Research on the Ecological Risk Monitoring and Restoration Evaluation System of Petroleum Exploitation

Xiaohui Wang*
Technology Inspection Center of Shengli Oil Field, Dongying 257000, China
*Corresponding author: wangxiaohui@slof.sinopec.com

Abstract. According to the characteristics of petroleum development projects, the paper identifies the impact of its ecological environment factors. Among the ecological environment factors, the soil is the most affected, and the accident risk among the acting factors has the greatest impact on the ecological environment. The specific analysis of the ecological environment factors Finally, the corresponding ecological protection measures are proposed.

1. Introduction
Petroleum extraction is one of the important basic industries supporting the development of China's national economy. Petroleum is widely used in transportation, petrochemical and other industries, and is called the "black gold" and "economic blood" of the economy and the entire society. Large consumer countries have paid too much attention to rapid economic growth in the course of development in the past few decades, and have given little consideration to resources, environment, ecology and sustainable development of human beings, leading to increasingly prominent problems of oil pollution. The process of oil extraction and a series of related human Activities have led to the emergence of ecological safety issues, especially heavy metal pollution, which has serious ecological hazards. Therefore, it is of great significance to carry out ecological risk assessment of heavy metal pollution in the soil of terrestrial oil extraction areas [1]. The author investigated an oil field in operation the surface soil of the oil well site and the two oil well sites with different production suspension years, analysed the residual characteristics of 16 priority control pollutants, and used the Nimeiry comprehensive pollution index method to evaluate the ecological risk of pollutants in the soil. The expectation is the risk control and treatment of oil-contaminated soil provide a scientific basis.

2. Materials and methods

2.1. Sampling distribution and sample collection
A land oil extraction area selected in this study belongs to a super large sandstone oil field with a mining history of more than 50 years, covering different drilling methods, mining years and mining methods. The oil production wells are located in urban areas, suburbs, farmland areas and undeveloped areas. The original wetlands and grasslands of the country [2]. After field survey, 6 oil wells were selected as sampling wells in the study area. Among the 6 sampling wells, 3 sampling wells are selected according to the two production methods of "water flooding" and "polymer flooding" and different production periods (1-2 years, 4-6 years, 8-10 years). Each oil well A total of 9 sampling points are set up in two
vertical directions according to different distances from the wellhead (0m, 3m, 6m, 10m, 30m), and 2 control points are set up 50m away from the wellhead, and 5 samples are set for each sampling point. Depth (0-5cm, 10-15cm, 20-25cm, 30-35cm, 45-50cm), layered according to the plum blossom method, collect the soil in the middle position layer by layer from top to bottom, mix the layered soil evenly and take 500g each Samples, layered and bagged.

2.2. Research methods
In this study, for acute toxicity, the median effect concentration (EC$_{50}$) of heavy metals on terrestrial organisms obtained from the USEPAECOTOX database was used to evaluate (Table 1). Although the toxicity data of heavy metals on all terrestrial organisms was not collected, and the collected data may be non-native organisms, but the data in Table 1 involves most representative species, and in general, the difference in toxicity tolerance within different regions is much smaller than the difference between species, so these data can be used in this study. In addition, point estimation quotient in the evaluation, the no-observed concentration (NOEC) data (1×10$^5$ng/g dry soil) of heavy metals on lettuce for 14 days obtained from this database is used for evaluation. Although lettuce is not necessarily the most sensitive organism, its toxicity value is the smallest value of the chronic toxicity concentration of heavy metals to terrestrial organisms currently available, so this data can be used to evaluate the screening level in the evaluation method of the point estimator.

| Terrestrial creatures | Experiment period (d) | EC$_{50}$(g/m$^2$) |
|-----------------------|-----------------------|---------------------|
| Cicada                | 8                     | 15.1                |
| Nosema                | 8                     | 13.2                |
| Arthropod             | 8                     | 11.0                |
| Collembola            | 8                     | 13.9                |
| The child loves to win the earthworm | 2 | 46.7 |
| Spider                | 8                     | 11.5                |
| Midstrophic Suborder  | 8                     | 12.6                |
| Oribatida             | 8                     | 14.2                |
| Anterior valve suborder mites | 8 | 16.9 |

2.3. Hakanson potential ecological risk index method
The content of heavy metals in soil is potentially harmful to terrestrial ecosystems. This paper uses the potential ecological risk index method proposed by Hakanson et al. to analyse the pollution degree and potential ecological risk level of each sampling site and heavy metals. The Hakanson potential ecological risk index method is based on 3 assumptions, that is (1) the potential ecological risk index (RI) increases with the increase of heavy metal pollution in the soil, that is, the element abundance response; (2) the toxicity coefficient of each heavy metal element is different, and the heavy metal element with strong toxicity is in the potential ecological risk index (3) The ecological risk of heavy metals in the soil can be added. The more types of heavy metals, the greater the potential ecological risk, that is, the synergistic effect of multiple pollutants. In the ecological risk index evaluation method, the i-th species in the soil the calculation of the potential ecological risk coefficient of heavy metals and the comprehensive potential ecological risk index (RI) of multiple heavy metals are expressed as equations (1) and (2), respectively.

$$E_i = T_i \times C_i$$

$$RI = \Sigma\Sigma E_i = \Sigma\Sigma T_i \times C_i$$

$$RI = \Sigma\Sigma \frac{T_i \times C_i}{C_i}$$
In the formula, $T_i$ is the toxicity coefficient of the $i$-th heavy metal in the soil, which is mainly used to reflect the toxicity level of heavy metal $i$ and the sensitivity of organisms to heavy metal pollution; $C_{ej}^i$ is the enrichment coefficient of the $i$-th heavy metal element to measure the degree of enrichment of heavy metals; $C_{ef}^i$ is the measured value of the concentration of heavy metal $i$ in the surface soil; $C_{en}^i$ is the reference concentration of heavy metal $i$ in the soil (environmental background value). This method not only considers the content of heavy metals in the soil, but also integrates the ecological and environmental effects of heavy metals [3]. The combination of effects and toxicology takes into account the general migration and transformation law of heavy metal toxicity in the soil and the sensitivity of the evaluation area to heavy metals, as well as the difference in the background value of heavy metals in the area, eliminating the influence of regional differences and dividing the potential risk level of heavy metals. Reflects the characteristics of biological effectiveness, relative contribution and geographic spatial differences.

2.4. Ultrasound assisted extraction

Accurately weigh 10 g of soil samples and place them in a stoppered Erlenmeyer flask, add 30 mL of dichloromethane, and ultrasonically extract for 60 minutes at a water temperature of 30°C and a power of 120W. Then it was centrifuged at 4000r·min$^{-1}$ for 15min. After centrifugation, the supernatant was transferred to a round bottom flask and concentrated to 1mL by rotary evaporation. 10mL of n-hexane was added and concentrated to 1mL again.

2.5. Sample fractionation and purification

The paper uses dry packing method to pack the column, wash the column with methanol, n-hexane, and dichloromethane respectively, dry it and spread it with absorbent cotton at the bottom of the column, load 3g of activated silica gel and tap it lightly. Place about 0.5cm thick anhydrous Na$_2$SO$_4$ on top. Rinse the column with 20 mL of n-hexane and discard the effluent. When the anhydrous Na$_2$SO$_4$ is close to the liquid level, add the extracted sample to the column with a dropper, and transfer the sample completely with 3 mL of cyclohexane. First rinse with 30mL n-hexane, discard this part of the eluate, and then rinse the soil with 40mL V (n-hexane): V (dichloromethane) 1:1 mixture, collect the eluate, concentrate and high After drying with pure nitrogen, use n-hexane (chromatographically pure) to make the volume to be measured.

2.6. Analysis and determination

We use gas chromatography-mass spectrometry to analyse the samples, and the chromatographic column is HP5-MS quartz capillary. Measurement conditions: The temperature of the sample inlet is 280°C; the temperature of the detector is 300°C; the carrier gas is high-purity nitrogen, the carrier gas flow rate is 0.6mL·min$^{-1}$; the sampling method is split injection, and the split ratio is 5:1. The injection volume is 1μL; the chromatographic column adopts temperature program, the initial temperature is 50°C, stay for 1min, heat up to 170°C at 15°C·min$^{-1}$, stay for 2min, then heat up to 220°C at 8°C·min$^{-1}$, and finally Raise the temperature to 280°C at 3°C·min$^{-1}$ and stay for 20 minutes. The peak area was quantified by external standard method, and the GC-MS spectra of 16 soil mixed standard samples (10 mg·L$^{-1}$) are shown in Figure 2. The test result is the average of 3 repetitions. The recovery rate of the series compound is 78%-95%, and the standard deviation is 6.5% on average.
Figure 1. GC-MS spectrum of 16 soil mixed standard samples

3. Results

3.1. Comparison of exposure distribution/effect distribution
Exposure distribution/effect distribution comparison is currently a more commonly used probabilistic risk assessment method. In view of the small amount of data obtained, even if the distribution test of the obtained MECs and \( EC_{50} \) is performed, the conclusions are still very uncertain. For this reason, based on the research of related literature, the study assumes that the MECs of heavy metals in the surface soil around the pollutant bubble and the \( EC_{50} \) of heavy metals to terrestrial organisms conform to the log-normal distribution [4]. Based on this assumption, the MECs and \( EC_{50} \) in this study the probability density function expression of is as follows:

\[
 f(\ln MECs) = 0.2958e^{\frac{(\ln MECs - 4.213)^2}{1.1582}} \tag{3}
\]

\[
 f(\ln EC_{50}) = 0.5316e^{\frac{(\ln EC_{50} - 10.439)^2}{0.3596}} \tag{4}
\]

The probability density function of MECs and \( EC_{50} \) is shown in Figure 3. It can be seen from Figure 3 that the distribution curve of \( EC_{50} \) is on the right side of the MECs distribution curve and far from the MECs distribution curve, so the risk value calculated based on its overlapping area is close to 0. However, due to the large spatial variability of the concentration distribution of heavy metals in the soil,
the environmental concentration of heavy metals measured in the study may not be representative of the actual situation in the area, and the toxicity reference values obtained in the study may only reflect the toxicity of heavy metals to certain organisms in the environment. If a factor of 10 is used for toxicity data, the risk value of heavy metals to terrestrial organisms is 0.067%; if a factor of 100 is used, the risk value increases to 14.1%. If the factor multiples used are not appropriate, it may lead to the wrong judgment of the risk. Therefore, in the actual risk management, the appropriate factors can be selected for evaluation on the basis of comprehensive consideration of the data obtained and the actual situation of the site [5]. Implement corresponding risk management based on its evaluation results.

![Figure 2](image_url)

3.2. Analysis of ecological risk factors

It can be seen from Table 2 that the main ecological risk factor in the soil in the study area is Cd, and its potential ecological risk index reaches the maximum value (418.89) in the No. 6 sampling well. The potential ecological risk coefficient of a single heavy metal is evaluated by Cd as a medium ecological risk factor. The remaining 5 heavy metals are at a slight pollution level in all sampling wells. The content of Cu, Co, and Pb in the soil is relatively high, but due to its low toxicity coefficient of heavy metals, it is a secondary ecological risk relative to Cd, which has a large toxicity coefficient. Factors. In addition, the comprehensive potential ecological risk index of heavy metals in sampling wells 2, 3, and 5 has reached a medium level, and a strong risk in sampling well 6, indicating that the soil in sampling well 6 has a strong ecological risk, and necessary measures should be taken [6]. The risk avoidance measures of 4 out of all 6 sampling wells in this study have reached the medium risk level or above, which reflects that the potential ecological risk of heavy metals in this study area is relatively common. In the 6 sampling wells, the potential ecological risk level of each sampling well the order is 6>5>3>2>1>4. By calculating the average potential ecological risk index of the 6 sampling wells, it can be seen that the 6 sampling wells selected in this study have an average comprehensive potential ecological risk index the risk level is medium.
Table 2. Potential ecological risk assessment of heavy metal pollution in soil

| Sampling point | Potential ecological risk index | Comprehensive potential ecological risk level |
|----------------|--------------------------------|---------------------------------------------|
|                | Pb    | Cd    | Cu    | Zn    | Cr    | Co    | RI   |                          |
| 1              | 3.23  | 22.06 | 3.23  | 0.38  | 0.47  | 3.06  | 32.44| Slight                   |
| 2              | 1.81  | 194.09| 2.99  | 0.27  | 0.49  | 3.68  | 203.34| Medium                   |
| 3              | 2.28  | 200.45| 2.35  | 0.36  | 0.33  | 4.77  | 210.55| Medium                   |
| 4              | 1.71  | 10.62 | 0.21  | 0.05  | 0.96  | 3.68  | 12.59| Slight                   |
| 5              | 2.78  | 220.96| 1.59  | 0.27  | 0.13  | 4.04  | 229.78| Medium                   |
| 6              | 3.75  | 418.89| 2.83  | 0.39  | 0.42  | 3.78  | 430.07| Strong                   |
| Ei             | 2.6   | 176.08| 3.94  | 0.32  | 0.32  | 3.22  |                 |
| Single heavy metal potential ecological risk level |                  | Slight | Medium | Slight | Slight | Slight | Slight |

4. Conclusion

In the risk management of petrochemical contaminated sites, you can first use the point estimator method that requires less data to evaluate the screening level, and then gradually adopt the exposure distribution/effect distribution comparison according to the information and risk management needs. And based on the distribution quotient to carry out higher-level evaluations to reduce the uncertainty in the evaluation, make the evaluation results more real and reasonable, and provide a more scientific basis for the risk management of the site.

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