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Research Article

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Tea waste as a low cost adsorbent for the removal of COD from landfill leachate: Kinetic Study

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Abstract Leachate pollution is the result of biological, chemical and physical processes in landfills combined with waste composition and landfill water regime .A low cost adsorbent, tea waste was used for adsorption studies. The results showed that Maximum COD removal rates for 84% in coagulation for the alum pretreated leachate, the maximum COD removal is 87.5% using tea waste adsorbent with optimum dose of 1 g/L. Therefore combination of coagulation and absorbed is sufficient for treatment of this leachate such as tea waste adsorption should be applied.

Keywords Leachate, tea waste, adsorbent, treatment

Introduction

The generation of landfill leachate is an inevitable consequence of municipal solid waste landfilling. Landfill leachate is high strength waste water generated when waste moisture and rain water percolate through the landfill with the solid waste having a water content above the field capacity [1]. These characteristics vary depending on several factors such as waste composition, landfill age and climatic conditions. Furthermore, recent analytical advancements have led to the detection of a wide variety of organic micro-pollutants [2]. If not properly collected and treated, landfill leachate can contaminate surface water, ground water and soils. To prevent this, collection, treatment and safe disposal of leachate is mandatory [2, 3]. A combination of two physico-chemical treatments can give optimum results in removal of organic compounds leachate, as reflected by a significant decrease of the COD values after treatment [3]. Air stripping, adsorption, and membrane filtration are major physical leachate treatment methods [4, 5]; coagulation flocculation, chemical precipitation, and chemical and electrochemical oxidation methods are the common chemical methods used for the landfill leachate treatment [5, 6]. Adsorption is an affordable method that has been approved as a method for separating organic material from the water. Absorber plants have been taken more attention, due to availability and cheapness in recent years [7]. Waste biomass, industrial waste, and mineral waste have been investigated by many workers and biomass has shown better adsorption properties [8]. This research is aimed at harnessing the potentials in tea waste, which is usually discarded after usage in cafes and restaurants In Iran and many part of the world [3]. The aim of this study is investigate the Combination of Coagulation and absorbed Processes for Treatment of Landfill Leachate of Zahedan.

Materials and methods

The leachate samples collected from the landfill site in Zahedan city were analyzed. The leachate characteristics were as follows (Table 01):

Table 1: Zahedan landfill leachate characterization

pH	COD(mg/L)	BOD_5(mg/L)	EC(μs/cm)	NH_3-N(mg/L)	BOD_5/COD
7.23	1633	200	5.5	20	0.12

The optimum coagulant dose concentration and pH were determined by jar test. Then the tea waste was washed several times with distilled water to remove surface impurities and dried at 100 ^{0}C for 4 h, ground and sieved to produce desired particle size (200–250 mm). The material was stored in vacuum desiccators for further use. The Tea waste was added into 1000 ml Leachate Then identical mixtures were shaken on orbital shaker at 130 rpm for 60 min. The supernatant was filtered through Wattmann 40 filter paper before COD analysis [9]. The COD was determined by the dichromate method, colorimetric method at 600 nm with Hach spectrophotometer (HACH DR/5000)[10]. The removal efficiency and sorption capacity of the bentonite were determined by Eq. (1) and (2), respectively [11]:

$$Qe = \frac{(C_0 - C_e)V}{M} \quad (1)$$

$$RE = [\frac{(C_0 - C_t)}{C_0}] \times 100 \quad (2)$$

Where; R (%) and qe (mg/g) are the removal efficiency and adsorption capacity, respectively. Co (mg/L) is the initial COD concentration, Ce (mg/L) is COD concentration at the equilibrium, m (g) is the mass of the sorbent and V (L) is the volume of the leachate.

Results and Discuses

Coagulation was then performed using various coagulant dosages at the appropriate pH values**.** The data in Table 02show that the highest COD removal efficiencies of 84% were achieved at pH= 4, 3 g /L of alum. As a result, the COD concentration of the leachate was reduced from about 1633 mg/ L to 84 mg/ L in these conditions. This result is mainly due to the fact that the optimum coagulant dosage produced flocs having a good structure and consistency. But in doses lower than optimum, the produced flocs are small and influence the settling velocity of the sludge [3].

Table 2: Results of experiments with alum

Jar Test No	ALUM Dose (mg L^{-1})	pH	COD (mg L^{-1}) Raw sample	COD (mg L^{-1}) Effluent from pretreatment with alum	Removal of COD (%)
1	50	4	1633	725	55.6
2	150	4	1633	699	57.2
3	200	4	1633	361	77.9
4	300	4	1633	260	84

Effect of pH on adsorption

The solution pH is an important parameter in adsorption processes. Fig. 1 shows the effect of initial pH of solution on the adsorption of leachate by Tea waste. An investigation of the effect of pH on adsorption of the leachate was carried out at pH range of 2–12. Removal of COD in pH = 2 have been carried out by adsorption process using Tea waste increased removal rate in pH: 12 was related to pH_{zpc} and pK_a. The point of zero charge is the point where the charge on catalyst surface is zero [12].

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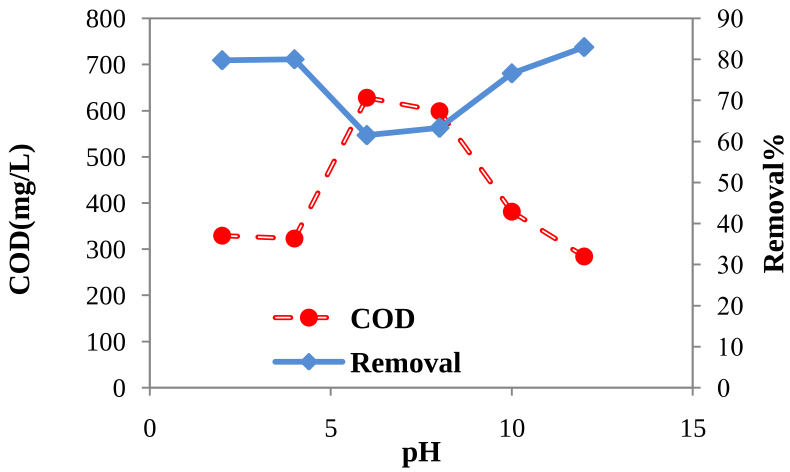

Figure 1: Effect of pH on COD removal efficiency

Effect of adsorbent dose

The effect of adsorbent dose on removal of leachate was studied by varying the dose of adsorbent from 1 to 20g/L. From fig 02, it is evident that adsorbent dose significantly influences the amount of adsorbed. The results showed tea waste that the removal efficiency decreased from 87% to 75.9%; in fact the level of deletion significantly depends on active places and by increasing the dosage of Nano particle to an appropriate level, the deletion efficiency will also be increased [13].

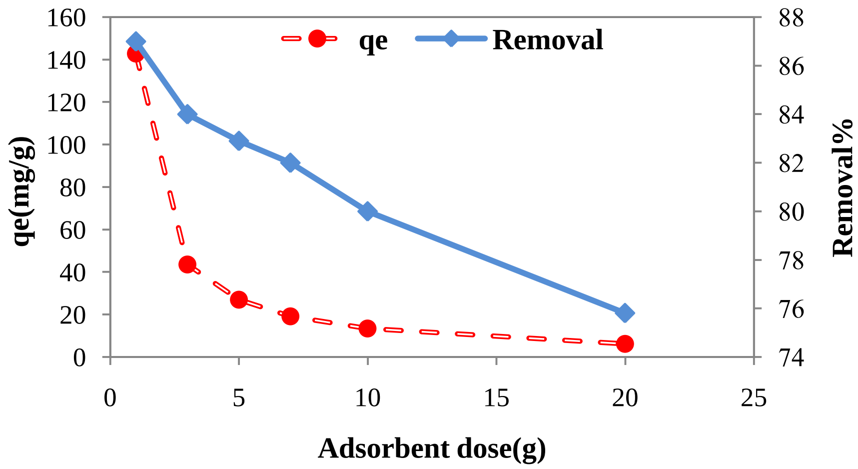

Figure 2: Effect of biomass dose on COD

Effect of contact time

The contact time between adsorbate and adsorbent is one of the most important design parameters that affect the performance of adsorption processes. Figure0 3 shows the effect of contact time on the adsorption capacity and percent removal efficiency of leachate onto the tea Waste adsorbent dosage. The uptake of leachate on adsorbent was rapidly in the first 60 min (%87.5) and then the adsorption rate decreased gradually from 60 to 180 min and finally reached equilibrium in about 90 min. The reason for increasing the deletion efficiency at the early hours is that by passing the time the made cavity and corrosion on tea waste level will be expanded and so increase the cross section of absorption and efficiency [3].

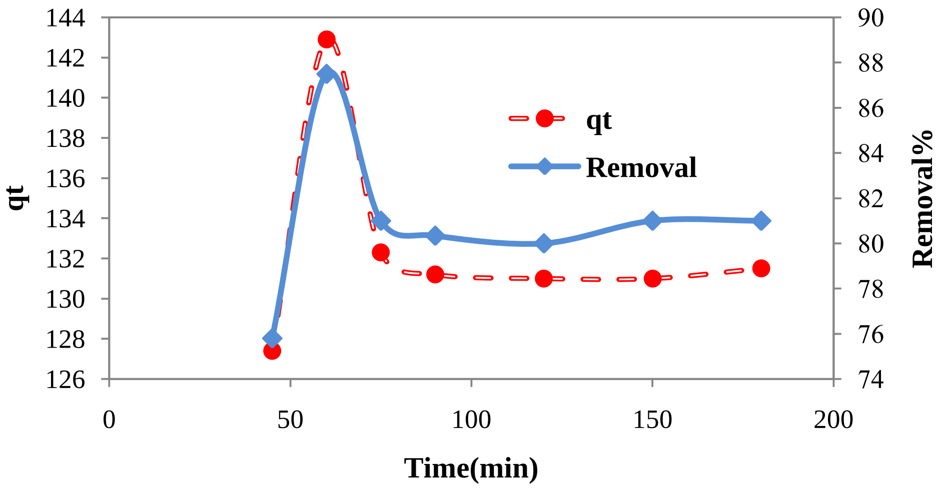

Figure 3: Effect Time on removal COD

Adsorption kinetic

The pseudo-first-order model

The synthetic of absorption depended on chemical and physical absorbent that was influenced on absorption mechanism. Linear equations relating to synthetics are showed as follow (pseudo second-order, pseudo First order and Elovich and Intraparticle diffusion model).

The pseudo-first-order rate equation is defined as Eq. 3 [14]:

$$\mathrm{Log}\,(q_e - q_t) = \log(q_e) - \frac{k_1}{2.303}t \qquad (3)$$

Where q_t and q_e are the amount adsorbed at time t and at equilibrium (mg/g) and k_1 is the pseudo first-order rate constant for the adsorption process (min^{-1}).

The pseudo second-order model

The pseudo second-order model can be represented in the following form equation 4 [14, 15]

$$\frac{t}{q_t} = \frac{1}{k_2 q^2} + \frac{t}{q_e} \qquad (4)$$

And Where K_2 the second -order rate constant (g $mg^{-1}min^{-1}$), q and qe are the amount of the adsorbed on the adsorbent (mg/g) at equilibrium and at time t.

The Intraparticle diffusion model

The Intraparticle diffusion model is given by the Matching equation: Eq 5[16]

$$q_t = K_{pi} t^{0.5} + c \qquad (5)$$

Where, c is constant and kid is the intraparticle diffusion rate constant (mg/g min1/2), q_t is the amount adsorbed (mg/g) at time t (min).

The Elovich

The Elovich model can be represented in the following form equation 6[17]

$$Qe = \frac{1}{\beta}\ln(\beta\alpha) + \frac{1}{\beta}lnt \qquad (6)$$

A plot of qe versus Lnt enables the determination of the constants α and β. The correlation coefficient (R^2> 0.998) in pseudo second- order model was better than other models. In this model, Pseudo First-order model, it agreed with Elovich model. As it is showed in Table 03, the correlation coefficient in pseudo second- order model for tea waste was high.

Table 3: The adsorption kinetic model constants for the Absorption Ciprofloxacin

Pseudo-first order			Pseudo-second order			Elovich			Intraparticle diffusion		
K_1	**qe**	**R^2**	**K_2**	**qe**	**R^2**	α	β	R^2	Kp	C	**R^2**
0.09	1132	0.897	0.007	131.6	0.998	6.9	0.93	0.785	1.51	149.2	**0.5425**

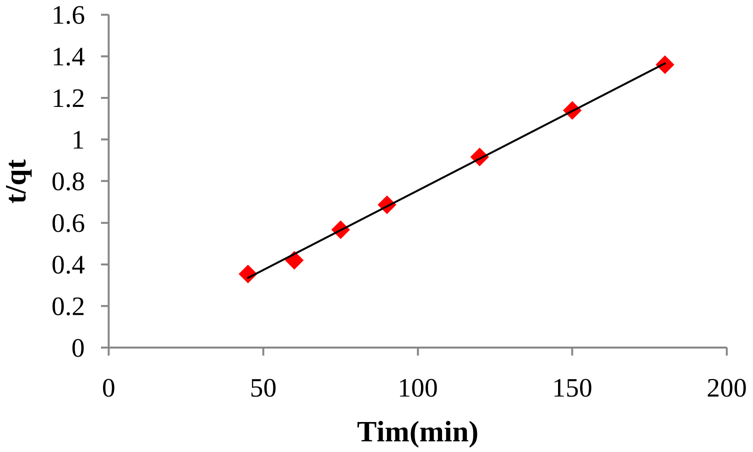

Figure 7: Kinetic isotherms pseudo-second-order

Conclusion

The experimental study shows that absorbed process can have high efficiency in treatment of the zahedan landfill leachate. The results of this study indicate that the Adsorbent process to Optimum conditions for the operation with pH=12, bentonite dose=0.1mg/l at time of 60 min can treatment a large impact on the concentration of leachate. Leachate requires efficient treatment techniques prior dispose to the natural environment. Selection of an appropriate efficient treatment technique depends on the quality and age of the landfill leachate.

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