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Improvement of residuals treatment efficiency from water treatment plant by auto supernatant drain system

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ABSTRACT

Recently, a novel system with high efficiency has been developed to drain only supernatant of residuals effectively from water treatment plant, which results in high removal efficiency in water treatment by enhancing the quality of residuals and recycling water. The system could positively cope with the variation of water quality by a monitoring device. It was also operated automatically by an auto-control program. The purpose of the present investigation is to evaluate the treatment efficiency of an auto supernatant drain system (ASDS) in treating the residuals from water treatment plant by operating pilot tests as well as column tests. The ASDS improved BOD of the water flowing into the residuals basin by 40.6% and that of the water flowing into the thickener by 90.8%. The improvement effect of COD by the system were 26.7% and 83.9% for the recycled water and the effluent, respectively. The system also improved 1.62 mgL^{-1} and 0.17 mgL^{-1} in terms of the mean TN and TP, respectively. The ASDS improved 4.56% of the mean moisture content and 87.3% of the mean recovery rate.

Introduction

In Korea, 589 water treatment plants are in operation, including those run by 16 metropolitan and provincial governments and the Korea Water Resources Corporation (Hwang, 2012). In a water treatment plant, the water is treated to ensure clean water supply through coagulation·sedimentation, filtration, and disinfection after the water intake, and it inevitably produces residuals. It is reused as recycled water after the residuals treatment process (balancing, thickening, dehydration, and disposal), or discharged as the final effluent (Dong et al., 2011). In Korea, the effluent must be appropriately treated and discharged according to the Water Quality and Aquatic Ecosystem Conservation Act enforced in January 1, 2013. The effluent quality standard has been greatly strengthened since 2013, so that BOD and SS must be less than 10 mgL^{-1} and, COD and T-N must be less than 20 mgL^{-1}. In addition, the poor quality of recycled water would affect the quality of the treated water supplied to consumers, and stable water quality control is required for the residuals treatment system (Bai et al., 2014).

As shown in Fig. 1, the residuals from the water treatment process undergoes unit processes such as balancing, thickening, dehydration, drying, and disposal. All or some of the unit processes are used depending on the properties and amounts of the residuals and the sludge. The balancing process is conducted in the residuals basin and the sludge discharge basin, and adjusts the amount and properties of the sludge discharge (Ippolito et al., 2011). The residuals basin holds the washed residuals from the rapid filter basin, and the sludge dis charge basin holds the sediment sludge thickened in the sedimentation basin. The residuals basin and the sludge discharge basin control the temporal change in the residuals and maintain the treatment volume after the thickening process (Babatunde and Zhao, 2007).

Although the residuals process should be uniformly distributed over 24 hours, it is difficult for most water treatment plants to ensure stable residuals treatment due to systematic problems, lack of operations workforce, and the difficulty of the 24 h shift (Zhao, 2003; Lee, 2012). In addition, the residuals is treated only during working hours and improperly due to overloading of the residuals treatment facility. This degrades the quality of the supernatant and the residuals, and increases the treatment cost due to the excessive moisture content of the final sludge (Zhao, 2004; Ban, 2013). In this study, a new-concept ASDS was developed to address the problems in residuals treatment, and was applied to the backwash residuals and the treated water in the thickener of an actual water treatment plant to examine the resulting treatment efficiency.

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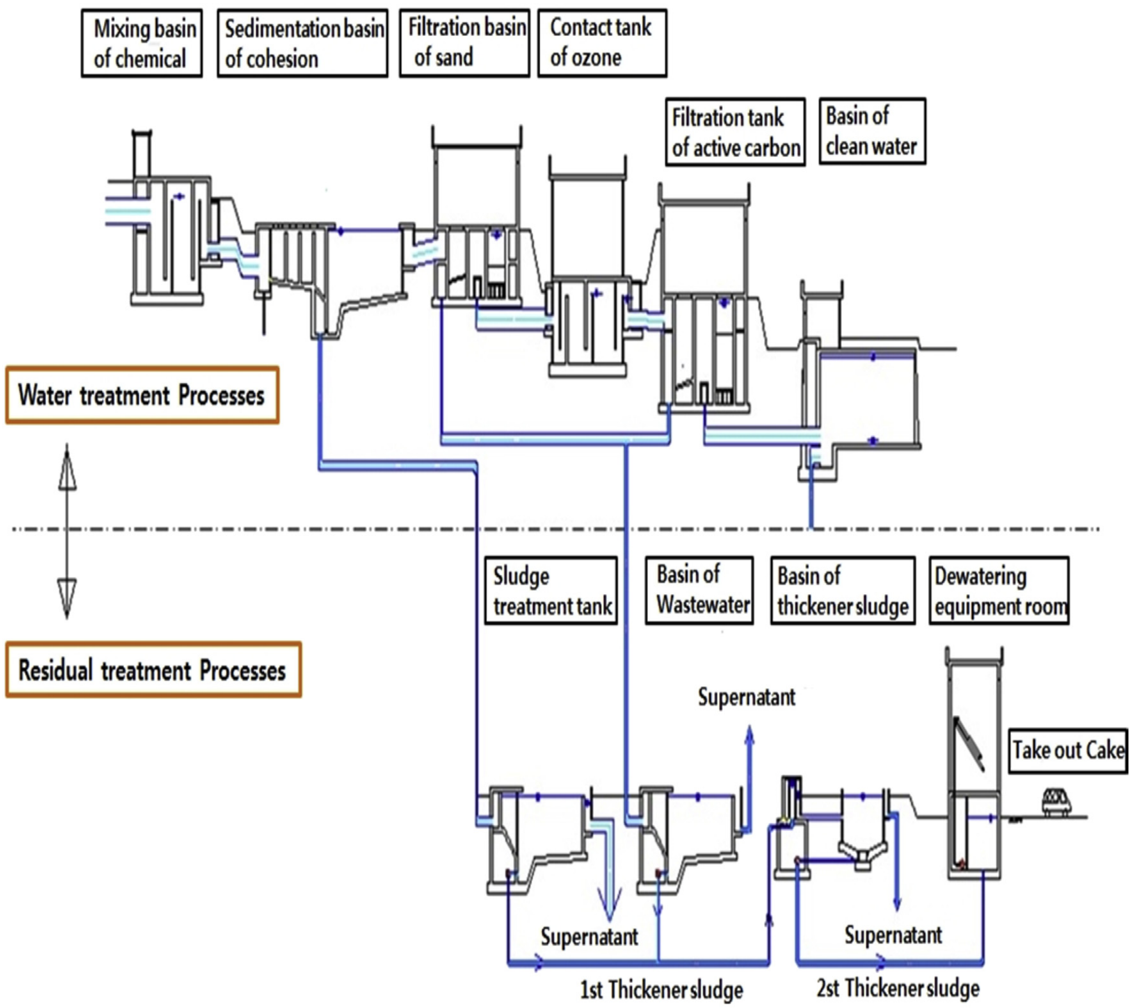

Fig. 1. General processes for water and residuals treatment in water treatment plant.

Materials and methods

The optimal factors of the operation of the ASDS were determined by examining the quality of the backwash residuals and the raw water in the thickener according to the sedimentation time. As shown in Fig. 2, two sedimentation test columns were installed for the column test in the residuals building of the Myeong-dong Water Treatment Plant located at Gimhae in South Korea. The columns were transparent PE cylinders with a 200 mm diameter and a 3000 mm efficient height. For the water quality sampling, sampling holes were made on the column at 600 mm intervals.

As shown in Fig. 2, the two columns were operated in different conditions. The left column had no ASDS, unlike the right column, the treatment efficiency of which was examined. For the water quality sampling, a total of five sampling holes were made at 0.6 m intervals. The two columns were filled with the backwash residuals and the raw water in the thickener (backwash sludge + sedimentation basin sludge), and the turbidity was monitored according to the sedimentation time. To reduce the error in the water quality analysis, the residuals injection speed and quantity for the two columns were kept constant (Yan et al., 2013). The turbidity was measured seven times at 15-min intervals during the 90-min operation. With the treated water sampled 2.4 m from the column, five residuals quality standards–BOD, COD, SS, TN, and TP–were analyzed. In addition, to predict the quality of the recycled water, the supernatant collected from the ASDS of the right column was sampled and analyzed.

As shown in Fig. 3, a pilot-scale ASDS was installed on the residuals basin and the thickener of the residuals building of the Myeong-dong Water treatment Plant in Gimhae, and the quality of the raw water that flowed into the treatment tank, residuals, recycled water, effluent, and dehydrated cake was analyzed. With the raw water that flowed into the water treatment plant (surface water of Nakdong River), the water quality was analyzed twice each month according to the five aforementioned criteria. To analyze the quality of the influent in the residuals treatment facility, the qualities of the backwash residuals and the raw water in the thickener were analyzed in terms of five aforementioned criteria (twice each week). The water quality analysis for the treated water from the residuals treatment facility covered the supernatant in the residuals basin (the recycled water) and the supernatant in the thickener (the effluent). The recycled water was analyzed according to six criteria (the coliform group, BOD, COD, SS, TN, and TP), and the effluent, according to the five aforementioned residuals quality criteria. The water qualities were analyzed according to protocols described in Standard Method for Water and Wastewater (American Public Health Association, 2009).