

海河流域植物中碳的输出(或存留)量 和土壤中的库存量*

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摘要 研究了海河流域地区植物中碳的输出量(或存留量)和土壤库存量。结果指出:不同作物-土壤系统中各种作物碳的输出量和归还量有很大不同,作物碳输出量一般为归还量的 3—17 倍;海河流域地区不同子流域土壤中碳的库存量也有差异,以海河干流流域土壤碳的库存量最高,大清河流域土壤中碳的库存量最低。不同植被类型主要植物叶中碳的存留量以盐生草甸最高,山地灌、草丛最低;不同土壤类型碳的库存量以山地棕壤最高,新积土最低。这些为海河流域土地合理利用和碳的良性循环提供科学依据。

关键词 输出量, 库存量, 碳, 海河流域。

海河流域是我国重要的农业基地,由于长期不合理利用土地,使土壤贫瘠,肥力下降,生产力降低,研究碳及其他生命元素在植物、土壤中的输出、归还及库存量,为该区的碳循环和合理利用土地,提高生产力提供理论依据。笔者在海河流域调查植被与土壤,并采集样品,在河北省(31 个采样点)、山西省(25 个点)、天津(9 个点)、山东省(7 个点)、北京(6 个点)、河南(4 个点)等省市共采集植物样品 424 个(其中栽培植物 342 个,野生植物 82 个),土壤样品 151 个,用重铬酸钾容量法分析植物、土壤中的有机碳。地区的自然条件及地理位置研究见文献[1]。

1 作物中碳的输出量和归还量

作物碳的输出量是指作物收获后带走的有机碳的量,由地上部分生物量乘以作物中碳含量。从表 1 的结果看出,海河流域不同作物-土壤系统中各种作物有机碳的输出量差异甚大,粮食作物以谷子最高,每年输出达 $24574.3 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,小麦最低,每年输出 $2888.2 \text{ kg}/(\text{hm}^2 \cdot \text{a})$;作物碳输出量的顺序为:谷子>玉米>白薯>高粱>小麦;经济作物以棉花碳的输出量最高,每年输出达 $5934.4 \text{ kg}/\text{hm}^2$,大豆的输出量最低,经济作物碳输出量的大小顺序

为棉花>芝麻>花生>大豆;蔬菜作物碳的输出量以白菜最高,其顺序为白菜>马铃薯>油菜。

作物的归还量是指作物收获后根茬归还到土壤中的碳的含量,以根茬的生物量与其碳含量的乘积来计算。从表 1 中看出,海河流域不同作物-土壤系统中各种作物的归还量由于其根茬生物量和碳含量不同,归还到土壤中的碳的数量也有很大差别。粮食作物中以谷子最高,每年平均归还的碳达 $1966 \text{ kg}/\text{hm}^2$,小麦的归还量最小,每年归还碳只 $243 \text{ kg}/\text{hm}^2$,作物的碳归还量大小顺序为谷子>高粱>玉米>水稻>小麦;经济作物碳的归还量以芝麻>棉花>大豆。白薯、马铃薯等块根作物地下部分主要作食用输出,归还量无法计算。

从海河流域不同作物-土壤系统中作物有机碳的输出量与归还量的比例看出(表 1):本区大部分作物都是输出量大于归还量,一般粮食作物为 3:1—12:1;经济作物为 4:1—17:1。说明本区农田生态系统每年由作物输出的有机碳可为归还到土壤中有有机碳的 3—12 倍。

2 海河流域不同子流域土壤中碳库存量比较

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土壤中碳的来源也是多种多样的,无机碳主要由土壤母质风化积累形成,有机碳在自然界存在形式主要是腐殖质,其形成与土壤熟化程度、施肥条件、植物的枯枝落叶、生物固氮和土壤微生物的活动条件等有关^[2,3]。现按海河子流域土壤碳库存量比较看出(表 2):以滦沱河子

流域碳的库存量最高,其次为永定河子流域。大清河子流域最低,其余各子流域碳库存量差异不明显。这充分反映出各子流域土壤成土条件、水热条件、植被和土壤微生物等生物地球化学的地域差异,以及人类活动与土地集约程度的不同。

表 1 海河流域不同作物碳的输出量和归还量[$\text{kg}/(\text{hm}^2 \cdot \text{a})$]

作 物 名 称	样 品 数	输 出 量	归 还 量	输出量与归还量之比
粮食作物				
玉米 <i>Zea mays</i> L.	36	6560.04	571.9	11:1
谷子 <i>Panicum miliaceum</i> L.	9	24574.3	1965.5	12:1
小麦 <i>Triticum aestivum</i> L.	2	2888.2	242.8	12:1
高粱 <i>Sorghum vulgare</i> Pers.	11	4020.9	845.8	5:1
白薯 ¹⁾ <i>Ipomoea batatas</i> (L.) Lam.	3	5079.5		
水稻 <i>Oryza sativa</i> L.	1	(775.5) ²⁾	294.1	3:1
莠麦 <i>Avena nuda</i> L.	1	(230.0) ²⁾	82.0	3:1
经济作物				
棉花 <i>Gossypium hirsutum</i> L.	15	5934.4	659.6	9:1
芝麻 <i>Sesamum indicum</i> L.	1	3131.2	885.6	4:1
大豆 <i>Glycine max</i> (L.) Merr.	20	1318.8	76.6	17:1
花生 ¹⁾ <i>Arachis hypogaea</i> L.	4	2303		
向日葵 <i>Helianthus annuus</i> L.	3	(127.5) ²⁾	120.6	1:1
蔬菜类				
马铃薯 <i>Solanum tuberosum</i> L.	3	1341.2		
白菜 <i>Brassica pekinensis</i> Rupr.	2	25861.5		
油菜 <i>B. juncea</i> (L.) Czern. et Coss.	2	(560.6) ²⁾	149.6	4:1

1) 白薯、花生等块根大部作食用输出,归还量略去 2) 缺少果实部分,故偏小

表 2 海河流域地区不同子流域土壤碳库存量比较

流域名称	海拔高度 (m)	土壤类型	碳库存量 (kg/hm^2)
潮白河子流域	1—16	盐碱土、潮土	1.7×10^4
永定河子流域	27—1291	褐土	1.8×10^4
大清河子流域	1—7	盐碱土、潮土	1.2×10^4
漳卫河子流域	3—52	潮土	1.6×10^4
滦沱河子流域	134—3058	褐土、潮土	4.4×10^4
子牙河子流域		潮土	1.4×10^4

3 不同植被和土壤类型有机碳的存留和库存量

3.1 主要天然、半栽培植物叶中碳的存留量

本区天然、半栽培植物,每年植物残体除部分通过人或风等因素输出生态系统外,大部分植物的凋落物都存留在系统内,与作物收获后被带走的情况完全不同。本区天然、半栽培

植物中有机碳的存留量如表 3 所示,不同植物种碳的存留量差异甚大,水果类植物以沙果叶碳的存留量最高,达 $9076 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,各种水果叶中碳的存留量平均 $3148 \text{ kg}/(\text{hm}^2 \cdot \text{a})$;阔叶树中以臭椿叶碳的存留量最高,每年存留量达 $3388 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,其次为小叶杨,每年存留量达 $2716 \text{ kg}/\text{hm}^2$,阔叶树平均叶中碳库存量每年 $1364 \text{ kg}/\text{hm}^2$;针叶树的存留量约 $476—533 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,平均 $504 \text{ kg}/(\text{hm}^2 \cdot \text{a})$;灌木、半灌木的存留量约 $85—528 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,平均碳存留量 $349 \text{ kg}/(\text{hm}^2 \cdot \text{a})$;草本植物碳的存留量约为 $217—9344 \text{ kg}/(\text{hm}^2 \cdot \text{a})$,各种草本植物平均为 $2152 \text{ kg}/(\text{hm}^2 \cdot \text{a})$ 。不同类型植物叶中(或地上部分)碳存留量大小顺序为草本植物>水果类>阔叶树>针叶树>灌木、半灌木。

表 3 海河流域主要天然、半栽培植物叶中(或地上部分)碳的存留量

植 物 名 称	存留量 kg/(hm ² ·a)	植 物 名 称	存留量 kg/(hm ² ·a)
水果类	12591	落叶松(<i>Larix principis rupprechtii</i> Mayr	532.8
枣(<i>Zizyphus jujuba</i> var.)	1307.8	灌木、半灌木	613.4
杏(<i>Prunus armeniaca</i> L.)	1225.9	三裂锈线菊(<i>Spiraea trilobata</i> L.)	85.1
苹果(<i>Malus pumila</i> mill.)	961.6	铁杆蒿(<i>Artemisia sacrorum</i>)	528.3
沙果(<i>M. asiatica</i> Nakai)	9095.7	草本植物	15647.8
阔叶树	8184.2	芦苇(<i>Phragmites communis</i> Trin.)	9543.5
旱柳(<i>Salix matsudana</i> Koidz.)	382.8	黄背草(<i>Themeda triandra</i> var.)	434.2
小叶杨(<i>Populus simonii</i> Carr.)	2716.3	羊胡子草(<i>Carex rigescens</i> Krecz.)	216.5
刺槐(<i>Robinia pseudoacacia</i> L.)	501.6	糙苏(<i>Phlomis umbrosa</i> Turcz.)	386.9
臭椿(<i>Ailanthus altissima</i> (mill.) Swingle)	3388.7	嵩草(<i>Kobresia bellardii</i> (All.) Dagl.)	507.2
五台青杨(<i>Populus cathayana</i> Rehd.)	534.2	灵灵草(<i>Lysimachia foenumgraecum</i> Hance)	1236.1
加拿大杨(<i>P. canadensis</i> Moench)	660.6	鹅冠草(<i>Roegneria kamoji</i> Ohwi)	1884.7
针叶树	1008.5	唐松草(<i>Thalictrum baicalense</i> Turcz.)	1488.7
油松(<i>Pinus tabulaeformis</i> Carr.)	475.7		

3.2 不同植被和土壤类型碳的存留量和库存量

从表 4 看出,海河流域不同植被类型碳的存留量差异甚大,变动范围 349—9544 kg/hm²,以盐生草甸碳的存留量最高;山地灌草丛最低。不同植被类型碳的存留量大小顺序为盐生草甸>农田植被>水生沼泽>城市植被>河滩草甸>果园、杂木林>人工林>亚高山草甸>亚高

山针叶林>温性针叶林>山地灌、草丛。其中城市和农田植被由于每年物质循环不是全部存留在系统中,而是大部由收获或以枯枝落叶形式输出在系统外。按各植被类型分布在全流域所占的面积估算,植被对碳的存留量(或输出量)是相当可观的。

表 4 还可看出:本区不同土壤类型碳的库

表 4 海河流域不同植被和土壤类型的碳存留(或输出)量¹⁾和库存量

植被类型	碳的存留量 (kg/(hm ² ·a))	全流域碳存留量 (t/hm ²)	土壤类型	碳的库存量 (kg/hm ²)	全流域土壤碳库存量 [t/(hm ² ·a)]
亚高山草甸	1060.7	1.6×10 ⁵	亚高山草甸土	7.4×10 ⁴	1.1×10 ⁷
落叶阔叶林			山地暗棕壤	8.9×10 ⁴	1.3×10 ⁶
亚高山针叶林	532.8	6.5×10 ⁵	山地棕壤	9.1×10 ⁴	1.3×10 ⁶
温性针叶林	475.7	6.1×10 ⁵	淋溶褐土	2.6×10 ⁴	5.3×10 ⁷
山地灌草丛	349.21	7.2×10 ⁵	盐化草甸土	2.9×10 ⁴	4.8×10 ⁶
盐生草甸	9543.5	1.6×10 ⁶	草甸土		
河湖滩地草甸	2050.1	7.4×10 ⁵	盐碱土	1.4×10 ⁴	2.6×10 ⁵
盐生植被			草甸沼泽土		
水生沼泽植被	2672.4	1.5×10 ⁵	褐土(山前)	1.8×10 ⁴	3.8×10 ⁶
人工林	1318.04	2.8×10 ⁵	褐土性果园土	1.3×10 ⁴	1.6×10 ⁶
果园杂木林	1516.96		新积土	4.3×10 ³	
城市植被	2530.6	3.3×10 ⁵	草甸潮土、褐土	1.5×10 ⁴	2.4×10 ⁸
农田植被	4160.9	5.8×10 ⁸			

1) 存留量只包括植物叶,不含树干和根的量

存量也有很大差别,其变动范围 $4.3 \times 10^3 - 9.1 \times 10^4 \text{ kg/hm}^2$,以山地棕壤碳的库存量最高,新积土最低。其大小顺序为山地棕壤 > 山地暗棕壤 > 亚高山草甸土 > 盐化草甸土 > 淋溶褐土 > 褐土(山前) > 草甸潮土 > 盐碱土 > 褐土性果园土 > 新积土。按各土壤类型在全流域所占的面积估算(表4),土壤中碳的库存量比相应的植被类型更多。

4 结语

(1) 海河流域不同作物-土壤系统中各种作物的碳输出量和归还量由于作物的生物量和碳含量不同,差异甚大,作物碳的输出量都大于归还量,一般输出量为归还量的 3—12 倍。

(2) 海河流域天然、半栽培植物叶中碳的存留量不同植物种差异甚大。不同类型植物的存留量以草本植物最高,灌木、半灌木植物的存留量最低。

(3) 海河地区不同子流域土壤中碳的库存量由于各子流域的成土、水热条件、微生物活

动、土壤熟化程度不同,土壤中腐殖质积累数量各异,造成土壤碳含量的差异,因而各子流域土壤中碳库存量有明显不同,以滹沱河流域土壤碳的库存最高,大清河最低。

(4) 本区不同植被类型碳的存留量和不同土壤类型碳的库存量差别都很大。不同植被类型的存留量以盐生草甸最高,山地灌、草丛最低;不同土壤类型碳的库存量以山地棕壤最高,新积土最低。这些结果都反映出人类活动对土地利用程度的不同,人类活动较轻的山地暗棕壤土,破坏相对较轻,土壤中碳含量和有机质含量都较高,而人为活动程度高的潮土、盐碱土、新积土的碳含量和有机质含量都较低。

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• 环境信息 •

接触甲苯对印刷工人神经内分泌的作用

甲苯像许多其它有机溶剂一样具神经系统毒作用,特别是对中枢神经系统(CNS)的急性作用已众所周知,而在长期接触高浓度甲苯后对CNS的残留损伤尚有怀疑。BG Svensson 对瑞典2个轮转凹版印刷公司的47名(平均44.4岁)接触不同浓度甲苯的男工进行了研究。对每人做了全面临床体检,空气中甲苯的时间加权平均浓度低于瑞典的TLV 80 ppm,工人血液中甲苯浓度是 $0.19 - 7.99 \mu\text{mol/L}$ 。同时以46名非接触有机溶剂(平均43.5岁)的其他工人为对照。通过测定血浆中睾丸素(Test)、激乳素(SH)、黄体生成素(LH)和卵泡刺激素

(FSH)等浓度并与对照组作比较,以调查人体接触甲苯是否影响垂体激素的分泌。

结果发现随接触甲苯浓度从 $< 5 \text{ ppm}$ 增高到 $> 45 \text{ ppm}$,则可见血浆中LH浓度的降低($P=0.003$)和Test浓度降低($P=0.02$)具有统计学意义。没有发现累积接触($\text{ppm} \times \text{年数}$)与血浆中激素浓度之间呈明显相关。本研究表明,接触低浓度甲苯时,对丘脑-垂体轴具有继发性降低睾丸素分泌的作用。

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Abstracts

Chinese Journal of Environmental Science

Study on the Subjective Assessment on a Noise Comprising Different Direction Components. Fu Lixin (Dept. of Environ. Eng., Tsinghua University, Beijing 100084), Qin Youguo and Ce Shiguang (Dept. of Architecture, Tsinghua University, Beijing 100084); *Chin. J. Environ. Sci.*, 16(5), 1995, pp. 1-5

It was found that in a sound field different people would have different subjective sensation levels, although a same level of real sound pressure was exerted on them. Psychological experiments were carried out on the loudness and noisiness of a noise in a free sound field, a reverberant sound field and an intermediate sound field between them, and a noise comprising different direction components in a free sound field, to give the degree of difference in subjective sensation levels in these cases and the corresponding difference in sound pressure levels. The results show that both loudness and noisiness were higher in a reverberant sound field than in a free sound field, with a distinct degree of about 0.3, corresponding to a sound level divergence of 1-2 dB. There was a positive correlativity of about 0.4 between loudness and noisiness. In a horizontal plane, the distinct divergence of sensation occurred at a noise in a wide range of frequency over 2 kHz. Subjective loudness and noisiness were smaller in a rear semi-plane than in a front one, with a distinct degree of about 0.6 and 2 dB, respectively. The results would be useful in noise reduction and the environmental impact assessment of indoor noise.

Key words: reverberant sound field, direction composition, noise reduction, subjective assessment.

Electrode Behavior in the Process of Magneto-Electrolysis for Industrial Wastewater Treatment. Zhu Youchun et al. (Dept. of Environ. and Resources Eng., Guangdong Univ. of Technology, Guangzhou 510090); *Chin. J. Environ. Sci.*, 16(5), 1995, pp. 6-9

For the sake of raising the electrolytic efficiency, reducing the energy consumption, and improving the characteristics of recovered deposit, the influences of applied magnetic field on the electrode process were studied by means of magneto-electrolytic tests and polarization curve determination for industrial wastewater containing copper. The

results indicate that during the magneto-electrolytic treatment of industrial wastewater the allowable current density was increased by over 100%, and the overpotential under the condition of tested current density was decreased by over 50%. Thus the cell voltage and the energy cost were decreased, and the metal deposit with excellent characteristics was obtained.

Key words: industrial wastewater, magneto-electrolysis, electrode behavior.

Production Process of Ferric Solution Based on the Catalytical Oxidation by Pyrolusite Tailings.

Tian Baozhen and Tang Hongxiao (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085); *Chin. J. Environ. Sci.*, 16(5), 1995, pp. 10-13

Pyrolusite tailings containing more than 32% of β - MnO_2 were found to be a catalytical oxidizer for the oxidation of $\text{Fe}(\text{I})$ to produce ferric solution. The kinetic characteristics and mechanism of $\text{Fe}(\text{I})$ oxidation reaction catalyzed by pyrolusite tailings were studied. It was found that the $\text{Fe}(\text{I})$ oxidation reaction proceeded at an extremely fast rate of 309 g/(L · h) and more than 80% of $\text{Fe}(\text{I})$ were removed within the first 15 minutes of the $\text{Fe}(\text{I})$ oxidation reaction. There was a saturated oxidation value of up to 0.49-0.73 g of $\text{Fe}(\text{I})$ per gram of pyrolusite tailings, depending on the content of MnO_2 in the pyrolusite tailings. The pyrolusite tailings and the resulting ferric solution were analyzed with the X-ray diffraction X-ray fluorescent spectrometry method and ICP, respectively. The results show that after the $\text{Fe}(\text{I})$ oxidation the pyrolusite tailings were corroded so that most of manganese species were reduced and entered into the liquid phase, and the remaining manganese and other elements entered into the sediment.

Key words: ferrous oxidation, oxidizer, catalytical oxidation rate, pyrolusite tailing.

The Output of Carbon by Plants and the Storage of Carbon in Soils of the Haihe River Basin in North China. Huang Yinxiao et al. (Institute of Botany, Chinese Academy of Sciences, Beijing 100044); *Chin. J. Environ. Sci.*, 16(5), 1995, pp. 14-17

The results show that the output of carbon significantly varied with different crops and so did the

Abstracts

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Study on the Subjective Assessment on a Noise Comprising Different Direction Components. Fu Lixin (Dept. of Environ. Eng., Tsinghua University, Beijing 100084), Qin Youguo and Ce Shiguang (Dept. of Architecture, Tsinghua University, Beijing 100084); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 1—5

It was found that in a sound field different people would have different subjective sensation levels, although a same level of real sound pressure was exerted on them. Psychological experiments were carried out on the loudness and noisiness of a noise in a free sound field, a reverberant sound field and an intermediate sound field between them, and a noise comprising different direction components in a free sound field, to give the degree of difference in subjective sensation levels in these cases and the corresponding difference in sound pressure levels. The results show that both loudness and noisiness were higher in a reverberant sound field than in a free sound field, with a distinct degree of about 0.3, corresponding to a sound level divergence of 1—2 dB. There was a positive correlativity of about 0.4 between loudness and noisiness. In a horizontal plane, the distinct divergence of sensation occurred at a noise in a wide range of frequency over 2 kHz. Subjective loudness and noisiness were smaller in a rear semi-plane than in a front one, with a distinct degree of about 0.6 and 2 dB, respectively. The results would be useful in noise reduction and the environmental impact assessment of indoor noise.

Key words: reverberant sound field, direction composition, noise reduction, subjective assessment.

Electrode Behavior in the Process of Magneto-Electrolysis for Industrial Wastewater Treatment. Zhu Youchun et al. (Dept. of Environ. and Resources Eng., Guangdong Univ. of Technology, Guangzhou 510090); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 6—9

For the sake of raising the electrolytic efficiency, reducing the energy consumption, and improving the characteristics of recovered deposit, the influences of applied magnetic field on the electrode process were studied by means of magneto-electrolytic tests and polarization curve determination for industrial wastewater containing copper. The

results indicate that during the magneto-electrolytic treatment of industrial wastewater the allowable current density was increased by over 100%, and the overpotential under the condition of tested current density was decreased by over 50%. Thus the cell voltage and the energy cost were decreased, and the metal deposit with excellent characteristics was obtained.

Key words: industrial wastewater, magneto-electrolysis, electrode behavior.

Production Process of Ferric Solution Based on the Catalytical Oxidation by Pyrolusite Tailings. Tian Baozhen and Tang Hongxiao (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 10—13

Pyrolusite tailings containing more than 32% of β - MnO_2 were found to be a catalytical oxidizer for the oxidation of Fe(II) to produce ferric solution. The kinetic characteristics and mechanism of Fe(II) oxidation reaction catalyzed by pyrolusite tailings were studied. It was found that the Fe(II) oxidation reaction proceeded at an extremely fast rate of 309 g/(L · h) and more than 80% of Fe(II) were removed within the first 15 minutes of the Fe(II) oxidation reaction. There was a saturated oxidation value of up to 0.49—0.73 g of Fe(II) per gram of pyrolusite tailings, depending on the content of MnO_2 in the pyrolusite tailings. The pyrolusite tailings and the resulting ferric solution were analyzed with the X-ray diffraction X-ray fluorescent spectrometry method and ICP, respectively. The results show that after the Fe(II) oxidation the pyrolusite tailings were corroded so that most of manganese species were reduced and entered into the liquid phase, and the remaining manganese and other elements entered into the sediment.

Key words: ferrous oxidation, oxidizer, catalytical oxidation rate, pyrolusite tailing.

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