EFFICACY OF MODIFIED REDUCTIVE NANO IRON POWDERS (RNIPs) FOR PFAS AND Cr(VI) REDUCTION FROM AQUEOUS SOLUTION

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INTRODUCTION

The aim of this presentation is to explore the efficacy of modified Reductive Nano Iron Powders (RNIP), produced by Nakamurakiso Group Co. Ltd, Hiroshima, Japan, for the groundwater remediations focusing on various concerning pollutants in aquatic systems worldwide. Groundwater quality deterioration due to exposure to different agricultural, industrial, mining, and municipal solid waste contaminants has caused severe threats to humans, environment, and ecology. The degradation in groundwater quality due to industrial, urban sewage, and agricultural runoff is of grave concern. Given the increasing demand for groundwater and its high vulnerability to contamination, proper management of groundwater resources is necessary. Zero-valent iron (ZVI) has been reported as a successful remediation agent for environmental issues, being extensively used in soil and groundwater remediation. Further, zero-valent nanoparticles (NZVIs) have arisen as a highly effective method due to their high specific surface area (Singh and Bose, 2016). NZVI has already been proven to be a highly effective method to remediate a variety of contaminated sites worldwide, targeting chlorinated hydrocarbons, heavy metals, perchlorate, etc., from groundwater under appropriate conditions due to its high reductive capacity and a benign environmental impact. RNIP is also one of the commercially acceptable NZVI for the remediation of various contaminated sites worldwide (Kim et al., 2010). In the last two decades, RNIP has already been applied for the remediation of chlorinated volatile organic compounds (cVOCs) discharging from pharmacy, machinery, chemical, and electronic device factories. Post-application, RNIP successfully remediated all these contaminated sites within the desired limit through mixing and injection techniques. Hence, the demand for exploring the efficacy of RNIP towards the treatment of other concerning contaminants, such as heavy metals, per- and polyfluoroalkyl substances (PFAS), and other emerging pollutants, from contaminated sites is significantly required. Therefore, Nakamurakiso Group Co. has prepared the modified RNIP in composition with activated carbon (AC), which could work for efficient treatment of these concerning contaminants from various groundwater and soil remediation fields around the world. Therefore, this study explored the utilization feasibility of newly modified NZVI/AC composite RNIP for the degradation of PFAS and hexavalent chromium (Cr(VI)) from the contaminated groundwater.

METHODS

This study has examined the efficacy of newly developed NZVI/AC composite RNIP for the removal of PFAS and Cr(VI). The removal of the pollutants was carried out by a combination of adsorption, degradation and / or co-precipitation processes employing multiple short-term batch experiments (lab scale). The efficacy of NZVI/AC composite RNIP was checked at various different scenarios, i.e., dosage of modified RNIP, initial concentrations of PFAS and Cr(VI), at different pH levels and under buffer conditions.

RESULTS AND DISCUSSIONS

Newly modified NZVI/AC composite RNIP is highly efficient for the complete removal of PFAS and Cr(VI), as shown in Fig. 1 and Fig. 2, respectively, at various extreme scenarios.

Higher concentration of PFAS and hyperalkaline medium of Cr(VI), pH > 10, in aqueous solution are very recalcitrant to remediate. However, NZVI/AC composite RNIP showed a high potential to remediate these contaminants, compared to existing RNIP, with 100 % removal efficacy in the aqueous solution under the highly defiant pollution conditions. Even at a very lower dosage of 0.5 g/L modified RNIP Cr(VI) and PFAS both are effectively removed from the aqueous solution, and the removal efficiency is extremely high compared to previous commercial RNIP. Therefore, it increases the viability of modified RNIP for the treatment of various contaminated sites of Cr(VI) and PFAS worldwide on a field-scale.

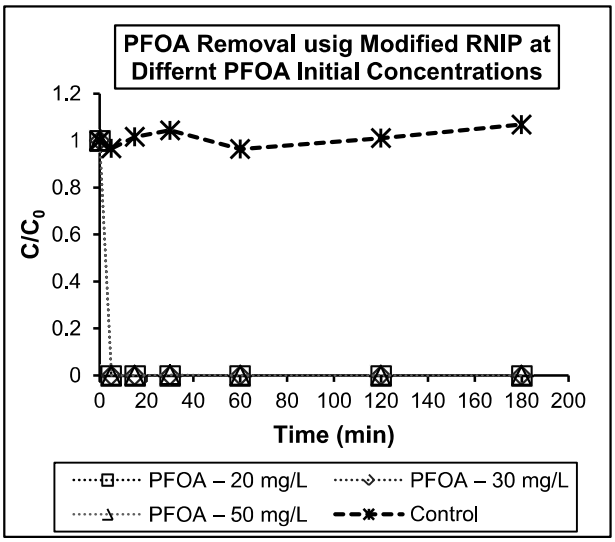

Fig. 1. Efficacy of modified RNIP in PFOA removal for three different PFOA concentrations, i.e., 20 mg/L, 30 mg/L, and50 mg/L, with constant dosage of modified RNIP – 10 g/L, and mixing speed – 300 rpm, in PFOA spiked aqueous solution.

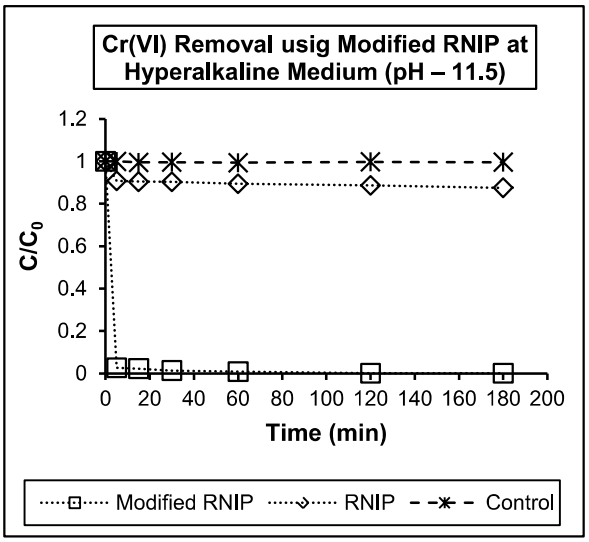

Fig. 2. Comparative Efficacy of modified RNIP over RNIP for Cr(VI) removal at hyperalkaline aqueous medium with pH – 11.5, with constant dosage of modified RNIP – 10 g/L & RNIP – 100 g/L, initial concentration of Cr(VI) – 50 mg/L, and mixing speed – 300 rpm.

CONCLUSIONS

Compared to other ZVIs brands, NZVI/AC composite RNIP proved highly reactive for Cr(VI) and PFAS removal from aqueous solution. This modified NZVI/AC composite RNIP could be proved as a booster for covering a big market of groundwater and soil remediation in Asia-Pacific, Europe, and other parts of the world. The low cost of modified NZVI/AC composite RNIP could be taken hand to hand in various developing as well as in developed countries for the remediation of heavy metals, PFAS and other emerging pollutants, respectively, due to their growing demands for the treatment for a variety of contaminated sites.

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