Factors dominating stratification cycle and seasonal water quality variation in a Korean estuarine reservoir

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A comprehensive monitoring program was conducted during 2005–2007 to investigate seasonal variations of hydrologic stability and water quality in the Yeongsan Reservoir (YSR), located at the downstream end of the Yeongsan River, Korea. A principal component analysis (PCA) was performed to identify factors dominating the seasonal water quality variation from a large suite of measured data—11 physico-chemical parameters from 48 sampling sites. The results showed that three principal components explained approximately 62% of spatio-seasonal water quality variation, which are related to stratifications, pollutant loadings and resultant eutrophication, and the advective mixing process during the episodic rainfall-runoff events. A comparison was then made between YSR and an upstream freshwater reservoir (Damyang Reservoir, DYR) in the same river basin during an autumn season. It was found that the saline stratification and pollutant input from the upstream contributed to greater concentrations of nutrients and organic matter in YSR compared to DYR. In YSR, saline stratification in combination with thermal stratification was a dominant cause of the longer period (for two consecutive seasons) of hypoxic conditions at the reservoir bottom. The results presented here will help better understand the season- and geography-dependent characteristics of reservoir water quality in Asian Monsoon climate regions such as Korea.

Introduction

Seasonal stratification cycles are usually observed in sufficiently deep lakes or reservoirs and are closely tied to seasonal water quality variations such as eutrophication phenomena. In a typical freshwater lake or reservoir of the northern hemisphere temperate region, thermal stratification generally occurs in the summer due to a vertical temperature gradient formed between relatively warm surface water and relatively cold deep water, often causing oxygen depletion at the bottom water or in sediment.[1] In spring and autumn, the vertical temperature gradient becomes reversed and vertical mixing occurs, resulting in pollutant resuspension and turbidity increase. In an estuarine reservoir, another concern is the saline stratification resulting from seawater intrusion through or under the estuarine dam into the reservoir.[2,3] A more significant water quality concern arises in an estuarine reservoir than in a freshwater reservoir because it receives pollutants from upstream areas and the estuarine dam prevents the pollutants in the reservoir from being diluted out to the open sea by the tidal effect.[4,5]

In addition, a prolonged thermal or saline stratification prevents vertical mixing of water and can lead to oxygen depletion (*i.e.*, hypoxia) in the bottom water and sediment in lakes, reservoirs, or estuaries.[6,7] Hypoxia in a surface water system is technically defined as the state that the concentration of dissolved oxygen (DO) is below 5 mg L^{-1} and is divided into two sub-state categories, *i.e.*, moderate hypoxia (2 mg L^{-1} < DO < 5 mg L^{-1}) and severe hypoxia (DO ≤ 2 mg L^{-1}). Hypoxia not only affects the bio-geochemical cycles of constituents but also

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Environmental impact

As an artificial estuarine reservoir, the Yeongsan Reservoir (YSR) in Korea has specific geographical and morphological configuration, differentiating its spatio-temporal patterns in water quality from those of a typical freshwater lake or reservoir of the northern hemisphere temperate region. This study reports on a large suite of water quality monitoring data in YSR, with a multivariate statistical interpretation for characterizing the stratification cycle and seasonal water quality variation, with an emphasis on oxygen depletion. In addition, a comparison was also made in the vertical water quality profiles between YSR and a freshwater reservoir in the upstream of the same river basin to understand how geographical differences affect the water quality of a reservoir. This study reveals important site-specific factors dominating the spatio-temporal variations in water quality of a contaminated estuarine reservoir in Asian Monsoon climate regions such as Korea.

