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Removal of Chromium From Waste Water By Using Potato and Banana Peels As Bio-Adsorbent

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ABSTRACT:

Heavy metals are commonly released in the waste water from various industries. So a great deal of interest in the research for the removal of heavy metals from industrial effluent has been focused on the use of agro-waste as adsorbents. The use of agro-waste in bioremediation of heavy metal ions is known as bio-sorption. In this research the efficacy of the Banana peel (*Musa sapientum*) and potato (*Solanum tuberosum*) peel biomass is used as an bio-waste, was tested for the removal of chromium metal ions using batch experiments in single metal solution under controlled experimental conditions. It is found that metal sorption increases when the equilibrium metal concentration rises but it decreases the removal efficiency of bio-sorbent. At highest experimental solution concentration used (50 mg/L) and the removal were 58% for chromium with banana peel. The removal of metal ions was found to be 92.532 % for chromium with banana peels, at lowest experimental solution concentration (2mg/L). Bio-sorption equilibrium isotherms were plotted for metal uptake capacity (q) against residual metal concentrations (Cf) in solution. The (q) versus (Cf) sorption isotherm relationship was mathematically expressed by Langmuir and Freundlich models. The values of separation factor were between zero and one indicating favorable sorption for tested metal on the bio-sorbent. The non-living biomass of potato (Solanum tuberosum) was found to be more efficient in removing lead at low concentrations.

KEYWORDS: Bio adsorption, Equilibrium isotherm, Langmuir isotherm, Freundlich isotherm, Jar test, Heavy metal, Hexavalent Chromium, AAS

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I INTRODUCTION

Metal of specific weight, Metal of relatively high density (Specific gravity greater than about 5) or of high relative atomic weight (especially one i. e poisonous) for example mercury or lead are called as heavy metals[1]. Hawkes suggested referring to heavy metals as "all the metals in Groups 3 to 16 that are in periods 4 and greater[1].Chromium possess properties like atomic weight 51.996, atomic no. 24, density 7.19 g/cm^3, atomic radius 128pm, oxidation states +3 and +6. It is essential to realize that the metal is only "removed" from solution when it is appropriately immobilized[2] . Chromium found widely dispersed in nature with some large localized deposits[3]. Chromium found in groundwater primarily from leaching of geological deposits containing the metals or from contamination due to industrial usage[3].

The tanning process is one of the largest polluters of chromium all over the world. The maximum levels permitted in waste water are 5 mg/l for trivalent chromium and 0.05 mg/l for hexavalent chromium.

This heavy metal impart toxicity and make it unfit for any intended use[1]. Another important concern is due to the ability of the heavy metals for bioaccumulation, and biomagnifications in the environment[5] . So the waste water containing heavy metals needs to be treated before discharging in any of the disposing site. The heavy metals are removed using many methods have been undertaken in the process to remove these unwanted contaminants such as physio-chemical methods, various biological methods and to large extent Nano-based techniques and chemicals like silica, activated carbon etc also using ion exchange process[7]**.** These are not eco-friendly methods of treating water, which again leads to pollution while disposing them. One of the eco-friendly methods will be known as bio-adsorption. Bio-sorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physic-chemical pathways of uptake[10]. Minced banana peels and potato peels from the food waste can be used instead of chemicals for removing chromium. Potato and banana peels are used in this research for removal of chromium from industrial effluent.

II. MATERIALS AND METHODS

2.1 Preparation of bio-adsorbent

Banana and potato peels were collected from local market. The biomass was dried in sun rays for four days. This causes considerable reduction in mass and volume of the biomass. The dried biomass of both the peels has a change in colour which will be observed in fig.

This biomass was washed to remove any dust, foreign particles and extra undesired impurities attached to biomass. The washed biomass would be dried at 52°C for hrs. It was ground to powder in the domestic grinder. After adequate grinding the resultant powder is very fine. The bio-sorbent was sieved with 200 micron mesh. The particles retained in this sieve were again ground to fine particles to make its reuse.

Fig.1 Potato peel powder after processing

Fig.2 Carbonated potato peel powder

2.2 Preparation of stock solution for Chromium

Stock solution was prepared from the salts of Chromium Sulphate. The required concentration was prepared by adding the calculated dose of salt in distilled water. The concentration ranges from 1-50 mg/l. the solution was stirred for 5 min to dissolve the salt completely. The solution prepared was kept in airtight bottles for further use.

2.3 Methods used

Batch Studies**:** Jar test was selected for the batch studies. In that following procedure is followed.

Solutions of fixed volume (100 ml) with varying concentrations in jars would be thoroughly mixed with 0.5 g of bio-adsorbent dose, size of 255 to 355 micron at 30°C and 100 revolutions per minute (rpm) shaking speed 30 min to 180 min. At the end of experiment solution would be separated from the biomass by filtration through filter paper (whatmans 41). The de-ionized water would be analyzed for metal concentration using flame atomic absorption spectrometry (AAS). After metal concentration analysis, the final concentration would be subtracted from the initial concentration in order to find the metal to be sorbed.

Amount of metal bound by the bio-sorbent which disappeared from the solution was calculated based on the mass balance for the bio-sorbent in the system. The resulting expression at equilibrium, at the completion of mass transfer for process is given by

$\mathbf{Q_e = -V/M\ (C_e - C_o)}$ (1)

Where q_e is adsorbent phase concentration after equilibrium, mg adsorb ate/g adsorbent M mass of adsorbent in grams, V is the volume of liquid in reactor, C_e final equilibrium concentration of adsorb ate after absorption has occurred mg/lit, C_0 initial concentration of adsorb ate in mg/lit[4].

Adsorption Kinetics

For equilibrium achieved required time period is described by study of adsorption kinetics. For determining the adsorption rate and adsorption mechanism parameters of adsorption kinetics given the information which is used for design the system.

Freundlich and Langmuir adsorption isotherm model were selected for further calculation of sorbed metal concentration. To characterize the bio-adsorption Langmuir and Freundlich models would be used. The Langmuir model makes assumptions such as monolayer adsorption and constant adsorption energy while the Freundlich model describes heterogeneous adsorption. Langmuir equation of adsorption isotherm is

$1/q = 1/q_{max} + 1/(b.q_{max})\ (C_f)$ (2)

Where qmax and b are the Langmuir constants.[4]

The Freundlich equation of adsorption isotherm is $\log q = \log K + (1/n) \log C_f$ (3)

Where q is the amount adsorbed per unit mass of adsorbent and Cf is equilibrium concentration.[4]

2.4 Analytical instrument and techniques used

(1) Atomic Absorption Spectrophotometer (AAS): Atomic line absorption spectra are used for analyzing various metals. Atomic absorption spectrophotometer (AAS) offers sensitivity, selectivity and simplicity in analysis of heavy metals in samples.

Standard solutions for AAS**:** Concentrations of the metal ion standard solutions need to cover a range of 0 to 25 mg/L (i.e. 0 to 25 ppm). Some metal ion stock solutions (250 mg/L) will already have been prepared and simply require dilution to the appropriate final concentrations. Other metal ion stock solutions need to be prepared. The spectrometer uses a different lamp for each metal to be analyzed, so complete the analysis of one metal (calibration curve and duplicate sample measurements) before commencing analysis of another metal. The same solution can be used to analyze for a number of metal ions (2) Jar test apparatus

Jar test apparatus was used for proper mixing of the bio-sorbent with solution. The apparatus was run for 30 min at the speed of 150 rpm for each experimental batch.

III RESULT AND DISCUSSION

Following table represents the comparative study of metal (chromium) removal by using bio-adsorptive (both potato peel and banana peel) by keeping metal concentration constant on 12 mg/lit and varying dose of bio-adsorptive from 4 gm to 24gm.

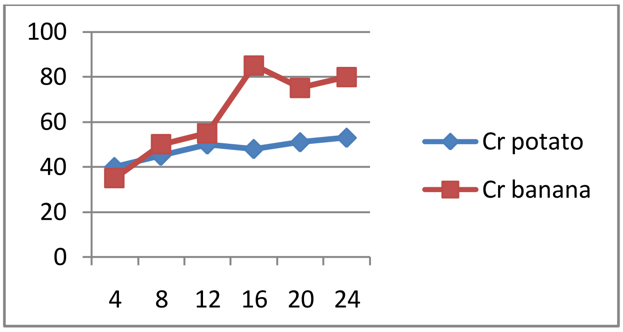

Fig.3 Efficiency vs. Bio-Adsorbent dose for banana & potato peels.

The higher removal is obtained for the dose of 24 g/lit, with the efficiency of 53%. So there is potential to achieve higher efficiency if the dose of bio sorbent is increased. But it increases the dissolved solids, COD of the sample that's why 24 g/lit is considered as the optimum dose for further experiments.

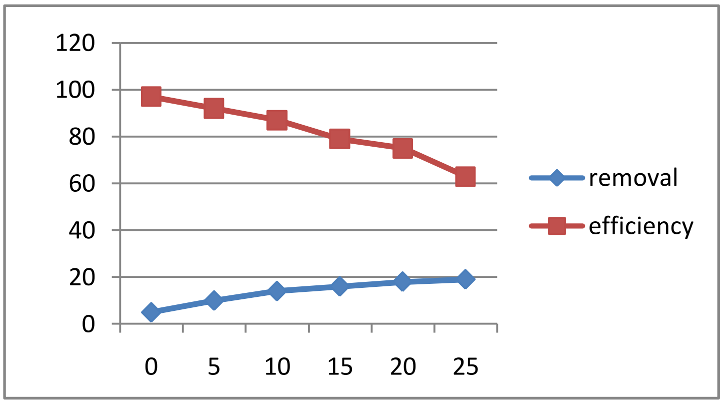

Fig.4 Comparison of efficiency and metal removal verses initial metal concentration

Efficiency given by the potato peels for the removal of chromium is not satisfactory so it is discarded and only banana peels would be examined for further studies. For more study these bio-adsorbent were mixed with alum to check further results which is shown in following table:

Table 1: Combination of bio-adsorbent and alum doses with their respective efficiencies

Dose (g/l)	Removal (mg/l)	Efficiency %	pH
24g/l potato carbonated	3.9106	77.214	6.5
16g/l banana carbonated	4.5565	89.96	8.00
0.4g/l alum + 16g/lit non carbonated banana	4.367	86.34	5.8
0.4g/l alum	1.9215	37.45	4.4
0.4g/l alum + 8g/lit banana carbonated	4.716	91.320	8.20

IV CONCLUSION

Removal of poisonous hexavalent form of chromium from solutions was possible using selected adsorbents. Banana peel powder and potato peel powder do have potential for use as cheap bio-adsorbent for removal of metals from water and wastewaters.

Highest experimental solution concentration used (50 mg/L) and the removal was 58% for chromium with banana peel. The removal of metal ions were 92.532 % for chromium with banana peels, while at lowest experimental solution concentration (2mg/L). Carbonated banana peel powder has greater bio-sorption potential than potato peel powder. But overall carbonated peel powder and non carbonated peel powder have no significant change in results. Addition of bio-sorbents results in increase in turbidity and COD as well as impart colour. The potato peels and banana peels can be developed as alternative for removal of hexavalent chromium for industries generating waste water with low volume and lower concentration as pretreatment prior to secondary treatment.

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