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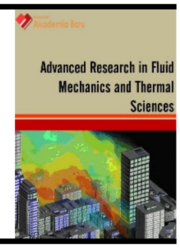

Combined Adsorption and Biological Treatment for Landfill Leachate Management

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ABSTRACT

Although landfilling is generally used for solid waste disposal, use of landfill will always accompanied with production of turbid, odorous and dark brownish liquid which known as leachate. Due to leachate adverse impacts towards public health, environment and ecosystem, raw leachate wastewater should be treated properly before discharging into the environment and leachate wastewater can be treated biologically, physically and chemically. The treatment efficiency will be mainly affected by leachate composition and treatment method. In this study, B. panacihumi strain ZB1 was used for leachate biological treatment and light weight aggregates was used as adsorbent for pollutants removal. The leachate samples were treated by combined adsorption and biological treatment. Sole biological treatment removes nearly 40% of COD and nearly 40-50% of ammonia nitrogen from leachate samples. Adsorbent able to remove high levels of ammonia nitrogen and increase of adsorbent doses would increase the removal efficiency. Due to cost and efficiency consideration, combined adsorption and biological treatment had been applied for leachate management. Combined treatment allowed more than 70% of ammonia nitrogen from leachate wastewater. Since removal of COD from leachate wastewater does not being reported in this study, other treatment methods or optimization step should be carried out.

Keywords:
Leachate, biological treatment, adsorption

1. Introduction

Due to urbanization and industrialization, huge amount of solid wastes is generated in Malaysia and landfilling is most generally accepted disposal way due to economic advantage and simple operation [1]. Use of landfill for waste disposal will always accompanied with production of turbid, odorous and dark brownish liquid which known as leachate [1]. The leachate treatability and biodegradability will be affected by pollutants composition such as organic materials and heavy metals that present in the leachate wastewater [1]. Due to leachate adverse impacts towards public health, environment and ecosystem, the leachate can be treated biologically, physically and

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chemically [2,3]. The leachate wastewater characteristics may be varied depend on their source and composition, hence, leachate treatment method should be selected wisely to improve the overall treatment efficiency and treated wastewater quality [4].

Leachate wastewater can be characterized into young and mature leachate. As compared to young leachate, mature leachate will be less amenable to biological treatment due to presence of refractory compounds in the mature sample [4]. Presence of high levels of refractory compounds in the leachate sample may exhibit different degrees of inhibition effects on microbial growth [5,6] and adversely affect the biological treatment efficiency. Hence, use of adsorption process for pollutants removal from wastewater is highly recommended especially for wastewater sample that is less amenable to biological treatment [6]. Generally, many different types of adsorbent such as sand, peat and activated carbon can be used for adsorption process [7]. The criteria needed for selection of suitable adsorbent for wastewater treatment process are high porosity, high surface area, high stability and strong adsorption force [7-9]. Although use of adsorbent has brought many advantages, adsorbent is currently not so appropriate for large application due to high cost required [9].

Use of adsorption process together with the biological treatment process is expected able to reduce the amount of adsorbent used for wastewater treatment process and improve the overall treatment efficiency. In this study, biological treatment process is used together with physical adsorption method and light weight aggregates is used as adsorbent for pollutants removal.

2. Methodology

Leachate samples used for this research study were collected from landfills located at Johor, Malaysia and the samples were named as sample A and B. For leachate treatment, combination of physical adsorption and biological treatment were used.

A preliminary study was carried out to determine the suitable dose of light weight aggregates that could be used as adsorbent for leachate wastewater management. The detailed information of light weight aggregates was presented previously [8]. 12%, 24% and 50% (w/v) of light weight aggregates were used for 10 days leachate management. *B. panacihumi* strain ZB1 was used for leachate biological treatment and added when light weight aggregates showed maximum adsorption capability. Leachate biological treatment was started with anaerobic condition and further carried out under aerobic condition.

After treatment process, treated samples were centrifuged at 4000 rpm for 15 minutes [10]. The parameters used for treatment efficiency determination were COD concentration and ammonia nitrogen that present in raw and treated samples. The COD concentration was measured by Reactor digestion method [11] and ammonia nitrogen level was measured by Nesslerization method [12].

3. Result and Discussion

B. panacihumi strain ZB1 was used for leachate biological treatment under sequentially anaerobic-aerobic treatment condition and the detailed result of leachate treatment by using sole *B. panacihumi* strain ZB1 was presented previously [13,14]. Table 1 summarized the removal rate of ammonia nitrogen and COD from leachate wastewater after 42-days treatment session [13,14].

Table 1
Sole biological treatment of leachate samples by using *B. panacihumi* strain ZB1

Parameter	Leachate sample	Removal rate (%)		
		21- days anaerobic treatment	21- days aerobic treatment	Overall removal
Ammonia nitrogen	A	-10.6	52	47
	B	-62	62	37.6
COD	A	27.3	27.3	27.3
	B	35.9	35.9	35.9

*(-) refers to increase of pollutants concentration after treatment process

As reported in the study by Er *et al.,* [13,14], nearly 40% of COD and nearly 40-50% of ammonia nitrogen were removed from the leachate samples via sole biological treatment by using *B. panacihumi* strain ZB1. As shown in Table 1, anaerobic condition was mainly responsible for COD removal and aerobic condition was mainly responsible for ammonia nitrogen removal. Since sole biological treatment can only displayed certain treatment efficiency for leachate wastewater management, adsorption process had been used together with biological treatment enhance the treatment efficiency.

Different doses of light weight aggregates had been used for leachate wastewater management and Table 2 showed the removal efficiency of using different doses of light weight aggregates. As observed from Table 2, higher ammonia nitrogen removal efficiency could be achieved as the doses of light weight aggregates increased. Light weight aggregates with mass concentration of 24% (w/v) and 50% (w/v) allows approximately 50% and above for removal of ammonia nitrogen and non-target pollutants from both treatment samples. As reported by Hegazi [15], higher mass concentration of adsorbent will provide larger surface area that provides higher adsorbent surface for pollutants attachment.

Table 2
Sole adsorption treatment of leachate samples by using different doses of light weight aggregates

Treatment sample	Adsorbent (w/v)	Ammonia nitrogen concentration (mg/L)		Removal efficiency (%)
		Before treatment	After treatment	
A	12%	2100	1120	46.7
	24%		1080	48.6
	50%		207.5	90.1
B	12%	960	680	29.2
	24%		370	61.5
	50%		55.5	94.2

As summarized from Table 2, light weight aggregates with doses of 24% (w/v) was selected for combined adsorption and biological treatment due to cost consideration. Figure 1 showed the concentration of ammonia nitrogen being removed from both of the leachate samples via combined adsorption and biological treatment.

As shown in Figure 1, decreasing trend of ammonia nitrogen concentration showed after combined adsorption and biological treatment. After 10-days adsorption process, light weight aggregates able to remove 48.6% and 61.5% of ammonia nitrogen from leachate sample A and sample B. Fluctuation of ammonia nitrogen concentrations during adsorption process might be contributed by desorption of pollutants from the surface of light weight aggregates. Weak bonding between ammonia nitrogen and adsorbent surface would lead to desorption or leaching process [7,9].

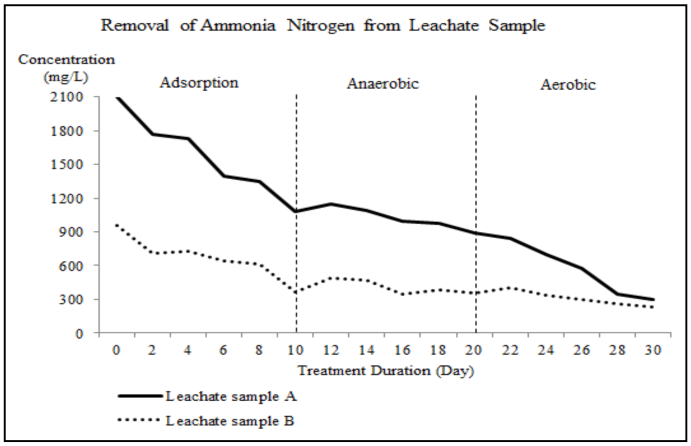

Fig. 1. Removal of ammonia nitrogen from leachate samples

Initial addition of *B. panacihumi* strain ZB1 into the leachate samples had slightly increased the ammonia nitrogen concentration. This might be contributed by degradation of COD by *B. panacihumi* strain ZB1. After 10-days anaerobic treatment process, ammonia nitrogen removal rate has been increased to 57.6% for leachate sample A and 62.5% for leachate sample B. Leachate treatment under aerobic condition has been carried out for another 10 days and overall removal of ammonia nitrogen from leachate sample A and sample B were 86% and 76% respectively. Ammonia nitrogen was used by microorganisms for their growth and biosynthesis process [16,17].

As shown in Figure 2, during the combined treatment process, the COD concentration in both leachate samples showed fluctuation. The COD concentrations of leachate sample A and sample B were increased to 29% and 5% after adsorption process. Increase of COD concentration might due to releasing of sand or cement from the light weight aggregates. Addition of *B. panacihumi* strain ZB1 into the leachate samples had reduced the 21% and 2% of COD from leachate sample A and sample B under anaerobic condition and contributed to increase of ammonia nitrogen concentration as shown in Figure 1. Increase of COD concentration after aerobic treatment process for both leachate samples might be contributed by growth of *B. panacihumi* strain ZB1 in the leachate samples.

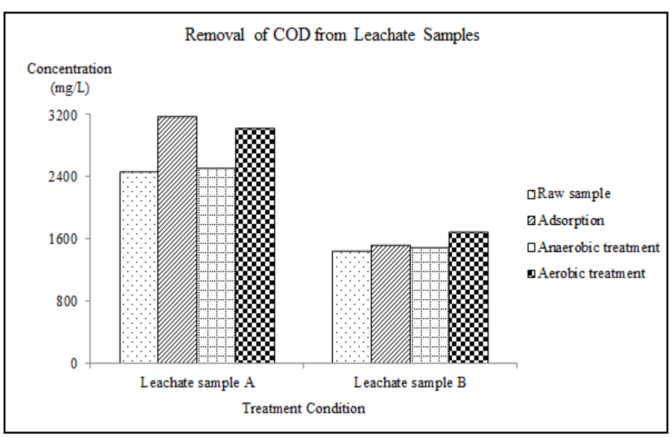

Fig. 2. Removal of COD from leachate samples

As referring to the data summarized above, sole biological treatment could only remove certain levels of target pollutants from leachate wastewater samples, while high doses of adsorbent able to remove high levels of pollutants within short duration. Due to cost and treatment efficiency consideration, combined adsorption and biological treatment is highly recommended for leachate management.

4. Conclusion

In a nutshell, use of light weight aggregates as adsorbent for leachate management able to remove high level of ammonia nitrogen from leachate sample. As the doses of light weight aggregates increased, high removal rate can be achieved within short duration. After adsorption process, the ammonia nitrogen toxicity is expected to be reduced and inhibition effect exerts on biological treatment system is reduced. Hence, microorganisms have better growth environmental condition and allow further removal of ammonia nitrogen from leachate sample above 70%. Since removal of COD from leachate wastewater does not being reported in this study, other treatment methods or optimization step should be carried out.

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