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APPLICATION OF BIO-SYNTHESIZED AG NANOPARTICLES IN WATER TREATMENT

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ABSTRACT

Advanced filtration and purification techniques are well suited to nanomaterials such as Graphene oxide, metal-oxide nanoparticles, and carbon nanotubes because of their exceptional properties, including a huge surface area, increased reactivity, and improved adsorption capabilities. New technologies, such as photocatalytic nanomaterials and nanomembranes, also provide ways to desalinate water, kill microbes, and eliminate heavy metals. Despite its immense potential, challenges such as scalability, environmental impact, and safety of nanomaterials must be addressed to ensure widespread adoption. These studies highlight the need of integrating nanotechnology via multidisciplinary methods and with the backing of policymakers. into mainstream water purification practices, paving the way for safer and more effectively manage water resources.

Keywords: Application, Bio-Synthesized, Nanoparticles, Water and Treatment

INTRODUCTION

The economy of any industrialized nation may benefit from better water quality since water purification procedures, such as chlorination, filtration, and disinfection, can provide a return of five to ten dollars for every dollar invested. Water treatment is a significant challenge in underdeveloped countries due to factors such as insufficient maintenance, unreliable supply, contamination, and absence of chlorination. In this regard, nanotechnology may be of great assistance in meeting the need for clean, drinkable water from an ever-increasing population. Techniques using particles in the nano range are included under this technology. Because of their enormous surface area, these nanoparticles exhibit novel physicochemical characteristics. The level of filtration at which nanotechnology is used determines the approach used for water purification. Nanotechnology has the potential to eliminate sediments, many kinds of bacteria, and harmful substances such as arsenic, mercury, and others. Despite nanoparticles' highly reactive nature and very large surface area to volume ratio, ratio make them dangerous, nanotechnology offers the possibility of purifying water in a way that doesn't hurt people or the environment.

Modern water filtration systems employ devices based on nanomaterials. The greater surface area of devices based on nanomaterials gives them an edge over other approaches. These nanotechnology-based water filtering methods are beneficial since the chlorine procedure, which uses chloramine or chlorine, releases carcinogenic byproducts. Water purification applications might benefit from photocatalyzed titania nanomembranes because of their resistance to ultraviolet radiation, which kills germs and biological pollutants.

The atomic layer deposition technique may also be used to cover these nanomembranes with photocatalytic and antibacterial materials. Such nanomembranes could contribute to the improvement of poor nations' water purification systems. Water may be treated using nanostructured materials including carbon nanotubes, iron zeolite, magnetic nanoparticles, and cadmium ions to remove thallium (III), silver (I), arsenate (V), metals such as nickel, copper, cadmium, and mercury were used.

Metal ions provide serious health risks to humans. It is possible for chargeless nanoscale ions to degrade persistent contaminants by photochemical oxidation and serve as adsorbents. The extensive adsorption capabilities of carbon nanotubes and dendrimers make them popular building blocks for state-of-the-art water systems.

In order to maintain life and promote public health, everyone has the right to consume water that is free of contaminants. Nevertheless, toxins such heavy metals, organic pollutants, and microbes present in polluted water greatly endanger human health. Researching emerging technology is essential. since conventional water treatment procedures are not always successful in eliminating these impurities. By capitalizing on the distinct characteristics of nanoparticles, nanotechnology has recently gained traction as a potential strategy for water purification.

LITERATURE REVIEW

Manayil Parambil, Ajith & Rajamani, Paulraj. (2021). Sustainable development cannot be achieved without water purification. This goal and the treatment of harmful and untreatable contaminants may be accomplished with the use of nanotechnology and other advanced technologies. More large-scale studies are needed to fully explore the solutions that use nanotechnology to enhance the efficacy and efficiency of water purification. For nanomaterials to be widely used in water purification, their low fabrication costs are crucial. Another important aspect of nanoparticle application is reducing toxicity and improving stability. Consequently, it is imperative that future research evaluate the related processes of water treatment, increase stability, decrease toxicity, and improve their economic efficiency.

Sharma, Rama. (2021). Everyone on Earth needs access to clean water for survival. However, at this same moment, the supplies of pure water are being polluted. When it comes to cleaning up wastewater, nanotechnology is a simple and effective solution. Nanotechnology has the potential to eliminate sediments, many kinds of bacteria, and harmful substances such as arsenic, mercury, and others. In order to purify water, technologies based on nanomaterials are being used. Since nano filters are readily cleaned by back flushing and need little pressure to move water through them, they provide many benefits over more traditional methods of water filtering. Carbon nanotubes are ideal for the elimination of almost all water pollutants due to their smooth interior. Nanostructured materials outperform their micro structured counterparts due to their higher surface area.

Pandey, Shivam. (2024). Nanotechnology has emerged as a promising topic with potential uses in several industries, including water management and irrigation systems. This chapter discusses the present status and future possibilities of nanotechnology in boosting the reliability, longevity, and effectiveness of agriculture and water resource management irrigation methods. Nanotechnology-based solutions, such as nanomaterials, nano-sensors, and nano-membranes, provide unique features and functions that may meet the issues encountered in water purification, desalination, pollutant detection, precision irrigation, and crop monitoring. The chapter focuses on the main uses of nanotechnology, such as water treatment using nano-adsorbents, soil moisture monitoring using nano-sensors, targeted nutrient delivery using nano-fertilizers, and improved irrigation system performance through nano-coatings.

Mohajerin, Ramtin. (2016). This topic is presented in two parts. The first part provides a concise overview of various water purification technologies and introduces nanotechnology as a means to improve water safety, quality, accessibility, and affordability. The second part, which will be presented in the next issue, delves deeper into other nanotechnologies used for water purification, comparing and contrasting various methods and discussing their benefits and drawbacks, as well as environmental and human hazards that may arise.

Hilal, Ahmed & Saleh, Raghad. (2024). The environment and natural resources are under intense strain due to the world's expanding population and rising demand. In light of this circumstance, the SDGs were set up with the aim of protecting people's rights and making sure their basic requirements are satisfied by the year 2030. Making ensuring everyone has available sanitary facilities and potable water is among the program's aims. The Middle East is an area with a rising population and limited water supplies; this analysis focuses on their water dilemma. This study proposes a revolutionary approach to water purification and sanitation using nanotechnology. In addition to helping with Middle Eastern water problems, this technology may help bring about the goal of universal, cheap, and sustainable the Sustainable Development Goals' need for access to potable water.

MATERIALS AND METHOD

- ### Synthesis of Fe_2O_3 Nanoparticles

Following Massart's (1981) description, the nanoparticles were created using the co-precipitation technique. We purchased the chemicals from MERCK (India) and were of analytical quality. To create iron oxide nanoparticles, a solution of 0.5M sodium hydroxide (NaOH) and 0.01M ferric nitrate [Fe (NO3)3] was mixed vigorously with a magnetic stirrer until the pH reached 10.7.The pH was corrected to 8.7 after washing the precipitate with distilled water.The precipitate was dissolved with 1 ml of HCl, and re-precipitation was accomplished using 0.1M NaH2PO4. The precipitate was washed and dried after being heated to 100oC.

- ### Developing Nanoparticles and Their Characterization

To immobilize nanoparticles, we used a one-step encapsulating method in semi-permeable alginate beads. To include 2.0 wt % Fe2O3 nanoparticles and 2.0 wt % sodium alginate, the mixture was combined with distilled water and stirred at 85ºC for 30 minutes. The next thing to do was to inject the solution as little drops into a stirred solution that included calcium chloride (10.0 wt %) in order to make spherical gel beads that were 2-3 mm in diameter. Following a 12-hour period of incubation in the CaCl2 solution, the gel beads were removed and rinsed with distilled water. Scanning electron microscopy with energy dispersive X-rays (Horiba SU-6600) was used to examine the trapped beads' properties.

- ### The Making of Different Metal Solutions

Lead, arsenic, and chromium were dissolved in a stock solution. By diluting the stock solution appropriately, working solutions (influent) of varying concentrations were created. To make 100 mg/L arsenite stock solutions, the appropriate amount of arsenic trioxide (As2O3) was dissolved in distilled water. Similarly, 1000 ml of distilled water was used to dissolve lead nitrate and Cr (NO3)3 to generate a lead and chromium solution with a 1000 ppm concentration.

- ### Kinetic Studies

A pyrex glass column with a length of 30 cm and an interior diameter of 1.8 cm was used for the column investigations. The column was filled to capacity with adsorbent by tapping it into place, ensuring that there were no gaps. The column was then supplied with the influent solution, which had a concentration that was known. Everything that was tested was done at ambient temperature. The photometric and voltametric methods were used to estimate the concentration of metals after adsorption from the effluent solution, which was collected at regular intervals. The reaction processes were examined by varying a number of parameters, including contact duration (10, 20, 30, 40, 50, 60, and 90 min), pH (2, 4, 6, 8, 10, and 12), adsorbent dose (10, 15, 20, 25, 30, and 40 g), and starting metal concentration (0.50, 1.0, 2.0, and 3.0 mg/L). Because it sheds light on the practical use of design, research into adsorption isotherms in water treatment is crucial.

The connection between the amount adsorbed and the amount left in the solution at a constant temperature at equilibrium may be described by an isotherm.

RESULTS AND DISCUSSION

Toxic Heavy Metals Removal from Water Using Fe_2O_3 Nanoparticles

Fe_2O_3 nanoparticles synthesized by chemical precipitation method were characterized using SEM and EDS spectra. Fe_2O_3 nanoparticles synthesized by chemical precipitation method shows very good promise for practical applicability the extraction of arsenic (III), lead (II), and chromium (VI) from water. At pH 12 (Fig.1), these metals may be removed 90% of the time in under 30 minutes. The ideal amount of adsorbent and contact duration for maximal removal of arsenic and chromium were determined using batch research.

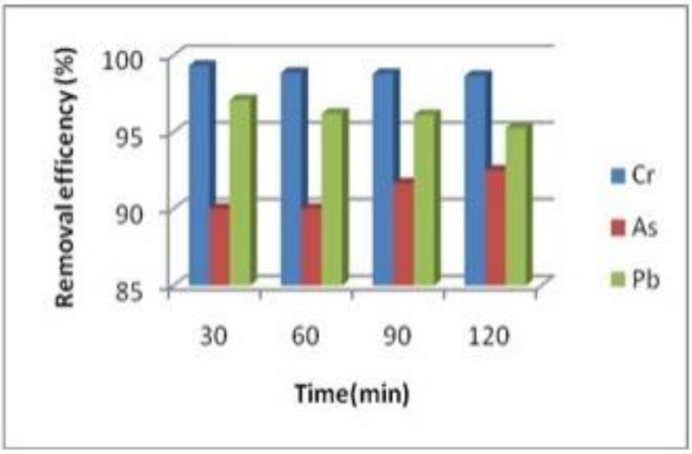

Fig. 1 A time-dependent plot illustrating the percentage of arsenate, lead, and iron ions adsorbed. The initial metal content was 2 ppm, and the pH was 12.

How pH Affects

Heavy Metal Removal from Water using nanoparticles, pH is one of the key variables. From a starting point of 2 to 12, researchers looked at how different pH levels affected the elimination of chromium and arsenic. Figure 2 shows the pH-dependent chromium and arsenic adsorption capacities. starting with a 2.0 mg/L As (III) concentration, the alginate surface absorbed about 95% of the metal across a pH range of 4.0 to 10. The rate of elimination drops significantly when the pH rises. Iron oxide-loaded alginate beads showed almost pH-independent As (III) adsorption over a pH pH 4–10, with somewhat higher adsorption in the more acidic pH range. The best method for chromium removal was seen at a pH of 2.4.

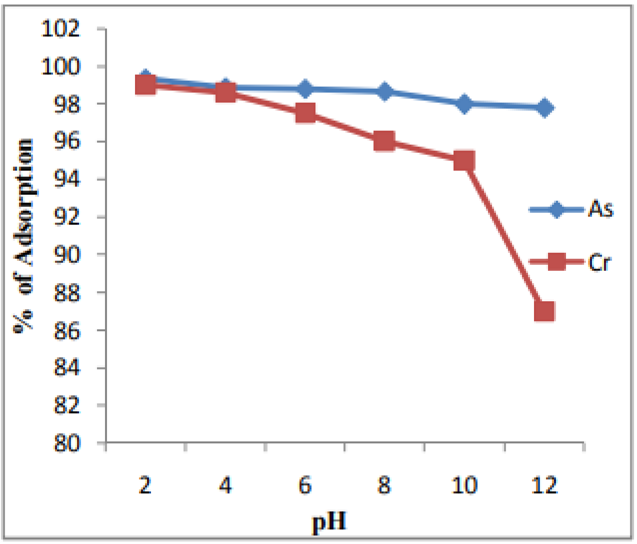

Fig: 2 Relationship between pH and percentage adsorption

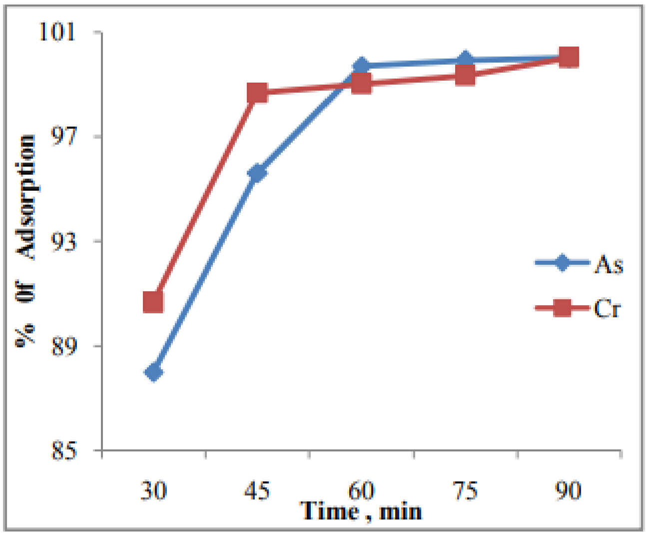

Fig: 3 Adsorption percentage against time

Impact of Interaction Duration

Adsorption of 1.5 mg/L of metals at pH=4.5 using a 25 g adsorbent dose was used to study the kinetics of the adsorption process.There was a wide range of interaction times, from 30 to 90 minutes. adsorption was highest in the beginning phases, and then reached a maximum of 99.33% removal after 75 minutes. Increasing the contact duration to 90 minutes had no additional effect on the chromium.

The Influence of Adsorbent Strength

How the adsorbent affects the adsorption process is seen in Figure 4. With a greater adsorbent dosage, the removal is enhanced. More adsorption sites could be to blame for this. The removal of arsenic is around 75% with 10 g of alginate beads with 1.5 g of iron, and it may reach 97.5% with 25 g of adsorbent at 2 mg/L arsenic. The elimination also improved when the adsorbent dosage was increased for Cr(VI). With a dose of

10g of adsorbent, 90.66% of the Cr(VI) was removed.In the experiment, a 25g dose of adsorbent resulted in a 100% removal efficiency. Once a specific value was attained, the removal effectiveness is constant regardless of the quantity of adsorbent added; beyond this point, it increases proportionately with the amount of adsorbent. Because there are more adsorption sites on a larger surface area, the percentage of removal grows exponentially with increasing adsorbent dosage.

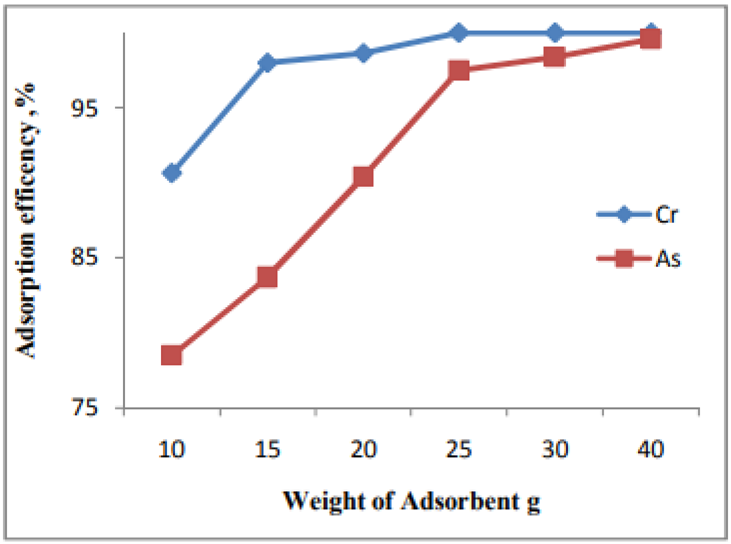

Fig: 4 Adsorption percentage against adsorbent dosage

The Influence of Minimum Metal Content

With By manipulating the initial concentration from 0.5 mg/L to 3.0 mg/L, researchers studied the effects with a constant adsorbent dosage of 25 g, a neutral pH of 7, and a contact length of 60 minutes. The ability of the adsorbent to remove all metals was shown in Figure 4 at a concentration of 0.5 mg/L.Raising the initial concentration to 1 mg/L reduced the removal efficiency for arsenic to 98.7 percent, and it remains unchanged at 2 mg/L as well. A decrease to 83% clearance efficiency was seen at 3 mg/L. There was a negative correlation between the original arsenic content and the percentage of arsenic removed. The findings revealed that the iron oxide nanoparticles included a greater amount of Cr (VI) removed at higher concentrations. Adsorbate concentration is a direct predictor of the adsorptive response rate at the optimal contact time.

Investigating the Adsorption Kinetics of Arsenate and Chromium

Also investigated were isotherms of adsorption, which display the amount of solute adsorbed per unit of adsorbent in relation to the bulk solution equilibrium concentration at a certain temperature. Patterns of arsenic and chromium adsorption by adsorbent iron oxide were determined using the Freundlich and Langmuir equations. One empirical model that takes adsorption on heterogeneous surfaces into account is the freundlich isotherm. Physical and chemical adsorption on different surfaces is the focus of the Freundlich equation, which also gives information about the loading factor or adsorption capacity. The Freundlich equation, in its linearized version, is expressed as:

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

A solution's equilibrium solute concentration (Ce) in milligrammes per litre (mg/L), the mass of the adsorbent (m), a constant (K) that measures the adsorption capacity, and an intensity measure (n) are all part of this equation.

For adsorption on a single layer, the Langmuir isotherm holds true. The core premise is that the adsorbate does not transmigrate across the surface's plane and that each adsorption site has an identical affinity for the adsorbate's molecules. A solution to the Langmuir equation in its linear version is

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

in here x is the amount of solute adsorbed, m is the mass of the adsorbent, Ce is the arsenic equilibrium concentration in milligrammes per litre, an is the amount of solute adsorbed per unit mass of the adsorbent required for surface monolayer coverage (also called monolayer capacity), and b is the Langmuir constant linked to the sorbent-sorbate affinity. The Langmuir model states that once an adsorbate occupies a site, no further adsorption may occur from that site. Distributed adsorption occurs across the adsorbent's active areas.

After 30 minutes of equilibration at room temperature with varying metal concentrations, we achieved the target adsorbent concentration of 0.5g by adjusting the system. Fitting the equilibrium data was done using the Freundlich and Langmuir isotherms. Arsenic adsorption may be described by the Freundlich adsorption isotherm because the relationship between log Ce and log (x/m) is linear. We determined K and n by comparing the potential arsenic removal rate with the logarithm of x/m and the logarithm of Ce. When the adsorption of As (III) was plotted against Ce as 1/X, a straight line was produced. With a computed goodness of fit of r2=0.711, the surface-functionalized nanoparticles may be adsorbing As (III) using the Langmuir model. The Langmuir constants a and b, which are relevant to this study, are 0.318 and 0.33 mg/g, respectively.

The linearity of the log Ce vs log (x/m) indicates that the Freundlich adsorption isotherm may be used for chromium adsorption using iron oxides nanoparticles. plot for chromium. The positive adsorption of chromium onto iron oxide is represented by the value of 1/n<1. K is determined to be 0.5248. A straight line is produced by plotting Ce against Ce/(x/m) which suggests that the Langmuir equation may be used. The Langmuir constant has a value of 1.2194.The current investigation determined K to be 0.822 mg/g and n to be 1.32. There was a strong association (r=0.994) between the isotherm and the adsorbent.Adsorption capacity (K) values that are much greater for alginate that has been encapsulated with nanoparticles suggest that it may be utilized to efficiently remove these metals from water.

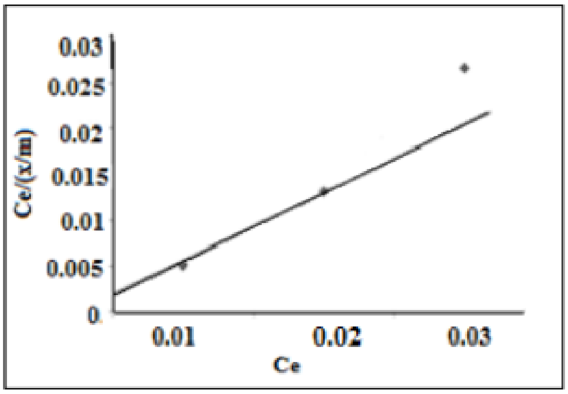

Fig 5 a Adsorption isotherm via Langmuir isotherm Chromium

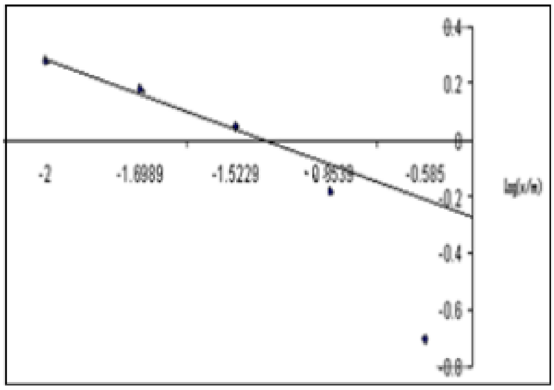

Fig.5 b Freundlich adsorption of Chromium

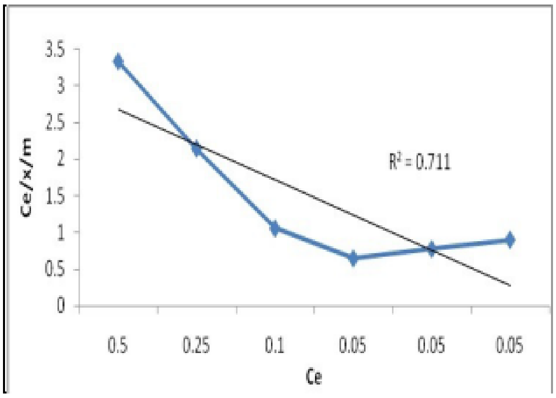

Fig 6a Adsorption isotherm via Langmuir of Arsenic.

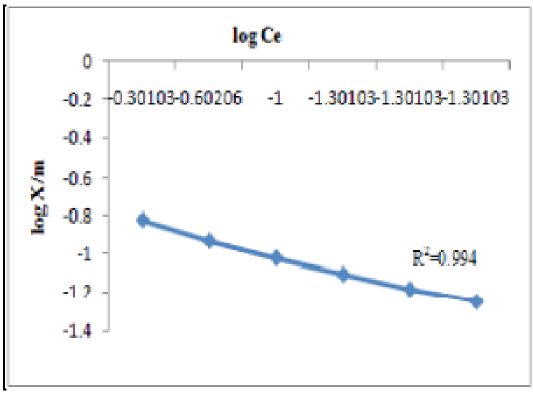

Fig. 6b Biocompatible adsorption of isotherm Arsenic

CONCLUSIONS

The research has shown that nano silver disinfection is a practical and inexpensive option for the average person. Results from the lab provide a high-level overview of potential approaches to integrating nano silver disinfection technology into point-of-use filters. Additionally, the function of iron nanoparticles as an adsorbent in purifying water was examined. The use of appropriate adsorbents in an adsorption-friendly environment allows for a highly successful and cost-effective method of removing metals or dyes from water streams. Over a broad pH range, Fe2O3 nanoparticles removed arsenic (III) and chromium (VI) from water with an efficiency of up to 99.9 percent, using a modest adsorbent dosage and a relatively short period. In order to find the equilibrium, we used the Freundlich and Langmuir isotherm equations. Adsorbents coated with iron oxide and sodium alginate were successful in removing toxic metals from water solutions, even at low concentrations, according to the findings.

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