WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.10 (3&4): 1555-1557. 2012 *www.world-food.net*

Ecological risk assessment of water in petroleum exploitation area in Daqing oil field

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Received 12 April 2012, accepted 6 October 2012.

Abstract

Ecological risk assessment (ERA) has been highly concerned due to the serious water environment pollution recently. With the development of socio-economic, preliminary ERA are placed in an increasingly important position and is the current focus and hot spot with great significance in terms of environment monitoring, ecological protection and conservation of biodiversity. Polycyclic aromatic hydrocarbons (PAHs) is a major ecological environment pollutant, especially in water pollutants. In this paper, we assessed the ecological risk of water in the petroleum exploitation area in Daqing oil field. The concentration of naphthalene in the water samples of study area is the basic data, and Hazard Quotient (HQ) is the major method for our assessment. According to the analysis of the amount of naphthalene, the ratio coefficient and the space distribution characteristic in the study area, and deducting quotient value of naphthalene hazard spatially with Spatial Extrapolation Toolkit, we used contour lines to complete the preliminary assessment study on aquatic ecological risk in the region. The aim of this paper is to simulate the spatial distribution of naphthalene in water in the study area and tell people where the ecological risk is high. The research result indicates that the ecological risk is low in the southwest and that is high in the north east of the Daqing oil field. The result could provide technical support and scientific reference for protecting and controlling the water environment for the local government in Daqing City.

Key words: Water, petroleum exploitation area, naphthalene, ecological risk assessment.

Introduction

Ecological risk assessment (ERA) is an important part of environmental risk assessment. Petroleum ecological risk is the risk that ecosystem and its components suffer in the oil mining area, and it refers to the effects that uncertain oil accidents or disasters have on ecosystems and their components within a certain area [1]. These effects will result in damage to ecosystem structure and function, thus endangering the safety and health of ecosystems. Ecological risks in oil exploitation areas have a property of uncertainty and fuzziness. The current study of relevant ecological risk assessment in oil exploitation areas mainly focus on assessing the damage probability brought by pollutant to the ecological system and its components with the pollutants as the major source of risks.

The research evaluated the ecological risk caused by oil based on the data of concentration of naphthalene in water in the oil exploitation in Daqing oilfield. The research area is 45.9°N to 46.7° N and 124.5°E to 125.1°E. Daqing city is in the central in Song Nen plain, and it is in the northwest of Harbin, the provincial capital of Heilongjiang in a distance of 150 km with an average elevation of 146 m. Its area of natural water surface is 292,700 ha and water resources are from Nenjiang River, Songhuajiang River and natural rainfall. Daqing has large number of lakes with a total area of 3,000 km^2 and 284 lakes have an area more than 100 mu.

Material and Methods

Data: The study collected and analysis 16 water samples data (Table 1) in February 2011 in the oil extraction field in Daqing, and get the concentration of naphthalene in water through field measurement.

Methods: The quotient method sets the reference concentration index with the aim to protect one certain receptor, it is one simple method to represent the ecological method and is applicable to the small-scale risk assessment projects since its experiment is simple and cost is low [5]. The hazard quotient is calculated with the following equation:

$$HQ = EC/TRV$$

where EC refers to the environmental exposure concentrations

Table 1. The concentration of naphthalene in water through field measurement (μg/L).

Point	The first	The second	The average	point	The first	The second	The average
#1	563.83	564.13	563.98	#9	500.25	500.47	500.36
#2	781.49	781.81	781.65	#10	1315.83	1315.97	1315.9
#3	1272.29	1272.55	1272.42	#11	2047.83	2048.01	2047.92
#4	2084.86	2085.24	2085.05	#12	7.92	8.04	7.98
#5	2272.33	2272.55	2272.44	#13	4712.93	4712.79	4712.86
#6	2249.99	2249.35	2249.67	#14	5735.87	5736.01	5735.94
#7	2606.69	2607.05	2606.87	#15	71.81	70.99	71.4
#8	1218.67	1218.55	1218.61	#16	29.15	29.07	29.11

that is actually observed (EEC) or predicted with the model (PEC), TRV means the toxicity reference value (ecological benchmark value). There is potential risk if HQ is above 1, the larger HQ is, the greater the risk is. The condition is safe if HQ is below 1.

Since there is significant spatial heterogeneity of naphthalene in different sample points, a non-parameter interpolation method -the Spatial Extrapolation Toolkit was used in this study to deduce the spatial data. This tool uses the kernal regression to smooth the spatial data with the following regression equation:

$$y = R(x) + \varepsilon$$

where ε is the error item, $R(x)$ is the regression function. $R(x)$ is calculated with the weight sum of $y_1 ... y_s$, the average of which is S with the following equation:

$$R(x) = R_\theta^S(x) = \sum_{s=1}^{S} y^s P_\theta^s(x)$$

$R(x)$ determined by $P_\theta^s(x)$ with the given x value, can contribute to the comprehensive estimation of the dependent variable y at the x point. The weights are generally determined with the kernel density function, e.g., Gaussian kernel density function:

$$\psi_\theta(\mu) = \frac{1}{2\pi}\exp\left(-\frac{1}{2}\mu^2\right) \qquad (\mu = \frac{x - x^s}{\theta})$$

where the kernel density reaches the maximum value when μ=0, and reduce as the distance increases and depends on θ. Then the function to measure the weights y^S of is consequently obtained

$$P_\theta^s(x) = \begin{cases} \dfrac{\psi_\theta\left(\left(x - x^s\right)/\theta\right)}{\varphi_\theta^S} & \varphi_\theta^S(x) > 0 \\ 0 & \varphi_\theta^S(x) \leqslant 0 \end{cases}$$

The denominator $\varphi_\theta^S(x) = \sum_{s=1}^{S} \psi_\theta\left(\left(x - x^s\right)/\theta\right)$ guarantees that the sum of all the weights equals 1. The user may define the optimal window size with the following equation to meet the optimal standard:

$$\theta = \left(\frac{4}{n(d+2)}\right)^{\frac{1}{d+4}}$$

where d is the number f parameters involved in the interpolation, n is the number of the known interpolated data.

Results and Discussion

Hazard quotient value of each sample point: The results we got by using the traditional risk value method are shown in Table 2 and the ecological baseline value that naphthalene exists in freshwater is 490 μ g/L [4].

Table 2. Concentration naphthalene and hazard quotient value of each sample point.

Point	Naphthalene(μg/L)	HQ	Point	Naphthalene(μg/L)	HQ
#1	563.98	1.15	#9	500.36	1.02
#2	781.65	1.59	#10	1315.9	2.69
#3	1272.42	2.60	#11	2047.92	4.18
#4	2085.05	4.26	#12	7.98	0.02
#5	2272.44	4.64	#13	4712.86	9.62
#6	2249.67	4.59	#14	5735.94	11.70
#7	2606.87	5.32	#15	71.4	0.14
#8	1218.61	2.49	#16	29.11	0.06

Time-space deduction of hazard quotient value: We used contour lines to complete the preliminary assessment study on aquatic ecological risk in the region, the assessment results achieved by using the Spatial Extrapolation Toolkit are shown in Fig. 1.

As shown in Fig.1, the high ecological risk concentrated in the northeast of the study area alerts the relevant departments to increase the intensity of checks of related enterprises. We need further research, by increasing the density of water sample collection points to further confirm the condition of ecological risk in this region. Further studies, which need to employ sophisticated models and other common component of the (PAHs) should be taken into account in the study area.

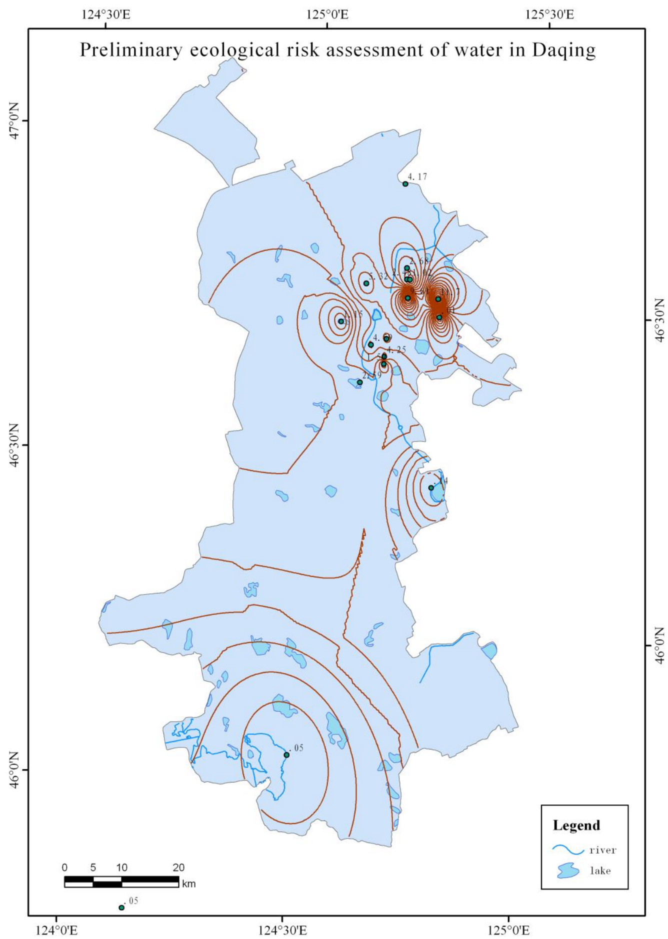

Figure 1. The hazard quotient value of naphthalene in waters of the study area.

Conclusions

By collecting water sample data of oil exploitation in certain sample in Daqing oil field area, we conducted preliminary ecological risk assessment using against value (HQ) of the region. By analyzing the results, we found that based on the hazard quotient (HQ) commonly used in oil field risk assessment method, we initially get some larger points of ecological risk, these indicate ecological risk in oil exploitation areas do exist, and should be paid further more attention. Based on spatial distribution of the hazard quotient (HQ) value of naphthalene in water, we preliminary get judgment of the study area: there are greater ecological risk in the Northeast, Central area is in the second, and there are no ecological risk in the Southwest. Therefore, there are of significance in the relevant regional environmental governance, ecological protection, and other policy decisions. We just use a simple method (hazard quotient) to give a berif answer about the only risk source naphthalene to value the ecological risk assessment of the study area, for further study, we will increased the density of the water sample and explore and adopt a more rational algorithms on a comprehensive assessment of polycyclic aromatic hydrocarbons.

Acknowledgements

This research was supported by China National Key Technologies R&D Program of Ministry of Science and Technology (2008BAC43B01) and the National Scientific Foundation of China (41171434; 41071343). Data support from the projected funded by the Ministry of Science and Technology of China (2010GXS5B163; 2008BAK50B05; 2008BAK50B06) and the State Major Project for Water Pollution Control and Management (2009ZX07106-001) are also greatly appreciated.

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