



# To Make the Water Safer

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## Abstract

Water quality affects human health and ecological biodiversity, as water ingestion is the primary exposure pathway of human health risk, and water is the most active natural element participating in the transformation of ecological system. In this paper, the background of editing this special issue was outlined, and the main contents and contributions of papers published in this special issue were introduced. Several research directions that are important to guarantee the water safety in the Yellow River basin were proposed. This special issue provides a platform for researchers to share their latest research results, which will not only be helpful for enhancing water protection and management in the Yellow River basin, but also benefit the international community in addressing similar issues.

**Keywords** Water resources · Water pollution · Health risk · Ecological environment · Drinking water quality

## Introduction

Water is one of the most significant fundamental resources to mankind. With the continuous development of the society, it becomes more and more important due to the increasing demand of it. However, water is in shortage considering its uneven spatial and temporal distributions across the globe (Oki and Kanae 2006). The water shortage crisis is further stressed by the climate change and the water contamination of human activities. It is even regarded by some researchers as the potential cause of wars (Chellaney 2013; Lowe and Silvester 2014; Han et al. 2016). The important role of water in natural processes and social revolution should not be underestimated, because its quality significantly affects the human health and social stability (Li and Wu 2019a, b).

The Chinese Loess Plateau is one of the most drought-stricken areas. Like many other arid and semi-arid regions

of the world, the Chinese Loess Plateau is in short of water resources for drinking and other usages due to limited rainfall, although the second largest river of China, the Yellow River runs across this area. It is the most serious region with severe soil erosion and water issues that have drawn much attention from researchers (He and Wu 2019a, b; He et al. 2019; Li et al. 2018, 2019a, b; Li and Qian 2018; Liu et al. 2017; Qiao et al. 2018; Tian and Wu 2019; Zhang et al. 2018, 2019; Wei et al. 2017; Wu et al. 2019, 2020). In 2019, the Chinese President, Xi Jinping, delivered his landmark speech at a symposium on ecological protection and high-quality development in the Yellow River basin (Xi 2019), and he emphasized the importance of protecting the Yellow River and reviewed the great achievements in Yellow River governance since the founding of the People's Republic of China. Most importantly, he pointed out the important future goals and tasks for ecological protection and high-quality development in the Yellow River basin. The Chinese Loess Plateau is the most important but fragile part of the Yellow River basin. The success of water governance in the Loess Plateau determines the success of water governance in the whole basin.

To achieve a real success in the water governance of the basin, the entire basin should be considered as a whole. What is done in the upper reaches of the river basin will affect what the middle and lower reaches will become, and vice versa. In addition, joint efforts from all sectors and departments must be made to achieve the success, which requires

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collaboration not only from domestic researchers and policy makers, but also from international communities. To fully recognize the progress of water governance and environmental protection in the past several decades, the International Symposium on Soil and Water Resources and Ecology in the Loess Plateau was held in Xi'an, China from November 1 to 3, 2019. This conference attracted around 100 delegates who are active researchers and professors from the USA, Canada, South Africa, India and China to share their latest research achievements and illuminating thoughts (Fig. 1). More than 60 abstracts and full manuscripts were received before the conference, and they were peer reviewed. Select submissions on water quality and public health were recommended for inclusion in this special issue.

## Papers in this Special Issue

This issue includes 7 research papers and 2 review papers. The topic of these papers varies from local and regional water contamination and temporal water quality changes to health effects quantification and hydrogeochemical characterization. According to the word cloud generated using the paper titles and abstracts (Fig. 2), the most frequently used word is groundwater, and followed by water, risk, health, Cr<sup>6+</sup>, quality, study area, China, samples and carcinogenic. These frequently used terms reflect the topics reported in the special issue. The main findings and contributions of these papers are outlined below.

Seeking an efficient approach for risk assessment and decision-making is vital, as the processes of risk assessment and decision-making have great uncertainty. Set pair

analysis (SPA) is a novel method of describing and dealing with the uncertainties using the connection number. This approach, which was proposed 30 years ago, has been widely used in earth and environmental sciences, and is becoming more and more important in decision-making for environmental protection, risk evaluation, and disaster prediction. The review paper by Su et al. (2020a) briefly introduced the basic concept of SPA, and then reviewed the development and application of SPA in several disciplinary branches of earth and environmental sciences including engineering geology, hydrology and water resources, meteorology, climatology, and atmospheric environmental science, ecology, and agriculture. The challenges and future prospects of SPA application in earth and environmental sciences were further discussed. The merits of this review paper are that (1) it comprehensively summarized the status of SPA development and its application in different disciplines of earth and environmental sciences, enabling readers to gain a full picture of SPA advantages, and (2) it proposed the future development directions of SPA based on the analysis of challenges that it faces.

The review paper by He et al. (2020) summarized the distribution and hydrochemical characteristics of high-arsenic and high-fluoride groundwater in China. The distribution of arsenicosis and fluorosis corresponding to the high-arsenic and high-fluoride groundwater was delineated. Wide distribution of high-arsenic and high-fluoride groundwater contributed to occurrence of arsenicosis and fluorosis in more than half of the provinces/autonomous regions in China. The review paper also reviewed the effective and efficient measures for arsenicosis and fluorosis management including techniques for arsenic and fluoride removal

**Fig. 1** Opening ceremony of the conference





the temporal changes of groundwater quality and the affecting factors. They believed that the change in groundwater circulation pattern due to overexploitation is a vital factor affecting the groundwater quality. The authors also proposed a Grey Markov prediction model which incorporated the GM(1,1) model and the Markov chain theory and applied it in the prediction of groundwater salinity within the groundwater depression cone. The delineation and prediction will provide valuable and scientific support for local groundwater quality management.

The suitability of water for beneficial uses is significantly affected by seasonal climate factors. Ji et al. (2020) investigated the seasonal characteristics of drinking water in the Hancheng City of China which was a serious endemic disease-stricken city two decades ago. They concluded that drinking water quality experiences seasonal changes, though over 80% of the water samples meet standards for drinking and other purposes. Their research also indicated that the health risk is unacceptable in some sampling locations where the overall water quality is, however, acceptable for drinking. This finding emphasized the importance of the health risk assessment as a supplement to traditional water quality assessment. This issue has also been raised by Wu et al. (2020) who incorporated health risk weighting into traditional water quality assessment.

Zhang et al. (2020) took a local area in the Chinese Loess Plateau as the study region, and reported the groundwater chemistry composition in this area based on physicochemical analysis for 51 groundwater samples. They assessed the non-carcinogenic health risks through ingestion and dermal contact exposure pathways. The main contribution of this research is the application of the criteria importance through inter-criteria correlation (CRITIC) in determining the weights of the water quality parameters. This is an objective weighting method with easy equations. The measures proposed for sustainable groundwater quality management may help local decision makers in seeking effective water quality management techniques.

### **Collaboration to Make the Water Safer in the Yellow River Basin**

To guarantee the safety of water in the Yellow River basin, more work should be carried out collaboratively. The following five aspects, in my opinion, should be given top priority.

#### **Investigation on Current Water Environment Status in the Yellow River Basin**

Understanding the current water environment status is the basis for securing water safety in the Yellow River basin. Based on field investigation, water sample collection and

analysis, a comprehensive investigation of the current status of surface water and groundwater environment in the Yellow River basin should be carried out to ascertain the current status of the surface and groundwater environment in the river basin. Water environmental problems caused by resource development and utilization, such as soil salinization, land subsidence, ground fissures, land desertification, and sea-water intrusion should be thoroughly investigated in terms of occurrence, distribution, historical evolution, causes and influencing factors.

#### **Water Quantity Safety in the Yellow River Basin**

Water quantity safety is the basic aspect of water safety in the Yellow River basin. Although the Yellow River is the second largest river in China, many parts of the basin experience arid and semi-arid climate. The total amount of water is inadequate for various purposes and is unevenly distributed in time and space. To properly manage the water resources in the basin, it is vital to understand completely the water cycle in the watershed. Climate change and human activities should be simultaneously considered to quantify the water resources (groundwater, surface water and rainfall). The changing trends of these factors and the mutual transformation between different water resources in the Yellow River basin should be clarified and revealed. The controlling mechanisms and key factors affecting floods, droughts and other water-related disasters must be understood. Finally, a basin scale water resources safety evaluation system should be established.

#### **Water Quality Safety in the Yellow River Basin**

Water quality is directly related to human health. Pollution of surface water, groundwater and soil in the Yellow River basin should be investigated. The evolutionary trend and laws of water and soil pollution should be paid more attention. The key factors and causes of common and emerging pollutants should be quantitatively studied. To do this, the water and soil should be considered as an integrated system. Finally, a basin scale water quality safety evaluation system should also be developed for the Yellow River basin.

#### **Ecological Safety in the Yellow River Basin**

Hydro-ecology is important for high-quality economic development in the Yellow River basin. Based on the research on water quantity and quality of the basin, the main eco-environmental problems in the basin and the key influencing factors should be identified. Numerical models are essential to propose new strategies for solving key water environmental problems such as eutrophication, soil salinization, and land desertification in the basin. It is also vital

to carry out research on hydro-biogeochemical processes of aquatic ecological evolution, and to develop new technologies for the prevention and control of adverse ecological and environmental impacts.

### Synergetic Development of Water Safety and High-Quality Economy in the Yellow River Basin

General and specific indicators of the basin scale water safety evaluation system should correspond to the goal of ensuring sustainable high-quality basin development. Based on the comprehensive water safety evaluation, a basin scale water safety early warning system which considers natural environmental change and anthropogenic impacts should be set up. This early warning system should consider the economic and social development goals, and should be set up based on solid scientific research.

### Final Remarks

The year 2020 is difficult to the world, as recent outbreak of the novel coronavirus pandemic (COVID-19) strikes almost every country of the world. During the urgent and unprecedented period, most of people stay at home, mourning each death and praying for normal life to come. During this period, I think deeply about what and how hydrogeologists and environmentalists can do to guarantee a safer environment, especially a safer water environment for the world. Learnt from the experience of doctors and governments in combating the COVID-19, I should say collaboration of research from the deep heart of every hydrogeologist and environmentalist may be a promising way. For example, by collaborative research researchers at Cranfield University have found that wastewater testing can be used to estimate the spread of the novel coronavirus more accurately than reagent testing (Cranfield University 2020). A new wastewater-based epidemiology (WBE) method for detecting the novel coronavirus is being developed. This method can effectively and quickly predict the possibility of potential novel coronaviruses spread by identifying biomarkers from the feces and urine of disease carriers entering the drainage system (Mao et al. 2020). The world needs collaboration to become better and the hydrogeologists need collaboration to make water safer. There are so many challenges in the water community, all of which cannot be solved by a single person. Only collaboration can finally find ways to overcome these challenges.

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### Compliance with Ethical Standards

**Conflict of interest** The author declares that they have no conflict of interest.

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