Research on Environmental Risk Assessment Method of Chemical Industry Park

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Abstract. Environmental risk assessment of industrial parks is a hot spot in the field of environmental management and safety engineering. Risk assessment can quantify the possible extent of the impact or loss of risk events on life, property, environment and other aspects. This study sorts out three types of current approaches for risk assessment in industrial parks. We introduced the applications of those approaches, intending to prompt the further study of ERA for industrial park.

1. Introduction

Table 1. Three Scheme comparing.

| Method                                           | Risk source                                      | Case                                                | Citation |
|--------------------------------------------------|--------------------------------------------------|-----------------------------------------------------|----------|
| Evaluation method based on specific environmental risk sources | hazardous materials, equipment, techniques        | Five-plant chemical industry cluster in Jiangsu province | [3]      |
|                                                  | Hazardous substances, production processes, equipment, environmental management and plant location | A chemical industrial park downstream of the Yangtze River | [4]      |
| Multi-factor assessment method based on environmental risk system | Risk sources, control mechanisms and receptors | Tianjin Binhai New Area                             | [5]      |
| Multi-dimensional assessment method based on environmental risk system | materials, production processes, dangerous equipment, technology, factory environmental safety, health | 21 enterprises in the Nanjing Chemical Industry Park | [6]      |

The large number and various kinds of chemical storage tanks [1] as well as the fragile ecological environment in chemical industry parks that pose considerable risks to human health and the environment. The safety management of chemical industrial park needs to carry out risk assessment [2]. Risk assessment can quantify the possible extent of the impact or loss of risk events on life, property, environment and other aspects. There is currently no uniform standards or rules to make quantitative decisions about the degree of risk for the chemical industrial park in general. It is common practice for researchers to evaluate environmental risks in chemical parks in the reference to the principles and
procedures of regional environmental risk assessment. The research on environmental risk assessment can be divided into three stages. The primary stage focuses on the effects of various toxic and harmful pollutants on human health, and focuses on the effects of a single pollutant. The second stage, target pollutants have also evolved from single species to multiple environmental impacts. The research on environmental risk has developed from simple qualitative research to quantitative research on various complex factors. In the third stage, the environmental risk assessment system has been optimized in depth, and multi-dimensional factors such as space and economy have begun to be considered.

2. Evaluation method based on specific environmental risk sources

The traditional risk assessment methodology was developed in 1983 by the US National Academy of Science (NAS) and consists of the following stages: hazard identification, dose–response assessment, exposure assessment: to what extent is the subject of protection exposed to the agent, risk characterization [7]. The main approach is to filter risk sources based on standard specifications or statistical analysis of environmental events, and then classify environmental risk sources.. Such a methodology needs basic information of hazardous substances, such as, the properties, the amount, the exposure of the environment, and environmental management and plant location [4]. If it is equal to or exceeds the corresponding critical amount, it is determined as a major source of danger. Some specifications, such as Classification method for environmental accident risk of enterprise (HJ 941-2018) in 2018 (China, Ministry of Ecology and Environment of the People’s Republic of, 2018a) has a detailed description of the critical mass of risk substances. Comprehensive index method is used to calculate and grade environmental risk factors. It is based on the calculation of a comprehensive evaluation index that summarizes the effects of multiple sources of risk using weight factors, and that summarizes the cumulative effects of these factors to describe the overall regional environmental risk [3].

Because the weights are usually determined by a group of experts, they are somewhat subjective, and for this reason, the method can be considered semi-quantitative [8]. This method has the characteristics of easy to operate, and low costs. It relies heavily on the quality of the data, but does not consider the occurrence of some complex situations [3].

3. Multi-factor assessment method based on environmental risk system

Environmental risk assessment integrated progressively more elements, such as social vulnerability (Dai et al. 2012), eco-environmental sensitivity (Ge et al. 2013), risk control mechanisms, and safety management measures [9]. A growing body of research suggests that the environmental risk level of chemical industry park should be comprehensively evaluated from the perspective of environmental risk system. The researchers established a comprehensive evaluation model of hazardous chemicals, which uses the comprehensive risk score as the risk grading standard of the evaluation [10].

A large number of MCDA methods have been already applied in the range of complex environmental decisions [11]. MCDA is used to evaluate and rank, or select, of different alternative, simulate run in the lack of data [12]. MCDA includes a wide variety of methods, such as, analytic hierarchy process (AHP) and fuzzy set theory. Most of the time, Methods tend to be combined in order to get a scientific evaluation [13].

3.1. Analytic hierarchy process

Analytic hierarchy process is a classical multiple attribute decision making tool that has been used in almost all the applications related with decision-making [14]. The basic idea of AHP is to express a complex decision-making problem as an ordered hierarchical structure and gives the order of alternatives [5] through subjective judgment and scientific calculation [15]. The AHP calculate the relative size of each risk and establish a scientific and comprehensive environmental risk assessment system [9]. The specialty of AHP is its flexibility to be integrated with different techniques like Linear Programming, Quality Function Deployment, Fuzzy Logic, etc.
3.2. Fuzzy mathematics based method

Due to the nature of uncertainty and complex of the environmental risk assessment, it is hard to show relations between events and probability [16]. Fuzzy mathematics based method set theory can rank objects and determinate their optimality [17]. Applying the fuzzy set theory can treat with the constraints from data sources, the inconsistency and non-uniformity of data and other problems. It can make up for the information blank caused by the incompleteness of data, and change the single-valued samples into set-valued samples. This method excavated the internal contained in the incomplete sample so as to achieve the aim of making full use of the information. It is efficient in dealing with small-sample problem [18]. This method has been applied to different situations, such as, risk analysis for water, flood natural disasters, liquefied natural gas stations, and grassland biological disasters.

The main problem is that, for a small sample, to select better information diffusion function is very difficult because there is not enough information.

4. Multi-dimensional assessment method based on environmental risk system

Environmental risk management often neglect the multidimensional nature of spatial impacts (e.g., social, economic, human) [19]. The rapid development of artificial intelligence technology, satellite remote sensing, and Geographic Information System (GIS) provides new methods for environmental system risk. The environmental risk management system can easily obtain, store, manage and display various environmental risk information. Environmental risk management system fully consider the types of industries in a chemical industrial park, the regional characteristics, and superposition of pollution sources [20]. The system has four main functions: petrochemical enterprise registration and declaration, environmental risk source information correction and confirmation, environmental risk source evaluation and classification, and environmental risk source management [6].

Combine of MCDA techniques and spatial analysis that can be applied to different receptors, which proved to be reliable and consistent with the environmental experts’ expected results [21]. Combining risk information with GIS is beneficial to the improvement of risk management level in chemical industry parks.

5. Conclusion

As the research progresses, the types of risk factors considered in the assessment become more and more comprehensive. The evaluation method of environmental risk in chemical industry park is becoming more and more comprehensive, scientific and reasonable. At present, most domestic researches focus on the monitoring and collection of hazard data, and pay insufficient attention to the processing and analysis of acquired data and the early warning of possible risk accidents. Environmental risk prevention regulatory system is more important than the supervision of environmental risk accident emergency response.

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