

# Biosorption of lead and cadmium ions from aqueous solution by tea and coffee wastes

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## ABSTRACT

Due to toxicity and non-biodegradable nature of lead and cadmium, they are reported as most detrimental metal. In this paper aptness of tea and coffee wastes is examined to treat lead and cadmium ions. FTIR study of tea and coffee wastes confirmed the existence of various functional groups that have adequate tendency to attract positively charged heavy metals ions and form complex with the electrostatic interaction. The tendency of heavy metal is highly dependent on pH, adsorbent dosage, contact time, metal ion concentration and temperature. Maximum percent adsorption was found at pH 5 for both ions. Temperature effect was examined in the range of 25 to 65 °C for both lead and cadmium ions on tea and coffee wastes respectively, that reveals the exothermic nature of adsorption process.

*Key words* : Non-biodegradable, Toxicity, Functional group, Adsorption.

## Introduction

Discharge of heavy metals in the environment is a big worldwide problem. Heavy in the metals discharge in water through the discharge of wastes materials due to natural and the discharge activates is the cause of agglomeration of metals in eco system. Due to high abundance, ductility and high density lead and cadmium play a vital role in electroplating, nuclear fission plants, welding, paints, metal coating, radiation shielding, construction, plumbing and pigmentation, etc. Due to non-bio degradability of these metals and persistence nature, they get accumulate in the food chain and results in severe health issues in the (Kumari and Sharma, 2018). Lead and cadmium are one of the most toxic metals. Ingestion of high level of cadmium and lead causes mental abnormality, lung cancer, vomiting, mental disorder, kidney damage and fragile bones. Cadmium poisoning also causes Itai-itai disease. In order to treat toxicity caused by these metal several physical,

chemical and biological methods have been used. Most commonly used techniques are ion exchange, reverse osmosis, electrochemical treatment, extraction and adsorption etc. (Kumari and Sharma, 2018; Witek-krowiak *et al.*, 2011). All these techniques have their pros and cons in the application. Some techniques are highly expensive, produces large toxic sludge and incomplete removal. Hence, need is to provide some alternative technique for productive treatment of heavy metal form the environment that should be more efficient, low cost and eco-friendly. Bio sorption is the one of the best suited process to eradicate these metals from environment especially from water (Monika Kumari and Sharma, 2018). Many bio sorbent such as moringa oleifera, plant waste, coconut shell, chestnut shell, plumb Shell, water plant, wheat straw, tamarind wood, coffee husk, pecan nutshell, fruit and vegetable compost, peanut hull, tea waste, cow dung ash, soy sauce residue etc. have been efficiently used in previous research by various investigators (Enkh-

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Amgala *et al.*, 2017; Saravanan *et al.*, 2017; Imran *et al.*, 2019; Acharya *et al.*, 2009; Adhiambo *et al.*, 2015; Ahmad *et al.*, 2017; Ahmed and Mustafa, 2008; Ali *et al.*, 2016; Aliabadiet *et al.*, 2018; Ab Aziz *et al.*, 2016; Herald *et al.*, 2018; Souza *et al.*, 2017; Tavares *et al.*, 2017).

Tea and coffee are the most widely used beverages worldwide. Waste tea leaves, coffee powder and coffee husk have been studied for their application mainly to treat wastewater as their large availability and cost-effectiveness (Amarasinghe and Williams 2007; Hussain *et al.*, 2018; Abbas, 2014; Cheraghi *et al.*, 2015; Chakrabarty *et al.*, 2017; Agwaramgbo *et al.*, 2016; Ghasemi *et al.*, 2017; Azouaou *et al.*, 2014). In this study the effectiveness of cooked tea and coffee wastes were examined to treat lead and cadmium ion from aqueous solution.

## Material and Methods

### Preparation of tea and coffee wastes

Tea and coffee wastes were collected from the JECRC University cafeteria. These adsorbents then washed with double distilled water to remove impurities and dried at room temperature for 24 hours. To remove moisture content completely adsorbents were dried in the hot oven for 48 hours at 50 °C. After drying at 50 °C, it was ground and screened (using a sieve with mesh size 100 mesh or .045µm).

### Preparation of stock solution

The stock solution of heavy metals Pb(II) and Cd(II) were prepared using standards (1000 ppm) by diluting with a suitable amount of Milli-Q water. Hydrochloric acid (0.1N HCl) and sodium hydroxide (0.1N NaOH) with the highest purity available were used from Merck (Darmstadt, Germany) to adjust pH of the solution. Different concentration of metals was used in this study by diluting the stock solution in appropriate proportions.

### Batch adsorption experiments:

Batch adsorption studies were performed to calculate the amount of metal ions removed by using low-cost adsorbents (tea and coffee wastes). Known the concentration of 50 mL of heavy metal ions was taken in centrifuge tubes. An optimum amount of bio sorbents that is 0.2 grams were added to these solution. pH of the solution was adjusted 5 for both

lead and Cadmium for tea and coffee wastes by using 0.1 N HCl and 0.1 N NaOH solutions. 360<sup>0</sup> rotary shaker was used to agitate the solution for different time interval. Whatman filter paper 0.45 µm was used to filter the solution. The remaining concentration of metal ions in the solution were detected by Atomic Absorption Spectrometer and the equilibrium metal uptake ( $q_e$ , mg/g) remained in the adsorbent phase the following equation was used

$$q_e = V \left[ \frac{C_0 - C_e}{m} \right] \quad \dots (1)$$

Where  $C_0$  and  $C_e$  are the initial and equilibrium metal ion concentration (mg/L) in solution, V is the volume of solution taken (mL) and m is the mass or weight of adsorbent in grams.

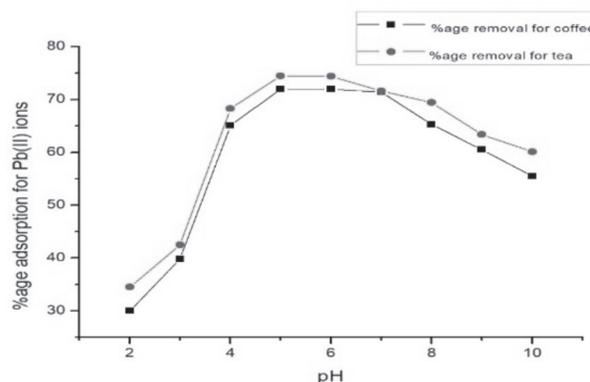
Metal removal efficiency (R%) was calculated by the following equation

$$R\% = \frac{C_0 - C_e}{C_0} \times 100 \quad \dots (2)$$

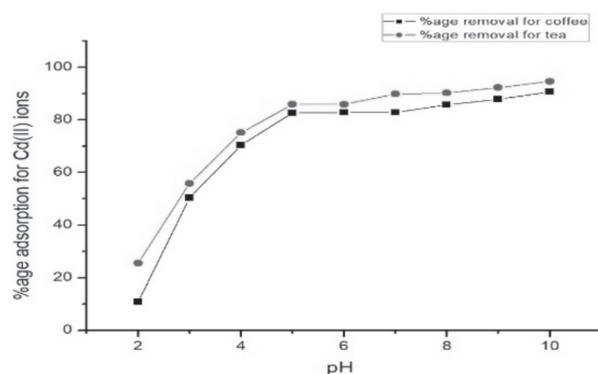
## Results

### Effect of pH

The effect of an initial pH on the percentage removal of Pb(II) and Cd(II) ions in the pH range from 2 to 10 at room temperature (25 °C) and the initial Pb(II) and Cd(II) concentration fixed at 2 mg/L were investigated. Result is presented in Fig. 1. and Figure 2, for lead and cadmium removal using tea and coffee wastes respectively. It is clear from the figure that the adsorption percentage was increased



**Figure 1.** Effect of pH on the percent adsorption of Lead ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm, adsorbent dose 0.2 g at room temperature with contact time 2 hours).

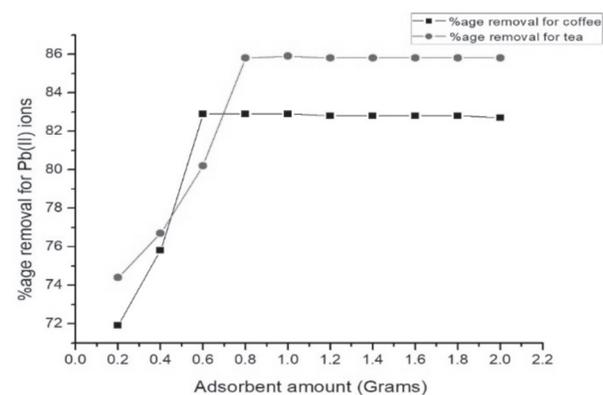


**Figure 2.** Effect of pH on the percent adsorption of Cadmium ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm, adsorbent dose 0.2 g at room temperature with contact time 2 hours).

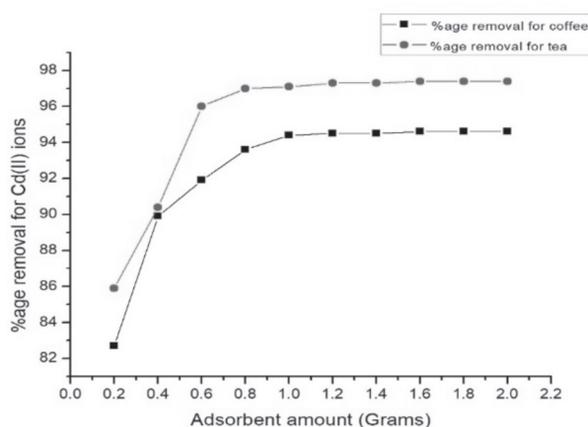
by increasing the pH and reached a maximum at pH 5 for lead ion removal and maximum at pH 6 for cadmium ions.

**Effect of adsorbent dose**

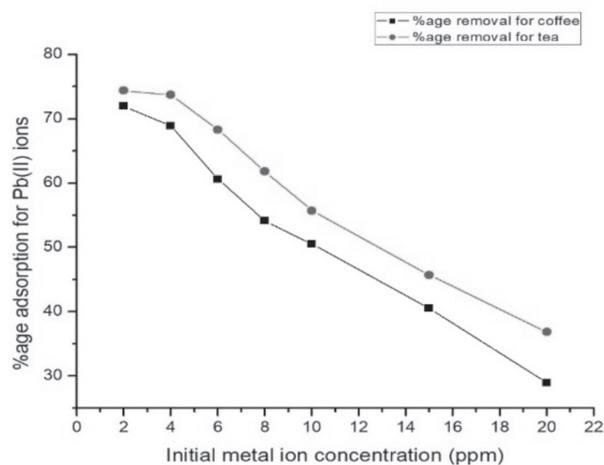
The effect of adsorbent dose on the percentage removal of Pb(II) and Cd(II) ions at room temperature (25 °C) with the initial Pb(II) and Cd(II) concentration fixed at 2 mg/L were investigated using different amount of adsorbents ranges from 0.2 to 2.0 grams at fixed pH 5 for both lead and cadmium ions with tea and coffee wastes respectively. Result is presented in Figure 3 and Figure 4, for lead and cadmium removal using tea and coffee wastes respectively. It is clear from the figure that the adsorption



**Figure 3.** Effect of adsorbent dose on the percent adsorption of Lead ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm having pH 5, 25 °C temperature and contact time 2 hours were investigated for tea and coffee wastes respectively).



**Figure 4.** Effect of adsorbent dose on the percent adsorption of Cadmium ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2ppm having pH 5, 25 °C temperature and contact time 2 hours were investigated for tea and coffee wastes respectively).

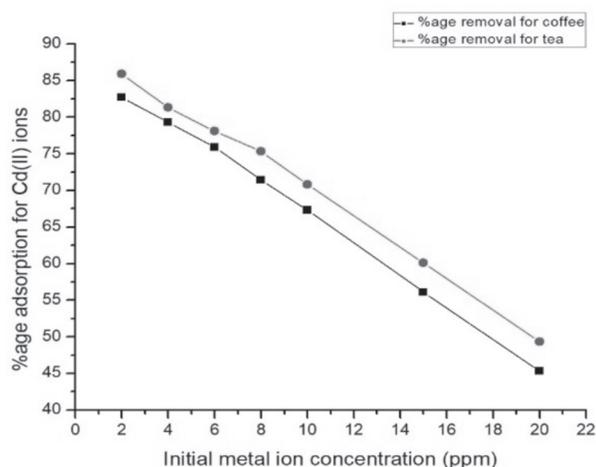


**Figure 5.** Effect of metal ion concentration on the percent adsorption of Lead ions using tea and coffee waste with fixed initial parameters (0.2 g adsorbent dose, solution pH was maintained at 5, 25 °C temperature and shaking time was 2 hours were investigated for tea and coffee wastes respectively).

percentage was increased by increasing the adsorbent dose and reached a maximum value after equilibrium is attained.

**Effect of metal ions concentration**

The effect of initial lead and cadmium ions concentration ranging from 2 to 20 ppm is presented in Figure 5 and 6. The results shows that the increase in



**Figure 6.** Effect of metal ion concentration on the percent adsorption of Cadmium ions using tea and coffee waste with fixed initial parameters (0.2 g adsorbent dose, solution pH was maintained at 5, 25°C temperature and shaking time was 2 hours were investigated for tea and coffee wastes respectively).

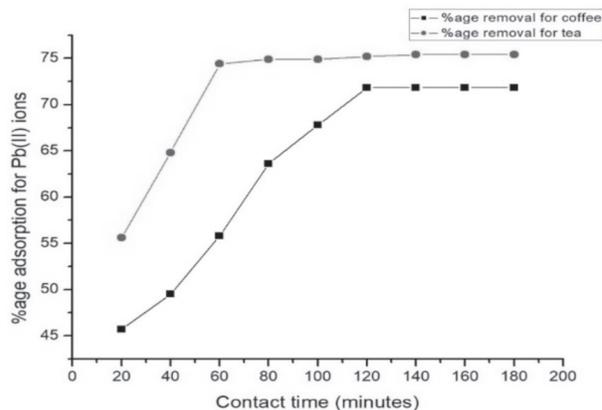
initial concentration of lead and cadmium ions decreased its percentages removal at fixed pH 5 with 2 hours contact time on adding 0.2 grams adsorbent dose at room temperature (initial conditions) were examined for both the tea and coffee wastes respectively.

#### Effect of contact time

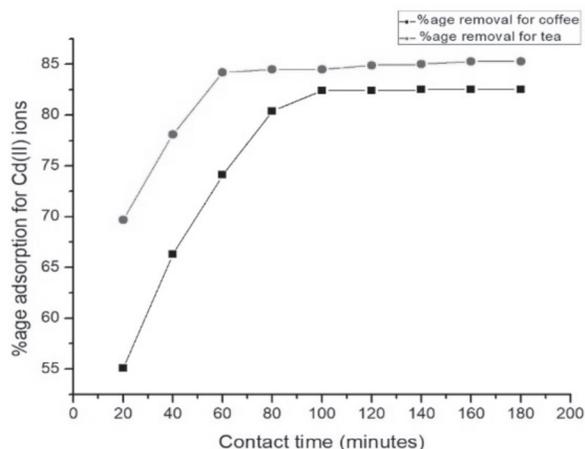
The removal of lead and cadmium ion increases with increasing contact time and attains equilibrium at about 60 minutes and 120 minutes for tea and coffee wastes respectively. The results for the effect of contact time from a range of 20 to 180 minutes on lead and cadmium removal using initial parameters that is 0.2 grams adsorbent dose at fixed pH 5 at room temperature are presented in Fig. 7 & 8. And Fig. 3.4.2. The plots represent the percentage removal of lead and cadmium ions versus the contact time for the 2 ppm initial metal concentration.

#### Effect of temperature

The removal of lead and cadmium ion was investigated at different temperature ranging from 25 °C to 65 °C with initial metal ion concentration 2 ppm having constant pH 5 and 0.2 grams adsorbent dose was added with shaking time of 2 hours at room temperature using tea and coffee wastes respectively. Results are shown in Figure 9 and Figure 10. Results shows that 25 °C is the optimum tempera-



**Figure 7.** Effect of contact time on the percent adsorption of Lead ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm having pH 5, 0.2 grams adsorbent dose and 25 °C temperature were investigated for tea and coffee wastes respectively).

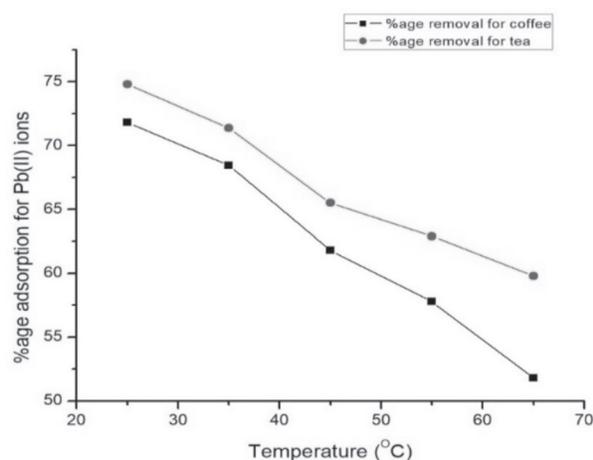


**Figure 8.** Effect of metal ion concentration on the percent adsorption Effect of contact time on the percent adsorption of Cadmium ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm having pH 5, 0.2 grams adsorbent dose and 25 °C temperature were investigated for tea and coffee wastes respectively).

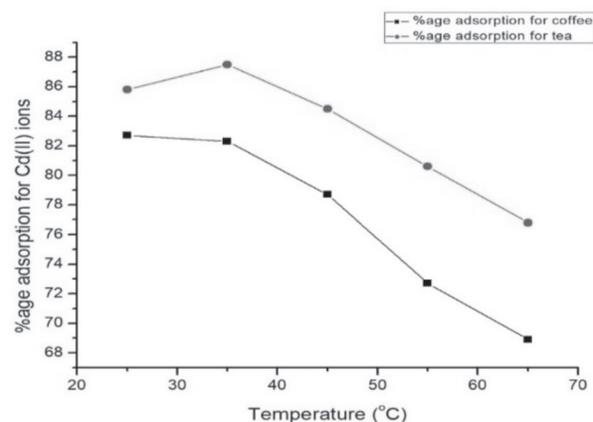
ture to get maximum percent adsorption for lead ion with both adsorbents and 35 °C is the optimum temperature for cadmium removal using tea wastes and at 25 °C maximum percent adsorption was achieved for cadmium removal using coffee waste.

#### FTIR spectra of tea and coffee waste

FTIR study disclosed the presence of functional groups like alcohol, carboxylic acid, amines, nitro,



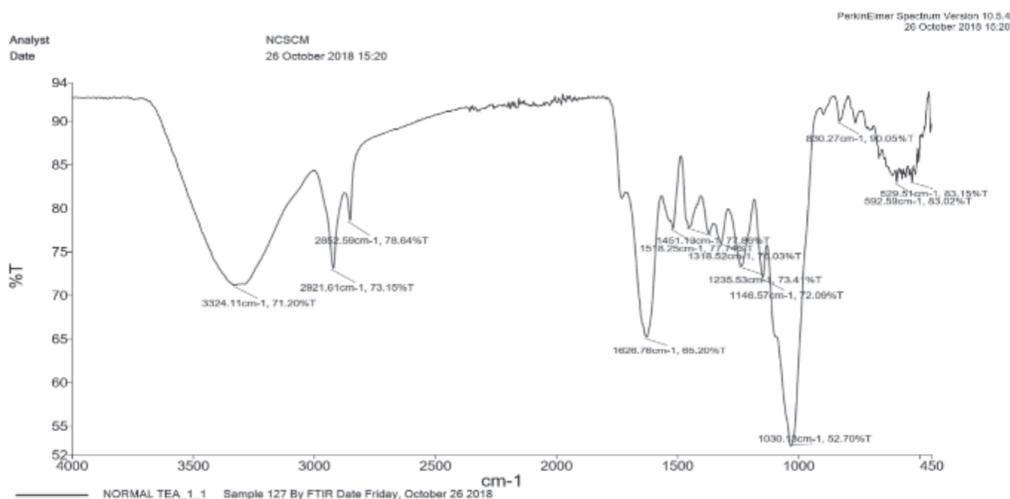
**Figure 9.** Effect of temperature on the percent adsorption of Lead ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm having pH 5, 0.2 grams adsorbent dose and shaking time was 2 hours were investigated for tea and



**Fig. 10.** Effect of temperature on the percent adsorption of cadmium ions using tea and coffee waste with fixed initial parameters (initial metal ions concentration 2 ppm having pH 5, 0.2 grams adsorbent dose and shaking time was 2 hours were investigated for tea and coffee waste respectively).

halo, sulphoxides and alkenes etc. in the adsorbents. The Strong vibration peaks in between 4000-3000  $\text{cm}^{-1}$  indicates the presence of OSH stretching and NH stretching of hydroxyl and amines functional groups. 3000-2500  $\text{cm}^{-1}$  frequency range indicates CH stretching of alkene, alkane, alkyne, thiol and aldehydes. Peaks at 2400 – 2000  $\text{cm}^{-1}$  indicating the presence of O=C=O stretching of carbon dioxide, N=C=O stretching of isocyanate, Nitrile stretching, alkyne stretching, azide stretching, ketene stretching, allene, isothiocyanate and ketenimine stretch-

ing. The vibration peaks at 2000-1650  $\text{cm}^{-1}$  indicating the presence of C=O groups that is aldehyde, acids, acid halides, ketones, lactone, lactum, esters, oximes, and amides (primary, secondary and tertiary amides). 1670-1600  $\text{cm}^{-1}$  frequency range indicates C=C stretching of alkene and N=H bending of amines. Peaks at 1600-1300  $\text{cm}^{-1}$  indicates the N-O stretching of nitro compound and C-H bending of alkane and aldehyde. 1400-1000  $\text{cm}^{-1}$  indicates the O-H bending of alcohol, phenol and carboxylic acid, S=O stretching of sulfate, sulfonyl chloride,



**Figure 11.** FTIR spectra of Raw Tea Waste

sulphonamide, sulfate acid, sulfone and Sulfoxide. 1000-650  $\text{cm}^{-1}$  range shows the C=C bending of monosubstituted, disubstituted and trisubstituted alkene and C-X stretching of halo compounds. 900-700  $\text{cm}^{-1}$  indicates the C-H bending of benzene.

In Figure 11 and 12, the intense and broad band of 3324 and 3332  $\text{cm}^{-1}$  for tea and coffee are indicating the presence of OH stretching of hydroxyl group (intermolecular hydrogen bonding). 2921.61  $\text{cm}^{-1}$  and 2923.78  $\text{cm}^{-1}$  frequency range for tea and coffee indicates the C-H stretching of alkane. 2852.59  $\text{cm}^{-1}$  and 2854.26  $\text{cm}^{-1}$  showing the C-H stretching of aldehydes groups for tea and coffee wastes respec-

tively. 1626.76 showing the C=C stretching of alkene for tea and 1743.12  $\text{cm}^{-1}$  showing the C=O stretching of ester and lactone for coffee. 1518.25  $\text{cm}^{-1}$  and 1646.07  $\text{cm}^{-1}$  showing the N=O stretching of the nitro compound and C=C stretching of alkene for tea and coffee respectively. 1451.13  $\text{cm}^{-1}$  and 1376.45  $\text{cm}^{-1}$  range of frequency of tea and coffee indicates the C-H bending of methylene group and OH bending of phenol group. Strong band of 1318.52  $\text{cm}^{-1}$  for tea is indicating the presence of S=C stretching of sulfone and 1242.10  $\text{cm}^{-1}$  showing the C-N stretching of amines. 1235.53  $\text{cm}^{-1}$  and 1149.07  $\text{cm}^{-1}$  showing the C-H stretching of amines for tea and C-O stretching

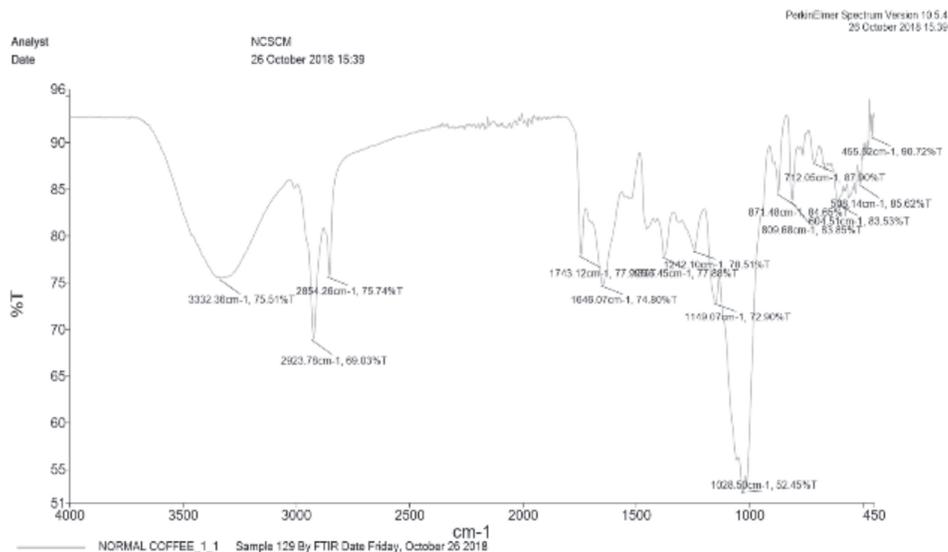


Figure 12. FTIR spectra of Raw Coffee Waste

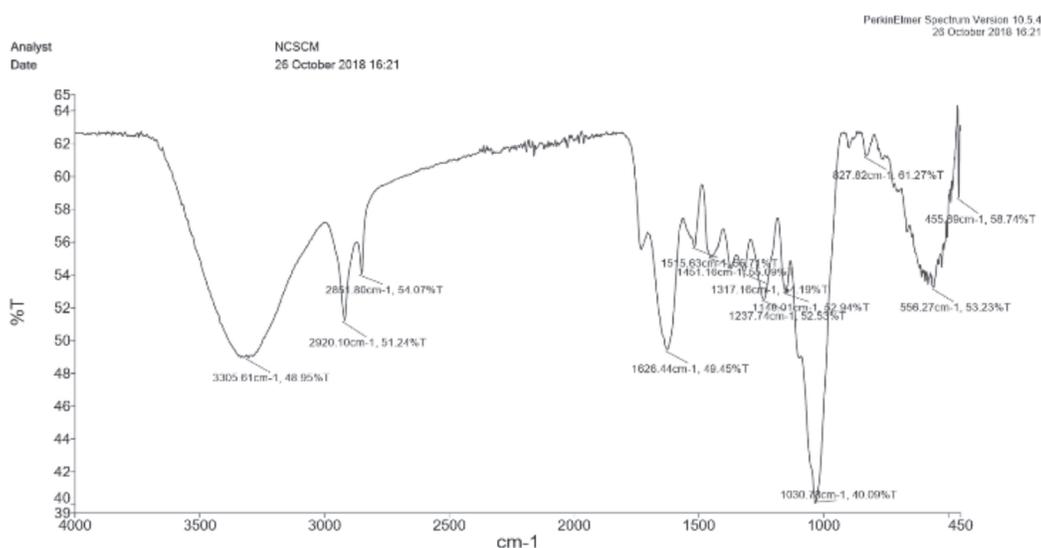


Figure 13. FTIR spectra of tea waste after Pb(II) metal ion adsorption

of aliphatic ether for coffee. S=O stretching frequency of sulfoxides is confirmed at  $1030\text{ cm}^{-1}$  and  $1028\text{ cm}^{-1}$  for both tea and coffee wastes.  $830\text{ cm}^{-1}$  indicates the C-Cl stretching of halo compounds for tea. The frequency range that is  $871\text{ cm}^{-1}$  and  $809\text{ cm}^{-1}$  showing the C-H bending of 1,3-disubstituted and 1,4-disubstituted benzene derivatives for coffee.

## Discussion

Figure 13 and 14 are showing Fourier Transformed Infra-red result of tea and coffee wastes after metal

ions (Pb) adsorption and detected functional groups along with their comparison with functional groups on tea and coffee wastes before metal ions adsorption is expressed in Figure 11 and 12. Following functional groups have been detected on tea and coffee after Pb(II) metal ion adsorption. It has been cleared from the comparison in between raw tea and metal loaded tea that at wave number  $1743.01\text{ cm}^{-1}$  and  $1451.13\text{ cm}^{-1}$  peak appeared for carbonyl and amine functional group but was absent in raw tea waste. In raw tea O-H stretching of alcohol has been detected at wave no.  $3324.11\text{ cm}^{-1}$  but in metal

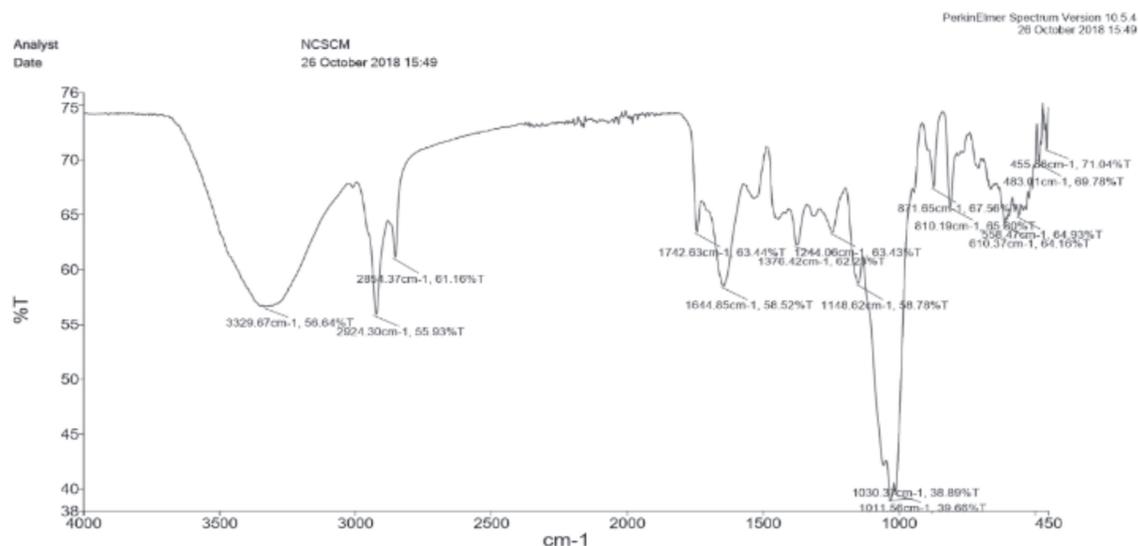


Figure 14. FTIR spectra of coffee waste after Pb(II) metal ion adsorption

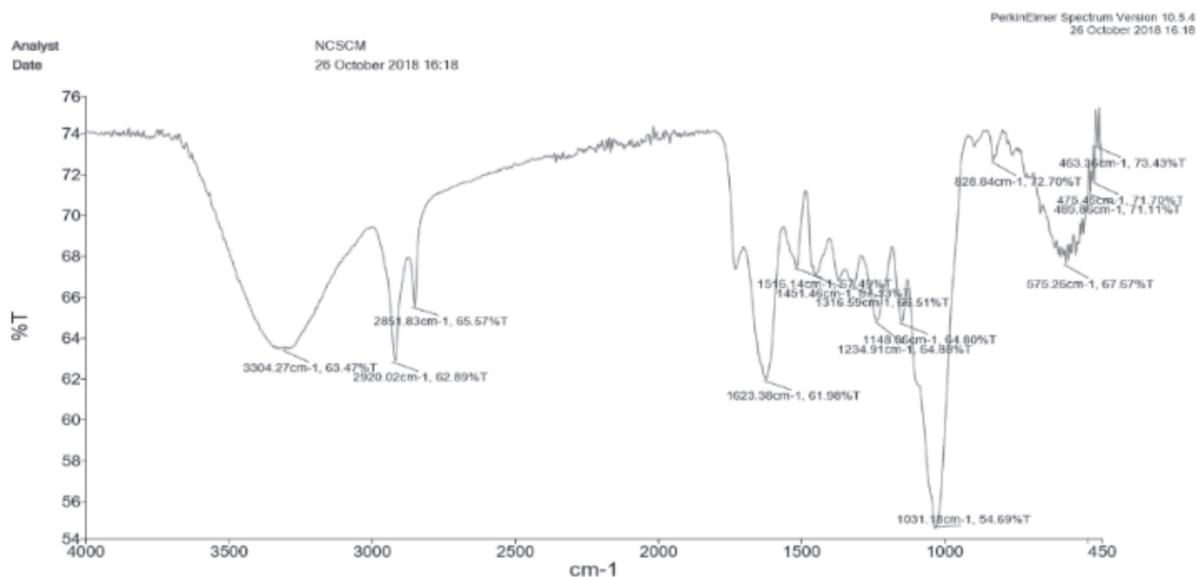


Figure 15. FTIR spectra of tea waste after Cd(II) metal ion adsorption

loaded tea, peak appeared at wave number  $3322.37\text{ cm}^{-1}$ . There is a remarkable shift in C-H stretching of alkane, C=C stretching of alkene, N-O stretching of nitro group, O-H bending of phenol, C-N stretching of amine, S=O stretching of Sulfoxide and C=C bending of alkene. It has been cleared from comparison between raw tea and metal loaded tea that there was also a shift in C-X stretching of halo compounds. It has been cleared from comparison between raw coffee and Pb(II) metal loaded coffee that there is no remarkable shift in C=O stretching of aldehyde, O-H bending of phenol and C-H bending of alkane. In raw coffee O-H stretching of alcohol has been detected at wave no.  $3332.36\text{ cm}^{-1}$  but in metal loaded coffee, peak appeared at wave number  $3322.37\text{ cm}^{-1}$ . C=C stretching of alkene appeared at  $1646.07$  in raw coffee but after metal adsorption peaks have been detected at  $1645.81\text{ cm}^{-1}$ . C-N stretching of amine appeared at wave number  $1242.10\text{ cm}^{-1}$  in raw coffee but after metal, adsorption peak has been detected at  $1243.08\text{ cm}^{-1}$ . It was clear from Figure 12 and 14 that there was a shift in C-X stretching of halo compounds also. In raw coffee C-X stretching of halo, compounds have been detected at  $604.51\text{ cm}^{-1}$  and after loading metal peak appeared at wave number  $608.68\text{ cm}^{-1}$ . C=C bending of alkene appeared at  $712.05\text{ cm}^{-1}$  in raw coffee waste but was absent in the metal loaded coffee sample. There is a little shift in C=O stretching of aliphatic ether, C-H stretching of alkane, C-H bend-

ing of 1,2,4 trisubstituted benzene and 1,4 disubstituted benzene derivatives in the raw and metal loaded coffee sample.

Figure 15 and 16 are showing Fourier Transformed Infra-red result of tea and coffee wastes after metal ions (Cd) adsorption and detected functional groups along with their comparison with functional groups on tea and coffee wastes before metal ions adsorption is expressed in Figure 11 and 12. Following functional groups have been detected on tea and coffee after Cd(II) metal ion adsorption:

It has been cleared from the comparison in between raw tea and metal loaded tea that there is no remarkable shift in C-H bending of alkene, has been detected. In raw tea O-H stretching of alcohol have been detected at wave no.  $3324.11\text{ cm}^{-1}$  but in metal loaded tea, the peak appeared at wave number  $3304.27\text{ cm}^{-1}$ . C-N stretching of amines has appeared at  $1235.53\text{ cm}^{-1}$  in raw tea waste but in metal loaded tea, the peak appeared at wave number  $1234.91\text{ cm}^{-1}$ . C-H stretching of alkane has appeared at  $2921.61\text{ cm}^{-1}$  in raw tea waste but in metal loaded tea, the peak appeared at wave number  $2920.02\text{ cm}^{-1}$ . C=C stretching of alkene has been appeared at  $1626.76\text{ cm}^{-1}$  in raw tea waste but in metal loaded tea, the peak appeared at wave number  $1623.38\text{ cm}^{-1}$ . N=O stretching of Nitro compounds has appeared at  $1518.25\text{ cm}^{-1}$  in raw tea waste but in metal loaded tea, peak appeared at wave number  $1516.14\text{ cm}^{-1}$ . O-H bending of phenol has appeared at  $1318.52\text{ cm}^{-1}$  in

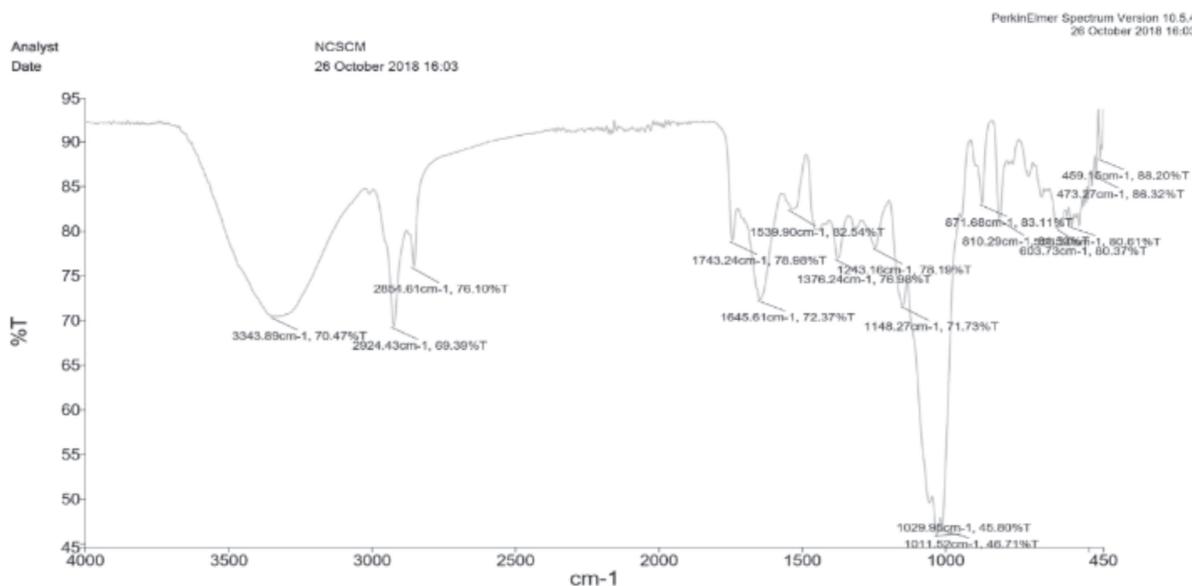


Figure 16. FTIR spectra of coffee waste after Cd(II) metal ion adsorption

raw tea waste but in metal loaded tea, the peak appeared at wave number  $1316.59\text{ cm}^{-1}$ . After comparing raw tea and metal loaded tea from Figure 11 and 15 it has been cleared that There was a shift in peaks of O-H stretching of tertiary alcohol, S=O stretching of sulphoxides and C=C bending of alkene. In raw tea C-Br stretching has been appeared at wave number  $592\text{ cm}^{-1}$  and after loading metal peak appeared at wave number  $575.26\text{ cm}^{-1}$ . It has been cleared from the comparison in between raw coffee and Cd(II) metal loaded coffee that there is no remarkable shift in C=O stretching of aldehyde, O-H bending of phenol and C-H bending of 1,2,4-trisubstituted benzene derivatives. In raw coffee O-H stretching of alcohol have been detected at wave no.  $3332.36\text{ cm}^{-1}$  but in metal loaded coffee, peak appeared at wave number  $3343.89\text{ cm}^{-1}$ . C=C stretching of alkene appeared at  $1646.07\text{ cm}^{-1}$  in raw coffee but after metal adsorption peak have been detected at  $1645.01\text{ cm}^{-1}$ . C-N stretching of amine appeared at wave number  $1242.10\text{ cm}^{-1}$  in raw coffee but after metal adsorption peak has been detected at  $1243.16\text{ cm}^{-1}$ . It was clear from Figure 12 and 16 that there was a shift in C-X stretching of halo compounds also. In raw coffee C-X stretching of halo compounds has been detected at  $604.51\text{ cm}^{-1}$  and after loading metal peak appeared at wave number  $603.73\text{ cm}^{-1}$ . There was a shift in C-I stretching of halo compounds. C=C bending of alkene appeared at  $712.05\text{ cm}^{-1}$  in raw coffee waste but was absence in metal loaded coffee sample. There is a little shift in C=O stretching of aliphatic ether, C-H stretching of alkane and 1,4 diasubstituted benzene derivatives in raw and metal loaded coffee sample.

These results in shift in peaks shows the role of various functional groups in adsorption of Pb(II) and Cd(II) metal ions adsorption.

Adsorption of the lead and cadmium ions from aqueous solutions were possible using tea and coffee wastes as an adsorbents. It has been found from this study that tea waste have more removal efficiency compare to coffee wastes. It has been cleared from Figure 3 and 4 that increasing the adsorbent dose from 0.2 grams to 2.0 grams the percent adsorption also increases ranges from 74.4% to 85.8% (Pb(II) for tea), 71.98% to 82.79% (Pb(II) for coffee) and 85.9% to 97.4% (Cd(II) for tea), 82.7% to 94.6% (Cd(II) for coffee). It can be explained on the basis that for the constant metal ions concentration, as the amount of adsorbents increase, the number of active site also increases on the surface of adsorbent results

in good percent adsorption but after a certain dose saturation occurs and no further adsorption was reported for both lead and cadmium ions using tea and coffee wastes. 0.6 grams tea and 1.0 grams coffee was enough to get highest lead ion adsorption and 0.8 grams tea and 1.0 grams coffee was the maximum amount to get saturation for cadmium ions. pH of the solution in the adsorption process of heavy metal ions can affect both solution chemistry and availability of active sites on the adsorbent surface. As it is clear from Figure 1 and 2, adsorption capacity for lead and cadmium ions increased by increasing the pH and reached maximum at pH 5 using tea and coffee wastes respectively. As discussed in various literature that the effect of pH can alter the adsorption percent depending upon the nature of metal ion and the adsorbent. At lower pH that means at strong acidic conditions there will be electrostatic repulsion between  $\text{H}^+$  ion and positively charged metal ions on the surface of adsorbents resulting in low adsorption percent (Low *et al.*, 1993; Saeed *et al.*, 2002). At higher pH, negatively charged sites on the adsorbent surface increases and resulting in electrostatic attraction between metal ions and adsorbent surface and hence increasing percent adsorption (Chang, 1997). The present study shows that the optimum pH for adsorption was found to be in the range from 5 to 7 and 5 to 6 for lead and cadmium ions respectively, at which Pb(II) removal reaches 74.5% for tea waste and 71.9% for coffee waste and cadmium removal reaches 85.9% for tea and 82.6% for coffee wastes. At higher pH precipitation was observed for both lead and cadmium ions as their hydroxides are formed as reported by various studies (Okoye *et al.*, 2010; Enkh-Amgala *et al.*, 2017; Abdel-Ghani *et al.*, 2007; Zuorro and Lavecchia, 2010). Cay *et al.*, 2004, they found the optimum pH 5.5 for lead removal and after pH 8 the adsorption was due to precipitation. Amarasinghe and Williams in 2007, conducted an experiment to treat lead ion by tea wastes and the optimum pH found was 5. Imran *et al.*, 2019, have conducted an experiment in the pH range from 2-10 to treat lead ion (40mg/l) using 0.7 grams Moringa oleifera biomass/100ml. maximum adsorption was observed form 4 to 6 pH range. Ahmad *et al.*, 2017, have reported the cadmium adsorption compost derived from fruits and vegetables. Their study revealed that the maximum adsorption was examined at pH 6 and minimum have been reported at pH 4. Initial metal ions concentration also plays a significant role

in adsorption process. As shown in the Figure 5 and 6 it is cleared that as the metal ions concentration increases the removal percent decreases. The reason is that for the fixed adsorbent dose, limited active sites are available on surface of adsorbent thereby decrease in percentage adsorption corresponding to increase in concentration of ions (Chakrabarty *et al.*, 2017). Similar results have been reported by various research (Acharya *et al.*, 2009; Adhiambo *et al.*, 2015; Ahmad *et al.*, 2017; Ahmed and Mustafa, 2008; Ali *et al.*, 2016; Ab Aziz *et al.*, 2016). Contact time is also an important parameter that enhance the percent adsorption. It is clear from Figure 7 and 8. That the equilibrium was found to be nearly 60 min for both lead and cadmium removal on tea wastes and 120 minutes for lead, 100 minutes for cadmium, was sufficient to achieve equilibrium using coffee wastes. It is clear from the figure that the percentage adsorption of lead and cadmium ions was increased with the increase in contact time. This is mainly because of availability of large number of active sites on the adsorbent in the beginning. With the passage of time reduction in the active sites observed that results decrease in percent adsorption after the equilibrium time was achieved. The effect of contact time on lead removal from tomato waste and apple juice residue have been studied by Heraldry *et al.*, 2018. For the first 15 minutes, 94% Pb(II) removal was observed as more vacant sites were available or unoccupied for sorption. As time lapsed the surface sites became occupied and it became difficult to occupy the remaining free site due to repulsive interaction in between the molecules of solute on the adsorbent and bulk phases. Same results have been reported by various study (Imran, 2019; Mathivanan *et al.*, 2018; Acharya *et al.*, 2009; Souza *et al.*, 2017; Tavares *et al.*, 2017). Temperature can affect both the movement and solubility of metal ions. The experimental results are shown in Figures 9 and 10. Temperature effect was examined in the range of 25 to 65 °C for both lead and cadmium ions on tea and coffee wastes respectively. Results shows that for lead removal percent adsorption decrease with increasing temperature this is mainly because of the weakening of adsorption forces between lead and active sites of adsorbents. Maximum percent adsorption for lead ions was achieved at 25 °C with both adsorbents. But in case of cadmium the maximum percent removal was achieved at 35 °C using tea wastes and 25 °C using coffee wastes after this the percent adsorption starts decreasing. This is due

to the fast mobility of metal ions and also the change in the surface structure or swelling effect of the adsorbent in the starting on increasing temperature that enable the metal ion to get penetrate further into the absorbents results in increase in adsorption rate. These results indicate that the adsorption is an exothermic process. Similar results have been investigated by Saravanan *et al.*, 2017 in the temperature range from 30 to 60 °C for the removal of Cd(II), Cu(II) and Pb(II) ion using by different adsorbent Raw Caryotaurens seeds (RCUS), sulphuric acid treated activated biomass (SMCUS) and ultrasonic assisted activated biomass (UACUS).

## Conclusion

The efficiency of Tea and Coffee wastes have been investigated to treat lead and cadmium ions. Results shows that the optimum initial pH found to be 5 for both lead and cadmium removal. Temperature effect was examined from 25 to 65 °C that indicates the exothermic nature of adsorption. For the fixed amount of adsorbent the percent adsorption starts decreasing with increasing concentration of metal ions because of the limited number of active sites on adsorbents for the higher concentration of metal ions. But by increasing adsorbent dose, availability of active sites or surface area also increases results in good percent adsorption. This study provides a path to investigate the kinetics and isothermal process involved in adsorption of lead and cadmium ions. The data obtained from this study also helps us to find out the mechanism involved in adsorption of lead and cadmium ions.

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