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Biosorption of cadmium from industrial waste

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ABSTRACT

Cadmium is a toxic, non-biodegradable and non-essential heavy metals that may lead to dysfunction of the lungs, kidneys, and bones, even in low quantities Due to the heavy usage of cadmium in industry, it causes natural problems, so, removal is mandatory for environmental protection. There are many metal degradation techniques that have their own advantages and disadvantages, and various biologically active substances have the potential to remove toxic metals from industrial effluents. These are cheap, highly efficient, and environmentally friendly techniques. In this present study, the biosorption of industrial effluents containing cadmium was studied using tea (*Camellia sinensis*) waste. Tea (*Camellia sinensis*) waste fine particles were utilized as biosorbent substances in optimized environmental conditions by means of a solution of cadmium and the impact of specific factors, i.e., time of contact, pH, initial metal concentration, temperature, and biomass quantity. In the current study, among the biomass tea waste, 0.4g showed 83% best biosorption in 120 minutes of incubation under continuous shaking conditions (180 rate per minute) at pH 5, initial metal concentration (15 mg/L), and 30°C. For structural and morphological analysis, different techniques were used, such as FTIR (Fourier-transform-infrared-spectroscopy) and SEM (Scanning-Electron-Microscope). For the analysis of the concentration of cadmium, the titrimetric method was used. Consequences have shown that tea (*Camellia sinensis*) waste is verified as a superior biosorbent for the degradation of cadmium.

KEYWORDS

Cadmium; Effluents; Biomass; Biosorbent; *Camellia sinensis*

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Introduction

Cadmium (Cd) is non-essential toxic transition metal that possesses certain health risks for mammals. Agricultural and industrial effluents released into the environment constitute a certain amount of cadmium, which behaves as an environmental pollutant and can contaminate food or water, which can lead to Cd toxicity [1]. Heavy industrialization is leading to the manufacture and utilization of heavy metals, including cadmium, and increasing worldwide metal pollution. Cadmium, having an atomic mass of 112.41 and an atomic number of 48, is associated with group XII of the periodic table. It is silvery white, soft metal that resembles zinc and mercury in various chemical as well as physical properties. Cd, being post-transition metal, constitutes 2 electrons in s-orbital and the filled d-orbital. Cd is a nonflammable and water insoluble entity. It does not corrode, so it is used as a protective agent. In nuclear fission reactions, Cd manages the neutron flux as it acts as neutron poison [2].

Cadmium levels in the environment are accelerating due to certain human activities, such as the use of fertilizers, the combustion of fossil fuels, and smelting and refining. Cd is also being used in industry as a color pigment, corrosive reagent, stabilizer in PVC items and Nickel Cadmium batteries. Natural phenomena such as volcanic eruptions, soil and rock abrasion and erosion, and forest fires contribute to the escalation of Cd levels in the environment [3]. It is absorbed in high quantities from water, food, and air contamination. Vegetation grown in contaminated soil and shellfish usage as food can lead to more Cd exposure as compared to omnivores. Cd possesses hydro-chemical properties that enhance its mobility in underground water. Utilization of this water in irrigation is contaminating various cereals, such as rice, which has been seen in Japan [4]. Thus, the water bodies around factories or mines are more susceptible to Cd toxicity. Cigarette smoke is more of the major cause leading to Cd toxicity, as one cigarette contains 1–2 µg of Cd [5].

Mammals can encounter Cd, usually through respiratory tack, while GIT and skin also contribute a little toward Cd toxicity. Erythrocytes and albumin assist its transport in the blood; later, it gets accumulated in the gut, liver, and kidneys [6]. Cd possesses a half-life of 25-30 years, so it can remain in the living body for a long time, leading to chronic toxicity. Due to non-biodegradable nature of cadmium, even its minute concentration can block the functional groups of various enzymes. Cd has affinity for the thiol groups, even for the methyl donor S-adenosyl methionine, leading to methyl modification, which ultimately affects DNA methyl-transferase affairs. This epigenetic modification can have detrimental effects on embryogenesis, fetal development, and placenta formation [7]. Cd exposure can lead to certain detrimental effects, such as pulmonary edema, osteomalacia, testicular damage, hepatic and renal dysfunction, and damage to the adrenals and hemopoietic system. Epidemiological data exhibit that Cd acts as a carcinogen, which can induce lung, pancreas, kidney, breast, prostate, and naso-pharynx cancers

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[8]. Coronary heart disease, peripheral artery disease, stroke, and atherogenic changes were also observed in Cd toxicity.

Due to heavy industrialization throughout the globe, defilement is accelerating, which is causing serious disorders in the population. Certain heavy metals, such as Cd, possess the capacity to induce epigenetic modification, which can lead to mutagenesis, which further manifests serious detrimental effects. Since ancient times, scientists have been working to mitigate the minacious effects of cadmium on living bodies as well as try to diminish it from industrial effluents to protect the environment and life within. To abridge the Cd contamination, certain conventional methods have been administered, such as flocculation, ion exchange, microbial decay, membrane filtration, and electro-chemical precipitation [9]. But most of them have proven to be fruitless in bringing the contaminant concentration to an acceptable level. The ion exchange method exchanges the metal among insoluble materials, which are resins, but resins are much more expensive, which makes this protocol economically unfit. Electro- winning, cementation, electro-coagulation electrocoagulation utilize electrical discharge to eliminate metal ions from waste water, but electricity utilization makes it costly. Electrodialysis and osmosis are membrane processes that extract the poisonous metal, but this method faces the issues of deficient stream rates, fluctuation of membranes in salty and acidic surroundings, and stinking by organic and inorganic division [10].

Adsorption methods have gained attention as they are affordable, comparatively cheap, straightforward, and promising. Biosorption is the use of dead bio-material that absorb contaminants. Naturally occurring biomass like banana pitch, chitin, and chitosan clears heavy metals up to 100 mg/L. Like other organic biomass, tea waste can be used to eliminate heavy metal ions, and the effectiveness of action can be as high as 100% with a precise choice of biosorbent quantities [11]. Tea is a mainly utilized drink around the globe, as evidenced by the fact that over 3,500,000 tons of tea leaves are grown per year, after waste. There are different types of tea beverages, like green, oolong, or black tea, depending on production techniques [12]. Pakistan is manufacturing approximately 200,000 tons of waste tea leaves, as around 100 billion cups of tea are utilized each year. Approximately 22kg of dried tea is manufactured from 100kg of green tea, of which 18 kg is packed for the marketplace. The extra 4kg of dry tea matter is desecrated. This bulky amount of tea waste (from the coffee bar, canteen, or tea processing factory) is frequently eliminated into the atmosphere without any management [13]. In agriculture, tea waste was used to enhance yield under heavy metal stress. *Vigna radiata* was cultivated under chromium stress with tea waste as a favorable adsorbent combined with soil to protect plants from Cr^{3+} phytotoxicity by altering various metabolic transitions [14]. More studies are required to know the effect of different immobilization processes on the speed of bio-sorption and contaminant removal by immobilized biomass. Biosorbents can also be utilized for the refining of ionic drugs such as peptides, proteins, and antibiotics. Column chromatography proved to be much more useful for highly purified products than fixed bed or moving adsorption.

To ensure the quality of water, different treatments have been administered to treat the effluents before discharging into the environment, but they have proven either economically ill or eco-toxic. Clean water is a crucial need for the prosperity of the environment and life within. In this study, we have tried to use waste tea to mitigate the Cd level in industrial waste, as it is both cheap and eco-friendly.

Materials and Methods

The research was done in the Mineral and Material Chemistry Laboratory, Department of Chemistry and Biocatalysis Laboratory, Department of Biochemistry, University of Agriculture Faisalabad. The investigation was carried out in three phases. Firstly, biomass preparation was studied; secondly, heavy metal adsorption from effluents was studied, lastly, the condition was optimized for maximum adsorption.

Adsorbent preparation

For Cd biosorption, tea (*Camellia sinensis*) waste has been used as a biomass. Tea waste was collected from a tea stall located in the Faisalabad Agricultural University Market, Pakistan. The collected biomass was cleaned with boiling water to remove the colored and soluble parts. This process was repeated until the water was thoroughly cleaned. Finally, the tea was washed with distilled water and dried in sunlight. Then the dried mass was ground into a fine powder and stored in sealed glass bottles (Figure 1).

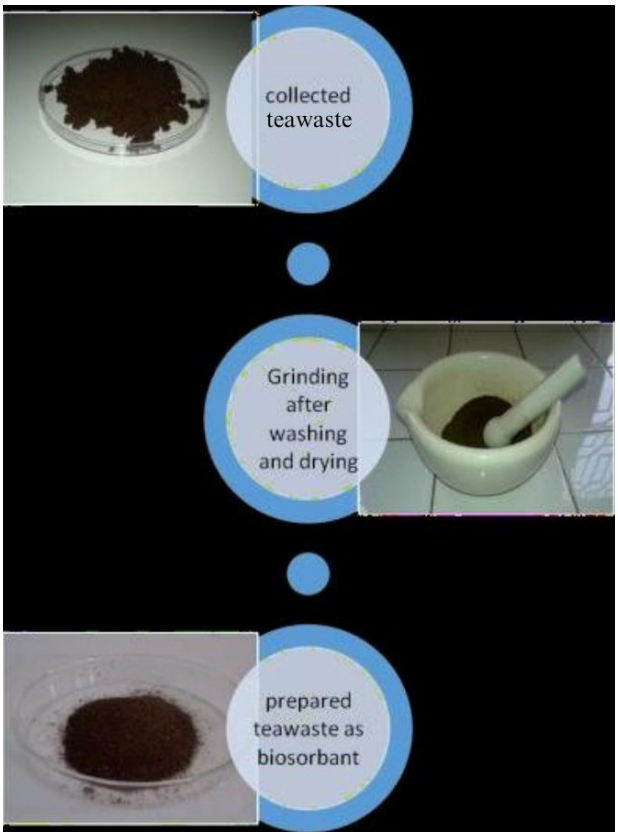

Figure 1. Preparation of biosorbent tea (*Camellia sinensis*) waste.

Experimental procedure

A cadmium nitrate stock solution was prepared by dissolving 2.1g of cadmium nitrate [$Cd(NO_3)_2$] in 100 ml of distilled water in a measuring cylinder containing 1g of cadmium metal. 0.1 g of biomass was added into 250 ml flasks, consisting of a 50 ml target metal solution. The pH was maintained during entire

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study by using dilute ammonia solution or HCl. The flasks were subjected to a thermostatic incubator shaker at 120 rpm (revolution per minute) for 90 min. Sample solution was then filtered to get rid of any remaining tea waste and analyzed for the concentration of metal ions. Filtrate was analyzed for metal concentration by using the titrimetric method. Target metal uptakes were predicted by using mass balance before and after the procedure. All batch runs were performed in duplicate for data assessment.

Optimization of parameters

Various physio-chemical parameters such as pH, initial concentration of metal, temperature, contact time, and biomass quantity. Were optimized for the biosorption of cadmium.

Optimization of pH

The pH effect on the biosorption of cadmium was observed at different pH levels (1-9). Dilute ammonia and HCl were used to manipulate the pH [15]. Other factors, such as temperature (30 °C), contact period (90 minutes), biomass quantity (0.1 g), agitation speed (120 rpm), and initial metal concentration 10mg/L were remained constant. After each experiment, solid residue was collected for analysis. To measure the concentration of remaining cadmium, titration of the filtrate was done with EDTA.

Concentration of biomass

The effect of biomass amount on cadmium biosorption was evaluated by altering the concentration from 0.1g to 1g [15]. Other factors, such as temperature, contact period, pH, agitation speed, and initial metal concentration, were kept constant. After each experiment, solid residue was collected for analysis. Titration of the filtrate was done with EDTA, to measure the concentration of the remaining cadmium.

Incubation period

The effect of incubation duration on cadmium biosorption was investigated by varying the contact duration from 60 min to 150 min [16]. Other factors, such as temperature, biomass concentration, pH, agitation speed, and initial metal concentration, were kept constant. After each experiment, solid residue was collected for analysis. Titration of the filtrate was done with EDTA, to measure the concentration of the remaining cadmium.

Temperature

The effect of temperature on cadmium biosorption was studied by revising the temperature from 30°C to 50°C [17]. Other factors were kept constant. Solid residue was collected for analysis. The filtrate was subjected to titration with EDTA (ethylenediaminetetraacetic acid) to measure the persisting Cd concentration.

Initial metal ion concentration

The effect of the initial metal concentration on cadmium sorption was investigated by varying the metal ion concentration from 5 mg/L to 25 mg/L [15]. Other parameters remained constant. To study the persisting concentration of Cd, titration was done with EDTA.

Agitation speed

The effect of agitation speed on cadmium biosorption was investigated by altering the agitation speed from 120 rpm to 240 rpm (revolution per minute) [18]. While other factors remained constant. After each experiment, solid residue was collected, and the amount of remaining Cd concentration was evaluated by titrating with EDTA.

Experimental analysis

Titrimetric method

EDTA titration was carried out to calculate the cadmium concentration present in the filtrate after the procedure. 5 ml of filtrate was taken in the flask consisting of 2-3 ml of buffer, then 2 to 3 drops of EBT were added, and an immediate color transition was observed as the transparent solution turned pink [19]. Later on, it was titrated against a 0.1M EDTA solution, and now the pink color solution turned blue, as shown in Figure 2. Volume of consumed EDTA solution was noted to calculate the amount of cadmium in the filtrate.

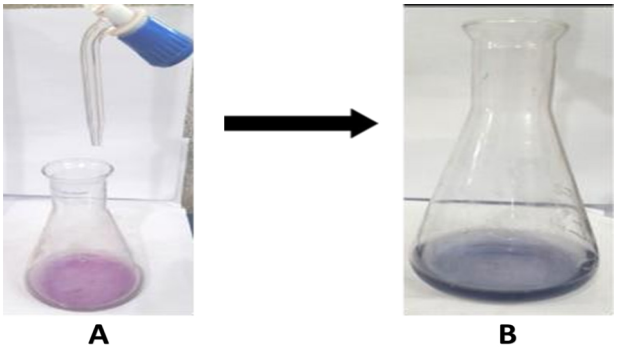

Figure 2. (A) Cadmium solution before titration; (B) cadmium solution after titration with EDTA.

SEM (Scanning electron microscopy)

Scanning electron microscopy was used to evaluate the morphological impact of cadmium ions adsorption on tea surface.

FTIR (Fourier transform infrared)

FTIR was used to obtain infrared absorption spectrum. It collects information with extremely high spectral resolution across a broad spectral range at once. This shows a significant improvement over a dispersive spectrometer, which at one moment calculates intensity over a limited spectrum of wavelength. Fourier transform infrared spectroscopy is based on the need for a Fourier transformation (a mathematical process) to convert raw information into the real spectrum. When infra-red radiation passes by a sample, some radiation is absorbed by the sample, and some passes through. The resultant signals at the detector are a spectrum representing a molecular "fingerprint" of the sample (Figure 3).

Figure 3. Flowchart indicating the complete process in biosorption of Cd by tea waste.

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Results and Discussion

This study was conducted to devise a low price, efficient, and eco-friendly biosorption protocol that proves effective enough to be used as an alternative technique to extract cadmium metal from industrial effluents. Certain other biological technologies are available to eradicate the pollutants but they are restrictive in the mud and can damage the soil. Biosorption is a relatively clean technique, as the use of inactive biomass has made an important contribution to eliminating toxins from wastewater. Metal ions assimilated by the biosorbent are due to the existence of certain functional groups present on them. Tea waste has been used as biomass in this current research. The primary concept of this research was to discover the capability of tea waste to adsorb cadmium and develop a cost-effective technique of biosorption. The impacts of various parameters have been examined, like pH, biomass concentration, initial metal concentration, temperature, and agitation speed.

Optimizing experimental biosorption parameters

The effect of various operating variables on tea biosorption of cadmium was explored using batch methods to acquire the full potential of biomaterial for biosorption.

The examination of pH effect

The effect of different pH ranges was studied, and the results are shown in Figure 4. pH (1-5) seems to be more potent in removing Cd from tea waste. Particularly, the extraction capacity of tea waste at pH 1–3 was very minor but accelerated at pH 3–5 and again decreased at pH 7–9. The pH-dependent trend could be experimentally explained through the ion exchange procedure between the functional biomass surface groups, e.g., phenolic hydroxyl and carboxyl, and the solution cations [20].

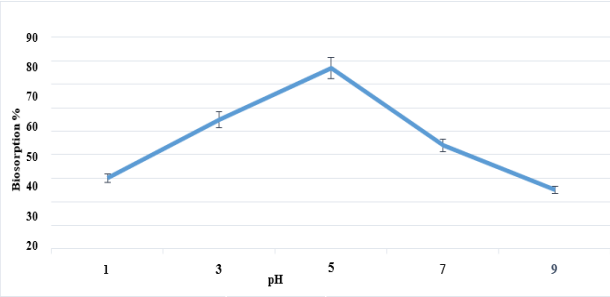

Figure 4. Effect of different pH levels on cadmium adsorption.

Conditions: Adsorbent Quantity 0.1g; Contact Time 90 minutes; Initial Concentration of Cadmium 10 mg/L; Rpm 120; Temperature= 30°C.

The concentration of H+ ions in acidic pH is high, and these H+ ions bind Cd with them to increase their biosorption, while at high pH, the concentration of OH-ions increases and the deposition of Cd declines [21].

The adsorbent concentration effects

While keeping the other factors constant, the effect of different adsorbent concentrations (0.1g to 1g). Figure 5 shows the impact of different adsorbent amounts on Cd ion biosorption. The results indicated that with the addition of the biosorbent amount, the rate of removal of Cd ions from tea waste improved. While increasing the quantity of biosorbent also enhances the number of binding domains of biosorbent for Cd ions, further addition of biosorbent reduces the rate of adsorption [22].

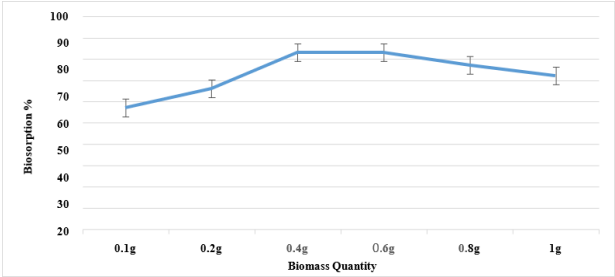

Figure 5. Effect of various adsorption quantities on cadmium adsorption.

Conditions: pH 5, contact time of 90 minutes, initial concentration of cadmium (10 mg/L), Rpm of 120, temperature of 30°C.

The proportion of biosorption decreased at a greater adsorbent dose. This linear combination of biosorption domains contributed to reducing the entire surface area of the biosorbent for metallic ions and enhancing the diffusion path length [23]. Percentage adsorption increased if the quantity of adsorbent increased. The reason is that the number of active sites on the adsorbent increased due to a rise in its dosage. But an increase in the quantity of biosorbent has a restricted increase in extraction performance, and this is because after a certain quantity of adsorbent, the highest biosorption is reached, the quantity of ions binds to the biosorbent, and the number of available ions remains unchanged with a higher absorbent dosage. The results were predicted so that, for a set initial metal concentration, there is a higher adsorbent surface or site for biosorption [24].

The incubation period effect

The impact of varying contact times ranging from 60 minutes to 150 minutes was investigated. According to the data obtained, the rate of Cd removal increased with the elevation of contact time, and after 120 minutes, it achieved the highest elimination rate of Cd; thus, this period is regarded as equilibrium response time. The data of various contact times on the rate of Cd ions are revealed in Figure 6.

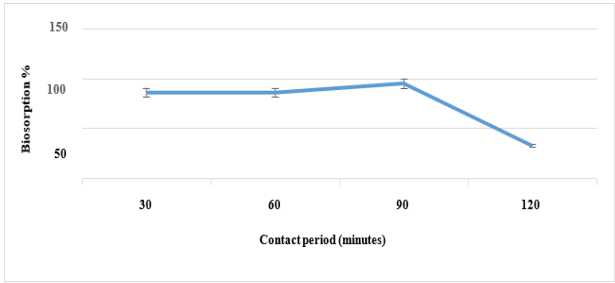

Figure 6. Effect of contact time on the cadmium adsorption rate.

Conditions: pH 5, adsorbent quantity of 10 g/L, initial concentration of cadmium of 10 mg/L, temperature of 30°C, rpm of 120.

The biosorption of Cd ions was investigated for 60-120 minutes. The adsorption rate increased as the contact period

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increased for about 120 minutes, but it was alleviated quickly due to a reduction in the available active site. 120 minutes have been concluded to be the best contact time to eliminate Cd ions to a greater extent, as the biosorption rate reduces after 120 minutes. The high biosorption rate in the initial 120 minutes is due to the existence of large numbers of biosorbent domains, and a later decrease in the rate of biosorption would be due to the formation of repellent forces between the metals on the solid surface and in the aqueous medium [25,26].

The effect of temperature

While keeping the other factors constant, the effect of different temperatures ranging from 25 to 50°C was investigated. As the temperature increased from 25 to 30 °C, the biosorption percentage also increased. The optimal level was achieved at 30°C. The percentage elimination of Cd (II) ions from the liquid phase was not affected by further increasing temperature [17]. Figure 7 indicates that the biosorption of cadmium ions on the biosorbent was dependent on temperature.

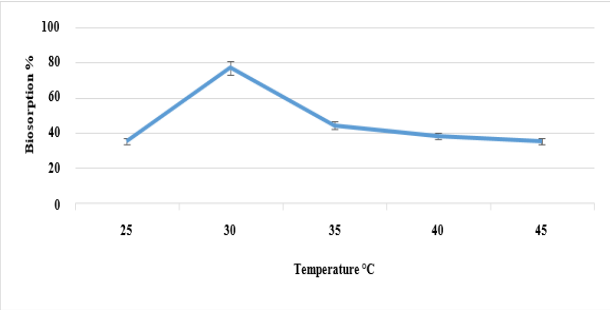

Figure 7. Effect of various temperatures on cadmium adsorption.

Conditions: pH=5, adsorbent quantity=0.4 g/L, initial concentration of cadmium=10 mg/L, contact time=120 min, rpm=120.

The adsorption rate of Cd was partially impacted by the rise in temperature. Results indicate that low temperatures are beneficial for cadmium ion adsorption, and high temperatures decrease the adsorption capability of tea waste because, at high temperatures, Cd ions escape from the solid phase to the bulk phase. This proposed that the adsorption mechanism related to Cd ion degradation involves a physical phenomenon in which adsorption takes place due to electrostatic interaction, which is usually related to low adsorption heat [27]. This indicates that adsorption has an exothermic character, due to which an increase in temperature does not affect the removal of Cd (II) [28]. Additionally, it was recognized that the time of equilibrium is independent of temperature.

The effect of the initial cadmium concentration

The impact of distinct initial metal concentrations varying from 5 mg/L to 25 mg/L was investigated while maintaining other variables constant. Figure 8 indicates that the adsorption capability was enhanced with the rise of the initial Cd concentration, but if the original Cd concentration decreased from 5 to 15 mg/L the adsorption capability was improved. The proportion of cadmium removal was further improved in the initial Cd concentration from 72% to 55%. This issue can be resolved by having more free adsorbent bands and exchanging ions at minimal cadmium concentrations.

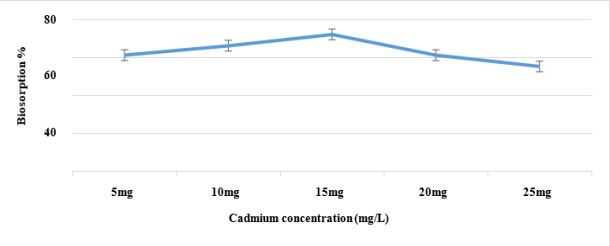

Figure 8. Effect of different initial concentrations on the percentage of removal of cadmium.

Conditions: pH 5, Adsorbent Quantity 0.4 g/L, Contact Time 120 Minutes, Rpm 120, and Temperature 30°C.

The initial Cd ions concentration generates an attractive force in the batch adsorption mechanism to reduce the resistance of biomaterial movement between liquid and solid phase. Consequently, with the increased concentration of Cd ions in the solution at a specific level, increases the ability to absorb Cd ions [21]. But if the concentration of metal ions increased more, the rate of biosorption reduced as all active domains got engaged, and further increases in the metal ion concentration did not affect the rate of biosorption.

The effect of rpm

While keeping the other parameter constant, the effect of different agitation speeds ranging from 120 to 240 rpm was studied. Figure 9 presents the statistics of the impact of various rpm values on Cd (II) adsorption. Adsorption experiments were conducted using a 15 mg L^{-1} Cd (II) solution using a magnetic shaker at pH 5.0. As the agitation rate increased from 120 to 180 rpm, the ability of tea to absorb Cd improved from 66% to 83%. Agitation at high speed enhances the extraction rate by reducing the resistance of the film to transfer mass around the adsorbent particles, but it can also damage the biosorbent's physical structure [29].

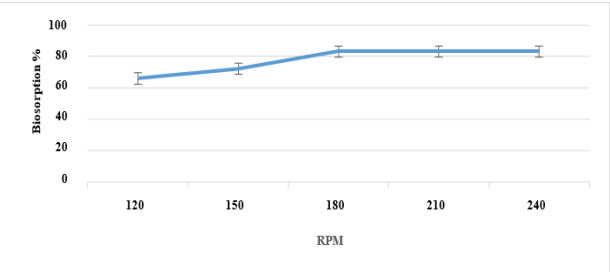

Figure 9. Effect of the different rpm on the percentage removal of cadmium.

Conditions: pH 5, adsorbent quantity of 0.4 g/L, contact time of 120 minutes, initial cadmium concentration of 15 mg/L, temperature of 30°C.

It can be noted that with stirring velocity, the efficiency of metal degradation improves until it achieves a definite value and then decreases without advantage (i.e., above 180 agitation speed). Furthermore, these results clearly demonstrate that a stirring velocity of 180 rpm is adequate to achieve the highest extraction effectiveness by decreasing the thickness of the boundary layer to a minimal level [18]. After 180 rpm, the biosorption percentage was constant, and further increases in rpm did not affect the biosorption percentage.

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Morphological and surface area study of tea waste by SEM

Using SEM, the surface topography and sample structure were identified when electrons interfered with the atoms of the sample and produced various signals containing the sample surface characteristics. Secondary electrons size is a function of surface tilt. The plum is slightly exposed on a tilted surface, and a massive amount of electrons is emitted, but the plum of secondary electrons is often contained by the sample on a flat surface. By scanning the samples and detecting the secondary electrons, a micrograph presented the surface tilt produced [30].

Scanning electron microscope exposed the micro porous structure of biomass (tea waste) Figures 10 (a) and (b) display pictures taken by scanning electron microscopy (SEM) from the tea waste surface structure. Figure 10 (a) demonstrates the pictures in magnified form demonstrating porous structure before the adsorption of tea waste while Figure 10 (b) demonstrates the pictures that metals have filled pores and the adsorption process was examined at a magnification power of 500x under scanning electron microscopy.

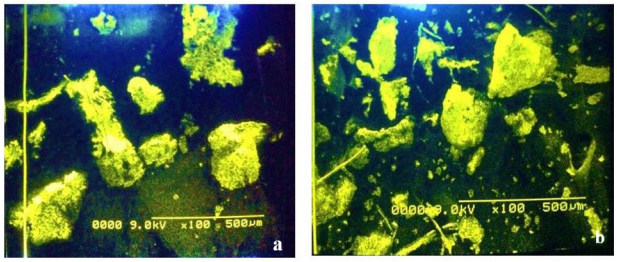

Figure 10. (a) SEM image before biosorption of metal by tea waste; (b) SEM image after biosorption of metal by tea waste.

No traces of metal ions were examined as the sample became unstable on stage due to high energy beams of electrons. The sample could not remain solidified for a longer period of time. At 500x magnification, a clear micrograph of metal-treated tea waste was achieved, exposing the presence of heavy metal ions at the tea waste surface pores. The tea waste micrographs collected from SEM displayed a large surface area for the adsorption of heavy metal ions.

Fourier Transform Infrared (FTIR) analysis

The FTIR spectrum of tea waste samples loaded with metal ions was conducted to further investigate the metal adsorption mechanism on tea waste. FTIR evaluation of tea waste laden metal, and the new one exhibiting a set of absorption peaks had changed after adsorption of toxic metal. These statistics reported that the displacement of C=O at (1600-1800 cm-1), secondary amine group at (3500-3300 cm^{-1}), aliphatic C–H group at (3100-2900 cm^{-1}), and –OH bearing groups at (3600-3300 cm^{-1}) played an important part in the degradation of tea waste cadmium metal ions [31]. In addition, Si-O stretching and Si-O bendingweres recorded as peaks at 1049.63 cm^{-1} [32].

The unique adsorption mechanism of Cd ions verified the above explanation of the sequence of Cd metal adsorption capacity in tea waste. Also, the C=O displacement ion exchange system and bonded–OH groups with metals also verified the deduction of the pH dependent stated above. In addition, the combined impacts of various functional groups have shown that tea waste is an exceptional adsorbent to eliminate hazardous metal ions. The observed peaks and their descriptions are summarized in Table 1. Carboxylic acid, aromatic, amine, and hydroxyl were suggested among the functional groups to be responsible for the adsorption of heavy metal ions on the adsorbent cell surfaces (Figures a & b) [33].

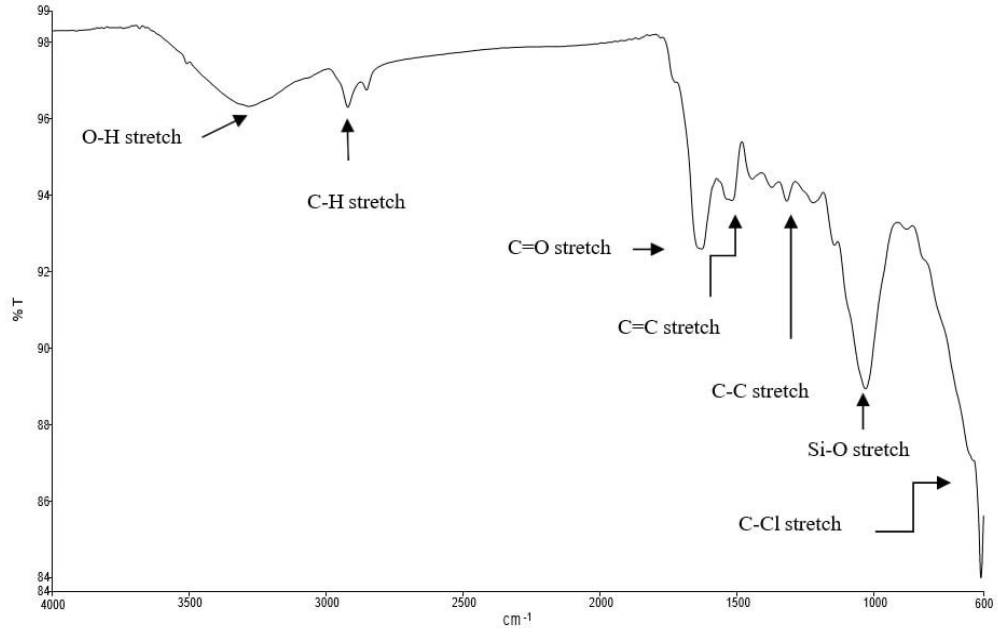

Figure 11. (a) Tea waste FTIR spectrum before adsorption.

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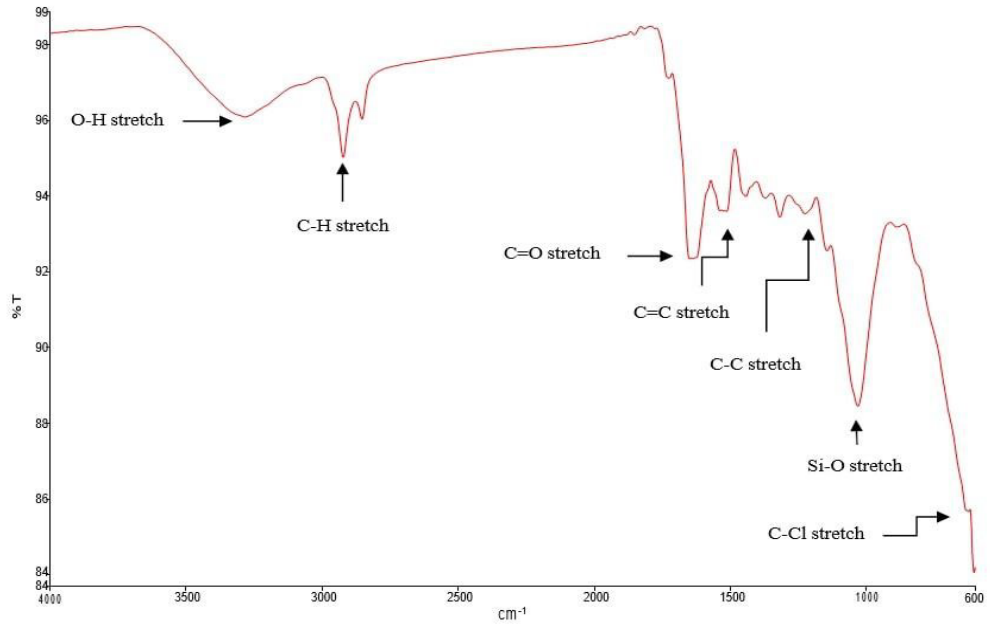

Figure 11. (b) Tea waste FTIR spectrum after adsorption.

Table 1. Functional groups before and after biosorption tea waste biomass loaded with cadmium ions.

	Wave Number: cm^{-1}	
Assignment Functional Groups	Before Adsorption 11 (a)	After Adsorption of Cd ions 11 (b)
Hydroxyl group (O-H stretch)	3308	3326
Carboxyl group (C-H aldehyde stretch)	2924	2938
Amides (C=O stretch)	1648	1652
Aromatic (C=C)	1662	1668
Carboxyl group (C-C ketone stretch)	1196	1210
Alkyl Halides (C-Cl stretch)	632	648
Silica (Si-O stretch)	1030	1038

Conclusions

In the current study, the potential of tea waste for biosorption of cadmium from industrial waste was investigated to develop a cheap and eco-friendly waste treatment process. By optimizing the parameters, the biosorption was significantly improved, and 83% biosorption of cadmium from waste water was achieved in the biological process. Due to heavy industrialization, heavy metal bearing industrial effluents are getting released into water bodies. Metals are deadly to every living species existing on the globe. So, it should be our first priority to generate protocols to get rid of these heavy metal ions. Some techniques are available that can remove heavy metals from waste water, such as ion exchange schemes, physical or chemical therapy systems, and membrane microfiltration systems, but these are costly and have some disadvantages. This study was conducted in order to demonstrate quite a cheap as well as more efficient technique, such as biosorption, to remove metal ions from industrial effluents. The tea waste was used as biomass in powder form. Tea waste has been obtained from a UAF Mart tea stall. The tea waste biosorption assay was performed under various parameters. For Cd recovery, the optimal pH was 5.0, at which tea waste had a peak biosorption of 77%. The optimum amount of biosorbent for maximum biosorption was 0.4g which gave the highest level of biosorption (83% in the presence of tea). At 120 minutes of contact time, a 95% biosorption rate was measured. The optimum temperature was 30°C, at which 77% biosorption was measured. At an initial concentration of 15mg /L of metal, the maximum biosorption rate was 72%. The biosorption rate at 180 rpm was 83%, which is the optimum rpm for the total removal of tea waste from cadmium. The results of the study are expected to form the basis for the development of economical and eco-friendly technology for the biosorption of cadmium metal from wastewater using tea waste as a biosorbent.

Disclosure statement

No potential conflict of interest was reported by the authors.

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