

Effect of discharge on hydrodynamics and sediment transport by the operation of tidal power plant

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Shihwa Lake was located in the southern part of Gyeonggi Bay in South Korea, which has been formed by seawall of Shihwa. After the construction of seawall leading to the restriction of free exchange between freshwater discharge and seawater, the sedimentation and water pollution in Shihwa Lake became worse by continuous inflow of point and non-point source from the living, agriculture and industrial water. To solve this problem, desalination of Shihwa Lake was abandoned by decision of government in December 2000 and the Shihwa Tidal Power Plant (STPP) was constructed in middle of seawall for energy generation and water quality improvement in August 2011. The STPP has been operating for power generation during flood periods and the repetition of strong inflow and artificial discharge over tidal cycles caused rapid changes in hydrodynamics and sediment dynamics in the vicinity of STPP (Ra *et al.*, 2011; Won *et al.*, 2012). The study focused on the spatial and temporal variability of hydrodynamics and suspended sediment concentration (SSC) which had been investigated using the long-term moorings in the vicinity of STPP (Fig. 1).

The mean water depth was measured about 23, 8, 20m at the ST1, ST2 and ST3, respectively. The mean tidal range measured at Songdo tidal station was about 5.5m and the mean ranges for spring and neap tides were approximately 7.7 and 3.3m, respectively. The freshwater input was low in spring, fall and winter (0.16 to $0.47 \times 10^3 \text{m}^3 \text{s}^{-1}$) and high in summer (0.87 to $2.31 \times 10^3 \text{m}^3 \text{s}^{-1}$) by the discharge of Han River. Therefore, the freshwater was only affected to the vicinity of STPP in summer. The predominant wind was the northwest wind in winter and became weaker southerly wind in summer. Episodically, an extreme tropical storm passed in summer monsoon season.

The moorings were configured with a surface float. Each buoy was equipped with 600-kHz Acoustic Doppler current profiler (ADCP) and Conductivity-Temperature-Depth (CTD), which were used to measure current profile, temperature, and salinity. The ADCP was located 0.5m under the surface to obtain the profiles of velocity and echo intensity backscattered by suspended sediments. The bin size was set at 0.5m and blanking distance was set to 0.8m. Two CTDs were located at 0.5m below the surface and 1.5m above bottom. The measurements were conducted every 10 minutes for approximately 37 days at ST1, ST2 (from March 9 to April 15, 2013) and ST3 (from June 9 to July 16, 2013). The profiles of SSC were obtained from calibrated acoustic backscatter data using an optical backscatter sensor (OBS) and bottle samples. Additional physical data including sea level, wind, and freshwater discharge were integrated to evaluate the function of external forcing conditions.

The hydrodynamics and SSC were greatly affected by the presence or absence of artificial discharge at the STPP. In the short-term (spring and neap) scale, the current speed increased ($>1.0 \text{ms}^{-1}$) and vertically sheared by high artificial discharge. The depth-averaged SSC increased, because of greater resuspension of bottom sediment by high artificial discharge at ST1, ST2 and ST3. In contrast, the current speed decreased ($< 0.5 \text{ms}^{-1}$) and vertically sheared two-layer flow persists and the depth-averaged SSC decreased by the low artificial discharge. In the long-term (seasonal) scale, effects of freshwater and artificial discharge were comparatively strong because of large rainfall in summer compared with winter. In summer, the current speed increased at surface layer by powerful artificial discharge and shear was stronger than in winter. But the depth-averaged SSC was low, despite powerful artificial discharge, because of the strong stratification formed by freshwater ($\Delta S > 7 \text{psu}$).

