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COLUFNAS as Potential Ecofriendly Bio sorption for Leachate Improvement

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Abstract:
Waste management issues have always been a challenging task to most developing countries. Introducing COLUFNAS geotextile as a new adsorbent material in the waste landfill was an alternative way to reduce the amount of chemicals used for leachate treatment. The laboratory work was carried out using geotextile fabric consisted of cylindrical luffa sponge fiber, granular activated charcoal and coconut husk that were fitted into PVC pipes. The filtration was regulated at contact time of 30 minutes and 1 hour treatment. The experimental results showed that the geotextile efficiency exhibited low total suspended solids (TSS) removal, valued 18.74%, 32.27% for turbidity, 49.71% for biological oxygen demand (BOD5), 10% for chemical oxygen demand (COD), 23.61% for ammoniacal nitrogen and 16% for Total Kjeldahl Nitrogen (TKN) in 30 minutes treatment. Alkalinity was increased as the pH value changes from 5.1 to 5.4 after treatment. This study demonstrated that COLUFNAS is applicable for improving the leachate quality.

Keywords:*COLUFNAS; Filtration; Geotextile; Leachate; Wastewater treatment*

I. INTRODUCTION

In a waste landfill, solid waste is one of the main sources for soil and water contamination. The accumulated leachate consists of large amounts of suspended solid and dissolved organic materials from the waste mass of the land-fill site which is heavily contaminated with microbial contaminants and toxic metals. Due to that, the leachate has to be collected and treated through various filtration process and chemical treatment before being released into the environment which require a systematic engineering technology and management method to minimize the potential hazards of solid waste.

Geotextile is mainly used for soil reservation particularly in soil reinforcement, erosion control and minimise surface runoff. Another application of geotextile include separation and filtration between various type of materials, drainage and containment. Geotextile is identified as permeable textile applied along with soil, rock, earth, foundation or geo-engineering materials. The common materials used to produce geotextile include polypropylene, polyethylene, polyamides or polyester.

In this study, an innovative system was developed to improve the quality of leachate through the application of geotextile from luffa and coconut husk. This technology can be used as filtration material for leachate collection system. This innovative solution was more economical and applicable which is an advantage to the waste landfill operator.

Luffa acutangula is widely used across the world as materials for hybrid biodegradable geo-polymer composites and sound adsorbing [1]. The major features of Luffa fibre are high cellulose content, cheaper, biodegradable, and good water adsorbent. Luffa fibre has a thick texture and many pores that prevent the water from passing through easily which is suitable to trap contaminants and solid residues. The previous study conducted by Adie et al. [2] found that luffa fibre has the potential to be used as a primary wastewater filter as the fibre was able to reduce the suspended solid and adsorb the heavy metal. In this research, the luffa fibres was obtained from Sarawak, Malaysia.

According to the data from the coconut industries, Malaysia is ranked the top ten country producing the highest number of coconut each year in the United Nations [3]. There are thousand tonnes of coconut waste disposed into the landfill. Coconut waste is an agro-waste composed of organic matter that can be upgraded into valuable products.

For the filtration system, the coconut husk acted as a clarifier and absorbent at the same time due to their compact fibre structures. The highest cellulose content in coconut husk make it capable to withstand a suspended solids and absorb the pollutant [4]. The study by Aravind et al. [5] showed that coconut husk has great adsorption capability towards Nickel (Ni), Copper (Cu) and Cadmium (Cd).

Other than natural fibres, activated charcoal by product of coconut shell that has gone through the activated process, was also obtained from the agriculture waste. Activated charcoal is commonly used in wastewater treatment plant as agents to adsorb heavy metal, increase pH value and to improve the concentration of ammoniacal nitrogen and colour of leachate liquid [6].

Based on this concept, a filtration system consisted of agriculture waste labelled as COLUFNAS was developed as a filtration adsorbent material .Therefore, the objectives of this research was to implement the COLUFNAS filtration system and evaluate its effectiveness in improving the leachate quality from the landfill.

II. METHODOLOGY

A. Materials and Methods

The experimental materials, methods and set-up for this study was designed by applying the actual situation of leachate landfill.

1) COLUFNAS Geotextile Preparation: In this study, the luffa fibre, coconut husk and activated charcoal were obtained as ready to use with no further treatment needed. In the laboratory, the luffa fibre was cut into two. The coconut husk and activated charcoal were inserted into the vascular space of luffa fibres as shown in Figure 1.

2) COLUFNAS Geotextile Filter Media Preparation: The 30 cm PVC pipe was drilled with small holes (0.5 cm in diameter) to allow steady flow of leachate to pass through. Then, the COLUFNAS geotextile was inserted into the 8 PVC

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pipes. The filter media was assembled in Container 2 as shown in Figure 2.

3) *Experimental Set-up:* This experiment involved three parts; the untreated leachate in Container 1 (C1), the leachate with COLUFNAS geotextile filter media in Container 2 (C2) and the treated leachate in Container 3 (C3) as shown in Figure 3. The pump was placed in Container 2 and Container 3.

4) *Sampling Method:* For sampling, the sample was collected from the leachate landfill at Kuala Lumpur Transfer Station. The 25 L of untreated leachate was taken from the outlet of oil skimmer tank. The untreated leachate was filled into Container 1, passed to Container 2 and Container 3 and pumped back to Container 1. The filtration process was continued in a circulation motion as shown in Figure 3. The treated leachate sample in Container 3 was collected at 30 minutes and 1 hour.

Fig. 1 COLUFNAS geotextile

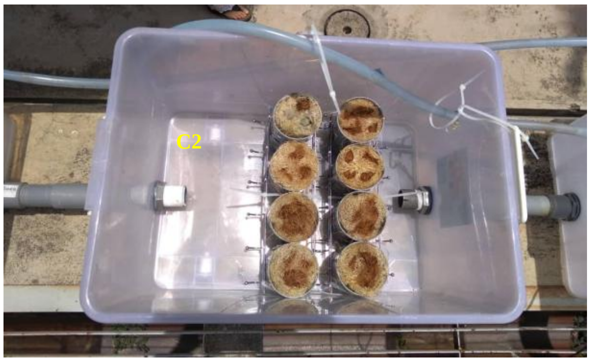

Fig. 2 COLUFNAS geotextile filter media in Container 2

Fig. 3 Flow of leachate liquid in the filtration system

B. Analytical Procedure

For leachate quality measurement, three types of samples were collected (2 litres each) to carry out eight parameters analysis; (1) the untreated leachate,

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(2) the 30 minutes of treated leachate and (3) 1 hour of treated leachate samples. The parameters were analysed according to the guidelines by the American Public Health Association, 21st Edition (2005), as shown in Table I below [7]:

TABLE I

THE PARAMETERS OF LEACHATE QUALITY ANALYSIS

No.	Parameter	Analysis Method
1.	pH	pH Meter
2.	total suspended solids (TSS)	APHA 2540 D
3.	turbidity	APHA 2130 B
4.	biochemical oxygen demand (BOD_5)	APHA 5210 B
5.	chemical oxygen demand (COD)	APHA 5220 C
6.	nickel as Ni	APHA 3111-B, APHA3030 F
7.	zinc as Zn	APHA 3111-B, APHA3030 F
8.	ammonia as TKN	DOE (M'SIA 1995)(REF)
9.	ammoniacal nitrogen	APHA 4500 NH_3 B

5) pH: The leachate sample was poured into a beaker. The portable pH meter was rinsed with distilled water before used. The sample was stirred vigorously until the pH reading was constant.

6) Total Suspended Solids: A piece of filter paper was weighed. The 20 mL of leachate was filtered through Buchner funnel then transferred to an oven at a temperature of 100 ^{o}C for 1 hour and weighted. The data was recorded in mg/l unit.

7) Turbidity: The leachate sample was filled in the vial before being placed into the turbiditimeter. The reading was recorded in mg/l unit.

8) Biochemical Oxygen Demand: 20 mL of leachate sample was poured into the BOD bottle. The BOD bottle containing leachate sample was filled up by an aeration water. The BOD bottle was checked again to ensure no air bubble inside the bottle before being sealed. The sample was left for 5 days in the incubator. The reading was measured by portable digital BOD meter after 5 days.

9) Chemical Oxygen Demand: The 2 mL of leachate sample was poured into a vial containing COD reagent. The mixture was mixed and transferred into the reactor. The vial was heated up at 150 ^{o}C for 120 minutes. Then, the vial was cooled down under tap water for 20 minutes. After that, the vial was placed into a spectrophotometer for measurement reading.

10) *Ammoniacal Nitrogen:* 25 mL of leachate sample was filled into a mixing cylinder while 25 mL of deionized water was filled into another mixing cylinder (controller). Three drops of mineral stabilizer was added to each mixing cylinder. The mixing cylinder was closed by the stopper and mixed. Three drops of polyvinyl alcohol dispersing agent was added to each of mixing cylinder then, mixed. After that, 1 mL of Nessler Reagent was added into each mixing cylinder and then mixed. The mixtures were left for 1 minutes to react. The 10 mL mixture of controller cylinder was poured into the sample cylinder. The controller cylinder was inserted into the cell holder, the zero button was pushed and the 0.00 mg/L NH_3-N reading was shown. The steps were repeated for the sample cylinder to obtain the results.

11) *Ammonia as Total Kjeldahl Nitrogen:* The leachate sample was preserved with sulphuric acid (H_2SO_4) to ensure the pH level was less than 2. The 25 mL of leachate was poured into the digestion tube. Then, the 10 mL of copper based digestion solution was added to the digestion tube. The vortex mixer was used to mix the mixture. Two boiling stones were added into the tube. The TKN digestion block was preheated to 160 ^oC. Next, the tube was placed in the block at a stable temperature of 160 ^oC for an hour. After an hour, the temperature was heated up to 380 ^oC for 1 hour. The temperature of 380 ^oC was stabilized for 30 minutes. The tube then was removed and allowed to cool for 10 minutes. The reagent water was then added into the tube until the volume reach 25 mL. The probe was inserted into the tube and the reading was recorded.

12) *Nickel and Zinc Determination:* The sewage sludge of leachate liquid was dried at 105 ^oC. The 6cm^3 nitric acid, HNO_3 and 2 cm^3 of hydrochloric acid, HCl were added to 0.5 g of dried sewage in a beaker. The beaker was covered and the solution was left to be boiled on a hot plate for 2 hours. After 2 hours, the remaining precipitate was placed into the 100 cm^3 volumetric flasks. Then, the flask was filled with deionized water before being filtered. The amount of nickel and zinc present in the sample was determined by spectrometer [8].

III. RESULT AND DISCUSSION

Table II below shows the physical and chemical properties of leachate before and after filtration by using COLUFNAS geotextile. The samples were taken at an interval of 30 minutes and 1 hour treatment and physically and chemically tested to monitor the efficiency of the COLUFNAS throughout the treatment process.

Total Suspended Solids (TSS) was described as a particle exists in leachate that can be screened by a filter media. TSS consists of wide variety of matter, suchlike plant and animal decay, sediment, plankton and sewage [9]. The results showed that the TSS present in the leachate revealed a greater amount of suspended solid for the untreated leachate. However, after the filtration, the amount of suspended solids has decreased significantly from 8,380 mg/l to 6,810 mg/l at 30 minutes treatment and 6,460 mg/l at 1 hour treatment. Therefore, this demonstrated that the geotextile filter containing luffa and coconut husk were capable in filtering the sediment [4], [2], [10].

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TABLE II
PHYSICAL AND CHEMICAL BEHAVIOR OF LEACHATE

No.	Parameter	Unit	Untreated	30 Minutes of Treatment	1 Hour of Treatment
1	pH	-	5.1	5.4	5.5
2	total suspended solids (TSS)	mg/l	8,380	6,810	6,460
3	turbidity	mg/l	21,321	14,015	16,474
4	chemical oxygen demand (COD)	mg/l	40,000	36,000	33,333
5	biochemical oxygen demand (BOD_5)	mg/l	20,674	10,397	10,397
6	nickel (Ni)	mg/l	0.06	0.02	0.02
7	zinc (Zn)	mg/l	0.02	0.01	0.01
8	ammoniacal nitrogen	mg/l	504	385	399
9	ammonia as TKN	ADMI	1,400	1,176	1,709

The decrease of TSS readings consequently affect the clarity of water sample. High suspended solids reduce water transparency. However, turbidity measurement is not exactly represent the TSS materials in the leachate sample. As the TSS reading gradually decreased, the leachate clarity was dramatically increased in 30 minutes treatment at about 34% from 21,321 mg/l to 14,015 mg/l. The low turbidity reading represent high water clarity and quality. There were approximately 23% increment in turbidity efficiency at 1 hour treatment. The decomposition of organic matter by bacteria has contributed to the decreasing of turbidity removal. According to Islam et al., the amount of turbidity removal was directly proportional to the number of bacteria present [10]. Some of the existing solids subsequently will degrade after a long time period.

COD and BOD_5 are necessary parameters during the leachate treatment. Chemical oxidation is required for the leachate treatment containing soluble organic which unable to be removed by physical filtration. The findings indicated that the COD removal efficiency gets higher with increasing time. The COD reading of untreated leachate was recorded as 40,000 mg/l, respectively. The organic removal rate efficiency was calculated as 10% in 30 minutes treatment while 17.5% in 1 hour treatment. The results demonstrated that the COLUFNAS geotextile filter enhanced the degradation of organics in the leachate. The biomass attached to the fibre was decomposed by the bacteria and the metabolic activity of the bacteria consumed the available oxygen in the system [2], [5], [11].

BOD commonly represent an identical parameter to COD. However, BOD test express the biodegradable portion of the organic matter in the leachate sample. It was clearly seen that the efficiency of BOD_5 removal value reduced by 50% in 30 minutes treatment from 20,674 mg/l to 10,397 mg/l. The value was maintained for 1 hour treatment. This positive results mainly related to the change in the amount of microorganisms and the decomposition of organic compounds due to the adsorbent behaviour of COLUFNAS geotextile fibres. The used of activated charcoal increased the efficiency of adsorption in this treatment because of its high microspore volume characteristic [12].

The total contents of Ni and Zn in the leachate sample and the corresponding discharge standard are presented in Table II below. Ni and Zn showed a progressive reduction. The concentration of Ni decreased to 0.02 mg/l, 67% lower than the untreated leachate values of 0.06 mg/l. The Zn contents slightly decreased from 0.02 mg/l to 0.01 mg/l. The contents of Ni and Zn were still in the control range. The higher and rapid adsorption capacity of activated charcoal towards heavy metal and pollutant promote the stability to the system as it has a larger surface area and even pore size distribution [13]. The present of luffa fibre and coconut fibre added more impact to the heavy metal removal in the system [2], [5].

The ammoniacal nitrogen values as tabulated in Table II showed the ammonia, NH_3 concentration of leachate showed various changes over time. There are no stable trend in the ammonia reading concentration as time passed by. The ammoniacal nitrogen of raw leachate was recorded as 504 mg/l, respectively. The 30 minute treatment of COLUFNAS geotextile filtration of leachate stated that the concentration of ammonia decreased to 385 mg/l at 30 minutes treatment and then slightly increased by 3.3% to 399 mg/l after 1 hour of treatment. The previous study carried out on the sugar base derived activated charcoal for wastewater treatment discussed that the carbon of activated charcoal was highly recommended to lower the level of ammoniacal nitrogen in the wastewater [14].

Most of the nitrogen content in the leachate is in the form of ammonia, NH_3 while the ammonia commonly exists in an ionized form as ammonium, NH_4^+ resulting from the association of ammonia molecule with water, H_2O. The lowest value of ammonia content in leachate indicates the highest value of pH. It was strongly agreed as the values of pH increased from 5.1 to 5.4 in 30 minute treatment while 5.5 in 1 hour treatment. It can be concluded that the concentration of ammonia is inversely proportional to pH value [15].

However, there were not much differences in the amount of nitrogen concentration falling at zero hour to 30 minutes treatment. The nitrogen content decreased by 16% from 1,400 ADMI at the beginning to 1,176 ADMI at 30 minute treatment. However, the TKN reading showed an increment of nitrogen concentration to 1,709 ADMI at 1 hour treatment progress. The TKN value is the total amount of ammonia and total organic nitrogen. Thus, the TKN is always greater that ammonia concentration [15].

IV. CONCLUSIONS

In this study, it was observed that the optimum time of COLUFNAS geotextile filtration was at 30 minute treatment. The performance of geotextile filter exhibited excellent improvements for all parameters such as reducing suspended solids, turbidity, COD, BOD_5, heavy metal, ammonia and nitrogen concentration. It can be concluded that the COLUFNAS geotextile made up of agriculture waste was proven to be effective in treating leachate at the landfills. This product offers a reliable and economic alternative in reducing high cost chemical filtration using the natural and biological approaches.

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