JOURNAL OF INDUSTRIAL ECOLOGY

中文摘要
《产业生态学报》
第3卷第4期

翻译
施涵

Chinese Abstracts
Journal of Industrial Ecology
Volume 3, Number 4

Translated by
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《产业生态学报》

1999 年冬，第 3 卷第 4 期，43–58 页

题目：斯德哥尔摩市生物可降解废物的管理规划

作者：Anna Björklund, Charlotte Bjuggren, Magnus Dalemo, Ulf Sonesson

关键字：生物固体废物，生命周期评价(LCA)，城市废物管理，营养物循环，有机废物研究模型(ORWARE)，物质流分析(SFA)

摘要：斯德哥尔摩市的生物可降解废物主要有焚烧和添埋两种处理方法。本文介绍了一种新的对营养物进行大规模循环利用的综合处理模式，包括大规模堆肥、厌氧发酵和尿液单独收集利用等。研究人员通过一个基于计算机的有机废物研究模型(ORWARE)，对传统生物固体废物处理系统和新型系统在不同生命周期阶段的污染排放、废物生成、能量回收和资源消耗等因素进行了评价研究。斯德哥尔摩市的人口密度较高，周边耕地较少，对交通运输有一些不利的影响。但即使对营养物质进行更大规模的循环利用，废物运输过程的环境影响仍比较低。对最终结果影响最大的是发电、集中供热等辅助设施。虽然回收的尿液在作为肥料前需酸化处理，但生物可降解废物中的营养成分的回收仍可以改善斯德哥尔摩市的总体环境影响。值得注意的是，随着生物可降解废物的广泛回收利用，耕地中有害金属的含量难免增加。在所有回用废物中，尿液所受的金属污染是最小的，再利用其他受污染较重的废物时必须严格限制其有害金属的含量。

Journal of Industrial Ecology

1999, Vol. 3, Issue 4, pp. 43-58

Planning Biodegradable Waste Management in Stockholm

Anna Björklund, Charlotte Bjuggren, Magnus Dalemo and Ulf Sonesson

KEYWORDS:
biosolids, life-cycle assessment (LCA), municipal waste management, nutrient recycling, ORWARE, substance flow analysis (SFA)

SUMMARY:
The environmental impact of the management of biodegradable waste in Stockholm, based mainly on incineration and landfilling, was compared to systems with significant nutrient recycling; large-scale composting, anaerobic digestion, and separate collection and utilization of urine. The systems' emissions, residual products, energy turnover, and resource consumption were evaluated from a life-cycle perspective, using a computerized model, ORWARE (ORganic WAste REsearch model). Transportation was of relatively low importance to over-all environmental impact, even at high rates of nutrient recycling. This is remarkable considering the geographical setting of Stockholm, with high population density and little nearby farmland. Ancillary systems, such as generation of electricity and district heating, were crucial for the overall outcome. Increased recycling of nutrients in solid biodegradable waste in Stockholm can reduce net environmental impact, whereas separation of human urine to be spread as fertilizer cannot yet be introduced without increased acidification. Increased nutrient recycling from solid biodegradable waste inevitably increases spreading of metals on arable land. Urine is by far the least contaminated residual product. Spreading of all other residuals would be limited by their metal content.

《产业生态学报》

1999 年冬，第 3 卷第 4 期，59–75 页

题目：产品的功能特性与环境表现的集成设计：一个机械元件的设计实例

作者：Diana Bauer, Paul Sheng

关键字：面向环境的设计(DfE)，功能设计规格，多准则危害评价，滚子轴承，转轴，表面规格

摘要：产品的面向环境的设计(DfE)往往有赖于产品生命周期评价(LCA)所提供的产品的环境表现信息。目前 LCA 仍侧重于对原材料开采、产品生产、使用、处置等不同生命周期阶段的清单分析和环境影响分析。改进分析，理论上是 LCA 的一项重要内容，但实施起来却十分困难，因为很难将不同阶段的物流分析和环境影响分析结果与产品设计和制造直接联系起来。随着产品开发过程由串行设计向并行设计的转变，为了进一步平衡产品的环境表现与其它特性，产品的环境影响评价必须与产品设计过程有效互补、充分协调。本文在保证产品功能设计的基础上，引入了一个环境影响分析工具。对生产者而言，产品的局域环境影响往往与其全球环境影响一样重要，同时还涉及不同生命周期阶段的环境影响的妥协问题。文中详细分析了两种不同机械零件（滚子轴承和转轴）的功能特性（表面光洁度）和局域环境影响，以便于产品设计和制造过程的统筹优化。本项研究表明功能模拟有助于改进产品的环境特性，应该成为 LCA 的一个重要部分。

Journal of Industrial Ecology

1999, Vol. 3, Issue 4, pp. 59-75

Integration of Functional and Environmental Performance Design Decisions: A Mechanical Component Case Study

Diana Bauer and Paul Sheng

KEYWORDS:
design for environment (DfE), functional design specification, multi-criteria hazard scoring, roller bearings, rotating shafts, surface specification

SUMMARY:
Product design-for-environment (DfE) has traditionally relied on life-cycle assessment (LCA) as a primary means of assessing environmental performance. To date, LCA has focused on static inventory and impacts of material streams during the stages of resource extraction, component manufacture, product use, and end of life at a high level of aggregation. Improvement analysis, though theoretically an important stage of LCA, is practically very challenging to implement using LCA alone. One reason for this is that the focus on detailed characterization of material streams does not facilitate a development of an understanding of the mechanistic relationship between design intent and material, manufacturing, and use-phase potential impacts. As the product development community transitions from sequential design to more streamlined concurrent design, interactive design tools are needed as a supplement to assessment tools in order to facilitate trade-offs among environmental and other factors. This article presents an environmental analysis approach based on detailed process modeling which evaluates components from a functional design point of view. From a manufacturer's perspective, local potential effects in aggregate are often as important as global potential impacts. Furthermore, impacts often relate to explicit trade-offs between different life-cycle stages, such as production and use. In this article, the influence of functional design and manufacturing specifications (surface tolerance and finish) on localized potential impacts is illustrated through two different mechanical component (steel roller bearing and rotating shaft) case studies. Detailed analytical tools are key in enabling optimization and trade-offs by designers and process planners. The functional modeling approach is an important complement to LCA in providing a well-defined view of environmental performance.

《产业生态学报》

1999 年冬，第 3 卷第 4 期，77–95 页

题目：采用荧光增白剂和过氧化物漂白剂来漂白机械浆的环境表现之比较

作者：Martin Scheringer, Daniel Halder, Konrad Hungerbühler

关键字：漂白，荧光增白剂，生命周期影响评价，机械浆，持久性，风险评价

摘要：荧光增白剂可替代诸如过氧化物等氧化漂白剂来漂白机械制浆过程所生产的机械纸浆。荧光增白法通过增强 400–500 纳米波长的蓝光的反射白化纸浆，这是一个物理过程，并不发生破坏木材生色基团的化学反应。本文对典型的荧光增白剂和过氧化物漂白剂的生产及其在造纸过程中的应用进行了比较。生命周期清单分析的结果显示，生产荧光增白剂会向水体排放更多的无机盐和可吸附有机卤素(AOX)。但漂白等量纸浆所需的荧光增白剂比过氧化物漂白剂少的多，所以前者仍具有一定优势。生产过程的影响评价基于 Eco-indicator 95 标准。由于该方法并未涵盖漂白/增白过程中排放到水体环境中的化学品的环境影响，所以本文进一步深入研究了各种化合物在水体的迁移转化情况及其水体毒性。

Journal of Industrial Ecology

1999, Vol. 3, Issue 4, pp. 77-95

Comparing the Environmental Performance of Fluorescent Whitening Agents with Peroxide Bleaching of Mechanical Pulp

Martin Scheringer, Daniel Halder and Konrad Hungerbühler

KEYWORDS:
bleaching, fluorescent whitening agents, life-cycle impact assessment, mechanical pulp, persistence, risk assessment

SUMMARY:
The use of fluorescent whitening agents (FWAs) instead of oxidative bleaching agents such as peroxide is an alternative for the bleaching of mechanical pulp. By this approach, the chromophores of the wood components in the pulp are not destroyed chemically but the brightness of the pulp is achieved by increased re-emission of blue light in the range of 400-500 nm. In this study, a typical FWA and peroxide bleaching chemicals are compared with respect to both production and application in the pulp mill. The life-cycle inventory shows that, on the one hand, the production of the FWA leads to higher releases of salts and absorbable organically bound halogens (AOX) to surface waters and that, on the other hand, significantly less FWA is required in the application step in order to reach the same pulp brightness. The life-cycle impact assessment of the production step is presented in terms of Eco-indicator 95. These results, however, do not cover the environmental fate of various chemicals released to the aquatic environment in the course of the bleaching/whitening step. Therefore, this part is assessed by means of a more detailed investigation of the chemicals' environmental fate in rivers and their aquatic toxicity.

《产业生态学报》
1999 年冬，第 3 卷第 4 期，97–115 页

题目：混合三角形：一种图示化的生命周期评价决策工具

作者：Patrick Hofstetter, Arthur Braunschweig, Thomas Mettier, Ruedi Müller-Wenk, Olaf Tietje

关键字：环境危害指标的相关性，重要性分析，图形界面，LCA 解释，生命周期评价，权重三角

摘要：生命周期影响评价(LCIA)研究的最新进展之一就是能够即时模拟可能的环境影响变化并采取相应的预防措施。为开展上述模拟，需要定义环境危害指标体系并能够对不同替代方案的环境影响进行比较。本文针对一个具体的 LCIA 方法，加权分析了其环境危害指标体系的相关性，并给出了一种图形化的指标权重确定方法。研究通过对 82 种替代产品所作的 15 项 LCA 评价，发现环境危害指标往往是不相关的。但在一些特定情况下，如对同类产品进行评价时，指标间的相关性会很高，只需利用很少的指标就可选出环境最优的产品方案。这一发现也有助于 LCA 的简化研究。文中提出了一个直观的混合权重三角形，依据三项准则即可确定所有指标的相对权重。对每一组权重集，混合三角形还可给出参评方案的评价结果。利用混合三角形法可有效地简化权重确定程序，更好地完成 LCA 影响评价，并能够向决策者提供一个清晰直观的评价结果。

Journal of Industrial Ecology
1999, Vol. 3, Issue 4, pp. 97-115

Dominance Analysis in the Mixing Triangle: Graphical Decision Support for Comparisons with LCA

Patrick Hofstetter, Arthur Braunschweig, Thomas Mettier, Ruedi Müller-Wenk and Olaf Tietje

KEYWORDS:
correlation of damage indicators, dominance analysis, graphical interface, LCA interpretation, life-cycle assessment, weighting triangle

SUMMARY:
Recent developments within life-cycle impact assessment (LCIA) allow direct modeling of changes to predefined safeguard subjects that represent the environment to be protected. These changes are often expressed in a few damage indicators and calculated for each product alternative to be compared. This article analyzes the correlation among damage indicators within one specific LCIA methodology, assesses the implications of such correlation for the use of weighting methods, and proposes a method for graphically displaying choices with respect to weighting. An empirical analysis of 15 life-cycle assessment (LCA) studies including 82 product alternatives showed that damage indicators are typically not correlated. However, in some cases, correlation within the study was high enough that one of the product alternatives scored lowest on all damage indicators, so that the environmentally best alternative could be identified without further weighting of damage indicators. The correlation between damage indicators often rises if the analysis is limited to relatively homogenous product alternatives. This finding may be used to develop simplified LCA methodologies. The need for weighting methods arises when no alternative scores lowest on all damage indicators. Then, a weighting triangle can be used to represent the results graphically. In the triangle, relative weights are attributed to three decision criteria in this case, damages to environmental safe-guard subjects. Any relative weighting can be shown in the triangle. For each weighting set, the triangle then shows graphically which alternatives score best. The presented methodology aims to minimize the use of value-laden weighting information. Some examples illustrate the feasibility and utility of the triangle as a new graphical interface between LCA practitioners and decision makers. In many cases, the weighting triangle can simplify and clarify the discussion about environmental superiority.

《产业生态学报》
1999 年冬，第 3 卷第 4 期，117–130 页

题目：挪威科技大学的产业生态学教育

作者：Rolf Marstrander, Helge Brattebø, Kjetil Røine, Sigurd Støren

关键字：环境教育，研究生教育，产业生态学课程，交叉学科学习，系统思维

摘要：本文回顾了挪威科技大学(NTNU)为跨专业硕士和博士研究生开设产业生态学课程的历程。在过去三年中，作者尝试了产业生态学课程的多种讲授方法。该课程总的来说是成功的，它增进了学生对生命周期各个阶段的环境问题的总体把握，培养了相关的工业环境技能。产业生态学课程应该是一种自下而上的问题导向型课程，在讲座之外应尽可能增加专题讨论课，并积极邀请其他学科的学者及来自政府和企业的人员参加。产业生态学课程同时也改变了大学传统的教学方式，无论是课堂教学、课外研究还是学生的助研助教，都需要各个系多位教员和学生之间的广泛协调和密切合作。为此，挪威科技大学提倡一种跨学科战略，并从 1993 年起就组成了第一个跨学科研究小组。作者由此得以开展一项越来越全面的产业生态学教育项目(即 IndEcol)。

Journal of Industrial Ecology

1999, Vol. 3, Issue 4, pp. 117-130

Teaching Industrial Ecology: Experiences at the Norwegian University of Science and Technology

Rolf Marstrander, Helge Brattebø, Kjetil Røine and Sigurd Støren

KEYWORDS:
environmental education, graduate education, industrial ecology curriculum, interdisciplinary learning, systems thinking

SUMMARY:
We reflect on our experiences in developing and teaching industrial ecology to interdisciplinary classes of M.Sc. and Ph.D. students. During a three-year period different ways of teaching a course in industrial ecology were tested. We conclude that an industrial ecology course has positive effects on the students' ability to acquire a holistic understanding of life-cycle environmental performance, a skill much in demand by industry. Such a course should be based on problem-oriented learning. We recommend the use of thematically-focused seminars with time for both lectures and workshops. We found that substantial participation by teachers from different disciplines and partners from industry and government is very effective. Such a course also facilitates a broader process of change within the university. Implementing industrial ecology in the university requires a joint effort and collaboration among various faculties and departments, where research activities, student projects, as well as regular student teaching and tutoring, must be complementary elements of a major interdisciplinary strategy. Such a strategy has been employed at the Norwegian University of Science and Technology (NTNU) since the first initiatives in this area were taken in 1993, and this has led to our present more comprehensive Industrial Ecology Programme (IndEcol).

《产业生态学报》
1999 年冬，第 3 卷第 4 期，131-144 页

题目：棋盘游戏——一个产业生态学的模拟工具

作者：Benoit Cushman-Roisin, Norman J. Rice III, Michael A. Moldaver

关键字：汽车工业, 面向环境的设计, 教育与训练, 生命周期评价, 污染预防, 模拟

摘要：棋盘游戏是一个产业生态学的仿真游戏，对产业生态学基础教学很有帮助。游戏以汽车工业的很多现实问题和现实数据为基础，通过模拟仿真，阐明了很多不仅适于汽车业而且适于其他产业的产业生态学的基本原理和基本概念，如污染预防、面向环境的设计（包括面向拆卸的设计等）、环境管理和生命周期评价等等。这项游戏已经得到了工学院和商学院教授、环境工程研究生、政府机构代表、企业经理等各方面人士的实践验证。对游戏前后的学员进行产业生态学基本知识的测试，发现经棋盘游戏训练后学员的成绩比游戏前大有提高，由此可见棋盘游戏确实有助于产业生态学的教学。

Journal of Industrial Ecology

1999, Vol. 3, Issue 4, pp. 131-144

A Simulation Tool for Industrial Ecology: Creating a Board Game

Benoit Cushman-Roisin, Norman J. Rice III and Michael A. Moldaver

KEYWORDS:
automobile industry, design for environment, education and training, life-cycle assessment, pollution prevention, simulation

SUMMARY:
This article presents a board game that was developed for use as a simulation tool in teaching the basic concepts of industrial ecology (IE). The game, with the automobile industry as its theme, includes realistic numbers and displays a variety of IE principles. The objectives of the simulation, however, transcend the automobile industry and apply to other manufacturing industries. They include: pollution prevention, design for environment (in several forms, including design for disassembly), environmental management, and life-cycle assessment. The game has already been played by engineering and business professors, graduate students in environmental engineering, government representatives, and industry executives. A statistical analysis performed on pre- and post-game questionnaires indicates that the game is an effective teaching tool.