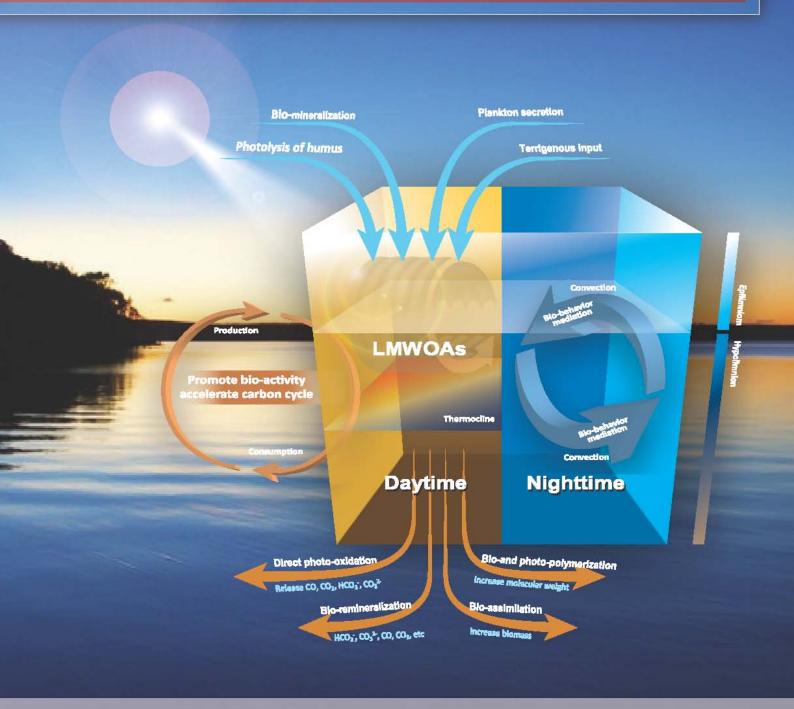
# JES

# JOURNAL OF ENVIRONMENTAL SCIENCES

ISSN 1001-0742 CN 11-2629/X

February 1, 2013 Volume 25 Number 2 www.jesc.ac.cn







### **CONTENTS**

Investigation of Inve-molecular weight organic acids and their spatrotemporal variation characteristics in Hongfong Lake, China Min Xian, Freighang Win, Liping Wang, Xinging Li, Rongschang Huang.  224 Investigation of acetylated kapok libers on the sorption of cil in water Jinto Wang, Vin Theng, Asing Wang.  Growth characteristics of algae during early stages of phytoplankton bloom in Lake Taihu, China  Yilong Jia, Johnson Dan, Min Zhang, Fianktang Kong.  255 Immobilization of airtice oxidizing bacteria using biopolymeric chitosam media  Penne Lerisuthisvong, Danagcheewan Boorquak, Wilstornikk Pungrasmi, Sorawit Powtongsook.  266 Preliminary studies on occurrence of monosina antibiotic in Bosque River Watershed  Sodarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne Melartand, Forrest Mitchell  268 Aa inovariet integrated system utilizing solar neergy as sower for the teament of decentralized wastewater  Changhi Han, Junxin Liu, Hanwen Liang, Xuesong Guo, Liu Li  278 Settling and dewatering characteristics of granulated melanue-oxidizing bacteria  Kwang Ho Ahn, Kwang Soo Kim, Sang Won Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko  280 Quantification, morphology and source of humic acid, kerogen and black ourbon in ofisbore marine sediments from Xiannen Guif, China  Yanting Chen, Jingong Zhan, Lipinar Win, Instance, Glore, Donogita yi Yunta Chen, Jingong Zhan, Lipinar Win, Instance, Ghor, Donogita yi Yunta Chen, Jingong Zhan, Lipinar Win, Instance, Ghor, Donogita yi Yunta Chen, Jingong Zhan, Lipinarchang Sibi, Yanging Song  Elefects of ion concentration and natural organic marter on aeneitol'y removal by nanofiltration under different transmenbrane pressures Yang Yu, Changway Zhao, Yangha Changing Song  292 Elefects of ion concentration and natural organic marter on aeneitol'y removal by nanofiltration under different transmenbrane pressures Yang Yu, Changway Zhao, Yangha Chang Song Jing Song Changa Yi, Jinging Ren  Characterization of cash byser structure on the microfiltration membrane permeability by iro	Aquatic environment	
Insentinguiation of acetylacet lapok fibers on the sorption of oil in water Jintion Wing, Yian Zheng, Aiqin Wang.  Growth characteristics of algue during early stages of phytoplankton bloom in Lake Taihu, China Yuhong Jia, Johnson Dan, Min Zhang, Fanstang Kong.  Zhumobilization of intrine exidizing bacteria using biopolymeric chitosan media Peance Lerisuthikwang, Diangchecwan Boonpatak, Wiboonluk Pungrasmi, Sorawit Powtongsook.  Pelluliniany studies on occurrence of monestin antibiotic in Bougue River Waterschel Sudarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell An innovative integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changfu Han, Junxin Liu, Hamwen Laing, Xuesong Gloo, Lin Li Settling and dewatering characteristics of granulated methane-oxidizing bateria.  Kwang Ho Ahn, Kwang Soo Kim, Sang Won Kang, Chu Yong Urn, Won Tae Lee, Kwang Blak Ko Quantification, morphology and source of humis acid, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liquin Yi, Jinsheng Chen, Dongsing Yuan Yang Chang, Jingan Hang, Jingan Lain, Jingan Chen, Dongsing Yuan Yang Chang Chang, Jingan Hang, Jingan Song Yang Yu, Changwei Zhao, Yanguu Wang, Welbong Fian, Zhaokan Luan Yang Yu, Changwei Zhao, Yanguu Wang, Welbong Fian, Zhaokan Luan Yang Yu, Changwei Zhao, Yanguu Wang, Welbong Fian, Zhaokan Luan Churxiao Chen, Binghui Zheng, Xia Jiang, Zhong Zhao, Yuehu Zhao, Fengiao Yi, Jiaying Ren Yang Yang, Siru Pan, Dongjing Luo Yang Yang, Pangeron Siru Pan, Dongjing Luo Yang Yang, Ya	Investigation of low-molecular weight organic acids and their spatiotemporal variation characteristics in Hongfeng Lake, China	
Jintao Wang, Yian Zheng, Aiqin Wang Growth characteristics of algae during eurly stages of phytoplankton bloom in Lake Taihu, China Yuhong Jia, Johnson Dan, Min Zhang, Fanxiang Kong Immobilization of nitric oxidizing bacteria using biopolymeric chinesan media Prance Letrathiwong, Danaghewan Boonpusk, Wibconils Pungasmi, Sorawit Powrongsook ———————————————————————————————————	Min Xiao, Fengchang Wu, Liying Wang, Xinqing Li, Rongsheng Huang ·····	237
Growth characteristics of algae during early stages of phytoplankton bloom in Lake Taihu, China Yuhong Jia, Johnson Dan, Min Zhang, Fanxing Kong Immobilization of nitrite oxidizing bacteria using biopolymeric chitosan media Prance Lertsuthiswong, Duangeheevan Boonpuak, Wiboonlak Pungrasmi, Sorawit Powtongsook ———————————————————————————————————		
Yuhong, Jin, Johnson Dan, Min Zhang, Fanxining Kong Immubilization of nitrite oxidizing bacteria using biopolymeric chitosam media Prance Lertsuthiwong, Duangcheevan Boonpuak, Whoonluk Pungrasmi, Sorawit Powtongsook 266. Preliminary studies on occurrence of monerasin antibiotic in Bossque River Watershed Sudarshan Kurwaddar, Victoria Sicking, Barry Lambart, Anne Merfardand, Forrest Michell An imnovative integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changful Han, Junxin Liu, Hanwen Liang, Xuesung Guo, Lin Li 276. Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won The Lee, Kwang Balak Ko 280. Quantification, morphology and source of humin each, Ecoego and black activon in offshore marine sediments from Xianen Gulf, China Yaring Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan 286. Evaluation of oxygen transfer parameters of fine-bubble aceation system in plug flow aceration tank of wastewater treatment plant Xianoboug Zhou, Yunnyuan Wil, Hanchang Shi, Yanqing Song 297. Effects of ion concentration and natural organic matter on arsenicity) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwed Zhao, Yanqiu Wang, Welmong Pan, Zhaokam Luan 200. Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Lao 300. Spatial distribution and pollution assessment of mercury in sediments of Luke Taihu, China Chunxiao Chen, Bingbiu Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren 301. Atmospheric environment Review of heterogenous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He 201 Pollutant emission characteristics of rice busk combustion in a vortexing fludicade bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin,	Jintao Wang, Yian Zheng, Aiqin Wang ·····	246
Ismobilization of nitrite oxidizing bacteria using biopolymeric chitosan media Prance Lertsutthiwong, Duangchewan Boonpuak, Wiboonluk Pungrasmi, Sorawit Powtongsook. 26. Preliminary studies on occurrence of monensia antibiotic in Bosque Kiver Walershed Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell Sadarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne Sagary Sadarshan Kurwadkar, Sadarshan Kanasar, Sadarshan Kanasar, Sadarshan Kanas		
Penelmanary studies on occurrence of monensia antibiotic in Bosque Kier Watenhed Sudarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell An innovative integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changfu Han, Junkin Liu, Hammen Linag, Nasong Gno, Liu Li  277. Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Uin, Won Tae Lee, Kwang Baik Ko  288. Quantification, morphology and source of humia exid, keropen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan  287. Settling and dewatering Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan  288. Sexhalation of Oxygon transfer parameters of fine-bubble caration system in plug flow acration tank of wastewater treatment plant Xiaohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song.  289. Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Xangai Wang, Welshong Fan, Zhaokun Luan  300. Characterization of cake layer structure on the microfiltration membrane permeability by iron proc-coagulation Jin Wang, Siru Pan, Dongping Luo  Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren  301. Atmospheric environment  Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  301. Pollutant emission characteristics of fice buss combustion in a votersiae fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso  302. Pollutant emission characteristics of fice buss combustion in a votersiae fluidized bed incinerator Feng Duan, Chiensong Chyang,	Yuhong Jia, Johnson Dan, Min Zhang, Fanxiang Kong ·····	254
Preliminary studies on occurrence of monemsin antibiotic in Bosque River Watershed Sudarsham Kurwadkar, Victoria Sicking, Barry Lumbert, Anne McFarland, Forrest Mitchell An innovative integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changfu Han, Junxin Liu, Hanwen Liang, Xuesong Guo, Lin Li Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko Quandification, morphology and source of humin eards, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Inping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan  Evaluation of oxygen transfer parameters of fine-bubble aeration system in plug flow aeration tank of wastewater treatment plant Xiaohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song  Effects of fon concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Welhong Fan, Zhaokun Luan  Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Sin Pan, Dongping Luo- Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zhene, Xia Jiang, Zheng Zhao, Yuzhu Zhao, Fengjiao Yi, Jiaying Ren  31c Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  20p Dulluan emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso Feng Duan, Chiensong Chyang, Yucheng Chin,		
Sudarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell An innovative integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changfu Han, Junxin Liu, Hamwen Linag, Nacoong Guo, Liu Liu Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ann, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko 280 Quantification, morphology and source of humic acid, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan 281 Evaluation of oxygen transfer parameters of fine-bubble earation system in plug flow aeration states of wastewater treatment plant Xiaobong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song. 292 Elffects of ion concentration and natural organic matter on arsenict(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan—300 Jin Wang, Siir Pan, Dongqing Luo—300 Jin Wang, Siir Pan, Dongqing Jin Wang, Pan, Dongqing Jin Wang, Pan, Dongqing Jin Wang, Pan, Do	Pranee Lertsutthiwong, Duangcheewan Boonpuak, Wiboonluk Pungrasmi, Sorawit Powtongsook · · · · · · · · · · · · · · · · · ·	262
An innovaive integrated system utilizing solar energy as power for the treatment of decentralized wastewater Changfu Han, Junxin Liu, Hanwen Liang, Xuesong Guo, Lin Li Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko 280 Quantification, morphology and source of humic acid, koregon and black earbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan 281 Evaluation of oxygen transfer parameters of fine-bubble aeration system in plug flow aeration tank of wastewater treatment plant Xiaohong Zhao, Vianqiuw Mu, Hanchang Shi, Yanqing Song 292 Elifects of ion concentration and natural organic matter on anemica(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangiu Yang, Weihong Fan, Zhaokun Luan Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Luo Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chansiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren 304 Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol — A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Forg Duan, Chiensong Chyang, Yucheng Chin, Jin Tso Forg Duan, Chiensong Chyang, Yucheng Chin, Jin Tso Holocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolgowska, Zdzisław M. Migaszewski, Artur Michalik BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoe Lan, Plum Anh Minh  Environmental biology The Change and phosp		
Changfu Han, Junxin Liu, Hanwen Liang, Xuesong Guo, Lin Li Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Woo Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko Quantification, morphology and source of humic acid, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan 28: Evaluation of oxygen transfer parameters of fine-bubble acration system in plug flow aeration tank of wastewater treatment plant Xianohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Welhong Fan, Zhaokun Luan 30: Characterization of cake layer structure on the microlitration membrane permeability by iron pre-coagulation Jin Wang, Sin Pan, Dongping Lu 30: Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren 31: Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxim Ma, Chang Liu, Hong He 32: Pollutant emission characteristics of rice hask combastion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso 43: Psylocomium splendens (Hedw) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabima Dolgowska, Zdzisław M. Migaszewski, Artur Michalik BTEX pollution caused by motorcycles in the megacity of HoChilvlinh Tran Thi Ngoc Lan, Pham Anh Minh  Environmental biology Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Ly, Anzhou Ma, Xuanming Tang, Zhibui Bai, Hongyan Qi, Guoqia	Sudarshan Kurwadkar, Victoria Sicking, Barry Lambert, Anne McFarland, Forrest Mitchell · · · · · · · · · · · · · · · · · ·	268
Settling and dewatering characteristics of granulated methane-oxidizing bacteria Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won Tae Lee, Kwang Baik Ko————————————————————————————————————		
Kwang Ho Ahn, Kwang Soo Kim, Sung Won Kang, Chul Yong Um, Won The Lee, Kwang Baik Ko.  Quantification, morphology and source of humic acid, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongsing Yuan  28: Evaluation of oxygen transfer parameters of fine-bubble acration system in plug flow acration tank of wastewater treatment plant Xiaohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song  29: Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan  Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Luo  Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren  Atmospheric environment  Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso  33:  Hylocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties  Sabina Dolggowska, Zdzisław M. Migaszewski, Artur Michalik  ETEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Anh Minh  Environmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere  Di Lv. Anzhou Ma, Xuanming Tang, Zhibui Bai, Hongyan Qi, Guoqiang Zhuang  36: Effects of nitrogen and phosphorus concentrations on the bioaccumulation of polybrominated diphenyl ethers by Prorocentru		274
Quantification, morphology and source of humic acid, kerogen and black carbon in offshore marine sediments from Xiamen Gulf, China Yanling Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan  28: Evaluation of Oxygen transfer parameters of fine-bubble aeration system in plug flow aeration tank of wastewater treatment plant Xiaohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song  29: Effects of ion concentration and natural organic matter on arsenic (V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwed Zhao, Yangui Wang, Weithong Fan, Zhaokun Luan  30: Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Luo  30: Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China  Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren  31: Atmospheric environment  Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere  Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  20: Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator  Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso  33: Hylocomium splendens (Hedw.) B.S.G. and Pleuroziam schreberi (Brid.) Mitt, as trace element bioindicators: Statistical comparison of bioaccumulative properties  Sabina Dolegowska, Zdzisław M. Migaszewski, Artur Michalik  BTEX pollution caused by motorcycles in the megacity of HoChiMinh  Tran Thi Ngoc Lan, Pham Ash Minh  24: Environmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere  Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang  35: Tolerance of Chrysamenum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps  Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González  Effect		
Yanting Chen, Jinping Zhao, Liqian Yin, Jinsheng Chen, Dongxing Yuan  Svabation of oxygen transfer parameters of fine-bubble aeration system in plug flow aeration tank of wastewater treatment plant Xiaohong Zhou, Yuanyuan Wi, Hanchang Shi, Yanqing Song  295  Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan  306  Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Luo  307  Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren  Atmospheric environment  Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jirzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  302  Pollutant emission characteristics of rice buse combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso  333  Hylocomium splendens (Hedw.) B. S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolggowska, Zdzisław M. Migaszewski, Artur Michalik BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Ahh Minh  346  Environmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Ly, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang  357  Tolerance of Chrysantenum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps  Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González  Effects of nitrogen and phosphorus concentrations on the bioaccumulation of polybrominated diphenyl ethers by Prorocentrum donghaiense  Chao Chai,		280
Evaluation of oxygen transfer parameters of fine-bubble aeration system in plug flow aeration tank of wastewater treatment plant Xiaobong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan 300. Characterization of cale layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Sira Pan, Dongping Luo 300. Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Churkiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren 310. Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He 100. Feng Duan, Chiersong Chyang, Yucheng Chin, Jim Tso 100. Feng Duan, Chiersong Chyang, Yucheng Chin, Jim Tso 100. Holtonenium sphendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dobgowska, Zdzisław M. Migaszewski, Artur Michalik 100. 100. 100. 100. 100. 100. 100. 100		
Xiaohong Zhou, Yuanyuan Wu, Hanchang Shi, Yanqing Song  Effects of ion concentration and natural organic matter on arsenic (V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhou, Yangui Wang, Weihong Fan, Zhaokun Luan		287
Effects of ion concentration and natural organic matter on arsenic(V) removal by nanofiltration under different transmembrane pressures Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan 30. 30. 30. 30. 30. 30. Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren 31. Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jouan, Chiensong Chyang, Yucheng Chin, Jim Tso 32. Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso 33. Hylocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties 3abina Dolegowska, Zdzisław M. Migaszewski, Artur Michalik BTEX pollution caused by motorcycles in the megacity of HoChilMinh Tran Thi Ngoc Lan, Pham Anh Minh Tan Thi Ngoc Lan, Pham Anh Minh Tenvironmental biology Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang 35. Tolerance of Chrysantemum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps Ma, del Carmen A. González-Chávez, Rogelio Carrillo-González Chao Chai, Xundong Yin, Wei Ge, Jinye Wang Environmental health and toxicology Umbilical cord blood mercury levels in China Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Mengin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Mengin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Fifect of biomass addition on the surface and adsorption characterization of carbon-based adsorbents from		
Yang Yu, Changwei Zhao, Yangui Wang, Weihong Fan, Zhaokun Luan		295
Characterization of cake layer structure on the microfiltration membrane permeability by iron pre-coagulation Jin Wang, Siru Pan, Dongping Luo  301 Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren  316 Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  326 Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso  336 Hylocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolegowska, Zdzisław M. Migaszewski, Artur Michalik BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Anh Minh Tran Thi Ngoc Lan, Pham Anh Minh  248 Tenvironmental biology Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang  357 Tolerance of Chrysantemum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps Ma. del Camen A. González-Chávez, Rogelio Carrillo-González Chao Chai, Xundong Yin, Wei Ge, Jinye Wang Cenvironmental health and toxicology Umbilical cord blood mercury levels in China Meiqin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Menigin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Menigin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Menigin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Menigin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou Menigin Wu, Chonghual Yan, Jian Xu, Wei Wu, Hui Li, Wang, Pengfei Jing Influence of supports on photocatalytic degradation of phenol and 4-chlorophenol in		
Jin Wang, Siru Pan, Dongping Luo Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren Atmospheric environment Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Journal Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal Chiensong Chyang, Yucheng Chin, Jim Tso Journal May Journal May Migaszewski, Artur Michalik  Environmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang Journal May Journal May Journal May May Journal May Jou		302
Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren		
Chunxiao Chen, Binghui Zheng, Xia Jiang, Zheng Zhao, Yuzhu Zhan, Fengjiao Yi, Jiaying Ren		308
Atmospheric environment  Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere  Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  September Spuan, Chiensong Chyang, Yucheng Chin, Jim Tso  Sabina Doltgowska, Zdzisław M. Migaszewski, Artur Michalik  Sabina Doltgowska, Zdzisław M. Migaszewski, Artur Michalik  Sabina Doltgowska, Zdzisław M. Migaszewski, Artur Michalik  BTEX pollution caused by motorcycles in the megacity of HoChiMinh  Tran Thi Ngoc Lan, Pham Anh Minh  Tran Thi Ngoc Lan, Pham Anh Minh  Tran Thi Ngoc Lan, Pham Anh Minh  Cenvironmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere  Di Ly, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang  357  Tolerance of Chrysantemum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps  Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González  Chao Chai, Xundong Yin, Wei Ge, Jinye Wang  Chao Chai, Xundong Yin, Wei Ge, Jinye Wang  Tenvironmental health and toxicology  Umbilical cord blood mercury levels in China  Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou  Revironmental from coal combustion flue gas by modified fly ash  Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing  Influence of supports on photocatalytic degradation of phenol and 4-chlorophenol in aqueous suspensions of titanium dioxide  Kashif Naeem, Feng Ouyang  Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang  Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang  Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang  Changzi Wu, Aira Coated FeyO, nanomaterial: Preparation and application in removal of phosphate from water		
Review of heterogeneous photochemical reactions of NOy on aerosol – A possible daytime source of nitrous acid (HONO) in the atmosphere Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He Jinzhu Ma, Yangchem Migaszewski, Artur Michalik Jinzhu Mitta a trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolęgowska, Zdzisław M. Migaszewski, Artur Michalik Jinzhu Migaszewski, Artur Michalik Jinzhu Mitta a trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolęgowska, Zdzisław M. Migaszewski, Artur Michalik Jinzhu Mitta a trace element bioindicators: Statistical comparison of bioaccumulation of polygomental biology Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang Jintha del Carmen A. González-Chávez, Rogelio Carrillo-González Jinzhu Ma, d		316
Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He  Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso Bioaccumulative properties Sabina Dolęgowska, Zdzisław M. Migaszewski, Artur Michalik  BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Anh Minh Tran Thi Ngoc Lan, Pham Anh Minh Tolic the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang  357 Tolerance of Chrysantemun maximum to heavy metals: The potential for its use in the revegetation of tailings heaps Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González  616 626 637 638 646 647 648 648 649 649 640 640 640 640 640 640 640 640 640 640	-	
Pollutant emission characteristics of rice husk combustion in a vortexing fluidized bed incinerator Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso		
Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso	Jinzhu Ma, Yongchun Liu, Chong Han, Qingxin Ma, Chang Liu, Hong He · · · · · · · · · · · · · · · · · ·	326
Hylocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of bioaccumulative properties Sabina Dolegowska, Zdzisław M. Migaszewski, Artur Michalik		
bioaccumulative properties Sabina Dolęgowska, Zdzisław M. Migaszewski, Artur Michalik	Feng Duan, Chiensong Chyang, Yucheng Chin, Jim Tso · · · · · · · · · · · · · · · · · · ·	335
Sabina Dolęgowska, Zdzisław M. Migaszewski, Artur Michalik 346 BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Anh Minh 348 Environmental biology Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang 357 Tolerance of Chrysantemum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González 367 Effects of nitrogen and phosphorus concentrations on the bioaccumulation of polybrominated diphenyl ethers by Prorocentrum donghaiense Chao Chai, Xundong Yin, Wei Ge, Jinye Wang 376 Environmental health and toxicology Umbilical cord blood mercury levels in China Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou 388 Environmental catalysis and materials Mercury removal from coal combustion flue gas by modified fly ash Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing 399 Influence of supports on photocatalytic degradation of phenol and 4-chlorophenol in aqueous suspensions of titanium dioxide Kashif Naeem, Feng Ouyang 399 Effect of biomass addition on the surface and adsorption characterization of carbon-based adsorbents from sewage sludge Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang 409 La-EDTA coated Fe <sub>3</sub> O <sub>4</sub> nanomaterial: Preparation and application in removal of phosphate from water	Hylocomium splendens (Hedw.) B.S.G. and Pleurozium schreberi (Brid.) Mitt. as trace element bioindicators: Statistical comparison of	
BTEX pollution caused by motorcycles in the megacity of HoChiMinh Tran Thi Ngoc Lan, Pham Anh Minh		
Tran Thi Ngoc Lan, Pham Anh Minh	Sabina Dołęgowska, Zdzisław M. Migaszewski, Artur Michalik·····	340
Environmental biology  Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere  Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang		
Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere  Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang		348
Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang	Environmental biology	
Tolerance of Chrysantemum maximum to heavy metals: The potential for its use in the revegetation of tailings heaps  Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González	Profile of the culturable microbiome capable of producing acyl-homoserine lactone in the tobacco phyllosphere	
Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González	Di Lv, Anzhou Ma, Xuanming Tang, Zhihui Bai, Hongyan Qi, Guoqiang Zhuang ······	357
Effects of nitrogen and phosphorus concentrations on the bioaccumulation of polybrominated diphenyl ethers by <i>Prorocentrum donghaiense</i> Chao Chai, Xundong Yin, Wei Ge, Jinye Wang		
Chao Chai, Xundong Yin, Wei Ge, Jinye Wang	Ma. del Carmen A. González-Chávez, Rogelio Carrillo-González·····	367
Environmental health and toxicology  Umbilical cord blood mercury levels in China Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou		
Umbilical cord blood mercury levels in China Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou  Environmental catalysis and materials  Mercury removal from coal combustion flue gas by modified fly ash Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing  Influence of supports on photocatalytic degradation of phenol and 4-chlorophenol in aqueous suspensions of titanium dioxide Kashif Naeem, Feng Ouyang  Seffect of biomass addition on the surface and adsorption characterization of carbon-based adsorbents from sewage sludge Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang  405  La-EDTA coated Fe <sub>3</sub> O <sub>4</sub> nanomaterial: Preparation and application in removal of phosphate from water	Chao Chai, Xundong Yin, Wei Ge, Jinye Wang ····	376
Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou	Environmental health and toxicology	
Environmental catalysis and materials  Mercury removal from coal combustion flue gas by modified fly ash  Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing	Umbilical cord blood mercury levels in China	
Mercury removal from coal combustion flue gas by modified fly ash  Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing	Meiqin Wu, Chonghuai Yan, Jian Xu, Wei Wu, Hui Li, Xin Zhou	···· 386
Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing	Environmental catalysis and materials	
Wenqing Xu, Hairui Wang, Tingyu Zhu, Junyan Kuang, Pengfei Jing	Mercury removal from coal combustion flue gas by modified fly ash	
Influence of supports on photocatalytic degradation of phenol and 4-chlorophenol in aqueous suspensions of titanium dioxide  Kashif Naeem, Feng Ouyang	· · · · · · · · · · · · · · · · · · ·	393
Kashif Naeem, Feng Ouyang		
Effect of biomass addition on the surface and adsorption characterization of carbon-based adsorbents from sewage sludge  Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang		399
Changzi Wu, Min Song, Baosheng Jin, Yimin Wu, Yaji Huang $\cdots$ 405 La-EDTA coated Fe $_3$ O $_4$ nanomaterial: Preparation and application in removal of phosphate from water		
La-EDTA coated Fe <sub>3</sub> O <sub>4</sub> nanomaterial: Preparation and application in removal of phosphate from water		405
		413
Serial parameter: CN 11-2629/X*1989*m*184*en*P*24*2013-2		



Available online at www.sciencedirect.com



Journal of Environmental Sciences 2013, 25(2) 316-325

JOURNAL OF ENVIRONMENTAL SCIENCES ISSN 1001-0742 CN 11-2629/X

www.jesc.ac.cn

# Spatial distribution and pollution assessment of mercury in sediments of Lake Taihu, China

Chunxiao Chen<sup>1,2</sup>, Binghui Zheng<sup>2</sup>, Xia Jiang<sup>2,\*</sup>, Zheng Zhao<sup>2</sup>, Yuzhu Zhan<sup>2,3</sup>, Fengjiao Yi<sup>2</sup>, Jiaying Ren<sup>2</sup>

1. Beijing Normal University, Beijing 100875, China. E-mail: fayechen226@163.com
2. State Key Laboratory of EnvironmentalCriteria and Risk Assessment, Chinese Research Academy of Environment Sciences, Beijing 100012, China
3. Shanghai Waterway Engineering Design and Consulting Co., Ltd., Shanghai 200120, China

Received 01 April 2012; revised 04 July 2012; accepted 09 July 2012

#### **Abstract**

Spatial distribution patterns of total mercury (THg) in 36 surficial sediment samples representing five regions of Lake Taihu were assessed using the ArcGis geostatistical analyst module. The pollution levels of THg were also evaluated from the same five lake regions. Concentrations of THg were in a ranged of 23–168 ng/g (mean 55 ng/g) in surfical sediments, which was significantly higher than those established baseline levels of the lake. Results of THg indicated that the northern region exhibited notably higher values, the bay regions showed elevated values relative to open areas, and the lakeside regions were higher than those observed in the central area. Lake Taihu suffered moderate to high Hg pollution, and expressed clear Hg enrichment status according to monomial pollution index  $I_{\text{geo}}$  and human activity factors. The concentrations of THg in the surficial sediments of Lake Taihu showed moderate-strong variation (coefficient of variation 52%). Geostatistical analysis indicated a weak spatial self-correlation, suggesting the contamination of Hg in Lake Taihu is primarily the result of anthropogenic activities.

Key words: assessment; geostatistics analysis; mercury; sediment; spatial distribution

**DOI**: 10.1016/S1001-0742(12)60033-3

#### Introduction

The continued acceleration of industrialization and urbanization deposits large amounts of heavy metals into aquatic ecosystems (Förstner and Wittman, 1979; Frignani and Bellucci, 2004; Binelli et al., 2008). Mercury (Hg) is a highly toxic trace heavy metal with volatile, bio-accumulation, and teratogenic effects. Therefore, Hg content in foods should be strictly controlled (Torres-Escribano., 2011; Coelho et al., 2005). Natural aquatic systems generally possess low Hg concentrations, but some studies have detected elevated Hg concentrations in fish from Northern America and Northern Europe lakes far from pollution sources (Verta, 1990; Lindqvist et al., 1991). Mason et al. (1999) reported the Hg contamination burden occurs worldwide (including Hg in sediment), which is three times higher than that in pre-industrial period due to human activities.

In aquatic systems, sediments play an integral role in Hg biogeochemical cycling (Yan et al., 2008), and have

\* Corresponding author. E-mail: jiangxia@craes.org.cn

been recognized as an important Hg sink and source (Shi et al., 2005), and the key microbial methylation location (Hammerschmidt and Fitzgerald, 2004, 2006). Hg contamination problems increase when contaminated sediments pollute the water column, and enrich biota and/or aquatic food chains. Contaminated fish consumption is considered the predominant human exposure to MeHg, the most toxic form of Hg (Tchounwou et al., 2003; Clarkson et al., 2003). Lake sediment Hg concentration in Northern America and Northern Europe has generally increased in recent 100 years (Ouellet and Jones, 1982; Verta et al., 1989; Swain et al., 1992; Hermanson, 1993; Lockhart et al., 1995, 1998; Lucotte et al., 1995; Gubala et al., 1995). Researchers have studied Hg enrichment in part of rivers, lakes, estuaries and reservoirs throughout China (Huang et al., 2004; Shi et al., 2005; Lin et al., 2007; Yan et al., 2008; Feng et al., 2009; Zhang et al., 2009).

The Lake Taihu is a significant drinking water resource and a typical shallow hyper-eutrophic lake in China. Heavy metals contamination has been investigated in the lake (Dai and Sun, 2001; Yuan et al., 2004, 2011; Liu et al., 2004, 2005, 2010; Zhu et al., 2005; Wang et al.,

2008; Zhan et al., 2011). Through the research conducted investigates on Hg in the lake (Wang et al., 2002, 2011; Rose et al., 2004; Shen et al., 2005; Qu et al., 2001; Huang et al., 2005; Xiang et al., 2006), however, the spatial distribution and pollution levels of Hg in sediments need to be systematically evaluated. The aims of the present study were to: (1) determine Hg spatial distribution in the sediments of Lake Taihu; (2) quantify Hg contamination levels and anthropogenic impacts on Hg enrichment in the sediment; and (3) provide recommendations for future decision-making and watershed management.

#### 1 Materials and methods

#### 1.1 Study area

Lake Taihu (30°50′–32°80′N, 119°80′–121°55′E) is in the center of the Changjiang River Delta (Qin et al., 2007), and is the third largest freshwater lake in China. It is the source of drinking water for Suzhou and Wuxi in Jiangsu Province, including multi-uses of fisheries, aquaculture, farming, shipping, and flood control, etc. (Qu et al., 2001).

With rapid industrial and agricultural development since 1978, the Lake Taihu catchment was heavily polluted with nutrients and heavy metals due to the massive domestic sewage and industrial wastewater input, particularly in the north area, such as in Zhushan and Meiliang Bays adjacent to Wuxi and Changzhou Cities, respectively (Fan et al., 2002; Qu et al., 2001; Dai and Sun, 2001; Yuan et al., 2002; Lu et al., 2003). Approximate 70% of Lake Taihu contaminants originated from surrounding tributaries (Wu et al., 2007). Subsequently, the lake ecology deteriorated and water quality degenerated as a result of untreated and/or partially treated wastewater from industries. The major contributions were from high-risk companies, such as non-ferrous metal smelting, electroplating, printing and dyeing, agriculture pesticide run-off; and sewage.

#### 1.2 Sample collection

A total number of 36 surficial sediment samples (approximately the upper 5 cm) were collected using a grab sampler in August 2010 (**Fig. 1**). Sampling sites 1–3 and 4-7 were located in the northern lake area of Zhushan and Meiliang Bays, respectively. The sites 1 and 5 were near the Baidugang and Liangxi River inlets, respectively. These sites have become eutrophic in recent decades, and suffered serious heavy metals contamination due to nonpoint and point source pollution (Qu et al., 2001). Sites 8–16 were located in the eastern lake area, which included Gonghu (sites 8–10), Manshanhu (sites 11–13), and Xukou Bay (sites 14-16). Gonghu, Manshanhu, and Xukou Bay possess inflows that carry large amounts of untreated domestic sewage into Lake Taihu. Sites 17-19 were located in the southeast lake area (locally called East Taihu Lake), and approximate 97% of this area was covered at the time of the study by submerged macrophytes,

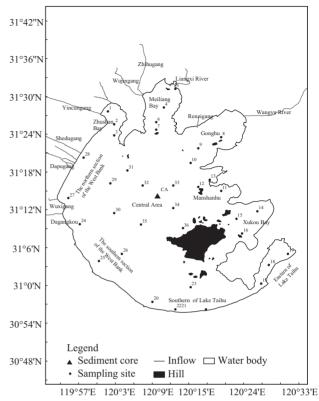


Fig. 1 Sampling site locations at Lake Taihu, China.

and floating leaves. This area has several outflows, and is referred to as a macrophyte-type basin and aquaculture region (Qu et al., 1999; Wang et al., 2011). Sites 20–23 were located in South Taihu Lake (the east and south Taihu Lake were collectively classified as the southern lake area). Sites 24–26 and 27–30 were located in the southern and northern west bank regions, respectively. Sites 31–36 were distributed in the central lake region, which is regarded as the least polluted area in Lake Taihu.

A gravity corer (CA core) (04.23 BEEKER, Eijkelkamp, NL) was used to obtain a sediment core approximately 60 cm long in the central Lake Taihu area. The bottom 6 cm of the core was sectioned into 1 cm intervals rapidly *in situ*.

Each sediment sample was placed in a 50-mL centrifuge tube, which was cleaned by acid washing, rinsed with double-deionized water to remove any organic matter, and Hg adsorbed on the vessel. All sample tubes were sealed with Parafilm to avoid cross contamination, transported in an ice-cooled container to the laboratory within 24 hr of collection, and stored in the refrigerator (4°C) until analysis.

#### 1.3 Analytical methods

In the laboratory, lake sediment samples were lyophilized (freeze-dried), ground, and sieved to <100 mesh-sized particles. For THg analysis, lake sediment samples were subjected to acid digestion following (Li et al., 2005): 0.2 g of dry weight (dw) sample (accurate to 0.0001 g)

was placed inside a 25 mL glass tube covered with a glass ball; 5 mL double-deionized water and 5 mL fresh aquaregia (HCl+HNO<sub>3</sub>, V/V, 3:1) were added; digested at 95°C in water bath for 5 min. Subsequently, 1 mL BrCl solution (1.08 g of reagent grade KBr and 1.52 g reagent grade KBrO<sub>3</sub> dissolved in 100 mL of low-Hg HCl, accurate to 0.0001 g) was added to oxidation at 95°C in a water bath for 30 min, then the sample was diluted to 25 mL with double-deionized water, and reacted overnight for complete digestion after cooling.

Following oxidation, 0.2 mL NH<sub>2</sub>OH·HCl solution (25 g of reagent grade NH<sub>2</sub>OH·HCl was dissolved in 100 mL double-deionized water, accurate to 0.0001 g) was added to samples to eliminate excess halogens prior to cold vapour atomic fluorescence spectroscopy determination after SnCl<sub>2</sub> reduction (Jones et al., 1995; PS Analytical, 2001) on a PSA 10.025 Millenium Merlin System (PS Analytical, Kent), which using high purity argon (99.99%) as the carrier gas.

#### 1.4 Quality control

Quality assurance and quality control of the Hg analytical process were performed using method blanks, blank spikes, matrix spikes, spike recoveries, certified reference materials (GB W07305), and blind duplicates. Method blanks and duplicates were generated regularly (>10% of samples) throughout the sampling process (Yan et al., 2005). A mean THg concentration of  $100.23 \pm 0.52$  ng/g (n=7) was obtained from the GB W07305 geological standard with a certified value of  $100.00 \pm 0.02$  ng/g. The average recovery percentage on spiked samples was in the range of 90.1%-110.3% for THg analysis. The relative standard deviation on precision was < 5% for THg in sediments.

#### 1.5 Statistical analysis

Microsoft Excel (2007) was used to data management in all experiments, and the normal distribution test was performed with Origin 8.0 software. All statistical analysis performed in this study were processed using SPSS 16.0, and spatial analyses completed by ArcGis 9.0 and Origin 8.0.

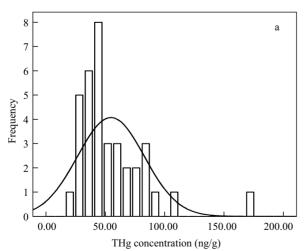
#### 2 Results and discussion

## 2.1 Hg concentration in the surficial sediments of Lake Taihu

Statistical analysis results of Hg content in surficial sediments from different areas of Lake Taihu are presented in **Table 1**. The original Hg concentration date from Lake Taihu sediments resulted in a positively skewed distribution (P < 0.05, **Table 1**, **Fig. 2a**), and a normally distribution following a logarithmic transformation (P > 0.05, **Table 1**, **Fig. 2b**). Total Hg concentration in different regions correspond to normal and log-normal distribution (P > 0.05, **Table 1**).

Geochronology results showed that the bottom lake catchment sample represent end of 19th century to early 20th century sediments (Wu et al., 2008) without anthropogenic contribution to heavy metal enrichment. Therefore, the mean THg concentration (22 ng/g) in the bottom 6 cm of the CA sediment core was regarded as the Lake Taihu baseline, which is consistent with other studies (Huang et al., 2005). Lakes with nonpoint source contamination have reported Hg concentrations ranging from 50 to 300 ng/g dw, while Hg concentration can reach 10 µg/kg in some Hg contaminated aquatic systems (Ram et al., 2003; Jacek and Janusz, 2003).

The mean Hg concentration (55 ng/g) (**Table 1**) in surficial sediments from Lake Taihu was significantly higher than the baseline level. The exceeding rate was 154%, with moderate Hg contamination status, and notable accumulation levels. In addition to central area, Hg content in surficial sediments of the four other regions was significantly higher than baseline levels. Industrial activities have in the past and continue to contribute substantially



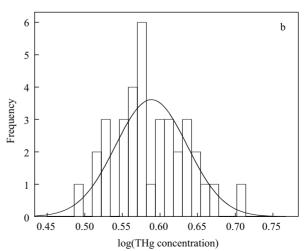


Fig. 2 Histogram of frequency of total Hg (THg) concentration in surficial sediments of Lake Taihu.

Table 1 Total Hg (THg) concentrations and distribution in the surficial sediments of Lake Taihu

Samp	ling area	Sampling site	THg (ng/g)	Mean ± SD (ng/g)	Coefficient of variation	$P_{\text{s-w}}*$	$P_{s-w}$ (logarithmic transformation)
Northern Area	Zhushan Bay	1	168	90 ± 40	44%	0.38	0.99
		2	93				
		3	87				
		4	105				
	Meiliang Bay	5	73				
		6	61				
		7	45				
		8	66				
Eastern Area	Gonghu	9	55	$43 \pm 11$	27%	0.32	0.73
		10	42				
		11	36				
	Manshanhu	12	38.				
		13	43				
		14	43				
	Xukou Bay	15	37				
	•	16	27				
		17	80				
Southern Area	Eastern area	18	75	$59 \pm 20$	33%	0.17	0.23
	of Lake Taihu	19	84				
		20	40				
	Southern area	21	38				
	of Lake Taihu	22	46				
		23	53				
		24	58				
West Bank Area	Southern section	25	51	$51 \pm 10$	20%	0.32	0.31
The state of the s	of the west bank	26	42				
		27	62				
	Northern section	28	65				
	of the west bank	29	42				
		30	39				
		31	27				
Central Area	Central area	32	36	$29 \pm 4$	15%	0.74	0.75
		33	29				
		34	23				
		35	30				
		36	30				
All of the areas				$55 \pm 28$	52%	$3 \times 10^{-5}$	0.83

 $P_{\text{s-w}}$ : level of significance for a normal distribution with S-W method; \* > 0.05 indicates data exhibited normal distribution.

to Hg contamination in surficial sediments of the northern area. The region bordering the northern Lake Taihu area is highly industrialized, and results showed that the sediments exhibited the highest Hg contamination (up to 90 ng/g). Compared with the baseline value, the exceeded Hg concentration of northern, eastern, southern, and western region were 320%, 100%, 176% and 138%, respectively, which indicated that Hg contamination existed at different levels among regions, and had accumulated to varying degrees throughout the lake.

The overall concentration coefficient of variation of Hg in surficial sediments was 52% (**Table 1**). Among areas, the coefficient of variation ranged from 15% to 44%, indicating that Hg in surficial sediments exhibited moderate-strong spatial differences. The coefficient of variation of Hg contents in surficial sediments of the southern, eastern, and northern regions were 33%, 27%, and 44%, respectively. The wastewater inflow from various industrial plants, and subsequent outflows may be integral in the spatial distribution of Hg in the surficial sediments

of Lake Taihu.

A comparison of Hg concentrations in surficial sediments of Lake Taihu with other lakes around the world (**Table 2**) suggested that the Hg content revealed in this study was significantly lower than that of lakes contaminated by mining and industrial activities (Hongfeng Lake (He et al., 2008), Baihua Lake (Yan et al., 2008), and Lake Jinzai (Chandrajith et al., 1995)), but higher than those of lakes, which are in the baseline level (i.e. uncontaminated) lakes. Although Hg concentrations in most regions in this study were much lower than the Grade I (150 ng/g) threshold of China's soil quality standard (GB 15618-1995), Lake Taihu has shown an accumulation degree and enrichment effects exceeding those in uncontaminated lakes worldwide.

## 2.2 Spatial distribution of Hg in Lake Taihu surficial sediment

The Hg spatial distribution map in surficial sediments of Lake Taihu is presented in Fig. 3. The map indi-

Table 2 Comparative Hg concentrations in surficial sediments collected from lakes worldwide

Study area	Hg concentration (ng/g)	Reference	Study area	THg (ng/g)	Reference
Lake Taihu, Jiangsu, China	55	This study	Lake Ontario, USA-Canada	39	Marvin et al., 2007
Lake Donghu, Wuhan Urban, China	199	Su et al., 2006	Lake Erie, USA-Canada	185	Marvin et al., 2002
Lake Liangzi, Wuhan Suburbs, China	78.3	Su et al., 2006	Lake Superior, USA-Canada	80-110	Kerfoot et al., 2004
Lake Chaohu, Anhui, China	238	Wang et al., 2003	Lake Jinzai, Shimane Prefecture, Janan	193	Chandrajith et al., 1995
Lake Dongting, Hunan, China	220	Yao et al., 2006	Lake Michigan, Michigan, USA	78	Rossman, 2002
Poyang Lake, Jiangxi, China	208	Tao, 2004	Baihua Lake, Guizhou, China	12900	Yan et al., 2008
Dianchi Lake, Yunnan, China	180	Shao, 2003	Hongfeng Lake, Guizhou, China	392	He et al., 2008
Lake Hongze, Jiangsu, China	332	Liu et al., 2005	Lake Shijian, Anhui, China	58.8	Xiao et al., 2010

cates moderate Hg contamination in Lake Taihu, and Hg concentrationst in surficial sediments with visible spatial alterations. Concentrations of THg concentration in lake bays were significantly higher than those observed in open regions, suggesting a major source from inflows contaminated with Hg (Yuan et al., 2004). Mean Hg levels of 116, 71, and 54 ng/g were detected in Zhushan, Meiliang Bay and Gonghu Bay, which were 5.4, 3.3, and 2.5 times higher than the baseline value, respectively. Results also indicated that Hg concentration decreased with distance from the bay, and bay sediments showed an increase trend due to deposition of particulate Hg, the major form of Hg in water. This distribution feature conforms to contaminants' transportation law. The velocity of inflow become lower after it enters into lake from river. Particulates and its absorbed heavy metals settle at estuary firstly. With the distance increasing, the impact of inflows decreases and the content of heavy metals in sediment reduce as well.

Qu et al. (2001) also observed significantly higher Hg concentrations in the Liangxi River and Zhihugang bay compared to other sites due to untreated domestic sewage deposition, and reported that the Hg concentration in Meiliang Bay (130 ng/g) was higher than Wuli Lake (80 and 110 ng/g, respectively), which is the route for the Liangxi River into Lake Taihu. In addition, Hg concentration in the northern lake region was substantially higher (nearly twice) than the average concentration of Wuli Lake (Fig. 3 and Table 1), suggesting the northern region has experienced more serious Hg contamination due to industrialization. Wang et al. (2002) and Gu and Wu (2005) also found that the northern Taihu Lake region exhibited the highest Hg pollution in surfical lake sediments, which congruent with Qu et al. (2001). The Hg content in central area was significantly lower than that in any other region of the lake, indicating that the effects of anthropogenic Hg deposition on central Taihu Lake have been reduced due to gradual pollutant deposition during water flow transportation.

Previous research (Yan et al., 2008; He and Feng, 2010; Bai et al., 2007) reported that Hg concentrations in outflows were much lower than in reservoirs as the result of deposition. East Lake Taihu is impacted by aquaculture effluent and has several outflows, and as a result showed the relatively high Hg content in sediments. Sediment re-suspension and macroalgae blinding were likely respon-

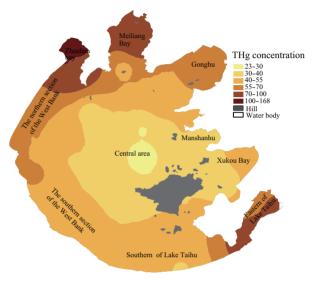


Fig. 3 Spatial distribution of THg concentrations in surficial sediments.

sible for increased Hg levels in this area. Compared with other reservoirs, Lake Taihu is shallow with a mean depth of only 1.9 m. Sediments readily re-suspend, and suspended particulates can blind large amount of heavy metals (Chi and Zhu, 2005, 2006). In addition, field sampling was conducted in August during the highest of algal blooms. Pardal et al. (2004) reported that as eutrophication processes occur worldwide, freshwater bays shift from stable, macrophyte makes systems to highly dynamic macroalgae based systems. In such systems, macroalgae may represent a substantial Hg pool, as a result of its reported capacity to bind trace metals (Radway et al., 2001; Vasconcelos and Leal, 2001), and rapid growth rate. When macroalgae (as sub-suspension sediments) move with the water current and/or settle as sediment, the Hg distribution can be altered in aquatic systems (He et al., 2008; Zhu et al., 2005).

#### 2.3 Hg contamination assessment in the surficial sediments of Lake Taihu

Human activity factors (AFs) were used to evaluate the Hg contamination conditions in the surficial sediments of Lake Taihu (**Fig. 4**). Results for the entire lake showed 50% of the AFs values ranged from 1.0 to 2.0, with a mean of 2.5, indicating a moderate pollution status. The Hg pollution levels in sediments from different lake regions based on AFs from highest to lowest were as follows: northern area

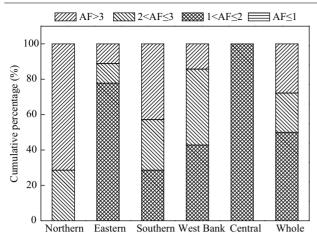


Fig. 4 Activity factors (AFs) accumulative frequencies for THg in the surficial sediment from different regions.

(4.2) > southern area (2.8) > west bank area (2.4) > eastern area (2.0) > central area (1.4). All AFs for the northern lake region investigated were in levels of AFs > 2 and exhibited huge impacts of anthropogenic activies. Industrial enterprises and factories are densely distributed in the northern region, and it is a heavily populated area. Large amounts of industrial wastewater and domestic sewage flow from the Baidugang, Shatanggang, Wujingang and Liangxi Rivers into the lake. Results showed moderateserious Hg contamination in the southern area (43% of AFs > 3), and a slight-moderate Hg pollution in both the west bank area and eastern region (14% and 11% of AFs > 3, respectively). These two regions exhibited similar Hg contamination due to similar sewage disposal and industry types. The mean AFs level (1.1) in the central area indicated decreased particulate Hg deposition, reflecting the lower incidence of human activities affecting the central part of the lake. AFs from all central regionsampling sites range from 1.0 to 2.0.

Atmospheric Hg deposition can also contribute to sediment Hg enrichment (i.e. Hg escapes from electrolytic Cl<sub>2</sub> production, and fossil fuel combustion), and untreated industrial effluents from electroplating, printing and dyeing, smelting and machine manufacturing, pollution from urbanization in decorating materials, debris or powder mixed with garbage, and sewer deposited in the lake through inflows. According to the Annual Statistical Information of Jiangsu Province in 1998, the emissions of mercury and its inorganic compounds reached 710 kg in 1997. In addition to inflows that carry large Hg amounts from industry waste, damaged high pressure mercury lamp, fluorescent tubes, lead-battery discarded from vehicle repair, mercurochrome and thermometer frequently used in hospitals, which are not disposed properly all become significant sources of Hg pollution. Furthermore, in the last few decades the rapid development of shipping has increased pollution on the rivers systems that inflow into Lake Taihu, likely resulting in Hg contamination particular in central area.

Overall, the results of our study clearly demonstrated the

entire Lake Taihu sampled in this study suffers from Hg contamination, and the spatial distribution of Hg pollution in surficial sediments was closely related to industrial production, anthropogenic activities, and input and output channels. Hg concentration exhibited the following levels from highest to lowest concentration areas: northern > southern > west bank > eastern > central. These results are inconsistent with those reported by Wang et al. (2011), where the Hg content of surficial sediments in Lake Taihu exhibited the following levels from highest to lowest concentration: north > east > central > west. However, Wang et al. (2011) had a much smaller sample size (only 1-2 sediment core in each region), therefore could not accurately reflect the mean Hg content and spatial distribution characteristics. However, Hg content in present study was lower than that detected by Xiang et al. (2006) and Gu and Wu (2005). The reason maybe that our sampling was in summer (August) during to algal blooms, and surfical sediment resuspension caused by seasonally increased wave action in the shallow freshwater lake. Algal and suspension particulate matter can blind substantial Hg from sediments. In summary, the results of this study provide evidence for urgent restoration efforts of Lake Taihu to prevent further ecological damage from pollution and eutrophication, and being restoration, especially in the northern lake region. In recent years, land use changes, increased urbanization, and industrialization production processes in areas adjacent to the lake have been modified leading to more complex pollution in lake sediments.

#### 2.4 Effectiveness of spatial interpolation prediction tests

Kriging is a moderately quick interpolator that can be exact or smoothed depending on the measurement error model. It is a flexible means to evaluate graphs of spatial autocorrelation. Kriging uses statistical models that generate a variety of map outputs, e.g., predictions, prediction standard errors, and probability. However, Kriging flexibility often require decision-making. Kriging assumes the data are derived from a stationary stochastic process, and some methods assume normally distributed data.

The spatial distribution of Hg in Lake Taihu based on geostatistics analysis using Kriging interpolation is depicted in Fig. 5.  $I_{geo}$  results for Hg distribution in surficial sediment detected an  $I_{geo}$  mean value of 1.4 for the norther area of Lake Taihu, indicating high contamination levels. These results remain consistent with the other analyses conducted in our study. The Hg enrichment of central area is low ( $I_{geo} < 0$ ). In addition, the Hg levels in sediment of eastern region were higher than those of the west bank area, and the results are congruent with the AFs analysis. However, compare with  $I_{geo}$  and AFs assessments applying  $I_{geo}$  analysis alone to evaluate Hg contamination · 60. or enrichment levels might lead to underestimates.

The semivariogram equation parameters for the Hg

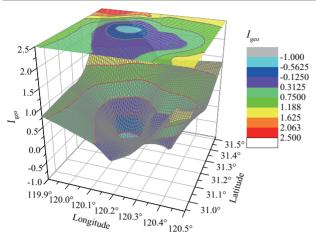


Fig. 5 Distribution of THg concentration  $I_{geo}$  in the surficial sediments.

content in surficial sediments of Lakef Taihu (Spherical model) were as follows:  $C_0$  0.033239,  $C_0+C$  0.0430096,  $C_0/(C_0+C)$  77.28%, and range 1801.72 m. Nugget ( $C_0$ ) depicted random variation was derived from measurement error and sampling scales which are smaller than the smallest variation caused by non-continuous variance. The partial sill ( $C_0+C$ ) was expressed as the total variance within the system, and typically indicated structural and random variation. The ratio  $C_0/(C_0+C)$  was the response to spatial heterogeneity of regional variables, and revealed any spatial correlation among regional variables. In general, the ratio < 25% indicates a strong spatial correlation, a ratio in the 25% to 75% range showed a moderate correlation, and a ratio > 75%, a weak spatial correlation (Spijker et al., 2005).

At present study, Semivariogram was determined and the results were a ration of 77%. Therefore Hg in surficial sediments of Lake Taihu exhibited a weak spatial self-correlation, suggesting the natural environment (local topography, climate, and bedrock, among other factors) had little influenced on the spatial variability of Hg in Lake Taihu. The primary factors responsible for high Hg levels in the lake are anthropogenic effects, and include industrial emissions, coal-fired process, and other anthropogenic disturbance factors, consistent with those report by Liu et al. (2004).

Kriging interpolation accuracy can be evaluated according to several cross-validation indicators as follows: the absolute value of the average standard error (MSE) should be close to 0; minimize the root mean square prediction error (RMSE), which should be close to the mean standard error (AME); and the standard root mean square (RMSS) should be close to 1. Meeting the conditions above can lead to better spatial interpolation accuracy. The cross-validation errors of Kriging interpolation are as following: ME 0.030, RMSE 0.34, ASE 0.33, MSE 0.080 and RMSSE 1.0, indicating that the ordinary Kriging spatial interpolation method performed more reliability for Hg prediction.

#### 3 Conclusions

The Hg concentrations of Lake Taihu were in the range of 23–168 ng/g with a mean value of 55 ng/g, which were significantly higher than baseline values (exceeding rate was 154%). The Hg content in the surfical sediments of Lake Taihu showed the following levels from higher to lower concentrations: northern > southern > western bank > eastern > central regions; the exceeding rate were 320%, 176%, 138%, 100% and 36%, respectively.

The coefficient of variation for overall Hg content in surfical sediments was 52%. Geostatistical analysis indicated that Hg concentration expressed weak spiral self-correlation, which suggested that the natural environment had little impact on Hg levels, and Hg contamination was primarily the result of anthropogenic causes, such as industrial activities, urbanization, shipping, domestic waste, and other impacts.

Kriging interpolation analysis on the single Hg pollution index in the surfical sediments of Lake Taihu showed that lake sediments possess moderate to high Hg contamination, with high contamination in the northern and lakeside regions, and critical management should be given before further degradation of the freshwater ecosystem occurs.

#### Acknowledgments

This work was supported by the National Natural Science Foundation of China (No. 21077097). The authors are grateful to Fuhong Sun and Shan Wu in the Chinese Research Academy of Environment Sciences for their field assistance.

#### References

Bai W Y, Feng X B, Jin Z S, 2007. The Infuluence of rigers on the transport and fate of mercury species in the Aha reservoir. *Acta Mineralogica Sinica*, 27(2): 218–224.

Binelli A, Sarkar S K, Chatterjee M, Riva C, Parolini M, deb Bhattacharya B et al., 2008. A comparison of sediment quality guidelines for toxicity assessment in the Sunderban wetlands (Bay of Bengal, India). *Chemosphere*, 73(7): 1129–1137.

Chandrajith R L R, Okumura M, Hashitani H, 1995. Human influence on the Hg pollution in Lake Jinzai, Japan. *Applied Geochemistry*, 10(2): 229–235.

Chi Q Q, Zhu G W, 2005. Heavy-metal contents in suspended solids of meiliang bay, Taihu Lake. *Environmental Chemistry*, 24(5): 582–585.

Chi Q Q, Zhu G W, Zhang Z P, Qin B Q, 2006. Effects of windwave disturbance on heavy metal contents in suspended solids of Lake Taihu. *Journal of Lake Sciences*, 18(5): 495– 498.

Clarkson T W, Magos L, Myers G J, 2003. Human exposure to mercury: the three modern dilemmas. *The Journal of Trace Elements in Experimental Medicine*, 16(4): 321–43.

Coelho J P, Pereira M E, Duarte A, Pardal M A, 2005. Macroalgae response to a mercury contamination gradient in a tem-

- perate coastal lagoon (Ria de Aveiro, Portugal). *Estuarine*, *Coastal and Shelf Science*, 65(3): 492–500.
- Dai X L, Sun C, 2001. The characteristics of heavy mentals distribution and pollution in sediment from Lake Taihu. Shanghai Environmental Sciences, 20(2): 71–75.
- Fan C H, Zhu Y X, Ji Z H, Zhang L, Yang L Y, 2002. Characteristics of the pollution of heavy metals in the sediments of Yili River, Taihu Basin. *Journal of Lake Sciences*, 14(3): 235–241.
- Feng X B, Jiang H M, Qiu G L, Yan H Y, Li G H, Li Z G, 2009. Mercury mass balance study in Wujiangdu and Dongfeng Reservoirs, Guizhou, China. *Environmental Pollution*, 157(10): 2594–2603.
- Frignani M, Bellucci L R, 2004. Heavy metals in marine coastal sediments: Assessing sources, fluxes, history and trends. *Annali di Chimica*, 94(7-8): 479–486.
- Förstner U, Wittman G T W, 1979. Metal Pollution in the Aquatic Environment. Springer, Berlin.
- Gu Z F, Wu W, 2005. Investigation and evaluation of heavy metals pollution in Lake Taihu. Gansu Science and Technology, 21(12): 21–23.
- Gubala C P, Landers D H, Monetti M, Heit M, Lasorsa B, Allen-Gil S, 1995. The rates of accumulation and chronologies of atmospherically derived pollutants in arctic Alaska, USA. Science of the Total Environment, 160–161: 347–361.
- Hammerschmidt C R, Fitzgerald W F, 2004. Geochemical controls on the production and distribution of methylmercury in near-shore marine sediments. *Environmental Science and Technology*, 38(5): 1487–1495.
- Hammerschmidt C R, Fitzgerald W F, 2006. Methylmercury cycling in sediments on the continental shelf of southern New England. *Geochimica et Cosmochimica Acta*, 70(4): 918–930.
- He T R, Feng X B, 2010. Distribution of mercury species and controlling factors in inflows and outflow of Hongfeng Reservoir. *Environmental Science & Technology*, 33(7): 139–142.
- He T R, Feng X B, Guo Y N, 2008. Geochemical cycling of mercury in the sediment of Hongfeng Reservior. *Environmental Science*, 29(7): 1768–1774.
- He T R, Feng X B, Guo Y N, Qiu G L, Li Z G, Liang L et al., 2008. The impact of eutrophication on the biogeochemical cycling of mercury species in a reservoir: A case study from Hongfeng Reservoir, Guizhou, China. *Environmental Pollution*, 154(1): 56–67.
- Hermanson M H, 1993. Historical accumulation of atmospherically derived pollutant trace metals in the Artic as measured in dated sediment cores. *Water Science and Technology*, 28(8-9): 33–41.
- Huang H, Yue Y J, Wang X D, Wang L S, 2004. Pollution of heavy metals in surface sediments from Huaihe River (Jiangsu section) and its assessment of potential ecological risk. *Environmental Pollution & Control*, 26(3): 207–208.
- Huang S S, Fan D F, Chen B, Jin Y, 2005. A temporal assessment on ecological risk caused by heavy metals in north Taihu basin. *Jiangsu Geology*, 29(1): 43–45.
- Jacek B, Janusz P, 2003. Horizontal and vertical variabilities of mercury concentration and speciation in sediments of the Gdansk Basin, Southern Baltic Sea. *Chemosphere*, 52(3): 645–654.

- Jones R D, Jacobson M E, Jaffe R, West-Thomas J, Arfstrom C, Alli A, 1995. Method development and sample processing of water, soil, and tissue for the analysis of total and organic mercury by cold vapor atomic fluorescence spectrometry. Water, Air, and Soil Pollution, 80(1-4): 1285–1294.
- Kerfoot W C, Harting S L, Jeong J, Robbins J A, Rossmann R, 2004. Local, regional, and global implications of elemental mercury in metal (copper, silver, gold, and zinc) ores: Insights from lake superior sediments. *Journal of Great Lakes Research*, 30(1): 162–184.
- Li F C, Shen Y F, Wang X H, Kang X J, 2005. Monitoring organochlorine pesticides and polychlorinated biphenyls in Baiyangdian Lake using microbial communities. *Journal of Freshwater Ecology*, 20(4): 751–756.
- Lin C Y, Zhou Y X, Hu L J, Guo W, He M C, Yan B X et al., 2007. Ecological risk assessment of mercury pollution in the sediment of Songhua River. *Acta Scientiae Circumstantiae*, 27(3): 466–473.
- Lindqvist O, Johansson K, Bringmark L, Timm B, Aastrup M, Andersson A et al., 1991. Mercury in the Swedish environment: Recent research on causes, consequences and corrective methods. Water, Air, and Soil Pollution, 55(1-2): 12–21.
- Liu E F, Shen J, Liu X Q, 2005. The changes and pollution history of heavy metals and nutrient in Lake Taihu sediments. *Science in China Series D: Earth Sciences*, 35: 73–80.
- Liu E F, Shen J, Zhu Y X, Xia W L, Zhu G W, 2004. Source analysis of heavy metals in surface sediments of Lake Taihu. *Journal of Lake Science*, 16(2): 113–119.
- Liu H L, Yin C Q, Tang Y P, 2010. Distribution and speciation of heavy metals in sediments at a littoral zone of Meiliang Bay of Taihu Lake. *China Environmental Science*, 30(3): 389–394.
- Lockhart W L, Wilkinson P, Billeck B N, Danell R A, Hunt R V, Brunskill G J et al., 1998. Fluxes of mercury to lake sediments in central and northern Canada inferred from dated sediment cores. *Biogeochemistry*, 40(2-3): 163–173.
- Lockhart W L, Wilkinson P, Billeck B N, Hunt R V, Wagemann R, Brunskill G J, 1995. Current and historical inputs of mercury to high latitude lakes in Canada and to Hudson Bay. *Water, Air, and Soil Pollution*, 80(1-4): 603–610.
- Lu M, Zhang W G, Shi Y X, Yu L Z, Zheng X M, 2003. Vertical variations of metals and nutrients in sediments from northern Taihu Lake and the influencing factors. *Journal of Lake Science*, 15(3): 213–220.
- Lucotte M, Mucci A, Hillaire-Marcel C, Pichet P, Grondin A, 1995. Anthronopogenic mercury enrichment in remote lakes of Northern Quebec (Canada). *Water, Air, and Soil Pollution*, 80(1-4): 467–476.
- Marvin C H, Charlton M N, Reiner E J, Kolic T, MacPherson K, Stern G A et al., 2002. Surficial sediment contamination in Lakes Erie and Ontario: A comparative analysis. *Journal of Great Lakes Research*, 28(3): 437–450.
- Marvin C, Painter S, Rossman R, 2004. Spatial and temporal patterns in mercury contamination in sediments of the Laurentian Great Lakes. *Environmental Research*, 95(3): 351–362.
- Mason R P, Lawson N M, Lawrence A L, Leaner J J, Lee J G, Sheu G R, 1999. Mercury in the Chesapeake Bay. *Marine Chemistry*, 65(1-2): 77–96.

- Ouellet F, Jones H G, 1982. Palaeolimnological evidence for the long-range atmospheric transport of acidic pollutants and heavy metals into the province of Quebec, eastern Canada. *Canadian Journal of Earth Sciences*, 20(1): 23–36.
- Pardal M A, Cardoso P G, Sousa J P, Marques J C, Raaelli D, 2004. Assessing environmental quality: a novel approach. *Marine Ecology Progress Series*, 267: 1–8.
- PS Analytical, 2001. Millenium Merlin Method for Total Mercury in Drinking, Surface, Ground, Industrial and Domestic Waste Waters and Saline Waters. P.S. Analytical Ltd., Orpington, Kent, U K.
- Qin B Q, Xu P Z, Wu Q L, Luo L C, Zhang Y L, 2007. Environmental issues of Lake Taihu, China. *Hydrobiologia*, 581(1): 3–14.
- Qu W C, Dickman M, Wang S M, Wu R J, Zhang P Z, Chen J F, 1999. Evidence for an aquatic origin of ketones found in Taihu Lake sediments. *Hydrobiologia*, 397: 149–154.
- Qu W C, Mike D, Wang S M, 2001. Multivariate analysis of heavy metal and nutrient concentrations in sediments of Taihu Lake, China. *Hydrobiologia*, 450(1-3): 83–89.
- Radway J C, Wilde E W, Whitaker M J, Weissman J C, 2001. Screening of algal strains for metal removal capabilities. *Journal of Applied Phycology*, 13(5): 451–455.
- Ram A, Rokade M A, Borole D V, Zingde M D, 2003. Mercury in sediments of Ulhas estuary. *Marine Pollution Bulletin*, 46(7): 846–857.
- Rose N L, Boyle J F, Du Y, Yi C, Dai X, Appleby P G et al., 2004. Sedimentary evidence for changes in the pollution status of Taihu in the Jiangsu region of eastern China. *Journal of Paleolimnology*, 32(1): 41–51.
- Rossman R, 2002. Lake michigan, 1994–1996 surficial sediment mercury. *Journal of Great Lakes Research*, 28(1): 65–76.
- Shao X H, 2003. The distribution of heavy metals in Dianchi sediment. Master Thesis. Nanjing Normal University, Jiangsu China.
- Shen G Q, Lu Y T, Wang M N, Sun Y Q, 2005. Status and fuzzy comprehensive assessment of combined heavy metal and organo-chlorine pesticide pollution in the Taihu Lake region of China. *Journal of Environmental Management*, 76(4): 355–362.
- Shi J B, Liang L N, Jiang G B, Jin X L, 2005. The speciation and bioavailability of mercury in sediments of Haihe River, China. *Environment International*, 31(3): 357–365.
- Spijker J, Vriend S P, Van Gaans P F M, 2005. Natural and anthropogenic patterns of covariance and spatial variability of minor and trace elements in agricultural topsoil. *Geoderma*, 127(1-2): 24–35.
- Su Q K, Qi S H, Jiang J Y, Ma Z D, Wu C X, Ni Q, 2006. Environmental geochemistry assessment of mercury from lakes in Wuhan City, Hubei Province, China. *Geochimica*, 35(3): 265–270.
- Swain E B, Engstrom D R, Brigham M E, Henning T A, Brezonik P L, 1992. Increasing rates of atmospheric mercury deposition in midcontinental North America. *Science*, 257(5701): 784–787.
- Tao C, 2004. A study on environmental geochemistry of trace mercury in Poyang Lake. Master Thesis. Chengdu University of Technology, Chengdu, China.
- Tchounwou P B, Ayensu W K, Ninashvili N, Sutton D, 2003. Environmental exposure to mercury and its toxicopatholog-

- ic implications for public health. *Environmental Toxicology*, 18(3): 149–175.
- Torres-Escribano S, Denis S, Blanquet-Diot S, Calatayud M, Barrios L, Vélez D et al., 2011. Comparison of a static and a dynamic in vitro model to estimate the bioaccessibility of As, Cd, Pb and Hg from food reference materials *Fucus* sp. (IAEA-140/TM) and Lobster hepatopancreas (TORT-2). *Science of the Total Environment*, 409(3): 604–611.
- Wang H, Wang C X, Wang Z J, 2002. Speciations of heavy metals in surface sediment of Taihu Lake. *Environmental Chemistry*, 21(5): 430–435.
- Wang Q, Ding M Y, Zhang Z J, Jiang X, Jin X C, Xu Z X, 2008. Seasonal varieties and influential factors of heavy metals in sediments of Taihu Lake. *Ecology and Environment*, 17(4): 1362–1368.
- Wang S F, Xing D H, Jia Y F, Li B, Wang K L, 2011. The distribution of total mercury and methyl mercury in a shallow hypereutrophic lake (Lake Taihu) in two seasons. *Applied Geochemistry*, 27, 343–351.
- Wang Y H, Liu Z Y, Liu W, Yu N N, Jin X C, 2003. Distribution and correlation characteristics between pollutants in sediment in Chaohu Lake, China. *Acta Scicentiarum Naturalum Universitis Pekinesis*, 39(4): 501–506.
- Vasconcelos M T S D, Leal M F C, 2001. Seasonal variability in the kinetics of Cu, Pb, Cd and Hg accumulation by macroalgae. *Marine Chemistry*, 74(1): 65–85.
- Verta M, 1990. Mercury in Finnish Forest Lakes and Reservoirs: Anthropogenic Contribution to the Load and Accumulation in Fish. National Board of Waters and the Environment, Finland
- Verta M, Tolonen K, Simola H, 1989. History of heavy metal pollution in Finland as recorded by lake sediments. *Science of the Total Environment*, 87-88: 1–18.
- Wu Y H, Hou X H, Cheng X Y, Yao S C, Xia W L, Wang S M, 2007. Combining geochemical and statistical methods to distinguish anthropogenic source of metals in lacustrine sediment: a case study in Dongjiu Lake, Taihu Lake catchment, China. *Environmental Geology*, 52(8): 1467–1474.
- Wu Y H, Jiang X Z, Liu E F, Yao S C, Zhu Y X, Sun Z B, 2008. The enrichment characteristics of mercury in the sediments of Dongjiu and Xijiu, Taihu Lake catchment, in the past century. *Science in China Series D: Earth Sciences*, 51(6): 848–854.
- Xiang Y, Miao Q L, Feng J F, 2006. Pollution of heavy metals in the bottom mud of Lake Taihu and its assessment of potential ecological risk. *Journal of Nanjing Institute of Meteorology*, 29(5): 700 –705.
- Xiao Y H, Gao L M, Liu Y L, Wen H, Zhang C L, Kai X L et al., 2010. Research on mercury pollution status in Shijian Lake of Huainan City. *Journal of Anhui Agricultural Sciences*, 38(1): 472–474.
- Yan H Y, Feng X B, Jiang H M, Qiu G L, Li G H, Shang L H, 2005. The concentrations and distribution of mercury in aquatic ecosystem of Baihua Reservoir. *Chinese Journal of Geochemistry*, 24(4): 377–381.
- Yan H Y, Feng X B, Shang L H, Qiu G L, Dai Q J, Wang S F et al., 2008. The variations of mercury in sediment profiles from a historically mercury-contaminated reservoir, Guizhou province, China. Science of the Total Environment,

- 407(1): 497-506.
- Yao Z G, Bao Z Y, Gao P, 2006. Environmental geochemistry of heavy metals in sediments of Dongting Lake. *Geochimica*, 35(6): 629–638.
- Yuan H Z, Shen J, Liu E F, 2011. Assessment and characterization of heavy metals and nutrients in sediments from Taihu Lake. *Environmental Science*, 32(3): 649–657.
- Yuan X Y, Wang A H, Xu N Z, 2004. hemical partitioning of heavy metals and their characteristics for sediments from Lake Taihu. *Geochimica*, 33(6): 611–618.
- Zhan Y Z, Jiang X, Chen C X, Gao H G, Jin X C, Li C et al., 2011. Spatial distribution characteristics and pollution assessment

- of heavy metals in sediments from the southwestern part of Taihu Lake. *Research of Environmental Sciences*, 24(4): 363–370.
- Zhang J F, Feng X B, Yan H Y, Guo Y N, Yao H, Meng B et al., 2009. Seasonal distributions of mercury species and their relationship to some physicochemical factors in Puding Reservoir, Guizhou, China. *Science of the Total Environment*, 408(1): 122–129.
- Zhu G W, Qin B Q, Gao G, Luo L C, Wang W M, 2005. Accumulation characteristics of heavy metals in the sediments of Lake Taihu, China. *Journal of Lake Science*, 17(2): 143–150.



#### JOURNAL OF ENVIRONMENTAL SCIENCES

#### (http://www.jesc.ac.cn)

#### Aims and scope

Journal of Environmental Sciences is an international academic journal supervised by Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. The journal publishes original, peer-reviewed innovative research and valuable findings in environmental sciences. The types of articles published are research article, critical review, rapid communications, and special issues.

The scope of the journal embraces the treatment processes for natural groundwater, municipal, agricultural and industrial water and wastewaters; physical and chemical methods for limitation of pollutants emission into the atmospheric environment; chemical and biological and phytoremediation of contaminated soil; fate and transport of pollutants in environments; toxicological effects of terrorist chemical release on the natural environment and human health; development of environmental catalysts and materials.

#### For subscription to electronic edition

Elsevier is responsible for subscription of the journal. Please subscribe to the journal via http://www.elsevier.com/locate/jes.

#### For subscription to print edition

China: Please contact the customer service, Science Press, 16 Donghuangchenggen North Street, Beijing 100717, China. Tel: +86-10-64017032; E-mail: journal@mail.sciencep.com, or the local post office throughout China (domestic postcode: 2-580).

Outside China: Please order the journal from the Elsevier Customer Service Department at the Regional Sales Office nearest you.

#### **Submission declaration**

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. The submission should be approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If the manuscript accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

#### **Submission declaration**

Submission of the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. The publication should be approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If the manuscript accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

#### **Editorial**

Authors should submit manuscript online at http://www.jesc.ac.cn. In case of queries, please contact editorial office, Tel: +86-10-62920553, E-mail: jesc@263.net, jesc@rcees.ac.cn. Instruction to authors is available at http://www.jesc.ac.cn.

#### Journal of Environmental Sciences (Established in 1989)

Vol. 25 No. 2 201

CN 11-2629/X	Domestic postcode: 2-580		Domestic price per issue RMB ¥ 110.00	
Editor-in-chief	Hongxiao Tang	Printed by	Beijing Beilin Printing House, 100083, China	
	E-mail: jesc@263.net, jesc@rcees.ac.cn		http://www.elsevier.com/locate/jes	
	Tel: 86-10-62920553; http://www.jesc.ac.cn	Foreign	Elsevier Limited	
	P. O. Box 2871, Beijing 100085, China		Local Post Offices through China	
	Environmental Sciences		North Street, Beijing 100717, China	
Edited by	Editorial Office of Journal of	Domestic	Science Press, 16 Donghuangchenggen	
	Sciences, Chinese Academy of Sciences	Distributed by		
Sponsored by	Research Center for Eco-Environmental		Elsevier Limited, The Netherlands	
Supervised by	Chinese Academy of Sciences	Published by	Science Press, Beijing, China	

ISSN 1001-0742

