自然资源学报 2011, 26(10) 1801-1810 DOI: ISSN: 1000-3037 CN: 11-1912/N

论文

城市物质能量代谢相关研究述评——兼论资源代谢的内涵与研究方法

张力小, 胡秋红

北京师范大学 环境学院 水环境模拟国家重点实验室,北京 100875

摘要:

物质能量代谢分析已成为城市生态系统研究的一个重要视角与工具。论文在对当前各种代谢概念与方法进行系统梳理和分析的基础上,借鉴资源科学相关研究的最新成果,重新整合城市代谢相关的研究内容和分析边界,将物质能量代谢概念拓展为资源代谢的概念,试图涵盖物质性资源和非物质性资源、能量性和非能量性资源,并引入资源来解决城市资源代谢的生态统一核算问题,实现资源稀缺性和有用性的有效度量。此外,引入资源流过程分析特别是网络分析的方法,可打破传统代谢研究"灰箱"分析的局限,实现资源流在系统内部流动的代谢路径跟踪,实现城市生态系统结构化与网络化的深度分析,从而完善城市代谢研究的理论与方法体系。

关键词: 城市生态系统 代谢分析 资源 资源流

A Critical Review on Material and Energetic Metabolism for Urban Ecosystem: Resource Metabolism and Its Contents

ZHANG Li-xiao, HU Qiu-hong

State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University, Beijing 100875, China

Abstract:

Metabolism analysis is one of the important perspectives and tools for urban ecosystem research. Conducted in this paper is a critical review on research of urban metabolism with regard to concepts and methods. Currently, the metabolism concept associated with urban ecosystem are consisted of social metabolism, urban metabolism, industrial metabolism, as well as energy metabolism and ecological energetic metabolism, connotation and denotation of which are both overlapped and varied. In addition to the diverse research purpose, the lacking of unified accounting method is the real reason for the varied metabolism concepts and frameworks to some extent. In fact, the available framework of urban metabolism has only paid attentions to physical resource, while ignoring non-physical resources such as solar energy, wind power and information. However, the new developments in resources sciences, i.e., resource flow, network analysis and exergy accounting provide new ideas and methodology assistance for solving the problems in urban metabolism analysis. Therefore, a new concept of resource metabolism was put forward, which extends the research content and systematic boundary, including material resources and non-material resources, energetic resources and non-energetic resources. In definition, the concept of urban resource metabolism can be regarded as the process of resource consumption and waste generation of the cities for some time, and the process of the quality degradation of flows of the material and energy, which is necessary input for maintain the basic urban structures and functions. In addition, the exergy method was suggested to be introduced to solve the unified accounting problem and quantify the availability and scarcity of resources. Furthermore, the resource flow analysis tools as ecological network analysis method can also be incorporated to trace the metabolism route, hoping to change the traditional grey mode commonly used in metabolism analysis. This newly concept of resource metabolism and corresponding method would provide new integrate analyzing framework for urban ecosystem research. Nevertheless, it is just a primary concept and framework on resources metabolism, in-depth analysis and case studies are badly needed in near future to perfect and verify the conceived theory system.

Keywords: urban ecosystem metabolism analysis resource exergy resource flow

收稿日期 2011-01-24 **修回日期** 2011-05-03 **网络版发布日期**

DOI:

基金项目:

国家自然科学基金项目(40901293);国家重点实验室专项基金课题(11Y04ESPCN);中央高校基本科研业务费专项资金(2010)。

通讯作者:

作者简介:

参考文献：

[1] 黄书礼.都市生态经济与能量[M].台北:詹氏书局,2004. [2] 陶在朴.生态包袱与生态足迹——可持续发展的重量及面积观念[M].北京:经济科学出版社,2003. [3] Schandl H, Schulz N. Changes in the United Kingdom’s natural relations in terms of society’s metabolism and land-use from 1850 to the present day [J]. *Ecological Economics*,2002,41(2):203-221. [4] Fischer-Kowalski M. Society’s metabolism: The intellectual history of materials flow analysis, Part I: 1860-1970 [J]. *Journal of Industrial Ecology*,1998,2(1):61-78. [5] Krausmann F, Haberl H, Schulz N B, *et al*. Land-use change and socio-economic metabolism in Austria—Part I: Driving forces of land-use change: 1950-1995 [J]. *Land Use Policy*,2003,20(1):1-20. [6] Xu M, Jia X P, Shi L, *et al*. Societal metabolism in Northeast China: Case study of Liaoning Province [J]. *Resources, Conservation and Recycling*,2008,52(8/9):1082-1086. [7] Cusso X, Garrabou R, Tello E. Social metabolism in an agrarian region of Catalonia (Spain) in 1860-1870: Flows, energy balance and land use [J]. *Ecological Economics*,2006,58(1):49-65. [8] Niza S, Ferrao P. A transitional economy’s metabolism: The case of Portugal [J]. *Resources, Conservation and Recycling*, 2006, 46(3): 265-280. [9] Wolman A. The metabolism of cities [J]. *Scientific American*,1965,213(3):179. [10] Newcombe K, Kalina J D, Aston A R. The metabolism of a city: The case of Hong Kong [J]. *AMBIO,*1978,7(1):3-15 [11] Warren-Rhodes K, Koenig A. Escalating trends in the urban metabolism of Hong Kong: 1971-1997 [J]. *AMBIO,*2001,30(7): 429-438. [12] Newman P W. Sustainability and cities: Extending the metabolism model [J]. *Landscape and Urban Planning*, 1999, 44 (4): 219-226. [13] Hendriks C, Obernosterer R, Muller D, *et al*. Material flow analysis: A tool to support environmental policy decision making: Case studies on the city of Vienna and the Swiss lowlands [J]. *Local Environment*, 2000, 5(3): 311-328. [14] Sahely H R, Dudding S, Kennedy C A. Estimating the urban metabolism of Canadian cities: Greater Toronto area case study [J]. *Canadian Journal of Civil Engineering,*2003, 30(2): 468-453. [15] Chambers N, Heap R, Jenkin N E A. A resource flow and ecological footprint analysis of greater London , 2002. [16] 徐一剑,张天柱,石磊,等.贵阳市物质流分析[J].清华大学学报:自然科学版,2004,44(12):1688-1691. [17] 颜文洪,刘益民,黄向,等.深圳城市系统代谢的变化与废物生成效应[J].城市问题,2003(1):40-44. [18] 于术桐,黄贤金.区域系统物质代谢研究——以江苏省南通市为例[J].自然资源学报,2005,20(2):212-221. [19] Ayers R U, Kneese A V. Production consumption and externalities [J]. *American Economic Review*,1969,59(3):282-297. [20] Leontief W. Environmental repercussions and the economic structure: An input-output approach [J]. *Review of Economics and Statistics*,1970,52(I):262-271. [21] Ayres R U. Industrial metabolism: Theory and policy //Ayres R U, Simonis U K. Industrial Metabolism: Restructuring for Sustainable Development. United Nations University Press, 1994:3-20. [22] Michaelis P, Jackson T. Material and energy flow through the UK iron and steel sector, Part 2: 1994-2019 [J]. *Resources, Conservation and Recycling*,2000,29(3):209-230. [23] Daigo I, Matsuno Y, Adachi Y. Substance flow analysis of chromium and nickel in the material flow of stainless steel in Japan [J]. *Resources, Conservation and Recycling*,2010,54(11):851-863. [24] Haberl H. Human appropriation of net primary production as an environmental indicator: Implications for sustainable development [J]. *AMBIO*,1997,26(3):143-146. [25] Haberl H. The energetic metabolism of societies [J]. *Journal of Industrial Ecology*,2001,5(1): 11-31. [26] Haberl H. The energetic metabolism of societies, Part II: Empirical examples [J]. *Journal of Industrial Ecology*,2001,5(2):71-88. [27] Krausmann F, Haberl H. The process of industrialization from the perspective of energetic metabolism: Socioeconomic energy flows in Austria 1830-1995 [J]. *Ecological Economics*,2002,41 (2):177-201. [28] Ramos-Martin J, Giampietro M, Mayumi K. On China’s exosomatic energy metabolism: An application of multi-scale integrated analysis of societal metabolism (MSIASM) [J]. *Ecological Economics*,2007,63(1):174-191. [29] Huang S L, Lee C L, Chen C W. Socioeconomic metabolism in Taiwan: Emergy synthesis versus material flow analysis [J]. *Resources, Conservation and Recycling*,2006,48(2):166-196. [30] Zhang L X, Chen B, Yang Z F. Comparison of urban ecosystems of typical mega cities in China using emergy synthesis [J]. *Communications in Nonlinear Science and Numerical Simulation*,2009,14(6):2827-2836. [31] 夏传勇.经济系统物质流分析研究述评[J].自然资源学报,2005,20(3):415-421. [32] Schandl H, Grunbuhel C, Haberl H, *et al*. Handbook of physical accounting measuring bio-physical dimensions of socio-economic activities MFA-EFA-HANPP . Vienna: 2002. [33] Brunner P H, Rechberger H. Practical Handbook of Material Flow Analysis [M]. Boca Raton: CRC Press, 2003. [34] Eurostat. Economy-wide Material Flow Accounts and Derived Indicators—A Methodological Guide [M]. Luxembourg: Eurostat, 2001. [35] Odum H T. Environmental Accounting-Emergy and Environmental Decision Making [M]. New York: John Wiley & Sons,1996. [36] Rees W, Wackernagel M. Urban ecological footprints: Why cities cannot be sustainable—And why they are a key to sustainability [J]. *Environmental Impact Assessment Review*,1996,16(4/6):223-248. [37] Huang S L. Urban ecosystems, energetic hierarchies, and ecological economics of Taipei metropolis [J]. *Journal of Environmental Management*,1998,52(1):39-51. [38] Zhang Y, Yang Z F, Fath B D, *et al*. Ecological network analysis of an urban energy metabolic system: Model development, and a case study of four Chinese cities [J]. *Ecological Modelling*,2010,221(16):1865-1879. [39] 成升魁,闵庆文,闫丽珍.从静态的断面

分析到动态的过程评价——兼论资源流动的研究内容与方法[J].自然资源学报, 2005,20(3): 407-414. [40] Cheng S K, Xu Z R, Sun Y, *et al*. Spatial and temporal flows of China’s forest resources: Development of a framework for evaluating resource efficiency [J]. *Ecological Economics*, 2010, 69(7):1405-1415. [41] 沈镭,刘晓洁.资源流研究的理论与方法探析[J].资源科学,2006,28(3):9-16. [42] Krausmann F, Haberl H, Erb K H, *et al*. Resource flows and land use in Austria 1950-2000: Using the MEFA framework to monitor society-nature interaction for sustainability [J]. *Land Use Policy*, 2004, 21(3): 215-230. [43] Peter B. Green accounting and material flow: Alternatives or complements? WI papers No.106.2000. [44] Chambers N, Child R, Jenkin N, *et al*. Stepping forward: A resource flow and ecological footprint analysis of the southwest of England resource flow report . Best Foot Forward Ltd, United Kingdom, 2005. [45] Narayanaswamy V, Scott J B, Ness J N, *et al*. Resource flow and product chain analysis as practical tools to promote cleaner production initiatives [J]. *Journal of Cleaner Production*,2003,11 (4):375-387. [46] Fath B D, Patten B C. Quantifying resource homogenization using network flow analysis [J]. *Ecological Modelling*,1999,123(2/3): 193-205. [47] Ukidwe N U, Bakshi B R. Thermodynamic accounting of ecosystem contribution to economic sectors with application to 1992 U.S. economy [J]. *Environmental Science and Technology*,2004,38(18):4810-4827. [48] Reistad G M. Available energy conversion and utilization in the United States [J]. *ASME Journal of Engineering for Power*,1975, 97: 429-434. [49] Ayres R U, Ayres L W, Warr B. Exergy, power and work in the US economy, 1900-1998 [J]. *Energy*,2003,28(3):219-273. [50] Wall G. Exergy—A useful concept within resource accounting . Institute of Theoretical Physics, 1977, Report No.77-42. [51] Wall G. Exergy conversion in the Swedish society [J]. *Resources and Energy*,1987,9(1):55-73. [52] Wall G. Exergy conversion in the Japanese society [J]. *Energy*,1990,15(5):435-444. [53] Wall G, Sciubba E, Naso V. Exergy use in the Italian society [J]. *Energy*,1994,19(12):1267-1274. [54] Ertesvag I S, Mielnik M. Exergy analysis of the Norwegian society [J]. *Energy*,2000,25(10): 957-973. [55] Chen G Q, Qi Z H. Systems account of societal exergy utilization: China 2003 [J]. *Ecological Modelling*,2007,208(2/4):102-118. [56] Rosen M A. Assessing energy technologies and environmental impacts with the principles of thermodynamics [J]. *Applied Energy*, 2002,72(1):427-441. [57] Sciubba E. Beyond thermoeconomics? The concept of extended exergy accounting and its application to the analysis and design of thermal systems [J]. *Exergy, An International Journal*,2001,1(2):68-84. [58] Chen B, Chen G Q. Exergy analysis for resource conversion of the Chinese society 1993 under the material product system [J]. *Energy*,2006,31(8/9):1115-1150. [59] Chen G Q, Ji X. Chemical exergy based evaluation of water quality [J]. *Ecological Modelling*,2007,200(1/2):259-268. [60] Huang L Q, Chen G Q, Zhang Y, *et al*. Exergy as a unified measure of water quality [J]. *Communications in Nonlinear Science and Numerical Simulation,*2007,12(5):663-672. [61] Chen G Q, Chen B. Extended-exergy analysis of the Chinese society [J]. *Energy*,2009,34(9):1127-1144 [62] Chen G Q, Chen Z M. Carbon emissions and resources use by Chinese economy 2007: A 135-sector inventory and input-output embodiment [J]. *Communications in Nonlinear Science and Numerical Simulation*,2010,15(11):3647-3732 [63] Balocco C, Papeschi S, Grazzini G, *et al*. Using exergy to analyze the sustainability of an urban area [J]. *Ecological Economics*, 2004, 48(2): 231-244. [64] 李栋,刘晶茹,王如松.城市生态系统代谢分析方法与评价指标研究进展[J].生态经济,2008(6):35-39.

本刊中的类似文章

1．徐增让, 成升魁, 谷树忠, 沈镭.资源区域流动的驱动因子分析与流动潜力测度——以晋煤输出为例[J]. 自然资源学报, 2008,23(5): 773-780

2． 赵媛, 郝丽莎.我国石油资源空间流动的地域类型分析[J]. 自然资源学报, 2009,24(1): 93-103

3． 马林, 魏静, 王方浩, 马文奇, 张福锁.中国食物链氮素资源流动特征分析[J]. 自然资源学报, 2009,24(12): 2104-2114

4．苏筠, 成升魁.我国森林资源及其产品流动特征分析[J]. 自然资源学报, 2003,18(6): 734-741

5．苏筠, 成升魁.我国森林资源产品流动及其变化特征分析[J]. 自然资源学报, 2004,19(4): 472-479

6．成升魁, 闵庆文, 闫丽珍.从静态的断面分析到动态的过程评价——兼论资源流动的研究内容与方法[J]. 自然资源学报, 2005,20(3): 407-414

文章评论 (请注意:本站实行文责自负, 请不要发表与学术无关的内容!评论内容不代表本站观点.)

反馈人		邮箱地址	
反馈标题		验证码	9082