Analysis of chromium removal capacities of different bio-adsorbent ; comparison and scope in treatment of local water bodies.

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Chemical Engineering

Submitted By

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UNDER THE SUPERVISION AND GUIDANCE OF

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ABSTRACT

Chromium(VI) contamination in water bodies poses a significant environmental and public health concern worldwide. Many industrial operations such as electroplating , tanning and pigmentation release chromium contaminated water to the environment. If this chromium(VI) contaminated water is drunk then there can be serious danger to life. Bio-adsorption, a sustainable and cost-effective method, has emerged as a promising approach for removing chromium ions from aqueous solutions. Five bioadsorbents were used to compare their absorption capacity. These bio-adsorbents were collected from wastes. Absorption capacity of these bio-adsorbents have been observed wrt. their size variation which makes it significant from the other already done tasks in this feild. Experiment was performed with the stock solution which had resemblance with the tannery effluent.Titrative method of analysis was used to check the concentration of chromium. Therefore, it has enabled the comparision of the results obtained from this method and the spectroscopy .From the study it was found that the water chestnut shell and pomegranate peel shows maximum absorption capacity for Cr(VI) upto 97.83%.The scope of utilizing bioadsorbents in local water treatment is explored, emphasizing their scalability, cost-effectiveness, and environmental benefits. Case studies demonstrate successful applications of bio-adsorption in real-world scenarios, showcasing its practicality and effectiveness in addressing chromium contamination.

Keywords : Titration , Bio-adsorbents, Powder, Removal, Permeability

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IV Year

Chemical Engineering

CONTENT

Table of Contents

ACRONYMS

UTLP	-	Used tea leaves powder
PPP	-	Pomegranatepeels powder
RHP	-	Rice husk powder
WKP	-	Walnut kernel powder
WCSP	-	Water chestnut shell powder
FAS	-	Ferrous ammonium sulphate

NOMENCLATURE

K	-	Permeability coefficient
C	-	Permeability proportional parameter, which depends on shape of channel
$\in$	-	Porosity of bed
Sb	-	Specific surface exposed to fluid
rho	-	Density of inlet water having 50 ppm chromium concentration
V	-	Velocity of water
D	-	Diameter of bed
mu	-	Viscosity of bed
C_i	-	Initial amount of Cr(VI) in the stock solution
C_f	-	Final amount of Cr(VI) in the treated solution

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Chromium contamination in water bodies is a pressing environmental issue with detrimental effects on ecosystems and human health. Bio-adsorption, a sustainable and eco-friendly method, has gained recognition for its effectiveness in removing chromium ions from aqueous solutions. This comprehensive report aims to analyze the chromium bio-adsorption capacities of various bio-absorbents, compare their efficiency, and explore their potential scope in treating local water bodies.

Bio-adsorption involves the use of natural or modified biomaterials to adsorb and remove contaminants from water sources. Various bio-adsorbents, including agricultural waste, algae, and bacteria, have been studied for their chromium bio-adsorption capacities. A detailed comparative analysis reveals the unique characteristics of each bio-adsorbent and their effectiveness in binding chromium ions, highlighting the importance of surface properties and functional groups in the adsorption process.

The efficiency of chromium bio-adsorption is influenced by several factors, such as pH levels, temperature, contact time, initial chromium concentration, and bio-adsorbent dosage. Optimal conditions must be determined to maximize the bio-adsorption capacity of the selected materials and enhance the removal efficiency of chromium from water bodies.

The application of bioadsorbents in treating local water bodies offers a sustainable and cost-effective solution to chromium contamination. By utilizing locally available biomaterials, communities can address water pollution issues effectively while minimizing environmental impact. The scalability and adaptability of bio-adsorption make it a viable option for decentralized water treatment systems in rural and urban areas alike.[4]

Ongoing research in the field of bio-adsorption focuses on improving the efficiency and selectivity of existing bio-adsorbents, developing novel materials with enhanced chromium binding capabilities, and exploring hybrid systems for chromium removal. Advances in nanotechnology and biotechnology have opened new avenues for the design and synthesis of bio-inspired materials, promising further advancements in water treatment technologies.

One type of adsorption called chemisorption occurs when the adsorbate and the surface interact chemically. At the surface of the adsorbent, new chemical bonds are formed. Examples include more subdued effects related to heterogeneous catalysis, in which the catalyst and reactants are in separate phases, and macroscopic phenomena that can be extremely evident, such as corrosion[clarification needed]. New kinds of electronic bonds are produced by the intense contact between the adsorbate and the substrate surface.[25]

Adsorption is found in a wide range of physical, biological, and chemical systems as well as in many industrial applications, including water purification, synthetic resins, heterogeneous catalysts, activated charcoal, and the collection and use of waste heat to produce cold water for air conditioning and other process needs (adsorption chillers).[26]

Titration is a popular laboratory technique for quantitative chemical analysis used to find the concentration of an identified analyte (a material to be tested). It is also referred to as titrimetry[27] and volumetric analysis. A standard solution with a known concentration and volume is prepared as a reagent, often known as a titrant or titrator [28]. To find the analyte's concentration, the titrant reacts with an analyte solution, also known as the titrand[29]. Titration volume is the volume of titrant that reacted with the analyte.Acid–base titrations depend on the neutralization between an acid and a base when mixed in solution. In addition to the sample, an appropriate pH indicator is added to the titration chamber, representing the pH range of the equivalence point. The acid–base indicator indicates the endpoint of the titration by changing color. The endpoint and the equivalence point are not exactly the same because the equivalence point is determined by the stoichiometry of the reaction while the endpoint is just the color change from the indicator.

Certain biomasses have an innate physiochemical process called biosorption that enables it to bind and passively concentrate pollutants to its cellular structure.[30] The capacity of biological materials to extract heavy metals from wastewater by physico-chemical or metabolically mediated absorption mechanisms is known as biosorption.[31] Despite the fact that biomass has long been used in environmental cleanup, scientists and engineers are hopeful that this phenomena may offer a practical substitute for eliminating hazardous heavy metals from industrial effluent and help with environmental restoration.

A packed bed in chemical processing is a hollow pipe, tube, or other vessel that has packing material inside of it. The packed bed can be arranged in a planned manner or it can be haphazardly loaded with tiny items, such as Raschig rings. Catalyst particles or adsorbents like zeolite pellets, granular activated carbon, etc., may also be present in packed beds.The Ergun equation can be used to predict the pressure drop along the length of a packed bed given the fluid velocity, the packing size, and the viscosity and density of the fluid.The Ergun equation, while reliable for systems on the surface of the earth, is unreliable for predicting the behavior of systems in microgravity.

Unlike typical tray distillation, where each tray represents a discrete point of vapor-liquid equilibrium, packed columns have a continuous vapor-equilibrium curve. To indicate the packed column's separation efficiency in comparison to more conventional trays, it is helpful to compute a number of theoretical plates when modeling packed columns. In design, the packing height equivalent to a theoretical equilibrium stage—sometimes referred to as the height equivalent to a theoretical plate, or HETP—is also computed after the number of required theoretical equilibrium stages has been established. The number of theoretical stages multiplied by the HETP equals the total packing height needed.[33]

CHAPTER 2: LITERATURE SURVEY

Qingge Feng etal.studiedas rice husks are an agricultural waste, they account for about one fifth of the world's total gross rice weight (545 Mt) each year. Concerns about environmental pollution and the need for energy and resource conservation have led to efforts to use rice husks as an additional cementing material under controlled conditions and in controlled atmospheres. However, Rice husk ash properties have not been reported in his study. In this study, Lead and Mercury Ion Adsorption Using Treated Rice Husk Ash (ADR), High Specific Surface Area as an Adsorbent, has been studied under various operating conditions such as ADR particle Size, Initial Solution pH, Ionic Strength, and Solution Temperature. The finer the Rice Husk Ash particles used for adsorption, the higher is the pH of solution and lower is the concentration of supporting Electrolyte Potassium Nitrate Solution. The more lead and Mercury ions are absorbed on Rice Husk Ash. [1]

As per UNIDO report CETPs have not yet started to charge member tanneries based on their actual pollution load. Instead, they charge based on actual treatment cost divided by a factor equal to each tannery's installed capacity. The rate ranges from US$0.15/kg raw material processing capacity to US$0.37/kg. However, one of the Indian CETPs started to charge fixed (processing capacity / installed drums) related rates as well as variable rates as part of the CETP operational costs. At another one, flow meters are installed in each of the tanneries and the charges are based on actual flow rates.A private company called Chemways (Vellore) takes the precipitated chrome sludge and regenerates chrome using sulphuric acid. The recovered chromium is then sold on a commercial basis to the small tanneries in Ranipet by mixing fresh basic chromium sulphate with it as needed.The Ranitec (CETP) was one of the first attempts to prove the sustainability and economic viability of a regional model with an anaerobic treatment technology. Although this concept could not be proven in the CETP, the subsequent up-gradations also abandoned the anaerobic treatment step.[2]

Runping Hanet al. tested the adsorption of rice husk from the food production process as an adsorption agent for dyes using a model system for aqueous congo. red solutions.Congo red (1-naphthalenesulfonic acid, 3,3′-(4,4′-biphenylenebis(azo)) bis (4-amino-) disodium salt) is a benzidine-based dye of the structure: dye metabolizes to Benzidine .Benzidine is known to be a human carcinogenAllergic reactions to the dye.The followinginference can be made in light of the investigation's experimental findings: a. CR can be extracted from solution by using rice husk as an adsorbent. b. The flow rate, the inlet Cr concentration, and the bed depth all affected the biosorption of Cr. c. The Adams-Bohart model characterized the breakthrough curve's early region under all experimental conditions examined, while Thomas models were able to fully describe the breakthrough.[3]

SEN Met al. found thatone of the main environmental pollutants, chromium is commonly found in the wastewater from different industrial units. To remove chromium, a number of standard physical and chemical treatment methods can be applied. Nevertheless, these procedures are not only costly and extremely energy-intensive, but they also produce hazardous end- and by-products, the disposal of which ultimately results in further pollution. As an alternative to the current standard physico-chemical procedures, the potential applicability of microorganisms as a biosorbent for the removal of chromium has been acknowledged. Reviewing the removal of chromium from aqueous solution utilizing a range of biological and agricultural materials that have been investigated as possible chromium biosorbents is the goal of the current study.[4]

S.Tahiriet al. emphasized onindirectremoving hexavalent chromium from water, the possible application of vegetable tannins (T) directly immobilized on chrome shavings (CS) was examined in this work. In terms of adsorption capacity, the developed immobilized tannin adsorbents (CS-T) were characterized and their adsorption properties were discussed. The impact of multiple factors, including pH, chromium content, adsorbent dose, contact time and adsorption kinetics, on the adsorption capacity was assessed and deliberated. The adsorption isotherms for Langmuir and Freundlich have been used to assess the equilibrium data.TheFolin-Ciocalteu method yielded a polyphenolic component concentration of around 73.3 ± 1.9% for chestnut tannin and 64.2 ± 1.1% for mimosa tannin.Adsorbents such as immobilized chestnut and mimosa tannins on chrome shaving matrices have been employed directly to recover Cr(VI) from contaminated aqueous systems. Research findings show that immobilized tannin adsorbents are more effective than raw chrome shavings at extracting hexavalent chromium from water.[5]

H Aminet al.stated thatall parts of the environment, including the air, water, and soil, contain chromium. Environmental chromium pollution has grown to be a significant worry.The goal of the current study was to show how susceptible Hibiscus esculentus (L.) is to chromium metal stress by examining the phytotoxic effects of various chromium concentrations on this species.At the University of Sindh, Jamshoro's Green House of the Institute of Plant Sciences, a pot culture experiment was carried out. Three duplicates of each treatment were used in the fully randomized block design experiment. In order to commence the controlled experiment, soil was artificially polluted with varying concentrations of potassium dichromate solution (i.e., 0.5, 2.5, 5, 10, 25, 50, and 100 mg•kg−1) and an untreated control was also included.The current study's findings show that increased chromium concentrations have a negative effect on Hibiscus esculentus seeds' ability to germinate. Treatment with chromium at 0.5, 2.5, 5, 10, and 25 mg•kg−1 does not significantly affect seed germination ($p > 0.05$).[6]

Ali Shams-Nature et al. in their study found that weld and pomegranate peel were used as natural dyes to achieve the golden color on nylon. Four distinct dyeing techniques were used: non-mordanting, pre-mordanting, meta-mordanting, and after-mordanting. The aluminum potassium sulphate salt was utilized as the mordantingagent.Weld produced brighter and yellower hues when compared to pomegranate peel, according to colorimetric assessments. All of the dyed samples had outstanding rubbing fastness, while the pomegranate peel samples had superior washing fastness. Additionally, the after-mordanting dyeing procedure produced the best results in terms of light fastness.[7]

Y.I.et al.understanding the chemical makeup of tea aids in both evaluating its quality and managing the conditions under which it is grown, processed, and stored. Specifically, by identifying the components of tea that contribute to its flavor and scent, this understanding has made it possible to establish the links between the chemical makeup of tea and its qualities. As a result, evaluating the quality of tea involves not only subjective organoleptic evaluation but also objective physical and chemical approaches, along with the additional step of identifying the tea's most health-promoting ingredients. With this information, tea's nutritional content can be raised and its quality can be enhanced by optimizing its growing, processing, and storage environments.[8]

A Mizanet aimed intanneries at Hazaribagh use a large number of chemicals during processing and discharge their effluents to the river Buriganga without appropriate treatment and aggravate its pollution level. This study focuses on a plausible way for the abatement of pollution level of Buriganga river water using low cost adsorbentThe collected samples were passed through the activated carbon and a remarkable amount of pollutants were found to be adsorbed. TSS, TDS, BOD5, COD and chromic oxide content of polluted water were reduced significantly.[9]

TadesseAlemuet al. study's goal was to assess whether treated tannery wastewater effluent is suitable for vegetable irrigation and may be safely reused, with a focus on chromium detection in irrigated vegetables. It is one of the first concentrated studies in the nation into the repurposing of tannery wastewater for irrigation of food crops (vegetables), which could develop into an essential tactic for value addition and preservation of water bodies that receive effluent. Vegetable growth was facilitated via a field and pot experiment using randomized block design. Using established techniques, treated effluent, soil, and vegetable samples were examined for microbiological, physicochemical, nutritional, and Cr characteristics (APHA). The novel integrated treatment system has a removal effectiveness between 82 and 99.9%.[10]

Narayanan Aet al., 2019investigated that raw pomegranate (Punicagranatum L.) peel (RPP) was utilized as a biosorbent to remove chromium (Cr(VI)) without any modification or activation. In batch mode, the effects of operational factors such pH, contact time, temperature, and Cr(VI) concentration were investigated. For a Cr(VI) solution with a concentration of 20 mg/L, a maximum removal of 100% was accomplished in 3 minutes at an ideal pH and temperature of 2 and 313 K, respectively. The Langmuir adsorption isotherm exhibits the best correlation with experimental data of all the isotherms studied. Under equilibrium conditions, a maximum Cr(VI) biosorption capacity of 370.4 mg/g was reported at 313K. Cr(VI) can also be effectively removed at higher concentrations using RPP. The pseudo-second order kinetic model is the most suitable for the data among the kinetic models.[11]

T. Mitraet al. stated that in the nations that grow a lot of rice, rice husk (RH) is a well-known and easily accessible agricultural waste product. Worldwide rice production is estimated to be about 600 million tons, with 20% of that amount being husked on average.Small- and medium-sized businesses like those that make batteries, preserve wood, electroplate, etc. can be found in a great deal of India's rural areas.RH is tested as an adsorbent in continuous mode operation since it is an inexpensive and widely accessible substance. Comparatively speaking to other adsorbents, the adsorptive capacity is not particularly great. Therefore, it necessitates the employment of larger equipment and a greater quantity of adsorbents.The compatibility of rice husk for Pb(II) and Cr(VI) ions was determined by the column investigation. The function of bed height, flow rate, and contact duration is the packed-bed continuous column experiment. To assess the column performance breakthrough curve, the operational parameters are changed.[12]

Sverguzova S.V.et al. demonstrated that the sugars, lignin, and cellulose found in the shell of the chestnut fruit are the main components. It appears that functional groups found in the biopolymers found in the shell of chestnut fruits are responsible for the adsorption of several metal ions. The degree to which metal ions are extracted from aqueous solutions was found to be influenced by the acidity of the media, but the sorption capacity of the chestnut fruit shell is largely insensitive to temperature. It has been demonstrated that chemically altering chestnut shells can improve the sorption properties of contaminants.[13]

EvaPertileet al. summarized the outcomes of an extensive experimental study that investigated the viability of employing inexpensive waste biomaterial to extract hexavalent chromium from the aqueous environment. First, a set of seven biosorbents were studied in simple static batch systems: (1) Fomitopsispinicola; (2) a mixture of Norway spruce (Piceaabies) and Scots pine cones (Pinussylvestris); (3) peach stones (Prunuspersica); (4) apricot stones (Prunusarmeniaca); (5) walnut shells (Juglansregia); (6) orange peel (Citrus sinensis); and (7) Merino sheep wool.[14]

DaeseungKyunget al.investigated the ascorbic acid functionalization of spent tea leaves produced treated tea waste (t-TW), which aided in the adsorption of hexavalent chromium from water. By using a statistical experimental design, the adsorption removal of Cr(VI) was methodically examined as a function of four experimental factors: pH (2–12), initial Cr(VI) concentration (1–100 mg L−1), t-TW dose (0–4 g L−1), and temperature (10–50 °C). Comparing the t-TW to the other inexpensive adsorbents, it showed a competitive Cr(VI) adsorption capacity of 232.2 mg g−1. These findings lend credence to the idea of using tea trash to rid aquatic systems of dangerous metal pollutants.[15]

Rishav Garget al.performed the work as a practical and environmentally acceptable biosorbent for removing Cr(VI) from aqueous solutions. As demonstrated by BET analysis, the natural walnut shell powder (NWP) was chemically altered using citric acid (CWP) and alkali (AWP) to create modified biosorbents with a large supply of pores serving as active centers.CWP (75.26 mg/g) had the highest Cr(VI) adsorption capacity (qm), followed by AWP (69.56 mg/g) and NWP (64.82 mg/g).[16]

RanaDizajiet al. presented that higher amounts of heavy metals may be accumulated by fruits and vegetables grown in contaminated fields, particularly those where heavy metal contamination is present. A bioavailable and mobile form of chromium that has the potential to cause cancer is Cr(VI). This study showed that the quantity of Cr(VI) in carrots increases greatly with the total Cr content and that an accurate and precise approach for determining Cr(VI) is to use alkaline extraction followed by DLLME.THQ of Cr(VI) for grapes in case study A was 0.142 and 0.36, respectively, while for carrots it was 0.465 and 1.6 for adults and children, and for children in site B it was 0.26 with 95% confidence.[17]

This study gives the variation of %removal of Cr(VI) w.r.t. size of the bio-adsorbents. In this context, Cr (VI) removal efficiency of five different bio-absorbents, WKP,PPP,UTLP,RHP and WCP have been compared. The 50 mg/l Cr(VI) solution was used[11].The significant part of this study is that the Chromium concentration were measured using quantitative approach i.e. titration analysis, which was not used previously in this direction. Moreover, cost analysis for this treatment was also discussed. A new system is also presented for water treatment in rural areas.

CHAPTER 3: PROBLEM FORMULATION

Chromium is widely used element in industries. It is also used in electroplating and pigmentation.The water released by these industries are contaminated with Cr(VI).Tannery industries near by Unnao district and Kanpur are facing the problem of disposing tannery effluent.during my intership at ordinance factory Katni,I observed that Cr(VI) contaminated water was directly discharged into the ground. There were no bodies to look the same situation.

Cr(VI) is highly toxic element;adverse effects on humans health ,animal and plants.Bio-adsorption exhibit good adsorption capacity for Cr(VI).

Chromium removal capacity of bio-adsorbent depends upon several factors like pH of solution, speed of agitation, concentration of chromium and much advancement has already been done but are there any other factors that could significantly impact the removal capacity ?Can application of solution temperature be used to select best adsorbents among them?Is it possible to use the application of these bio-adsorbents in water treatment in actual practice? If so, how feasible is that option ?

CHAPTER 4: PROPOSED METHODLOGY

The stated problem was solved with the help of experiment. This experiment was done in the departmental laboratory. The methodology adopted during the experiment included principles of chemical engineering and basic science. There were several steps that were discussed with the guides before starting on the ground level. The methodology is presented in a way that readers have basic knowledge of chemical engineering.

4.1 Materials

Equipments : Magnetic stirrer , pH meter ,taylor standard sieves, weighing balance, grinder , filter paper,burette,flasks,beakers,watch glass etc.

Chemicals : 0.0125 N FAS, 0.141g/l of $K_2Cr_2O_7$, ditilled water, 0.1N $KMnO_4$,Sulfuric acid etc.

4.2 Analysis method

4.2.1 Stock solution preparation and storage

According to UNIDO, the average Cr(VI) concentration in tannery effluent is 150 ppm. A Stock solution of 50mg/l, prepared by dissolving 0.141 grams of potassium dichromate in one litre of filtered water. With the help of pH meter ,value was measured to be around 6.8 ,which is in similarity with the effluent pH 7 ± 0.2 [12,18].From the recent literature study it has been found that better separation is possible in neutral medium [12].The prepared solution was preserved in a close container for future use.

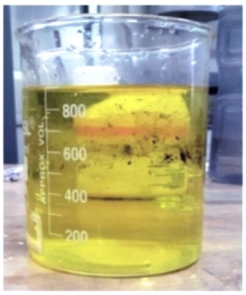
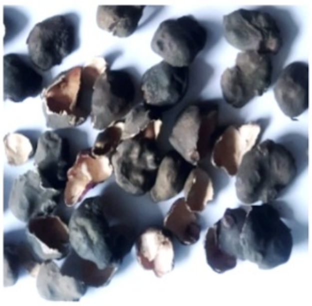


Fig.4.2.a 50 mg/l of Cr(VI) prepared stock solution.

4.2.2 Preparation of bio-adsorbents

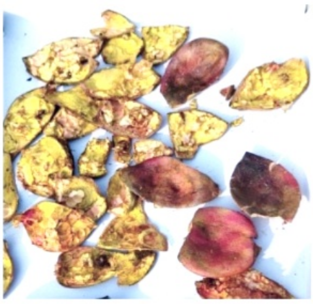
1st satge : Pomegranate peel was collected from a juice vendor. Water chestnut shell, walnut kernel and used tea leaves were collected from kitchen of the house. Rice husk was collected from the village. After that, these were washed with water and allowed to dry in the sun. It took 7 days to remove moisture. All these were then dried in an electric oven to drycompletely.

a.) Used tea leaves after



b.) water chestnut shell

c.) walnut kernel after



d.) pomegranate peel

e.) rice husk after

Fig. 4.2.b Condition of bioadsorbents after complete drying.

2nd stage : Here these were ground and converted into powder. Size analysis was conducted to separate all these bio-adsorbents into three different particle sizes. Standard Taylor screens of BIS 16, 72, and 85 were used.

The screen sizes used for analysis 16 by 1190, 72 by 210 and 85 by 180 microns.

a.) for WKP

b.) for UTLP

c.) for PPP

d.) for WCSP

e.) for RHP

f.) Screens used for size analysis

Fig. 4.2.c -72/85 sizes of all bio-absorbents

4.2.3 Experimental analysis

The chromium removal efficiency of all five bio-adsorbent was determined.100 ml of stock solution was poured into a beaker and 1 gram of WKP -72/85 bio-adsorbent was added in a batch manner. The solution was then stirred manually for 120 minutes at pH 6.8. Similarly for sizes of WKP 85/pan and 16/72.Therefore, for the five types of bio-adsorbents, 15 different samples were associated in the experiment. Moreover, most studies show that maximum removal is possible with higher rpm but in this experiment stirring was provided manually. For each contact time, treated samples were filtered with the help of filter paper and placed in another container for analysis.

For determining the chromium concentration of treated samples, an old standard titration method (method of quantitative analysis) was used. Chromium(VI) treated samples were titrated against FAS(Ferrous ammonium sulphate).10ml of each of the treated fifteen samples was taken out and titrated until two concordant readings were obtained. The

strength of FAS used was 0.0125N.The strength of FAS was confirmed by titrating against 0.1 N $KMnO_4$.

When titration was performed on WKP(size : -72/85) treated sample ,following titre readings were obtained

Initial volume of FAS = 0 ml

Initial volume of the above sample = 10 ml

Strength of FAS = 0.0125N

Initial burette readings	Final burette readings
0	0.2
0	0.3
0	0.2

Table 4.2.aTitre readings for 1st WKP sample (-72/85)

The strength of this treated solution comes out to be 0.00324g/l

Name of bio-adsorbent	Strengths(mg/l)		
Size(BIS)	-85/pan	-72/85	-16/72
WKP	2.16	3.24	4.32
PPP	1.08	1.62	5.40
UTLP	2.70	3.24	6.48
WCSP	1.08	2.16	4.86
RHP			

Table 4.2.b Strength of each treated sample of different sizes

4.3 Calculation of percentage Cr(VI) removal

Percentage Cr(VI) removal from stock solution= $\left(\frac{Ci - Cf}{Ci}\right) * 100$.....................(Eq.1)

4.4 Treatment of drinking water: scope for rural areas near industrial areas

Living things are seriously threatened by the direct disposal of Cr(VI)-containing tannery effluents into the environment[20].Their produce, fruits, and drinking water sources have all been contaminated[17].A single tannery has the potential to contaminate groundwater and surface water in an area 6-7 kilometers around it. Cr(VI) concentrations were not detected in many of the study area, according to a ground water research conducted in the Unnao district of Uttar Pradesh, with the exception of the MIRZA tannery drain in Unnao (184.80 mg/l), the Unnao distillery (174.980), and JAR Inter college in Dharamkata (207 mg/l)[21]. Cr(VI) concentrations are not very high in these locations, but a long-term accumulation of Cr(VI) can be problematic for everyone. Cr(VI) poses a serious risk to human health. Bio-adsorbents may be a very effective way to handle this issue. Such as PPP, RH.

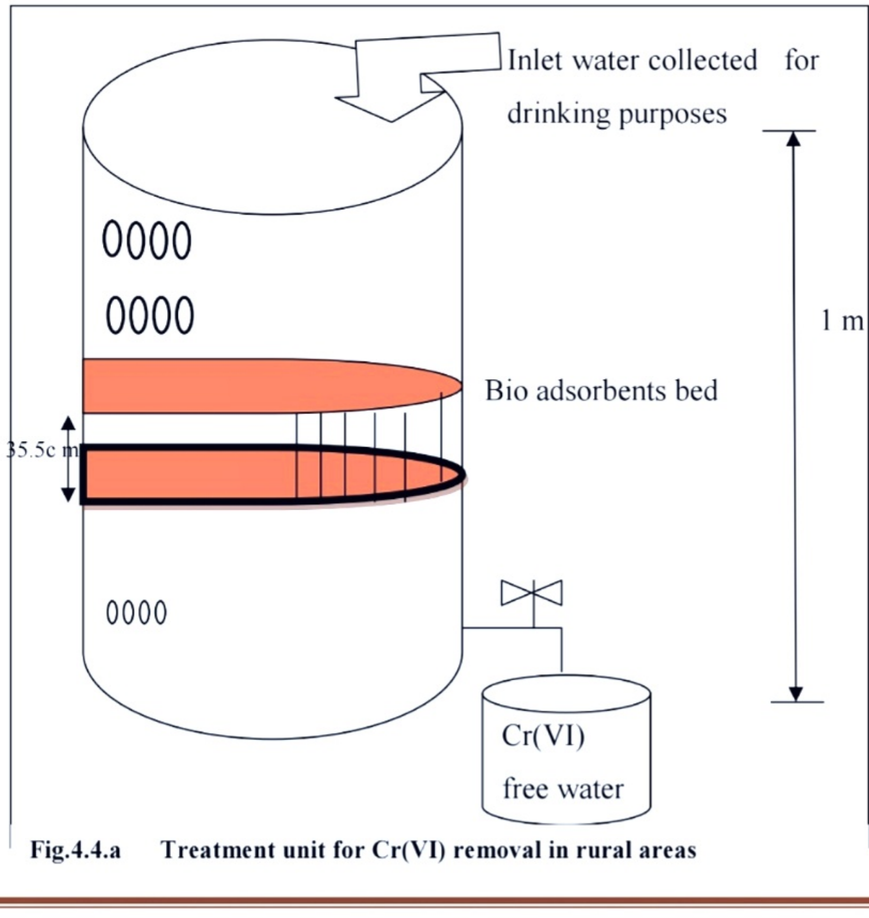


Fig.4.4.a Treatment unit for Cr(VI) removal in rural areas

It was found that at a bed depth of 4 cm, the maximum retention time for efficient mass transfer happens.[12] Thus, a bio-adsorbent bed height of 35.5 cm was chosen, according to the scale. In this study, a column with a length of one meter and a radius of 0.18 meters was employed. After the adsorbent was examined, this investigation determined that the ideal size ranged from 220 to 180 microns. A metal sieve was used to physically support the bio-adsorbent bed, and 4.45 mm glass wool was added to the sieve plate to prevent any adsorbent loss[12].The metal sieves can be readily removed from the vessel and replaced with a fresh bed of bioadsorbents for easy washing. room temperature was used for the experiment.. For significant metal uptake, a water flow rate of 355 ml/min was employed. Other naturally occurring contaminants may also be present in the inlet water for the removal of Cr(VI), which would lower the treated solution's exit flow rate. Therefore, it must be necessary to have an ongoing supply of intake water at a specific flow rate. The column bed's bottom needs to be big enough to accommodate an adequate amount of treated water. It can be concluded that the column can effectively supply two days' worth of treated water to a family of four. If these additional pollutants continue for an extended period of time, the bed's porosity is reduced. As a result, a new bed will subsequently be needed. The water's impurity determines when to replace bioadsorbents, but generally speaking 48 hours is required.

This is enough time to handle the system as villagers already practice daily washing and changing their drinking containers. Fresh water can be collected continuously from the tap.This bed will also remove some other impurities likeif the bed is of PPP, it can remove copper traces, TSSetc. The presented technique is suitable,time efficient and cost-effective for Cr(VI) treatment.

Calculation for permeate flux :

Cross section Area = 0.1017 m^2

Inlet flow rate = 355 ml/min $\cong 5.91 * 10^{-6}$ m^3/s

Velocity in inlet section of bed = $5.82* 10^{-5}$ m/s

Porosity for proposed bed = 0.2289[22]

Therefore, Reynolds no. for this flow can be calculated as

$$Re = \frac{rho*V*D}{mu*(1-\epsilon)} \qquad \text{..........(Eq.2)}$$

Re = 2.716

Thus, theKozeny-Carman equation for this Reynolds number will be used to calculate the pressure drop across the bed

Pressure drop across the bed = 33.39 Pa/m

Now by applying Bernoulli's principle on the inlet and outlet section of bed

Outlet flow rate comes out to be = 161.31 ml/minute

Hence volumetric permeate flux is = 95.17 l/m^2s

Depending on their availability, rural areas close to the tannery can treat sources of collected drinking water, such as lakes, rivers, and wells, that may be contaminated with Cr(VI).In rural locations, these bio-adsorbents are widely accessible. Additionally, some bioadsorbents, like PPP, have the effect of reducing cardiovascular disease and cholesterol.

CHAPTER 5: RESULTS AND DISCUSSION

When strength was obtained for each treated sample, % removal was calculated using the formula mentioned above in section 2.4.

Name of bio-adsorbent	% removal of Cr(VI)		
Size(BIS)	-85/pan	-72/85	-16/72
WKP	95.675	93.5125	91.35
PPP	97.8375	96.75625	89.1875
UTLP	94.59375	93.5125	87.025
WCSP	97.8375	95.675	95.675
RHP	78.375	61.075	35.125

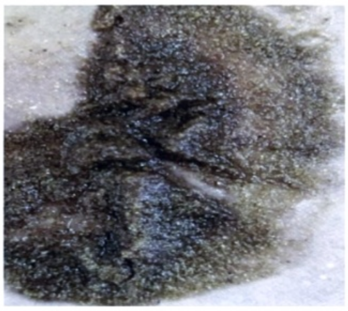
Table 5.a % Removal of Cr(VI) using all five bio-absorbents of three different sizes

From the past studies, maximum removal % of Cr(VI) was 100% from pomegranate peel[11],91.22 from walnut shell[16] ,85% from spent tea leaf [15] and 100% from water chestnut shell[13].

From the physical appearance of the treated solution, it was observed that the colour of WKP treated sample after filtration was lighter yellow than others, whereas the PPP treated solution was darker brown than the others because of the colouring agent in pomegranate peel. It ispresent as alkaloid form of N-methyl granatonine[7].The RHP treated solution didn't change colour significantly from the initial colour and it can be assumed that less absorption occurred in this case.

Fig. 5.a Treated samples appearance from all five bio-adsorbents WKP,PPP,UTLP,WCSP and RHP respectively

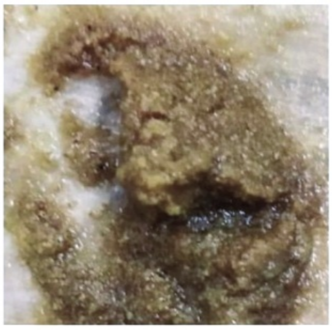
a.) For UTLP



b.) For WCSP

c.) For RHP

d.) For PPP

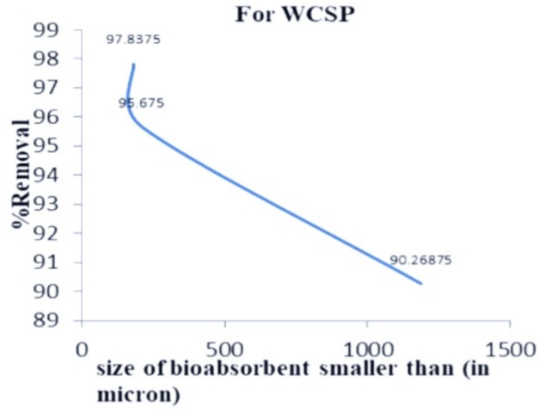


e.) For WKP

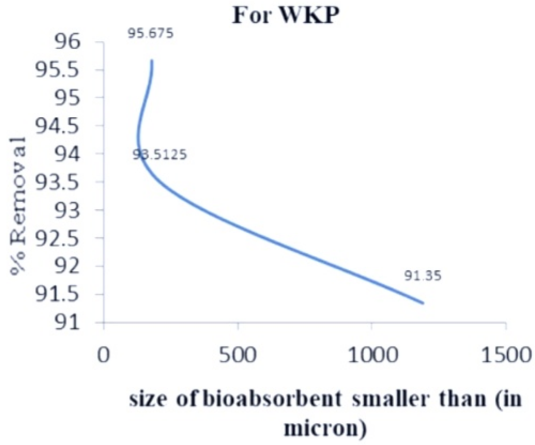
Fig. 5.b Final state of all bio-adsorbents

From the experiment conducted,it has become clear that by increasing the size of bio-adsorbents,the Cr(VI)removal capacitydecreases(% removal).

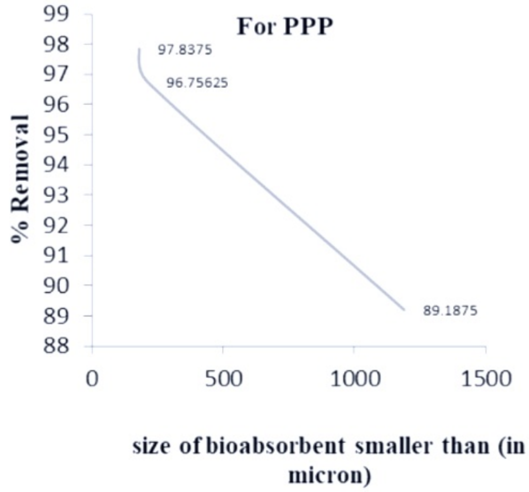
Graphical analysis



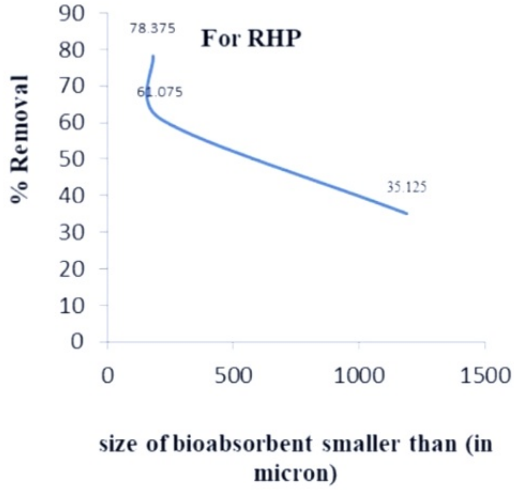
a.)



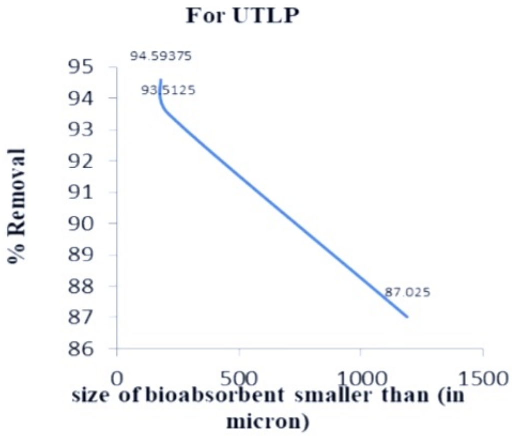
b.)



c.)



d.)



e.)

Fig. 5.c % Removal of Cr(VI) with bio-adsorbents size

The graphs show that for each type bio-adsorbent, the % removal decreases, meaning thatincreasing the size of bio-adsorbents reduces the Cr(VI) removal capacity regardless of the nature of bio-adsorbents. Under the same conditions, PPP and WCSP bio-adsorbents show maximum Cr(VI) removal capacity[as sodium ion linked with polyhydroxy or carboxy functionalities] [23]. From this study, it wasfound that RHP shows the least removal capacity for Cr(VI).For UTLP, small changes in size don't affect the Cr(VI) removal capacity. Increasing the size of bioadsorbents increases permeability because larger sized particles form less compact packing and also provide pathways for the solution to pass.[24] Additionally if the permeability of the bed is to be considered then the selection of optimum size will also depend on the permeability values obtained from bioadsorbents of different sizes. But the aim of the study is on the removal efficiency of bioadsorbents, that is why bioadsorbents of maximum Cr(vi) removal size have been used in the bed.

Temperature (K)	% Removal of chromium
293	87.025
313	91.35
333	93.5125
353	96.75625

Table 5.b Effect of temperature on %removal of Cr(VI) from UTLP

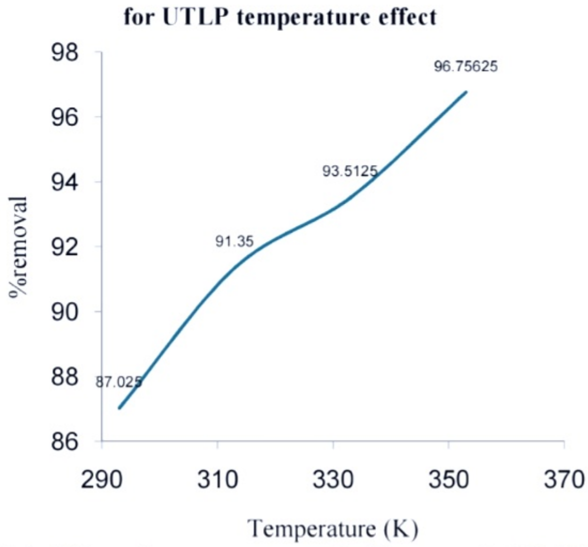


Fig. 5.d Effect of temperature on the % removal of Cr(VI) for UTLP

By increasing the temperature ofUTLP treated solution (there is hardly any research for this) during which it was allowed to stir for two hours, the Cr(VI) removal capacity increases to some extent. Past studies have shown[16] the % removal of Cr(VI) with walnut adsorbent is about 77.75% to 91.22% with variation of temperature(288-328) and the maximum removal is 100% for pomegranate peel adsorbent at 313K[11] .From these observations it can be concluded that UTLP has better removal capacity than walnut in given temperature range.The voidage increases as the temperature of the solution increases, because the pore pressure increases which in turn increases the permeability of the solution. This can be easily correlated by the Karman equation based on the above Reynolds number.

$$K = \frac{c * \epsilon^3}{5 * Sb^2 * (1-\epsilon)^2} \quad \text{.........(Eq.3)}$$

When the temperature goes much higher than the normal optimum, it starts having adverse effects on the integral and peripheral functional groups in the bed. Hence this limit will also be the deciding factor to choose the temperature value.

CHAPTER 6: CONCLUSION

The use of bio-adsorbents for treatment ofchromium contaminated water is highly beneficial in all aspects. There are some other benefits of using these materials as well. Different bio-adsorbents have different Cr(VI) removalcapacity depending on their surface morphology and their functionalities.

When the % removal of Cr(VI) was compared with the recent researches in this direction, it was found that there were many similarities in results such as % removal of Cr(VI) for PPP and WKP was found to be 97.83% which is almost equivalent to 100% removal from the work already done. The same estimate was obtained for the remaining bio-adsorbents.

The present study such as the effect of variation in size of bio-adsorbents on % removal of Cr(VI) gives us an idea to choose the optimum size for real applications. The effect of temperature on Cr(VI) removal capacity of UTLP provides it a significantly different behaviour compared to others. Cost analysis of the experiment has proved that the benefits of this treatment approach will be available in large scale plants. A titration method has been used for this study which is unique in this direction.

The proposed approach to treatment will prove to be highly beneficial for all people living in rural area.Using this bio-adsorption method, the use of chemicals in the treatment unit can be reduced, making thetreatment more environmentally and economically efficient. Overall, we can say that using these bio-adsorbents is fruitful.

CHAPTER : PROJECT ACHIEVED OUTCOMES AND SOCITAL RELEVANCE

7.1 Achieved Outcomes

1. Utilized the waste products as bio-adsorbents i.e. indirect energy savings.
2. Found the different method of tannery effluent other than conventional approach.
3. Identified the effect of bio- adsorbent size variation on %Cr(VI) removal capacity of bio-adsorbents. (optimum size selection)
4. Obtained the best cr(vi) removal among the five bio-adsorbents.
5. Found the effect of solution temperature of used tea leaves on its Cr(VI) removal capacity.
6. Solved the problem of Cr(VI) contamination in drinking water of people living in rural areas near by tannery industries with help of proposed technique.

7.2. Societal Relevance

This project presents the use of bio-adsorbent for the treatment of Cr(VI) contaminated water. We all know that Cr(VI) is harmful for all humans as it causes cancer of lungs, skin, stomach, itching, liver etc. Treatment of Cr(VI) contaminated water will not pose any risk to human health. The proposed technology can provide Cr(VI) free drinking water to the people suffering from the problem. Additionally it reduces medicinal and hospital related costs. This method is very cost effective and provides accessibility to all.

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APPENDIX

Daily Dairy

- Have decided to work with four bio,pomegranate peel ,used tea leaf and water chestnut.(15/01/24)
- bio-absorbents : Walnut shellchestnut, the newly added bio 6-7,time 2 hr ,dosage 0.14g/l. (16/01/24)
- Studied how to work with water chestnutabsorbent to my project. Previously research work shows that
- 95% removal of cr (VI) is possible with it.(05/02/24)
- Ph required between 6
- Possibility to fit freundlich equation with

Where qe = the amount of adsorbate of sorbent at equilibrium (mg/g

Co = Initial conc. Of

Collected pomegranate peels from juice vendor. (18/01/24)

- Started collecting used teal leaf from own house .(19/01/24)
- Collection of walnut shell.(20/01/24)
- After that these were then Sun dried .(21/01/24)
- It has taken 7 days for complete moisture removal.(22 to 29/01/24)
- Then these were grinded with the help of grinder.(01/02/24)
- All powdered form absorbent collected separately.(01/02/24)
- Size analysis were performed on it with the help of std. Screen.(03/02/24)
- Discussion on approach for start of project.(04/02/24
- Sample preparations calculations(06/02/24)
- Project started on ground (07/02/24)
- Prepared the solution of potassium dichromate. (07/02/24)
  Its ph measured as 6.46 & solution temperature 19.4 c.

  Associated calculation

  50 ppm Cr = 0.141 g of k2cr2o7 in 1 litre solution.

- Prepared the solution of FAS 0.0125N solution (08/02/24)
  Associated calculation
  4.9 gram FAS in 250 ml solution along with acidic medium

  volume of 0.1 N H2so4 .

- Prepared KMnO4 solution and titrate against FAS and verify the strength.(08/02/24)

- Add 1 gram solvent bio absorbent to stock solution and allowed it to be stirring manually for 120 minutes
- Method of qualitative analysis (titrative analysis) (08/02/24)

Date : 09/02/24

- Third trial used tealeaf (-72/85)
  Strength comes out to be = 0.018375

  %removal = 86.9

- Fourth trial used tealeaf(-85/pan)
  Strength comes out to be = 0.01225

  %removal=91.312

- Fifth trial walnut kernel(-85/pan)
  Strength comes out to be = 0.018375

  %removal=86.9 .

- Sixth trail pomegranate peel (-85/pan)
  Strength =0.006125

  %removal=95.65

  - Collected water chestnut shells (16/02/24).
  - Washing and allowed them to sun dry for 7 days.(16/02/24-22/02/24)
  - In mean time, collected rice husk from village. (17/02/24)
  - Separation of impurities and washing with water and then drying (17/02/24-22/02/24)

- Ground the dried rice husk and water chestnut (23/02/24)
- Visited in department and discussed with supervisor/mentor for further proceeding the experiment (23/02/24)
- Size analysis of these bio-adsorbents with the help of screens.(26/02/24)
- From preparation of std. K2cr2o7 solution to analysis of bioadsorbents titration value for all four samples.(27/02/24-29/02/24)
- The experiment for third sized (-16/72) was also performed to get more datasets for each bio-adsorbents. (27/02/24-29/02/24)
- Discussed with supervisor to start writing paper.(01/03/24)
- Paper writing (01/03/24-04/03/24)
- Discussed with mentor about the results obtained and presented in paper like graph nature and their comparison with paststudies.(04/03/24)
- Paper sent for plagiarism check and asked to reduce plagiarism.(04/03/24)
- Discussion of journal suitable for paper.(04/03/24)
- Paper submitted (04/03/24)
- Discussed with mentor about the final report to be submitted in end evaluation.(05/03/24).
- Start of final report writing (16/03/24 onwards)
- Contacted many times with the journal editor to provide fast decision.(15/03/24-05/04/24)

- Revision asked by the journal's editor for the submitted manuscript (06/04/24)

- Discussed with the mentor about revisions(09/04/24)
- Submitted revised manuscript(10/04/24)
- Discussed with supervisor about second asked revision in the manuscript and then submitted second revised manuscript(19/04/24)
- Got paper acceptance mail(23/04/24)
- Preparation for mid term evaluation (23/04/24-25/04/24)
- Final report preparation is continued.
- Start of final report writing (16/03/24 onwards)
- Contacted many times with the journal editor to provide fastdecision.(15/03/24-05/04/24)
- Revision asked by the journal's editor for the submitted manuscript (06/04/24)

- Discussed with the mentor about revisions(09/04/24)
- Submitted revised manuscript(10/04/24)
- Discussed with supervisor about second asked revision in the manuscript and then submitted second revised manuscript(19/04/24)
- Got paper acceptance mail(23/04/24)
- Preparation for mid term evaluation (23/04/24-25/04/24)
- Final report was completed(25-30 April 2024)
- Sent to Turnitin coordinator for plagiarism check .(02/05/24)
- Final presentation ppt and poster preparation have started.(02-20/05/24)
- Project evaluation will end on 24/05/2024.

******************** Happy Ending******************************