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Adsorption of Heavy Metals from Waste Waters on Tea Waste

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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 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 effect of variation in different parameters like initial concentration of metals in solution, adsorbent amount and contact time were investigated. 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. A comparative study for removal efficiency for Pb, Ni, Cd is also discussed. The adsorbent prepared from tea waste is efficient and it is proposed that it can be conveniently employed as a low cost alternative in the treatment of waste water for heavy metal removal.

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Strictly as per the compliance and regulations of:

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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 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 effect of variation in different parameters like initial concentration of metals in solution, adsorbent amount and contact time were investigated. 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. A comparative study for removal efficiency for Pb, Ni, Cd is also discussed. The adsorbent prepared from tea waste is efficient and it is proposed that it can be conveniently employed as a low cost alternative in the treatment of waste water for heavy metal removal.

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I. Introduction

Industrial waste constitutes the major source of various kinds of metal pollutants in natural water [1]. 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 [2]. 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 [3]. The release of large quantities of these metals into the natural environment, for eg. irrigation using sewage water, results in environmental contamination [4], and the metals due to their non-biodegradability and persistence, can accumulate in the environment elements such as food chain and pose a danger to human health [5] [6]. 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 [7]. Commonly used methods for separation and removal of metals are extraction, precipitation, crystallization, ultra-filtration, carbon adsorption etc. [8]. 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 [9]. Cost is an important factor for comparing the sorbent materials [10]. 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. Researchers have been done on many such materials like sugarcane, bagasse, straw, wool fiber, leaves, jute coir, rice husk, saw dust, cotton seed hulls etc. [11], [12]. Coal and straw are inexpensive but ineffective. Peat moss has been found effective in adsorbing heavy metals [13], coconut shell [14], saw dust [15], and crop milling waste [16], [17] also gave good results.

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. Very few investigations have used tea waste as an adsorbent for removing heavy metals [18]. Mahavi et al. used tea waste as an adsorbent for the removal of heavy metals from industrial waste. Malkoe and Nuhoglu investigated the removal of nickel from aqueous solutions using tea factory waste.

In this work, the efficiency of tea waste as an adsorbent has been determined in the process of removing heavy metals from aqueous solutions. The effect of various parameters such as initial concentration of metals in solution, adsorbent dose and the contact time has been studied.

II. Materilas and Methods

For the adsorption experiments carried out tea waste has been used as adsorbent. Tea waste used was washed several times with distilled water. It was

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then dried in an oven at 120°C and then ground and sieved on a screen with mesh size 40.Individual solutions of Ni, Pb, Cd with 4 different concentrations were prepared (5, 10, 20, 30 mg/l) synthetically. 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. Firstly 12 flasks were taken, each containing 0.5 gm adsorbent. 100 ml of solutions with known concentratios of lead were added (5, 10, 20, 30 mg/l) to four sets of three flasks each. Thereupon we had 3 similar concentrations for each experiment, for eg 3 flasks containing 5 mg/l, 3 containing 10 ml/l, 3 containing 20 ml/l and the remaining 3 having 30 mg/l lead.

All these flasks were located on a shaker with 150 rpm. Four flasks with different solution concentration were removed after 15 minutes. The contents were filtered through Whitman no. 40 filter paper to prevent the probable interference of turbidity. The lead concentration of the filtered solutions was then determined using atomic adsorption spectrophoto - meter. The same procedure was repeated after 30 min. and then after 1 hour from the starting. The readings for lead concentrations in terms of the percentage removal are reported.

These experiments were repeated for an initial adsorbent dose equal to 1gm and also for 1.5 g. The data for lead removal by adsorption are given in table 1.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 is reported in table 2 for Ni and in table 3 for Cd.

III. Results and Discussion

As the results of this study show, the adsorption efficiency is found to be maximum for Pb and minimum for Cd(evident from Table 1, 2 and 3).

Table 1: Percent removal of lead by adsorption

Adsorbent dose 0.5 gm				
Time (min)	Initial concentration of lead (mg/l)			
	5	10	20	30
15	51.3	42.5	40.7	35.6
30	86.2	83.2	78.4	72.3
60	96.2	90.5	85.1	83.2
Adsorbent dose 1 gm				
Time (min)	Initial concentration of lead (mg/l)			
	5	10	20	30
15	56.2	53.1	51.1	49.1
30	90.7	88.8	85.3	75.2
60	99.1	98.9	97.6	88.7
Adsorbent dose 1.5 gm				
Time (min)	Initial concentration of lead (mg/l)			
	5	10	20	30
15	60.5	52.2	49.1	45.3
30	93.8	90.3	89.2	79.1
60	100	100	99.4	97.6

Table 2 : Percent removal of Nickel by adsorption

Adsorbent dose 0.5 gm				
Time (min)	Initial concentration of Ni (mg/l)			
	5	10	20	30
15	43.8	40.2	37.4	30.5
30	61.3	58.5	50.5	48.3
60	78.2	71.5	68.1	59.2
Adsorbent mass 1 gm				
Time (min)	Initial concentration of Ni (mg/l)			
	5	10	20	30
15	49.8	46.3	40.1	33.7
30	68.5	61.4	55.2	50.8
60	89.6	80.3	75.1	71.2
Adsorbent dose 1.5 gm				
Time (min)	I Initial concentration of Ni (mg/l)			
	5	10	20	30
15	55.7	49.2	45.1	39.4
30	74.9	68.3	61.7	54.9
60	87.1	85.6	80.2	79.1

Table 3 : Percent removal of cadmium by adsorption

Adsorbent dose 0.5 gm				
Time (min)	Initial concentration of Cd (mg/l)			
	5	10	20	30
15	35.6	30.2	25.9	19.1
30	54.5	45.3	35.7	27.3
60	63.5	53.9	45.4	35.3
Adsorbent dose 1 gm				
Time (min)	Initial concentration of Cd (mg/l)			
	5	10	20	30
15	41.6	37.2	28.9	23.5
30	66.4	54.7	38.8	37.6
60	76.2	63.1	51.3	48.2
Adsorbent dose 1.5 gm				
Time (min)	Initial concentration of Cd (mg/l)			
	5	10	20	30
15	49.5	40.2	35.4	29.3
30	73.7	66.1	56.7	48.2
60	83.4	75.6	65.5	60.1

The rate of adsorption depends on the adsorbent amount and the initial concentration of metal in solutions and also on time of contact.

Tables 1-3 show the percent removal of metals. The data table of amount of metal adsorbed at various intervals of time, indicates that the removal of metal initially increases with time but the rate of adsorption decreases with time. It is evident from the data that the % removal of lead is 51.3 in first 15 minutes and reaches 96.2% in 60 minutes. The adsorption process was found to be very rapid initially and a very large fraction of total concentration of metal was removed in the first 30 minutes. The initial concentration of metal in solution affects greatly on the asorption rate. Though it was observed that the rate of adsorption of metals increased with an increase in initial concentration in the solution which shows the dependency upon the concentration of metal solution, but overall the percentage removal of metal decreases with the increase in metal concentration. For a particular experiment the rate of adsorption decreases with time. It gradually approaches a maximum adsorption; owing to continuous decrease in the concentration driving force and it also indicate that the adsorbent gradually becomes saturated. The adsorbent shows a great capacity for adsorption of metals for lower solution concentrations. The data also reveals the effect of various mass of adsorbent on the percentage removal of the metals. The tables also show a decreasing trend in metal concentration at a faster rate as the adsorbent mass is increased. Initially the rate of increase in the percentage metal removal has been found to be very fast but slowed down with the increase in the adsorbent dose.

This can be explained that at lower adsorbent mass, the metals are readily accessible and the removal of metals per unit mass of adsorbent is greater. The overall increase in adsorption by increasing the adsorbent amount seems to be an effect of increase in adsorption sites. Thereby it is possible to have increased adsorption by further reducing the particle size of the adsorbent. As we see 96.2% removal of Pb was possible from a 5 mg/l solution with 0.5 gm adsorbent but for 30 mg/l solution, 0.5 g adsorbent just gave 83.2% removal, but by increasing the amount of adsorbent to 1.5 gm it was possible to increase the efficiency of adsorption upto about 97.6% for the same 30 mg/l solution. Similar trends are observed for Ni and Cd. Larger surface area of adsorbent favours adsorption so the rise in adsorption with an increase in adsorbent dose is due to bigger driving force and larger surface area. Mahavi et al [18] used tea waste as an adsorbent for the removal of heavy metals (Cd, Pb, Ni) from industrial waste water. Their results showed 94-100% removal of lead, 86% removal for Ni and 77% for Cd, using tea waste as adsorbent and the present work in comparison gave better efficiency. The reason for this 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. By comparing the data in all three tables. It is also found that adsorption efficiency is dependent on the type of metal too. As we can note that the percent removal for Pb are maximum than for Ni and it has been noted the minimum for Cd.

For Pb, an initial concentration of 5 mg/l with 1.0 gm adsorbent shows a removal of 98.2%. For Ni in similar conditions it reaches upto just 87.3% and for Cd, it shows upto 73.2% removal in same time and similar conditions of initial concentration and amount of adsorbent.

IV. Conclusion

Analysis of the results of this study indicates 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

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