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Opinion

Cost-Effective Environmental Remediation - Emerging Trend of Green Synthesis

Ahmad F and Ahmad S*

Center of Excellence in Nanotechnology, India

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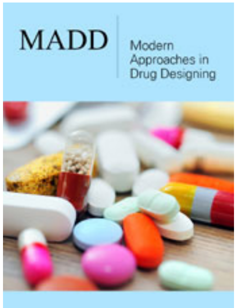

***Corresponding author:** Ahmad S, Center of Excellence in Nanotechnology, New Delhi, India

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Opinion

Anthropogenic pollutions of the hydrosphere and lithosphere has been emerging as a growing concern globally for sustainable development and human health. Current industrial activities with abandoned plants and mining sites in addition to everyday life has been a continuous source of environment pollution. In the context of growing need of cleaning the industrial and municipal effluents and remediating contaminated soil and groundwater, nanosized Zero-Valent Iron (nZVI) appears an emerging material due to its high reactivity and expected low impact on the environment due to higher abundance of iron in the earth crust. For testing the effectiveness of nZVI in contaminant removal from water and soil and to modify its physicochemical properties of this material a number of studies including field applications, and investigations for the environmental impact are growing fast.

Iron, being available in abundance in the earth crust, has been acquiring more and more importance in environmental remediation based on nano production of nZVI possessing different properties compared to the bulk iron. It is being considered as one of the important engineered nanomaterials very well suited for environmental remediation due to its relatively lower cost, higher reactivity, and good adsorption capacity. Having strong reducing power and sufficiently reactivity toward organic and inorganic compounds such as halogenated hydrocarbons, organic dyes, antibiotics, heavy metal ions and similar others, nZVI reacts with oxygen and water resulting in fast agglomerations. Consequently, these NPs are capped with various inorganic and organic materials or supported on various substrates reducing the reactivity to some extent. The advantages arising from nanoparticulate morphologies, however, get slightly reduced at the cost of enhanced stability and transport properties, what is essential for soil and groundwater, remediations Machado et al. [1], Zou et al. [2], Liu et al. [3], Phenrat et al. [4], Pasinszki et al. [5] and Tarekegn et al. [6].

A low-cost and environment friendly procedure for synthesizing nZVI was reported using some plant extracts to reduce iron to nZVI. The iron ion solution is mixed to the boiling plant extract that reduces iron to nZVI in the presence of polyphenols in which the extract serves both as reducing and capping agent producing spherical nZVI in the size range from 5 to 15 nm Plachtová et al. [7], Puthukkara et al. [8] and Tarekegn et al. [6]. In another study, a novel method was reported using mango peel extracts. The surface structure and composition of the synthesised NPs was carried out using XPS and FTIR. Depth profiling (XPS) indicated increasing intensity of FeO while the portion of Fe^{+2}/Fe^{+3} and the dominant species (i.e., C and O) were decreasing. The structural form of nZVI has a polyphenol layer followed by the oxides and hydroxides of iron onto the metallic iron, which has a shell structure of 'Fe^{+3}/Fe^{+2}-polyphenol' complex islands on the core metallic iron. The use of mango peel in the synthesis is a low-cost approach and economically viable providing new insight of waste recycling and nano remediation Desalegn et al. [9]. Aqueous seeds extract of Ricinus communis (RC) was used in another study to reduce and encapsulate nZVI-NPs that were characterised by steady-state absorption, SEM, TEM, FT-IR, EDS, XRD, XPS, and zeta potential. The maximum efficiency of methylene blue removal was 96.8% at pH 6 and 25 °C. The synthesized nZVI possesses good reusability and can be considered as a potential economic and environmentally friendly adsorbent Abdelfatah et al. [10].

The antibacterial properties from adsorption and penetration of nZVI on bacterial cell membranes block the cellular ducts causing structural changes or inhibiting mobility and nutrient intake resulting into bacterial death. Moreover, ROS generation in presence of nZVI causing accumulating in the cell denature the macromolecules like lipids, proteins, and nucleic acids, and damage intracellular structures finally ending up in cell death. Further studies in this context suggested both modifications and limiting the direct contact of the nZVI surface with cells reduce the toxicity.

The challenges met during the use of nZVI are rapid aggregation of the NPs, passivation, sorption to other materials and rapid sedimentation that consequently limit the mobility of NPs in the aquatic environment. Pure nZVI agglomerates easily. It is also very sensitive towards oxidation and reduces the electron donation during remediation of heavy metal containing wastewater. nZVI can be prepared in many ways, however, it is easily oxidized and difficult to preserve. Many of the preparation methods take place under strict conditions, and hence, it is very difficult to go for large-scale production. However, in general, it is a very promising reducing agent for cationic pollutants such as metal ions and cationic dyes, which can also be used in other heavy metal remediations. The heavy metal removal mechanisms are limited not only to reduction and adsorption but also to oxidation.

Increasing number of theoretical and empirical evidence are there to prove nZVI as effective and versatile for the treatment of contaminated water. The sorption, complexation and reduction processes played a great role for the removal of heavy metals. In recent years, there have been significant innovations in terms of manufacture techniques, physicochemical functionalisation and enhancements in sub-surface stability of nZVI. The tests that have been done on the removal activity of Pb, Cd and Cu showed the possibility of applying nZVI-NPs at field scale.

Various pilot-scale studies of removing the heavy metals were conducted in the context of green chemistry by treating the wastewater and recovering the heavy metals operating in continuous mode. To make the process affordable, nZVI was recirculated and reused. The results from practical pilot tests suggested that this nZVI process is much more efficient than conventional technologies of wastewater treatment, and some economic minerals such as copper could be easily recovered from the wastewater using this process Qasem et al. [11]. Development of green synthesis of nZVI is emerging with promising test results. Further studies are necessary to understand the processes involved in controlled synthesis of nZVI are expected to handle the large-scale processes of environmental remediations at affordable cost.

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References

1. Machado S, Pacheco JG (2016) Nanoremediation with zero-valent iron nanoparticles in from soil remediation. In: Albergaria JT, Nouws HPA (Eds.), CRC Press. (1st edn), Boca Raton, FL, USA, pp.108-120.
2. Zou Y, Wang X, Khan A, Wang P, Liu Y, et al. (2016) Environmental remediation and application of nanoscale zerovalent iron and its composites for the removal of heavy metal ions: A Review Environ Sci Technol 50(14): 7290-7304.
3. Liu P, Hong Y (2017) Magnetic nanomaterials for water remediation in magnetic nanomaterials. In: Hou Y, Sellmyer DJ (Eds.), Wiley-VCH Verlag GmbH & Co. (1st edn), New York, NY, USA, pp. 515-546.
4. Phenrat T, Lowry GV (2019) Nanoscale Zerovalent Iron Particles for Environmental Restoration, Fundamental Science to Field Scale Engineering Applications. In: Phenrat T, Lowry GV (Eds.), Springer International Publishing AG, Cham, Switzerland.
5. Pasinszki T, Krebsz M (2020) Synthesis and application of zero-valent iron nanoparticles in water treatment, environmental remediation, catalysis, and their biological effects. Nanomaterials 10(5): 917.
6. Tarekegn MM, Hiruy AM, Dekebo AH (2021) Nano zero valent iron (nZVI) particles for the removal of heavy metals (Cd^{2+}, Cu^{2+} and Pb^{2+}) from aqueous solutions. RSC Adv 11(43): 18539-18551.
7. Plachtová P, Medříková Z, Zbořil R, Tuček J, Varma RS, et al. (2018) Iron and iron oxide nanoparticles synthesized using green tea extract: Improved ecotoxicological profile and ability to degrade malachite green. ACS Sustain Chem Eng 6: 8679-8687.
8. Puthukkara PAR, Jose TS, Dinoop lal S (2020) Plant mediated synthesis of zero valent iron nanoparticles and its application in water treatment. J Environmental Chemical Engineering 9(1): 104569.
9. Desalegn B, Megharaj M, Chen Z, Naidu R (2019) Green synthesis of zero valent iron nanoparticle using mango peel extract and surface characterization using XPS and GC-MS. Heylion 5(5): e01750.
10. Abdelfatah AM, Fawzy M, Eltaweil AS, El-Khouly ME (2021) Green synthesis of nano-zero-valent iron using ricinus communis seeds extract: Characterization and application in the treatment of methylene blue-polluted water. ACS Omega 6(39): 25397-25411.
11. Qasem NAA, Mohammed RH, Lawal DU (2021) Removal of heavy metal ions from wastewater: A comprehensive and critical review. NPJ Clean Water 4: 36.