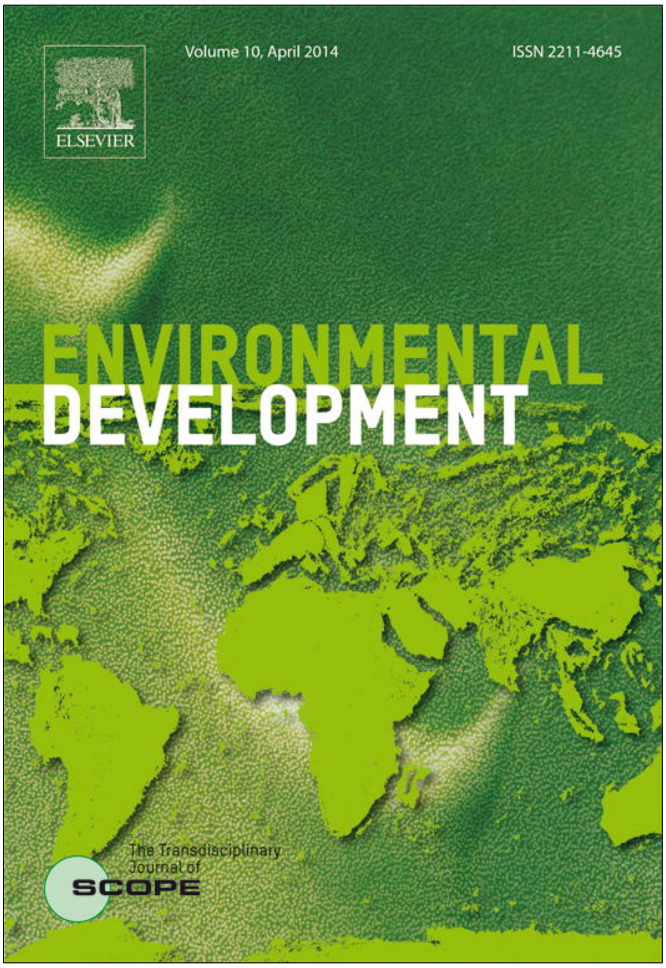
ELSEVIER
Volume 10, April 2014
ISSN 2211-4645
ENVIRONMENTAL
DEVELOPMENT
The Transdisciplinary Journal of
SCOPE

Environmental Development 10 (2014) 104–107

Contents lists available at ScienceDirect

Environmental Development

journal homepage: www.elsevier.com/locate/envdev

A national pilot scheme for monitoring and assessment of ecological integrity of surface waters in China

Yeyao Wang [a,*,1], Enjiang Teng [a], Tingliang Liu [a], Yibing Lv [a], Xiaowei Jin [a,**,1], John P. Giesy [b,c,d,e,f], Henner Hollert [f,g]

[a] *Department of Analytical Technique, China National Environmental Monitoring Center, Anwai Dayangfang No. 8, Chaoyang District, Beijing 100012, People's Republic of China*
[b] *Department of Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada*
[c] *Department of Biology & Chemistry, City University of Hong Kong, Kowloon, Hong Kong, SAR, People's Republic of China*
[d] *State Key Laboratory in Marine Pollution, City University of Hong Kong, Kowloon, Hong Kong, SAR, People's Republic of China*
[e] *School of Biological Sciences, University of Hong Kong, Hong Kong, SAR, People's Republic of China*
[f] *State Key Laboratory of Pollution Control and Resource Reuse, School of the Environment, Nanjing University, Nanjing, People's Republic of China*
[g] *Institute for Environmental Research, RWTH Aachen University, Aachen 52074, Germany*

ARTICLE INFO

Article history:
Received 3 December 2013
Received in revised form
18 February 2014
Accepted 18 February 2014

Keywords:
Ecological integrity assessment
Biological monitoring
Watersheds management
Asia

ABSTRACT

Monitoring of status and trends of quality of surface waters is important to assure sustainability of desired structures and functions of aquatic environments. Recently, several sets of legislation worldwide (USA, European Commission, Canada, Australia, South Africa, etc.) have been developed, that consider water bodies as ecological systems, in order to address ecological quality or integrity of watersheds. Current monitoring and assessment of water quality in China, which is still based on amounts of chemical pollutants, such as ammonia and BOD, has been deemed to be insufficient to adequately assess the quality of aquatic environments. Responding to this challenge, China has embarked on a pilot national monitoring program to assess ecological integrities of major watersheds beginning in 2010. The components used in this monitoring and assessment system include hydrology, river morphology, physico-chemical parameters, ecotoxicological aspects, types and numbers of biota and age and growth of fishes.

* Corresponding author. Tel.: +86 10 8494 3007; fax: +86 10 8494 7263.
** Corresponding author. Tel.: +86 10 8494 3201; fax: +86 10 8494 3189.
E-mail addresses: yeyaowang@163.com (Y. Wang), jinxiaowei07@mails.ucas.ac.cn (X. Jin).
[1] Both authors contributed equally to this work.

http://dx.doi.org/10.1016/j.envdev.2014.02.003
2211-4645

Based on the results of the pilot scheme an ecological integrity index for surface waters will be established; a national coordination and management system, including methods for comprehensive monitoring of ecological integrity of surface waters in China will be initiated.

Monitoring of status and trends of the quality of surface waters is an important method to assure sustainability of desired characteristics of aquatic environments, such as structure and function. Monitoring of aquatic environments in China began in the 1970s, and a preliminary nationwide system for monitoring of concentrations of selected indicator contaminants has been developed and has been functioning for several decades. The national monitoring network has 759 stations for monitoring of surface water, 45 cross-border international river sections and 149 automatic monitoring stations covering 10 major watersheds in China. Based on the data from the national monitoring network, surface water in China was determined to be contaminated in most areas, with chemical oxygen demand (COD), total phosphorus and BOD_5 being the indicators most affected at most locations (MEP, 2010). In 2010, 51.9% of the water sections included in the national monitoring program met Grades I–III quality standards, which was 3.7 percentage points worse than the proportion observed in 2009 and 14.4 percentage points worse than of 2005. In addition, 20.8% of water sections failed to meet Grade V standards (MEP, 2002). These results were the same as that observed in 2009, but was 6.6 percentage points worse than that observed in 2005, which met the target of $<22\%$, that was specified by the 11th Five-Year National Plan for Environmental Protection in China (MEP, 2007, 2010).

Current monitoring and assessment of water quality in China is still based on measurements of magnitudes of chemical pollutants, such as ammonia and BOD. This process has been deemed to be insufficient to adequately assess the quality of aquatic environments. Since the early 1980s, methods for assuring qualities of surface waters have changed in some countries, with a greater emphasis on overall quality of ecosystems (Borja et al., 2008).The United States Environmental Protection Agency (USEPA) Clean Water Act set a standard of “chemical, physical, and biological integrity” for rivers. By integrity, the Congress intended to “convey a concept that refers to a condition in which the natural structure and function of ecosystems is maintained.” In 1989, USEPA began Environmental Monitoring and Assessment Program-Surface Waters (EMAP-SW), a program for developing methods to monitor and assess status and trends in the nation's lakes and rivers in a statistically and ecologically rigorous manner (Hughes et al., 2000). Similarly, the European Commission enacted the Water Framework Directive (WFD) to manage European river basins in a sustainable way. The main objectives of the WFD are to achieve “good ecological and chemical status” for surface water bodies and the “good chemical and quantitative status” for ground waters by 2015 (Kallis and Butler, 2001). Results of current monitoring indicate that 90% of surface waters are yet to reach the WFD objectives and that improvement measures are needed. Recently legislation in countries including Canada, Australia and South Africa, has also been developed in order to address ecological quality or integrity of watersheds that consider water bodies as ecological systems. Most such legislations seek to define quality in an integrative way, by using several biological elements, together with physico-chemical indicators of pollution. Such an approach allows assessment of ecological status at the ecosystem level, rather than at the level of species or quality objectives based on chemical and physical parameters alone (Borja et al., 2008). While this approach has some advantages, such as being site-specific and integrative and accounts for biological availability and interactions between organisms and their environment. The greatest disadvantage is that effects and changes in the structure of ecosystems have already occurred once it is detected.

In China, biological monitoring began in the 1970s simultaneously with monitoring for chemical and physical parameters. In 1984, the Environmental Protection Agency of China held its first working meeting on biomonitoring, after which it promulgated the “Technical specification of biological monitoring: water environment section” in 1986. In 1993, the Environmental Protection Agency of China published “Aquatic Biomonitoring Manual”, and for the first time established a national aquatic monitoring network and began nationwide, routine biological monitoring. Since the 1990s, the quality of aquatic environments has deteriorated due to rapid development of industrial enterprises in China. In some waters fish and shrimp have disappeared (Hu and Cheng, 2013). In China, national environmental management policies have shifted to the reduction of discharge of chemical pollutants, such as ammonia and COD (He et al., 2012). At the same time, with rapid development of physico-chemical monitoring and aggravated workloads of physico-chemical monitoring, have led to national monitoring of surface waters to be concentrated on chemical and physical aspects, which are more easily measured and interpreted and can be linked directly to treatment processes. This shift has resulted in biological monitoring gradually being decreased or even canceled, with only bacteriological indicators retained for routine monitoring. Entering the 21st century, quality of aquatic environments needs to be gradually restored by continuously strengthened management and increased control by increased investment. However, conventional, physical and chemical indicators, such as COD, ammonia, and BOD are insufficient to meet the demand for management of aquatic environments and cannot accurately describe trends in quality of ecosystems. A new monitoring and assessment system is required (Dong et al., 2013; Hsu et al., 2012), based on ecological methodologies, which accurately represents status and trends in quality of aquatic environments.

Responding to this challenge, beginning in 2010, China embarked on a pilot national monitoring program to assess ecological integrity of major watersheds. The program includes 28 pilot locations on the Songhua and Liao Rivers, Lakes Tai, and Dianchi and the source of South-to-North Water Diversion. The components used in this monitoring and assessment system include hydrology, river morphology, physico-chemical parameters, and ecotoxicological aspects, such as types and numbers of biota and age and growth of fishes (Table 1). Based on an evaluation of these individual components, using either a numerical or descriptive classification, ecological integrity is being assessed and classified within a five-tiered system (Table 2). The final classification presented in an expert report is based on current conditions relative to a regional reference state.

The pilot national monitoring and assessment of ecological integrity surveys have demonstrated the value of probability-based sampling designs, quantitative assessments of multiple biological assemblages, a suite of qualitative habitat indicators and the use of historical information. Based on

Table 1
Parameters used for monitoring and assessment of ecological integrity of surface waters.

Parameter	Monitoring program	Water bodies
Hydrology	Hydrological regime, velocity pattern, connectivity to groundwater, and bed load regime	River
River morphology	Morphological river type and habitat (in-stream and littoral)	
Physico-chemical parameters	Data on water quality	River, lake, and reservoir
Biological diversity	Periphyticalgae communities, macrobenthos communities, and fish communities	River, lake, and reservoir
Fish residue	Heavy metal (Hg, Pb, Cd, Cr, and As), VOCs (BTEX and halogenated hydrocarbon), POPs (OCPs, PAHs, and PCBs), and odorous compound	River, lake, and reservoir
Fish growth	Fish grow observation in the icebound season	River and reservoir
Ecotoxicology	Ecotoxicity test data on hazardous substances or adverse effects, e.g. LC_{50}, NOEC, etc.	River, lake and reservoir

Table 2
Five-classes used for evaluation of integrity of freshwater ecosystems.

Class	Ecological integrity
1	Undisturbed
2	Slightly disturbed
3	Moderately disturbed
4	Significantly disturbed
5	Heavily disturbed

the results of the monitoring and assessment program the goals are to (a) establish monitoring index of ecological integrity; (b) establish comprehensive evaluation methods for ecological integrity; (c) establish a national coordination and management system for monitoring and assessing ecological integrity of surface waters in China. The system should accurately reflect the effectiveness of governance and protection of major watersheds.

Acknowledgment

This research was financially supported by the National Major S&T Program for Water Pollution Control and Treatment (2013ZX07502001) and the National Natural Science Foundation of China (21307165). We also would like to thank Dr. Susan Jackson from the Office of Science and Technology, U.S. Environmental Protection Agency, Washington, for the assistance with the manuscript and valuable comments. Prof. Giesy was supported by the Program of 2012 “High Level Foreign Experts” (# GDW20123200120) funded by the State Administration of Foreign Experts Affairs, P.R. China to the Nanjing University and the Einstein Professor Program of the Chinese Academy of Sciences. He was also supported by the Canada Research Chair program, a Visiting Distinguished Professorship in the Department of Biology and Chemistry and State Key Laboratory in Marine Pollution, City University of Hong Kong.

References

Borja, A., Bricker, S.B., Dauer, D.M., Demetriades, N.T., Ferreira, J.G., Forbes, A.T., Hutchings, P., Jia, X., Kenchington, R., Marques, J.C., 2008. Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide. Mar. Pollut. Bull. 56 (9), 1519–1537.

Dong, Z., Wu, Q., Wang, J., Ge, C., Cao, D., 2013. Environmental indicator development in China: debates and challenges ahead. Environ. Dev. 7, 125–127.

He, G., Lu, Y., Mol, A.P., Beckers, T., 2012. Changes and challenges: China's environmental management in transition. Environ. Dev. 3, 25–38.

Hsu, A., de Sherbinin, A., Shi, H., 2012. Seeking truth from facts: the challenge of environmental indicator development in China. Environ. Dev. 3, 39–51.

Hu, Y., Cheng, H., 2013. Water pollution during China's industrialtransition. Environ. Dev. 8, 57–73.

Hughes, R., Paulsen, S., Stoddard, J., 2000. EMAP-Surface Waters: a multiassemblage, probability survey of ecological integrity in the USA. Hydrobiologia 422/423, 429–443.

Kallis, G., Butler, D., 2001. The EU water framework directive: measures and implications. Water Policy 3 (2), 125–142.

MEP, 2010. Report on Environmental Quality of China. Ministry of Environmental Protection (MEP) of the People's Republic of China. China Environmental Science Press, Beijing, China 48–49 (in Chinese).

MEP, 2002. Environmental Quality Standards for Surface Water(GB3838-2002). Ministry of Environmental Protection (MEP) of the People's Republic of China; Beijing, China (in Chinese).

MEP, 2007. The National Eleventh Five-year Plan for Environmental Protection (2006–2010). Ministry of Environmental Protection (MEP) of the People's Republic of China; Beijing, China (in Chinese).