环境损害评估制度、方法与实例

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中国环境出版社

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中国环境出版社·北京

图书在版编目（CIP）数据

环境损害评估：制度、方法与实例/张红振，董璟琦著.
—北京：中国环境出版社，2016.6
ISBN 978-7-5111-2773-0

Ⅰ．①环… Ⅱ．①张…②董… Ⅲ．①环境污染—危害性—评估—研究 Ⅳ．①X503

中国版本图书馆 CIP 数据核字（2016）第 080505 号

出 版 人 王新程
责任编辑 黄晓燕
文字编辑 高 艳
责任校对 尹 芳
封面设计 宋 瑞

出版发行 中国环境出版社
（100062 北京市东城区广渠门内大街 16 号）
网 址：http://www.cesp.com.cn
电子邮箱：bjgl@cesp.com.cn
联系电话：010-67112765（编辑管理部）
010-67112735（第一分社）
发行热线：010-67125803，010-67113405（传真）
印 刷 北京中献拓方科技发展有限公司
经 销 各地新华书店
版 次 2016 年 6 月第 1 版
印 次 2016 年 6 月第 1 次印刷
开 本 787×960 1/16
印 张 12.75
字 数 200 千字
定 价 38.00 元

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致　谢

本书出版得到了国家自然科学青年基金项目（71403097）、国家高技术研究发展计划（863 计划）项目（2013AA06A211）、国家水体污染控制与治理科技重大专项（2013ZX07602-002）的联合资助。特别感谢环境保护部环境规划院环境风险与损害鉴定评估研究中心曹东研究员、於方研究员及其他同事在此项研究工作中给予的指导和帮助。

序 一

环境损害评估通常是指环境污染损害评估，是对因环境污染导致人体健康、财产价值、生态环境及其生态系统服务发生了可观察的或可测量的不利变化的评估。环境污染损害评估涉及人身、财产和生态环境三个方面的损害评估，包括损害定性、损害量化和损害赔偿金确定三部分。近30年来，美国、日本、加拿大、澳大利亚及欧盟等国家都结合当地社会经济与环境发展的阶段和特征，开展了丰富的环境损害鉴定评估理论研究和实践应用，成功地形成了类型各异的基于污染者付费等原则的环境损害责任制度。这些发达国家将环境损害相关立法及管理模式、损害评估方法与技术导则、资源环境、价值理念和自然文化传统融为一体，在自身环境保护发展历程中逐渐形成了独特的环境损害评估制度，演进出健全的资源环境保护和环境权益保障体系。

近几年，环境损害评估的研究、实践和制度建设在我国方兴未艾。随着新《环境保护法》的出台与执行，以及有关国家部委针对环境损害赔偿相关文件的发布及实施，环境损害评估工作逐渐在环境行政管理、环境责任纠纷和环境司法诉讼中起到越来越重要的基础支撑作用。环境保护管理的需求会进一步带动环境损害评估相关的法规制定、制度建设、技术方法建立、机构建设和鉴定评估整体能力的提高。环境损害评估与赔偿也会逐步成为我国绿色发展、环境保护制度改革创新和生态文明建设的有力抓手。显而易见，开展环境损害评估的制度、技术和案例研究，在我国环境损害评估管理体系建立和完善阶段，具有格外重要的现实意义。

《环境损害评估：制度、方法与实例》一书是在中国建立环境损害评估制度

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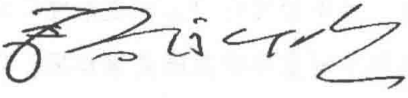
现阶段研究的系统总结。该书系统梳理了美国自然资源损害评估和恢复制度、日本环境公害应对、欧盟环境损害评估等发达国家的实践经验，分析了我国现行资源环境管理制度在环境损害评估与赔偿方面应用的现状，以及国内近10年来发生的各类环境污染事件和典型环境污染损害问题，指出了我国环境损害评估制度在法律法规、工作机制、技术规范、资金保障等方面的需求和研究方向，并提出了环境损害评估专业机构的基本能力要求，可为中国环境损害评估制度的构建提供基础性和技术性支撑。

本书的另一特点是针对国内突发水污染事件、铅污染事件、土壤和地下水污染场地、以及巨型流域性污染场地等环境损害评估，建立了不同类型环境污染损害评估的技术方法，并进行了典型案例分析。这些真实典型的案例研究工作，代表了现阶段国内环境损害评估方法学的进步和环境损害评估服务于环境管理决策及环境司法诉讼的水平。此外，该著作在制度建设章节还对国内外许多环境损害评估案例信息进行了总结。可以说，该书数据资料丰富、内容结构完整，对从事环境损害评估的研究、管理、实践和环境诉讼法律的相关人员具有重要的参考价值，将有力地推动国内环境损害评估的深入研究和工作实践。

中国科学院烟台海岸带研究所研究员



2016年4月30日

序 二

始于 2005 年松花江硝基苯污染事件，我与环境损害评估问题结缘。之后，脑中一直为这样的事儿“耿耿于怀”：当你与家人愉快地开着新购座驾郊游，突遭横冲直撞的大奔一记亲吻，伤心中，总还会有损害责任评估、修车索赔……伴你柳暗花明。然而，与你休戚与共的绿水青山，受到肆意的污染损害后，却得不到应有的责任追究，甚至大笔应急处理、恢复环境的费用反由纳税人买单。此等大概没有几人会不“搓火”的问题表明，打破环境损害管理上整体落后的局面，转变环境损害评估与责任制度长期缺失的状态，也已成为我国环境保护中亟待解决的突出问题。欣喜的是，伴随着我国环境管理与科技人员的促动与努力，自“十二五”以来，我国迈出了一系列推动环境损害评估与管理的有力步伐。特别地，2015 年中共中央办公厅、国务院办公厅出台了《生态环境损害赔偿制度改革试点方案》，更将生态环境损害评估和责任制度建设列为环保改革创新、推进我国生态文明建设的标志性内容之一。不难理解，这就是“为什么”本书具有重要意义之所在。

环境管理中，对环境损害及其赔偿责任的概念认识与实践，历经了一个拓展演变的过程。早期的环境损害，概指通过环境介质（through environment）而对人体健康与财产造成的损害。类似上文交通事故的受损事例，这类环境损害表征的是一“个体”利益（或者说私利）的受损问题。国际上，常称其为传统（环境）损害。随着环境保护的发展，一个新的环境损害概念，即对具有公共利益的环境本身（to environment）造成的损害，逐渐形成、落地，并为管理与改善环境功能质量奠定了实践基础。这种有如上文所说对绿水青山的损害，目前国内外使用着

含义相近的多种不同用语，如“自然资源损害”、“生态损害”、“生态环境损害”等。两种环境损害，由于受损对象、属性特征不同，因而国际上、尤其在欧美，呈现着两套并行的环境损害评估与责任管理体系。一套是，对经由环境导致的人体健康、财产这类传统环境损害，作为某种特定的侵权责任，纳入侵权法范畴内实施管理。另一套是，对具有公共利益的“无主”环境损害，则通过建立相应的环境责任法律制度实施管理。可以认为，这便是理解本书所论内容“是什么”的基本视角。

正是在上述背景下，《环境损害评估：制度、方法与实例》成书。该书集成了作者自清华大学博士后至环境规划院工作期间，在环境损害评估研究与实践中取得的大量成果。全书基于对美国、欧盟、日本为代表的国际上环境（本身）损害评估领域进展的分析总结，重点围绕环境（本身）损害管理与评估制度建设、环境（本身）损害评估方法及应用两大方面，立足国情，进行了较系统的研究阐述。以我观感，针对“怎样做”问题的现实思考、探索，则构成本书的核心与亮点。

全书内容丰富，概念与实例互补，有着较强的实践性和可读性。对从事和关心我国环境损害评估的科研、管理与从业人员具有难得的学研价值和启发作用。期待作者与同仁们，携手共进，进一步深化研究与实践，促进我国的环境损害评估与责任制度建设。

清华大学环境学院
张天柱　教授
2016 年 5 月 9 日

前　言

随着对资源环境的稀缺性和环境价值认同的不断深入，世界各国从污染防治和生态环境保护实践中逐渐形成并健全了环境损害评估制度。环境损害评估的实践活动在科学研究层面对环境法学、环境经济学、环境科学、环境工程等相关学科的发展提出了新的挑战；在应用层面不断推动相关法律法规、技术方法、工作机制、程序导则的形成和完善。目前，我国环境损害评估理论和实践都处于起步阶段，结合我国当前严峻的环境形势和社会经济发展特征，借鉴国外先进经验，提出了我国环境损害评估的定位和发展方向，对探索适合我国国情的环境损害评估制度具有重要意义。本书的主要内容包括环境损害评估的基本概念和理论方法的概述；国际上环境损害评估制度的演变分析和中国制度框架的建议；从突发水污染事件、典型铅污染事件、有色采选巨型污染场地、工业土壤和地下水污染场地等方面介绍了环境损害调查和评估的方法学及案例分析。本书主要研究内容和结果介绍如下。

（1）**梳理欧美日等发达国家的环境损害评估经验**。在比较分析美国、欧盟、日本等国家环境损害评估实践经验的基础上，明确了环境损害评估相关概念、内涵与范畴，系统梳理了各国相关法律法规、工作机制、技术导则、评估方法、资金来源及沟通协调等制度内容。针对我国环境损害管理面临的主要问题，基于当前已有的管理与技术体系，建立规范统一的环境损害评估制度，对于推进中国环境污染损害鉴定评估与赔偿恢复的实践工作，探索切实可行的环境损害定量管理具有重要意义。

（2）**探索中国的环境损害评估制度框架和业务分类体系**。环境污染导致

健康损害、财产损失和生态环境破坏已经成为当前政府、公众和全社会关注的焦点。发达国家的实践经验表明，环境损害评估制度必须依据各国面临的环境形势和主要环境问题，逐步构建符合国情的环境损害评估法律、技术和资金保障体系。我国在海洋生态环境、渔业资源损害评估、林业资源破坏损失估价、污染场地修复管理等方面已有一些基础，但从整体上来说，环境损害评估管理职能散落在不同的政府部门，存在环境公益损害赔偿几乎尚未涉及，环境私益损害认定和赔偿严重不足等缺陷。通过资料收集整理、发放调查问卷、走访环保法庭和政府部门，考察现有相关评估机构和人员座谈、开展实际案例评估、参与环境公益诉讼等方式，分析我国当前环境污染损害形势，整理相关法律法规和环境管理机制，梳理现有相关环境损害评估机构，探索环境损害评估资金来源。

（3）**构建突发水污染事件环境损害评估的管理和技术方法**。近年来频繁发生的突发水污染事件不仅会引发重大社会风险与环境安全隐患，还严重危害饮用水源地水质安全、下游工农业生产用水及敏感水生物种和生态系统服务，是国内环境损害评估与赔偿的重点关注对象。水污染事件的损害赔偿也是发达国家环境法规和管理部门的重点关注领域，在立法和技术导则及相关模型和方法方面有丰富的经验可以借鉴。在梳理我国近期发生和凸显的水污染事件特征与趋势的基础上，分析了国内环境损害评估管理的制度和能力基础，基于国内外典型案例实际评估经验，提出国内不同等级的水污染事件环境损害评估的类型划分、启动模式、评估原则与方法、评估范围与内容等制度框架。同时，对水污染事件环境损害评估中实地监测、试验分析、模型模拟等技术方法的优选与使用方法提出建议。初步构建了适用于我国当前实际情况的水污染事件环境损害评估工作机制与技术体系，并对开发更加精细化和可操作的管理模式、评估流程和技术方法提出阶段化推进的建议。

（4）**以 2012 年广西龙江河突发环境事件为例开展环境损害调查模拟的技术探索**。重金属污染突发水环境事件的应急处置和造成的环境损害与污染物的

化学形态及其环境行为密切相关。以2012年初发生在我国广西的龙江河镉污染事件为例，采用Minteq软件计算3种情景下河流水环境溶解态Cd的化学形态。结果表明，在天然背景条件下，龙江河Cd浓度约为5 μg/L时，水环境中Cd以Cd^{2+}为主，并主要受DOC含量的影响。镉污染事件发生后若无应急处置措施，天然水体对Cd的络合缓冲能力极其有限，以Cd^{2+}形式存在的Cd占75%以上，具有严重的急性生态毒性。投加聚合氯化铝和碱性物质可以有效控制河流中溶解态Cd含量，当pH超过9.0时，以Cd^{2+}存在的Cd迅速降低。Cd^{2+}含量对河流pH敏感性最高，DOC其次，水温影响最小。事件处置结束后应密切关注絮凝体中Cd的再释放规律及水体pH及DOC对Cd形态的影响。

（5）以我国南方某流域为例开展流域巨型污染场地的环境损害调查的典型案例分析。有色金属采选矿区污染往往呈现出历时久、污染重、污染区域面积大、涉及环境介质复杂等特征。为了解南方某小流域重金属污染的状况和成因，对该区域重金属污染的潜在来源进行了初步调查分析。结果表明，流域内有色金属采选活动导致对河道、农田和地表水、地下水的重金属污染，其中As、Pb、Sb、Zn是重点防控的元素。流域潜在污染源有9个，其中长城岭矿及周边区域、废弃冶炼厂及周边地下泉水、下涟选场周边尾砂和土壤是3个最主要的显性污染源。流域重金属污染来源复杂，包括尾砂释放、矿石淋溶、矿坑水、矿井水、地下泉水等点源和面源污染，其中青头江、下涟两个区域对流域下游河水Sb浓度的贡献分别达到60%～75%和15%～20%。区域历史遗留面源污染问题突出，河流底泥、沿岸尾矿砂冲积物等污染贡献度很难定量，针对河流水体采取的应急工程措施难以完全解决流域Sb浓度升高问题。

（6）初步提出铅污染造成的健康、财产和生态环境损害评估框架、程序及技术方法。目前我国铅污染事件频发，环境损害评估技术缺乏，损害赔偿不能足额到位，已成为我国局部地区触发群体性事件和社会不稳定的重要因素之一。在明确铅污染环境损害评估对象、界定评估时空范围的基础上，建立了铅污染环境风险与损害量化的耦合机制，提出不同类型损害的备选评估方法。设

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计了包括污染鉴定、范围界定、损害评估、结果表征的技术流程。提出分阶段逐步扩大评估范围和健全评估技术的具体建议，初步构建了适合我国实际情况的较完整的铅污染环境损害评估技术体系。

（7）**采用资源等值分析法开展某焦化厂污染场地环境损害评估案例**。我国当前面临着严峻的土壤和地下水污染，亟须构建基于等值分析和场地修复成本的环境损害评估方法体系。以某大型焦化厂土壤和地下水多环芳烃、苯污染损害评估为例，采用资源等值分析法分别开展场地土壤和地下水污染环境损害评估，并对评估结果的不确定性进行分析。结果表明，损害评估的数额（27.1亿元）与实际污染修复成本（20.5亿元）存在较大差异，损害评估数额明显大于污染治理修复成本；社会贴现率的取值选择对土壤污染损害评估结果影响最大，污染含水层厚度、含水层孔隙度、单位地下水修复成本等因子对地下水污染环境损害评估的结果影响较大。资源等值分析作为评估工业场地土壤和地下水污染的方法，从理论和技术上均较为可行，需要精细化的立法和明确的技术导则来规范损害评估的内容、程序和方法。

Preface

As the whole society gradually realized the scarcity of nature resources and environmental value, countries all over the world have evolved and improved the system of environmental damage assessment through the practices of pollution prevention and ecological environmental protection. On the one hand, in the research prospective, the practices of environmental damage assessment brought new challenges to environmental law, environmental economics, environmental science, environmental engineering, etc. On the other hand, they constantly promoted and developed relevant laws and regulations, techniques, working mechanism, and guidelines on procedure in practice. Based on the comparison and analysis international practices experiences from U.S, EU, and Japan, etc., this article identified relevant concepts, content, and scope of environmental damage assessment, and presented its scientific positioning and development direction. At present, both theory and practice of environmental damage assessment in China are in its infancy period. Considering current environmental situation and socioeconomic development features of China, learning international experiences and raising the orientation of environmental damage assessment has great mean in exploring the suitable environmental damage assessment system.

Health injury, properties compensation and ecological and environmental destruction have become the focuses of government, public and the society at present in China. The experiences of developed countries have revealed that the institution of environmental damage assessment must be established through forming environmental damage assessment legislations, technologies and funding guarantee system suitable for the nation's condition based on the specific environmental situation and main issues. China has some foundations in marine ecological environment, fishery resources

damage assessment, forest resources damage assessment and remediation management of contaminated sites; however, the management of environmental damage assessment fall in different governmental departments. There are also shortcomings of few environmental public compensation touched upon, insufficient environmental privacy determination and compensation, etc. Based on the methods of materials and information collections, questionnaires, visiting environmental court and government sectors, interviews to assessment organizations and professionals, launching practical assessments to related cases and joining in environmental public lawsuits, the Chinese situation of environmental pollution damages are analyzed, the related legislation and management mechanism are reviewed, the corresponding assessment organizations regarding environmental damages are sort out, and the funding sources of environmental damage assessment are explored. Aiming at the main issues in Chinese environmental damage management, a standard and unified institution for environmental damage assessment based on current managing and technological systems is important to improve the practical work in Chinese environmental pollution damage determination, assessment and compensation, and to further explore the feasible environmental damage quantitative management.

The acute water pollution incidents occurred frequently in recent years have caused serious society risks and potential environmental problems, such as threatening drinking water safeties and industrial and agricultural water usages downstream, and damaging sensitive aquatic species and ecosystem services, which have been focused a lot by Chinese environmental damage assessment and compensation. Since the damage compensation of water pollution incidents is the main focusing area in the environmental legislations and managements in developed countries, rich experiences in legislation, technical guidance, related models and methods could be learned by Chinese. Based on the summary of characteristics and trends of water pollution incidents happened recently in China, the domestic environmental damage assessment managing mechanism and capability basis were analyzed. According to the typical assessment case studies in and abroad, the mechanism scheme including catalogs division, trigger mode, assessment principles and methods, assessment scope and contents for water pollution incidents environmental damage assessment under

different incident levels were proposed. Meanwhile, the optimization and practical operating methods of field monitoring, experimental analysis, modeling and technical approaches in water pollution incidents environmental damage assessment was suggested. Eventually, the working mechanism and technical system of water pollution incidents environmental damage assessment suitable for Chinese current situation is proposed, and step by step suggestions are given for developing refinery and operable management modes, assessment processes and technical methods.

Chemical speciation of metals and their environmental behaviors are of great importance for the emergency responses and damage assessments of emergent environmental incidents caused by industrial releases. Based on the Longjiang river cadmium pollution accident occurred in year 2012 in Guangxi, China, the dissolved Cd speciation in the river for 3 different scenarios were calculated using Visual Minteq 3.1. It was shown that Cd^{2+} was the dominant Cd specie with a low concentration (0.005 mg/L), and it was strongly influenced by DOC content at the background situation. If there were no immediate responding activities in the river after the release of Cd, Cd^{2+} would cover more than 75% of the total dissolved Cd with a high concentration (0.4 mg/L) because of the little buffer ability of the natural aquatic system, which would present serious ecological emergency toxicities. Adding polymeric aluminum and alkali to the river in a proper way could reduce Cd content in the river efficiently and the ratio of Cd^{2+} also reduced rapidly when pH raise to 9.0 or higher. Cd^{2+} was sensitive mostly to pH, and secondly DOC, and was not sensitive to temperature. It was suggested that we should pay attention to the re-release of Cd in inorganic polymer flocculation bodies and the influences of pH and DOC.

Non-Ferrous metal mining areas are often seriously contaminated in a long history, large areas, and multi-environmental media involved. To understand the current status of heavy metal contamination and the sources, we investigated in a small river basin where mining activities kept for a long time. The results show that the mining activities have caused metal contaminations in river courses, farmlands, surface water and groundwater, within which As, Pb, Sb and Zn are the dominant pollutants. There are nine potential metal pollution sources, among which the Changchengling mine, groundwater and spring around the junction of Qingtoujiang river and Yuxi

river，and the tailings and contaminated soils around the Xialian dressing factories are the three most important explicit sources. Sources of heavy metal pollution in the river basin are complex，including many point and non-point sources，such as tailings，abandoned ores，mining water，groundwater and spring. The areas of Qingtoujiang and Xialian contributed about 60%～75% and 15%～20% to the Sb concentration in the downstream water separately. Since the historical non-point pollution is serious in the region and it is difficult to quantify the Sb contributions of sediments and tailings covered the area to the downstream surface water，the emergency responding measures focusing on the surface water may not be able to solve the problem of increasing Sb concentration thoroughly.

Lead pollution incidents occurred frequently in the country，and the compensation for damages was far from full amount，which has been one of key factors that mass disturbance and social instability were triggered in some areas of the country. Based on indentifying the object of damages assessment on lead pollution and its spatial-temporal scope，the coupling mechanism for environmental risk of lead pollution and damages quantification was established together with alternative assessment methods for different types of damages. The technique process was also devised，including pollution appraisal，scoping，damage assessment，and results characterization. Besides，the article presented suggestions to gradually enlarge the scope and perfect techniques，and initially constructed a fuller technical system for environmental damage assessment on lead pollution incidents，which would be suitable for the piratical situation in the country.

Soil and groundwater contamination is becoming worse in China，it's of emergency to establish environmental damage assessment（EDA）methods based on equivalency analysis and site remediation cost. Taking a cooking plant site contaminated by Polycyclic Aromatic Hydrocarbons（PAHs），benzene as example，soil and groundwater contamination damage assessment was carried out using Resources equivalency analysis（REA）methods，and uncertainty of results were also analyzed. The results show that，there is significant difference between the damage assessment results，which is 2.71 billion RMB，and actual site remediation cost，which is 2.05 billion RMB. The former is evidently larger than later. Social discount rate

influences the soil contamination damage assessment result most, and for groundwater, the most important factors are thickness of contaminated groundwater layer, porosity of aquifer, social discount rate and remediation cost per unit groundwater. ERA can be practically used to assess soil and groundwater contamination damage at contaminated industrial site, with a strong theoretically and technically basis. But we need Refinement of legislation and specific technical guideline to standard the EDA content, process and method.

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