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Landfill Leachate Treatment by Using Peat Soil and Laterite Soil as Natural Adsorbents

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ABSTRACT

Laterite soil and peat soil which are known to be environmentally friendly adsorbents are selected to treat stabilized landfill leachate from Matang landfill. The efficiency of these adsorbents to treat the landfill leachate were investigated based on manipulating the dosages of the adsorbents and adjusting the pH of the leachate in the range of 6 to 9. It was found that laterite soil was efficient in removing color, iron, nitrate and phosphate whereas peat soil was efficient in removing ammonia and COD from the landfill leachate. The best pH was 6 while the best dosages were found to be in the range of 50g to 70g for 200 ml sample. The combination of the best dosage and best pH were sufficient in removing 73.40% ammonia, 70.56% COD by peat soil and 97.65% of colour, 98.16% of nitrate and 99.35% of turbidity by laterite soil including phosphate that can be completely removed from the leachate. The results indicate that the isothermal adsorption data fit better with Freundlich models for laterite soil and peat soil. Therefore, as the laterite soil has the tendency to remove more pollutants compared to peat soil, it can be suggested that peat soil should be used as a medium for pre-treatment of landfill leachate followed by treatment by using laterite soil. Hence, based on the study conducted, the laterite soil and peat soil can be considered as a viable alternative for the treatment of landfill leachate via adsorption.

Keyword: peat soil; laterite soil; adsorption; leachate treatment

INTRODUCTION

Landfilling is the most common and essential solid waste management strategy for sustainable disposal and elimination of wastes in terms of its simplicity and capital costs [1]. Landfill is known as sites for wastes disposal. The purpose of landfill is to stabilize the solid waste through proper storage by using natural metabolic functions. Hence, municipal solid wastes (MSW) often end at landfills. It has become the preferred method of handling waste. Out of the total MSW collected worldwide, 95% is disposed in landfill with only small amount of wastes incinerated [2].

Malaysia also uses landfilling as the main disposal for MSW. There are two types of landfill which are open dumpsite and sanitary landfill. Open dumpsite does not have proper facilities such as leachate collection or treatment or even liner whereas sanitary landfill consists of liners, leachate collection and treatment, daily and final covers and also gas harvesting. There are 301 solid wastes disposal sites in Malaysia with only 190 active landfills including 10 sanitary landfills [3].

Based on study that has been carried out, there are over 23,000 tonnes of waste that are being generated each day in Malaysia and out of it 17,000 tonnes of MSW are produced in Peninsular Malaysia [4]. This value is estimated to increase to more than 30, 000 tonnes by the year 2020 [3]. The value is expected to rise due to the increase in development and population with the habit of recycling of less than 5% [4].

The generation of heavily polluted leachates creates major drawbacks [5]. Normally leachate contains complex organic substances, odor and colour. Yang and Englehardt [6] states that the leachate generated is a high strength wastewater exhibiting acute and chronic toxicity. Municipal solid waste (MSW) management constitutes a major environmental, economic and social problem mainly because the volume of waste is growing faster than the world's population.

The wastes that are continuously placed in landfills potent a high risk of infiltration from precipitation. Here without a proper treatment, landfill leachate will pose adverse environment impact such as contamination of soil, groundwater and surface water [7]. Moreover, the quantity and compositions of the leachates and the distance of landfill from water bodies are factors affecting severity of the pollution. The variations of the leachate composition is influenced by various factors such as waste composition, age of landfill, site hydrogeology, specific climate conditions, moisture content and also the landfill design and operation [8, 9].

There are many technologies that have been developed for landfill leachate treatment. These includes aerobic biodegradation, anaerobic biodegradation, Fenton treatment, microalgae treatment, leachate transfer, physical and chemical processes, membrane processes, coagulation- nanofitration process, catalytic oxidation, ozonation, electro-dialysis, electro-chemical oxidation, ultrasonication and others [10]. Nonetheless, adsorption is known to be environmentally friendly and cost effective process [11, 12].

The study was done to identify the best dosage and pH for the type of adsorbents that are used. The best pH and dosage are determined based on the percentage removal of turbidity, colour, nitrate, ammonia, phosphate, COD and iron.

MATERIALS AND METHODS

The application of peat and laterite soil was studied based on a proper methodology. In order to identify the best condition for the adsorption process, the best pH and dosage are selected to be investigated. The other factors such as the adsorbent size, agitation period and agitation speed were fixed to be constant. The size of the adsorbents used was synchronized throughout the batch study which is in between 1.18–2.00mm. The adsorption isotherms that were used are the Freundlich and Langmuir isotherms.

Acid Digestion

The soil samples were digested to be tested in the ICP-AES. The materials and chemicals used were soil sample, mortar and pestle, pipette, 100mL beaker, filtration unit, glass lid, volumetric flask, fume hood, concentrated nitric acid (HNO_3), hydrochloric acid (HCI), distilled water and hydrogen peroxide (30%).The digested sample was filtered by using filtration unit. The sample was diluted to 100mL and tested by using ICP-AES [13].Inductively coupled plasma atomic emission spectroscopy (ICP –AES) was used to identify the trace metals in the landfill leachate and also the adsorbents that are used. ICP-AES can be divided into two parts which are inductively coupled plasma source and the atomic emission spectrometry detector. This instrument uses the atmospheric pressure argon inductively couple plasma for sample atomization and efficient atomic excitation [14].

Leachate Sample and Soil Collection for Preparation

The leachate was collected at Matang landfill, Taiping, Perak. After the collection, the sample was brought to laboratory. The basic characterization of the sample was done as soon as possible. However, the measurement for certain parameters was done at the site itself. Multi parameter probe was used to take the leachate parameter in-situ. The collected samples were stored in a clean plastic bottle. The laboratory analyses were done as soon as possible so that most reliable results were obtained. Since the prompt analyses were impossible, the bottles were filled completely and cap tightly. The samples were stored cooling at 4^oC. Prior to analysis, the samples should be in the room temperature [13].

The soils are collected from two different places. Laterite soil was collected from Kuala Berang, Terengganu whereas the peat soil was collected at PayaBeriah, Perak. Before collecting the soils, shovel was used to remove the surface of the soil about 15 to 20cm. This method is to avoid the collection of soil deposits. After that the soils are collected and placed inside a sealed plastic bag. In the laboratory, the soils were placed with good ventilation. The soils was placed in the oven at 105-110°C for 24 hours prior of using it. After oven drying the particles that were bigger than 2mm and smaller than 1.18mm were removed from the samples by sieving because soil samples were not homogeneous especially the peat soil as it contain pieces of wood and twigs.

Analytical Procedure

The samples were characterized according to the Standard Methods for the Examination of Water and Wastewater [13]. All the experiments are carried out in triplicates. In order to measure the suspended solids the spectrometer DR2800 equipment was selected for measuring suspended solids at 810 nm, colour at 455nm, Chemical Oxygen Demand (COD at 620 nm, Iron using 1, 10 phenanthroline method at 510 nm. Ammoniacal Nitrogen byNessler Method at 425nm, Nitrate by Cadmium Reduction Method at 400nm, and Phosphorus using Reactive (Orthophosphate) Method. For the soil samples were analyzed using the Standard Methods.

Batch Study

The batch experiments were conducted at room temperature in a mechanical shaker at an agitation speed of 100rpm. The samples were weighed and placed into 500mL conical flasks. Then, 200mL of leachate was poured into the flasks and sealed. The flasks were placed into a shaker. Firstly, the best adsorbent dosage of laterite soil was identified by using varying adsorbent doses between 50 g/L to 350 g/L with 60 minutes shaking period. Then, the best dosage for peat soil was identified by using the same method but with doses in the range of 50 g/L to 350g/L. The adsorbent dosages were then used to run the next batch of tests which are by varying the pH from 6 to 9. Next, the pH value was changed to run the next batch of tests. For all set of batch study, the samples were allowed to settle for 5 minutes before it is filtered through filter paper. The filtrate collected will be used for further analysis.

The initial and final value of the parameters that were tested was recorded to calculate the percentage removal. The removal efficiency of the parameters that are tested was calculated by using Equation 1.

$$\text{Removal Efficiency} = \frac{(C_o - C)}{C_o} \times 100 \tag{1}$$

where,

C_o = Initial concentration of leachate
C = Final concentration of leachate

RESULTS AND DISCUSSION

Landfill Leachate Characteristics

The chemical oxygen demand (COD) for the raw landfill leachate measured is within the range of 857 to 982 mg/L with mean value of 919.5mg/L. Based on the COD value, the landfill leachate can be described as stabilized.This is according to a study conducted by Alvarez-Vazquez et al.[15] which stated the stabilized leachate has COD value lower than 3g/L. The COD value at Matang landfill is considered low for landfill leachate. This low value explains the lower organic pollutant load in the stabilized leachate [16].

As for the BOD_5 that was measured, it is in the range of 212 – 265 mg/L. The BOD_5 value is used to determine the ratio of BOD_5/COD. The ratio that was calculated for the raw leachate shows 0.259. Based on this value, the landfill leachate can be characterized as intermediate which is in between young and stabilized leachate [15]. The organic compounds in the stabilized leachate were low. This is due to the presence of more sensitive and slower growing methanogenic bacteria which gradually set up and start to consume these organic compounds producing a mixture of carbon dioxide and methane which is released as landfill gas.

The pH value for the landfill leachate collected is in the range of 7.90 to 8.30. This range comply the standard of discharge which is in the range of 5.5 to 9.0. According to Alvarez-Vazquez et al.,[15] this value also indicates that Matang landfill leachate is stabilized. The turbidity of the landfill leachate was found to be in the range of 164-199 NTU with the mean value of 181.5NTU. The turbidity of the leachate is related to the total suspended solids in the water sample. The higher turbidity value implies the liquid is murkier and will cause reduction in the dissolved oxygen in the receiving water body and directly will affect the aquatic organisms.

Next, the colour of the raw landfill leachate is in between 4054 to 7400 PtCo with mean value of 5727 PtCo. The value of colour indicates that the landfill leachate is very dark coloured liquid. This is primarily due to the percolation of precipitation via open landfill or even through the cap of the completed cells [17].

In general it can be concluded that the landfill leachate that was collected is stabilized based on the characteristics of the leachate. Table 1 shows the characteristics of leachate of Matang landfill and the range and the average values for the parameters measured to be compared with the discharge limit of Standard B of the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 under the Environmental Quality Act of Malaysia, 1974 [18].

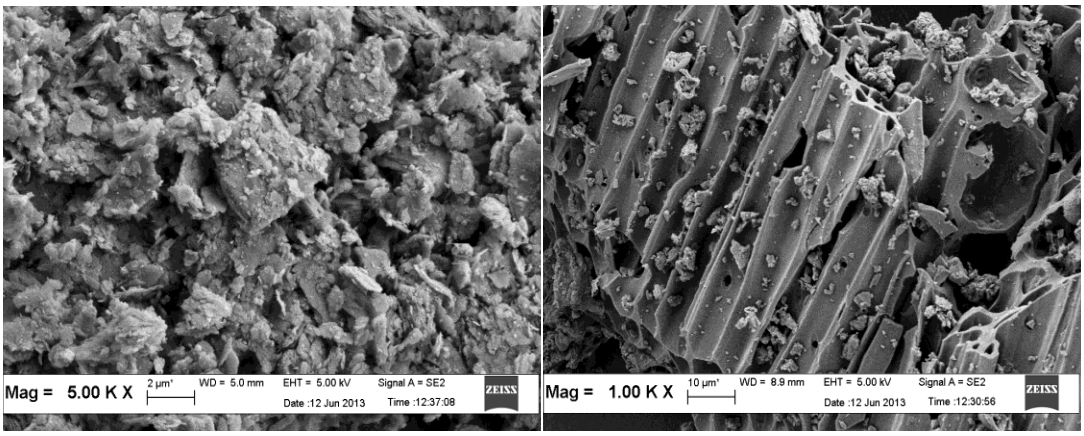
Table 1 Characteristics of raw landfill leachate collected from Matang landfill

Parameter	Unit	Range	Mean	Standard B*
Temperature	°C	30.0 – 32.0	31.0	40
pH	-	7.90 – 8.30	-	5.5 – 9.0
BOD_5	mg/L	212 - 265	238.5	-
COD	mg/L	857 - 982	919.5	100
BOD_5/COD	-	-	0.259	-
Colour	PtCo	4054 - 7400	5727	-
Turbidity	NTU	164 - 199	181.5	-
Ammonia	mg/L	1416 - 2682	2049	-
Nitrate	mg/L	110.7 – 137.3	124.0	-
Iron	mg/L	6.04 – 6.52	6.28	5.0
Phosphate	mg/L	8.78 - 9.29	9.04	-

Laterite and Peat Soil Characteristics

From laboratory experiments pH value of laterite and peat soil are in the range of 6.48 to 6.54 and 3.71 – 3.83 respectively. This value shows that the peat soil is more acidic and the natural moisture content of the laterite and peat soiland are 23.31% and 83.63 % respectively.

Figure 1 (a) and (b) show the image of laterite and peat soil by using SEM with five thousand times magnification. Figure 1(b) illustrates the image of the peat soil indicated that the pattern of the image describe that there is very high amount of carbon present in the material.



(a) (b)

Figure 1 (a) The surface image of laterite soil and (b) the surface image of peat soil with five thousand times magnification by using SEM

The chemical elements that have been identified by using EDX based on spot analysis for laterite soil were carbon (4.88%), nitrogen (1.01%), oxygen (38.90%), aluminium (22.09%), silicon (25.31%) and potassium (7.81%) in accordance to 100% by weight that illustrated in Table 2. The major element that was found in laterite soil is oxygen. By comparing the laterite soil with peat soil, it was found that laterite soil do not have the elements such as magnesium and phosphorus.

Table 2 Chemical elements found in laterite soil by using EDX

Element	Weight, %	Atomic, %
Carbon	4.88	8.41
Nitrogen	1.01	1.49
Oxygen	38.90	50.35
Aluminium	22.09	16.96
Silicon	25.31	18.66
Potassium	7.81	4.14

For Table 3 shows the chemical elements that are found in the peat soil by using EDX. The components that were identified are carbon (42.59%), nitrogen (2.54%), oxygen (17.58%), magnesium (1.90%), aluminium (10.48%), silicon (13.11%), phosphorus (1.54%) and potassium (10.27%). The ratio stated is in accordance to 100% by weight. The major element is carbon. Primarily, the content that are vital to be used as soil conditioner are originally available in the soil. Hence by using the soil to treat the landfill leachate prior to be used as soil conditioner, it gives an additional value as the nutrients from the leachate will be adsorbed on the peat soil.

Table 3 Chemical elements found in peat soil by using EDX

Element	Weight, %	Atomic, %
Carbon	42.59	58.40
Nitrogen	2.54	2.99
Oxygen	17.58	18.10
Magnesium	1.90	1.29
Aluminium	10.48	6.40
Silicon	13.11	7.69
Phosphorus	1.54	0.82
Potassium	10.27	4.33

The wet sieving that was conducted for both types of soil shows that both of the soils contain mostly clay and slit as shown in the grading curve in Figure 2. The peat soil has 99.99% passing the 63µm sieve size. The passing of laterite soil was slightly lower compared to peat which is 99.95%. The passing through 63µm sieve size shows that both the soil have high content of clay and silt as shown in the Figure 2. Higher amount of clay in the soil that was chosen is vital as clay is usually used as natural adsorbent. Based on the Figure 2, the peat soil has higher amount of the combination of clay and silt. Basically, this is one of the reason of choosing the peat soil or laterite soil as natural adsorbent. Most of the studies about the bentonite and sepiolite clays have shown their catalytic ability as an adsorbent property[19].Oyanedel-Caver and Smith,[20] states that the clay is normally selected due to the variety of structural and surface properties, high chemical stability and the large specific surface area.

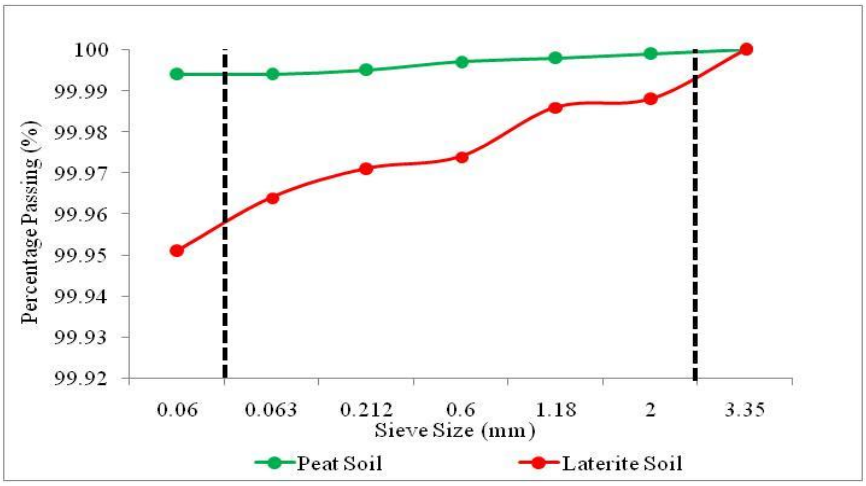


Figure 2 Grading curve

The result of ICP-AES in Figure 3 shows that the raw leachate has only a few prominent heavy metals such as cadmium, iron and magnesium. However, the peat soil has cadmium and iron. Laterite soils have cadmium and also iron. This result shows that the laterite soil have iron and aluminium elements.This serves as a confirmation that it can be used as adsorbent since most of the commercial adsorbents or coagulants contained both of iron and aluminium elements such as aluminiumsulphate, ferric chloride and ferrous sulphate.

Batch Adsorption Experiments

The batch adsorption tests were performed to identify the adsorption isotherm curves as it provides a graphical representation of material sorbed as a function of the equilibrium concentration of sorbate. The usefulness of peat and laterite soil in treating leachate depends on the type and concentration of the leachate that was used.

There are many pollutants that are present in landfill leachate and each of them will have to compete for the sorption sites and less of a particular ion may be bound. The pH of the aqueous solution is an important variable which controls the adsorption of the organic components at the solid water interfaces [21]. Hence, reducing the pH was found to increase the total sorption capacity [22].The optimum sorption pH is different for each metal. Thus, a generalized pH range was considered which is in between 6 to 9.

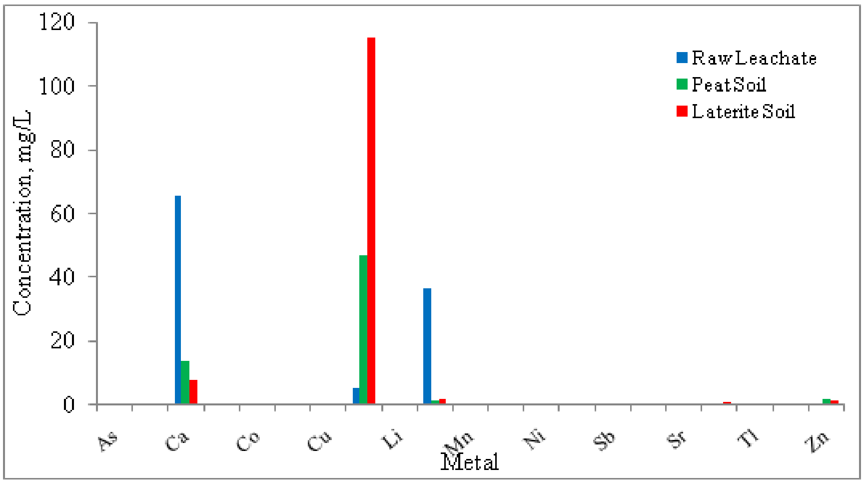


Figure 3 Metal concentration in raw leachate, peat soil and laterite soil by using ICP-AES

Percentage Removal of Ammonia

Figure 4 shows that the highest removal of ammonia was for laterite soil with 27.03% with a dosage of 70g. The lowest percentage removal is for a dosage of 10g with removal of 17.06%. As for the peat soil, the percentage removal started at 6.82% and increased to 20.45%.

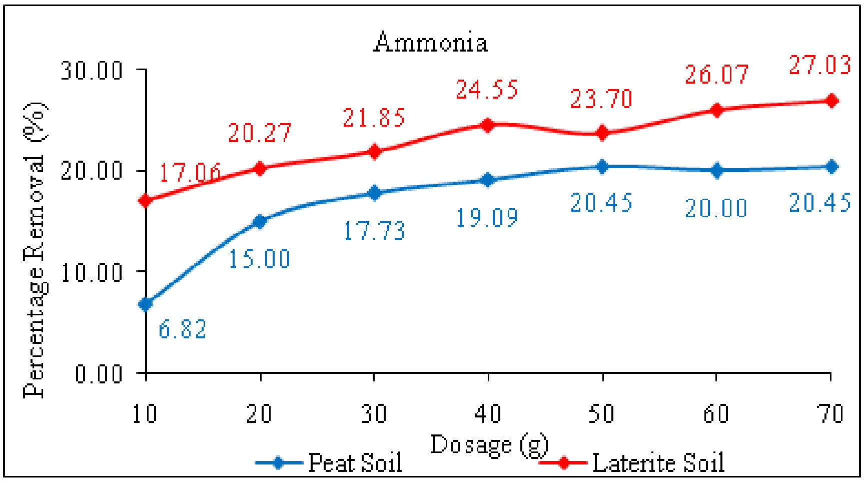


Figure 4 Percentage removal of ammonia versus dosage

It can be observed from Figure 5 that for the leachate treated with peat soil, the highest percentage removal was for peat soil with pH 6. The difference in percentage removal for pH 6 and 7 was insignificant. The leachate with pH 6 removed 73.40% whereas at pH 7 it removed 73.28%. As for the leachate with pH 9, the percentage removal was 19.55% respectively. The leachate with pH 8 shows moderate removal of 59.15%. The highest percentage removal for laterite was for pH 7 with 55.13% removal and lowest percentage removal is at pH 9 with 12.35% removal.

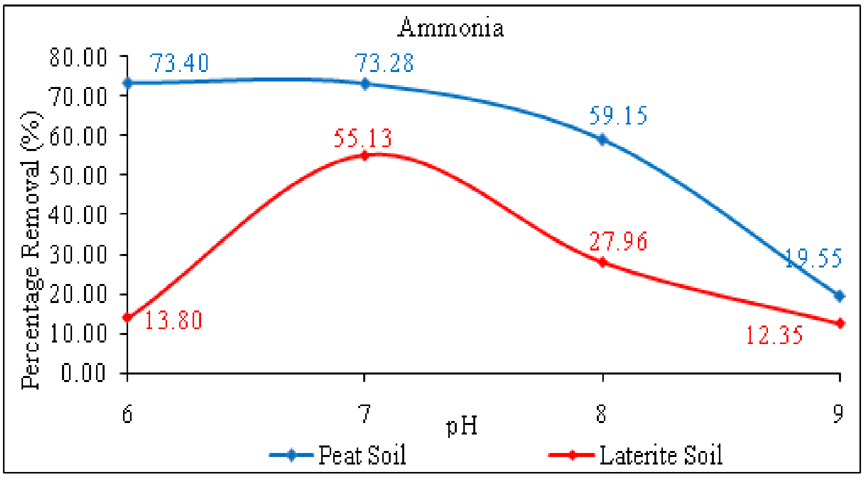
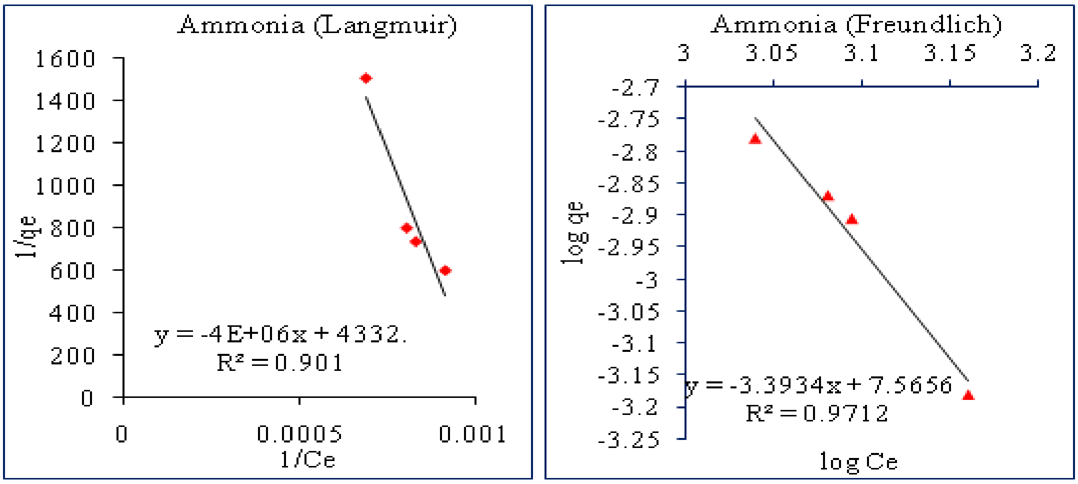


Figure 5 Percentage removal of ammonia versus pH

Adsorption Isotherms for Ammonia

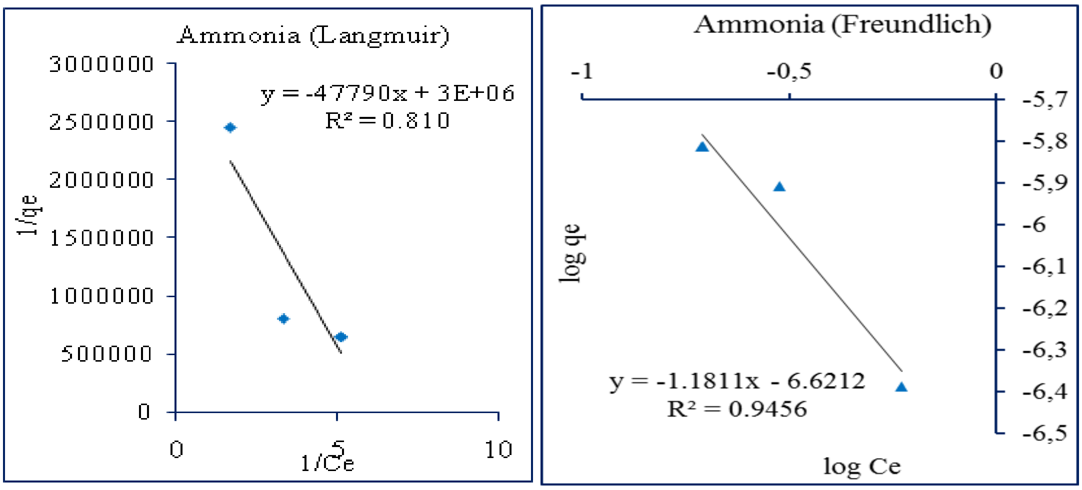
The Langmuir and Freundlich isotherm models for ammonia for the leachate treated with peat soil and laterite soil are shown from Figure 6 to Figure 7. The isotherm model and the coefficient determination is abstracted and summarized in Table 4 for laterite soil and Table 5 for peat soil. Based on the summary it was identified that the

Freundlich isotherm can be used, as the R^2 value fits the isotherm better in acidic condition. Hence, Freundlich isotherm is well fitted for the adsorption of ammonia on both soils.



(a) (b)

Figure 6Laterite soil adsorption modelfor ammonia (a) Langmuir (b) Freunlich



(a) (b)

Figure 7Peat soil adsorption model for ammonia (a) Langmuir (b) Freundlich

Percentage Removal of Chemical Oxygen Demand (COD)

The method that was used to identify COD has several drawbacks such as time consuming degradation process in highly acidic medium under high temperature. Besides, the COD was only reduced by 70.42% for the treatment by using peat soil with 60g dosage but even at 70g dosage the percentage removal was only slightly increased to 70.86%. As shown in Figure 8 the percentage removal increases as the dosage increases. The treatment by using laterite soil shows lower percentage removal compared to peat soil. As the dosage increases, the percentage removal increases. The percentage removal for leachate treated with 70g laterite soil was only 29.90%.

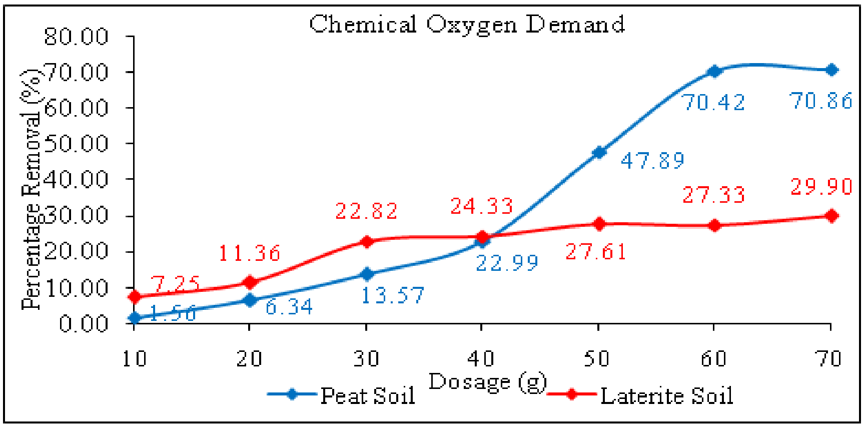


Figure 8 Percentage removal of COD versus dosage

Figure 9 shows irregular trend of COD removal by using peat soil versus pH. This is due to the addition of organic acid from the peat itself. The highest percentage removal is for leachate with pH 8 was 70.56 %. Besides, at pH 6.7 and 9 the percentage removal is insignificant. The treatment of landfill leachate by using laterite soil shows a decrease in the percentage removal as the pH increases. The highest percentage removal was at pH 6 with 58.33% removal and the lowest removal was at pH 9 with 30.47% removal.

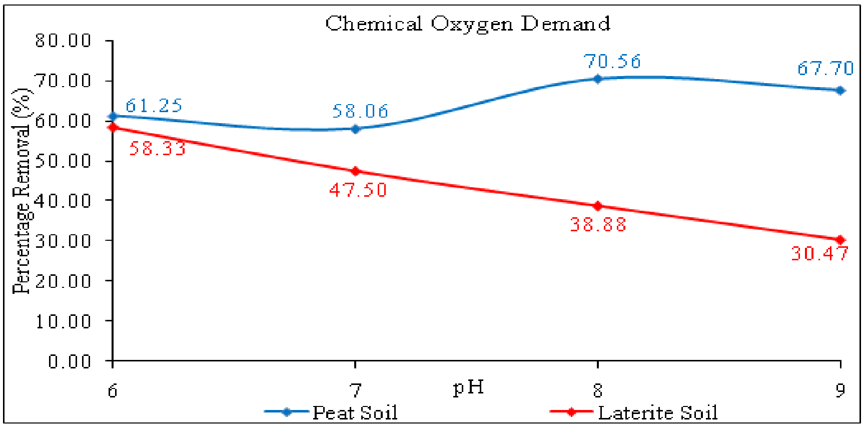


Figure 9 Percentage removal of COD versus pH

Percentage Removal of Color

The percentage removal of color by using laterite soil is shown in Figure 10. The highest percentage removal was shown in landfill leachate treated with laterite soil with the removal of 94.62% at a dosage of 70g. However, at dosage of 40g and above the percentage removal was already above 90%. Additionally, even at smaller dosage, the percentage removal was considered higher. At dosage 10g itself, the leachate shows 61.21% removal. As for the peat soil, at highest dosage of 70g, the percentage removal was 72.99% and the lowest percentage removal was for dosage of 10g with 9.54% removal. Both the laterite soil and peat soil shows an increase in percentage removal as the dosage increases

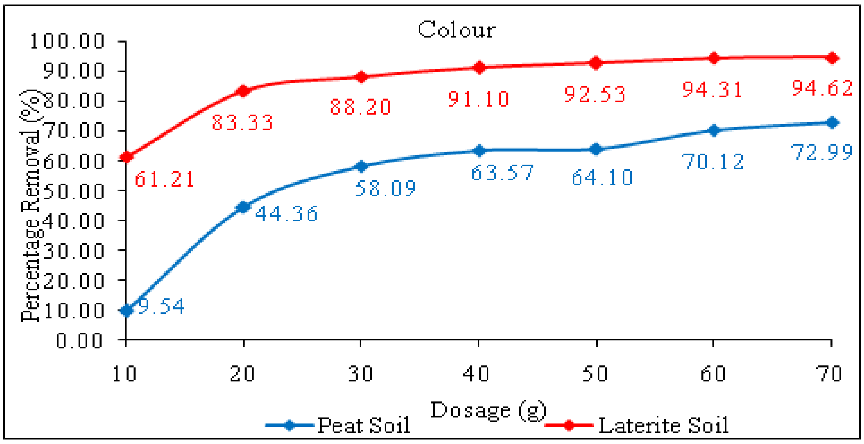


Figure 10 Percentage removal of colour versus dosage

Figure 11 describes the colour removal by using peat soil and laterite soil versus pH. The landfill leachate treated with laterite soil shows higher percentage removal compared to peat soil. The highest percentage removal by using laterite soil was at pH 6 with 97.65% removal. The other pH range shows similar rate of removal in the range of 90.39% to 95.08%. However, the highest percentage removal by using peat soil is still lower compared to the lowest level of removal by using laterite soil was 84.53% for pH 6. Besides, the percentage removal by using peat soil was insignificant with the changes in pH.

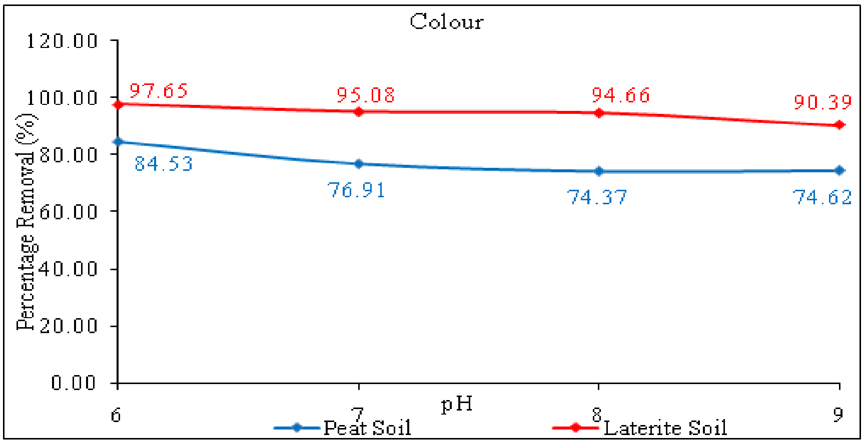


Figure 11 Percentage removal of colour versus pH

Percentage Removal of Iron

Based on Figure 12, the rate of removals for laterite soil were high for dosages of 30g and higher with above 90% removal. The highest removal is for dosage of 70g with 96.26% removal. Basically, all the increment is seem to be insignificant with the increase of the dosage for laterite soil after 10g. However, the highest percentage removal by using peat soil is still lower compared to the lowest level of removal by using laterite soil was only 62.69%.

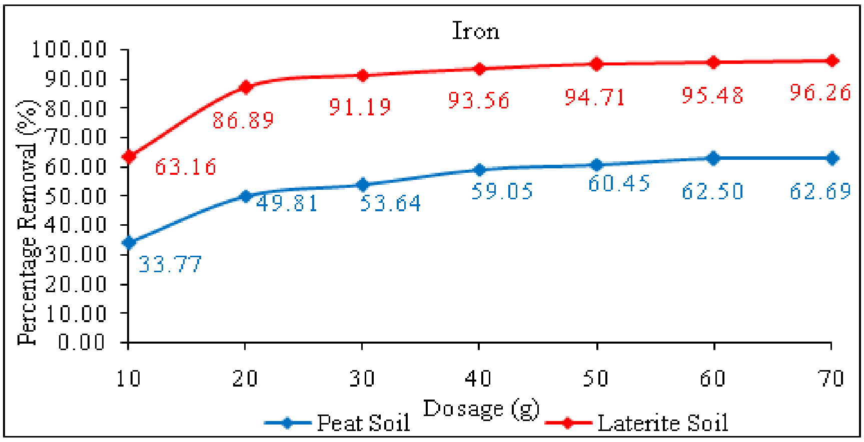


Figure 12 Percentage removal of iron versus dosage

Figure 13 shows the percentage removal for iron by using peat soil and laterite soil versus pH. Removal of iron for leachate at pH 6 shows highest percentage removal was 98.46%. The other pH range shows the percentage removal in between 93.10% to 96.96%. As for the peat soil, the highest percentage removal was at pH 9 with61.25% removal. However, pH of 6, 7 and 8 shows percentage removal of 53.78%, 59.29% and 58.98% removal respectively.

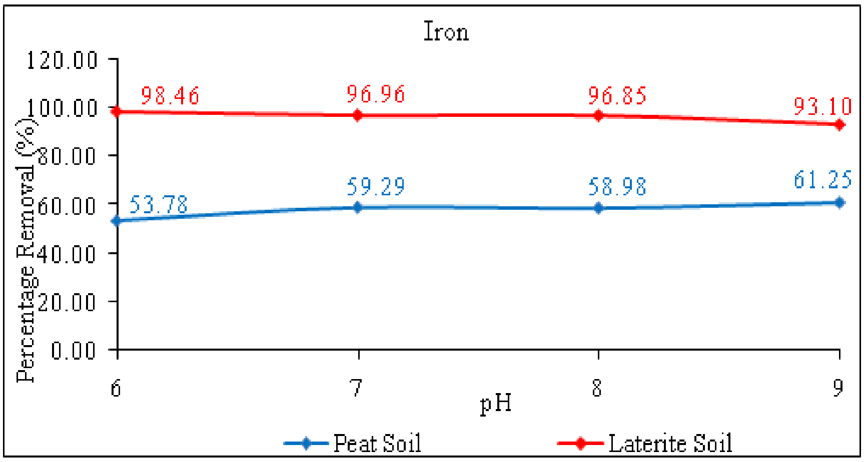


Figure 13 Percentage removal of iron versus pH

Percentage Removal of Nitrate

It can be observed from Figure 14 that there was highest removal of 93.15% for 70g dosage and the lowest percentage removal of 62.50% for 10g dosage of laterite soil. The landfill leachate treatment by using peat soil shows lower nitrate removal compared to laterite soil. The highest percentage removal was for 70g dosage of peat soil with removal of 29.66%. However, the percentage removal was insignificant with the dosage increment.

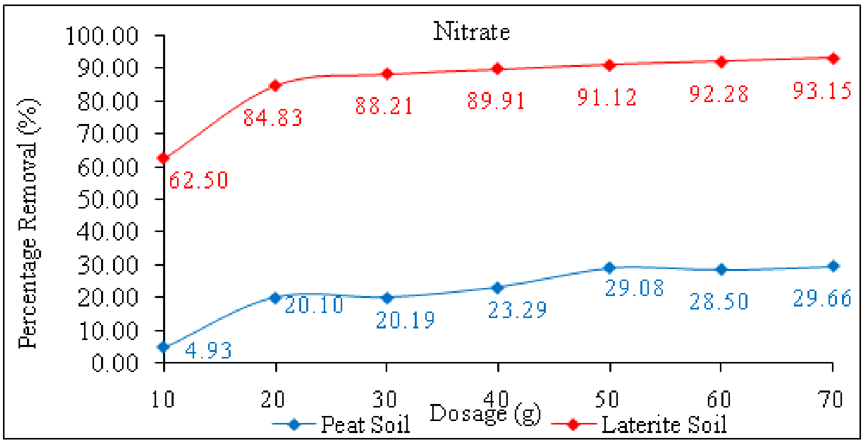


Figure 14 Percentage removal of nitrate versus dosage

It can be observed from Figure 15 that for the leachate treated with laterite soil, the highest percentage removal was for landfill leachate treated at pH 6. The difference in percentage removal was insignificant with the changes in pH. The leachate with pH 6 removed 98.16% whereas at pH 7 it removed 93.67%. As for the leachate with pH 8 and pH 9, the percentage removal was 93.98% and 62.72% respectively. The highest percentage removal for peat soil was at pH 7 with 84.93% removal and lowest percentage removal was at pH 9 with 50.83% removal.

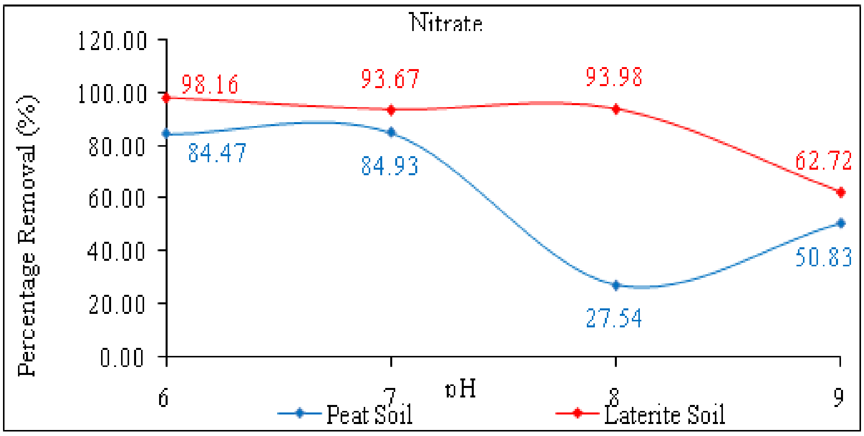


Figure 15 Percentage removal of nitrate versus pH

Adsorption Isotherms of Langmuir and Freundlich models are summarized in Table 4 for laterite soil and Table 5 for peat soil. It was found Freundlich isotherm fits well for the adsorption by peat soil and laterite soil based on the coefficient determination.

Percentage Removal of Phosphate

Generally, the laterite soil has the capability to sufficiently remove the phosphorus from the leachate. Hence the effluent that will be released into the water body have no necessity to be treated with alum or lime. Figure 16 describes that the phosphate removal proportional to the dosage range. However, the laterite soil has reached maximum percentage removal at 30g and above. The peat soil has removed 93.65% of phosphate at highest dosage of 70g.

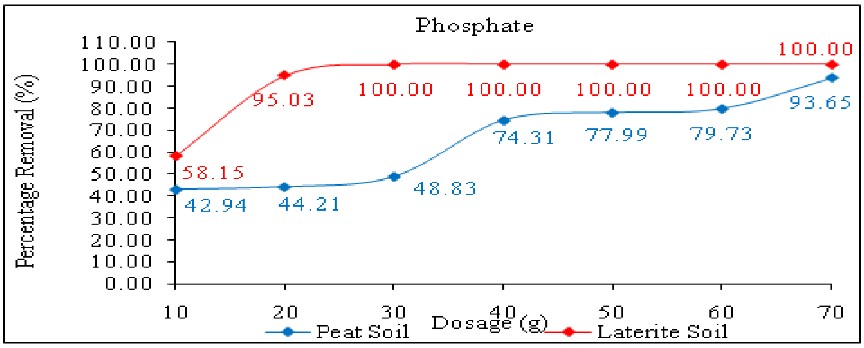


Figure 16 Percentage removal of phosphate versus dosage

Figure 17 shows that the influence of pH on phosphorus adsorption is not significant and it is in a small range. Therefore, the influence of pH on phosphorus adsorption of laterite soil and peat soil can be ignored [23].The highest removal by using peat soil is 94.39% at pH 6. At other pH, peats oil shows significant removal of more than 90% except for pH 9. As for the laterite soil, there was 100% removal for all the pH except for pH 9.

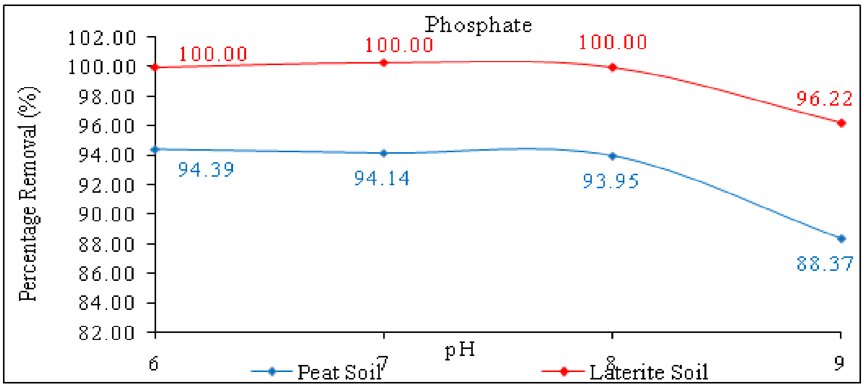


Figure 17 Percentage removal of phosphate versus pH

From Table 4 and Table 5 show the summary of Langmuir and Freundlich isotherms for both laterite and peat soils which fit to the Freundlich isotherm models for COD, colour, iron, nitrate, and phosphate adsorptions of laterite soil and peat soil.

Table 4 Summary of Langmuir and Freundlich isotherm models for laterite soil

	Freundlich Isotherm			Langmuir Isotherm		
	R^2	K_F	1/n	R^2	a_L	b_L
Ammonia	0.971	36779007.04	-3.393	0.901	-1.08E-03	0.000230798
	Y = - 3.3934x + 7.5656			Y = - 4E+06x + 4332.8		
COD	0.970	132.892	-1.243	0.886	-6.43E-04	0.002915877
	Y = -1.2427x + 2.1235			Y = -533026x + 342.95		
Color	0.997	0.0128	-0.251	0.988	-1.86E-02	0.002503505
	Y = -0.2508x -1.8914			Y = -21510x + 399.44		
Iron	0.998	5.42875E-06	-0.746	0.993	-1.92E+00	2.67695E-06
	Y = -0.7462x – 5.2653			Y = -194276x + 373559		
Nitrate	0.865	0.000573	-0.158	0.427	-1.07E+00	0.000333433
	Y = -0.1575x – 3.2419			Y = -2803.7x + 2999.1		
Phosphate	0.992	1.62181E-05	0.025	0.983	1.19E+02	1.6219E-05
	Y = 0.025x – 4.79			Y = 519.74x + 61656		
Turbidity	0.949	0.000425	-0.0207	0.841	-2.35E+01	0.000406951
	Y = -0.0207x – 3.372			Y = -104.6x + 2457.3		

Table 5 Summary of Langmuir and Freundlich isotherm models for peat soil

	Freundlich Isotherm			Langmuir Isotherm		
	R^2	K_F	1/n	R^2	a_L	b_L
Ammonia	0.946	2.39221E-07	-1.181	0.811	-6.28E+00	3.33E-07
	Y = -1.1811x – 6.6212			Y = - 477904x + 3E+06		
COD	0.996	0.137	-0.550	0.984	-4.00E-03	2.39E-03
	Y = -0.5495x – 0.8618			Y = -104478x + 417.62		
Color	0.938	0.0272	-0.0538	0.783	-6.85E-02	1.89E-02

	Y = -0.0538x – 1.5649			Y = -771.58x + 52.85		
Iron	0.940	1.57072E-05	-0.0378	0.764	-1.70E+02	1.61E-05
	Y = -0.0378x – 4.8039			Y = -363.77x + 62000		
Nitrate	0.919	6.0562E-05	-0.638	0.741	-6.66E-01	1.21E-05
	Y = -0.6383x - 4.2178			Y = -124201x + 82771		
Phosphate	0.999	1.27673E-05	-0.0918	0.996	-2.81E+01	1.26E-05
	Y = -0.0918x – 4.8939			Y = -2828.1x + 79489		
Turbidity	0.909	0.000177	-0.0651	0.726	-6.34E+00	1.53E-04
	Y = -0.0651x – 3.7531			Y = -1028x + 6520.1		

Percentage Removal of Turbidity

The clarity of treated water is not only important for water consumed directly by human but also for treated wastewater that will end up in natural body of water. Turbidity was tested promptly after the analysis. The vial consisted of the samples were agitated before testing to ensure representative measurement. Sample preservation should be avoided as it can cause the turbidity to increase. Figure 18 shows the turbidity removal was very good by using laterite soil that for dosages above 20g the percentage removal was more than 90%. The highest percentage removal was at 70g with 99.16% removal. The peat soil has lower percentage removal compared to laterite soil. The highest percentage removal for peat soil was 87.14% at 70g dosage.

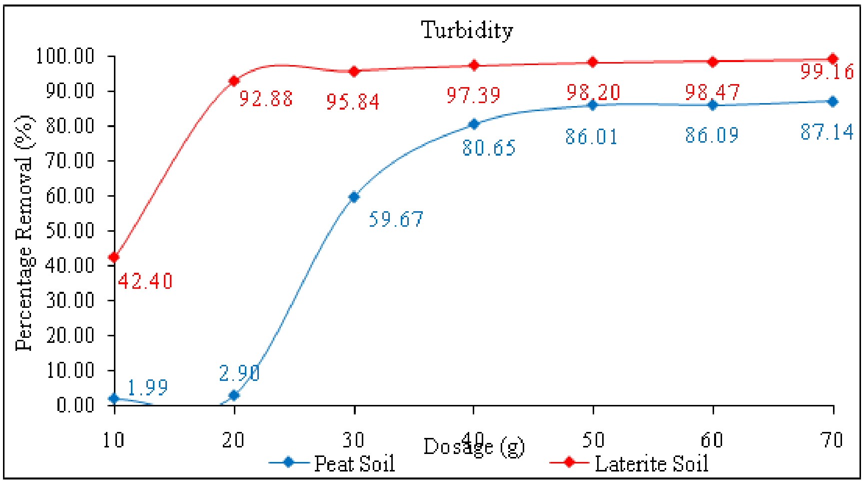


Figure 18 Percentage removal of turbidity versus dosage

Figure 19 describes that the turbidity removal by using laterite soil was highest at pH 6 which is 99.35%. However, at other pH range also gives removal above 90%.

The turbidity removal shown in Figure 41 explains that at pH 9, it has highest percentage removal for peat soil with 97.65% removal.

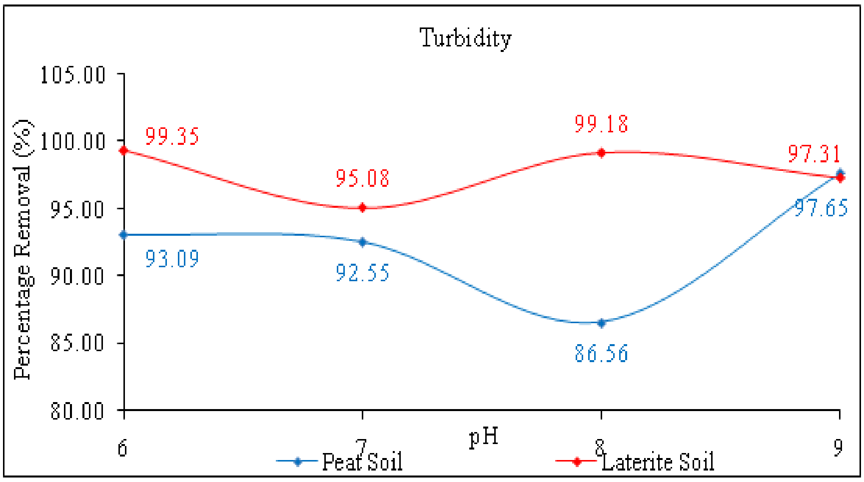


Figure 19 Percentage removal of turbidity versus pH

Adsorption Isotherms for Turbidity

Table 4 and Table 5 show the summary of Langmuir and Freundlich isotherm models and coefficient determination which can be used to identify the most suitable model that works for the adsorption. As for the adsorption by using laterite soil and peat soil for the removal of turbidity, Freundlich isotherm suits the best.

The larger of the value of K_f, the greater the adsorption capacity occurred for pollutants. The constant 1/n is a function of the strength of the adsorbent. The Freundlich isotherm describes reversible adsorption and it is not restricted to the formation of the monolayer [24]. However, higher value of 1/n shows that the adsorption bond is weak. In contrast, if the n value is larger than unity, it means that adsorption is relatively more efficient at low concentrations.

There are many origins of surface charge depending on the nature of the particle and it's surrounding medium. In aqueous media, the pH plays important factor that affects the charge. The particle in the leachate has a negative potential. Hence, if more alkali is added, the particles will tend to acquire more negative charge. In contrast, if acid is added, there will be a point whereby the charge will be neutralized. Further addition of acid will cause a build up a positive charge.

Once acid is added into the leachate, the dissociation of the acidic groups on the surface of a particle will give rise to a negatively charged surface. In contrast, in basic condition, the surface will take on a positive charge. Basically, in both situation, the magnitude of the surface charge depends on the acidic or basic strengths of the surface groups and on the pH of the solution.

Besides, as looking into the chemical properties of tropical residual soils, cation exchange capacity is considered as an important aspect. Cation exchange is a process where some cations of nutrients or metals to be attracted by the molecular structure of clay minerals. Normally, the soil with more organic matter and humus content will have higher cation exchange capacity [25]. Oorts et al., [26] studied that variable charge is related primarily with the oxides and soil organic matter (SOM). Due to the increase of anions from the organic matters, the cations of metals can be more easily attracted. Moreover, cations also have the ability to be exchanged for another positively charged ion from the surfaces of clay minerals and organic matter.

The Cation Exchange Capacity (CEC) can also be used to identify the classification and characteristics of the soils. Soil pH value can affect the CEC value in terms of the charges on the surface of clay minerals [27]. As the pH of the soil increased, the CEC value will be increased simultaneously. Similarly, the organic content in the soil will also contribute to the increase in pH.

Based on the previous research that have been conducted, when the CEC of a soil is higher, the ability of the charged soil surfaces to attract heavy metals cations will be greater in order to balance the charges on and in the soil structure [28]. Hence, if the leachate is allowed to penetrate the soil with higher CEC, the heavy metal ions will be easily absorbed and held to the soil structure. This condition will result in the decrease in the amount of concentration of heavy metals ions in the treated leachate [29].

The drawbacks of the performance depends on the sorbent's selectivity towards the metal whereby in many cases pre-treatment is required in order to improve the adsorption capacity[11]. Even though, chemical or even thermal treatment can be applied in order to modify the cation exchange capacity, the modification would not invariably increase the pollutant uptake. Hence, the adsorbent propriety for the removal must be practical in the real environment that it will be applied [21].

There was variation observed in the data due to the nature of soil materials tested. As the adsorbent and landfill leachate can have a wide variety of characteristics, the current characterization is vital for the application. Besides, the chemicals that are used throughout this study are expensive, corrosive and also highly toxic reagents. Hence, it should be disposed carefully to prevent any pollution.

In the batch study, the adsorbent was mixed with a specific volume of water until the contaminants have been removed to a desired level. Generally the results gained from the batch study will be used to conduct column study. As for the column study, the continuous flow has an advantage compared to batch study because the adsorption will depend on the concentration of solute in the solution being treated. Moreover, the adsorbent is continuously in contact with the influent. Besides, the concentration in the solution in contact with the adsorbents in the column changes very slowly whereas the concentration of the solute in the batch study undergo rapid process which decreases the effectiveness of the adsorbent for removing the solute.

The fixed bed was chosen because the rate of exhaustion of adsorbent is very low. The upflow is applicable for faster adsorption rates and also to avoid excessive head loss, air binding and fouling.

CONCLUSION

Based on the results that had been obtained, the best pH value was found to be pH 6 while the best dosage was found to be in the range of 50g to 70g. This is because the best sorption is different for each parameter that was tested. The combination of the best dosage and best pH was sufficient in removing 73.40% of ammonia and 70.56% of COD by using peat soil. The treatment by using laterite soil could remove 97.65% of color, 98.16% of nitrate and 99.35% of turbidity. Besides, the laterite soil is capable of totally removing phosphate from landfill leachate.

Based on the isotherms adsorption of soil, Freundlich isotherm has better fitting for adsorption by using laterite soil and peat soil. It can be suggested that the peat soil could be used for pre-treatment of landfill leachate followed by treatment by using laterite soil. This is because the capability of laterite soil that could remove various pollutants.In order to be used as adsorbent, as the pH of the system decrease, the number of negatively charged adsorbent sites will decrease. Hence, the number of cations will increase which would not favor the adsorption of positively charged ions due to the electrostatic repulsion. This can be related to the efficiency of peat soil that is more capable of removing ammonia and COD compared to other pollutants.

Moreover, the use of natural adsorbent with high content of clay is vital as an alternative adsorbent in wastewater treatment. This would provide several advantages due to its low cost, abundant availability, non-toxicity and also the potential of ion exchange for charged pollutants.The success of a performance of peat and laterite soil is directly related to the suitable design and maintenance of the system in real treatment facility. However, based on the batch studies that have been conducted, the performance of the peat is not prominent as stated in the previous studies. This may be due to many contributing factors mainly due to the heterogeneity of peat from different locations and also the degree of decomposition which makes the comparing study results to be difficult.

Increment of the dosage shows effectiveness in the removal. After the treatment process, the pH will decrease because as more ions are adsorbed onto the peat and more hydrogen ions will be released. Basically, the pH of the effluent treated by using laterite soil was found to be in the range acceptable by the Environmental Quality act. The proper disposal of municipal solid wastes will sustain the public cleanliness, abatement of environment contamination, transmission of disease and also for the aesthetical reason. The discharge of the leachate can cause serious damage to the eco-environment as it is drained into the water body. Treatment by using peat and red soil can help to reduce energy consumption, low operating management and even higher efficiency in the pollutant removal.

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