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EFFECT OF WATER TREATMENT PROCESS PARAMETERS SUCH AS ADSORBENT DOSAGE, CONTACT TIME AND PH

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ABSTRACT

With the use of a face-centered central composite design, the optimum values of pH, contact duration, and adsorbent dose were determined as process parameters for efficient boron removal in the current research. In order to determine the optimal settings for copper, a series of batch tests were performed. Mankind's actions cause a dynamic shift in the planetary heavy metal content. These have sparked widespread curiosity on the causes and effects of pollution. The influence of variables such as initial metal ion concentration, pH, adsorbent dosage, contact duration, temperature, and adsorption temperature was also calculated. Contact times of 360 minutes, adsorbent doses of 200 milligrams, and pH values of five were shown to be optimal for copper, whereas contact times of 180 minutes, 200 milligrams, and pH values of seven were found to be optimal for Sulphur. Adsorption kinetics might be described using either a pseudo first order or pseudo second order kinetic model.

KEYWORDAdsorption Dosage, Contact Time, Ph, Water Treatment Andparameters

INTRODUCTION

Changes in heavy metal concentrations in the environment are a result of human actions. The study of pollution has benefited greatly from this. Some of the most important natural pathways for these metals to enter the environment are via weathering of rocks and the release of these elements from terrestrial and marine sediments. The refining process gets rid of the trace amounts of heavy metals that may be present in crude oils. Waste water from metal plating, Pb, Cd - Ni battery, phosphate fertilizer, mining, pigment electroplating, corrosion, and other industrial waste sources released heavy hazardous metals into the environment. Because of the dangers they pose to ecosystems, heavy metal pollution has recently gained attention. Toxic heavy metals threaten human health and ecosystems. Recently, adsorption's merits as a cheap and efficient pollution removal strategy have come into wider recognition. Activated charcoal, synthetic resins, and water purification systems are just some of the many industrial uses for adsorption's wide-ranging applicability across the physical, biological, and chemical realms. Adsorption is a byproduct of surface energy, much as surface tension is.

A variety of well-established strategies, such as reverse osmosis (RO), membrane distillation, and ion exchange, are documented for removing boron from salt water. Existing methods have been shown to have limitations, however, including expensive costs and high energy intensities. Adsorption is a very efficient and suggested method for depleting even trace amounts of boron from water. Activated carbon, clays, fly ash, biological materials, natural minerals, nanoparticles, layered double hydroxide, and other complexing membranes are only some of the sorbents that have been employed in adsorption techniques to remove boron. In contrast, adsorption employing agro-based materials was shown to be a practical, environmentally acceptable, readily available, manageable, and selective method of removal. Moringaoleifera trees, commonly called drumstick trees, are fast-growing tiny trees with the deciduous shrub characteristics of the moringa plant. The tree may grow to a height of 10–13 metres and a width of 35–45 centimeters. Its crown is open and umbrella-shaped. The plant family Morigeau includes the ubiquitous Moringaoleifera. When ripe, the fruit becomes brown and often contains 10-50 seeds. Moringaoleifera seed coagulants have been shown to be effective in comparison to traditional chemical coagulants for water treatment, and have stood the test of time (alum). The adsorbent made from M. oleifera seeds stands out as a promising option for Boron removal from sea water due to its high efficiency removal rate and edible qualities. Using a face-centered central composite design, the optimum values of pH, contact duration, and adsorbent dose were determined in this work for efficient boron removal (FCCCD). Additionally, the created model's prediction ability was evaluated using the Freundlich and Langmuir adsorption isotherms.

Adsorption is another low-cost option that works well even at low metal ion concentrations. As adsorbents, activated carbon, biological materials, chitosan, fly ash, etc. are often employed to get rid of Cr (VI). High cost, poor adsorption capacity, difficulty of separation after adsorption, etc. are some of the drawbacks of commercially available adsorbents. Particles on the nanoscale are the focus of nanotechnology. Since nanoparticles are so much smaller than conventional adsorbents, mass transport resistance is drastically cut down. Nowadays, nanoparticles are often employed in wastewater treatment because of their large surface area and adsorption capability. Applications for magnetite nanoparticles include data storage, ferrofluids, nano adsorbents, biomedicine, biosensors, and many more. In the presence of a magnetic field, separation is simple upon adsorption. In the current investigation, magnetic nanoparticles were synthesized in the lab using the sol gel process and analyzed using energy dispersive X-ray spectroscopy and a thermogravimetric analyzer. Different factors, such as pH, contact duration, starting concentration, and adsorbent dose, were investigated in batch adsorption experiments.

LITERATURE REVIEW

TurkanKopac (2022) Reducing the number of devices, miniaturization, process integration, improving mass and heat transfer, novel energy and separation techniques, combined optimization and control methodologies, and other approaches are all part of the process intensification (PI) movement, which aims to create cleaner, safer, more energy-efficient sustainable technologies. In recent years, PI has also received interest in the field of adsorptive separations using aqueous media and wastewater treatment. There have only been a few of studies published so far, and there aren't any published guidelines for monitoring the increased processes involved in wastewater treatment. The purpose of this article is to provide a synopsis of current developments and applications in process-intensified decolorization of dyes, removal of aromatic hydrocarbons from wastewaters, and recovery of proteins, heavy metals, and rare earth elements from aqueous environments. With the hope of aiding in the development of applications in the future, we have highlighted a few of them in terms of the PI methodologies and outlined the process improvements that go along with them for many different instances. Significant process enhancements, such as enhanced process efficiency, enhanced adsorption and separation performance, and reduced sorbent demand and processing time, have been proven as achievable. Adsorption wastewater treatment employing a systems approach has seen significant advancements in recent years, but there is still room for improvement.

Mohammed Saedi Jami (2020) Boron is an essential element for plants, animals, and people alike. In excess quantities, however, boron in water sources like saltwater and groundwater might have devastating effects on human and ecological health. Due to its eco-friendliness and favorable removal efficiency of adsorbates, Moringaoleifera was chosen as a precursor adsorbent in this study. In addition, M. oleifera's treatment has little to no effect on the final pH or conductivity of the water. The primary objective of these studies was to learn more about M. Olivera's capacity for removing boron from salt water. Adsorption parameters were studied in detail, including pH (7–9), adsorbent dosage (4000–8000 mg/L of solution), and contact duration (60–180 min). To find the best possible values for these variables, we used a technique called Face-centered Central Composite Design (FCCCD). Therefore, a pH of 8, 120 minutes of contact time, and 6000 mg/L of adsorbent dose resulted in the maximum percentage of removal (65%). According to the adsorption experiments, the Freundlich isotherm provided a good match for the data. The results of this study demonstrated that an M. oleifera adsorbent may be effectively used to treat boron.

Praseetha P Nair,et.al (2018) Laboratory-prepared sewage was treated with chitosan nanoparticles to remove copper and zinc. Sodium tripolyphosphate and chitosan react to create these nanoparticles. Scanning electron microscopy and Fourier-transform infrared spectroscopy were used to investigate the synthetic particles. The results of experiments on batch adsorption were analyzed for their dependencies on pH, adsorption dose, contact duration, and temperature. For copper, the best results were achieved with an adsorbent dosage of 200 mg, a contact duration of 360 minutes, and a pH of 5, whereas for zinc, the best results were achieved with a contact time of 150 minutes, an adsorbent dose of 200 mg, and a pH of 7.

Wen, tao et.al (2019). Even though thallium, a very poisonous metal, is widely present in industrial effluent, very little research has been done on it. We performed adsorption tests on cerium-containing wastewater treated by chemical precipitation to better understand the appropriate adsorption kinetic parameters of the chelating resin containing hydrazine wastewater. In this chapter, we looked at how changing the pH, temperature, adsorption period, and adsorbent dose affected the optimal adsorption conditions, adsorption model, dynamic adsorption curve, and desorption and regeneration of adsorbent. When the pH is set to 9, the findings reveal that resin may remove up to 97.5% of the thallium in the wastewater. It took 80 minutes for the adsorption to achieve equilibrium at the optimal temperature of 30, which is where the temperature should be kept. Lagergren quasi-second-order adsorption and the Langmuir isotherm model are both suitable for describing the adsorption process. The resin's regeneration qualities are shown by the fact that, even after being used six times, the adsorption rates for the resin still exceed 95.8 percent. In conclusion, the thallium-containing wastewater may be effectively removed and reused thanks to the chelating resin.

Fatemehgorzin et.al (2018) For this study, we developed a novel, economically viable activated carbon from paper mill waste for the removal of Cr (VI) ions from aqueous solution. Experiments were conducted to determine the optimal conditions for adsorption, including the optimal dose, pH, contact duration, metal ion concentrations, and temperature. At an optimal pH 14 4.0, contact period of 180 min, and temperature of 45C, the adsorbent was able to equilibrium absorb 23.18 mg g1 of Cr (VI). The experimental data for equilibrium adsorption was analyzed using a number of different isotherm models, and it was found that the data best fit the Langmuir isotherm, as opposed to the Freundlich isotherm. A pseudo-second-order model was used to describe the kinetics of Cr (VI) adsorption onto activated carbon, and this suggests that a chemisorption mechanism predominates. It was found that Cr (VI) adsorption onto the adsorbent was possible, spontaneous, and endothermic based on the thermodynamic characteristics.

MATERIALS AND METHODS

The chemicals were all high-quality analytical reagents. For the purpose of making stock solutions, copper sulphate was used. The solution's pH was modified using hydrochloric acid and sodium hydroxide. All of the experiments were conducted using distilled water.

ADSORPTION EXPERIMENT

Using a constant quantity of chitosan (50mg) and varying copper concentrations (10-120 ppm), the adsorption capacity of chitosan was evaluated and the adsorption constant was calculated using various isotherms. Copper (II) solutions ranging in concentration from 10 to 120 ppm were employed, each with a volume of 50 mL. The flasks containing the chitosan (50 g) were heated to 250 degrees Celsius, and the chitosan was agitated at a speed of 100 revolutions per minute for a total of 360 minutes to extract copper. The adsorption capabilities of the adsorbent were assessed by measuring the concentrations of the solutions at their maximum adsorption wavelength both at the outset and at the conclusion of the experiment. Following the establishment of equilibrium, the metal uptake capacity of each sample was determined using equation (1), which represents a mass balance on the metal ion.

$$q_e = \frac{(C_0 - C_e)V}{m}$$

In this equation, m is the adsorbent's mass (in grammes), V is the solution's volume (in litres), C0 is the metal's initial concentration (in milligrams per liter), Ce is the equilibrium metal concentration (in milligrams per liter), and qi is the metal's quantity adsorbed at equilibrium (in milligrams per gramme). The pH levels at the start of the experiments were varied. Initial pH was controlled by adding either hydrochloric acid or sodium hydroxide to the mixture. The following equation was used to determine the purity level of the solution after metals had been extracted at a certain percentage.

$$\%removal = \frac{C_0 - C_e}{C_0} \times 100$$

In this equation, C0 (mg/L) represents the concentration of metal ions at the beginning of the process, and Ci (mg/L) represents the concentration at the end.

ADSORPTION KINETICS

Adsorption in wastewater is a good example of a system where a kinetic analysis would be useful, since it provides insight into the reaction pathways and mechanism. The mechanism of solute sorption from an aqueous solution onto an adsorbent has been the subject of kinetic models:

•A model of pseudo-first-order kinetics.

•Model of pseudo-second-order kinetics.

RESULTS

EFFECT OF pH

As can be seen in Figure 1, the pH of the aqueous solution had a clear effect on the efficiency with which copper ions were precipitated out. The findings showed that at pH 4, temperature 250C, and agitation speed 100 rpm, Cu (II) removal peaked and thereafter declined with pH change. At pH 5, Cu (II) was removed at a rate of nearly 89%. When the pH was below 5, the adsorption process was dominated by free Cu (II), the most abundant form of copper. Ramya et al. demonstrated that copper ions precipitated as Cu (OH)2 at a pH value above 5. (2005). Increases in metal removal with increasing pH may be explained by a reduction in positive surface charge, leading to less electrostatic repulsion between surface and metal ions, and a decrease in rivalry between proton and metal cations for identical functional groups. When the pH is increased above 5, soluble hydroxy compounds develop, causing a decrease in adsorption (R. Ramya et al., 2003). Results showed that solution pH had the greatest impact on Cu (II) ion adsorption.

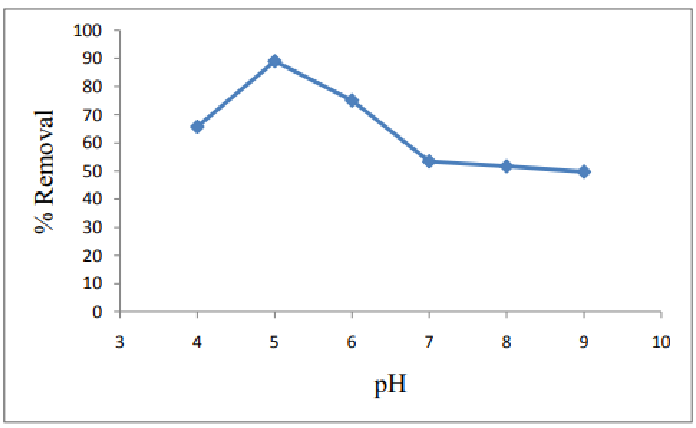

FIGURE 1: EFFECT OF PH ON ADSORPTION OF CU

EFFECT OF CONTACT TIME

Contact duration before equilibrium was established enhanced metal ion elimination, as seen in Figure2. The concentration of the adsorbent and the solution's pH were the only variables that were kept constant. From a contact time perspective, the findings showed that increasing the contact time from 10 to 360 minutes boosted Cu (II) removal from 15% to 89%. Because the equilibrium was attained at 360 minutes, the proportion of Cu (II) removal did not change from 360 minutes to 400 minutes. According to the findings, a contact period of 360 minutes was most effective for removing Cu (II) at a rate of 89%. This finding is significant since equilibrium time is a key factor in designing a cost-effective wastewater treatment facility.

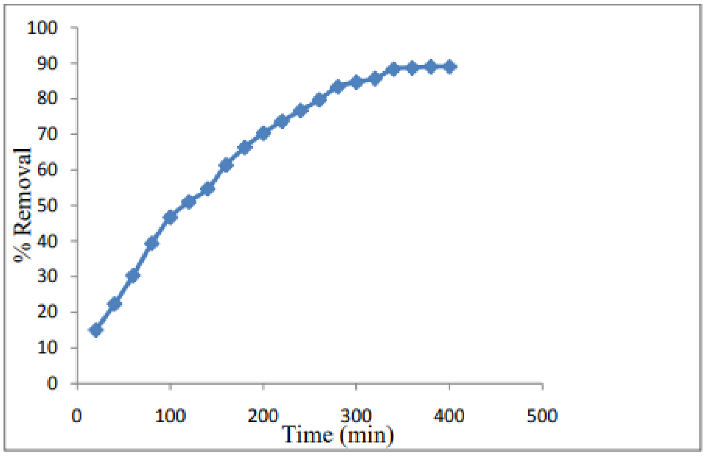

FIGURE 2: EFFECT OF CONTACT TIME ON ADSORPTION OF CU

EFFECT OF ADSORBENT DOSE

The effectiveness of adsorption for Cu (II) was investigated by changing the quantity of adsorbents from 50 mg to 200 mg while keeping all other parameters (pH and contact duration) unchanged. Figure 3 demonstrates that when adsorbent dosages were increased, copper removal efficiency generally increased. This may take place because there are more accessible exchangeable sites for the ions thanks to the larger dosage of adsorbents in the solution. The figure illustrates that when a specific quantity of adsorbent was added, the rate of adsorption could not be increased any further (200 mg). At 200 milligrams, Cu (II) was removed at a maximum percentage of around 88.17 percent. Moreover, these finding hints that the equilibrium conditions established and, therefore, the number of ions bound to the adsorbent and the number of free ions in the solution stay constant even with additional addition of the dosage of adsorbent.

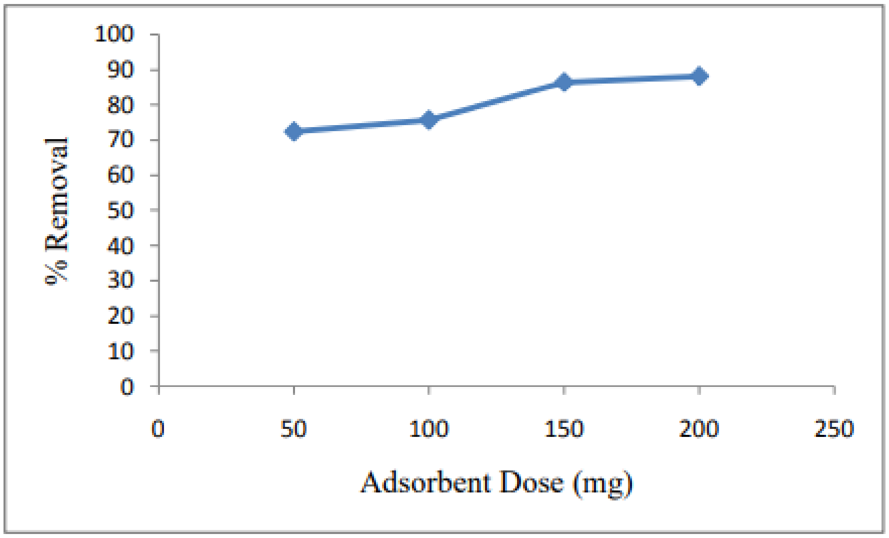

FIGURE3 EFFECT OF ADSORBENT DOSAGE ON ADSORPTION OF CU

ADSORPTION KINETICS

For a contact period of 10-360 min, the adsorption kinetics wereanalyzed. The pseudo first order and pseudo second order kinetic model were used to fit the data from the experiments (fig 4 & fig 5). Pseudo-second order model provides a superior match to the experimental findings, as shown by the stated R 2 value. In this light, the copper adsorption seems to be more pseudo second order.

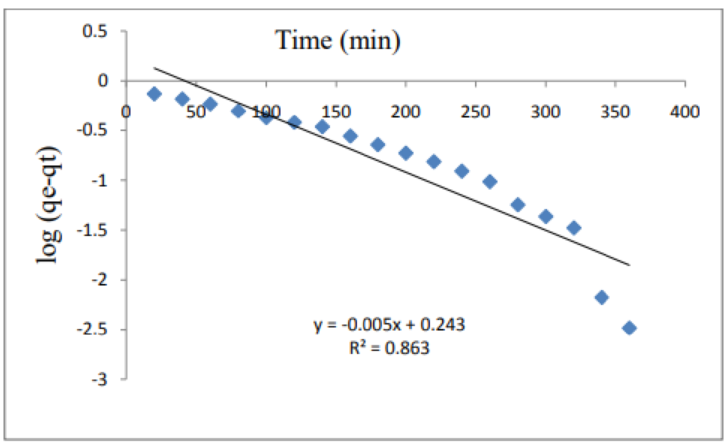

FIGURE 4: PSEUDO FIRST ORDER KINETICS PLOT FOR CU ADSORPTION

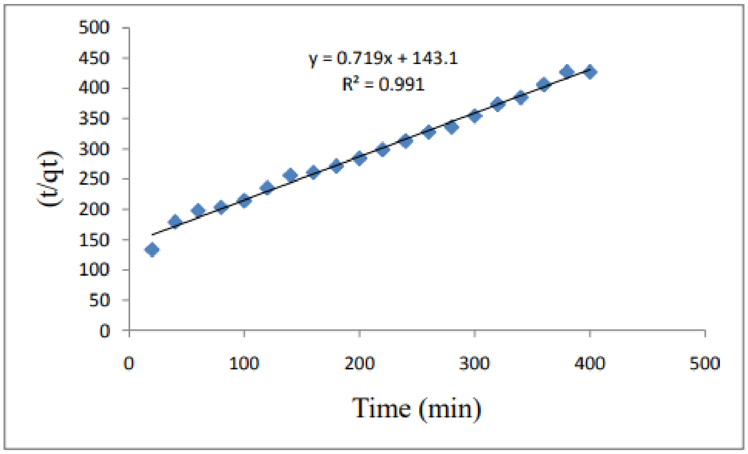

FIGURE 5: PSEUDO SECOND ORDER KINETICS PLOT FOR CU ADSORPTION

CONCLUSIONS

High cost, poor adsorption capacity, difficulties in separating after adsorption, etc. are some of the issues with currently available commercial adsorbents. Adsorption in a magnetic field allows for simple separation. It has been shown that the removal efficiencies of heavy metals may be somewhat influenced by process factors such pH, adsorbent dose, temperature, contact duration, and starting metal ion concentration. Specifically, 360 min was determined to be the sweet spot for copper adsorption. The adsorption process was shown to follow a pseudo second order kinetic model for both metals, according to the kinetic investigations.

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