



Risk assessment of lead emissions from anthropogenic cycle



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Abstract: The risk assessment right from the source of emissions can effectively guide the pollution control. A model was established, consisting of four part: source estimation, environmental fate analysis, exposure analysis and risk assessment. The human health risk, ecological risk and total risk of lead emissions were assessed. The factors were estimated to indicate the environmental decrease and exposure probability. Of all the 1887 t emissions in China in 2010 (quantified in the previous work), it is turned out 1.3 t reached human bodies (0.9 mg/ca), and 2.7 t reached the ecosystem. Lead mainly came from the Use stage for the source while lead causing risk mainly came from the Waste Management & Recycling and Production stages. As for chemical forms, PbO contributed most to the human health risk and PbSO₄ contributed most to the ecological risk. PbSO₄, PbO and Pb altogether contributed 71% to the total risk, indicating these three chemicals should be taken priority for the risk management.

Key words: lead; source; human health risk; ecological risk; total risk; life cycle

1 Introduction

Lead is one of the most abundant and toxic heavy metals in the environment [1]. There are both natural and anthropogenic sources for lead emissions, and the anthropogenic sources dominate the emissions [2]. According to study, more than 95% of the lead within the biosphere is of anthropogenic origin [3]. Although the lead abatement programs are provided in many developed countries, lead risk is still an important concern in the developing countries such as China [4]. Threaten imposed by lead pollution to human health and ecosystem still deserves our intensive attention. In this context, the risk assessment can be used to support the decision making in lead pollution management.

A wide variety of studies are already done on lead risk assessment, which can roughly be classified into the human health risk assessment and the ecological risk assessment. Human health risk assessment is defined as the process which estimates the likelihood of adverse health effects on humans who may be exposed to chemicals in contaminated environmental media [5]. Up to date, the human health risk assessment is generally determined by gauging the concentration in the

environment, applying the method recommended by US environmental protection agency (EPA) [6,7]. On the other hand, the ecological risk assessment evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors [8]. For the ecological risk assessment, the method of hazard quotient is most widely applied [9–11]. All the present studies provide a clear way to measure lead risk. However, they fail to take the pollution sources into account, which is an integral part of risk formation. A study attempted to assess the risk of lead losses, but it lacks a detailed speciation as well as the analysis of environmental fate and exposure [12]. Thus, the information on which process (or life cycle stage) should be paid attention to, and which chemical forms should be taken priority is still missing. This kind of knowledge is significant in helping direct limitation of social consumption and governmental resources management.

In this study, a model to assess lead risk was established. The source emissions were estimated and the environmental fate and exposure were analyzed. The factors were applied to estimate the environmental decrease and exposure probability. Finally, the risk scores showing the levels of risk were calculated.

$$R = Q \cdot f_e \cdot f_x \cdot E \quad (1)$$

2 Methodology

2.1 Framework for lead risk assessment

The framework for lead risk assessment consists of four components: source estimation, environmental fate analysis, exposure analysis and risk assessment (Fig. 1). The source estimation refers to the quantification and speciation of emissions from anthropogenic cycle. The environmental fate analysis refers to the analysis of the move and transformation of chemicals in the environment. The exposure analysis estimates the likelihood of exposure to chemicals in contaminated environmental media. And the risk assessment includes three types of risk: the human health risk, the ecological risk and the total risk.

The risk of lead emissions (R) can be influenced by four factors:

where Q is the emission quantity from the source with the unit of t, f_e is the fate coefficient indicating the quantity decrease in the environment, f_x is the exposure coefficient indicating the likelihood of lead exposure, E is the effect factor showing the toxicity of lead emissions, represented by the unit risk score in the Indiana Relative Chemical Hazard (IRCH) ranking system [13]. The IRCH ranking system provides the unit human health risk score, unit ecological risk score and unit total risk score for various lead chemicals. As the scores in the IRCH ranking system were obtained from the sum of the points assigned, therefore they do not have any units. In this study, the risk was calculated by multiplying the unit score by the emission quantities with a unified unit of t (ton). For easy comparison, the outcomes of the calculation were defined as scores without units.

The total risk for lead emissions integrates both the

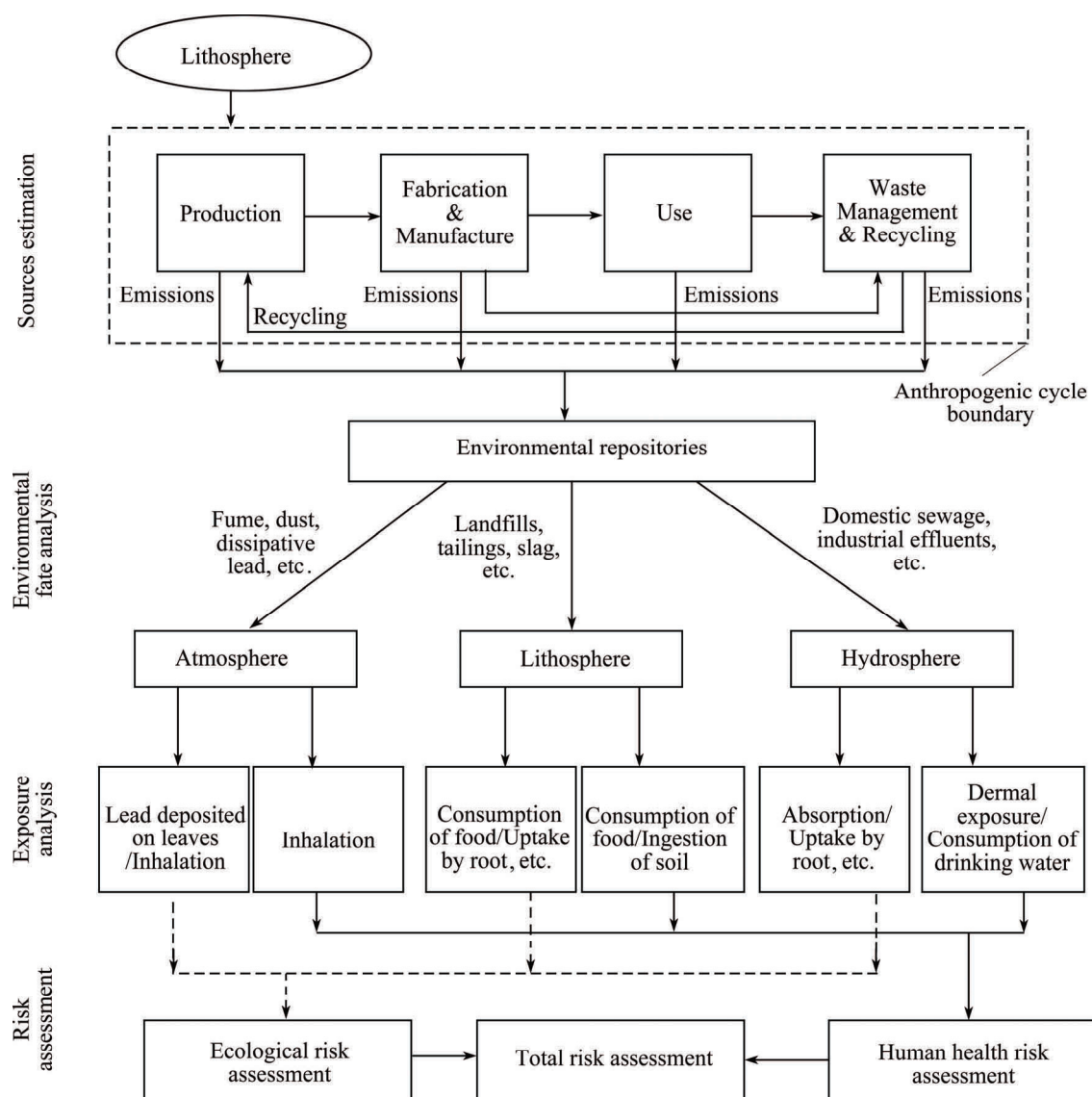


Fig. 1 Framework for lead risk assessment

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