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Environmental and ecological effects of Lake Shihwa reclamation project in South Korea: A review

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ABSTRACT

The Shihwa Coastal Reservoir (SCR) was created to supply agricultural water during the construction of dikes for land reclamation, with this project representing a striking example of policy failure regarding tidal flat reclamation in Korea. After the completion of dike construction in 1994, the water quality inside the SCR drastically deteriorated. As a result, in 1996, the sluice gates were opened to dilute water pollution levels through the physical mixing of seawater from outside and freshwater from inside. Over the last 20 years, the Korean government has invested more than US $ 1.5 billion to recover SCR water quality by improving public sewage treatment systems, which is 2.7 times the cost of the original dike construction. Yet, within the reservoir, water quality has minimally improved, sediment pollution continues to be detected, and anoxic layers have been observed, due to stratification in summer. Severe sedimentary pollution caused by heavy metals and trace organic pollutants originating from the upstream regions of the watershed was evident during the SCR project; however, pollution levels appeared to decrease after seawater circulation. In parallel, the pelagic and benthic communities have also been affected by the deterioration of multiple water and sediment quality indices. While the recent construction of the tidal power plant has significantly increased the volume of seawater circulation, it has not been enough to improve the water quality of the upstream region of the SCR, where the water remains polluted. The SCR project presents a clear example that how incorrect policy leads to the mishandling of both coastal ecosystems and substantial governmental budgets.

1. Introduction

Land reclamation is a process of coastal development that involves the construction of a dike across the tidal flat coastal zone to create new land surfaces for multiple uses, and results in the formation of a seawater zone to freshwater reservoir that is used as a water supply (Fig. 1a). The terrestrial national territory of South Korea is about 99,720 km^2, of which 66% is covered in forests; consequently, the percentage of available land for human use is relatively low. To resolve this land shortage, the government actively promoted a policy to increase the extent of agricultural, industrial, and urban land through the large-scale reclamation of tidal flats along the southwest coasts of the Korean peninsula over the last 40 years (Kim, 2010; Koh, 2001). For example, from the late 1960s to 2010, a total of 1,959 dikes were constructed, with the resultant reclaimed lands collectively representing about 1,900 km^2 in 1,612 districts (KRCC, 2010).

The Shihwa Coastal Reservoir (SCR) is a clear example of policy failure in terms of land reclamation, which illustrated the vicious

Abbreviation: APs, alkylphenols; BOD, biological oxygen demand; Chl-a, chlorophyll-a; COD, chemical oxygen demand; DO, dissolved oxygen; EIA, Environmental Impact Assessment; EMMP, Environmental Management Master Plan; HRWMA, Han River Watershed Management Agency; KORDI, Korea Ocean Research & Development Institute; KIOST, Korea Institute of Ocean Science & Technology; KWRC, Korea Water Resource Corporation; MLTM, Ministry of Land, Transportation and Maritime Affairs; MOE, Ministry of Environment; MOMAF, Ministry of Maritime Affairs and Fishery; MOLT, Ministry of Land and Transport; NPs, nonylphenols; PBDEs, polybrominated diphenyl ethers; PCBs, polychlorinated biphenyls; PAHs, polycyclic aromatic hydrocarbons; PFCs, perfluorinated chemicals; SCMA, Special Coastal Management Area; SCR, Shihwa Coastal Reservoir; SDC, Sustainable Development Committee; STP, Sewage Treatment Plants; TMDL, total maximum daily load; TP, total phosphorous; TPLMS, Total Pollution Load Management System; TPP, tidal power plant; US EPA, U.S. Environmental Protection Agency; WMC, Watershed Management Committee; WQ, water quality.

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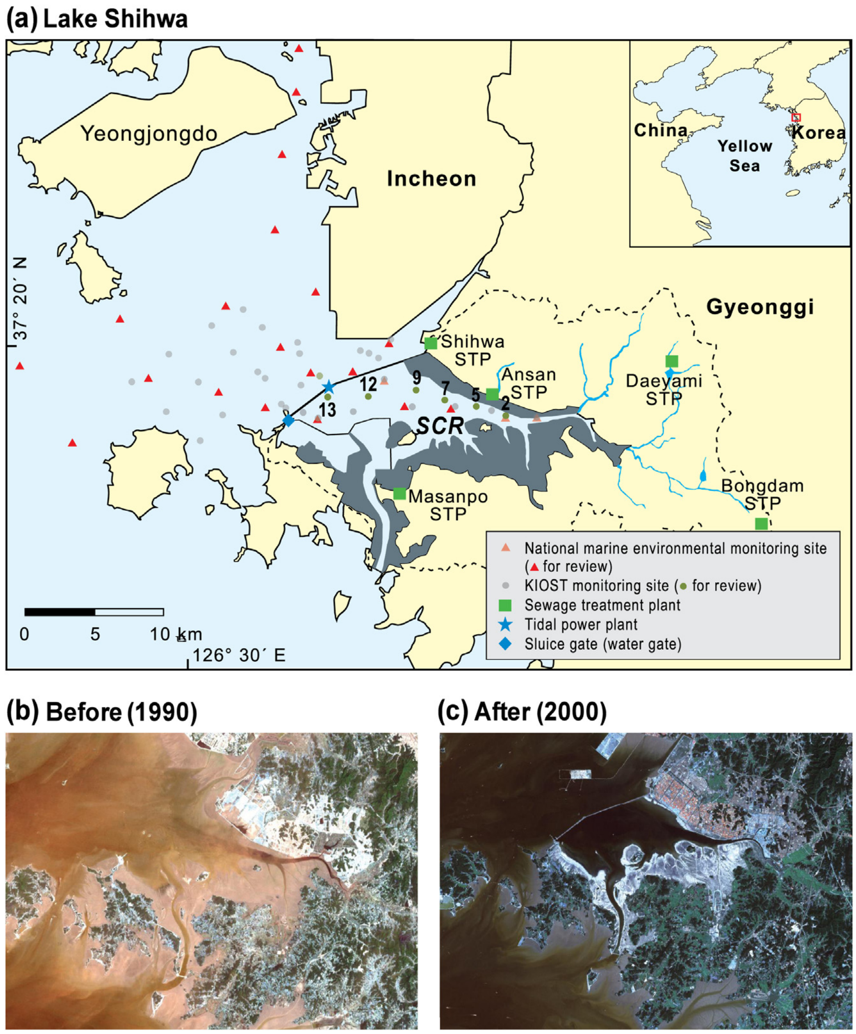

Fig. 1. Map showing the location and watershed boundary of Shihwa Coastal Reservoir (SCR). (a) Monitoring sites at the inner and outer regions of Lake Shihwa and satellite images of (b) before and (c) after the construction of the sea dike (in 1990 and 2000, respectively).

circle of environmental costs. First, coastal development did not take into account the natural environment, which resulted in the rapid deterioration of water quality; consequently, a huge budget was consumed for implementing uncertain water quality improvement techniques. The reservoir was theoretically planned to supply water for agricultural land covering an area of 65 km^2. However, after the sluice of the SCR dike was closed for water desalination, the water quality drastically deteriorated to the point where the Chemical Oxygen Demand (COD) exceeded 20 mg L^{-1} (Hong et al., 1997; Kim et al., 2002). Although the government implemented various short-term measures to improve water quality, including seawater circulation, the SCR desalination policy was officially abandoned, as it inevitably led to the further deterioration of water quality.

In fact, the SCR development was already anticipated to fail because the freshwater volume flowing into the SCR was so low that full desalination would require a longer period of time (KWRC, 2005). In addition, the volume of wastewater in the watershed drastically increased due to the rapid expansion of the adjacent national industrial complexes and the municipal districts. Delay in the construction of the wastewater treatment facilities further aggravated the situation, with the government failing to control untreated wastewater that was discharged into the SCR. However, over a short time frame, the government continued to develop the SCR, due to its tangible economic value, and did not review their policies. While the official decision for the SCR construction project was finalized in 1986, following two years of negotiations among the government parties, construction had already begun, even before the completion of negotiations. In addition, the potential impacts of the construction on the natural environment were not considered through a standard Environmental Impact Assessment (EIA) process. Therefore, the prerequisites of the EIA process were not fully addressed before the start of the SCR desalination project. Such prerequisites included the completion of public wastewater treatment facilities, the discharge of effluents from facilities to outside the dike, the prevention of wastewater inflow into the reservoir, and the operational plan of the dike to replace freshwater with seawater within the reservoir (Choi, 2001).

As a result, the water quality significantly deteriorated, which led to the government implementing various strategies to redress this issue. From the closure of the dike sluice gate (1994) until the abandonment of the desalination policy (2000), the government focused on short-term water quality improvement measures, such as seawater circulation and the discharge of wastewater treatment facilities outside the dike (MLTM, 2011a). These efforts improved the deteriorated water quality by up to 4 mg L^{-1} of COD; however,