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Optimization of Leachate Treatment with Granular Biomedia: Feldspar and Zeolite

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Abstract

Background/Objectives: Landfills generate leachate having an elevated concentration of contaminants and hazardous to health and the ecosystem. Feldspar and zeolite mixture was investigated for minimizing COD and ammonia from the leachate. **Methods/Statistical Analysis:** All adsorbent media were sieved to a particle size between 2.00 and 3.35 mm. The optimum shaking speed, mixing ratio, and pH were determined. Raw leachate Sample used in the study was collected from the influent of the detention pond at the SimpangRenggam Municipal landfill in Johor (Malaysia). **Findings:** Results of the leachate characteristics indicated a non-biodegradable leachate with a high concentration of COD (1763 mg/L), ammonia nitrogen (573 mg/L) and BOD5/COD ratio (0.09). The optimum condition for shaking speed was 150 rpm, the optimum mix ratio of zeolite and feldspar was 20:20, and the optimum pH was 6–6.5. **Applications/Improvements:** The mixed media produced encouraging results for leachate treatment. It will significantly be applicable in reducing zeolite usage conventionally and consequently decreasing the operational cost in leachate treatments.

Keywords: Ammonia, COD, Feldspar, Leachate, Optimization, Zeolite

1. Introduction

Sanitary landfills are engineered waste management processes in landfills that are built with layers of solid waste deposits and covered with soil or other types of covering materials[1]. Landfills constitute a problem in waste disposal because they produce leachate. Leachate is generated from the biochemical reaction that occurs within the waste deposit as it undergoes physical, biological, and chemical decomposition under aerobic and anaerobic conditions. It usually contains dissolved contaminants, volatile organic acids, toxic heavy elements, and high concentrations of organic matter, Chemical Oxygen Demand (COD), ammonia nitrogen, and biochemical oxygen demand (BOD)[2–6]. It contains high levels of dissolved contaminants and can directly enter an environment without prior treatment; consequently, it can contaminate soil and water bodies and therefore pose a critical threat to the environment and to public health eventually[7–10].

Almost all conventional leachate treatments involve high-technology processes. Such processes are considered to contribute to high initial and operational cost, generation of waste residue, and less adaptability to a wide variety of pollutants, among others[11,12]. Although much research has been conducted on adsorption via conventional media, such as zeolite, especially for the treatment of stabilized leachate, few studies have focused on the application of zeolite and feldspar mixture as substitute for conventional media in landfill leachate

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treatment. In the present study, granular mixed media are experimentally investigated to determine the optimum parameters for the minimization of COD and ammonia nitrogen from a stabilized leachate through the partial replacement of zeolite with feldspar.

2. Materials and Methods

2.1 Sampling

The leachate sample was collected manually at SimpangRenggam municipal landfill in Johor, located at a latitude of 10 53'41.64" north and longitude of 1030 22'34.68" east in Kluang district[13]. The landfill has been managed by the government for many years, and it receives about 250 tons of waste every day[14]. Raw leachate samples were collected from the influent of the detention pond using clean 20-liter high-density polyethylene plastic containers, transported to a wastewater research laboratory, and stored at 4°C in a cold room at University Tun Hussein onn Malaysia (UTHM) to maintain its initial characteristics. All chemical analyses for leachate characterization were performed within the following 24 hours in accordance with the Standard Methods for the Examination of Water and Wastewater[15]. All chemical analyses for leachate characterization were of analytical grade.

2.2 Media

The two media types used in this study were zeolite and feldspar. Natural zeolite (Mechastone brand) was purchased from Pt. AnugerahalamSdn. Bhd., Parit Raja, Johor Malaysia at a price of about 0.4RM per kilogram. The feldspar was purchased from CCS Corporation SdnBhd, Selangor, Malaysia at an average price of 0.12RM per kilogram. The chemical composition of the media was determined via X-Ray Fluorescence spectrometry (XRF) (Model Bruker S4 pioneer). The density of the media was determined conventionally (dry weight/volume). The feldspar and zeolite were sieved to obtain particle sizes between 2.00 and 2.35 mm. Tables 1 show the general properties of the media. At the beginning of this study, one parameter was studied, with all the other parameters kept constant.

Table 1. Composition of zeolite and feldspar

Formula	Zeolite(%)	Feldspar(%)
SiO_2	58.80	49.20
Al_2O_3	9.33	14.20
Fe_2O_3	1.16	1.37
K_2O	3.69	9.53
CaO	2.35	0.61
MgO	0.57	0.62
Na_2O	0.73	2.56
C	1.0	0.1

2.3 Optimum Shaking Speed

Optimum batch experiments were conducted in series of 250 ml conical flasks containing 100 ml raw leachate, and 5 cm^3 of the media were introduced into each flask. The flasks were shaken for a fixed time of 105 minutes, pH 7, and at an ambient temperature using an orbital shaker (model Daiki). The optimum shaking speed was determined by varying the shaking speeds from 50 rpm to 200 rpm. The samples were filtered using 0.45 µm filter paper. They were analyzed for ammoniacal nitrogen and COD, which are the major contaminants in leachate. The ammoniacal nitrogen in mg/L was determined using an ultraviolet visible spectrophotometer (Model HACH DR6000), and the COD was assessed via the closed reflux titrimetric method[15]. The rotational speed of the sample group that showed the maximum removal of ammonia and COD was selected as the optimum.

2.4 Optimum Mixing Ratio

In this experiment, the optimum mix ratio between zeolite and feldspar was determined for the removal of ammoniacal nitrogen and COD. The optimum shaking speed obtained in the previous experiment was used. A total mixture of 40 cm^3 in each conical flask was shaken. The sequence of the media mix ratios used were 5 : 35, 10 : 30, 15 : 25, 20 : 20, 25 : 15, 30 : 10, and 35 : 5 for zeolite to feldspar (Z:F). Subsequently, the optimum mix ratio between the combined two media was obtained by plotting the mix ratio against removal percentages. The mix ratio that showed sufficient removal percentage was selected as the optimum.

2.5 Optimum Solution pH

The optimum pH in the removal of COD and ammonia was determined by adjusting the leachate pH from 4 to 9. The pH adjustment was conducted using 97% H_2SO_4 and 1M NaOH. After every adjustment to a particular pH, the experiment was conducted at a predetermined optimum shaking speed and optimum mixing ratio. The optimum pH was then selected based on the pH that yielded the maximum removal of COD and ammonia.

3. Results and Discussion

3.1 Chemical Analysis of Leachate

Numerous published studies describe the variations of leachate quality from different landfills[2]. Table 1.0 presents the leachate characteristics investigated in this study. The table suggests that leachate has a high amount of COD and ammonia nitrogen. The average values of BOD5 and COD are 164 and 1763 mg/L, respectively, and that the biodegradability ratio (BOD_5/COD) of raw leachate ranges from 0.06 to 0.15 with an average of 0.09 (see Table 2). The data on the BOD_5 and COD indicate that it is a stabilized leachate[2,3,14]. The results are also consistent with findings from past studies[14] on stabilized leachate.

3.2 Effect of Shaking Speed

The COD and ammonia nitrogen percentage removal in the sample is shown in Figures 1 and 2, respectively, after shaking at 50 rpm to 200 rpm on an orbital shaker. The optimum removal by zeolite and feldspar is at 150 rpm (see Figure 1). Ammonia nitrogen removal is optimized at 150 rpm similarly using feldspar and zeolite as depicted in Figure 2 for a single medium.

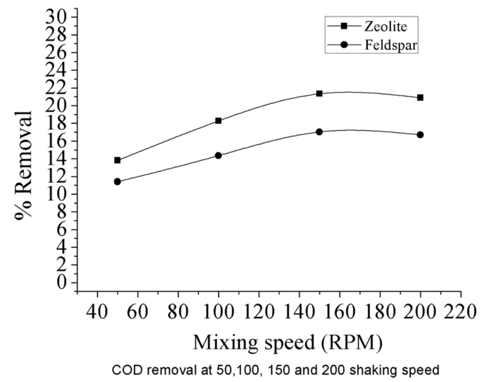

Figure 1. COD removal at the determined optimum shaking speeds.

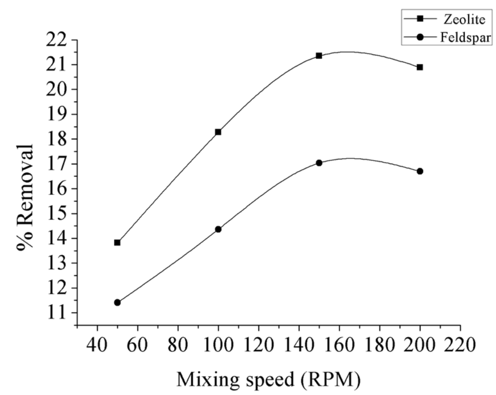

Figure 2. Ammonia nitrogen removal at the determined optimum shaking speeds.

3.3 Media Mix Ratio

Figures 3 and 4 exhibit the percentage removal for COD and ammonia nitrogen, respectively, in the sample after mixing feldspar with zeolite and shaking at various speeds to obtain the optimum mix ratio. Based on the figures, at

Table 2. Characteristics of leachate obtained from the SimpangRenggam landfill

Parameter	Minimum Concentration in Sample	Maximum Concentration in Sample	Average	*Malaysia Leachate Discharge Standard (mg/L)
COD (mg/L)	1682	1844	1763	400
BOD_5 at 20 °C (mg/L)	114	270	164	20
Ammonia Nitrogen (mg/L)	649	541	573	5
SS (mg/L)	585	671	633	50
Color (Platinum-Cobalt unit, Pt-Co)	4615	4721	4676	100
BOD_5/COD	0.06	0.15	0.09	
pH	7.85	8.26	8.11	6.0–9.0

*Acceptable condition for discharging leachate as stated in the 2009 Environmental Quality Regulations, second schedule (regulation 13) the initial ratio of 5:35, the removal is higher given that the composition of the media is more of the conventional media, which decreases with further replacement. The optimum conditions are adequate at a ratio of 20:20 (feldspar: zeolite by volume) and 150 rpm for COD and ammonia nitrogen removal. Hence, the ratio 20:20 is adopted to achieve some media replacement of the conventional media. Considerably, the ratio achieves a significant replacement of the conventional media without detriment to pollutant removal.

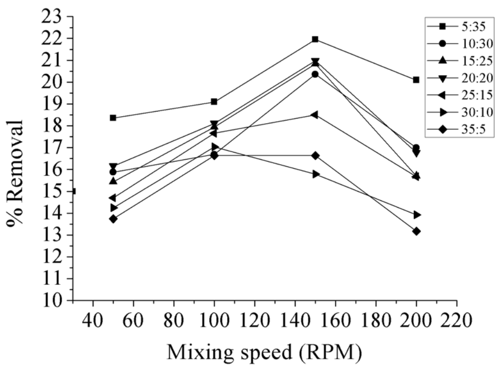

Figure 3. Mix ratio between feldspar and zeolite and in COD removal.

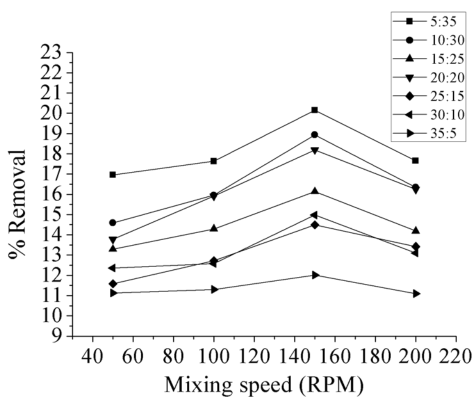

Figure 4. Mix ratio between feldspar zeolite in ammonia nitrogen removal.

3.4 pH

Figure 5 shows the removal of COD and ammonia at different pH values. Obviously, the pH range that shows the maximum removal occurs at pH 6 (35%) and pH 6.5 (29%) for COD and ammoniacal nitrogen removal, respectively. The results indicate that the optimum pH ranges from 6–6.5.

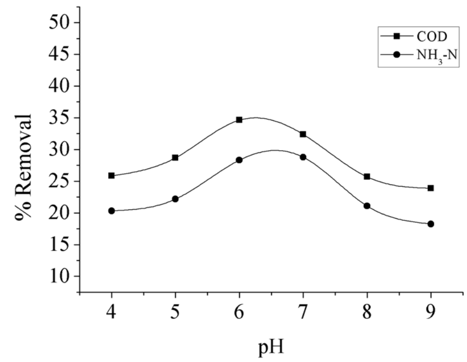

Figure 5. Optimum pH for COD and ammonia removal using feldspar and zeolite mixture.

4. Conclusions

The ability of the mixture of zeolite and feldspar to minimize COD and ammonia nitrogen from a stabilized landfill leachate is investigated. The results indicate that the optimum mixing ratio for zeolite and feldspar in the treatment of COD and ammonia nitrogen is 20:20 and that the optimum shaking speed of the mixed media is 150 rpm. The optimum pH ranges from 6–6.5.

The research outcomes of this study contribute to the existing literature on alternative media for leachate treatment, especially in developing countries. Further research is still in progress at the UTHM to determine other factors that may influence the field of study.

5. Acknowledgement

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6. References

1. Raghab SM, El Meguid AM, Hegazi HA. Treatment of leachate from municipal solid waste landfill. HBRC Journal. 2013 Aug 31;9(2):187–92.
2. Aziz HA, Mojiri A. Wastewater engineering: Advanced wastewater treatment systems. International Journal of Science and Research. 2014 Apr 1.
3. Kadir AA, Abdullah MMA, Sandu AV, Noor NM, Latif A, Lisanah A, Hussin K. Usage of palm shell activated carbon to treat landfill leachate. International Journal of Conversion Science. 2014;5(1):117–26.

4. Daud Z, Aziz A, Latif LMA. Coagulation-flocculation In leachate treatment by using ferric chloride and alum as coagulant. Journal of Engineering Research and Applications . 2012; 2(4):1929–34.
5. Han DH. A recycling method of rotten fish wastes. Indian Journal of Science and Technology. 2015 Dec 15;8(33).
6. Xie B, Lv BY, Hu C, Liang SB, Tang Y, Lu J. Landfill leachate pollutant removal performance of a novel biofilter packed with mixture medium. Bioresource Technology. 2010 Oct 31;101(20):7754–60.
7. Saheri S, Mir MA, Basri NE, Mahmood NZ, Begum RA. Life cycle assessment for solid waste disposaloptions in Malaysia. Polish Journal of Environmental Studies. 2012; 21(5):1377–82.
8. Agouborde L, Navia R. Heavy metals retention capacity of a non-conventional sorbent developed from a mixture of industrial and agricultural wastes. Journal of Hazardous Materials. 2009 Aug 15;167(1):536–44.
9. Zhao R, Novak JT, Goldsmith CD. Evaluation of on-site biological treatment for landfill leachates and its impact: A size distribution study. Water Research. 2012 Aug 31;46(12):3837–48.
10. Aziz SQ, Aziz HA, Yusoff MS, Bashir MJ, Umar M. Leachate characterization in semi-aerobic and anaerobic sanitary landfills: A comparative study. Journal of Environmental Management. 2010 Dec 31;91(12):2608–14.
11. Qi Y, Hoadley AF, Chaffee AL, Garnier G. Characterisation of lignite as an industrial adsorbent. Fuel. 2011 Apr 30;90(4):1567–74.
12. Latiff AA, Karim ATB, Ridzuan MB, Yeoh DE, Hung YT. Heavy metal removal by crops from land application of sludge. Environmental Bioengineering. 2010:211–32).
13. Daud Z, Fatihah N, Hanafi M, Awang H. Optimization of COD and colour removal from landfill Leachate by electro-fenton method. Australian Journal of Basic and Applied Science. 2013; 7(8):263–8.
14. Halim AA, Aziz HA, Johari MA, Ariffin KS, Bashir MJ. Semi-aerobic landfill leachate treatment using carbon–minerals composite adsorbent. Environmental Engineering Science. 2012 May 1;29(5):306–12.
15. Federation WE. Standard methods for the examination of water and wastewater. American Public Health Association (APHA), Washington, DC: USA; 2012.