IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 11, Issue 7 Ver. II (July. 2018), PP 40-46
www.iosrjournals.org

Preparation of Thermo-Modified Tea waste and Its Use to Study the Heavy Metal Adsorption from Waste Water

Akshay Sahu[1,] Dr. Jayati Chatterjee Mitra[2]
Department of Chemistry Dr. C.V. Raman University, Kargi road, Kota, Bilaspur(C.G.)
Corresponding Author: Akshay Sahu

Abstract: *Heavy metals in particular are a group of pollutants of major concern in the aquatic environment due to their toxicity. The need to find an inexpensive and effective method for heavy metals abatement from water becomes inevitable. Adsorption is very effectively used technique for this purpose but cost is an important parameter and the types of adsorbents conventionally used are expensive. This work aims to evaluate the adsorption of some heavy metals on waste tea leaves as a cheap purification method. In this experimental study, thermo modified prepared waste tea leaves are used as adsorbent for the removal of heavy metals from aqueous solutions. Adsorption experiments were carried out as batch studies at different contact time, pH, amount of adsorbent, initial metal concentration and temperature. The objective of this study is to use the tea waste as a low cost adsorbent for the removal of metal concentration in various waste waters of industry effluents etc. The effect of variation in different parameters was investigated. The adsorbent is very effective for lower concentration of metal solutions, and the absorbance increases with increase in adsorbent dose. As this adsorbent is cheap and easily available, it can be used in little excess amount to obtain higher percentage of metal removal. A comparative study of the removal efficiency for Pb, Ni, Cd has been done. The kinetic data obtained have been analyzed using pseudo-first-order and pseudo-second-order models. The best fitted kinetic model was found and the results suggest that tea wastes could be employed as a cheap material for the removal of these heavy metals from aqueous solutions.*

Keywords*: Heavy Metals****;*** *Adsorption; Thermo-modified; Tea-waste; Kinetics; Thermodyanmics*

Date of Submission: 09-07-2018 Date of acceptance: 23-07-2018

I. Introduction

Industrial waste constitutes the major source of various kinds of metal pollutants in natural water. This water pollution due to toxic heavy metals has been a major cause of concern for scientists. It is adversely affecting the health of the people and also damaging the environment. Metals can be distinguished from other toxic pollutants, since they are non biodegradable and can accumulate in the living tissues. The important toxic metals Cd, Ni, Pb etc. find their way to the water bodies through waste waters. The release of large quantities of these metals into the natural environment, for eg. irrigation using sewage water, results in environmental contamination, and the metals due to their non-biodegradability and persistence, can accumulate in the environment elements such as food chain and pose a danger threat to human health. Generally heavy metals are present in low concentrations in waste waters and are difficult to remove from water. Many physico-chemical methods have been proposed for their removal from industrial effluents. Commonly used methods for separation and removal of metals are extraction, precipitation, crystallization, ultrafiltration, carbon adsorption etc. But these conventional methods are neither much effective nor economical. Adsorption is an effective technique used in industry especially, in water and waste water treatment. Cost is an important factor for comparing the sorbent materials. The commercially used carbon adsorbents are expensive. Now-a-days various low cost adsorbents are investigated. The agricultural water products are much widely being studied for their adsorption efficiency. These products are readily available and low in cost also. In recent years tea waste is also gaining grounds as an efficient adsorbent for removal of metal ions from waste waters due to its potential to overcome these pollutants. Insoluble cell walls of tea leaves are largely made up of cellulose, lignin, tannins and structural proteins imparting it good potential as metal scavenger from solutions and waste waters since the above mentioned constituents contain the functional groups, mainly carboxylate, phenolic, hydroxyl and oxyl groups. Flavan-3-ols synthesised in tea leaves are the most important non-volatile constituent substrates of black tea. The flavan-3-ols provide characteristic taste and visual appeal to the liquor (Robertson,1992). Six major flavan-3-ols occur in tea; (+) -catechin (C), gallocatechin (GC), (-)-e picatechin (EC), (-)-epigallocatechin (EGC), (+)-gallocatechin(CG), (-)-epicatechin-3-gallate (ECg) and (-)-epigallocatechin-3-gallate (ECg). In black tea manufacture, the leaves are macerated to break down sub cellular compartments. This allows cytoplasmic polyphenol oxidase (PPO) to oxidise the flavan-3-ols in the Vacuoles. The main consequence of this enzymatic Oxidation process, formally known as the fermentation process, is the polymerisation of the flavan-3-flavan-3-ol monomers to form thearubigins (TRs) and theaflavins (TFs). It must be emphasised that this is not an anaerobic fermentation process and no alcohol is produced.

II. Materials & Methodology

2.1 Chemicals:

All chemicals used in present work were either of analytical reagent (AR) or laboratory reagent (LR) grade. $CuSO_4.5H_2O$ (99%), Cd $(NO_3)_2$ (99%), H_2SO_4 (98% w/w, 36N), HCl (98% w/w, 36N) supplied by S.D.Fine-chem limited, Mumbai. Distilled water was used in all preparations. Copper sulphate ($CuSO_4$) and Cadmium nitrate Cd $(NO_3)_2$ and deionized water were used to prepare synthetic heavy metals containing wastewater.

2.2 Adsorbent used:

Tea waste collected from tea stalls and restaurants were washed and boiled with hot distilled water (85°C) up to color removal. After color removal it is dried in hot oven at 105°C for 12 hours. The dried material converted into powder form by mixer grinder and screened to size 120 μm with mesh size 40. Again this powder dried at 105°C for 6 hours and then stored in plastic bags at room temperature. Now it was ready to use as an adsorbent (Lopez *et al.* 2003).

2.3 Adsorbate:

CuSO4.5H2O, and Cd(NO3)2 were obtained in analytical grade (Merck Co.) and used without further purification. Synthetic 1000 ppm stock solution prepared for each metal. ***Copper solution:*** 3.927 g of CuSO4.5H2O was added in the 100mL of distilled water in 1000mL volumetric flask. It was dissolved by shaking and the volume was made up to the mark. Copper concentration of this solution was 1000 mg/L.

Cadmium solution: 2.2.1 g of Cd(NO3)2 was added in 100 mL of distilled watwe in 1000 mL volumetric flask. It was dissolved by shaking and the volume was made up to the mark. Lead solution concentration of this solution was 1000 mL/L.

2.4 Glass wares and apparatus used:

All glass wares (Conical flasks, Pipette, Measuring cylinders, Beakers, Petri plates and Test tubes etc.) used are of Borosil/Rankem. A known weight of tea waste adsorbent (e.g. 0.5 g adsorbent) was equilibrated with 100 mL of the each heavy metals (namely Cu and Cd) solution of known concentration (10, 20, 50 and 100ppm) in 8 Stoppard borosil glass flask at a fixed temperature (30^0 C) in a orbital shaker for a known period (30-180 Min.) of time. After equilibration, collected sample (10mL) from each flask in time interval of 30, 60, 120 and 180 minutes, the suspension of the adsorbent was separated from solution by filtration using Whatman No. 1 filter paper.

The concentration of heavy metal ions remaining in solution was measured by uv visible spectrophotometer [(Single Beam) Systronics 118 & (Double Beam)Systronics 2205]. The effect of several parameters, such as pH, concentrations, contact time and adsorbent dose on the adsorption was studied. The pH of the adsorptive solutions was adjusted using sulfuric acid, sodium hydroxide and buffer solutions when required adsorption of metal ions on the walls of glass flasks determined by running the blank experiments was found negligible. The results of these studies were used to obtain the optimum conditions for maximum heavy metals removal from aqueous solution. The percent heavy metal removal was calculated using Eq.

Metal ion removal (%) = $[(Co–Ce)/Co]\times100$ ....…………………. (Eq1)

Where *C*o: initial metal ion concentration of test solution, mg/L Ce: final equilibrium concentration of test solution, mg/L (Babel and Kurniawan, 2003). The various instruments used during the study were pH-meter, UV-Vis Single & Double beam Spectrophotometer, Shaker, AAS, FTIR, SEM, Conductivity meter, Batch Apparatus etc. For the adsorption experiments so carried out, the thermo modified tea waste is used as adsorbent. As said earlier, the tea waste to be used is washed several times with hot distilled water. It is then dried in an oven at 105ºC and then ground and sieved on a screen with mesh size 40 and screened to 120μm . Individual solutions of Ni, Pb, Cd with 4 different concentrations were prepared (5, 10, 20, 30 mg/l) synthetically as mentioned above. The experiments were conducted to determine the efficiency of tea waste in adsorption of metals from their aqueous solutions. The effect of initial concentration of metals, the effect of adsorbent dose and the contact time were observed by conducting different sets of experiments. The experiments were performed in three parts. The same complete procedure was then done with Ni and also with Cd solutions. The percentage removal of these metals by adsorption on tea waste adsorbent was done for Ni and for Cd.

2.5 Characterization of Tea Leaves:

Moisture content was determined by an electronic moisture analyzer. FTIR spectra were acquired in the mid-IR region (4000–400 cm–1) using a spectrometer equipped with a Platinum sampling module.

III. Result and Discussion

The adsorbent prepared from tea waste is efficient and it is proposed that it can be conveniently employed as a low cost alternant. The rate of adsorption depends on the adsorbent amount and the initial concentration of metal in solutions and also on time of contact. The reason for the increase in percentage removal of metals may be explained firstly by the smaller particle size of the adsorbent that give rise to larger surface area available for adsorption of heavy metals and secondly by the higher speed of rotation on shaker, which causes more contact of metal ions with the adsorption surface. So we would have better treatment by using excess amount of tea waste adsorbent or by reducing the particle size of adsorbent and also using higher rpm on shaker. As this adsorbent in cheap and easily available, therefore there is no problem in increasing its consumption for better results. It is also known that adsorption efficiency is dependent on the type of metal too. The duration of heating caused a further improvement in the adsorption capacity of Tea Leaves. However, a parallel reduction in the mass of the adsorbent was observed, the measured weight loss approaching 90% under the most severe treatment conditions (2 h at 400 °C). From these results, it can be concluded that heating Tea Leaves at 300 °C for 1 h could be a good compromise between the adsorbent loss and the enhancement of adsorption capacity.

IV. Conclusion

The results of this study show that the adsorption efficiency are found to be maximum for Pb and minimum for Cd. Analysis of the results of this study indicate that tea waste can be used in the treatment process of heavy metals like the many other low cost natural adsorbents. Though, the initial concentration of metals in waste water solution, greatly affect the efficiency of its removal. This can give very high efficiency by precise choosing of the adsorbent quantity. Tea waste is a low cost material and easily available. So it can be very conveniently used for treating the industrial waste water as an efficient adsorbent for the heavy metals. The results of this investigation also show that the thermo-modified waste Tea Leaves has excellent adsorption capacity for the removal of Heavy metals from aqueous solutions. Analysis shows that morphological feature of Tea Leaves change after modification. The adsorption isotherm experiment was conducted at different temperatures (303, 313 and 323K), and it was found that the uptake of heavy metals decreased with increasing temperature and hence adsorption process is exothermic in nature.

References

[1]. Ajmal, M., A. Mohammad, R. Yousuf and A. Ahmad, 1998. Adsorption behaviour of cadmium, Zinc, Nickel and Lead from aqueous solution of mangifera India Seed Shell, India. J. Environ. Hlth, 40: 15-26.

[2]. Azadeh EP, Seyed FH, Ardovan Y (2015) Surfactant-Modified Wheat Straw: Preparation, Characterization and its Application for Methylene Blue Adsorption from Aqueous Solution. J Chem Eng Process Technol 6: 231. doi:10.4172/2157-7048.1000231

[3]. Al-Asheh, S. and Duvnjak, Z. 1997. Sorption of cadmium and other heavy metals by pine bark. *Adv. Environ. Res*. 1 : 194.

[4]. Amara singhe, B.M.W.P.K. and Williams, R.A. 2007. Tea waste as a low cost adsorbent for the removal of Cu and Pb from wastewater. *Chem. Eng. J.* 132 : 299-309.

[5]. Babel, S. and Kurniawan, T.A. 2003. Low-cost adsorbents for heavy metals uptake from contaminated water. *J. Hazard. Mater.* 97 : 219–243.

[6]. Banum, S.J. 1982. *Introduction to Organic and Biological Chemistry*, 3rd ed., Macmillan Publishing Co., New York, NY. pp. 541.

[7]. Barrell, D.C. 1975. *Atomic Spectrophotometer Analysis of Heavy Metals Pollutants in Water*. Ann Arbor Science Publishers Inc., Ann Arbor. Vol. 3 : 25.

[8]. Beliles, R.P. 1979. The lesser metals, In: F.W. Oehme (Ed.), *Toxicity of Heavy Metals in the Environment*, Part 2, Marcel Dekker, New York, pp. 383.

[9]. Boonamnuayvitaya, C. Chaiya, Tanthapanichakoon, W. and Jarudilokkul, S. 2004. Removal of heavymetals by adsorbent prepared frompyrolyzed coffee residues and clay. *Sep. Purif. Technol*. 35 : 11-22.

[10]. Cay, S., Uyanik, A. and Ozasik, A. 2004. Single and binary component adsorption on copper (II) and cadmium (II) from aqueous solution using tea industry waste. *Sep. Purif. Technol*. 38 : 273-280.

[11]. Cho, H., Oh D. and Kim K. 2005. A study on removal characteristics of heavy metals from aqueous solution by fly ash. *J. Hazard. Mater*. 127 : 187-195.

[12]. Corupcioglu, M.O. and Huang, C.P. 1987. The adsorption of heavy metals onto hydrous activated carbon. *J. Water Res*. 21 : 1031.

[13]. Gupta V.K. and Ali, I. 2000. Utilisation of bagasse fly ash (a sugar industry waste) for the removal of copper and zinc from wastewater. *Sep. Purif. Technol*. 18 : 131-140.

[14]. Jalali, R., Ghafourian, H., Asef, Y., Davarpanah, S.J., Sepehr, S. 2002. Removal and recovery of lead using nonliving biomass of marine algae. *J. Hazard. Mater*. 92: 253-262.

[15]. Kabata-Pendias, A. and Pendias, H. 1992. *Trace Metals in Soil and Plants*, CRC press, Boca Raton, FL, pp 75-86.

[16]. Kadirvelu, K. 1998. *Preparation and characterization of activated carbon, from coir pith and its application to metal bearing wastewater*, Ph.D. Thesis, Bharathiar University, Coimbatore, India.

Observation Table & Figures:

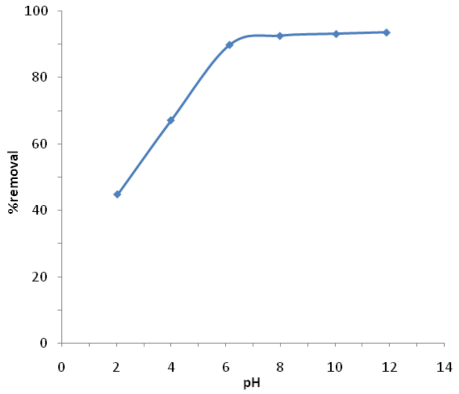

Fig: 1.1 Effect of pH on Adsorption with respect to Percentage Removal

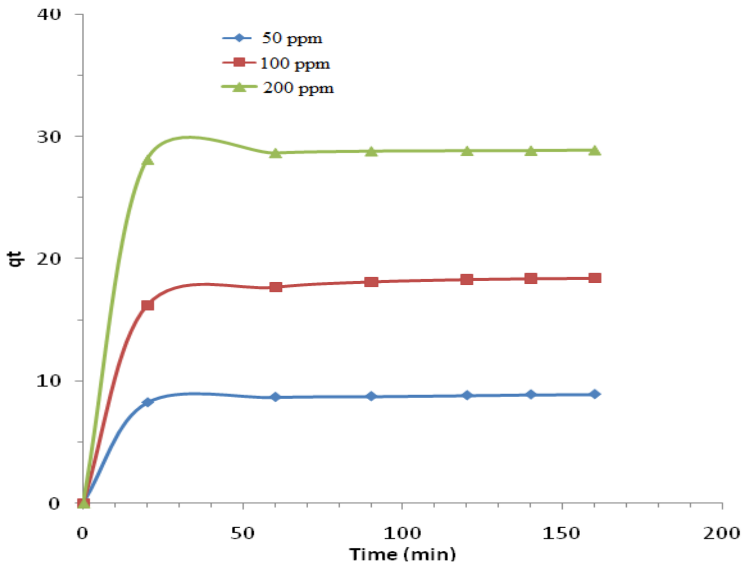

Fig:1.2 Effect of Contact Time on Adsorption

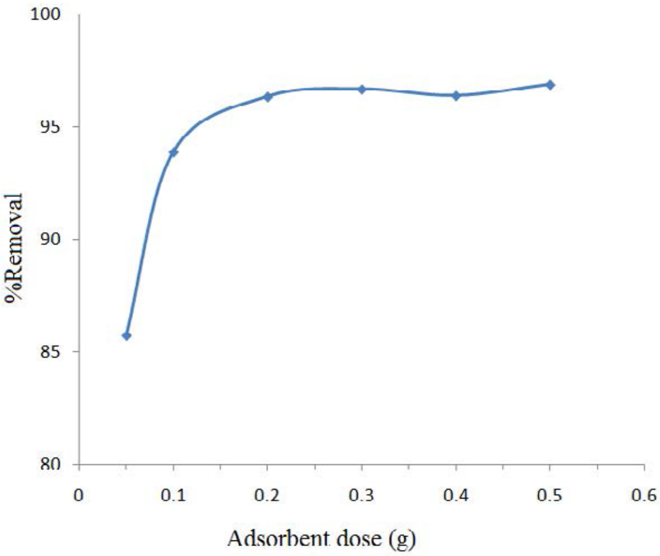

Fig:1.3 Effect of Adsorbent dose on adsorption wrt % Removal

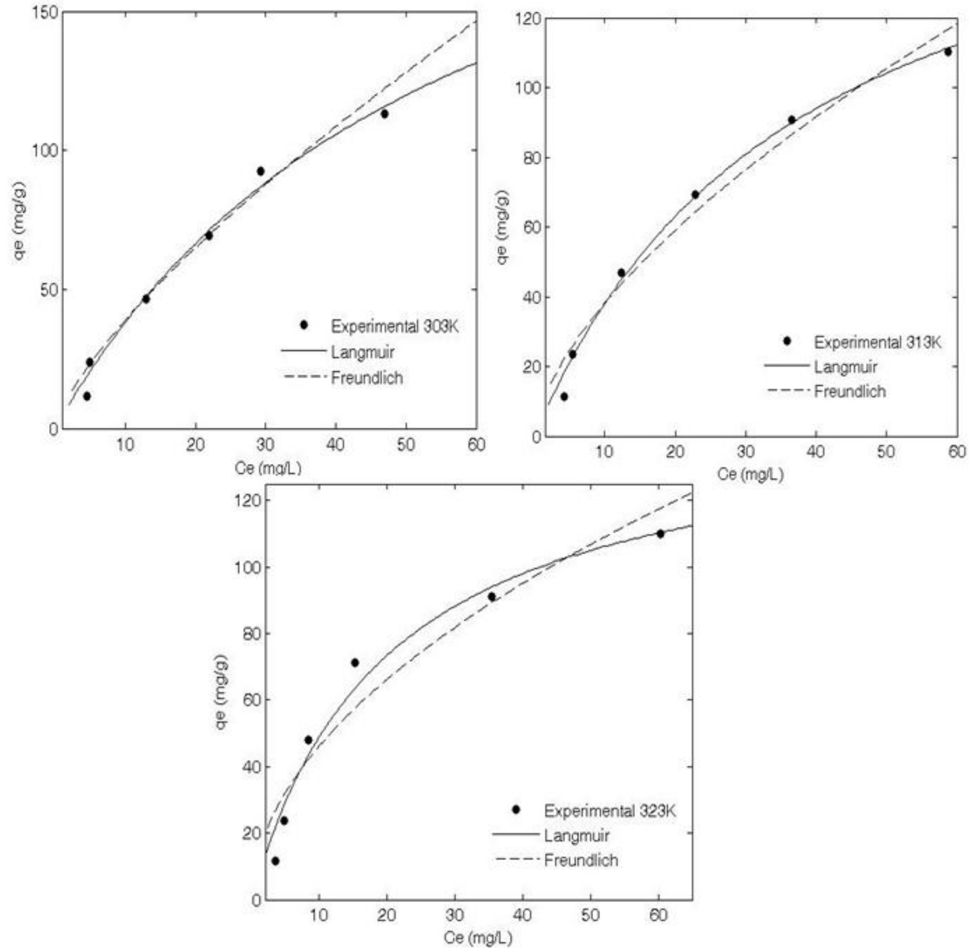

Fig. 1.4 Isotherm plots for Heavy metal adsorption on modified waste Tea Leaves at different Temperatures.

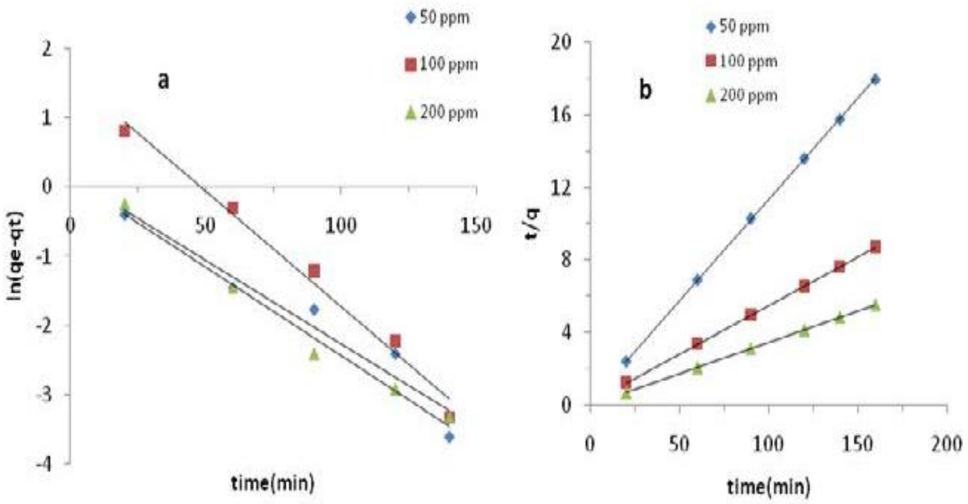

Fig. 1.5 Plot for Adsorption Kinetic models (Rate Equations)

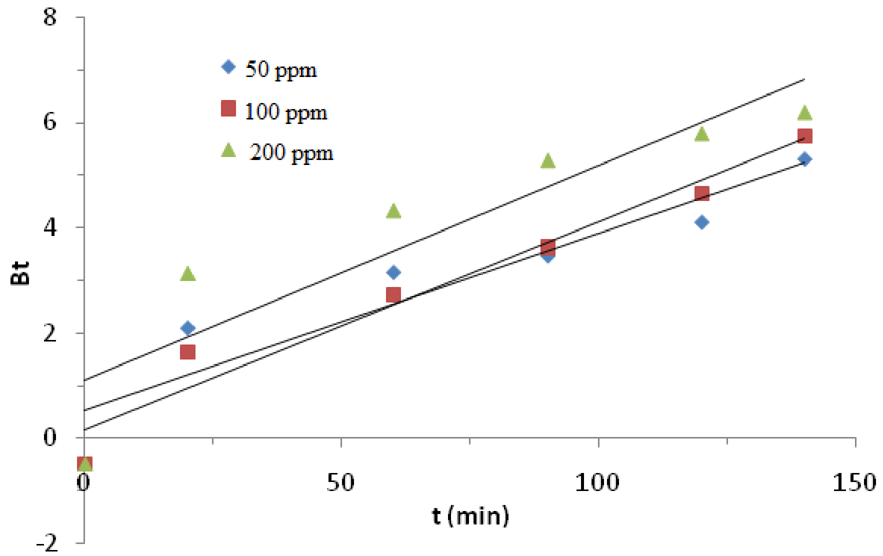

Fig. 1.6 Plot of Bt Vs Time for different initial Concentrations

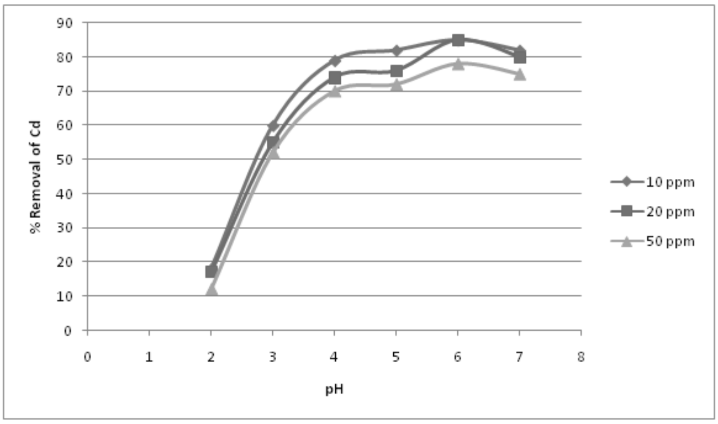

Fig. 1.7 Effect of pH on % removal of cadmium ion by tea waste adsorbent at adsorbent dose 0.5 g and contact time 120 min

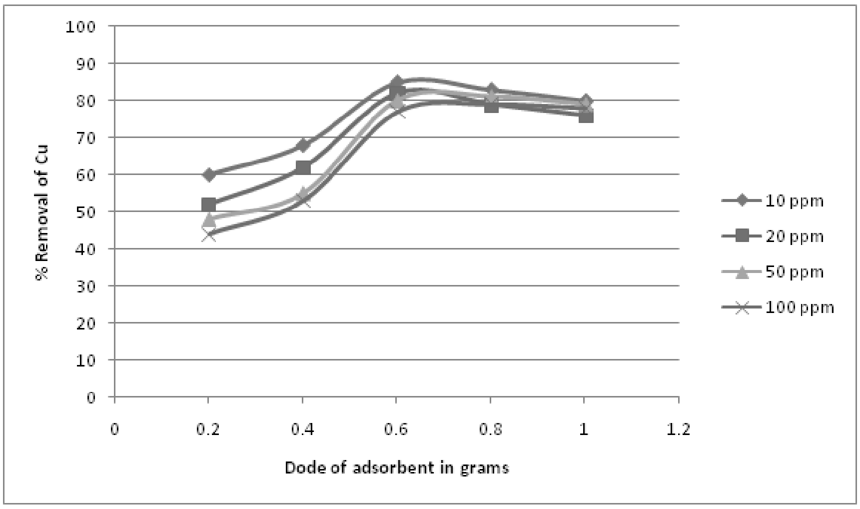

Fig. 1.8 Effect of adsorbent (amount) dose on % removal of copper by tea waste adsorbent at pH 5 and contact time 120 min

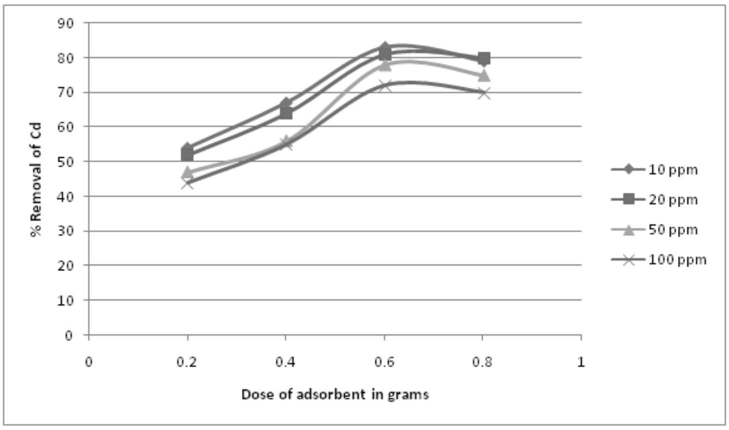

Fig. 1.9 Effect of concentration on % removal of metal ions by tea waste adsorbent at adsorbent dose 0.5 g pH 5 and contact time 120 min

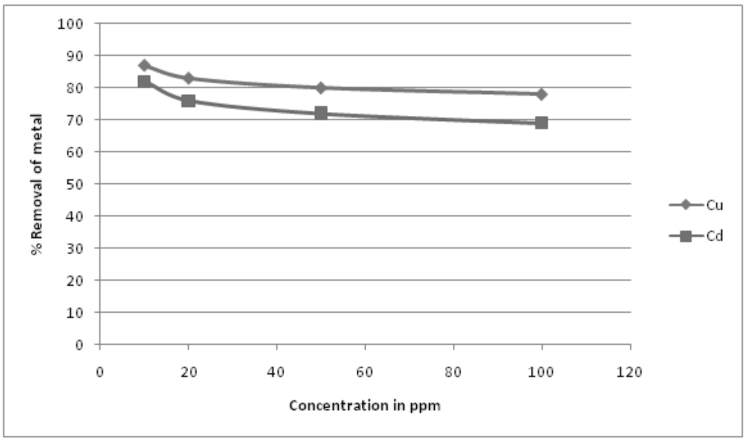

Fig. 1.10 Effect of adsorbent (amount) dose on % removal of cadmium by tea waste adsorbent at pH 5 and contact time 120 min

IOSR Journal of Applied Chemistry (IOSR-JAC) is UGC approved Journal with Sl. No. 4031, Journal no. 44190.

Akshay Sahu "Preparation of Thermo-Modified Tea waste and Its Use to Study the Heavy Metal Adsorption from Waste Water." IOSR Journal of Applied Chemistry (IOSR-JAC) 11.7 (2018): 40-46.