Column experiments of the settling characteristics of suspended solids in mine water treatment facilities

Seong-Sook Park[1], Ga-Hyeon Lee[2], Duk-Min Kim[3], Mi-Sun Park[4], Sun-Joon Kim[5]

[1]*Department of Earth Resources and Environmental Engineering, Hanyang University, Wangsimni-ro 222, Seongdong-gu, Seoul, 04763, Republic of Korea, pss2907@hanyang.ac.kr, ORCID 0000-0001-6934-3704*

[2]*Department of Earth Resources and Environmental Engineering, Hanyang University, Wangsimni-ro 222, Seongdong-gu, Seoul, 04763, Republic of Korea, dlrkgus1122@hanyang.ac.kr*

[3]*Department of New Energy and Mining Engineering, Sangji University, Sangjidae-gil 83, Wonju, Gangwon-do, 26339, Republic of Korea, kdukmin8@sangji.ac.kr*

[4]*Korea Mine Rehabilitation and Mineral Resources Corporation, Hyeoksin-ro 199, Wonju, Gangwon-do, 26464, Republic of Korea, mspark@komir.or.kr*

[5]*Department of Earth Resources and Environmental Engineering, Hanyang University, Wangsimni-ro 222, Seongdong-gu, Seoul, 04763, Republic of Korea, nnsjkim@hanyang.ac.kr*

Extended Abstract

As water systems in various regions of the Republic of Korea have been contaminated by mine water containing suspended solids (SS) and potentially toxic elements, active and passive treatment methods have been applied nationwide since 1992. In particular, active treatment methods, such as slaked lime neutralization treatment and electrochemical treatment, are under operation (Cheong and Kang 2004). The prediction of settling efficiencies is required for the appropriate design of treatment facilities. The settling characteristics of SS in the precipitation tank throughout the treatment process at existing mine water treatment facilities at the Yeongdong (YD), Hambaek (HB), and Hamtae (HT) abandoned coal mines (Table 1) were identified in order to assess the settling efficiencies.

A laboratory-scale column device with a total length of 2 m simulating the settling tank was designed and manufactured to measure the change in turbidity over time to assess the settling characteristics. Water samples from the pH adjustment tank, just before entering the settling tank of each treatment facility, were filled in the column using a pump, and the water samples were collected from the sampling ports of various depths at certain specific time intervals to measure SS concentrations. Zeta potential was analyzed to assess the cohesiveness of SS, and particle size distribution was also assessed. For the small particle size group, the D^{50} value of the sample from YD was 4.15 µm, which was larger than that of HB (average 0.95 µm) and HT (average 2.70 µm). The small particle size group was applied because it did not have aggregation during storage after sampling. During the column experiment, the boundary surface of the SS was distinct only at YD, which had the highest SS concentrations (Fig. 1). In the case of HB and HT, the SS concentrations seem to be close to homogeneous throughout the depths. It is thought to be due to the fact that the particle diameters of HB and HT were relatively small compared to the YD samples, and the SS concentration was not high. The settling rates of SS for YD, HB, and HT were about 7.0, 0.048, and 1.11 cm/min, respectively (Fig. 2). Moreover, zeta potential values of YD, HB, and HT were +1.8 mV, -16.3 mV, and -10.1 mV, respectively.

The zeta potential near zero may have been favorable for generating lager flocs. Also, hydrated lime for pH adjustment was applied at the YD and HT facilities, which led to a coagulation effect. Therefore, it was confirmed that the larger particle diameters and higher SS concentrations resulted in higher settling rates. Moreover, larger particle diameters were possibly related with application of hydrated lime and zeta potentials near to zero.

Table 1 Characteristics of water treatment facilities for this study

Facility	Mine type	Flow rate (m^3/d)	Major contaminants	Treatment method
Yeongdong (YD)	Abandoned coal mine	3,000	Fe, Al, Mn	Semi-active / lime addition
Hambaek (HB)	Abandoned coal mine	7,200	Fe	Active / electrochemical
Hamtae (HT)	Abandoned coal mine	26,000	Fe, Mn	Active / lime addition

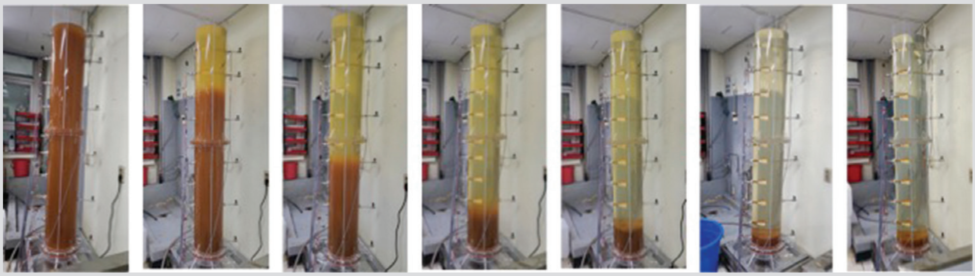

***Figure 1** Settling pattern of SS in the column over time (a: 0 min, b: 10 min, c: 20 min, d: 30 min, e: 60 min, f: 240 min, and g: 1440 min) for the water sample from YD*

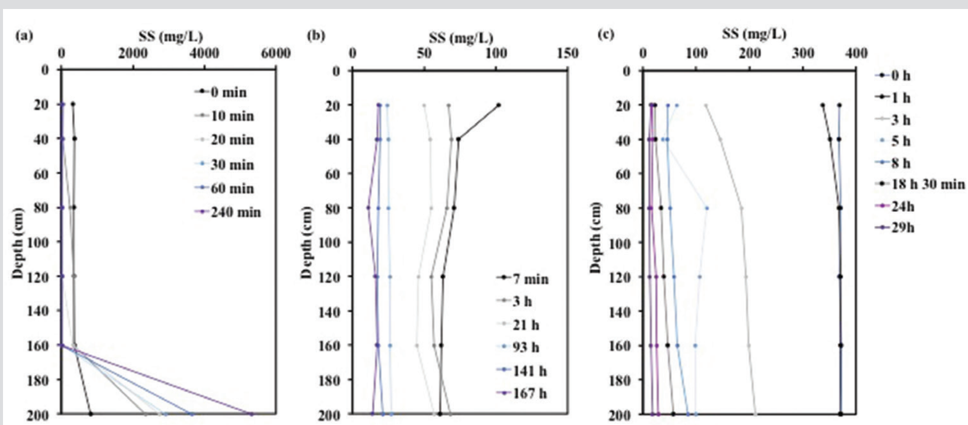

***Figure 2** SS concentration change by depth in column using water samples from (a) YD, (b) HB, and (c) HT*

Keywords: Settling, suspended solids, mine water, treatment facilities, active treatment

Acknowledgements

This work was supported by R&D Project of the Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR) in 2022–2023, Republic of Korea.

References

Cheong YW, Kang SS (2004) Changes in characteristics of sludge and water quality of acid mine drainage by neutralization-sedimentation method of sludge return. Journal of the Korean Society of Mineral and Energy Resources Engineers 41(5):389–394 (in Korean)