Resources, Conservation and Recycling xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

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

Full length article

Developing surface water quality standards in China

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ARTICLE INFO

Article history:
Received 28 January 2016
Received in revised form 29 July 2016
Accepted 1 August 2016
Available online xxx

Keywords:
Water quality standards
Lake nutrient criteria
Structure equation model
China

ABSTRACT

A methodology for setting lake nutrient standard was proposed in this study based on review of water quality standards (WQS) in China and understanding of lake nutrient criteria. There are very few studies about lake nutrient criteria and water body classification system, which may cause difficulties in nutrient level assessment and management. This paper reviewed WQS system in the US, EU, and Japan, and then presented the development procedures for revising surface WQS in different periods in China. The amendment includes indicators, standard values, and framework of the standard system. However, current WQS set in light of the criteria and standards of the US and Europe couldn't adapt to the natural conditions of lakes in China. Therefore, by learning from the water quality criteria setting method of USA and taking the regional differences into consideration, a methodology of combining structure equation model and expert elicitation was recommended for setting WQS. Furthermore, it considered to investigate the differences (climate, elevation and geographical condition, etc.) in each region, and set lake nutrient criteria and standards on regional scale. Consequently, the proposed methodology for setting standards could be applied to each region in China. Yungui ecoregion was taken as an example for setting up the lake nutrient standards with considering TP, Chl-a, TN and COD_{Mn} four influence factors for designated use attainment, and a suitable TP standard 0.02 mg/L was recommended by using the proposed methods.

1. Introduction

Water quality is currently deteriorating rapidly due to water pollution and human activities all over the world. The domestic and industrial wastewater has contributed significantly to water pollution. Meanwhile, the water treatment plants are not upgraded in a timely fashion for adequately treating the source water in compliance with the water standards. WQS is an effective approach for water quality protection and water basin system management.

Some developed countries proposed WQS to protect the water body a long time ago. In June 1975, the Council of European Communities (EC) adopted a Council Directive for the Member States concerning the required quality of surface water intended for the abstraction of drinking water (EC, 1999). The EC Directive divided raw water quality criteria into three classes according to the respective water treatment methods. Class I water treatment involves simple purification processes including filtration and disinfection. Class II water treatments include coagulation, flagellation, sedimentation, filtration and disinfection. Class III, the most extensive method, includes Class II processes and the activated carbon process. For each class of source water criteria, there are two sets of limit values. In order to meet with the high demand of good water quality and improvement of wastewater treatment technology, Water Framework Directive (WFD) was adopted in 2000 by EU, and it has become a key piece of EU legislation that brings together many aspects of water protection and management. The purpose of the Directive is to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater from a long-term view. The WFD emphasizes river basin management and states that the release of untreated water is prohibited throughout the EU to ensure "good status" for water ecosystems. EU water directives have brought considerable changes to national legislative statutes, even in the countries with most developed environmental regula-

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http://dx.doi.org/10.1016/j.resconrec.2016.08.003
0921-3449/

tions. The measures to achieve the goals will be coordinated at the geographical/administrative level of the river basin district (WHO, 2003). River basin agencies may be based on existing authorities but should not be based on hydrological administrative barriers (Kallis and Butler, 2001). River basin districts should correspond to large catchment basins incorporating the smaller sub-basins. The latest plan for sustainable development of the Rhine was agreed in accordance with the ecological and sustainable focus of the WFD and is embodied in the "Rhine 2020" agreement of International Commission for the Protection of the Rhine (ICPR).

In April 1970, the Water Quality Committee of the Japanese Living Environment Council published WQS for water resources area to protect the source water quality as well as public health (Rook, 1974). Similar to the EC Directive, Japanese source water standards were divided into three classes according to the type of water purification process. In 1971, at the request of the US Environmental Protection Agency (USEPA), the United States Public Water Supplies Panel proposed water quality criteria for source water based on water treatment processes, which were similar to Class II of the EC Directive stated previously. In the USEPA, WQS defined the water quality goals of a water body by designating water its uses or treatments, by setting criteria necessary to protect the uses, and by preventing degradation of water quality through anti-degradation provisions (USEPA, 1980). States adopt WQS to serve the purposes of the Clean Water Act, enhance the water quality, and protect public health or welfare (Cheremisinoff, 2002). EPA first published a WQS regulation in 1975as a part of EPA's water quality management regulations. The first WQS Regulation did not specifically address toxic pollutants or any other criteria. It simply required "appropriate" water quality criteria necessary to support designated uses. Due to the problem of Lake Eutrophication, Nutrient Criteria Technical Guidance Manual was published in 2000, as a reference for setting nutrient standard on the state scale (Gibson et al., 2000). There were no general water standards in the USA, but USEPA provided water quality criteria on the regional scale, and standards were determined by state government with the consideration of designated usages of water body and characteristics of local economy and environment (USEPA, 2002).

Different countries have different approaches for water environmental protection. Economic policy and market intervention play an important role for solving environmental problems in the USA and European countries, while basic approach for pollution control is legislation in Japan where environmental protection is mainly relying on law regulations and administrative guidance. However, water environmental quality standard plays an important part in water environmental management system in China. Water quality criteria and standards from the USA, and WQS from Japan and European countries (WHO, 1993, 2003) were taken as references for setting water body standards in China. The first water environmental quality standard (GB3838-83) in China was promulgated in 1983 by the Ministry of Environmental Protection of People's Republic of China (MEP). However, due to the conflicts between increasing population and limited water resource, economic development and environmental degradation, and the technique promotion and new pollution emerging, GB3838-83 could not satisfy and effectively support water environmental management. Therefore, GB3838-83 was converted to a new version, and its latest version was published in 2002. The standard values in the standard of GB3838-2002 were mostly set based on references from developed countries, which could not reflect the water environmental condition in China, so the GB3838-2002 needs to be further revised and refined in recent years.

As there is no specific and profound research on the development of China's WQS, it is wise to review the development of WQS system in China, so as to know China's water quality management concept and demand, and seek for a methodology for establishing WQS framework and determining standard levels satisfying the demand. Therefore, the main purpose of this study is to, 1) review the development of WQS in China, especially emphasizing on the step changes and revision in order to understand future needs in water environmental management; 2) develop a new technique for setting WQS in China. The development procedures of WQS in China are discussed in Chapter 2. Then Chapter 3 describes different approaches for determining WQS in the USA for reference. Eventually a new methodology for setting WQS based on experiences in the USA is proposed and discussed in Chapter 4 in this study.

2. Review of the development of WQS in China

According to the demand of surface water quality of national environmental policy, the first national WQS "Surface Water Environmental Quality Standards" was issued in 1983 under the name of GB3838-83. Ever since then, it has been revised for 3 times. The first revision was made in 1988 to form the version of GB3838-88. It was then converted to GHZB 1-1999 in 1999 after 11 years of its implementation. In 2002, the standards experienced the third revision and became the latest version (GB3838-2002) being effective until now. After these 3 revisions, National Surface WQS developed a comprehensive system in which nutrient indicator values in lakes and reservoirs have been identified.GB 3838-2002 has become the core for national water environmental monitoring, and plays a very important role in water pollution prevention regulation and water environmental management system. The development procedure of surface WQS is listed in Table 1, and revised details are explained below.

2.1. Water environmental quality standards (GB3838-83)

GB3838-83 was promulgated by the Ministry of Urban and Rural Construction and Environmental Protection of the People's Republic of China renamed as MEP in 2008 in light of "Environmental Protection Law of the People's Republic of China". There are 3 classes corresponding to various water quality levels in GB3838-83 (SEPA, 1983). Class I: water quality is in good conditions so that the water could be used for various functions. Class II: water quality is at middle level, and the water can be served as drinking water resource and for fisheries. Class III is the lowest demand for surface water pollution regulation. And 20 comprehensive indicators were recommended in this standard to indicate different water conditions.

This standard effectively acted as preventing water pollution, ensuring human health, protecting resource, maintaining ecological balance, and conserving sustainable economic development. It could be applied to rivers, lakes, reservoirs, and other water basins, and became a major regulation for environmental planning, environmental management, water quality assessment, and pollutant discharge.

2.2. From GB3838-83 to GB3838-88

GB3838-83 played a significant role in establishing water quality planning and setting objective for water pollution prevention in 2000. However, with the economic development and scientific improvement, the enforcement of GB3838-83 could not effectively support environmental management any more.

Two driving factors contributed to the revision from GB3838-83 to GB 3838-88. Firstly, the WQS of GB3838-83 was subdivided into 3 classes but the division system was not closely related to different functions of water body. Secondly, there was no clear expression for the implementation scope and detection method. Therefore, it was imperative to make necessary revision to GB3838-83 so as to prevent water environmental deterioration caused by

Please cite this article in press as: Su, J., et al., Developing surface water quality standards in China. Resour Conserv Recy (2016), http://dx.doi.org/10.1016/j.resconrec.2016.08.003