INVESTIGATION OF NANO ZERO VALENT IRON PERFORMANCE ON THE REMOVAL OF EMERGING CONTAMINANTS FROM WASTEWATER IN CONTINUOUS FLOW EXPERIMENTS

I. Panagou1, M. Kalli1, C. Noutsopoulos1, D. Mamais1, E. Koumaki1, S. Malamis1

1 Sanitary Engineering Laboratory, Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, 15780, Greece, iliana.panagou14@gmail.com, mariax24k@gmail.com, cnoutso@central.ntua.gr, mamais@central.ntua.gr, elenakoumaki@gmail.com, malamis.simos@gmail.com

Abstract

The frequent presence of emerging contaminants in the aquatic environment is nowadays rather concerning. Many of these substances are known to have adverse effects on aquatic life and on human health, even at trace levels. Due to their diverse physicochemical properties, their large number, and the limited knowledge regarding their occurrence and fate, their elimination is quite challenging. Conventional WWTPs have been proved incapable of removing completely these compounds from wastewater, limiting the potential for the reuse of reclaimed water. Thus, the need for investigating new low-costs post-treatment technologies targeted on their removal is urgent. In this scope, nano Zero Valent Iron (nZVI) can be a promising material for removing emerging contaminants from wastewater. Due to its high reactivity and large specific area, it has been successfully employed for removing a wide range of organic and inorganic pollutants both from water and soil. In addition, recent studies indicate that nZVI can be produced by herbal extracts, thus minimizing the cost of treatment. However, experiments exploring the process performance of nZVI in continuous flow systems are still very scarce.

In this study, the utilization of ZVI nanoparticles made of green tea extracts and supported in a host porous matrix was investigated for the removal of selected emerging compounds from wastewater. More specifically, the green method for nZVI synthesis that was followed, included the incorporation of trivalent iron into a cation-exchange resin and then the reduction of the adsorbed trivalent iron Fe(III) to nZVI by polyphenols contained in green tea extracts. After the synthesis, the nZVI material was equally distributed into four identical columns operating under continuous downward flow with the aid of a peristaltic pump. Target compounds, belonging to endocrine disrupting chemicals (EDCs) and non-steroidal anti-inflammatory drugs (NSAIDs), were spiked in the inlet tank and samples were taken at the exit of each column. During the experiments, pH, dissolved oxygen and temperature were monitored at regular intervals. The pilot system treated 26 L d^{-1} of tertiary treated wastewater. The process performance of nZVI was evaluated for four different contact times. Ibuprofen was selected as representatives of NSAIDs, whereas for EDCs, Bisphenol-A was selected.

Results indicated that the removal efficiency of the targeted compounds was maximized at the beginning of the experiments and then it decreased gradually in all columns. In addition,

the pH value was acidic at the beginning of the experiment due to the acidic nature of both the nZVI and the resin, and gradually increased with the increase of the treated volume till it equalized to the pH of the inlet tank's solution, starting from the first to the last column. Furthermore, the dissolved oxygen concentration and the temperature remained constant during the experiments in all columns. For Ibuprofen, the breakthrough of the first column was obtained after 6 hours of continuous operation, whereas for Bisphenol-A, it occurred after 96 hours. Interestingly, the breakthrough for Ibuprofen was approximately at a ratio of treated water volume to pore volume of 200-400 for all the investigated contact times, whereas for Bisphenol-A this ratio was significantly higher. Since the pH increase did not occur simultaneously with the breakthrough of each column for the targeted compounds, it could be assumed that it was resulted mainly by the nZVI-material's saturation.

This study investigated the use of a nZVI-based method, utilizing nZVI made from green tea extracts and supported into a cationic exchange resin to remove selected compounds from wastewater. Based on the results, the nZVI's reactivity was apparent for the selected NSAID but it diminished after 6 - 30 hours of treatment, indicating that larger amount of nZVI is necessary in order to obtain breakthrough at a larger operation time. This fact could minimize the economic advantages of the use of 'green produced' nZVI. However, for Bisphenol-A, the nZVI performance was rather satisfying. Nevertheless, further research for developing and optimizing the use of nZVI in continuous flow systems is needed in order to identify the limitations of the nZVI-based treatment process and obtain its full potential.

Keywords: nano Zero Valent Iron, emerging contaminants, green synthesis, endocrine disrupting chemicals, non-steroidal anti-inflammatory drugs

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