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A Review: Heavy Metal Removal from Waste Water using Tea and Coffee Waste

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Abstract: ***Every Creature on earth survives on water. Water forms the basis of life, hence its conservation is essential. The reuse of water by treating the waste water is an option for mitigating the water crisis. Treating waste water for removal heavy metals in particular is very necessary, as they cause adverse effects on health of humans, flora and fauna. The removal of heavy metals from waste water from commercial and industrial sectors using cost efficient adsorbing materials from wastes like tea and coffee waste are found to have best adsorbing capacities for removal of heavy metals. The study has found that Tea and coffee waste effectively adsorbs Pb, Cd, Zn, Ni, Cu, Fe and In. The maximum pH for removal of heavy metals was found to be ranging between 4.5 to 8. Out of the heavy metals mentioned the tea waste showed maximum removal of lead (Pb). Also Coffee waste showed highest removal of lead than other metals. The study states that the tea and coffee wastes are cost efficient waste materials along with high capacity for adsorption of heavy metals.***
Keywords: Tea waste, Coffee waste, adsorption, Waste water, Heavy metals.

I. INTRODUCTION

Our Earth is facing various Environmental problems like the air pollution, solid waste disposal problems, waste water discharge problems etc. Out of which waste water discharge problems in particular is slowly emerging as a major issue for cities, towns etc. Waste water dispensed out from domestic and industrial sectors contains chemicals, heavy metals, biological organisms etc. Hence a proper treatment and disposal of such type of water is required. Now days with advancement in technologies, some waste water treatment methods have developed and are in use to tackle the waste water problems. The waste water is being treated by removing the physical, chemical and biological elements from the water and making it possible to utilize again. The heavy metal removal is one of the parts of waste water treatment. Heavy metal removal by conventional methods like physic chemical method, chemical precipitation, Electro dialysis, ion exchange, membrane filtration, Electro chemical treatments, Biological Methods have high cost of operation and maintenance, so not found to be economical. Out of the waste water treatment techniques mentioned above, the adsorptions of heavy metals using various waste materials are found economical.

Image1: Tea Waste

Image2: Coffee Waste

Tea and coffee waste are generated more in our country as they are most likely consumed one. The tea and coffee waste is readily available at houses, hotels, restaurants and that to in each and every corner of our country. Hence waste material is easily achieved. Hence utilizing tea and coffee waste is studied for heavy metal removal from waste water.

Heavy Metal Hazards are threatening for human health. The toxic effects of heavy metals are made more serious because of their non-biodegradable nature which makes heavy metals pollution a serious environmental problem. (meenakshi nandal). The heavy

metals are do not dissolve, and other methods prove somewhat lacking in completely removal, hence adsorption is best method for removal. The effects of heavy metals could be seen in table below.

Effects of Heavy metal occurring on human health

Sr.No	Heavy Metals	Hazards	MCL (mg/l)
1	Arsenic	Skin Manifestations, Visceral cancer, vascular disease.	0.05
2	Cadmium	Kidney damage, renal disorder, human carcinogen	0.01
3	Chromium	Headache, diarrhoea, nausea, vomiting	0.05
4	Copper	Liver damage, Wilson disease, insomnia.	0.25
5	Nickel	Dermatitis, nausea, chronic asthma, coughing.	0.20
6	Zinc	Depression, lethargy, increased thirst	0.80
7	Lead	Damage the fetal brain, diseases of kidney, circulatory systems.	0.006
8	Mercury	Rheumatoid arthritis, kidney and circulatory system diseases.	0.00003
9	Iron	Anemia, heart disease, cancer, diabetes, choroiditis, retinitis.	0.3

Table 1: Heavy Metal effects on Human Health (*source: Internet*)

II. LITERATURE REVIEW

1) *Sumon Chakrabarty et.al. (2017)* studied that evacuation of iron (II) from watery arrangements was contemplated utilizing bounteously accessible tea leaves waste under different trial conditions. The expulsion of iron (II) ion on tea leaves waste was considered under different sorption parameters, for example, contact time, impact of pH and initial concentration of metal ions on the adsorption limit. The most extreme expulsion effectiveness of 81% was accomplished at pH 8.0 for Iron (II) at equilibrium conditions. Adsorption qualities showed by tea leaves waste were acceptable and the isotherms were in similarity with both Langmuir and Freundlich isotherms.
2) *Lovell Odili E. Agwaramgbo et.al. (2016)* carried out work stating that the industrial effluents are known to contain more than one heavy metal; thus, the paper presented here examines the effects of dose of adsorbent, metal type, and the presence of another metal on heavy metal removal by coffee waste. Results showed that (1) increasing the dose of coffee waste increases the removal of heavy metal from the samples. As the adsorbent dose increased from 1 g - 4 g, the percent metal removal increased from 73-92% for copper and 50-74% for zinc from single-metal solutions and from 26-78% for copper and 18-58% for zinc from binary-metal solutions (2) there is selectivity in favor of copper removal from the binary metal mixture by the coffee waste as shown above (3) ion type effect was observed in that more copper was adsorbed from both mono and binary metal samples (4) the presence of another metal as impurity increased metal adsorption hence, more adsorption occurred from binary metal solution than from the single metal solution.
3) *Mehrdad Cheraghi et.al. (2016)* has found that in batch tests, the effect of parameters like pH (1.0-8.0), initial metal concentration (100-800 mg L-1), contact time (15-120 min), adsorbent dose (1.0-5.0 g) and temperature (25-55 °C) on the adsorption process was studied. The results demonstrated that the maximum percentage of Cd(II) adsorption was found at pH 6.0 and the equilibrium was achieved after 60 min with 3.0 g tea wastes. The experimental isotherm data were analyzed, using the Langmuir and Freundlich models and it was found that the removal process followed the Langmuir isotherm. In addition, the adsorption kinetics followed the pseudo-second-order kinetic model. The maximum adsorption capacity calculated by Langmuir fitting was 71.4 mg g−1. The results suggest that tea wastes could be employed as an effective material for the removal of Cd(II) ions from aqueous solutions and the maximum adsorption capacity was found to be 71.4 mg g−1.
4) *Sadegh Ghasemi et.al. (2016)* revealed that the results, the maximum efficiency of cadmium adsorption was 99.50% obtained in pH of 5 and contact time of 90 minutes and 10 g/L of adsorbent. With the increase of initial concentration of cadmium, the amount of the adsorbed metal increased, but the removal percentage decreased. Data for this study indicated a good correspondence with both isotherms of Longmire and Freundlich. The analysis of kinetic indicated that cadmium adsorption was consistent with the second-degree kinetic adsorption model. According to the high efficiency of cadmium elimination by tea waste, this approach is applicable as an efficient and affordable trend to remove cadmium from aqueous solution without any chemical or physical pre treatment.
5) *Hanit Kumar Thapak et.al. (2015)* has explained that the influence of Tea Waste and sawdust quantity on adsorption capacity and efficiency adsorption processes. Activated carbon are used as a good adsorbent but its cost is very high so we used Tea

waste and sawdust as a low cost adsorbent. For better adsorption efficiency it was recommended to apply larger amounts of sawdust, if it is not cause problems with delaying of used adsorbents. Smaller amounts of adsorbent were better utilized in two or three stage adsorption processes. Tea Waste collected in tea stall and restaurants its Insoluble cell wall of tea leaves are made up of cellulose and hemicelluloses, lignin, condensed tannins and structural protein. The result shows maximum removal efficiency of copper ion by tea waste is higher than sawdust adsorbent. Thus experiment result showed that maximum removal of Cu2+ ion by tea waste and sawdust is 90% and 88%.

6) *Jurgita Seniunait et.al. (2014)* has discussed that analysis have performed by using different fractions (>200 >m and <200 >m particle size) of adsorbent in solutions with four (0.5, 1.0,1.5 and 3.0 mg/L) different concentrations of both metal. Studies showed that coffee grounds are great adsorbent for heavy metal removal from aqueous solutions. Using the >200 >m fraction of coffee grounds for copper removal the treatment efficiency is 85.9% when the metal concentration is 0.5 mg/L, while the lead is 87.2%. Increasing metal concentration in the solution of the adsorbent treatment efficiency decreases to 71.76% for Cu and 86.76 % for Pb. When the smaller fractions (>200 >m) are used in coffee grounds treatment efficiency increases by 6–1 1% for copper, and 8–9% for lead.
7) *Meenakshi Nandal et.al. (2014)* has stated that Heavy metals are major pollutants in marine, ground, industrial and even treated wastewaters. Mining activities, agricultural runoff, domestic and industrial effluents are mainly responsible for the increase of the metals released into the environment. Tea waste has been utilized in agricultural field to enhance the production under heavy metal stress. After water, tea is the most widely consumed beverage in the world With great production and consumption large quantities of tea wastes(From the Caff, Cafeteria, or tea –processing factory) are usually discarded into the environment without any treatment. The main objectives of the review is to determine the effectiveness and feasibility of some low cost agricultural waste material (Tea waste, coconut husk and coconut shell) in the process of heavy metals removal from waste water.
8) *Naima Azouaou et.al. (2014)* has described that Removal of lead by untreated coffee grounds was investigated in a packed bed up-flow column. The experiments were conducted to study the effect of important design parameter such as flow rate (5, 7 and 10 mL/min). Data confirmed that the breakthrough curves were dependent on flow rate. At a bed height of 7.5 cm and flow rate of 10 mL min−1, the metal-uptake capacity of coffee grounds for lead was found to be 78.95 mg g−1. The breakthrough time increased and the saturation time decreased with the increase of flow rate. The Adams–Bohart, Thomas and BDST models were applied to the adsorption under varying experimental conditions to predict the breakthrough curves and to evaluate the model parameters of the fixed-bed column that are useful for process design. The Adams–Bohart model was in good agreement with the experimental data. The untreated coffee grounds column study states the value of the excellent adsorption capacity for the removal of Pb (II) from aqueous solution.
9) *A.K. Dwivedi et.al. (2013)* has found that adsorption is one of the alternatives for such cases and is an effective purification and separation technique used in industry especially in water and wastewater treatments. Cost is an important parameter for comparing the adsorbent materials. Therefore, there is increasing research interest in using alternative low-cost adsorbents. The use of tea waste as the low-cost adsorbents was investigated as a replacement for current costly methods of removing heavy metal ions from aqueous solutions. The experiment results showed that maximum removal of copper and cadmium ion by tea waste is 89% and 87% respectively at optimum condition.
10) *Lokendra Singh Thakur et.al. (2013)* stated that adsorption is one of the alternatives for such cases and is an effective purification and separation technique used in industry especially in water and wastewater treatments. Cost is an important parameter for comparing the adsorbent materials. Therefore, there is increasing research interest in using alternative low-cost adsorbents. The use of tea waste as the low-cost adsorbents was investigated as a replacement for current costly methods of removing heavy metal ions from aqueous solutions. The experiment results showed that maximum removal of Nickel ion by tea waste is 94% and for Copper & Zinc ion are 89% & 90% respectively at optimum condition.
11) *Shraddha Rani Singh et.al. (2012)* has revealed that Adsorption in very effectively used technique for this purpose but cost is an important parameter and the types of adsorbents conventionally used are expensive. The aim of this study is to use the tea waste as a low cost adsorbent for the removal of metal concentration in industry effluents. The adsorbent is very effective for lower concentration of metal solutions, and the adsorbance increases with increase in adsorbent dose. Around 96% removal of lead, 78% removal of nickel and 63% removal of cadmium is obtained using 0.5 gm of adsorbent and the efficiency is increased to 100% for Pb, 87% for Ni and 83% for Cd, by using 1.5 gm of the adsorbent. As this adsorbent is cheap and easily available, it can be used in little excess amount to obtain higher percentage of metal removal.

12) *Bindra Shrestha et.al.(2012)* has discussed that The aminated tea leaves (ATL) was characterised by elemental and spectral analysis. The batch adsorption study was performed using ATL for the removal of Pb++ and Zn++ from their aqueous solution. Adsorption experiment was conducted as the function of solution pH, initial metal concentration and contact time. The maximum adsorption capacity of the adsorbent was found to be 120.8 mg/g for Pb++ and 79.76 mg/g for Zn++. These results indicated that the aminated tea leaves hold great potential to remove Pb++ and Zn++ from aqueous solution.
13) *Dr.Parag Dalal et.al. (2012) has found that* study removal of Nickel, Cadmium and Lead from industrial waste has been investigated by using tea-waste as an absorbent. This research is experimental type and the analyses are performed using different amount of absorbent in the solution with six different concentrations of each metal and its complex. Results indicate that the removal efficiency is maximum for Lead and is minimum for Cadmium. 905 of lead are removed by using 0.5g tea-waste and 100% by 1.5g tea-waste as sorbent for solutions having 5mL and 10mL concentration of lead. Whereas 1.5g tea waste can absorb 85% of 5mL nickel solution and 76% of 5mL cadmium solution.
14) *George Z. Kyzas (2012)* has revealed that The maximum adsorption capacity of the coffee residues can reach 70 mg/g for the removal of Cu(II) and 45 mg/g for Cr(VI). The kinetic data were fitted to pseudo-first, -second and -third order equations. The equilibrium was achieved in 120 min. Also, the effect of pH on adsorption and desorption was studied, as well as the influence of agitation rate. Ten cycles of adsorption-desorption were carried out revealing the strong reuse potential of these low-cost adsorbents; the latter was confirmed from a brief economic approach.
15) *B.M.W.P.K. Amarasinghe et.al. (2007)* has studied that Adsorption of copper and lead ions onto tea waste from aqueous solutions was studied to enable comparison with alternative commonly available absorbents. Batch experiments were conducted to determine the factors affecting adsorption and kinetics of the process. Fixed bed column experiments were performed to study practical applicability and breakthrough curves were obtained. Tea waste is capable of binding appreciable amounts of Pb and Cu from aqueous solutions. The adsorption capacity was highest at solution pH range 5–6. Pb showed higher affinity and adsorption rate compared to Cu under all the experimental conditions. Kinetic studies revealed that Pb and Cu uptake was fast with 90% or more of the adsorption occurring within first 15–20 min of contact time. The kinetic data fits to pseudo second order model with correlation coefficients greater than 0.999. Increase in the total adsorption capacity was observed when both Cu and Pb ions are present in the solution. Higher adsorption rate and the capacity were observed for smaller adsorbent particles. Tea waste is a better adsorbent compared to number of alternative low cost adsorbents reported in literature.
16) *H. Djati Utomo et.al. (2006)* has found that The adsorption of the heavy metal ions Cu2+, Zn2+, Cd2+ and Pb2+ from aqueous solution by used coffee grounds has been investigated as a potential low-cost treatment method for heavy metal-containing waste waters that is based on a readily available natural by-product. The results show that metal ion adsorption is efficient over a fairly wide pH range and adsorbed metals are reversibly leached from the exhausted coffee by dilute acid without significant loss of the adsorptive capacity for subsequent re-use.

III. SUMMARY OF LITERATURE

The Study performed from the above literature has found that the heavy metal removal from waste water by tea and coffee waste is effective. The heavy metals namely Pb, Cd, Zn, Ni, Cu, Fe and In are removed by tea and coffee waste. The tea and coffee waste when crushed to powdered form of less than 200μm is found to provide higher adsorption. The maximum pH suitable for removal of heavy metals from waste water is found to be between 4.5 to 8.The heavy metal removal capacity increases with increase in pH. Since at low ph the positive ions are more and repel the positive charged ions present in tea, coffee waste, but as ph falls towards neutral than adsorption increases. Iron (Fe) showed high ph of 8 for removal of iron from waste water. The literature has also found that percentage removal of metal ions decreases with increase in initial metal ion concentration. The Contact time of adsorbent was found to be suitable between 60 min to 120 min. The Increase in adsorbent amount or dose leads to increase in adsorption of heavy metals. The above literature also reveals that the results obtained states that equilibrium data fits with freundlich and Langmuir isotherms. The tea and coffee waste have affinity more for lead (Pb), followed by Ni, Zn, Cu, Cd, Cr and Fe. The adsorption of heavy metals decreases with increase in temperature, hence temperature parameter must be taken into account.

IV. CONCLUSION

The study from the literatures has found the conclusion that the Heavy metal removal increases with increasing the tea, coffee dosing and the contact time provided whereas the adsorption capacity decreases with increase in initial metal concentration and temperature. The particle size if less gives best results as surface area available is more. The study states that tea and coffee waste is a best material available for the purification of waste water consisting of heavy metals without any pretreatment but modifications

in the tea and coffee waste could be made so as to enhance the adsorbance capacity. Since it is readily available material also its use for waste water treatment stands good.

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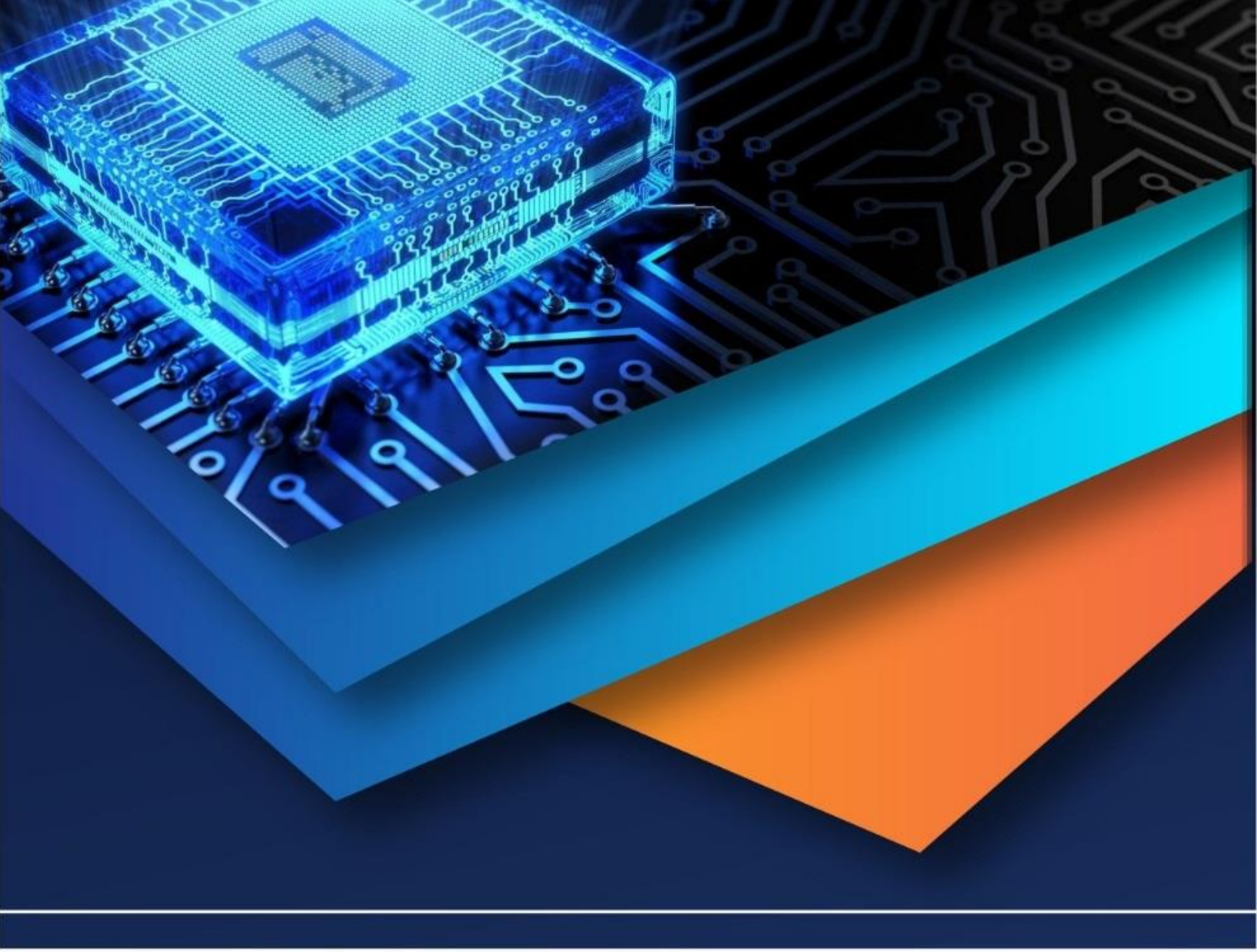

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