

# The Effectiveness of Peat-AC Composite Adsorbent in Removing Color and Fe from Landfill Leachate

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**Abstract:** Adsorption is a commonly used method for the removal of such various pollutants from aqueous solutions. Nowadays, due to cost-effectiveness, the adsorbent should be economical and cheaply available in abundance and it should require minimal for discharge into water bodies. This study was undertaken to investigate the efficiency of activated carbon (AC) to partially replace with peat as an inexpensive adsorbate composite medium for removing color and iron (Fe) from landfill leachate. The process of identifying the optimum composition of the composite adsorbent was carried out using batch technique. It shaken for 2 hours with 200 rpm at pH 7. The optimum ratio of peat and AC had been chosen as 2.0:2.0 for color while 2.5:1.5 for Fe. The value of the removal percentage for color and Fe were 74.4% and 79.6% in respectively. This indicates that peat can be used as a cost-effective medium to partially substitute of commercially AC in the composite for color and iron removal at a considerably lower cost.

**Keywords:** Peat, Activated carbon, Composite, Landfill leachate, Leachate treatment, Adsorption

## 1. Introduction

The contamination of organic and inorganic from leachate due to poor management of landfill site can lead untreated leachates to permeate ground water or mix with surface waters and contribute to the pollution of soil, ground water and surface water [1]. Leachate additionally may cause malodors and aerosols though these effects tend to be temporary and local. Usually, leachate may contain large amounts of organic contaminants, which can be measured as chemical oxygen demand (COD), biological oxygen demand (BOD), ammoniacal nitrogen, halogenated hydrocarbons suspended solid, significant concentration of heavy metals and inorganic salts [2].

The common pollutant in landfill leachate is color [3]. Generally, leachate produced by an old landfill with low biodegradability ( $BOD_5/COD < 0.1$ ) is classified as a stabilized leachate [4]. Stabilized leachate classically contains high levels of organic substances such as humic and fulvic compounds, which can be indicated by leachate color [5]. The presence of iron in excess may cause a severe color condition. When exposed to air, iron present in the water body become indissoluble and leave the water with brown-red color. The problem caused by iron are not only aesthetic problem, but also an indirect health concern, affect the ecosystem and economic

problem [6]. Hence, it is important to treat the contaminants as mentioned above from the landfill leachate.

Various technologies have been explored for the treatment of landfill leachate including biological treatment, chemical precipitation, coagulation, ammonia stripping, ion exchange, reverse osmosis and advanced oxidation process (AOP) as well as natural systems such as constructed wetlands and leachate recirculation have been developed in recent years [7, 8]. However, all these methods can extremely high operational cost and are unsuitable for small-scale industries or do not lead to a satisfactory result.

Among these technologies, one of the most popular treatment physico-chemical processes for stabilized leachate is via an adsorption. This process seems to be more user friendly and effective if combined with appropriate adsorbent and regeneration steps. Nowadays, there has been a tendency to use low-cost available materials for the removal of contaminants in landfill leachate from different kinds of wastewater and aqueous solutions for the past few decades. A wide variety of materials have been used as low-cost alternatives to activated carbon [9]. Most applications for these materials are focused toward landfill leachate. Therefore, the finding for a new environment-friendly technology that

needed to be developed to reduce pollutants in landfill leachate to acceptable levels at inexpensive costs.

Peat is a kind of low-cost available natural material and usually found in the river valleys and estuaries. Based on the global chart of total peat deposit around the world, Malaysia is the 9<sup>th</sup> country with the highest total area of peat soil. The total area of peat soil in Malaysia is about 2.6 million hectares (approximately 26000 km<sup>2</sup>), of which about 13% are in the peninsular Malaysia, over 80% in Sarawak and about 5% in Sabah [10]. Peats are those soils that have an organic content more than 75% and less than 25% of the mineral [11] and highly porous with a surface area of more than 200 m<sup>2</sup>/g [12]. The application of peat as a filter or natural sponge for cleaning up domestic wastewater and oily contaminated water has been studied for several years and the results suggest that peat is efficient in removing contaminants from aqueous [13].

Since peat is available in plenty, and it has the possibility to function as an adsorbent, the objective of this study was conducted to substitute of conventional adsorbent (AC) with peat in landfill leachate treatment to improve the adsorption properties and reducing treatment cost. Previous research has been stated that composite material has also been developed for many purposes, such as improving adsorptive properties or producing low-cost adsorbents [14]. The efficiency of using a mixture of AC and peat as an adsorbate composite medium in removing color and Fe was also investigated throughout this study. Thus, the results will be used as a basis for seeking an alternative media for this type of landfill sites.

## 2. Materials and Methods

### 2.1 Landfill Leachate Sampling

The leachate samples were collected from Simpang Renggam landfill site located in Johor, Malaysia [2]. The collection and preservation of samples were done in accordance with the Standard Methods for the Examination of Water and Wastewater [15]. All reagents used in this study were of analytical grade. Chemical analyses for leachate characterization were performed within 48 hours. The samples were tested for pH, Biochemical Oxygen Demand (BOD<sub>5</sub>), Chemical Oxygen Demand (COD), suspended solid (SS), ammoniacal nitrogen (NH<sub>3</sub>-N), color and iron. The characteristics of the leachate are listed in Table 1.

### 2.2 Preparation of Adsorbents

Unconventional low-cost natural adsorbent (peat) and commercially AC were purchased locally at RM4500/ton and collected at Kampung (Kg.) Parit Nipah, located about 10 kilometers from Universiti Tun Hussein Onn Malaysia (UTHM), respectively. The sampling and preparation was conducted according to the procedure outlined by [13,16]. Both peat and AC were pulverized and sieved to obtain particle size with a size of 75 to 150 μm (passed through sieve No. 100 and retained on sieve no. 200) using a ceramic ball mill.

### 2.3 Optimum Ratio

The optimum ratio between peat and AC in this study were determined based on previous researcher proposed for various amounts (by weight) [14]. The total weight of the media mixture used was 4.0 g for each conical flask. The media ratios between AC and peat used in the experiments were 0:4, 0.5:3.5, 1:3, 1.5:2.5, 2:2, 2.5:1.5, 3.0:1.0, 3.5:0.5 and 4:0. The batch equilibrium experiments were conducted by mixing a fixed amount of media (as mentioned above) with 100 mL of raw leachate sample in a 250 mL conical flask at pH7, agitation speed 200 rpm and 2 hours contact times. The optimum mixture ratios were determined which reveal in terms of achievable maximum removal of all parameters. Three replicates per sample were done and the average results were used. The percentage removal of all parameters in the solution was evaluated by using Eq. (1).

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

Where,

$C_i$  and  $C_f$  are the initial and the equilibrium of all parameters concentrations of leachate in mg/L, respectively.

### 2.4 Leachate Analysis

pH was measured by using Hach Sension 1 portable pH meter. Color measurement was reported as true color assayed at 455 nm using a HACH/DR6000 spectrophotometer and reported as platinum-cobalt (Pt-Co) method, the unit of color being produced by 1 mg platinum/L in the form of chloroplatinate ion. The samples were filtered using 0.45 μm filter paper before each measurement. While COD and BOD were measured in accordance with Method 5220D (closed reflux, colorimetric method) and the measurements of oxygen consumed in a 5-d test period, respectively. Total suspended solid was determined by gravimetric method of the residue dried to a constant weight at 103 to 105°C. Ammoniacal nitrogen (NH<sub>3</sub>-N) was determined by the Nessler method at 425 nm using a HACH/DR6000 spectrophotometer (Method No. 8038, Hach) and total iron was determined using the phenanthroline method. All methods were adapted from the Standard Methods for the Examination of Water and Wastewater [15]. All tests were conducted in triplicates to obtain consistent results at room temperature 25±2°C.

## 3. Results and Discussion

### 3.1 Leachate Characterization

Table 1 listed the value for physico-chemical parameters of landfill leachate obtained from Simpang Renggam Landfill site. Sample from the landfill is categorized as stabilized leachate since its BOD<sub>5</sub>/COD ratio is <0.1 and difficult to be further degraded biologically [4]. The value of color and total iron were higher than the allowed limit. Therefore, adsorption may work well for this type of leachate [7, 8].

The presence of high concentration of color in landfill leachate is due to the presence of high organic substances that associated with suspended solids [17]. Iron-base material waste, such as construction materials, paints, pigments, color compounds, polishing agents and electrical materials commonly constitute color [3]. Some of them may be accumulated in an adsorption process.

Table 1 Characteristics of raw leachate from Simpang Renggam Landfill Site

Parameter	Values			Std. Dev.	MEQA (1974)**
	Min.	Max.	Ave.*		
pH	8.05	8.32	8.19	0.11	6.0-9.0
SS (mg/L)	143	213	177.22	22.63	50
NH <sub>3</sub> -N (mg/L)	1555	2010	1765.34	190.54	5
COD (mg/L)	2440	2990	2739.06	225.68	400
BOD <sub>5</sub> (mg/L)	156	329	249.45	61.51	20
BOD <sub>5</sub> /COD	0.06	0.12	0.09	0.02	-
Fe (mg/L)	6.45	8.94	7.19	0.93	5.0
Color (Pt-Co)	4061	4748	4539.56	260.00	-

\* Average for the period between Mac 2014 and August 2014 (Weekly sample).

\*\* Malaysian Environmental Quality (Control of Pollution from Solid Waste Transfer Station Landfill) Regulation 2009, under the Laws of Malaysia Environmental Quality Act (MEQA) 1974

### 3.2 Optimum Composite Ratio

The results are shown in Figure 1 and 2. It can be seen that the removal efficiency of color and Fe appear to increase with increasing AC dose until it reached a maximum value at 74.4% and 79.6%, respectively and thereafter decreased for higher AC dose. This can be explained by the increase of available sorption sites may result in aggregation which can decrease the probability of molecules contacting all available adsorption sites [2]. The results obtained agreed with previous work carried out by [5, 14].

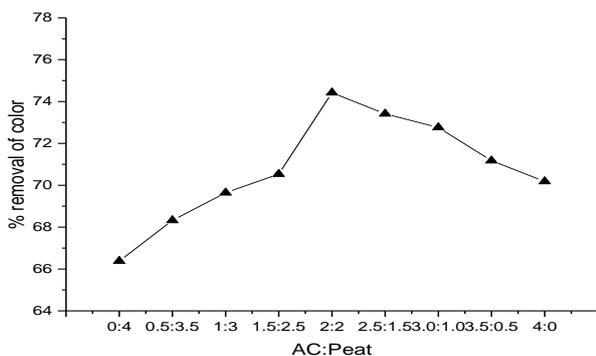


Fig. 1 The mixing ratio between AC and peat for color removal

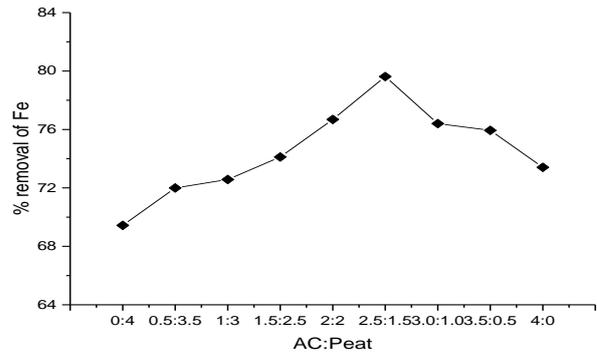


Fig. 2 The mixing ratio between AC and peat for Fe removal

### 4. Conclusions

This work was devoted to assess the capability of peat and AC as potential composite adsorbent for the removal of color and Fe from a stabilized landfill leachate. The highest removal efficiency were obtained with 74.4% for color at optimum ratio peat:AC (2:2) while 79.6% for Fe at optimum ratio peat:AC (2.5:1.5). It is believed that the research objective stated in the introduction has been met with the completion of this study.

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