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Role of Fe_2o_3 Nanoparticles in Heavy Metal Removal

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Abstract – The low-cost adsorption technique is considered the most promising technology for eliminating heaven metal ions from wastewater Adsorption or surface complexation mechanical mechanisms is the reaction between adsorbent, an ion or a molecule and the functional group of an adsorbent surface. In this study we have discussed about the Various Forms of Iron oxide Nanoparticles and its application of Fe_2o_3 nanoparticles in heavy metal removal.

Keywords – Nanoparticle, Removal, Heavy Metal

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INTRODUCTION

Various toxins, including heavy metal ions, organics, microbes, viruses and so on, that are seriously detrimental to human health are introduced into the water sources because of the accelerated industrialization of human civilization. Heavy metals are of special interest because of their elevated toxicity at low concentrations across the vast number of chemical pollutants impacting water supplies. Topical heavy metal, based on the type and amount of the metal consumed, may induce severe ill health consequences with varying symptoms. Metals like titanium, arsenic cadmium, lead and mercury are usually introduced to humans. They are found as colloidal, particulate and dissolved forms in water

Nanotechnology provides great potential for effective, economical and environmentally-friendly water quality solutions. Several bimetallic nanoparticles have also found to be effective in decontaminating heavy metal water. Nanoscale iron particles are a modern wave of technology for environmental preservation and can offer cost-effective alternatives to some of the most difficult environmental problems. Several mineral-containing nanos-sized iron have been tested for wastewater treatment adsorption processes.

Various Forms of Iron oxide Nanoparticles

Magnetitic (Fe3O4) and maghemite (µ-Fe2O3) were the two most highly researched iron oxides. Usually 2-3 orders smaller than bacteria, the tiny scale of these nanoparticles gives a far broader surface than ferric oxide usual for water treatment. The ferrites are generally referred to as magnetic iron oxide minerals. Different ferrites were used to increase the removal of iron and cobalt from groundwater simulated**.**

LITERATURE REVIEW

Mohammad Darvish Motevalli et al. (2019) This study demonstrates the effectively decreased COD and TOC of the electro oxidation of saline wastewater. In addition, RSM was a powerful technique to optimize electric oxidation COD and TOC variables. The findings indicate a good instrument for optimizing the experimental data parameters in superficial reaction approaches. A quadratic model was suggested as a good approximation for a COD and TOC removal calculation. The findings indicate that the experimental data are well matched with the predicted equation.

Sirés et al. (2014) In recent years there has been a growth in the use of advanced electrochemical oxidization processes (EAOPs) within the AOPs. In 1889 (Chen, 2004) electricity was first proposed to be used for water treatment and since then several of the electrochemical technologies for wastewater treatment have been developed. These processes may be categorized into the technologies of separation that distinguish xenobiotics from aqueous media without modifying their chemical properties (e.g., electrocoagulation) and the technologies of degradation involving chemical transformations. Its environmental compatibility is the most advantages of electrochemical systems as the principal reagent is a clean reagent electron.

They are scalable methods of high performance, automation, simple handling and secure working conditions. The main disadvantages include the costs of energy supply, the need for electrolytes and pH power, as well as lack of operation and shortening of electrodes' lifespan by fouling from organic deposition on their surface.

Woisetschläger et al. (2013) In this project organic and inorganic compounds, the rate of degradation is examined. Laboratory and pilot-scale tests are carried out with synthetic and commercial wastewater. The production parameters were calculated in terms of the total demand for organic carbon/chemical oxygen (COD), the simple utilization of energy and the existing efficiency. This new oxidation technology, together with conventional technology was then used in a wastewater treatment principle of wasted leachate. Crude leachate has been electrochemically oxidated in a waste water device or water system for the preparation of purified leachates with a low biochemical oxygen/COD ratio. The cost and expenses of operating the wastewater treatment industry was discussed in terms of the economy. The figures of spending. The RSM technique was used to detect best parameters for the removal by electrochemical oxidation of COD and TOC from the saline wastewater.

Ajayan et al. (2011) The WHO reports that about 80 percent of water contamination in developed countries is induced by household waste. Untreated wastewater polluted the fresh water by releasing enormous quantities of high BOD and COD water, while commercial wastewater applied a broad range of heavy metals to this wastewater, resulting in a high degree of water degradation. In India the rate of sewage output in metropolitan cities was calculated at 120 liters per day and in cities, at 60 liters per person per day.

Kumar (2010) Secure drinking water access is still an emergency as 30% of urban and 90% of rural households still depend entirely on untreated surface or groundwater. Therefore, fluoride, asbestos and microbial pollution are the issues most often faced in the rural community. Measuring water quality is vital to show worldwide comparability and provides the foundation for effective water resources management decisions, tracking challenges, biological quality etc. Measurements of water quality are important. Physical, chemical and biological properties of water are water content. Water quality. It is also commonly used to refer to a collection of criteria that may be tested for conformity. According to the institute on water and sanitation the same water quality line is a word used to define, typically with respect to the suitability of water for the intended intent, the chemical, physical and biological characteristics of water.

OBJECTIVES OF THE STUDY

- To study about the Various Forms of Iron oxide Nanoparticles.
- To study about the applications of FE2O3 nanoparticles in heavy metal removal.
- To study about the Biosynthesis of Silver Nanoparticle Using Microorganisms.

MATERIAL AND METHODS

Synthesis of Fe_2O_3 Nanoparticles

The composites were obtained by researchers using a co-precipitation process. All the chemicals used were purchased from MERCK analytical grades (India). In iron oxide 01 M Ferric Nitrate synthesis [Fe $(NO_3)_3$], the supernatant washed with purified water and the pH was changed to 8.7. Their 1 ml HCl was applied to the dissolving of the precipitates and 0.1 M NaH2PO4 to the precipitate. The moisture was added in the synthesis with 0,5M Sodium Hydroxide (NaOH) in the intense stirring by magnetic stirrer till pH=10.7. This formulation has been heated to 100°C, cleaned and dried.

Immobilization and Characterization of Nanoparticles

In semi-permeable alginate beads, we use one phase encapsulation process for the immobilization of nanoparticles. The Fe-2,0 wt. percent solution was prepared with purified water and stirred for 30 minutes at 85 ^{o} C, comprising Fe2O3 nanoparticles and sodium alginate (2,0 wt. percent). The solution was then extruded red into a stirred solution of calcium chloride (10 wt.%) by means of a syringe as tiny drops, with spherical gel beads of 2-3 mm in duration. In the $CaCl_2$ solution for 12 hours the gel beads were maintained for hardening and cleaned with purified water. The characteristics of the beads encroached were done by the EDX Electron Scanning Microscope (Horiba SU-6600).

Preparation of Various Metal Solutions

Stock lead, arsenic and chromium solution had been produced. By sufficient dilution of the stock solution, the working solutions (influential) at various concentrations were created. Sufficient arsenic trioxide (As_2O_3) in distilling water was dissolved by dissolving stock solutions of arsenate (100 mg/L). Related 1000 ppm solutions for plum and chromium is dissolved in 1000ml of purified water by plum nitrate dissolving and Cr $(NO_3)_3$.

Kinetic Studies

In a 1.8 cm internal diameter and 30cm long Pyrex glass column experiments were conducted. The pillar was adsorbed by tapping such that no lapses are put in the full volume of adsorbent. A column was moved to the affected solution containing a known concentration. At room temperature, both tests were performed. After photometric and voltametric process adsorption was calculated, the effluent solution was collected at normal time intervals and metal concentrations. In terms of their impact on reaction processes, the results were investigated in different parameters including contact periods (10, 20, 30, 40, 50, 60 or 90 min), pH (2, 4, 6, 8, 10 and 12), the adsorbent dose (10, 15, 20, 25, 30 and 40 grams), and initial metal amounts (0,50,1,0, 2,0 or 3,0 mg/l). Adsorption isotherms are considerably examined during the water treatment process as they offer useful insight into practical design. The comparison between some of the adsorbed quantity and that remained in the solution at a constant volume at balance is defined.

DATA ANALYSIS AND RESULTS

Toxic Heavy Metals Removal from Water Using Fe_2O_3 Nanoparticles

Fe_2O_3 SEM and EDS spectra have been described as nanoparticles synthesized through the rate of a chemical reaction accumulation. Fe_2O_3 chemical-precipitation nanostructures display very high potential for functional application of aqueous solution removal of Arsenic (III), Lead (II) and Chromium (VI). For these metals at pH 12.90 percent elimination is feasible with 30 minutes. The batch research investigated the optimal dosage and length of the touch for arsenic and chromium removal.

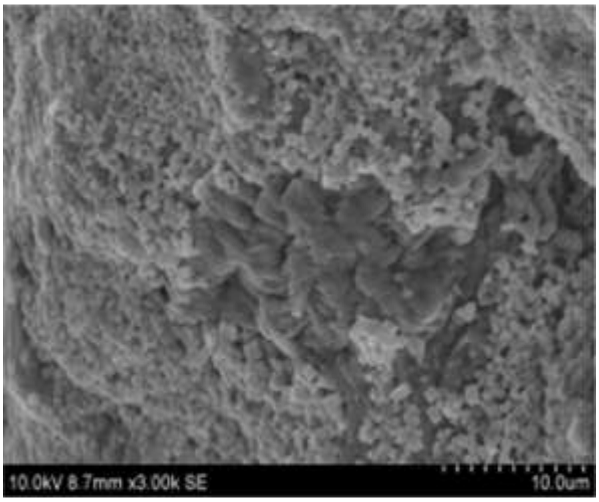
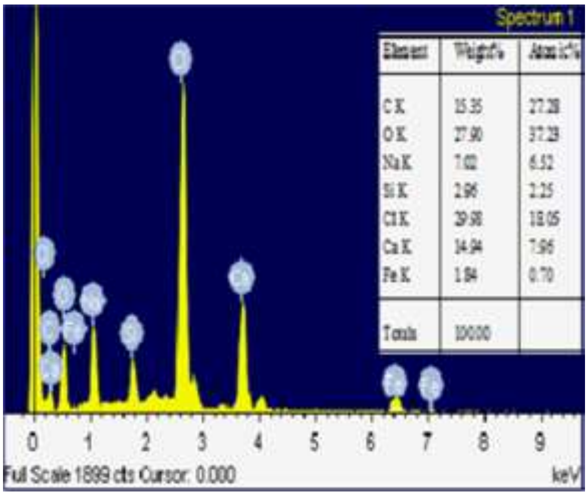


Figure 1: SEM image of Fe nanoparticles



Element	Weight%	Atomic%
C K	15.35	27.28
O K	27.90	37.23
Na K	7.02	6.52
Si K	2.96	2.25
Cl K	29.98	18.05
Ca K	14.94	7.96
Fe K	1.84	0.70
Totals	100.00	

Figure 2: EDS analysis of Fe nanoparticles

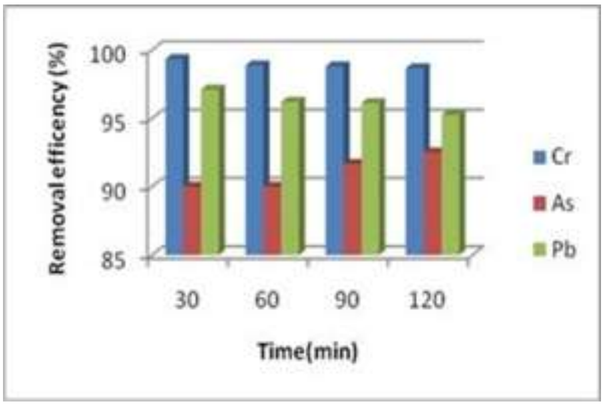


Figure 3: Percentage of adsorption of As (III), Pb (II) and Cr (VI) as a function of time. Initial concentration of metals: 2 ppm, pH 12

Effect of pH

The pH of nanoparticles from drinking water is one of the significant considerations in the separation from heavy metal. Initial pH ranges 2 to 12 were examined for the influence of pH on chromium and arsenic elimination. Variant chromium and pH-arsenic adsorption capacities have also been seen in Fig. 4 From Fig. 5, it is clear from the original As (III) 2.0mg/L concentration that about 95% of As (III) was adsorbed on an alginate coating with an alginate pH of 4.0-10. As (iii) adsorption on iron oxide charged bead surface was almost pH-independent, although marginally higher oxidation was in the acidic pH zone. The pH range of the bead has been almost pH-independent in the scale 4-10. With respect to chromium, maximal elimination at pH 2.5 is observed.

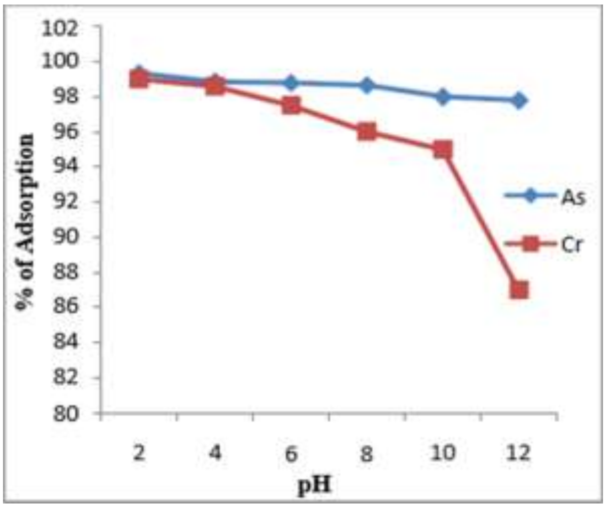


Figure 4: Percentage adsorption as a function of pH

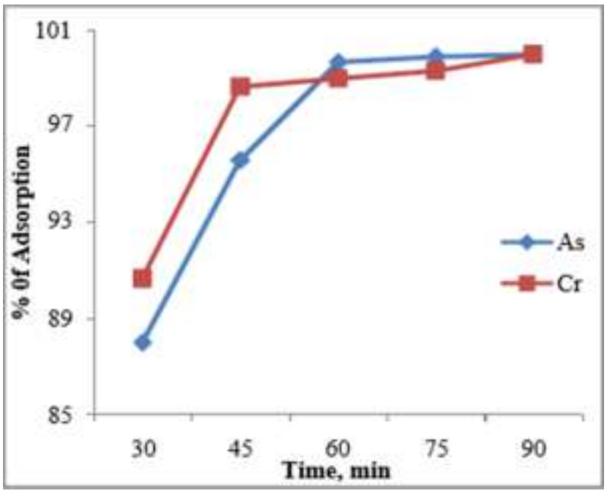


Figure 5: Percentage adsorption as a function time

Effect of Contact Time

Adsorption kinetic analysis was studied with 1.5mg/L metal adsorption at pH=4.5 with an adsorbent posology of 25g. The touch time ranged from 30 to 90 minutes. From Fig, it is clear. 7.16 adsorption was improved at the first steps and the elimination optimum percentage was reached after 75 minutes by 99.33 per cent. When the contact time was extended for chromium to 90 minutes, no more improvements were found.

7.2.4 Adsorbent dosage result Effect

The adsorbent influence as seen in Figure 6. The elimination of the adsorbent dose is more essential. This may be because more adsorption places are open. Arsenic elimination is roughly 75% with an adsorbent dose of 25 g of 2 g/l arsenic for an ad sourcing concentration of 1,5 g of iron, with a rise in adsorbent dose of 2 mg/l of Cr (VI) being induced as well. The reduction of Cr (VI) was 90.66 percent at 10 g of the adsorbent dose. A 100 percent removal performance in the adsorbent dose of 25g was achieved. Removal efficiency improved proportionally by the adsorbent sum until a certain value had been achieved; the removal efficiency would then be retained continuously even though an adsorbent was introduced. The percentage elimination improves easily due to a wider supply of the adsorbent sites on the soil.

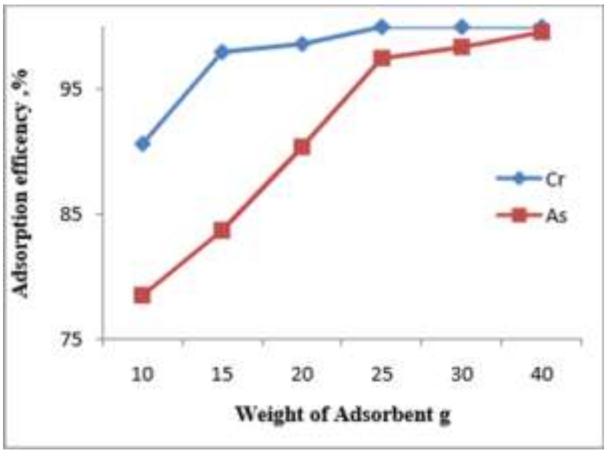


Figure 6: Percentage adsorption as a function of adsorbent dose

Effect of Initial Metal Concentration

Initial experiments have been carried out with an adsorbent dose of 25 g at a neutral pH (7) and communication time of 60 minutes increasing from 0.5mg/ L to 3.0mg/L. when arsenic concentration was 0.5 mg/L, it is clear that the adsorbent would fully eliminate metals (100 percent). For arsenic, the removal efficiency was decreased to 98.7% with an initial concentration of 1 mg/L, which remains unchanged for 2 mg/L. The removal efficiency was lowered by 3 mg/L to 83 percent. The amount of arsenic extraction that corresponded to an elevated initial arsenic concentration is found to decrease. Results revealed that iron oxide nanoparticles had improved their removal percentage of Cr (VI) at higher concentrations. In addition, during the optimized touch cycle, the rate of this adsorption reaction specifically varies with the adsorbate concentration.

As (III) and Cr (III) kinetical adsorption experiments

Adsorption isotherms were also studied, which indicate the volume of solute adsorbed in a constant temperature in a bulk solution as a feature of the balance concentration. The patterns of adsorption of adsorbent iron oxide were used to detect arsenic and chromium through Freundlich and Langmuir equations. The Freundlich isotherm is an analytical paradigm focused on heterogeneous surface adsorption. The

Freundlich Equation protects heterogeneous surfaces of physicochemical adsorption (indicates the adsorptive capacity or loading factor). The linear form is given as the Freundlich equation:

$$\mathrm{Log}(x/m) = \log K + 1/n \log Ce$$

Where x is the solute adsorbed mass m is the adsorption mass used, Ce is the solution's balancing concentrations and K is a constant that is the adsorbed capability calculation and n is the adsorption process strength measurement.

For single-layer hydrolysis, the Langmuir isotherm is correct. The presumption is that any adsorption position has the same affinity with the adsorbate molecules and that there are no technological breakthroughs of the adsorbed species on the sample surface. The Langmuir system is a linear form

$$Ce/\ (x/m) = 1/a + (1/b)\ Ce$$

Where x is the sum of the solute adsorbed, m is the quantity of the surface ad sourcing mass, Ce (mg/L) is the arsenic density in balance, and b (mg 1) is the Langmuir constant, which corresponds to the affinity between the substrate and the sorbate, by unit weight, of the salt adsorbed adsorbents essential for monolayer surface coverage. Adsorption occurs in the working sites of the adsorbent universally, and no more adsorption can arise from this site while an adsorbate occupied a site, according to the Langmuir model.

The machine was balanced with an adsorbent 0.5 g at room temperature for 30 minutes at varying iron concentration. The collected balance data were modified to the isotherms Freundlich and Langmuir. The linearity of the plot log Ce versus log (x/m) for Freundlich's oxidation in the event of arsenic isotherm. The values K and n for arsenic removal were obtained from the route and the plot interception between log (x/m) and log Ce. The 1/X vs. Ce plots for As (III) adsorption were straight. The approximate fitness of r2=0,711 is relevant to As (III) surface-functional nanoparticles and allows the pertinence of the Langmuir models. For this analysis, the Langmuir constants a and b are 0.33 mg/g and 0.318. The plot linearity for log Ce vs. log (x/m) for chromium indicates that Langmuir isotherm for the chrome adsorption by utilizing iron oxides nanoparticles is applicable. The 1/n<1 value is a positive chromium adsorption on an iron oxide value, with a K value of 0.5248. The plot of Ce with Ce/(x/m) provides a straight-line suggesting Langmuir equation applicability. The Langmuir meaning is 1,2195. The values value and n were 0.822 mg/g and 1.32 in the presented study. The isotherm is well suited for the adsorbent with a coefficient of correlation 0.94. Moreover, higher adsorption capability (K) values obtained from encoded alginate nanoparticles suggest that these metals can effectively be extracted from water.

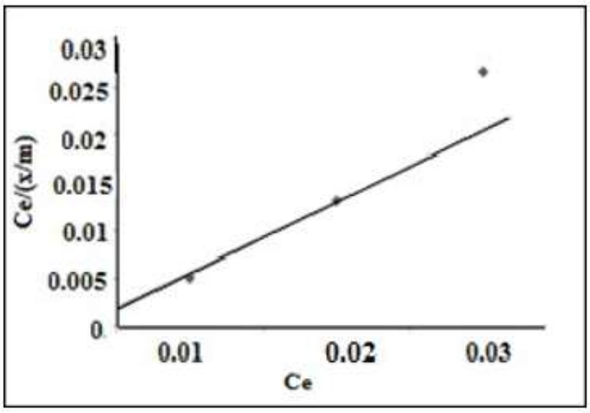


Figure 7: Langmuir adsorption isotherm of Chromium

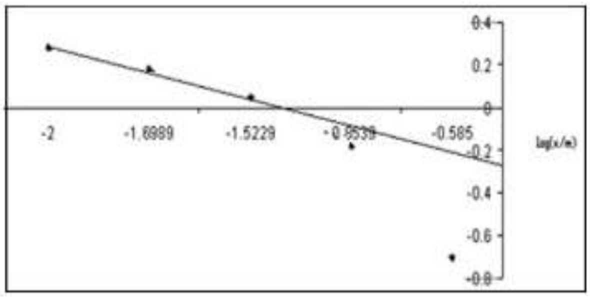


Figure 8: Freundlich adsorption of isotherm Chromium

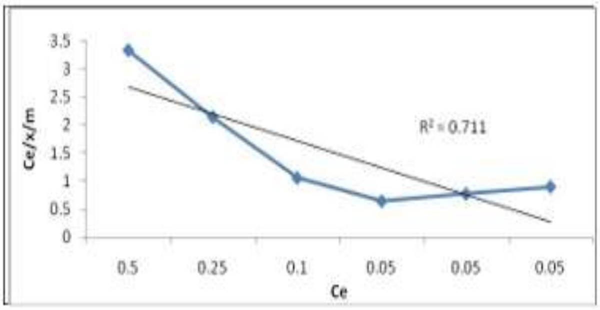


Figure 9: Langmuir adsorption isotherm of Arsenic.

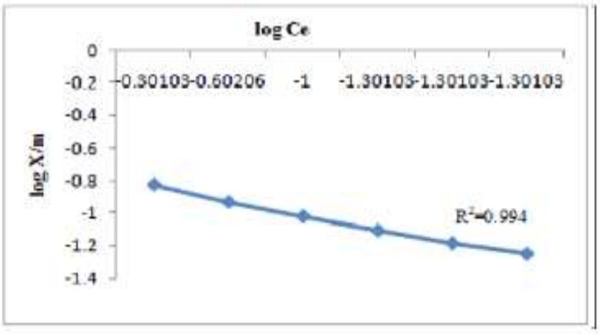


Figure 10: Freundlich adsorption of isotherm Arsenic

CONCLUSION

We had examined the role of iron nanoparticles as adsorbents in water treatment. Adsorption is an efficient and inexpensive procedure where the appropriate adsorbents in an atmosphere favoring adsorption are used in methods for extracting metals or dyes from a water source. Fe_2O_3 nanoparticles from the aqueous solution were extracted with a low adsorbent dosage of up to 99.9 percent efficiency of elimination of Arsenic (III) and Chromium (VI) for a wide pH range and were very short. The findings have shown that sodium alginate impregnated with iron oxide may be used as an outstanding adsorbent, even with low amounts, to removing harmful metals from aqueous solutions. In general, wastewater pollution restrictions are difficult to achieve for the textile industry, particularly in the case of dissolved solids, ionic salts, pH, COD, color and often heavy metals. A comfortable laboratory scale effluent treatment system was established using UV light based on the potential for immobilized TiO2 nanoparticles in photocatalytic degradation of dyes.

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