ADSORPTION AND REMOVAL OF HEAVY METAL IONS OF NICKEL AND CADMIUM FROM WASTEWATER BY USING ACID ACTIVATED CARBON OF SAMANEA SAMAN.

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Abstract

Nickel and Cadmium play an important role in metallurgical, electroplating, and other chemical industries. About 40% of the Nickel and Cadmium produced is used in steel factories, Nickel batteries, and the production of some alloys. On the other hand, it may pollute aqueous streams, arising therefore several environmental problems. An adsorbent prepared from Samanea saman by acid treatment was tested for its efficiency in removing nickel and cadmium The agitation duration, initial Nickel and Cadmium ion concentration, adsorbent dosage, Ph, and temperature were between the process variables studied. The adsorption followed a second-order reaction equation, and intra-particle diffusion primarily determines the rate. The equilibrium adsorption data were connected with the Radlich-Peterson, Jovanovic, Halsay, Hurkins-Jura, Temkin, Freundlich, Dubinin-Radushkevich, and BET isotherm models. The Langmuir isotherm plot's measurement of the adsorption capacity (Q_m) at initial pH 6.5 and temperatures of 30, 40, 50, and 60 ºC with a 0.5 ºC error The elimination of metal ions was significantly influenced by pH, and the adsorption increased as temperature rose. Using 0.1M HCl, some of the nickel and cadmium ions from the used APANC were salvaged.

Keywords: Activated Samanea Saman Leaves Carbon (ASSLC), Equilibrium, Thermodynamic Parameters, Nickel Ion, Cadmium Ion, Adsorption Isotherm,

1. Introduction :

Water quality is negatively impacted by heavy metal pollution of water and water bodies, which is a severe environmental issue. Reduced water availability, higher purifying costs, eutrophication of water bodies, and lower aquatic output are the results [1In order to tackle the menace posed by heavy metal pollution of water, several options have been adopted. These include oxidation and reduction, chemical precipitation, filtration, electrochemical treatment, ion exchange, membrane separation, reverse osmosis, adsorption, evaporation, and electrolysis [2]. However, adsorption has been proven to be one of the best options available for the removal of heavy metals from aqueous solutions [3, 4]. In view of the above, several studies have been conducted using various materials as adsorbents [5–7]. However, some of these adsorbents also contain other toxicants; some are expensive and are characterised by a limited surface area for adsorption.

A literature search indicated that fruit stones have been used to remove various heavy metals from aqueous solutions, but there is little information available on the use of fruit stone-derived activated carbon for the removal of the ions Ni (II) and Cd (II) from aqueous solutions. As a result, the goal of the current study is to look at the viability of employing ASSLC.

2. MATERIALS AND METHODS

2.1 Adsorbent

SAMANEA SAMAN LEAVE

2.2 Chemicals

A set of aqueous metal solutions displaying various concentrations of cadmium (Cd) and nickel (Ni) were established by diluting cadmium nitrate (Cd (NO3)24H2O) and nickel nitrate (Ni (NO3)26H2O) with distilled water. The pH of the solutions was adjusted using HCl (0.1 N) and NaOH (0.1 N) to achieve the desired values. The Samanea Saman Samples of leaves were collected in the Tiruvarur District. To get rid of surface imperfections and pollutants (such sand and salt), the leaf samples were first washed with deionized water. After being cleaned, leaf samples were dried in the sun for 24 hours. After being crushed, dried leaf samples were sieved to a 0.5-1.0 mm particle size. After being sieved, the samples were cleaned with deionized water and dried for 24 hours in a 70 °C oven. After that, sodium chloride (NaCl) was used to perform a surface alkaline treatment on the samples.

2.3 Batch Experiments

In batch adsorption studies carried out at 30–60 °C, the impact of different parameters on the removal of nickel ions from ASSLC was investigated. A 250 ml capped conical flask was used to hold 50 ml of a nickel solution with a known beginning concentration and pH for each experimental run. The solution is supplemented with a 25 mg dosage of adsorbent, and the mixture is shaken continuously for 150 rpm. At suitable intervals (10–60 min), samples are taken, and the adsorbent is filtered to separate it.

The nickel ion concentration in the residual solutions was assessed. By contacting 50 ml of a solution containing 50 mg/L of nickel ions with 25 mg of ASSLC until equilibrium was reached, the effect of the dosage of adsorbent on the removal of nickel ions was determined. With 50 ml of nickel ion solution and 25 mg of ASSLC dose, the adsorption equilibrium isotherm is investigated. In all sets of trials, the starting concentrations varied from 10 to 50 mg/L. The plugged conical flask was shaken for 60 minutes at a speed of 150 rpm. After then, the solution was taken out of the combination and its nickel ion content was examined. A mass equilibrium equation was used to determine the adsorption capacity and the results are as follows:

$$q_e = (C_0 - C_e) V/M \quad (1)$$

Where C_0 and C_e are the initial nickel concentration (mg/L) and equilibrium concentration, respectively, V is the experimental volume of nickel ion solution expressed in litres [L], and M is the adsorbent mass expressed in grammes [g]. The nickel ion ions percentage can be calculated as follows:

$$\%R = (C_0 - C_t) \times 100/C_0 \quad (2)$$

The effect of pH on the rate of adsorption was investigated using a nickel concentration of 20 mg/L and constant ASSLC dosage. The pH values were adjusted with diluted HCl and NaOH solutions. The adsorbent-adsorbate mixture was shaken at room temperature using 150 rpm of agitation for 60 minutes. Then the concentration of

nickel in the solution was determined.

3.RESULTS AND DISCUSSION

3.1 FTIR Techniques

The powerful bonds at 3400 1/cm (O-H stretching vibration), which can be attributed to hydroxyl functional groups, were visible in the FTIR spectra of the ASSLC (Fig. 1). The vibration modes of the C-H, aromatic CC, and COC= bonds, respectively, were assigned to the absorption bonds at 2900, 1640, and 1100 1/cm, respectively. The chemical attributes of ASSLC were assessed using the following ASSLCs: aromaticity, the degree of the aromatic ring, aliphatic chain length, oxygen function groups, and the C' factor. These ASSLCs were generated by integrating absorbance peak areas. A standard for identifying oxygen-containing groups in samples was the ratio of the C=O to CC= stretching group (also known as the C' factor).


Fig. 1 F T I R Analysis of. *Samanea Saman Leaves*
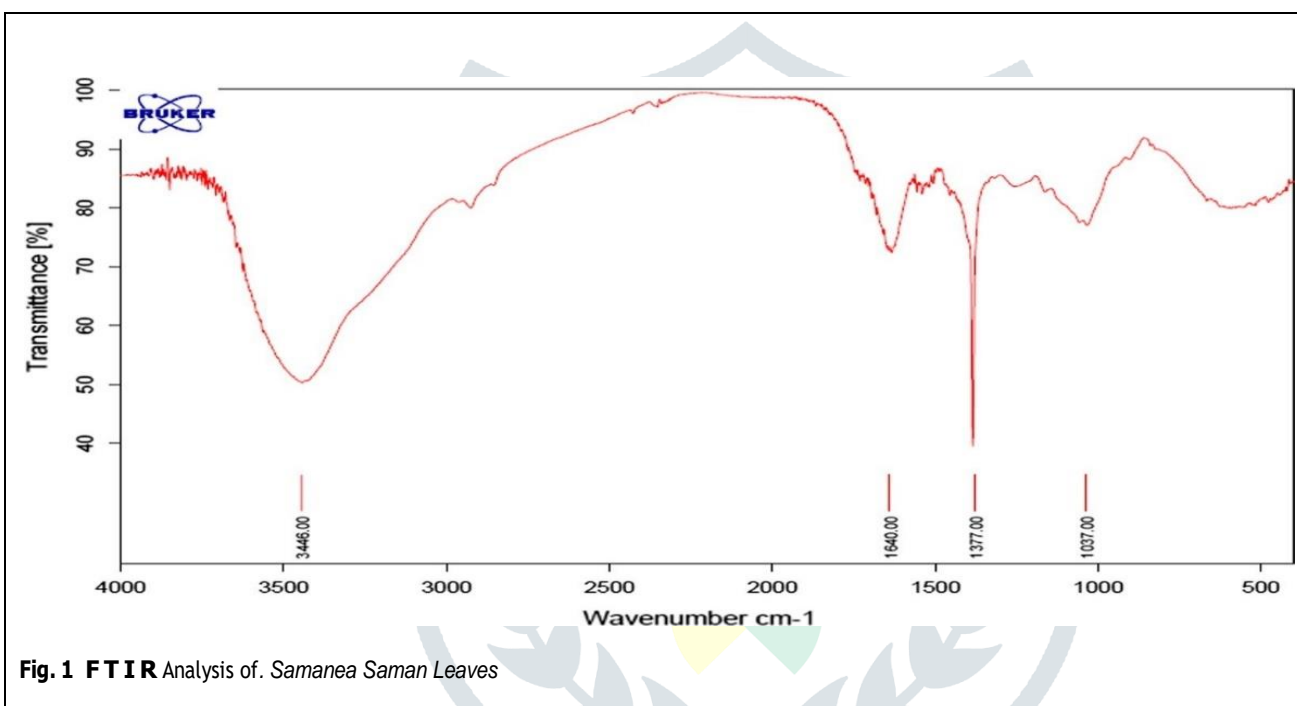
3.2 Effect of PH

According to the trials done at various pH levels, the % removed from metal ions changed throughout the whole pH range depicted in Fig. 3. This demonstrates the potent interaction between the metal ion and the ASSLC, such that the adsorption capacity may be impaired by either H+ or OH- ions. In other words, ion exchange mechanisms do play a role in the adsorption of metal ions on ASSLC and have an impact on it as the pH changes. The positive êH0 value observed and the type I and type II isotherms agree with this discovery, which points to irreversible adsorption caused most likely by polar interactions.

Fig. 2 Effect of pH on Ni (II) and Ca(II) adsorption onto the *samanea saman* adsorbent
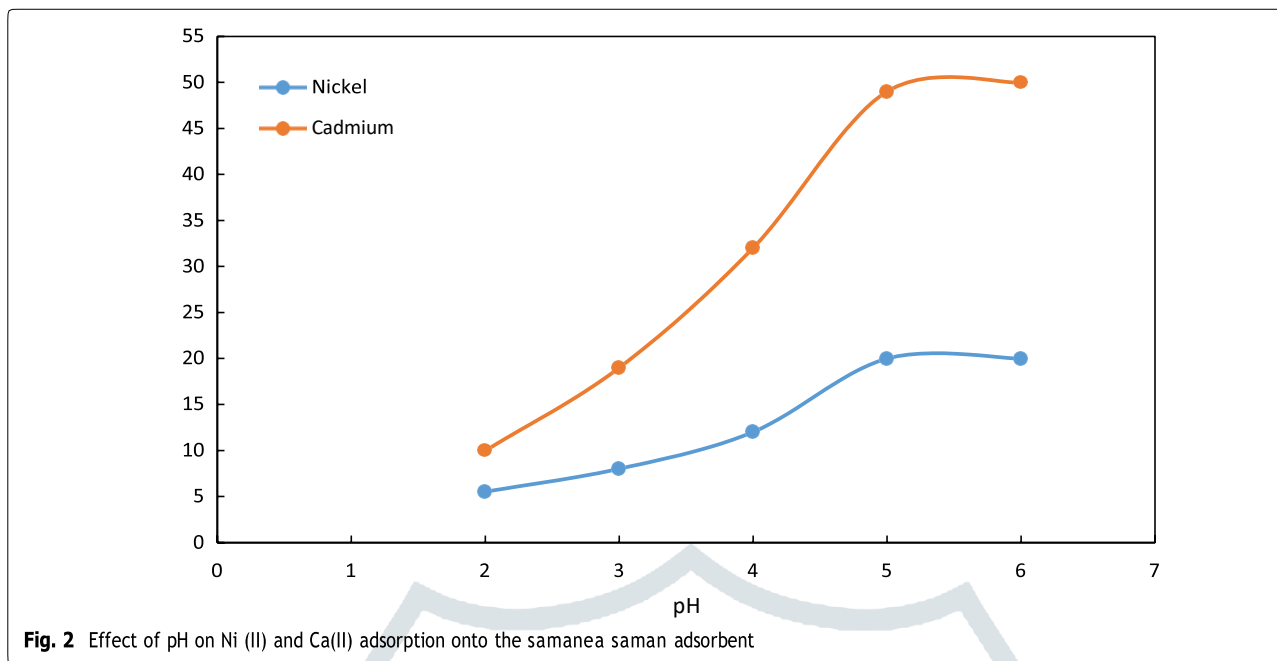
3.3 Effect of Adsorbent dosage

The dosage of the adsorbent is important since it can define the adsorbent's capacity for a specific initial metal ion concentration. At an initial metal concentration of 100 mg/L, a temperature of 25 °C, and a pH level of 6, the influence of adsorbent dosage in the range of 1-4 g/L on the uptake of Ni and Cd by NaCl-pretreated ASSLC is depicted in Fig. 3. Because some of the active sites remained unsaturated during the adsorption process, Fig. 4 shows that the capacity for adsorption of Ni(II) and Cd(II) from an aqueous solution decreased with the increase of the adsorbent dosage. However, the number of sites available on the NaCl-pretreated C. ASSLC increased with the increase in the biosorbent dosage. Therefore, a dosage of 1 g/L was chosen for further study.

Fig. 3 Effect of adsorbent dosagezxc of Ni(II) and Ca(II) onto NaCl-pretreated *ASSLC*
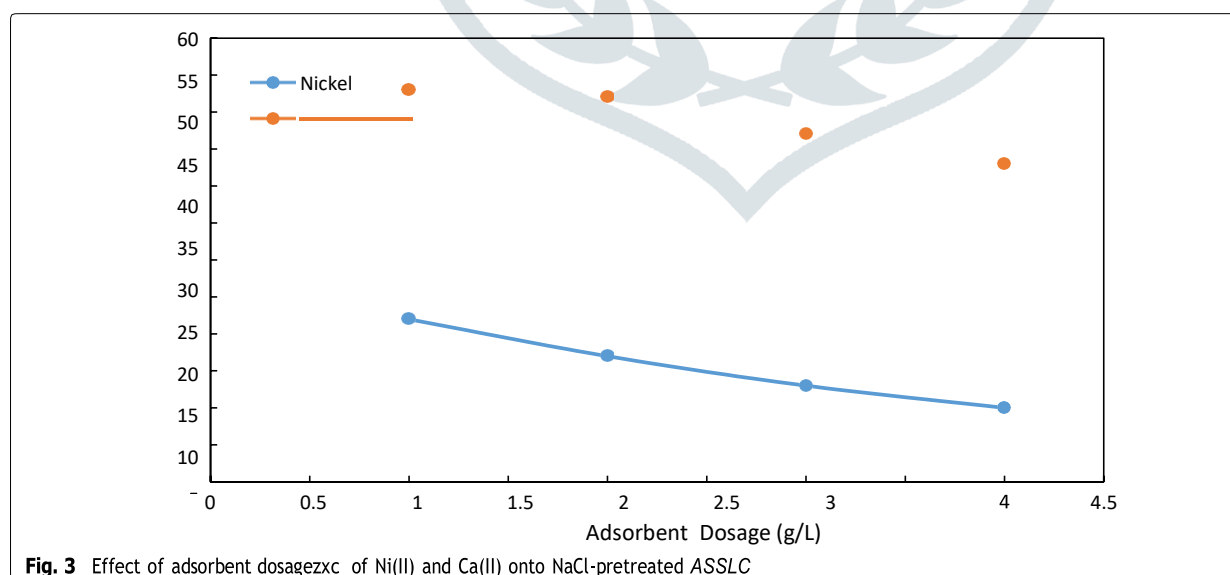
3.4 Effect of contact time

The rate of adsorption is of high importance in modelling and designing the adsorption process in industry. Therefor, the effect of contact time on nickel and cadmium sorption onto the *C. indica* is revealed in Fig. 4 at an initial concentration of 100 mg/L and 25 °C at pH 6 with a contact time that varies from 10 to 180 min. According to Fig. 3, biosorption capacity increased with increasing contact time. More than 95% of the total adsorption of nickel and cadmium occurs within the first 60 minutes. This behaviour might be due to the fact that initially all active sites on the adsorbent's surface are vacant and the solution concentration is high. After that period, few surface-active sites will be available, so only a very low increase in the metal uptake is observed. Therefore, a contact time of 180 minutes was selected for all the equilibrium tests. Yinghui and Fang studied the biosorption of Cu(II), Cd(II), Ni(II), and Zn(II) onto pretreated biomass of brown algae [34], and Ibrahim investigated the biosorption of Co(II), Cd(II), Cr(II), and Pb(II) by red macroalgae [35] and reported similar contact time behaviour for Cd(II) and Ni(II) metal ions as observed in the current study
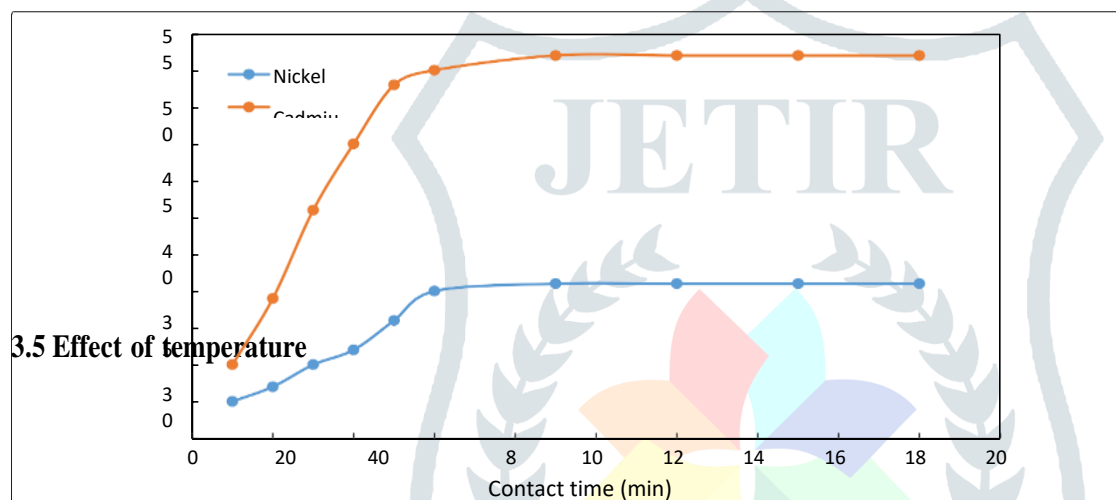

Fig. 4 Effect of contact time on adsorption of Ni (II) and Ca(II) onto *ASSLC*
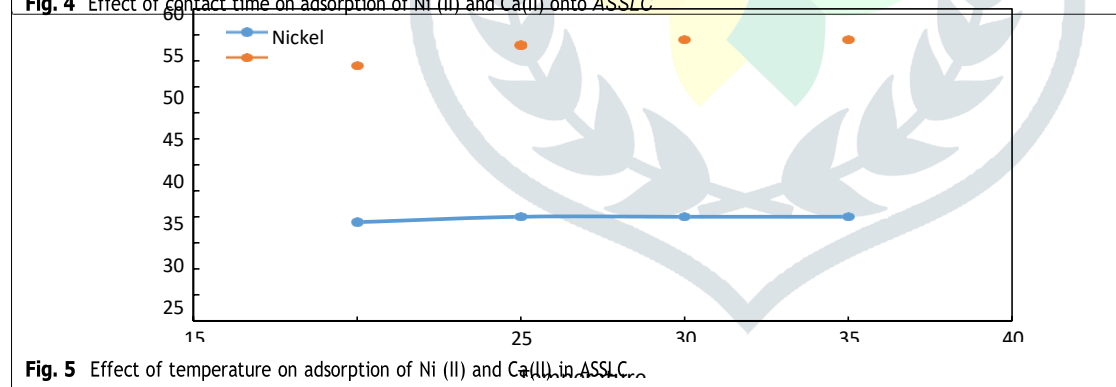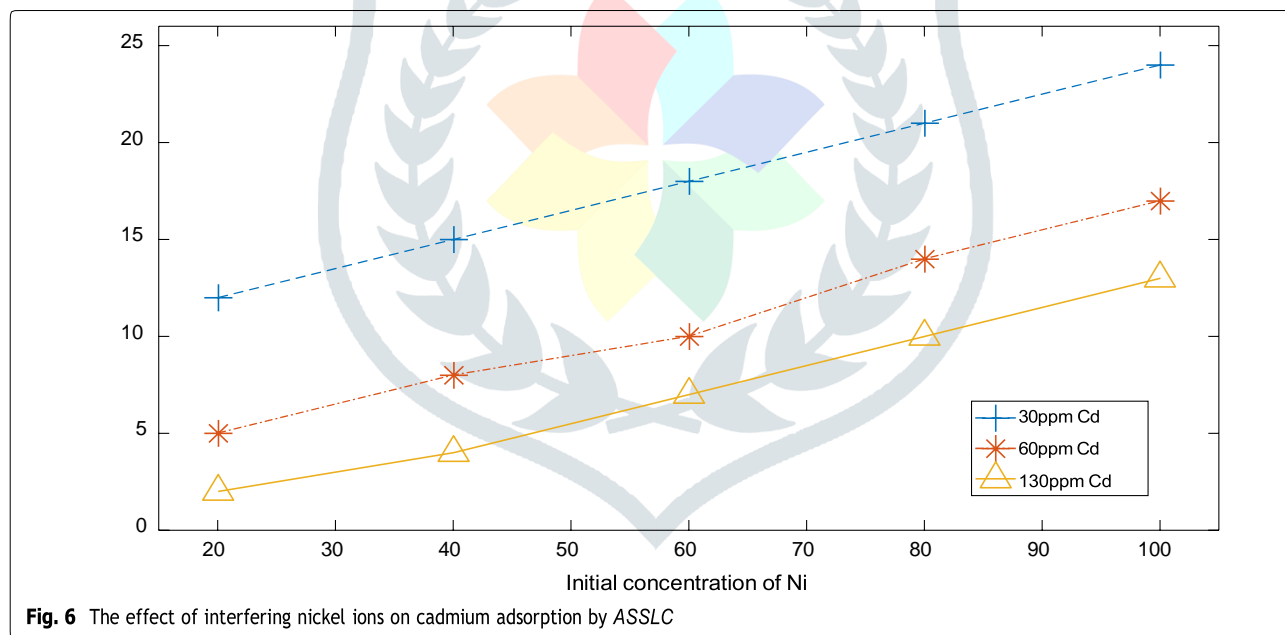
3.5 Effect of temperature

Fig. 5 Effect of temperature on adsorption of Ni (II) and Ca(II) in ASSLC
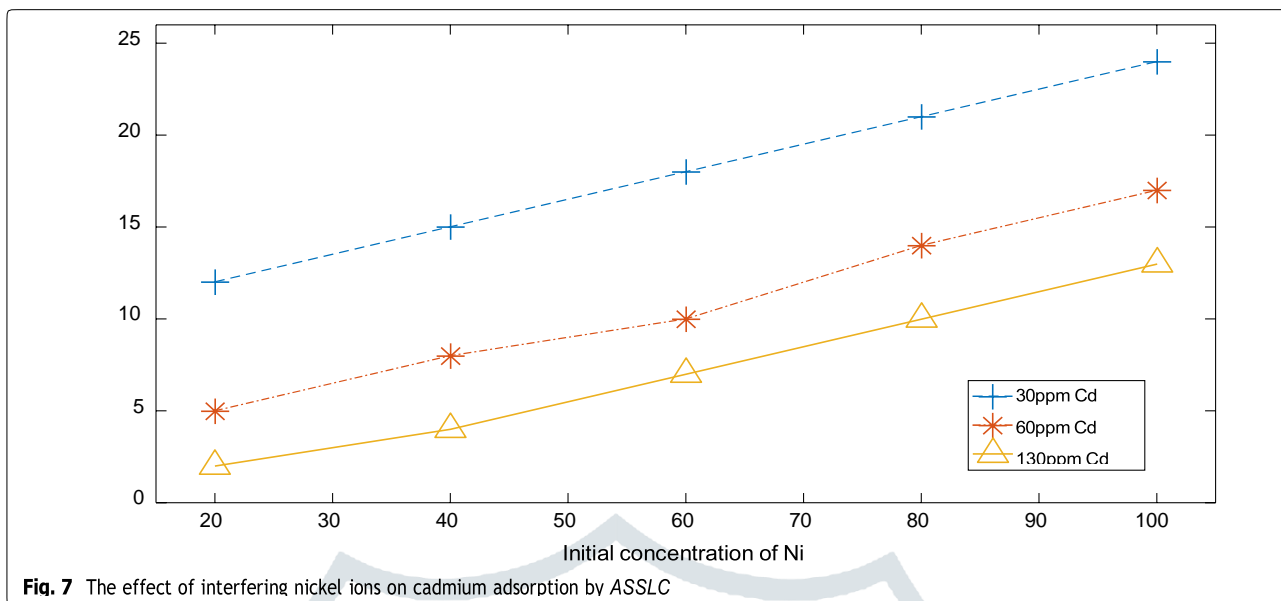
In ternary component systems, the adsorption experiments were conducted for both heavy metals at four different temperatures (20, 25, 30, and 35 °C). The findings are shown in Fig. 5. Over a contact period of 180 minutes, it was noticed that the adsorption capacity of cadmium increased as the temperature rose from 20 to 25 °C. Cadmium's capacity for biosorption remained consistent after 25 °C as well. On the other hand, nickel's adsorption capability remained constant as temperature rose.
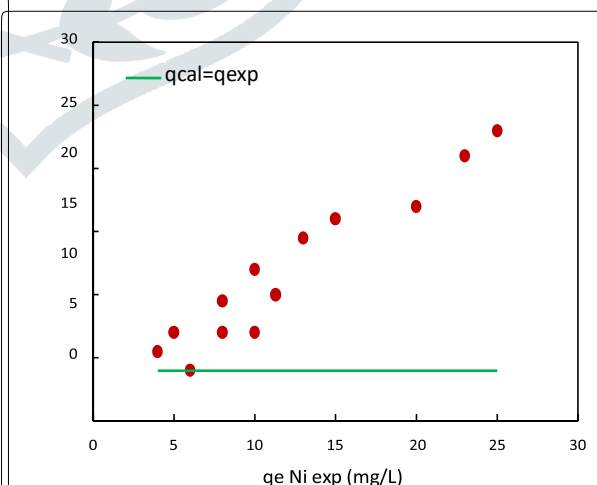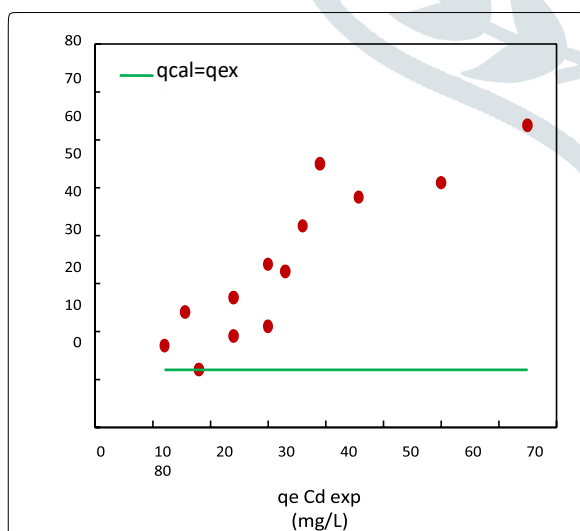
3.6 Effect of initial concentration

Tests were conducted to compare the adsorption performance of *ASSLC* with respect to nickel and cadmium. An initial concentration of nickel of 60 mg/L was set in three containers. In one of those containers, the initial concentration of cadmium was set at 30 mg/L; in the second container, it was set at 60 mg/L; and in the third container, it was set at 130 mg/L. The measured adsorption of nickel by *ASSLC* was 17.5, 9.6, and 5 mg/L, respectively, in the first, second, and third containers. . For comparison purposes, an initial concentration of cadmium of 60 mg/L was set in another three containers. In one of those containers, the initial concentration of nickel was set at 30 mg/L, in the second container, it was set at 60 mg/L, and in the third container, it was set at 130 mg/L. The measured adsorption of cadmium by *ASSLC* was 35, 20.6, and 10.1 mg/L, respectively, in the first, second, and third containers. These observations suggest that *ASSLC* clearly has a tendency to adsorb significantly more cadmium than nickel. Adsorption is believed to occur at several functional groups within algae, including carboxyl and sulfonic acids. There may also be other functional groups in *A* that are involved in the adsorption of both metal ions. Figures 6 and 7 display a synergistic effect in the binary system by which cadmium is more successfully adsorbed at active sites by *ASSLC*. Metallic behaviour in multi-component systems is believed to strongly depend on the physical and chemical characteristics of the adsorbent that, in turn, affect the equilibrium behaviour of the adsorption processes. The number and type of ions, the concentration of each component ion, pH, and the isotherm models considered will determine the equilibrium constants.
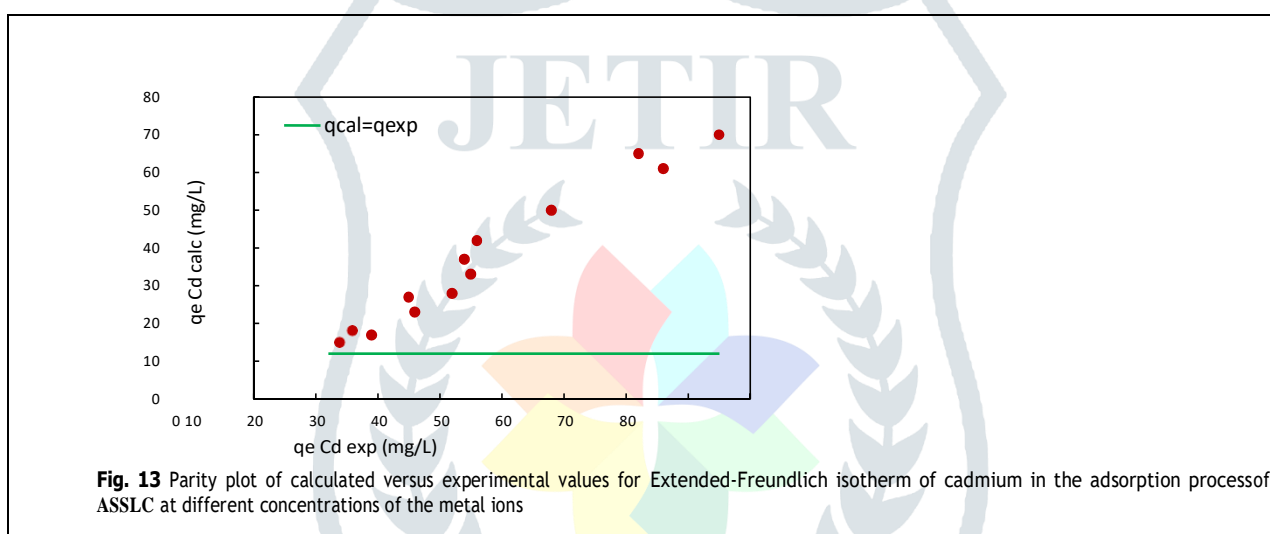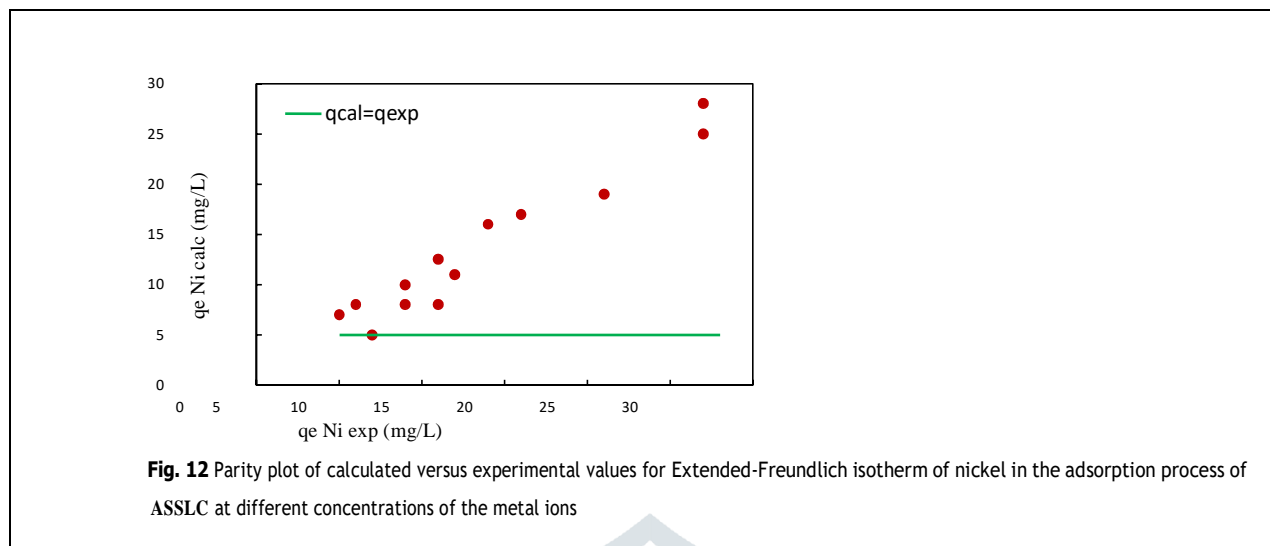

Fig. 6 The effect of interfering nickel ions on cadmium adsorption by *ASSLC*

Fig. 7 The effect of interfering nickel ions on cadmium adsorption by *ASSLC*

3.7 Adsorption isotherms

The isotherm constants and coefficient of determination (R2) were calculated from the tests for the *ASSLC* tests with the extended Langmuir and extended Frisch isotherms. The optimised conditions were obtained from the following sections: Initial concentration: 100 mg/L, pH 6, adsorbent dosage: 1 g/L. Also, all experiments lasted 180 min at 25 °C. The appropriate parameter values for the isotherm models considered for the ASSLC adsorption of nickel and cadmium are derived from the experimental data by maximising the objective function (i.e., R2). For the nickel and cadmium binary systems, the absorption equilibrium data for *ASSLC indicate that they* are better described (i.e., have a higher R2) using the extended Freundlich isotherm for nickel. On the other hand, the adsorption

Fig. 8 Parity plot of calculated versus experimental values for Extended-Langmuir isotherm of cadmium in the adsorption processof *ASSLC* at different concentrations of the metal ions

Fig. 10 Parity plot of calculated versus experimental values for Extended-Langmuir isotherm of nickel in the adsorption process of *ASSLC* at different concentrations of the metal ions

Fig. 12 Parity plot of calculated versus experimental values for Extended-Freundlich isotherm of nickel in the adsorption process of **ASSLC** at different concentrations of the metal ions

Fig. 13 Parity plot of calculated versus experimental values for Extended-Freundlich isotherm of cadmium in the adsorption processof **ASSLC** at different concentrations of the metal ions

4.CONCLUSION

Nickel and cadmium ions were successfully removed from aqueous solutions using an ASSLC made from Samanea saman leaves (Thoongumoonchi). Adsorption occurs more quickly, and intraparticle diffusion primarily determines the rate. The removal of nickel and cadmium ions using the sorption equation derived from the Langmuir and Freundlich isotherms was shown to be successful using ASSLC. The equilibrium data fit the Freundlich and Langmuir isotherm models nicely. The nickel and cadmium ion adsorption is endothermic and spontaneous, with greater unpredictability at the solid-solution interface, according to the temperature variation investigation. The pH of the nickel-ion and cadmium solution was shown to have a substantial impact on adsorption. The desorption of metal ions in mineral acids and pH-dependent data indicate that chemisorption and physisorption mechanisms are involved in the adsorption of metal ions on ASSLC.

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