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Micro-Peat as a Potential Low-Cost Adsorbent Material for COD and NH_3-N Removal

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Abstract. Micro-peat (M-P) was demonstrated in the present study as a potential low cost natural adsorbent for the removal of COD and ammoniacal nitrogen (NH_3-N) from landfill leachate. A series of batch experiments were carried out under fixed conditions and the influence of mixture ratio was investigated. The characteristics of leachate were then determined. Results indicated that leachate is non-biodegradable with high concentration of COD (2739.06 mg/L), NH_3-N (1765.34 mg/L) and BOD_5/COD ratio (0.09). The optimum ratio for activated carbon (AC) and M-P in the removal of COD and NH_3-N obtained were at 2.5:1.5 (87%) and 1.0:3.0 (65%) respectively. The low-cost natural adsorbent used in the present investigation is an attractive alternative to the conventional adsorbent (AC). Thus, M-P can be appropriated for use in leachate treatment that could be cost-effective due its local availability and adsorption property.

Introduction

Leachate is produced when water percolates through the waste in landfill that may contain large amounts of organic contaminants which can be measured as biochemical oxygen demand (BOD) and chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N), halogenated hydrocarbons, suspended solids, significant concentration of heavy metals and inorganic salts [1]. Due to its toxicity, landfill leachate can be a potential source of surface and ground water contamination, as it may percolate through soils and subsoil, causing pollution to receiving waters if not treated and safely disposed [2]. Organic contaminants in terms of COD and NH_3-N are two major problems in the landfill leachate. The excessive presence of ammonium in water streams and effluent causes eutrophication and decreases the dissolved oxygen required by aquatic organisms [3,4]. Moreover, almost of wastewater is tremendously polluted with several organics that may create hydrogen which contributes to greenhouse gases emissions [5,6].

Leachate must be treated properly and systematically before released into the environment. Leachate treatment is very complicated, high cost operation and generally requires multiple processes especially leachate containing high concentrations of contamination [7]. Young leachates are generated during early phase of landfill lifecycle are easily processed when compared to the stabilized leachate [8]. For young leachates were mainly containing high concentrations of biodegradable organic matters, and thus have a high BOD and COD ratio (BOD_5/COD > 0.5) [9], is suitable to be processed using biological treatment whereas unsuitable for the stabilized leachate, due to decrease of biodegradable matter (BOD_5/COD < 0.1) [10], increase of refractory components (e.g. humic and fulvic acids), and inhibitory compounds (e.g. ammonium) [11].

In recent years, the greater interest has been focused on physico-chemical treatment for treating wastewater and landfill leachate [10-12]. One of the effective ways to remove the contaminants from stabilized landfill leachate is adsorption by using AC or other adsorbents, such as zeolite, activated alumina, or low-cost adsorbents (e.g., micro-peat, limestone and rice husk ash). The advantages of adsorption method are the low energy and maintenance costs, simple design and the reliability [13]. Normally the conventional adsorbent using as the main medium for adsorption is usually AC is very expensive. ACs are highly effective adsorbents for removing organic pollutants in the aqueous or gaseous phase, thus widely applied in the purification of water and air [14].

A low-cost adsorbent generally can be defined as one which requires little processing and is abundant in nature [15,16]. The use of low-cost natural adsorbent such as micro-peat as a replaces conventional adsorbent consumptions for leachate treatment was the focus of this study. Micro-peat is relatively inexpensive material had been extensively used in the removal of organic contaminants. Various studies had indicated the capabilities of micro-peat as an adsorbent and filter material in leachate treatment processes [17,18]. Micro-peat is a highly organic substance derived primarily from plant materials and a representative material of soft soils [19]. It is formed when organic (usually plant) matter accumulates more quickly than it humidifies (decays). Other crops such as pineapples, corn, cassava is often typically growing in micro-peat [20]. Micro-peats are those soils that have an organic matter more than 65% or less than 35% of the mineral content and highly porous with a surface area of more than 200 m^2/g [21,22].

In this study, the potential of micro-peat as a low-cost natural and easily adsorbent to replace conventional adsorbent (AC) partially of removal efficiency for COD and NH_3-N which are among the significant contaminants present in the Simpang Renggam landfill site (SRLS) was investigated. The purpose of this study is to determine the optimum mixture ratio for the adsorption material above based on removal of COD and NH_3-N from landfill leachate. The results will be used as a basis for the partially replacement of an inexpensive and effective low-cost adsorbent for this type of landfill sites.

Materials and Methods

Adsorbents Preparation. Activated coconut shell carbon was purchased locally at about RM4500 per ton. Micro-peat was obtained from Kampung Parit Nipah, coordinate at 1°88' N / 103°20'E which is located about 10 kilometers from Universiti Tun Hussein Onn Malaysia (UTHM). The M-P was dried at a temperature of 105 ºC for 24 hours. Prior to the experiment, the composition of AC and M-P used in the experiment were determined by X-Ray Fluorescence spectrometry (XRF) (Model Bruker S4 Pioneer). The density of both AC and M-P were determined conventionally, i.e., weight/volume of media. Using ceramic ball mill, all media were ground to obtain particle size of less than 150 μm. The general properties of media were shown in Table 1.

Table 1. Composition of activated carbon (AC) and micro-peat (M-P) in percent.

Formula	C	CaO	SiO_2	Al_2O_3	MgO	K_2O	Fe_2O_3	TiO_2	SO_3	Na_2O	Others
AC	93	2.3	2.3	0.31	0.35	0.2	0.2	-	0.6	-	0.74
M-P	23.42	2.96	48.18	9.55	2.44	0.26	4.81	0.21	7.67	0.32	-

Adsorbate. The raw leachate used in this study was collected aseptically from Simpang Renggam landfill site in Kluang, Johor, Malaysia. The samples were collected in 30-L plastic containers, transported, and stored in the laboratory according with the Standard Methods for the preservation and storage of wastewater [23]. The characterization of the raw leachate was achieved before preservation and storage. All chemicals used were of analytical grade.

Optimum Ratio. The determinations of optimum ratio between AC and M-P adsorbent were determined based on the adsorption properties towards COD and NH_3-N, the major contaminants in leachate. Batch experiment study was performed in accordance to the procedure outline by [11,12] at pH7, 200 rpm, 120 minutes at room temperature to identify the adsorption properties that produce

the optimum ratio (i.e. the ratio that reveal in terms of achievable maximum removal of both contaminants). The percentage removal of COD and NH_3-N in the solution was evaluated by using Eq. (1) [2]

$$\text{Removal (\%)} = [(C_i - C_f) / C_i] \times 100 \quad (1)$$

where, C_i and C_f are the initial and final of COD and NH_3-N concentrations of leachate in mg/L, respectively.

Leachate Analysis. COD and NH_3-N was determined by reactor digestion closed reflux colorimetric method and Nesslerization method respectively [23].

Results and Discussion

Leachate Characterization. SRLS leachates have considerable amounts of COD (2739.06 mg/L), low amount of BOD_5 (258.06 mg/L), and a very low BOD_5/COD average ratio (0.09). Due to its low BOD_5/COD ratio and the high strength of NH_3-N (1765.34 mg/L), SRLS leachate can be classified as a stabilized leachate. The leachate is considered as a stable due to its pH (>7.5) and the BOD_5/COD ratio is very small (<0.1) [9]. Therefore, adsorption via AC or other adsorbents, becomes one of the appropriate options for stabilized leachate treatment. The characteristics of landfill leachate from the SRLS are illustrated in Table 2.

Table 2. Characteristics of landfill leachate sample from Simpang Renggam landfill site.

Parameter	Values			Std. Dev.
	Min.	Max.	Ave.	
pH	8.05	8.32	8.19	0.11
SS (mg/L)	143	213	177.22	22.63
NH_3-N (mg/L)	1555	2010	1765.34	190.54
COD (mg/L)	2440	2990	2739.06	225.68
BOD_5 at 20°C (mg/L)	156	379	258.06	76.43
BOD_5/COD	0.06	0.13	0.09	0.03
Fe (mg/L)	6.45	8.94	7.19	0.93
Color (mg.Pt-Co/L)	4061	4748	4548.72	263.38

Optimum Mix Ratio. See Figure 1 and Figure 2. The figures show the removal percentage of COD and NH_3-N respectively in the sample after mixing different ratio of M-P with activated carbon (AC) in 4.0 g at fixed conditions to obtain the optimum mix ratio. As can be seen, the optimum percentage for AC at 62.5% while M-P at 37.5%, where the removal percentage of COD declined after the percentage of AC increased. In other words, about 37.5% of AC could be replaced by M-P at maximum COD removal. The AC and M-P mixture attained the maximum removal rate, whereas the percentage of M-P increased to 75.0%; thus, only 25.0% of AC could be replaced by M-P for maximum NH_3-N removal. This is believed to occur due to considerably when the ratio achieves a significant substitution of the conventional adsorbent without detriment to contaminant removal. The results obtained agreed with previous work carried by [2,11].

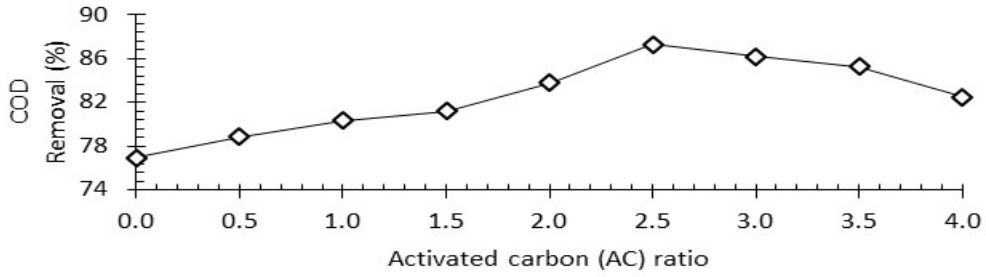

Figure 1. Mix ratio between AC and M-P in COD removal.

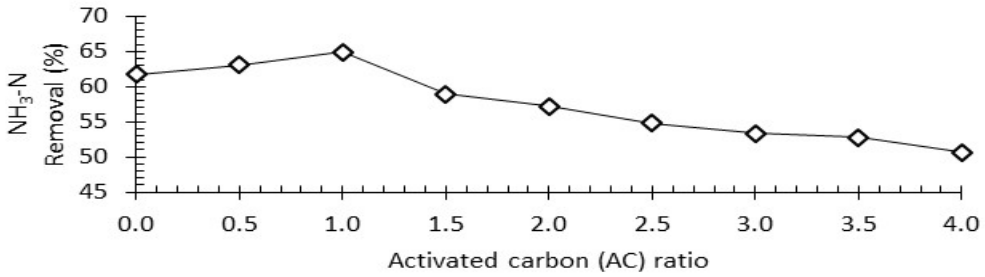

Figure 2. Mix ratio between AC and M-P in NH_3-N removal.

Conclusions

The use of commercially AC in this study could therefore partially substituted be in place of expensive adsorbent such as micro-peat due to its availability, removal efficiency and low-cost. The results obtained showed that combination of AC and M-P can be used for COD and NH_3-N removal from leachate. In respectively, the optimum COD removal percentage of 87% was obtained by AC:M-P (2.5:1.5), whereas NH_3-N removal percentage of 65% was obtained by AC:M-P (1.0:3.0). These results showed greater effectiveness for organic and inorganic matters from leachate at a considerably lower cost. This would be of benefit not only to the manufacturing industry in terms of minimizing cost of COD and NH_3-N treatment, but also to improve profit and furthermore to minimize the impact on the environment.

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