Feasibility study on membrane capacitive deionization system to highly concentrated sewage and wastewater for controlling phosphorus and nitrogen

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Introduction

Technologies for collecting nutrients (phosphorous and nitrogen) from sewage treatment facilities are distributed worldwide and are thus receiving widespread attention. Among the physical and chemical technologies used to treat nitrogen from water, deaeration, ion exchange system, electrodialysis, reverse osmosis(RO) and evaporation separate and remove nitrogen from sewage instead of decomposing nitrogen. Because high-concentration nitrogen in a different form is generated through such methods, an additional process to treat the residual materials is essential. Furthermore, chemical treatment and other methods including coagulation and adsorption are used to remove phosphorous, which is a substance that causes eutrophication from sewage and wastewater. Therefore, phosphorous can be mixed with various substances and be precipitated and included in sludge similar to other useful substances. In the past, the sludge of wastewater and sewage was perceived as a type of pollutant. Recently, however, its importance as a resource is being emphasized and relevant research on recycling is actively being conducted. This study attempted to apply the capacitive deionization(CDI) process as a suitable alternative over existing technologies in terms of energy efficiency, environmental friendliness, and the efficient removal of phosphorous and nitrogen. CDI technology applies electric energy to adsorb ions on electrode surfaces for removal. This method moves water to be treated between the electrodes and at this time, applies electric energy on the electrodes of both sides to adsorb ions with an electrode and opposite electrode through electric gravitation pull. Through this principle, it is possible to remove ions and when all ions that can adsorb electrodes are adsorbed, the electrodes on each side can be shorted or the opposite potential can be applied to recycle the electrode[1]. Likewise, CDI technology is a process that repeats the production and concentration processes to remove or concentrate dissolved ions. Therefore, this study aimed at verifying the possibility to apply the Membrane Capacitive Deionization(MCDI) process to collect and treat nutrients such as phosphorous and nitrogen within the reject water.

Methods

A single-cell CDI device to collect and treat nutrients such as phosphorous and nitrogen within reject water was configured to evaluate its applicability. The configured single-cell CDI device applies electric energy to the CDI unit cell and for this application, the Potentiostat (WonATech, WMPG100, 15 V, 24 A, Korea), which can analyze the applied quantity of electric charge, was configured. In addition, a TDS meter and pH meter that will measure the TDS of the treated water produced in the single cell were configured and each type of water quality data was collected using a data logger. Electrodes were produced with activated carbon and the valid area of electrodes is 0.01 ㎡. The electrode cell is comprised of two sheets of electrodes and the module configuration was configured by stacking in the order of anode, anion exchange membrane, electrode cell, cation exchange membrane, and cathode. The CDI device operation conditions are as follows. TDS 2,000 mg/L (approximate conductivity of 6,500 us/cm) of reject water was used for influent and was operated with a flux of 10, 20, 30, 40 ml/min, with a voltage supply in stage 1 (adsorption) of 1.5 V for 3 min, and -1.5 V for 3 min for stage 2 (desorption).

Results and Discussion

Figure 1 shows the TDS change curve of effluent according to the operating time. It was found that adsorption and desorption reactions occurred according to the voltage supply per time. Figure 2 shows the ion rejection rate of a maximum T-N 99.1% and T-P 84.9% according to the flux conditions, and it was found that when the flux was lowered with repeated operation, the collection rate increased and the ion rejection rate also increased. It was judged that with the CDI device, it is possible to remove or collect phosphorous and nitrogen ions within the reject water.

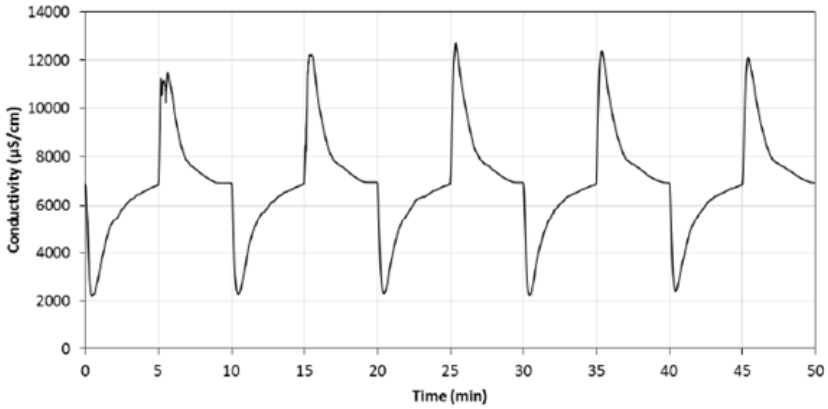
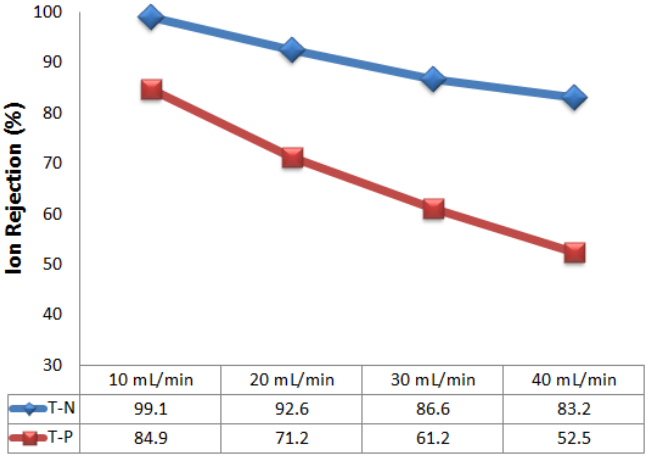


Fig. 1. TDS concentration change curve according to time



	10 mL/min	20 mL/min	30 mL/min	40 mL/min
T-N	99.1	92.6	86.6	83.2
T-P	84.9	71.2	61.2	52.5

Fig. 2. Ion rejection results according to flow rate

Conclusions

This study aimed at evaluating the CDI applicability to treat and collect high-concentration phosphorous and nitrogen in reject water and the technology was found to have ion removal rate results of a maximum T-N 99.1% and T-P 84.9%. Once the optimized operation conditions are deduced through operations per various operating conditions in the future, it is judged that phosphorous and nitrogen ions can be removed or collected within the reject water using the CDI device.

References

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