

Watershed Water Environment and Hydrology under the Influence of Anthropogenic and Natural Processes

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1. Introduction to Watershed Water Environment and Hydrology

Water resources imbalance of requirement and distribution has become one of the most vital limiting factors for regional and global sustainable development [1,2]. Under the global environmental change, water quality, including pollution risk, identification, and controlling factors, becomes the key to sustainable development and high-efficiency use of water resources. Watersheds are closely related to social and economic development around the world, as the most critical water resource unit in surface systems. However, the global water eco-environment poses many challenges for protection and management at different watershed scales. Under the influence of anthropogenic and natural processes, nutrients and other pollutants have difficulty being assessed accurately with respect to their transformation and migration at different watershed scales. By studying the biogeochemical cycle of substances and sources of pollutants in the water environment (e.g., rivers, reservoirs, and subterranean rivers) at the watershed scale, combined with hydrology methods, the mechanism of ecological environment changes at watershed scale can be explored under the influence of both anthropogenic and natural processes [3,4].

Generally, human activities (such as agricultural production, urban sewage, industrial discharge, and mining in the watershed) are the main sources of pollutants in the water environment, and natural processes (mainly rock weathering) are also important factors controlling the water chemistry of watersheds [5–7]. Meanwhile, besides natural hydrological processes, reservoir and dam construction (water conservancy projects) and land-use change are also important factors affecting material migration and transformation in the watershed water environment. In this Special Issue, we aim to promote paper publications that deal with watershed water environments and hydrology under the influence of anthropogenic and natural processes, mainly focusing on the quality and contamination of water bodies and their influencing factors. This Special Issue shares innovative/new ideas on the watershed water environment from different perspectives across the field.

The aims of this Special Issue are to (1) distinguish the evolution of watershed water ecological and environmental quality impacted by both anthropogenic and natural processes; (2) clarify the biogeochemical cycling of elements or pollutants driven by human activities and hydrological factors at watershed scale; (3) identify and quantify the sources of pollutants in watershed water environments; (4) assess the ecological risk and human health risk of pollutants in the water environment at different watershed scales.

A total of eight peer-reviewed articles were collected in this Special Issue. Six papers come from China, and the other two were from the United States of America and Russia, respectively. Overall, these papers in this Special Issue point out several perspectives of watershed water environment and are of great significance for realizing high-efficiency water environmental management and sustainable use of water resources. The research subjects involved different rivers and river-reservoir systems in China, the USA, Russia,



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and Sri Lanka, such as the Yangtze River Watershed and Wujiang River Basin in China, Triangle Area in the USA, and Nizhnekamskoe Reservoir Watershed in Russia.

2. Overview of This Special Issue

The topics of collected papers in this Special Issue are widespread and they can be divided into three parts as follows: (1) hydrochemistry-based watershed weathering processes and their environmental implications, (2) trace elements in watershed water environment and their risks, and (3) nutrients cycle in river-reservoir systems.

2.1. Hydrochemistry-Based Watershed Weathering Processes and Its Environmental Implications

Chemical weathering adjusts atmospheric CO₂ balance and the habitability of Earth-surface on a long-term scale. As the integration of solid and dissolved weathering products, river geochemistry can reflect the weathering processes and fluxes at the basin scale. Moreover, the river water hydrochemical compositions are not only the reflection of natural processes (mainly weathering processes), but also the carrier of environmental information of human activities.

Two papers deal with the water chemistry of river watersheds, focusing on the hydrochemical behavior under different basin backgrounds and geological conditions.

Ge et al. [8] reported the hydrochemistry and sulfur isotope ($\delta^{34}\text{S-SO}_4^{2-}$) compositions of a representative carbonate rock area to identify the potential origins of fluvial solutes (mainly weathering products), the human disturbance, and river water quality. The findings presented that K^+ , Mg^{2+} , F^- , HCO_3^- mainly reflected the rock weathering inputs, and atmospheric deposition was the contributor of Na^+ and Cl^- , while SO_4^{2-} and NO_3^- were defined as the anthropogenic inputs. The H_2SO_4 -involved processes were significantly facilitated by weathering processes. The sulfur isotope-based discussion further revealed that human emission controlled the fluvial SO_4^{2-} relative to sulfide oxidation, while the atmospheric impact was negligible.

Wang et al. [9] applied the Germanium/Silicon (Ge/Si) ratio to trace the influence of hydrothermal input and chemical weathering on Tibetan Plateau-originated river water (Yarlung Tsangpo River). Based on that Ge/Si ratio, this paper reflected the primary mineral dissolution and secondary clay formation. The main results highlight that the hydrothermal water contribution notably impacts the Ge/Si ratios of river water, particularly in the upper-mid reaches. About 11–88% of Ge was lost during the transported processes from hydrothermal water to river system. The contribution of hydrothermal sources should be considered if the Ge/Si ratio was used to trace silicate weathering in Tibetan Plateau rivers.

2.2. Trace Elements in Watershed Water Environment and Their Risks

The trace elements, including heavy metals (HMs) and rare earth elements (REEs) in the river system, are important and gain more concerns due to their potential toxicity on aquatic organisms and humans. Four papers in this issue determine the trace elements geochemistry in different watersheds to explore the natural and anthropogenic inputs of trace elements, and their potential health risks.

Zeng et al. [10] investigated the distribution, status, and sources of typical HMs, and further assessed the water quality and HMs-related risks in the upper Three Gorges Reservoir (TGR) of Yangtze River. The detectable HMs were 1.4–8.1 times higher than the source area of the Yangtze River, indicating potential anthropogenic inputs. V, Cu, As, and Pb concentrations along the main channel were decreased. Principal component analysis-based sources identification reflected that V, Ni, As, and Mo were the main contribution of human inputs, Cu and Pb were mainly from mixed sources of human emission and natural process, while the Zn and Cd were controlled by natural sources. Water quality assessment revealed a good water quality for the drinking purpose with limited exposure risk.

The article by Zabrecky et al. [11] is a good application of REEs (mainly Gadolinium, Gd) tracing the anthropogenic contributions on river water, in particular, the influences of surrounding wastewater treatment plants (WWTPs). The Gd anomalies were investigated

in North Carolina's Triangle Area. The quantified assessment of Gd in wastewater samples suggested that 98.1% to 99.8% Gd is an anthropogenic contribution, while the anthropogenic Gd contribution of upstream and downstream samples was estimated as an average increase of 45.3%.

Motovilov et al. [12] simulated the heavy metals (Cu, Zn, and Mn) cycling of the heavily polluted Nizhnekamskoe reservoir basin in Russia using the semi-distributed physically based ECOMAG-HM model. The spatial and temporal patterns of these HMs were also identified. The findings reflected that the riverine pollution is formed mainly by the metals diffuse wash-off into rivers from the soil-ground layer. The delta-change climatic scenario-based model highlighted that water quality characteristics should not be significantly changed up to 2050.

Xu et al. [13] described the spatial characteristics of groundwater geochemistry in Sri Lanka to link the water quality and the potential contributor to chronic kidney disease of unknown etiology (CKDu). The groundwater geochemistry exhibited significant spatial heterogeneity in Sri Lanka, and Cd, Pb, Cu, and Cr concentrations were within the limitation of World Health Organization guideline values. In contrast, the As and Al concentrations of some samples were higher than the limited values. Although the water quality data cannot explore if water quality is associated with the CKDu occurrence, more effective research should be conducted to confirm the synergistic effect of different chemical constituents on CKDu.

2.3. Nutrients Cycle in River-Reservoir Systems

The anthropogenic pollution of nitrogen and phosphorus in river watershed scales has become a global awareness due to their negative influence on aquatic quality. Given that the enrichment of N and P in the river-reservoir system has seriously affected the health of river water, and the knowledge of the main influencing factors controlling the N and P cycle is vitally significant. In this Special Issue, two papers aimed at the transportation and transformation of N and P in the river-reservoir system.

Hou et al. [14] performed their study on the nitrogen species and isotopes in the sediment of a deep reservoir (artificial reservoir of Wujiang River basin) in Southwest China to better understand nitrogen transformation under the condition of thermal stratification, in particular, the sediment–water interface (SWI) nitrogen cycle. This paper highlighted that the changes in dissolved oxygen primarily controlled the nitrogen cycling processes, and furthermore, nitrification, denitrification, mineralization, and diffusion of nitrogen species were largely varied with the presence of the oxygen.

The paper by Zhou et al. [15] investigated five sediment cores from the shallow YuQiao Reservoir in northern China to clarify the role of phosphorus (P) release from sediment by determining the characteristics and P fractions. The sediments presented a P sorption capacity of 7–10 times that of soil. The isotherm adsorption experiments identified the sediment contributes with a positive flux of P to the overlying water. The dredging of 30 cm surface sediments was the effective pathway to decline the soluble reactive phosphate.

3. Conclusions

Watershed water environments are complex earth–surface systems, as they integrate the influences of both natural processes and anthropogenic processes, which are also amongst the most significant freshwater resources, supporting the development of human societies over the world. This Special Issue collected eight peer-reviewed articles to clarify the watershed water environment and hydrology under the influence of anthropogenic and natural processes and further support the water eco-environmental protection and management on different watershed scales. These works cover several river watersheds and/or river-reservoir systems in China, the USA, Russia, and Sri Lanka. From the perspective of hydrochemistry-based weathering processes, trace elements and their risks, and nutrients cycle in different watersheds, the authors provide several benefits innovative/new ideas on watershed water environment and further help manage and balance the water resources.

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