Retraction

Retraction: Assessment of Ecological Risk of Soil in Rapid Urbanization Area by Risk Regionalization (IOP Conf. Ser.: Earth Environ. Sci. 687 012169)

Run Zhao¹ and Ning Li²,³

¹ College of Environmental Science and Engineering, Nankai University, Tianjin, 300071, China
² Beijing Normal University, Beijing, 100875, PR China
³ Guangxi Zhuang Autonomous Region Environmental Monitoring Centre, Nanning, 530028, PR China

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This article has been retracted at the request of the authors, who admit a similar paper has already been published based on the same project [1]. IOP Publishing confirms significant overlap between the two articles and agrees to retract on the basis of redundant publication. IOP Publishing expresses additional concern regarding the authorship of the article, which differs between the two articles. The authors state that all authors of the two papers are members of the same research group, and research achievements are the joint property of the group. This conflicts with the IOP Publishing ethical policy, which states all those who have made a significant contribution are cited as co-authors. Any other individuals who have contributed to the study in a lesser capacity should be acknowledged.

[1] Xiaoying Ye and Chaofeng Shao 2018, Ecological Risk Assessment of Soil in Rapid Urbanization Area by Risk Regionalization, International Conference on Advanced Chemical Engineering and Environmental Sustainability (ICACEES 2018) http://www.dpi-proceedings.com/index.php/dtetr/article/view/25496/24910

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Assessment of Ecological Risk of Soil in Rapid Urbanization Area by Risk Regionalization

Run Zhao¹, Ning Li²,3*
¹College of Environmental Science and Engineering, Nankai University, Tianjin, 300071, China
²Beijing Normal University, Beijing, 100875, PR China
³Guangxi Zhuang Autonomous Region Environmental Monitoring Centre, Nanning, 530028, PR China
*Corresponding author’s e-mail: Lining1972@sohu.com

Abstract. Rapid urbanization is a major source of environmental risk in soil. In this study, we developed the method of the potential ecological risk assessment, and investigated risk sources and soil pollution in a typical rapid urbanization area in Tianjin City, China. The proposed method was used to evaluate the level and spatial distribution of ecological risk of soil. Results show that the maximum of RI in all 114 sampling points was 1437.37, and four sampling points had RI exceeding 600, indicating extreme risk level. Moreover, the mean value of RI was 227.17, which was in moderate risk level. Among 10 heavy metals, Cd was the metal element that exhibited the most serious harm to the ecological environment, and reached high and extreme levels.

1. Introduction
Soil contamination has caused considerable concern in international and domestic communities because of the significant risk on land security, food security, and human health. In China, progress in industrialization and modernization over the past decades has resulted in urban sprawl of core cities and development of emerging towns. This phenomenon has led to the changes in land use patterns and industrial structure and deterioration of the ecological environment in newly urbanized areas. Related studies and the National Soil Pollution Survey Bulletin have shown that more than 10 million hectares of land in China are threatened by soil contamination[1]. Grading evaluation criteria, spatial distribution of pollutants, and specific cases in different regions of China have been studied for removing soil pollution caused by industrial and mining activities. Primary risk assessment methods in previous studies included pollution risk assessment, such as single factor index, potential ecological risk index, and human health risk assessment. The frequently used risk regionalization characterizes the intensity and spatial distribution of soil environmental risks and is based on the results of contents and spatial distribution of soil contaminants. In this study, a method was established to evaluate the ecological risk of soil environment in rapid urbanization area.

2. Methodology
Adverse effects of soil contaminants on ecological environment in typical rapid urbanization areas should be assessed to comprehend the environmental risk of soils in these areas. According to the US Environmental Protection Agency, ecological risk assessment (ERA) refers to the assessment of adverse
effects on ecological environment that may be caused by one or more external factors[2]. Assessing ecological risk facilitates the characterization of the risk of pollutants on soil environment. Studies on ERA are currently prominent in developed countries, and complete ERA system has been established and applied in numerous studies. Heavy metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and pesticides (e.g., DDT) have been the frequent concern in many assessment methods. However, previous studies reported that heavy metals are major pollutants in rapid urbanization area, but concentration and risk levels of organic pollutants in such areas are low. Therefore, this study mainly assessed ecological risk of heavy metals. Organic pollutants are not included in this work.

Rapid urbanization area are mostly located in mineral-rich regions, with high background values of metal elements. Ecological risk in these areas is strongly affected by human factors because of the high industrial and mining activities[1]. Contents, ecological effects, environmental effects, toxicology, and element background values of heavy metals should be considered for evaluating the ecological risk of rapid urbanization area. Accordingly, the Potential Ecological Risk Index (RI) method developed by Hakanson[3] was used in this study. Hakanson proposed Potential Ecological RI based on the nature and environmental behavior of heavy metals to determine the degree of pollution of heavy metals in soil or sediment. The calculations are as follows:

\[
E_i = \frac{T_i C_i}{B_i}
\]

\[
RI = \sum E_i
\]

where \(E_i\) is the ecological risk factor of single heavy metal contaminants in this study, \(RI\) is the monomial index of potential ecological risk, \(T_i\) is the toxicity factor of the heavy metal, \(C_i\) is the practical concentration of the metal in soil, and \(B_i\) is the background concentration of the heavy metal. Ten heavy metals, namely, As, Cd, Cr, Co, Cu, Pb, Ni, V, Zn, and Hg, were considered. \(T_i\) can be found in the results provided by Hakanson[3] and Xu et al.[4]. \(B_i\) values for the 10 heavy metals were extracted from the Soil Baseline Study of Tianjin issued by Tianjin Environmental Monitoring Center[5] and relative studies. The \(T_i\) and \(B_i\) values are listed in Table 1. The adjusted valuation criteria for \(E_i\) are as follows: \(E_i \leq 40\), low risk; \(40 < E_i \leq 80\), moderate risk; \(80 < E_i \leq 160\), high risk; and \(E_i > 160\), extreme risk. The valuation criteria for potential ecological risk value \(RI\) are as follows: \(RI \leq 150\), low risk; \(150 < RI \leq 300\), moderate risk; \(300 < RI \leq 600\), high risk; and \(RI > 600\), extreme risk.

Table 1. Toxicity factors of heavy metals

| Metals | As  | Cd  | Cr  | Cu  | Pb  | Ni  | Zn  | Hg  | Co  | V   |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Background value | 9.6 | 0.09 | 84.2 | 28.8 | 21.0 | 33.3 | 79.3 | 0.084 | 13.6 | 85.2 |
| Toxicity factors | 10  | 30  | 2   | 5   | 5   | 5   | 1   | 40  | 5   | 2   |

3. Study area

The selected study area is a typical rapid urbanization area in Binhai New Area, located southeast of Tianjin, China. The scope of the study area, as shown in Figure 1, mainly includes the southern region of Binhai New Area. The study area spans a total land area of approximately 1200 km² and experiences a warm, temperate, and semi-humid continental monsoon climate. The average annual temperature and precipitation levels in this area are 14 C and 600 mm, respectively[6].

Binhai New Area, the third special economic zone in China, is an important industrial and economic center in Tianjin, which is among the largest industrial cities of China. China has invested heavily in enhancing the functions of this international port city as an eco-city, as well as the northern economic center of Tianjin, as noted in the reports on National Major Function-oriented Zoning. The country is also focused on developing the Binhai New Area. Owing to its rich reserves of oil and metal resources near the Bohai Bay, this area is of significant strategic interest in terms of its location and natural resources. Since its establishment in 1994, the Binhai New Area has been an important zone of heavy
industry in Tianjin and in China as a whole. The study area is being developed as an important petrochemical industry base in northern China and is a typical rapid urbanization area which has made significant achievements in both economic and social development and urbanization.

The ecological environment in this area is extremely sensitive and fragile because it is located along the river, sea, and land border zones. The residential and industrial regions in the study area are also distributed unevenly. Therefore, humans significantly influence heavy metal contamination of the soil in this area. Previous studies[7-8] reported that heavy metals contaminate large portions of the study area and its vicinities. Specifically, rivers, farmlands, and coastal waters are polluted to varying extents by heavy metals because of the discharge of pollutants into water bodies over long periods.

![Figure 1. Location and scope of the study area](image-url)

4. Results
An overview of ecological risk factors ($E_i$) of the 10 heavy metal contaminants is shown in Table 2. The $E_i$ results of all sampling points revealed that, among the 114 sampling points, the potential ecological risk of six heavy metals, including Cr, Co, Cu, Pb, V, and Zn, was low, indicating that the sampling points of the six heavy metal contaminants were at low pollution risk level. Moreover, Cd was the metal element that exhibited the most serious harm to the ecological environment. Compared with most of the sampling points (96 sampling points, 84.21% of the total), the ecological risk of cadmium reached high and extreme levels; only two sampling points (1.75% of the total) showed low risk status. This result indicates that the potential ecological risk contribution of Cd to the study area was prominent. The overall level of the potential ecological risk of As was in low risk status; however, the proportion of the sample points whose risk level was moderate and above risk level was 13.16% (15 sampling points), indicating an increasing trend of ecological risk. For Ni and Hg, small parts of the sampling points showed moderate or high ecological risk.
Table 2. Potential ecological risk factors of the 10 heavy metals

| Potential ecological risk factors of heavy metals | Minimum | Maximum | Average |
|--------------------------------------------------|---------|---------|---------|
| As                                               | 10.42   | 280.21  | 28.74   |
| Cd                                               | 8.33    | 1140.00 | 172.21  |
| Cr                                               | 1.21    | 10.21   | 1.89    |
| Co                                               | 4.45    | 20.37   | 7.11    |
| Cu                                               | 2.62    | 7.73    | 4.99    |
| Pb                                               | 3.26    | 17.05   | 5.10    |
| Ni                                               | 3.36    | 81.53   | 5.82    |
| V                                                | 1.31    | 2.89    | 2.05    |
| Zn                                               | 0.67    | 4.06    | 1.20    |
| Hg                                               | 0.00    | 71.43   | 3.05    |

The potential ecological risk of all 10 heavy metals, namely, the value of RI for all 114 sampling points, was calculated using the Hakanson method. The results showed that the maximum of RI in all 114 sampling points was 1437.37, and four sampling points had RI exceeding 600, indicating extreme risk level. Moreover, the mean value of RI was 227.17, which was in moderate risk level.

Based on the results of the RI value, the spatial distribution of potential ecological risk in the study area is shown in Figures 2 (A and B) using ordinary Kriging interpolation method. In Figure 2-A, the risk regionalization results of the RI value were classified according to geometric interval, which can reflect the spatial trend of the potential ecological risks in the study area. Figure 2-B visually shows the potential ecological risk regionalization and classification results of the study area. The high risk areas in Figure 2-B are mainly concentrated in the northeast and the southwest regions of the study area. The potential ecological risk of the southern region of the study area was low, while most regions of the study area were at moderate risk. However, Figure 2-A revealed that the RI values of large areas located in the northwest, north, and east of the study area were relatively high (RI values between 250 and 300). Although these areas were still in a moderate risk level, the potential ecological risk level reached a state of alert.

The industrial zones and development areas are mainly located in the northeastern and eastern parts of this region. Figure 2-B shows that the high risk area in the northeastern region of the study area substantially coincided with the industrial zones, but the high risk area in the southwestern of the study area did not. Figure 2-A also revealed that the overall potential ecological risk level was even higher in large tracts of farmland in the western region of the study area than those of the northeastern. The prevailing wind direction in the study area is southwest wind[7], which has an effect on spatial distribution of soil pollutants. In addition, relevant studies also indicated that atmospheric deposition is an important pollution source of heavy metals[8], especially Cd and As, which made large contribution to the potential ecological risk in the study area. Thus, the distribution of high risk in the southwestern region confirmed the above statement.
Figure 2. Spatial distribution map of the potential ecological risk in the soil

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