Editorial

Magnetic Nanoparticles are an Excellent Remedy for Wastewater Treatment?

Janardhan Reddy Koduru, Kwangwoon University, Seoul, Korea
https://orcid.org/0000-0002-0000-1519

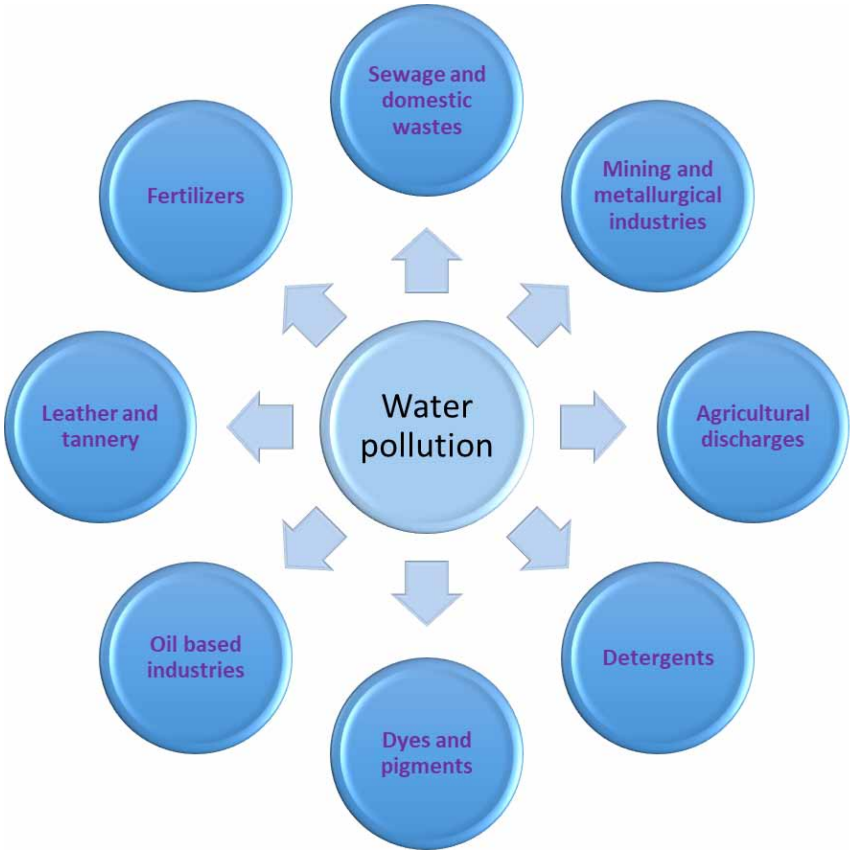
INTRODUCTION

As the population is rising, natural resources are being depleted continuously to cater to the needs of the vastly growing population. At the same time, Industrialisation and urbanization are also advancing at a rapid pace. However, industrial growth over the years has led to the release and accumulation of pollutants and hazardous chemicals in the air, water, and land, thereby contaminating them. Rapid urbanization is also contributing extensively to the production of wastewater, which mostly ends up untreated in water bodies, leading to water pollution (See Figure 1). Currently, water pollution is a global environmental concern and concentration of toxic pollutants in the water bodies are well above the limits defined by the World Health Organization and environmental protection agencies. Wastewater is quite dangerous because polluted water is harmful to human health and poses a severe threat to aquatic animals. It has been reported that nearly 10–20 million people die each year due to waterborne diseases (Leonard et al., 2003). People require pure freshwater for various domestic purposes (cooking, drinking, washing, etc.), so a system of adequate wastewater treatment is the need for everyone because the amount of freshwater on the planet is reducing steadily. Purification of wastewater could be a promising approach to mitigating this challenge. Therefore, the development of advanced technologies for the treatment of wastewater and supply of potable water from water bodies is essential.

Generally, various chemicals and microorganisms contaminated wastewater is more risk to human life. That is why there are several stages of water treatment: chemical, physical, and biological. The more significant part of the wastewater is treatment is treated in the unique wastewater treatment plants that purify water with the help of the various treatment methods. The water is filtered, treated by chemical and physical processes; there are supplied to the consumers all the time. Unfortunately, only a satisfied percent of wastewater is treated somehow, because the more significant part is discharged into the rivers, lake, or mixes with underwater, and as a result, the image of global water pollution is terrible.

The conventional wastewater purification techniques, including chemical coagulation, photodegradation, precipitation, flocculation, activated sludge, membrane separation, reverse osmosis, ion exchange, electrodialysis, electrolysis, and adsorption. According to the type of contamination in the wastewater, various forms of its treatment are practiced. Among these, reverse osmosis, ion exchange, electrodialysis, and electrolysis are costly technologies with a 10–450 US$ per million-liter cost for treated water. The cost of treated water by adsorption varies from 10 to 200 US$ per million liters. Adsorption is a fast, inexpensive, and widely applicable technique. Moreover, it is widely used, as it can be applied for the removal of soluble and insoluble contaminants as well as biological pollutants with a removal efficiency of 90–99%. At an industrial level, pollutants are removed from

Figure 1. Various sources of water pollution



water by using columns and contractors filled with suitable adsorbents — adsorption used for source reduction, reclamation for potable, industrial, and other purposes. Hence, the adsorption technique has been used widely for water treatment by adsorption.

However, the greatest hindrance in adapting this technique in the process industries was the highest cost of adsorbents available in the market, despite various available adsorbent regeneration techniques. The applications of adsorption processes can be increased by reducing the cost of adsorption. Therefore, there is a massive demand from the market to explore quickly and low-cost available adsorbents, especially from oil refineries, petrochemical, and pharmaceutical industries that produce major chromium contaminated effluents, besides other small/medium scale industries. These adsorbents can be from biomass and agricultural waste products (Sahu et al., 2009; Toor et al., 2015; Hamed et al., 2014; Karri et al., 2017). Many studies devoted to production of activated carbon from agricultural waste products were mostly focused on the preparation of high-quality activated carbon (Karri et al., 2017; Karri et al., 2017; Karri & Sahu 2018; Karri & Sahu 2018). Moreover, the use of activated carbon in the adsorption process is effective, but its applications are limited due to the complicated installation process, along with high operating costs. Hence, these drawbacks have necessitated the search for an alternative material that can be renewable and economical for water purification. Hence, recently activated carbons are impregnated with iron oxide nanoparticles have been widely used for removal of organic and inorganic pollutants and showed an excellent efficiency and enhanced removal capacity for pollutants (Park et al., 2015; Lingamdinne et al., 2019; Mishra et al., 2019).

Graphene and graphene oxide (GO) are widely used in various applications because they offer unique physical-chemical properties, including high specific surface area, electrical and thermal conductivity, and high potential adsorption capacity (Lingamdinne et al., 2018; Lingamdinne et al., 2018). Due to its imperishable hydrophilicity, GO has found to be a better material for use in many wastewater treatment applications. However, GO having high dispersibility, which leads to difficulty in separating GO from aqueous solution even after adsorption of pollutants. The magnetization of GO is the best solution to avoid the above problem, whereby using the external magnetic field, magnetized GO can be easily separated. Besides, magnetic materials not only have the advantage to easy and rapid separate from aqueous solution but also shows high adsorption capability towards pollutant (Lingamdinne et al., 2019; Koduru et al., 2019).

Magnetic nanoparticles (NPs) are fascinating due to their multiple properties, such as significant surface-to-volume ratio, interaction, magnetic separation, specificity, and surface chemistry. Magnetic NPs, in particular, nano zero-valent iron, magnetite, and maghemite have sparked the application in medicine, molecular biology, and remediation of polluted water (Ashraf et al., 2019; Bhateria & Singh 2019; Lingamdinne et al., 2017). In most circumstances, magnetite or maghemite is used to form the core of magnetic iron oxide nanoparticles. Magnetic iron oxide nanoparticles may be broadly divided into three main classes: paramagnetic, ferromagnetic and superparamagnetic behavior, Paramagnetic behavior denotes that the magnetic dipoles are oriented in random directions at average temperatures due to unpaired electrons, which causes a low positive susceptibility (weak interaction) in a magnetic field. Ferromagnetic materials depend on their domain structure to remain magnetized even in the absence of an applied magnetic field, but size decreases to less than the domain size when they undergo a significant change. Superparamagnetism tends to have more substantial magnetic susceptibility than paramagnets since the magnetic moment of the entire nanoparticle aligns in the direction of the magnetic field (Lingamdinne et al., 2017; Devi et al., 2019).

Generally, magnetic NPs are surface modified with carboxyl, hydroxyl, and amino groups for their specific interactions. For example, magnetic NPs can be capped with either a positive or negative charge material through surface chemistry in order to increase their stability. Recent studies revealed that microemulsion prepared magnetic iron oxide nanoparticles with protein binding resulted in a reduction of suspended particles and microbes (Lakshmanan et al., 2013; Okoli et al., 2012; Seifan et al., 2018). Adsorption of heavy metals such as copper, cadmium, nickel, zinc, arsenic, and lead from aqueous solution using carboxyl, amino, and thiol functionalized magnetic NPs (Guo et al., 2014; Xu et al., 2018). Therefore, functionalized magnetic NPs have a high degree of interaction and the ability to remove specific contaminant wastewater.

To this end, magnetic nanoparticles can be an excellent remedy for the treatment of polluted water to obtain clean and safe potable water.

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Janardhan Reddy Koduru (PhD) is currently associate professor of Environmental Engineering at Kwangwoon University, Seoul, Korea. He received Ph.D. in Chemistry in 2007 from S.V. University, Tirupati, A.P., India. After his post-doctoral fellowship (2008–2010) at Kyungpook National University, Korea, he worked as assistant professor of Chemistry and Environmental Engineering at Dongguk University, Kwangwoon University South Korea (2011–2016), respectively. His research interests include the development of low-toxicity nanocomposites for sustainable energy and environmental remediation. He received many prestigious awards from various academic agencies; include CSIR-SRF, Aufau International Young Scientist in Chemical and Environmental Sciences, the Environmentalist of the Year 2016 from NESA and Publons peer review awards. His biography recognized by Marquis Who's Who in the World and published in 33rd Edition. He has published over 75 papers and submitted three Korean patents. He has received many academic presentation awards from various conference organizations and associated with many societies and journals as a life member, an editorial board member, and an editorial advisor.