自然资源功能价值论初探 *

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摘要　本文以经典的价值理论为基础，探讨了自然资源的功能价值论，构筑了功能价值估算的基本模型，并对水资源用作渔业、饮用、旅游、农灌等功能价值作了具体阐述和实例计算，为自然资源的价值理论研究提供了一个新的思想角度，在自然资源核算中为自然资源的合理定价探讨了新的途径。

关键词　自然资源，功能价值，污染损失率。

70 年代初，挪威就开展了自然资源核算的研究工作，并于 1977 年向国会提交了关于物质资源和主要生物系统核算的初步研究报告[1]，1987 年又提交了"挪威自然资源核算"的研究报告。80 年代中期以来，世界上已有美国、加拿大、挪威、法国、荷兰等 20 多个国家政府或研究机构开展了自然资源核算或环境核算理论方法的研究与实践方案的探索和实验，一些重要的国际组织和研究机构、基金组织也相继开展了这方面的研究与探索或拨款资助[1,2]。

我国对自然资源核算的研究工作始于 1985 年。3 年后，由国务院经济技术社会发展研究中心自然资源核算课题组开展了自然资源核算及其纳入国民经济核算体系的研究工作。目前，已进入自然资源定价和纳入国民经济核算体系实施方案的研究阶段[3]。

进行自然资源定价，首先要承认自然资源的价值，但在自然资源是否有价值的问题上，长期以来一直争论不休。因为在经典的价值理论中，对自然资源的价值论述，有悖于现代经济社会发展的实际要求。

自然资源与人类表现为客体与主体之间的关系，它具有满足人类的需要和生存、发展的肯定作用。这种关系或作用的表现就成为价值。由此，在经典价值论的基础上，提出功能价值论以期解决自然资源可持续利用实际问题。

1　功能价值论原理

所谓功能价值论，就是根据自然资源的质

量和功能的变化来研究自然资源的变化规律，进而确定自然资源价值的理论。

自然资源的功能是指自然资源具有的满足人类某种需要的功能状态。任一自然资源对人类都具有特定的或多方面的功能，比如水资源能够为人类所认识、利用，提供饮用、渔业、航运、抗旱、灌溉、工业、发电、景观等各项功能。这些功能能为人类产生一种或多种效用。人类根据自身的特点及能力，对资源施以开发利用，使这些功能满足了人类某方面或多方面的需要，也就在过程中实现了功能价值。自然资源的功能越强越多，满足人类需要的可能性就越大，即具有较高的功能价值，反之则具较低价值。

自然资源在被开发利用过程中，其物理的、化学的、生物的性质都可能发生变化，即遭到不同程度的污染和折损，资源的质量因之下降，功能因之减退。这实质上是资源的价值降低，即资源作为资源在功能方面的损失。当不考虑其它因素或其它因素可以忽略不计时，可以把某资源的某一功能作为其质量的函数。在资源数量一定的情况下，资源的功能与质量之间的关系如图 1 所示。图 1 中横坐标表示自然资源的质量；纵坐标表示自然资源的功能，一般随自然资源的质量变坏，功能减退。当质量为 C_m 时，对应的资源功能为 F_m。在这一点上的切线 K_m 即可认为是在 (C_m, F_m) 状态下的资源功能
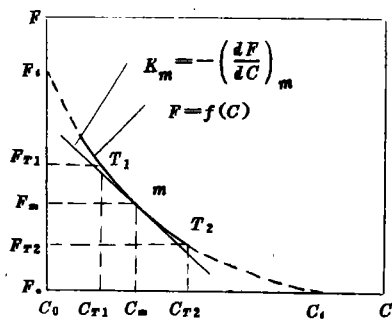
图1　自然资源的质量-功能关系曲线

价值，用公式表示为：　$K = \dfrac{b}{Q}\left(-\dfrac{dF}{dC}\right)$　（1）

式中 K 为资源的功能价值；F 为资源的功能；C 为资源的质量；b 为资源的功能参数；Q 为资源的数量。

当资源从状态 T_1 变化到状态 T_2 时，资源的功能降低值或功能损失为：

$$\Delta F = -\int_{T_1}^{T_2}\frac{Q}{b}KdC \tag{2}$$

式中，ΔF 为资源的功能降低值或功能损失值；F_{T_1} 为资源在状态 T_1 时的功能值；F_{T_2} 为资源在状态 T_2 时的功能值。b 是由特定的资源功能和质量确定的转换系数，且有确定的转换量纲。但实际中，b 和 K 的确定所需数据有限。通过对有限的 $F = f(c)$ 曲线的外推可以求得 C_0、F_t 状态下的 K_t，即为自然资源的价值。此外，还可以在上述原理思路的基础上，寻找其它方便的途径替代。以下对水资源的功能价值求算作具体探讨。

2　水资源功能价值模型

对水资源而言，根据地表水环境质量标准，水资源功能大致分为 5 类[4]，包括自然保护及分散式水源、集中或饮用水源、渔业、景观娱乐、农灌和工业用水。水资源的各种分功能，规定了不同的污染物的浓度限值。詹姆斯[5]和朱发庆[6]提出了水体中污染物引起的经济损失的"损失-浓度"模型。本文运用该模型提出"价值-浓度"模型：　$K = \dfrac{S}{R}$　（3）

式中，K 为水资源价值；S 为损失价值；R 为价值损失率。

（3）式中的 R 可用下式计算：

$$R = \frac{1}{1 + A\exp(-B\cdot X)} \tag{4}$$

式中，A 和 B 为污染物的价值损失参数；X 为污染参数，$X = c/c_0$，c 为污染物浓度（mg/L），c_0 为水资源分功能的水质标准值（mg/L）。

当水中存有一种以上的污染物时，其综合损失率不为各项损失率的简单加和，当有几种相互独立的污染物存在时，其综合损失率递推公式为：

$$R_i^{(n)} = R_i^{(n-1)} + (1 - R_i^{(n-1)})\cdot R_m \tag{5}$$

式中，$R_i^{(n)}$ 为第 i 分功能在 n 种污染物作用下的污染损失率；$R_i^{(n-1)}$ 为第 i 种分功能在 $(n-1)$ 种污染物作用下的污染损失率；R_m 为第 i 种分功能在第 n 种污染物作用下的污染损失率。

（4）式中的 A、B 参数值可由水质标准和毒性资料估算，即以 $X = c/c_0 = 1$ 时损失率为 0.01，$X = c_t/c_0$ 时的损失率为 0.99，估算 A、B：

$$\begin{cases} A = 99^{(X+1)/(X-1)} \\ B = 2\ln99/(X-1) \end{cases} \tag{6}$$

对 c_t，即下限临界浓度，一般以 c_0 的 5—10 倍为值，并以各类分功能水质标准的递增幅度作参考。

（3）式中 S 水资源功能损失价值，可以运用市场价值法、人力资本法、旅行费用法、支付愿望法和德尔菲法等传统方法及典型水资源的现状污染损失的统计资料得出。

水资源的功能价值应为各分功能价值之和：

$$K_z = \sum_{i=1}^{m} K_i \tag{7}$$

式中，K_z 为水资源的功能价值；K_i 为第 i 种分功能价值，m 为分功能类型数目，$i = 1, 2, \cdots, m$。下面将通过实例分析来了解"价值-浓度"模型的应用。

3　应用实例

某湖泊水资源具有渔业、饮用、旅游和农灌功能，其水资源总容量为 13420.87 万 m^3。污染物指标 COD、BOD、TN、TP、酚和汞的浓度，各功能参数 c_0、A、B，以及各功能的污染损

失价值均列在表1中，求算水资源价值。

<div align="center">表1　某湖泊水资源价值估算</div>

参　数		污染物浓度(mg/L)						R_i^q	S_i (万元)	K_i (万元)
		COD	BOD	TN	TP	酚	汞			
渔 业	c_0	17	5	0.5	0.05	0.004	0.00015	0.04132	362.3	8786.2
		15	4	1	0.1	0.005	0.0001			
	A	2118.6	570.0	160.6	160.6	622.1	145.2			
	B	3.0634	1.7505	0.837	0.4837	1.838	0.3829			
	R	0.01497	0.01514	0.00787	0.00787	0.00695	0.01206			
饮 用	c_0	9	3	0.25	0.025	0.002	0.00005	0.83815	1084.9	7294.4
	A	57388	24569	368	368	274.9	160.6			
	B	6.3625	5.5141	1.3129	1.3129	1.0211	0.4837			
	R	0.7428	0.2851	0.03618	0.03618	0.02727	0.02589			
旅 游	c_0	12	4	0.5	0.05			0.17137	659.51	3848.5
	A	97518	18896	799.4	799.4					
	B	6.8927	5.2516	2.0887	2.0887					
	R	0.15147	0.00362	0.00099	0.00099					
农 灌	c_0	25					0.001	0.01276	211.14	16547.0
	A	160.6					274.9			
	B	0.4837					1.0211			
	R	0.00858					0.00422			
水资源价值 K_z					30458.1 (万元)					

为了求算水资源价值，首先用(4)式计算各污染物对各分功能的价值损失率，用(5)式计算各分功能综合损失率 R_i，再用(3)式计算各分功能价值 F_i，最后用(7)式计算出水资源的价值。以上各步计算结果均列在表1中。求算得的某湖泊水资源价值为30458.1万元，折合成单价为2.27元/m³。

4　讨论

（1）污染后的水资源其水质中可能含有耗氧物质、营养物质、病毒病菌、重金属物质及其它有毒有害物质。考虑到目前我国各地大都缺乏病毒、病菌及反映水质感观性状等方面的完整数据，而耗氧物质、营养物质又能在很大程度上反映水质的感观性状及病毒、病菌含量，故选 COD、BOD、TN、TP、酚、氰化物、As、Hg、Cd、Pb、Cr 共11种常见污染物参与计算。严格地讲，各污染物间并不一定完全相互独立，它们间存在拮抗或协调作用。此外，对于不同的功能，其污染因子的选择也将有所

不同。因此在实例中，渔业和饮用水选择了5项因子，旅游用水选择了4项，农灌用水选择了2项。因子的选择是否正确，这对于价值的估算能否符合客观实际，将是十分重要的。

（2）水资源的不同功能对水质的要求也是不同的。"价值-浓度"法估算结果表明，该水资源用于饮用的功能价值最低(1294.4万元)，用于农灌的价值最高，与水质状况相符合，从而说明此法的客观合理性。

（3）资源价值取决于资源的质量和功能，根据其变化规律可以确定资源的价值，进而寻找一种新的货币量化途径，以此为自然资源的价值量核算提供科学依据。

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exhaust pipe was mixed with different catalysts to form dry samples. TG-DTA method was applied to investigate the combustion-supporting performance of different catalysts. It has been found that the dust combustion temperature T_{max} was greatly lowered when catalysts were used. The combustion-supporting performance of catalysts was ordered as following: $NiO/Al_2O_3 > CuO/Al_2O_3 > V_2O_5/Al_2O_3 > Pd/Al_2O_3 > Ag_2O/Al_2O_3 > Cr_2O_3/Al_2O_3 > CeO_2/Al_2O_3$ and had a certain correlation to the $-\Delta H$ of metal oxide. With the increasing of $-\Delta H$, a minimum T_{max} can be observed.

Key words: soot combustion, catalysts, TG-DTA method.

Microbial Degradation of Phthalic Acid Esters (PAEs). Wang Jianlong and Qian Yi (Department of Environmental Engineering, Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **16**(6), 1995, pp. 26—28

Microorganisms capable of degrading di-n-butyl phthalate (DBP) were isolated from coke-plant wastewater treatment plant sludge by enrichment and acclimation shaking culture, and purified by successive streak transfer on agar-plate medium. The time course of DBP degradation by different strains was investigated and compared. The growth characteristics and the kinetics of DBP biodegradation were studied by shaking flask test. The experimental results show that the DBP degradaiton can be described by Monod equaiton with μm and K_s being 0.4 h^{-1} and 28 mg/L, respectively.

Key words: dibutyl phthalate (DBP), microbial degradation, coke-plant, wastewater.

Study on the Metal Pollutant in Fly Ash from Coal Combustion of Power Plant. Yan Rong et al. (State Key Lab on Coal Comb. HUST, Wuhan 430074): *Chin. J. Environ. Sci.*, **16**(6), 1995, pp. 29—32

The contents of 8 metals in fly ashes with different sizes from coal combustion in 5.# boiler of Qinshan Power Plant have been determined, the pore and surface properties of the fly ashes have also been studied. It was found that the smaller the particle is, the bigger the surface of pores and the contents of metal compounds become. Both high temperature and reducing atmosphere accelerate the enrichment of heavy metals in fine particles. The different rules in metal compounds distribution of the ability of absorption and the condensation of vapor have been discussed.

Key words: fly ash, metal compounds, pollution, fine particle.

Experimental Study on the Collection of High Specific Resistivity Dusts by V-shaped Collecting Electrodes. Li jie and Liu Linmao (Dept. of Environ. Sci., Northeast Normal University, Changchun 130024): *Chin. J. Environ. Sci.*, **16**(6), 1995, pp. 33—35

The use of 45 to 90 degree angled V-shaped collecting electrodes in a transverse arrangement to change the configuration of collecting electrodes in an electrostatic precipitator was found to effectively separate free ions in space from charged dust particles and to reduce the current density on dust layes so that the high specific resistivity dusts with a resistivity of 10^{11} to 10^{13} $\Omega \cdot cm$ could be collected. By carrying out simulated experimental study, the distribution of current density on electrodes was given for clean electrodes covered with dielectric materials of different resistivities, which were V-shaped at an angle changing between 45 and 90 degree.

Key words: electrostatic precipitator, high specific resistivity dust, current density.

Environmental Conflict Analysis and Its Application in Environmental Planning and Management: Siting of Public Facilities. Lin Wei et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **16**(6), 1995, pp. 36—39

Siting of hazardous waste treatment facilities was exemplified to make an in-depth discussion on how to deal with the environmental conflicts occurred in siting public facilities (or those not in my backyard), to identify the possible solutions to this problem, and to discuss the existence, solitarity, Pareto optimality and fairness of a solution, as well as the validity of preventing false information from being reported. On this basis, tow kinds of more complicated conflicts in siting were discussed and the basic considerations that should be taken to develop a solution were suggested.

Key words: conflict analysis, environmental planning and management, public facilities siting, environmental conflict.

Theory on the Functional Values of Natural Resources. Yu Liansheng et al. (Dept. of Environ.

On the basis of some classical value theories, a theory on the functional values of natural resources was discussed in this paper, by building its elementary accounting model, studying the water resource in detail and giving an example. A new point of view was provided for the study on value theories of natural resources, together with a new method for pricing in the course of accounting.
Key words: natural resources functional value, integrated economical loss due to polltuion.

Development of a Planning and Management Model for Pollutants Discharge into a Tidal River. Huang Ping and Zhou Jingfeng (Dept. of Environ. Sci., Zhongshan University, Guangzhou 510275); Chin. J. Environ. Sci., **16**(6), 1995, pp. 43 — 46
Based on a differential river water quality model, a planning and management model for pollutants discharge into a tidal river has been derived, which described the relationship between a permissible discharge from each of all outfalls along the river reach, P_j, and its permissible discharge when they were discharging separately, Y_j, as a sum of $P_j/Y_j = 1$. Examples were used to present the application and validation of the model. It was concluded that the model was simple in structure, easy to calculate, and convenient to be used in planning, management and real time control for pollutants discharge into a tidal river.
Key words: outfall, permissible discharge, water quality management.

Coordination Planning of Economy and Environment: Comprehensive Planning of Benxi Shiqiaozi Development Zone. Ru Jiang et al. (Center for Environmental Sciences Peking University, Beijing 100871); Chin. J. Environ. Sci., **16**(6), 1995, pp. 47 — 49
To achieve sustainable developemnt, it is essential to address environmental and economic construction in the planning stages. But it is recognized that how to evaluate the coordination of plans becomes the key problem for planning. Using envirronmnetal supporting capacity (ESC), this presentation assesses three plans of Benxi Shiqiaozi development zone and chose one plan, which is sounds more practicable and reasonable on the comprehensive analysis of economic outputand the consequent environmental impacts, including the demands for resources and the relevant discharges of pollutants from the economic development.
Key words: coordination development, environmental supporting capacity (ESC), development zone, sustainable development.

Cooperation of Mixed Carriers in a Three Phase Airlift-Loop Reactor. Cai Jian'an et al. (Dept. of Chem. Eng., East China Institute of Metallurgy, Maanshan, Anhui 243002); Chin. J. Environ. Sci., **16**(6), 1995, pp. 50 — 52
Mixed carriers consisting of fine sand grains and coarse coke grains were found to have a good cooperation in a three phase airlift-loop reactor with a side settling zone for wastewater treatment. The treatment of coking industrial wastewater in this reactor indicated that, as compared to a single carrier, the mixed carriers were not easy to lose with effluent and gave a higher COD removal rate $[11 \text{ kg}/(d \cdot m^3)]$, a better effluent quality (e. g., phenol or cyanide had a concentration of $1/3 - 1/5$ times that in the case of a single carrier), the biomass easy to grow up on the surface of the carriers, and lower energy consumption.
Key words: carrier, airlift, three phase flow, wastewater treatment.

Study on a Straw Feed Treated with Mineral Saccharide. Fan Xiuying and Sun Lianchao et al. (EIA Unit, Chinese Academy of Scineces, Beijing 100085); Chin. J. Environ. Sci., **16**(6), 1995, pp. 53 — 54
A new straw feed has been developed by using a mineral saccharide, a filtrate left from straw pulping black liquor after recovering liqnin and chemicals from it, to treat crop stalks mixed with urea, resulting in an increased utility of crop stalks as domestic animal feed. The mineral saccharide was found to be rich in amino acids, raw proteins, essential elements and saccharides, to comply with the national standards (GB 13078-91) for feed hygiene, and to enable providing a source of nutrients for domestic animal and erecting straw due to its residual alkalinity. The 48 hours dry matter disappearance (DMdp) in the remen of sheep was used as an indicator of straw availabity for animal. Rice straw had a DMdp increased by 40% and a NDF (Neutral Detergent Fiber) reduced by 22.6%, when the straw was