oil exploitation, a large amount of oil-containing wastewater is also accumulated in the soil near the wellhead, resulting in the distribution of petroleum hydrocarbon concentration with the pollution radius [9].

![Figure 1](image-url)

**Figure 1.** Distribution characteristics of total petroleum hydrocarbon in oil well area
3.2 Difference of soil pollution among oil well areas with different operation conditions

From the test results in Table 1, it can be seen that the soil pollution level of 1# and 3# in the oil well area which is still in operation is higher than that of 2#, 4# and 5# in the abandoned oil well area. Among them, the soil oil pollution in 2# and 5# is about the critical value of soil remediation standard, which is due to the specific degradation effect of indigenous microorganisms on petroleum hydrocarbons in the soil, but this degradation mechanism is significantly affected by the physical and chemical characteristics of the soil [10].

Table 1. Characteristics of soil pollution in oil well area under different operation conditions

| Well Region                  | Sample NO. | Operational aspect | Average TPH (mg/kg) |
|------------------------------|------------|-------------------|---------------------|
| Oil well area in LQ town     | 1#         | running           | 880.00              |
|                              | 2#         | scrap             | 480.33              |
|                              | 3#         | running           | 739.67              |
|                              | 4#         | scrap             | 639.67              |
|                              | 5#         | scrap             | 499.00              |

4. Conclusion

The concentration range of petroleum hydrocarbon in the soil samples around the oil well is 73-1090 mg/kg, most of which is higher than the critical value of soil oil pollution (500 mg/kg). The distribution of petroleum hydrocarbon concentration with pollution radius is like a blessing. According to the standard of oil contaminated soil remediation (500mg/kg) stipulated by Oklahoma State of the United States and the standard of oil contaminated soil remediation (450mg/kg) in Canada, the soil around oil wells in different mining years needs to be restored. In addition, due to the specific degradation effect of indigenous microorganisms in the soil on petroleum hydrocarbons, the soil pollution level in the oil well area (1#, 3#) is higher than that in the abandoned oil well area (2#, 4#, 5#), among which the soil oil pollution level in the oil well area of 2# and 5# is about the critical value of the soil remediation standard.

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