STUDIES ON ADSORPTIVE BEHAVIOUR OF PALM PEEL POWDER ON HEAVY METAL-CHROMIUM

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Abstract

In this paper the removal of Chromium heavy metal is carried out with the help of bioadsorption technique.Palm peel powder was used as a low cost adsorbent which is used to remove Cr (VI). The adsorbent was characterized by FT-IR, SEM, and XRD. The removal percentage of the Heavy metal ion is determined by Atomic Adsorption Spectroscopy. The Removal of Heavy metal is employed through batch adsorption studies. The effect of contact time, initial concentration, pH, have been investigated. The removal rate of Heavy metal is increasing with increasing pH. The maximum Removal of heavy metal is obtained at pH 5 and 100 min of agitation. The results confirm that palm peel powder is the efficient bio sorbent for the removal of heavy metal chromium.

Key words: Biosorption,palmpeel, heavy metal

Introduction

The quality of water is affected mostly by human activities, like urbanization,industrialization etc., industrial wastages contribute huge amount of contaminants to water. (1) Each year the world generates perhaps 5-10 billion tons of industrial waste, much of which is untreated into rivers, oceans and other waterways.Different types of contaminants are released to waste water including heavy metal ions, organics, bacteria, viruses and so on which are making serious health defects for human. Water contaminated with heavy metal is a serious issue for earth [2,3]. The heavy metals like Pb^{2+},Cd^{2+},Zn^{2+},Ni^{2+},Cr^{6+},Hg^{2+} have high toxicity and non-biodegradable properties can cause serious health problems in animals and human beings (4). Among these Heavy metals Cr makes serious health issues, it has been widely used in various industries like textile, chemical manufacturing, metal finishing, paint industries, leather tanning industries, metal processing,stainless steel welding, chromate production and chromate pigments etc (5). Even though several methods are used to remove heavy metals in current status like chemical precipitation [6] ion exchange[7]reverse osmosis[8], solvent extraction[9], froth flotation andadsorption [10].Among these methods, adsorption is currently considered to be very suitable for wastewater treatment because of its simplicity and cost effectiveness[11].Adsorption process is highly appreciated for the materials what we using as a adsorbent it may be natural material or certain waste from industrial or agricultural operation is one of the resources for low cost adsorbents[12,13,14]. Adsorption process has great potential for the elimination of heavy metals from industrial wastewater using low cost adsorbents.so the main objective of this present study is eliminate the Chromium heavy metal by using the low cost adsorbent palm peel powder.

Materials & Methods

Potassium di chromate is used to prepare stock solution in a ppm range. NaOH and HCl were used to adjust pH. The chemicals which were used for this studywas Analytical Grade.

Preparation of Stock solution

Potassium dichromate ($K_2Cr_2O_7$) is used as the source for chromium stock solution. All the required solutions are prepared with analytical reagents and deionised water. 2.835 g of 99% $K_2Cr_2O_7$ is dissolved in deionised water of 1.0L volumetric flask up to the mark to obtain 1000 ppm (mg/L) of Cr (VI) stock solution. Synthetic samples of different concentrations of Cr (VI) are prepared from this stock solution by appropriate dilutions. For example, 100 mg/L chromium stock solution is prepared by diluting 100mL of 1000 mg/L chromium stock solution with distilled water in a 1000mL volumetric flask up to the mark. Similarly solutions with different metal concentrations such as (5, 10, 15, 20, 25 and 30 mg/L) are prepared.

$$\text{Cr equivalent to 1 gm} = \frac{\text{Molecular Wt. of } K_2Cr_2O_7 \times 100}{(\text{Atomic Wt of Cr} \times 2) \times \text{purity}}$$

Preparation of Biosorbent

Palm peel was collected from village premises and washed thoroughly; again it was washed with distilled water and dried in sunlight. The materials were ground using pestle and mortar, later were sieved to obtain homogeneous size. Ground materials were kept in self-sealing polythene bags to avoid Moisture effects.

Modification of Palm peel powder

The modification of Palm peel powder was done as follows, 3g of dry powder was added with 50ml 0.1N oxalic acid and it was agitated for 100 minutes and the supernatant was discharged. Again the material was treated with 10 ml of 0.1N DMSO and involved in agitation for 100 minutes and filtered. The modified biosorbent was dried in oven and kept in air tight container safely.

Characterization of Biosorbent

The surface morphology of the biosorbents was examined using Scanning Electron Microscope. i.e. Surface porosity and pore volume in adsorbents indicates the better quality of biosorbent as evidenced by filling of the pore after adsorption of sorbate ions as observed by SEM. XRD analysis deals about crystallographic structure of adsorbent. The presence of functional groups capable of interacting with metal ions to form complex or chelates on the biosorbents was confirmed by FT-IR spectrometer.

Modified biosorbent was subjected to characterization by standardized spectroscopic tools of Fourier Transform Infrared (FTIR) and UV-Visible spectroscopy. FTIR spectra of pressed pellet were recorded from 4000 cm-1 to 400 cm-1 on FTIR-8400, Shimadzu, Japan. The dried mass of biosorbent) was also pressed into pellet for observation under FTIR. UV-VIS spectra were fit with Gaussian curves measurement of λmax keeping distilled water for background correction. The samples surface morphology and size was determined with Scanning Electron Microscopy (SEM). Sample was sonicated and analyzed at different magnifications on 6490(LA) JEOL machine with gold sputtering at a potential of 20 kV prior to recording SEM.

Batch Adsorption Experiment

After preparing ppm range stock solutions and chemically modified biosorbent, batch mode were conducted by agitating 0.3g of biosorbent with 30 ml of stock solution for 90 minutes. This experiment is repeated with various parameters such as pH, contact time, adsorbent dosage. The metal ion concentration was determined by spectrophotometer.The solution containing adsorbate and adsorbent was taken in 250 mL capacity conical flasks and agitated at 180 rpm in a mechanical shaker at predetermined time intervals. The adsorbate was decanted and separated from the adsorbent by using Whatman filter paper.

The filtrate was analysed by atomic adsorption spectrophotometer for determining the amount of metal adsorbed.

Heavy metal Analysis

Final residual metal concentration after adsorption was measured by atomic adsorption Spectrophotometer. To estimate the percentage removal of chromium (VI) from aqueous solution, the following equation was used.

$$\text{Percentage removal of Cr (VI)} = \frac{C_{initial} - C_{final}}{C_{initial}} \times 100$$

Where, $C_{initial}$ and C_{final} are the concentrations of Cr (VI) at the beginning and at the end of theadsorption process. The metal uptake (*q*e) at equilibrium time was calculated from the followingequation

$$q_e = \frac{(C_0 - C_e)V}{1000w}$$

Where *q*e(mg/g) is the amount of chromium adsorbed per unit weight of adsorbent, C_0 and C_e are the initial and equilibrium chromium ion concentration (mg/L), V is the volume of aqueoussolution (mL), and w is the adsorbent weight (g).

Results and Discussion

SEM Analysis

The SEM images were used to examine the surface morphology of palm peel powder before and after modification. The images are shown in Fig() (). The surface of palm peel powder was smooth and with systematic microporous structures which has chemically modified with DMSO followed by oxalic acid. The modified palm peel images are detected with some irregularly distributed pores and these pores are acting as active sites, where the adsorption is going to takes place .The pores enhance the adsorption of metal ions. The micrograph of palmpeel powder after chromium (VI) adsorption shows a reduction of number of pores, pore space and surface area available. Hence it is confirmed that there is metal adsorption on the surface of adsorbent

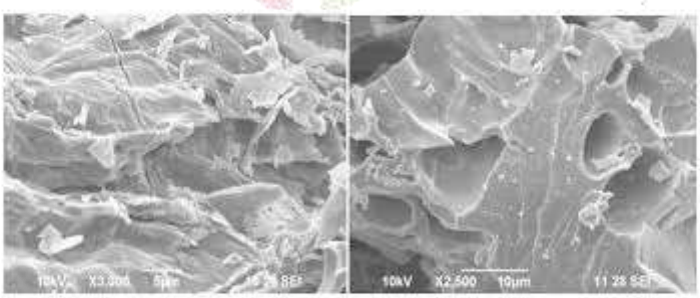
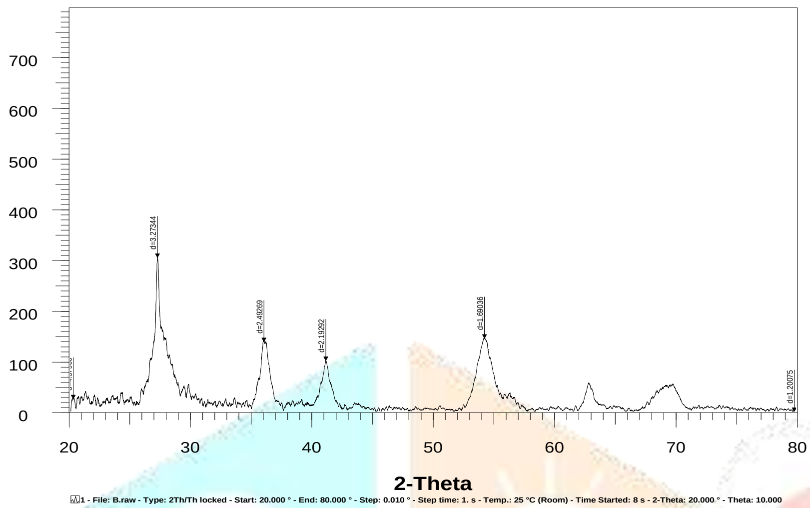


Fig:1 sem images of palm peel powder before modification and after modification.

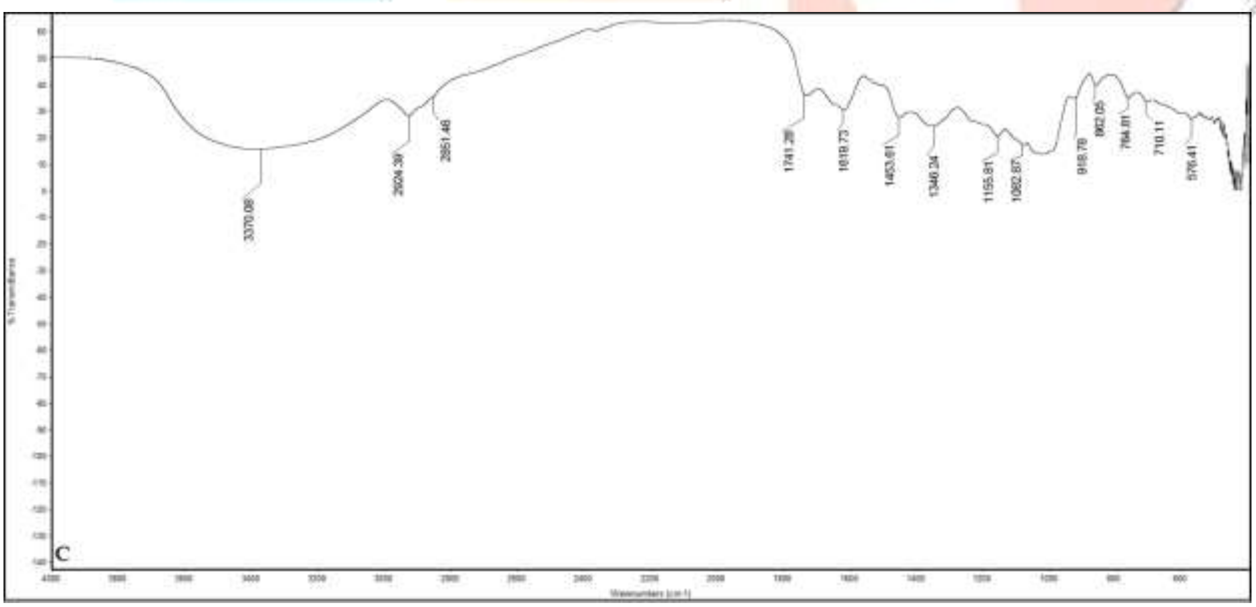
XRD Analysis

The crystallite size were determined from characteristic peaks obtained from the XRD image.The crystallite domain size was calculated from the width of the **XRD** peaks using Scherrer formula, assuming they are free from non-uniform strains. $D=0.94\lambda / \beta\cos\theta$ …. (Eq i), where D is the average crystallite domain size perpendicular to the reflecting planes, λ is the wavelength of Xray, β is the full width at half maximum (FWHM) and θ is the diffraction angle. . The biosorbent from the palm peel powder was further demonstrated by the characteristic peaks observed in the X-Ray Diffraction (XRD) image. The average crystallite size calculated from Scherrer formula was found to be in nanocrystalline form.



Fig(2) XRD image of modified Biosorbent

FT-IR ANALYSIS:



fig(3)FT-IR images of modified Biosorbent

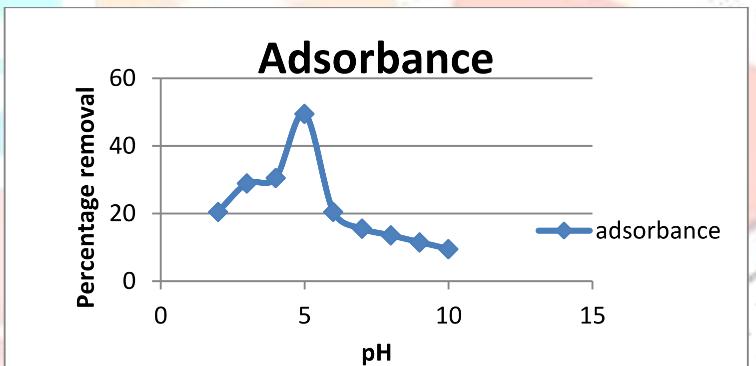
The identification and the existence of functional group present in the biomass of palm peel powder were studied by FT-IRanalysis.in spectra, a broad band range of 3370.08cm-1 corresponds to the presence of hydroxyl group associated with NHbond of amine group.it was justified by the presence of broad band in the range of 2924.39-2851.46cm-1correspondsto –CH stretching vibration of methylene hydrogen.The frequency at 1741.28cm-1attributed to carbonyl group.adsorption band at 1453cm-1revealed to the group of C=Cof arene .frequency at 1346cm-1 and at 918cm-1 corresponds to –OH group associated with carboxylic acid.strong broad band at 1155 and 1082cm-1corresponds to the presence of carbonyl group. The frequency range 710-862 cm-1 shows the presence of alkyl halide.Presence of carboxylic groups enhances the metal adsorption, so that we are using oxalic acid for chemical modification.

Effect of various parameters on the adsorption of Cr (VI) by palm peel powder

Biosorption of chromium metal is affected by various parameters.

Effect of pH on aqueous solution

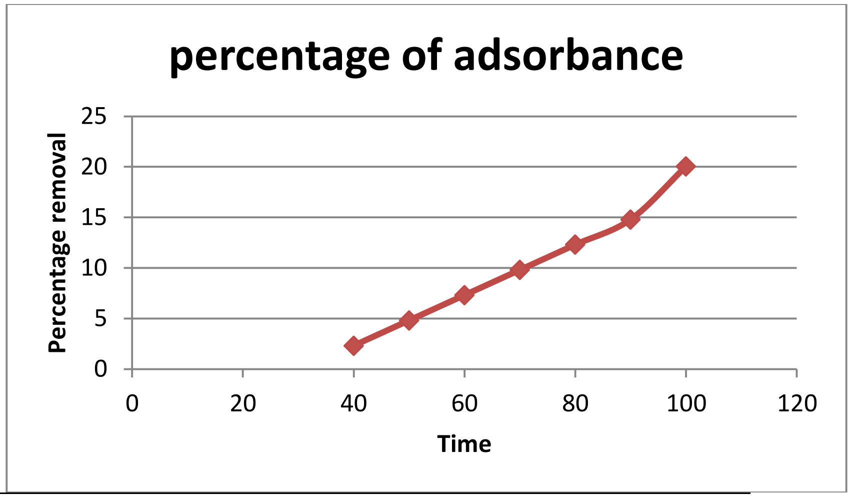
The pH of the solution affects the surface charge of the adsorbent, as well as the degree of the ionization and speciation of different pollutants. A change in pH affects the adsorptive process through the dissociation of functional groups on the adsorbent surface active sites. In this work, the effect of pH was studied at room temperature by adjusting and maintaining the pH of the wastewater to the required value (2-10) with a 1.0 M oxalic acid solutionand mixed with the optimum weight of the adsorbents and agitated at a preset equilibrium time. The effect of pH on heavy metal removal was conducted with palm peel powder, 0.3 g of palm peel powder added with 30ml of stock solution and the initial concentration of the solution is in 0.1M.The results obtained on the effects of pH on the quantity of heavy metal removals for palm peel powder are as presented in figure 3.The figure revealed that the maximum uptake percentage of heavy metal removal was observed at pH = 5,while increasing the pH the percentage of metal adsorption also increased, after pH 5 adsorption will gradually decreases.



Fig(4) Effect of pH

Effect of Contact time on aqueous solution

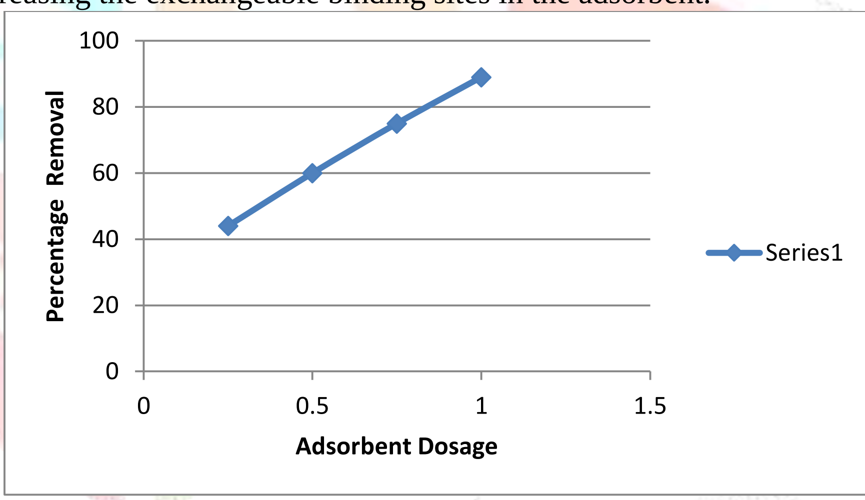
The contact time between the adsorbent and adsorbate has been considered as a major factor for calculating the percentage of heavy metal removal. So that number of batch adsorption experiments was done. The contact time is taken as 10-100 minutes constant 100rpm agitation speed. The percentage of removal is increased gradually when the contact time was increased. It attains maximum adsorption at 100 min of contact time.



Fig(5) Effect of contact time

Effect of Dosage

The dependence of Cr sorption dose was studied varying the amount of adsorbent while keeping the other parameters constant. It can be observed that removal efficiency of sorbent removed increased with increasing dosage because of increasing the exchangeable binding sites in the adsorbent.



Fig(6) Effect of dosage

Conclusion:

Biosorption is being demonstrated as a useful alternativeto conventionalsystemsfor the removaloftoxic metals from industrial effluents.This study was carried out to evaluate the efficiency of chromium metal removal from this palm peel powder as biosobent.contact time,adsorbent dose and pH as factors that affect adsorption process were studied using synthetically prepared waste water.The percentage of removal of metal ion is increased with increase of pH first and then gradually decreased. It shows maximum adsorption at pH =5. The removal efficiency is increased with increase of contact time and it is maximum at100 minutes.The removal of chromium is increased with increase of adsorbent dosage.Generally this study revealed that palm peel powder is a viable material for the removal of chromium from waste water.

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