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Waste-water Treatment Using Nano-particles

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ABSTRACT

In this modern era, nanotechnology is offering great potential for the treatment of wastewater in an extraordinary way as compared to the commercial methods. Traditional wastewater treatments involve high costs and deal with heavy metals. Use of nanomaterials for cleaning wastewater is a recent approach. On the contrary, use of various novel nanomaterials synthesized in-situ for the treatment of wastewater reduced with different pollutants, such as organic and inorganic content, toxic heavy metal ions have been exemplified, due to their unique activity towards contaminants. The fields of Nano-biotechnology and nanotechnology are under active research for the application of wastewater treatment. Nanoparticles consist of many strategies such as ultrafiltration membrane, osmosis, and sorption, Nano-filtration degradation, advanced oxidation process and water remediation as well as disinfection through nanomaterials. In wastewater, the eliminating contaminant concentration efficiency of nanoparticles is dependent upon the physical and chemical characteristics of nanomaterial, the contaminant, and wastewater. Actually various nanoparticles channel with nanofibers, and carbon nanotubes are one of the developing items which are used as a part of nanotechnology.

1 Introduction:

Water pollution is a major problem nowadays throughout the world. Water is polluted by sources such as industries, poultry, houses, factories etc. This polluted water caused hazard for health, population, social and economic problems. There are several ways to control this problem. There is one of the recent treatments used in treating the wastewater is nanotechnology.

Water is one of the most important resources for sustaining human life. Reliable and sustainable supply of water is one of the most basic humanitarian goals and yet remains a challenge to meet globally. Water on earth is one of the most abundant natural resources, but only about 1% of that resource is available for human consumption. Nanotechnology holds great potential in advancing water and wastewater treatment to improve treatment efficiency as well as to augment water supply through safe use of unconventional water sources. The major challenge in water supply chain is continuous contamination of freshwater resources by a variety of organic and inorganic pollutants. The existing technologies of wastewater treatments have several drawbacks such as high-energy requirement, incomplete pollutant removal and generation of toxic sludge. Among the various emerging technologies, the advancement in nanotechnology has proved an incredible potential for the remediation of wastewater and various other environmental problems.

The nanoparticles are those that have structure components with one dimension at least less than 100 nm. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and other properties emerge.

As the most prevalent morphology of nanomaterials used in consumer products, nanoparticles have an enormous range of potential and actual applications. Table below summarizes the most common nanoparticles used in various product types available on the global markets.

Clay nanoparticles, when incorporated into polymer matrices, increase reinforcement, leading to stronger plastics, verifiable by a higher glass transition temperature and other mechanical property tests. These nanoparticles are hard, and impart their properties to the polymer (plastic). Nanoparticles have also been attached to textile fibers in order to create smart and functional clothing.

The inclusion of nanoparticles in a solid or liquid medium can substantially change its mechanical properties, such as elasticity, plasticity, viscosity, compressibility.

Being smaller than the wavelengths of visible light, nanoparticles can be dispersed in transparent media without affecting its transparency at those wavelengths. This property is exploited in many applications, such as photo-catalysis.

Nanoscale particles are used in biomedical applications as drug carriers or imaging contrast agents.

2 Need of Study:

Nanotechnology is the field of nanoscience, the phenomena applied on a nanometer scale level. Nano-materials are the smallest structures that humans have developed, having size of a few nanometers. Nano-materials have been developed in variety of forms such as nanowires, nanotubes, films, particles, quantum dots and colloids. In wastewater treatment application, a variety of efficient, eco-friendly and cost-effective nanomaterials have been developed having unique functionalities for potential decontamination of industrial effluents, surface water, ground water and drinking water.

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The particle which is used in nanotechnology is very lesser size say lesser than 100nm. Nanoparticles has big absorbing, interacting and reacting capabilities due to its small size with aqueous suspension and thus can behave like colloid. The method of synthesis, application of nanoparticle mainly depends on the field at which it is used.

3 Literature Review:

D.Sivakumar, 2014 [01] found the nanoparticle as a field with greater scope in a variety of fields. Nanoparticle based treatment ensure eco-friendly, environmental friendly, cost-effective, energy and time saving approaches when compared to the traditional and conventional methods of waste water treatment. Few types of nanoparticles such as silver nanoparticle, titanium di oxide nanoparticle, iron nanoparticle, gold nanoparticle and carbonaceous nanoparticle are discussed so far. Apart from the above, there are other types of nanoparticles such as dendrimers, zeolites, copper nanoparticles etc. The choice of the type of the nanoparticle depends on the locality, availability, feasibility, economic conditions for the particular problem. The main advantages of using nanoparticles are large surface area and hence often able to react very quickly, the best example for this type is silver nanoparticle. Nanoparticle has its own drawback such as its uncertainty about the facts revealed so far, since this topic of nanotechnology is still under research. One research in BBC reveals in a report from 2011-12, total market of emerging nanotechnology products used in water treatment which includes Nano sorbents, will be around 80 million euro in 2015. Large scale of usage of nanoparticles such as Nano sorbents will be expected only in another 10 years of research.

Arijit Basu, 2017 [02] studied about the water purification technologies that provide high-quality drinking water, remove micro pollutants, and intensify the industrial processes. Nanotechnology provides the opportunity; unique properties of nanoparticles are ideal candidate for developing rapid water-treatment technology. Nanoparticles may eliminate metal ions, anions, organic compounds, and microorganisms. Nanoparticle doses required for the water treatment are low, making their application relatively economical. Different nanotechnologies are reviewed in this chapter. A few technologies are in laboratory research stage, some reached to pilot testing, and some are commercial. Among these technologies, Nano adsorbents, Nano membranes, and Nano-photo catalysts are most promising. Although, these technologies have been commercialized, their potential has not been reached for large-scale use in wastewater treatment. Risk assessment of recovered pollutants and exhausted nanoparticles still remains significantly unexplored. Therefore, eco-friendly waste management methods are required to avoid hazards and toxicities. The future of the nanoparticles in water treatment is quite progressive, but it requires collaborative efforts of academic and industrial resources to materialize a fast, economical, and feasible water-treatment technology. It will be possible by working together to solve water contamination globally.

Zuolian Cheng, 2012 [03] investigated the applicability of maghemite (γ-Fe_2O_3) nanoparticles for the selective removal of toxic heavy metals from electroplating wastewater. The maghemite nanoparticles of 60nm were synthesized using a co-precipitation method and characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM) equipped with energy dispersive X-ray spectroscopy (EDX). Batch experiments were carried out for the removal of Pb2+ ions from aqueous solutions by maghemite nanoparticles. The effects of contact time, initial concentration of Pb2+ ions, solution pH, and salinity on the amount of Pb2+ removed were investigated. The adsorption process was found to be highly pH dependent, which made the nanoparticles selectively adsorb this metal from wastewater. The adsorption of Pb2+ reached equilibrium rapidly within 15 min and the adsorption data were well fitted with the Langmuir isotherm.

Brahim Dkhil 2017 [04] evaluated that Hematite (a- Fe2O3) nanoparticles were synthesized via a simple chemical precipitation method. The impact of varying the concentration of precursor on the crystalline phase, size and morphology of a-Fe2O3 products was explored. The characteristic of the synthesized hematite nanoparticles was evaluated by X-ray diffraction (XRD), Transmission Electron

Microscopy (TEM), Scanning Electron Microscopy (SEM), Fourier Transform Infra-Red (FT-IR) spectroscopy, Raman spectroscopy, Differential Thermal Analysis (DTA), Thermo-Gravimetric Analysis (TGA), Ultraviolet–Visible (UV– Vis) analysis and Photoluminescence (PL). XRD data revealed a rhombohedral (hexagonal) structure with the space group R-3c in all samples. Uniform spherical like morphology was confirmed by TEM and SEM. The result revealed that the particle sizes were varied between 21 and 82 nm and that the increase in precursor concentration is accompanied by an increase in the particle size of 21 nm for pure a- Fe2O3synthesized with [Fe^{+3}] = 0.05 M at 82 nm for pure a-Fe2O3synthesized with [Fe^{+3}] = 0.4 M. FT-IR confirms the phase purity of the nanoparticles synthesized. The Raman spectroscopy was used not only to prove that we have synthesized pure hematite but also to identify their phonon modes. The thermal behaviour of compound was studied by using TGA/DTA results: The TGA showed three mass losses, whereas DTA resulted in three endothermic peaks. Besides, the optical investigation revealed that samples have an optical gap of about 2.1 eV and that this value varies as a function of the precursor concentration.

G E Campillo, 2016 [05] assessed that Mercury is one of the persistent pollutants in wastewater; it is becoming a severe environmental and public health problem; this is why nowadays its removal is an obligation. Iron oxide nanoparticles are receiving much attention due to their properties, such as: great biocompatibility, ease of separation, high relation of surface-area to volume, surface modifiability, reusability, excellent magnetic properties and relative low cost. In this experiment, Fe3O4and γ-Fe2O3 nanoparticles were synthesized using iron salts and NaOH as precipitation agents, and Aloe Vera as stabilizing agent; then these nanoparticles were characterized by three different measurements: first, using a Zeta sizer Nano ZS for their size estimation secondly UV−visible spectroscopy which showed the existence of resonance of Plasmon at max~360 nm, and lastly by Scanning Electron Microscopy (SEM) to determine nanoparticles form. The results of this characterization showed that the obtained Iron oxides nanoparticles have a narrow size distribution (∼100nm). Mercury removal of 70% approximately was confirmed by atomic absorption spectroscopy measurements.

H.K.Shon, 2010 [06] briefly studied the applications of nanotechnology for wastewater treatment. Under the nanotechnology umbrella, a number of new procedures for producing nanomaterials ultimately used for the treatment of wastewater are presented. These techniques extend from the fabrication of membranes from nanomaterials to the use of catalysts for the decomposition of noxious compounds in water. Research advances for the use of metals, bimetallic nanoparticles, mixed oxides, zeolites and carbon compounds in wastewater treatment are also reviewed. Finally, the impact of nanotechnology on human health and the environment is briefly discussed.

Mehali J. Mehta, 2015 [07] evaluated that Waste water treatment issues have been a growing problems these days. Its treatment is becoming must in this Industrial world. Nanoparticles have a great potential to be used in waste water treatment. Some of the unique characteristics of it having high surface area can be used efficiently for removing toxic metal ions, disease causing microbes, inorganic and organic solutes from water. The different classes of nanomaterials also have the authority to be efficient for water treatment like metal-containing nanoparticles, carbonaceous nanomaterials and zeolites. The review includes recent development in nanotechnology for water and wastewater treatment. The paper covers nanomaterials that enables the applications, advantages and limitations as compared to existing processes. Nanotechnology has led to various efficient ways for treatment of waste water in a more precise and accurate way on both small and large scale.

Dhermendra K. Tiwari, 2008 [08] represented that nanotechnology offers the possibility of an efficient removal of pollutants and germs. Today nanoparticles, Nano membrane and Nano powder used for detection and removal of chemical and biological substances include metals (e.g. Cadmium, copper, lead, mercury, nickel, zinc), nutrients (e.g. Phosphate, ammonia, nitrate and nitrite), cyanide, organics, algae (e.g. cyanobacterial toxins) viruses, bacteria, parasites and antibiotics. Basically four classes of nanoscale materials that are being evaluated as functional materials for water purification e.g. metal-containing nanoparticles, carbon-aqueous nanomaterials, zeolites and dendrimers. Carbon nanotubes and nanofibers also show some positive result. Nanomaterials reveal good result than other techniques used in water treatment because of its high surface area (surface/volume ratio). It is suggested that these may be used in future at large scale water purification. It is also found that the coliform bacteria treated with ultrasonic irradiation for short time period before Ag nanoparticle treatment at low concentration, enhanced antibacterial effect. In future, combination of both may be the best option for treatment of waste water.

Sharma Richa, 2015 [09] reviewed that Nanotechnology for water and wastewater treatment is increasing day by day. The exclusive properties of nanomaterials show great opportunities for water and wastewater treatment. All three categories viz. Nano adsorbents, nanotechnology enabled membranes, and Nano photo-catalysts have commercial products although they have not been applied in large scale water or wastewater treatment. Several other water treatment nanotechnologies have made immense enhancement in recent past for handling water contamination problems and are going to make additional advancements in coming future. Nanotechnology based treatment has offered very effectual, competent, resilient and eco-friendly approaches. These methods are more commercial, less tedious with very less waste generation than conventional bulk material based methods.

Bapusaheb B. Tambe Patil, 2015 [10] assessed that 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 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.

4 Methodology:

Chemical precipitation

In this strategy the size is control by arrested precipitation technique. The basic trick has been to synthesis and studies the nanomaterial in situ i.e. in the same liquid medium avoiding the physical changes and aggregation of the tiny crystallites. The synthesis involve reaction between constituent materials in suitable solvent. The dopant is added to the parent solution before precipitation reaction. The formed Nano crystals are separated by centrifugation, washed and vacuum dried.

Sol-gel technique

Colloidal particles are much larger than normal molecules or nanoparticles. However, upon mixing with a liquid colloid appear bulky whereas the Nano sized molecules always look clear. It involves the evaluation of networks through the formation of colloidal suspension (sol) and gelatin to form a networking continuous liquid phase (gel).

Sol-gel formation occurs in four stages:

Hydrolysis, Condensation, Growth of particles, Agglomeration of particles

Adsorption

Among the conventional methods, chemical precipitation and other are less efficient and also produce large quantity of sludge which is very difficult to treat. This suggest the emerging need for technological advancements in water treatment to benefit people in many parts of the world. Nano adsorbent offer significant improvement with their extremely high specific surface area and associated sorption sites, short intra particle diffusion distance and tuneable pore size and surface chemistry.

Chemicals

Hexa-hydrated nickel chloride, Hexa-hydrated ferric chloride, Zinc-chloride, Sodium Hydroxide, Acetone

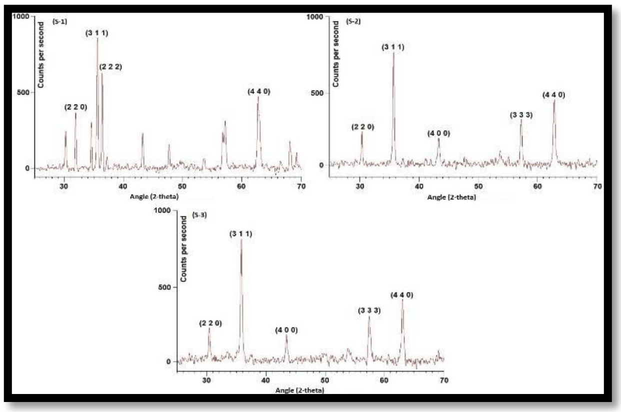
Experimental Procedure for Nickel Ferrite Nanoparticles

Synthesis of Nickel Ferrite Nanoparticles:

Dissolve calculated amount of hexa-hydrated nickel chloride, hexa-hydrated ferric chloride and zinc-chloride, acetone in distilled water. When precipitation take place maintain its pH around 12-13 by adding NaOH solution under continuous stirring for 120 minutes. Place the beaker with the dark brown precipitate in water filled preheated water bath. For the preparation of each sample, temperature of water bath was maintained at 75 degree Celsius for 2 hours. The precipitates were carefully filtered and cleaned with purified water to clear them from chloride ions and sodium. The filtration continues unless solution pH reach the value of 7. To extract moisture content, the material was dried in an electric oven for 4 hours at a heating temperature of 70 degree Celsius. To get fine ferrite powder, the fully dried samples were grinded with pestle and mortar. Both components were thoroughly cleaned with acetone before grinding to avoid contamination. The grinded product was calcined at 800 degree Celsius for 3 hours.

5 Result:

The calcined ferrite samples were characterized for their phases through XRD analysis. The XRD pattern of zinc- doped nickel ferrite nanoparticles is shown in figure 9. These patterns suggest the formation of crystalline structures of ferrite nanoparticles with defined phases. XRD peaks also confirmed that the sample was fine crystallized powder.



6 Conclusion:

We concluded that this study showed that the iron nanoparticles could be used as an alternate to the conventional adsorbents for removal of heavy metals ions from wastewater with high removal efficiency within very short time. During study we came to know that the nanoparticles have unique properties like greater surface area, able to work at low concentration etc... The small size and high surface area of magnetite nanoparticles make them ideal adsorbent. Iron nanoparticles are recommended as fast, effective and less expensive Nano- adsorbents for rapid removal of metal ions from industrial wastewater. But before the bulk application health effect and fate into environmental issues should be addressed. In near future, there should be further improvement in the methods for qualitative analysis of nanoparticles after synthesis. The further research could be extended in order to increase the yield of the product by using alternate methods of synthesis.

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