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Development process and perspective on ecological risk assessment

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ABSTRACT

This paper reviews the development history of ecological risk assessment (EcoRA) and presents a perspective for EcoRA and management. EcoRA, which is aimed at appraising a wide range of undesirable impacts on ecosystems exposed to a possible eco-environmental hazard, has been highly recommended for environmental decision-making. The research progress are reviewed, including research area, content and method are reviewed. Based on this inspection, an integrated framework characterizing problem formulation, risk characterization and risk assessment is depicted to illumine future EcoRA. We conclude that larger-scale assessment studies are still lacking, and assessment theories and methods are being developed. In addition, regional EcoRA needs to make further efforts, especially in theoretical study, uncertainty analysis, integrated use of GIS software and comprehensive risk assessment at regional scale in the future work.

Contents

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1. Introduction: development history of ecological risk assessment (EcoRA)

Risk assessment is a tool used to organize, structure and compile scientific information in order to help identify existing hazardous situations, anticipate potential problems, establish priorities and provide a basis for regulatory controls and/or corrective actions [76]. Environmental Risk Assessment rise in the 1970s and carried out in a foreign country relatively early and common, especially in the United States [52,38]. In the 1970s and the 1980s, in order to meet the needs of the laws and regulations a number of risk assessment methods were established which have been adopted by US Environmental Protection Agency (US EPA) and the Food and Drug Administration (FDA). However, the problem is more complex as the risk assessment carried out is not very long. Therefore, in spite of a clear concept, but its exact meaning has not yet been unified. Current environment risk assessment is probably divided into several modes: the US model, the EU model and the others. Environment risk assessment of US develops from the two different levels. One is the scientific research level and another is the technology level that closely associated with the environmental management [58,60–62]. That provides a comprehensive theoretical foundation and technical framework for the application of environment risk assessment.

1.1. Health risk assessment

As early as the 1930s, a primary formwork of health risk assessment had been formed, and most abundant achievements are in the US National Academy of Sciences and the US EPA in the 1980s. The landmark document is the Red Book—*the risk assessment of Federal Government Rating*: *management procedures* published by the US National Academy of Sciences in 1983. "Four-step" method of risk assessment was proposed, and they are hazard identification, dose–response relationship assessment, exposure assessment and risk characterization. Risk assessment framework has been developed since all parts of the method have a clear definition, and its core focus on human health and safety [63]. In the late 1980s, the US EPA promulgated a series of technical documents and guidelines of risk assessment, such as the risk assessment guidelines for carcinogenic and teratogenic risk, which meant scientific risk assessment system has been developed basically (see Table 1).

1.2. Ecological risk assessment

As above shown, the receptor of health risk assessment is humanity, which is different from Ecological risk assessment (EcoRA). The early 1990s, US scientists have suggested that the risk of the final receptor is not only humanity (Fig. 1), but also including all levels of the ecosystem. Barnthouse and Suter's evaluation framework tried to revise the human health evaluation framework to the EcoRA framework firstly, which reflects that the ecological risk emphasize the identification of sources risk, ecological describe and the choice of endpoint [60,61]. In 1998, US EPA promulgated "Ecological Risk Assessment Guidelines" formally, and proposed the

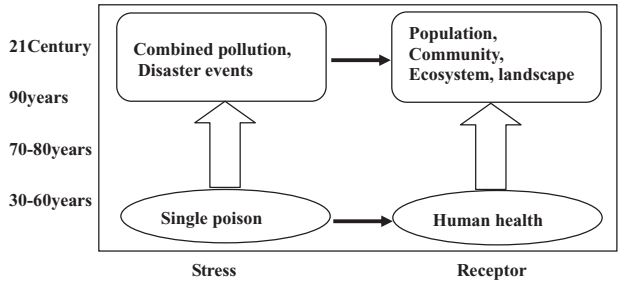

Fig. 1. Development of stressor and receptor in EcoRA.

"three-step method" of EcoRA that has been accepted by the majority of researchers, namely, problem formation, risk analysis, and risk characterization. Canada, Britain, Australia and other countries are also carried out the research work of the EcoRA in the mid-1990s. The stressors of the risk have been extended to a variety of chemical substances and ecological risk events from a single chemical substance, and risk receptors have been improved to populations, communities, ecosystems and watershed landscape level from human. At that time, relative perfect framework of EcoRA has been formed preliminary. In 1992, US EPA proposed non-chemical factors could be added into stressor, so stressors was developed to natural factors from chemicals (such as habitat destruction and soil erosion). In China, EcoRA study is relatively slow, and there are no specialized technical documents for EcoRA. Only the basic theory and technology studies have been reported about the water environment and regional EcoRA.

1.3. Regional and integrated risk assessment

People began to pay more attention to the formation mechanism and prevention of composite pollution from a single pollutant research, to regional environmental control from point source pollution control. How to carry out a regional risk assessment under a variety of stressors has become the hot topic of current risk assessment techniques. The object of the regional risk assessment is based on a large scale, so there are some different divisions according to different research objectives such as administrative division or natural watershed catchment division. Mostly large-scale EcoRA based on the guidelines of EPA in the late 1990s. According to the EcoRA of Clinch River Basin in Tennessee from Oak Ridge National Laboratory (ORNL) research group, it is possible to research the risk of the basin at large-scale. Xu [78] summarized the steps of regional EcoRA as: the definition and analysis of the study area, receptor analysis, sources analysis, exposure-hazard analysis and risk comprehensive evaluation.

2. Definition and characterization of EcoRA

The purpose of EcoRA is to provide information regarding the effects on an ecological systems for a given stressor profile so that pollution and other eco-environmental damages can be reduced to

Table 1
Development process of environmental risk assessment.

Development phase	Period	Development situation
Embryonic phase	30–60 years of the 20th century	Poison identification methods for health impact analysis, qualitative research-based
Peak phase	70–80 years of the 20th century	Quantitative evaluation; US NAS "four step" [43]; US EPA technical papers [64,65]
Improvement phase	90 years of the 20th century	US EPA proposed the concept of ERA and "Ecological Risk Assessment Guide" [66–68]; determined the theoretical framework of ERA [48]
Development stage of regional EcoRA	From late 1990s to early 2000s	Large-scale ecological risk assessment [77,9]; combined with health risk [62]