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Keynote Paper

Development of integrated water technology

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ABSTRACT

Impact of the climate change on water supply continues to dominate the world's science and policy agenda on global warming. The objective of this study is to develop an innovative technology (integrated water technology) which can contribute to reducing greenhouse gases and overcoming water crisis in Korea. Sub-objectives of this study are 1) development of high efficiency and energy saving wastewater system using integrated water technology 2) development of integrated SMART groundwater management system using spectroscopy and molecular dynamics. The study delineates the innovative strategy in terms of stability of water supply, securement of eco-friendly water treatment, conservation of energy and cost, and efficient recovery of energy. This study provides new insights and tools for sustainable integrated water treatment system, an increasingly important issue in view of the countermeasures on climate-change.

1. INTRODUCTION

Recently, climate change due to global warming causes many environmental catastrophes in the world. Losing from 5% to 20% of global gross domestic product (GDP) per year will be equivalent to the overall costs of climate change (Stern 2006). Sustainable water resource management, one of the important issues that are now being faced, is a worldwide problem arising as a result of climate change. According to the IPCC (Intergovernmental Panel on Climate Change) report (IPCC 2008), usable water resources significantly decreases due to contamination of surface water, strong increases in drought/flood frequency, and loss of reliable freshwater as the glacier. Therefore, many countries are zealously pushing forward the development of technologies regarding new water resources and reuse/remediation of contaminated water.

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In Korea, annual precipitation is 1.4 times higher than global average but available water resources per person is one eighth of global average because of Korea's high population density (KMA 2011). Also, total number of raining days in Korea is continuously decreased and amount of rainfall per precipitation increased as a result of climate change impact. Such phenomena are the clear sign that water crisis in Korea is steadily getting worse as time passes. Up to date, wastewater treatment for water reuse and groundwater development as a new water source is the major water sources. However, current wastewater treatment technologies (aerobic digestion) require much input of energy and generate large volumes of sludge. In addition, many groundwater sources have been contaminated by variable organic and inorganic contaminants (Information system of soil and groundwater 2011; MOE 2009; MOE 2010; MOE 2011).

Therefore, we proposed the integrated water technology including wastewater reuse and groundwater remediation/management to secure new water resources in Korea. Through the technology, both clean water and energy/resource recovery can be obtained from wastewater by application of novel reactor and advanced concept membrane. Also, we may be able to use 7 billon m^3 groundwater in Korea by integrated SMART groundwater management system using spectroscopy and molecular dynamics simulation. Molecular dynamic simulation enable remediation/management of the many groundwater pollution episodes and spectroscopy makes possible to sensitively monitor the contaminated groundwater.

2. INTEGRATED WATER TECHNOLOGY

2.1. WASTEWATER

Novel anaerobic membrane bioreactor will be developed based on sulfate-reducing bacteria for wastewater treatment. At the same time, this system can be used for recovering energy in wastewater and generating the electricity and highly valuable product by using by-product, which is produced during the treatment process. In addition, treated water will be recovered and reused. Finally, the reactor can solve the problems of current water treatment system.

The proposed technology is based on SRB-MBR that utilizes exhausted gas-originated SOx as precursor of SO_4^{2-}, which is a terminal electron acceptor. In this reactor, SRB degrades organic BOD in wastewater and reduces SO_4^{2-} into H_2S simultaneously. The generated H_2S is applied to a fuel cell system, recovering both electrical energy and elemental sulfur. The effluent of SRB-MBR and CO_2 is transported to microalgae cultivation system, which consumes N and P sources in wastewater, as well as CO_2, during their growth process. Cultivated microalgae is utilized in harvesting and dewatering processes, and then it is applied to bio-diesel production. Treated water after harvesting and dewatering will be further recovered through NF (Nano-Filtration) and CDI (Capacitive Deionization). In addition, new types of membrane for NF/UF (Ultra-Filtration) and FO (Forward Osmosis), which have resistivity against fouling, will be used to improve the performance of MBR and microalgae harvesting and dewatering.

2.2. GROUNDWATER

Integrated SMART groundwater management system will be developed to selectively remove target contaminants (PCE/TCE, heavy-metals, and U) and monitor their transport in groundwater. The system consists of development of novel nano-material[1)], optimization of reaction parameters using MD simulation[2)], development of module system for various contamination episodes[3)], and implementation of highly sensitive spectroscopic technologies for groundwater monitoring system[4)].

Detailed objectives are 1) Development of eco-friendly nano-material and highly sensitive spectroscopic technology: Various types of biogenic minerals and porous polymer; UV/Vis absorption spectrometer combined with LWCC system and modified fluorescent chemosensors/Au nano-particles for highly sensitive detection of heavy metals. 2) Optimization of reaction parameters using MD simulation: building the database for Ionization/bond energy and charge distribution to determine the most reactive nano- particles for selective degradation of PCE, TCE and long-term reductive stabilization of Cr(VI)/U(VI). The database also can be used for the selection of most effective porous polymers for adsorption/collection of heavy-metal in groundwater. Optimization of reaction parameters is able to be achieved based on results from simulations.

3. CONCLUSION

The ultimate objective of this study is to fundamentally overcome water crisis in Korea through integrated water technology (IWT). This IWT is an innovative strategy in terms of stability of water supply, conservation of energy and cost, and efficient recovery of energy.

The system for wastewater can be processed self-sufficiently due to the production of energy from the by-products, and other additional biomass so that we can reduce environmental concerns and ensure sustainability. The technology is a new paradigm about wastewater in order to upgrade the value of wastewater and to stimulate related researches and technologies. Also, integrated

SMART groundwater management system using spectroscopy and molecular dynamics is highly useful to remediate groundwater in Korea and to prevent further environment contamination. The highly sensitive spectroscopy can enhance the reliability of groundwater quality criteria. In addition, this can be applied for the safety assessment of a deep geological repository for nuclear waste.

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