

## Wastewater Treatment Using Nanoparticles

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### Abstract

Now-a-days the water treatment became the most worried topic all over the world. Increase in the population and industrialization resulting into the contamination of the water (reservoir and ground water). Therefore it is necessary to purify and recycle the industrial as well as the municipal waste water. From last decade the use of nanoparticles for water treatment have gained the special attention due to its property being highly profitable as an adsorbents and for using for filtration purpose. Further the type Magnetic Nanoparticles (MNPs) also possesses the properties like high surface area and being the super-magnetic in nature. The magnetic property of separation is useful by applying external magnetic field to them. Thus the MNPs are also being used for the removal of the toxic heavy metals/elements like cations, natural organic matter, biological contaminants, and organic pollutants, Nitrates, Fluoride and Arsenic from the contaminated water. The MNPs can be synthesized by various methods like mechanical grinding etc. Among the available different technologies, adsorption by MNPs is one of the best due to its easy handling, low cost and high efficiency. The environmental fate and toxicity of a material are critical issues in materials selection and design for water treatment.

**Keywords:** Nanoparticles; MNPs; Adsorbent; Toxic heavy metals; Nanofiltration

### Introduction

#### What are nanoparticles?

“Nano” is derived from the Greek word for dwarf. A nanometer is one billionth of meter ( $10^{-9}$ ) and might be represented by the length of ten hydrogen atoms lined up in a row. The several advances were made in the study of nano-scale structures, but the term nano-technology was first defined by Taniguchi as “Nano-technology mainly consist of the processing of, separation, consolidation, and deformation of materials by one atom or one molecule” the tools and the methods for nano technology involve imaging, measuring, modeling, and manipulating matter at the nanoscale. Diagnosis of particles at the nanoscale level contributed extensively to the production, modification and shaping of structures that were used in different industrial, health and environmental applications [1-4].

#### Need for water treatment

Water being a primary natural source, a basic human need and a precious national asset, its use needs appropriate planning, development and management, thus access to safe drinking water is necessary to protect public health. Despite environmental pollutants possess serious threats to freshwater supply, living organisms, and public health.

Contamination of water with toxic metal ions (Hg(II), Pb(II), Cr(III), Cr(VI), Ni(II), Co(II), Cu(II), Cd(II), Ag(I), As(V) and As(III)) is becoming a severe environmental and public health problem. In order to achieve environmental detoxification, various techniques like adsorption, precipitation, ion exchange, reverse osmosis, electrochemical treatments, membrane filtration, evaporation, flotation, oxidation and biosorption processes are extensively used. Among these, adsorption is a conventional but efficient technique to remove toxic metal ions and bacterial pathogens from water with the help of magnetic nanoparticles.

Nano-structured materials such as magnetic nanoparticle, carbon nanotubes, silver-impregnated cyclodextrin Nano-composites, Nano structured iron zeolite, carbon-iron nanoparticles, photocatalytic titania nanoparticles, nanofiltration membranes and functionalized silica

nanoparticles can be employed in water treatment to remove heavy metals, sediments, chemical effluents, charged particles, bacteria and other pathogens.

In particular, the use of magnetic nanoparticles as adsorbents in water treatment provides a convenient approach for separating and removing the contaminants by applying external magnetic fields. Thus, for the application of these nanoparticles in various potential fields the stabilization of the iron oxide particles by surface modification is desirable. The magnetic structure of the surface layer, which is usually greatly different from that in the core of the nanoparticles, can have a notable effect on the magnetic properties of nanoparticles. The control of the size and the polydispersity are also very important because the properties of the nanocrystals strongly depend upon the dimension of the nanoparticles. The magnetite particles with size of less than 30 nm have a large surface area and exhibit super paramagnetic properties that make them prone to magnetic fields and they do not become permanently magnetized without an external magnetic field to support them. These properties are highly useful in the development of novel separation processes.

#### Synthesis of nanoparticles

Magnetic nanoparticles have been synthesized with number of different compositions and phases, including iron oxides, such as  $Fe_3O_4$  and  $\gamma-Fe_2O_3$ , pure metals, such as Fe and Co, spinel-type ferromagnets, such as  $MgFe_2O_4$ ,  $MnFe_2O_4$ , and  $CoFe_2O_4$ , as well as alloys, such as  $CoPt_3$  and  $FePt$ . In the last decades, much research has been done for the synthesis of magnetic nanoparticles. Especially, it describes deficient synthetic routes to shape-controlled, highly stable, and monodisperse magnetic nanoparticles. Several popular methods

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including mechanical grinding, wet chemical method, sol-gel process, laser pyrolysis, Co-precipitation method, and template method techniques can all be directed at the synthesis of high-quality magnetic nanoparticles.

### Benefits of water treatment nanofiltration

- Lower operating costs,
- Lower energy costs,
- Lower discharge and less wastewater than reverse osmosis,
- Reduction of total dissolved solids (TDS) content of slightly brackish water,
- Reduction of pesticides and VOCs (organic chemicals),
- Reduction of heavy metals,
- Reductions of nitrates and sulfates,
- Reduction color, tannins, and turbidity,
- Hard water softening,
- Being chemical-free (i.e., does not use salts or chemicals), and
- Water pH after nanofiltration is typically non aggressive.

### Experimental setup for NF

The feed was taken from the feed tank and was pumped into the module. The filtration unit used in the system consisted of two stacks of plate-frame membrane modules, which was placed in series and had a total effective filtrating area of 36 cm<sup>2</sup>. The pressure difference between the feed inlet and the outlet during operation was normally from 0.005 to 0.015 MPa, therefore it could be omitted in calculation. Impurity was retained by the membrane to form a concentrated and the rest passes through the membrane becoming permeate stream. The rate of the permeate stream was measured by a rotameter and a gauged cylinder. The concentrate was then mixed with secondary effluent and returned to the feed tank to keep the mass balance (Figure 1) [5-7].

A self-made cellulose acetate Nanofiltration membrane is used in the experiment. The feed solution was prepared using three salts. The

pure distilled water was first used to measure the water permeability coefficient of membrane, M KW. Then, the synthetic wastewater of Na<sub>2</sub>SO<sub>4</sub> solution with a mass concentration of 0.15% was tested and aimed to obtain KW. Finally, the secondary effluent from a wastewater treatment plant after pretreatment was mainly used as the raw feed. During experiment, different feeds were tested in a range of pressure by changing the concentrate/permeate ratio to evaluate the performance of membranes. At stable operation, the experiments were carried out at operating pressure of 1.4 MPa. The samples from the permeate and the concentrate were picked up simultaneously during operations for analysis. Metallic ions determined by an ionic chromatography with conductivity detection.

### Conclusion

While nanotechnology is considered to be the new era by many scientists, information related to the subject remains largely unknown to many of the folk's because of novelty of the technology. But as we see, in future the Nano materials will be used in large amount for the purpose of water purification and treatment. Therefore this eureka will be considered as great milestone in the 21<sup>st</sup> century. Membrane process like NF is becoming the standardized water purification technique for public utilities and industry because it is flexible, intense and relatively easy to operate and maintain. Thus further laboratory investigations and pilot scale testing will be needed to integrate novel nanostructured membranes into existing water purification systems. Also the environmental destiny and toxicity of a material are the things to be taken in consideration in material selection and design for water treatment system.

MNPs were powerful tools to remove heavy metal from drinking water with high efficiency and low significant toxicity. MNPs are therefore suitable for the removal of various heavy metals like As. Compared to other disinfection technologies, MNPs disinfection is cost-effective and easy to operate, with bright future for its engineering application. The features of MNPs address the challenges of drinking water safety in rural areas of developing countries where are lack of resources and appropriate technology in water treatment. It is particularly suitable for small scale water treatment systems serving a population of between 500-1000 people and is an ideal emerging technology to provide clean water to these areas.

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