

## ORIGINAL ARTICLE

# The Effectiveness of Coconut-Dreg Based Mudball in Treating Leachate Contaminated River Water Near Jeram Sanitary Landfill Selangor

Muhammad Firdaus Jusoh <sup>1</sup>, Farah Ayuni Shafie <sup>1\*</sup>, Norhidayah Abdullah <sup>2</sup>, Saidatul Afzan Abdul Aziz <sup>2</sup>, and Noriza Ishak <sup>2</sup>

<sup>1</sup> Centre for Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM), Puncak Alam Campus, Selangor, Malaysia

<sup>2</sup> Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM), Puncak Alam Campus, Selangor, Malaysia

## ABSTRACT

**Introduction:** Leachate generated by the waste management industry contributes significantly to water pollution, highlighting the critical need for environmentally friendly, cost-effective, and energy-efficient wastewater treatment approaches. In pursuit of this purpose, coconut dregs, a by-product of the food industry, were chosen for their potential in a circular economy framework that adheres to the cradle-to-cradle principle. Mudball is a well-known biological treatment method for wastewater. Thus, this study investigates the effectiveness of coconut dregs as additional components to the mudball in enhancing the removal of pollutants in leachate contaminated river water. **Materials and Methods:** Parameters such as pH, temperature, turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal nitrogen were used to determine the characteristic, pollutant removal rate, and the significant difference between the efficiency of conventional EM mudball and coconut-dreg based mudball in treating leachate contaminated river water. **Results:** The outcomes from this study showed that mudballs made from coconut dregs performed better in terms of controlling turbidity (-1328%), maintaining chemical oxygen demand (-1292%), and ammoniacal nitrogen (-54%). The alkaline and fibrous nature of coconut dregs were identified as the main factors contributing to these favourable results. **Conclusion:** These findings make an essential addition to sustainable wastewater treatment practices, offering potential improvements in reducing the environmental impact of leachate discharge. Future research may look into the optimal mudball conditions suitable for specific types of wastewater and more effective wastewater treatment.

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## Corresponding Author:

Farah Ayuni Shafie, PhD

Email: farahayuni@uitm.edu.my

Tel: +603-3258 4450

## INTRODUCTION

Over the years, waste generation worldwide has increased dramatically due to rapid urbanisation and population growth. According to Karimi et al. (1), global garbage production is anticipated to increase by 72% due to increased urbanisation rising to 3.50 billion tonnes in 2050 from 2.0 billion tonnes in 2016. Waste can contain harmful substances that can cause environmental issues and health problems. Landfilling is the most common method of solid waste management by storing waste in sanitary landfills in cells that prevent infiltration into the ground (2). However, this method of storage results in the generation of highly polluting

waste effluent recognised as landfill leachate.

"Landfill leachate" describes any contaminated liquid or wastewater formed by stormwater runoff seeping through accumulated pollutants and waste products before migrating into the subsoil and adjacent areas (3). Hence, landfill leachates are generated because of too much precipitation infiltration through various waste layers within the landfill. Contaminants are transferred from municipal solid waste areas to the percolating or infiltrated water by a variety of physical, chemical, and microbial process combinations within the landfill component waste. The composition and amount of the leachate can vary significantly depending on various factors, such as the type of waste, operational circumstances, climate, hydrogeology, and landfill age (4).

The leachate acts as a strong wastewater that contains primary pollutants like inorganic macro components,

heavy metals, dissolved organic matter, and xenobiotic organic compounds that can pose a threat to both surface water and groundwater (5). The characteristics and quality of the generated leachate have significantly affected the depth of the waste, landfill operation, rate of water infiltration, and age of the landfill together with the disposal of sewage sludge and incinerated ash (6). Mudball is a green technology used in treating raw water by using effective microorganisms (EM) by consuming the organic matter and nutrients which will activate the sludge sitting on the bottom and start to decompose the sludge. At the same time, hazardous gases are consumed by phototrophic bacteria, preventing the release of unpleasant odours (7). Coconut dregs contain lignocellulosic material constituents and high carbohydrate content. Biomass-based adsorbent materials like coconut dreg residue can act as a cost-effective biosorbent for metal impurities (8).

In short, this study aims to contribute to a sustainable approach to landfill leachate wastewater management practices in the national waste management industry by highlighting the environmental challenges caused from leachate contaminated river water, the potential of mudballs as a wastewater treatment approach, and the significance of investigating the efficiency of coconut dregs as an additional composition in mudballs.

## MATERIALS AND METHODS

### Study Location and Sampling Method

The study location is at a downstream river beside the Jeram Sanitary Landfill which is located at Lot 2958, 2959 & 1598 Tuan Mee Estate, Jeram, District of Kuala Selangor, Selangor Darul Ehsan. The convenient access point was chosen in the sample collection process. The sample is stored in 5L sterile bottles and transported to the laboratory for sample preparation.

### Mudball Preparation

Both types of mudballs – conventional EM mudballs and coconut-dreg based mudballs were prepared before leachate contaminated river water samples were collected. Cellulose in coconut dregs offers enormous potential for use in the development of useful materials. The mudball formulations were tested in three batches as part of a pilot study, and the final formulations that came from the preliminary investigation were used in the later stages of the research.

### Experimental Setup

The collection involved a grab sample technique, extracting 6 liters of leachate contaminated river water from the sampling point. Daily observations were conducted over 22 days for the treatment process. The characterization of leachate contaminated river water samples was initiated on the first day of the experiment through comprehensive laboratory analysis.

## Study Design

A laboratory-based experimental method was used in this study to evaluate the effectiveness of coconut dreg as an additional component in conventional mudballs to treat leachate contaminated water from the landfill. The effectiveness of eliminating physicochemical characteristics from wastewater using conventional mudballs and coconut-dreg based mudballs will be compared within the scope of the study. This study includes the examination of various parameters, namely pH, temperature, turbidity, dissolved oxygen, ammoniacal nitrogen, and chemical oxygen demand.

## Data Collection and Analysis

The parameter reading of pH, temperature, turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal nitrogen was recorded every day starting from day 1 until day 22. Fig. 1 depicts the condition of leachate contaminated river water during day 1 and day 22. Data on the removal trend of physicochemical parameters, including turbidity, chemical oxygen demand, and ammoniacal nitrogen was collected during the experimental period. The data was analysed using an independent t-test, to assess the significant difference between the efficiency of coconut-dreg based mudball and conventional EM mudball in treating landfill leachate contaminated river water.

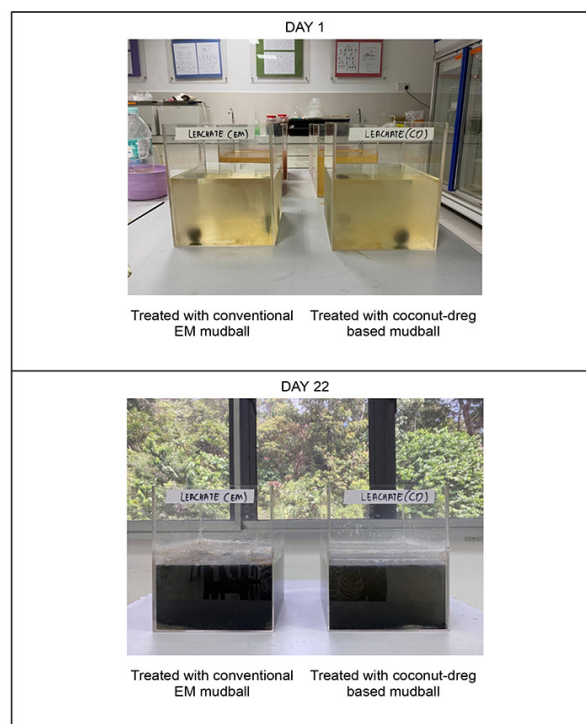


Fig. 1: The condition of leachate contaminated river water during day 1 and day 22.

## RESULTS

The characteristics data of landfill leachate contaminated river water is obtained from the initial parameter reading for pH, temperature, turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal

nitrogen. Table I shows the characterization of leachate contaminated river water characteristics based on pretreatment parameters.

**Table I: The characteristics parameters of leachate contaminated river water.**

Parameter	Leachate Contaminated Water	NWQS CLASS III
<b>Initial Readings</b>		
pH	6.09	5.0 – 9.0
Temperature (°C)	22.4	Normal + 2°C
Turbidity (NTU)	9.84	-
Dissolved Oxygen, DO (ppm)	3.12	3 - 5
Chemical Oxygen Demand, COD (mg/L)	45.5	0.9
Ammoniacal Nitrogen (mg/L)	21.4	50

The effectiveness of the conventional EM mudball and coconut-dreg based mudball were evaluated in terms of water improvement and comparison with the National Water Quality Standard (NWQS). The results of the parameter reading between the two types of mudballs are shown in Table II.

The pH, temperature, chemical oxygen demand, and ammoniacal nitrogen parameters indicate normal data distribution. However, turbidity and dissolved oxygen parameters indicate non-normal data distribution. In statistical data analysis, normal data distribution proceeded with a parametric test which is an independent t-test whereas non-normal data distribution proceeded

with a non-parametric test which is the Mann-Whitney test to measure the significance of the collected data. A p-value is the likelihood of finding a mean difference by chance if indeed there is no difference in the population and is mostly set at  $p=0.05$  (9). If a p-value reported is less than 0.05, then that result is said to be statistically significant and vice versa. The coconut-dreg based mudball shows slightly better performance in treating leachate contaminated river water than conventional EM mudball as shown in Table III.

**Table III: Comparison of the effectiveness of conventional EM mudball and coconut-dreg based mudball in leachate contaminated river water treatment.**

Parameter	Type of Mudball	Mean $\pm$ Std. Deviation	P-Value
pH	Conventional EM	6.69 $\pm$ 0.93	p=0.544
	Coconut-Dreg Based	6.89 $\pm$ 1.12	
Temperature	Conventional EM	22.42 $\pm$ 0.43	p=0.944
	Coconut-Dreg Based	22.43 $\pm$ 0.42	
Turbidity	Conventional EM	110.76 $\pm$ 46.57	p=0.156
	Coconut-Dreg Based	102.05 $\pm$ 42.90	
Dissolved Oxygen	Conventional EM	0.32 $\pm$ 0.63	p=0.011*
	Coconut-Dreg Based	0.35 $\pm$ 0.621	
Chemical Oxygen Demand	Conventional EM	361.47 $\pm$ 195.16	p=0.700
	Coconut-Dreg Based	339.45 $\pm$ 181.79	
Ammoniacal Nitrogen	Conventional EM	27.91 $\pm$ 4.11	p=0.533
	Coconut-Dreg Based	27.18 $\pm$ 3.56	

\*Statistical significance at  $p<0.05$

**Table II: The removal trend on selected parameters of mudball.**

Types of mudball	Parameters	Results			Removal (%)	NWQS CLASS III
		Initial	Final	Average		
Conventional EM Mudball	pH	6.09	7.78	6.94	-	5.0-9.0
	Temperature (°C)	22.4*	22.6*	22.5*	-	Normal+2°C
	Turbidity (NTU)	9.84	150.05**	79.95**	-1428	-
	Dissolved Oxygen (mg/L)	3.12	0.13*	1.62*	-	3-5
	Chemical Oxygen Demand (mg/L)	45.5**	682.5**	364.0**	-1400	0.9
	Ammoniacal Nitrogen (mg/L)	21.4	35.4	28.4	-65	50
Coconut - Dreg Based Mudball	pH	6.09	8.08	7.09	-	5.0-9.0
	Temperature (°C)	22.7*	22.6*	22.65*	-	Normal+2°C
	Turbidity (NTU)	9.84	140.54**	75.19**	-1328	-
	Dissolved Oxygen (mg/L)	3.12	0.18*	1.65*	-	3-5
	Chemical Oxygen Demand (mg/L)	45.5**	633.5**	339.5**	-1292	0.9
	Ammoniacal Nitrogen (mg/L)	21.4	33.0	27.2	-54	50

\* Lower than the range

\*\* Exceed the acceptable limit

A negative value in the removal rate indicates there is no removal of pollutants.

## DISCUSSION

Characterization of Leachate Contaminated River Water  
The results from the initial readings of various parameters in landfill leachate river water collected near Jeram sanitary landfill, Selangor sampling points, provide insights into the characteristics of the wastewater as shown in Table I. The pH level from leachate contaminated river water sample indicates the slightly low acidity of the wastewater. In nature, biological debris like plant matter releases acidic compounds like tannins and humic acids when it breaks down by bacterial action or by simple chemical decay, and the release of acidic compounds from animal tissue like amino acids makes the water body slightly acidic (10). The turbidity illustrates low suspended solids in the water, including silts, clays, industrial wastes, sewage, and plankton. Low levels of dissolved oxygen below 5 ppm in a water body are considered stressful for aquatic organisms (11). The chemical oxygen demand (COD) is considered quite high as the present high amount of oxygen required to chemically oxidise the organic material and inorganic nutrients in the leachate contaminated water (12). The higher the chemical oxygen demand level indicates that the water is more polluted. Lastly, the high level of ammoniacal nitrogen shows a high amount of ammonia that is present in water. All the parameters are within the National Water Quality Standard Class III requirement except for the chemical oxygen demand. The leachate contaminated river water sample shows the presence of landfill leachate as it contains low levels of dissolved oxygen, high-level chemical oxygen demand, and ammoniacal nitrogen.

### Effectiveness of Mudball in Treating Leachate Contaminated Water

Table II shows pH, temperature, turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal nitrogen reading for the landfill leachate contaminated river water for both types of mudball. The pH, temperature, turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal nitrogen data of the leachate contaminated river water samples.

By referring this value of pH to the National Water Quality Standards (NWQS), the pH value for both types of mudball is still in the range of pH 5.0 - 9.0 which falls in Class III. Effective microorganisms (EM) are a group of roughly 80 species of microorganisms divided into photosynthesizing bacteria, lactic acid bacteria, yeasts, actinomycetes, and fermenting fungi which can purify and rejuvenate nature (13). For instance, the main species that are commonly implicated are the *Lactobacillus plantarum*, *L. casei* and *Streptococcus lactis* (lactic acid bacteria), *Rhodospseudomonas palustris*, and *Rhodobacter spaeroides*, (photosynthetic bacteria), *Saccharomyces cerevisiae* and *Candida utilis* (yeasts), *Streptomyces albus* and *S. griseus* (actinomycetes), and *Aspergillus oryzae*, *Penicillium sp.* and *Mucor hiemalis*

(fermenting fungi) (13). It can be inferred that the microorganisms present may play a role in balancing the pH of the water sample through their metabolic activities by deploying reactions that produce basic compounds to help neutralize the low pH (14). Therefore, both mudballs are effective in stabilising the landfill leachate contaminated river water.

The water temperature for all sampling data ranges from 22.0 to 24.0°C which is below the normal range stated in National Water Quality Standards (NWQS) as the influence of the surrounding temperature. The National Water Quality Standards for Malaysia (NWQS) do not specify a single, universal temperature for water bodies because water temperature is expected to vary according to seasonal changes, altitudes, and daily fluctuations (15).

The coconut-dreg based mudball performs slightly better than conventional EM mudball as the coconut dregs' fibrous composition enhances the filtration of the wastewater samples. Wahid & Azman (16) stated that EMs are used in the biofilter system and are said to be effective in improving water quality where overall the level of turbidity decreased after the treatment. However, the improper application of the suboptimal amount of mudball used to the amount of wastewater sample and inadequate distribution of mudball led to localised increases in turbidity.

The dissolved oxygen value for both types of mudball is lower than the range of 3-5 which falls in Class III whereby the final dissolved oxygen value for conventional EM mudball treatment is 0.13 mg/L and for coconut-dreg based mudball is 0.18 mg/L. Dissolved oxygen in the water is necessary for microorganism growth to be capable of oxidizing the biodegradable organic matter in the wastewater sample. In wastewater treatment, the decrease in the dissolved oxygen level indicates the increase in microorganism activity and biological oxygen demand (BOD) for organic matter composition (17). Moreover, the leachate contaminated river water samples are kept in a controlled room with limited sunlight conditions, which is not optimal for phytoplankton activities in increasing the oxygen in water (7).

The chemical oxygen demand value for both mudballs exceeds the acceptable. COD is a key parameter of determining water quality which represents the degree of organic contamination in water bodies by measuring the amount of oxidant consumed during oxidation of organic substances present in water samples (18). According to Hach (19), the increasing level of COD value in both mudball indicates high concentrations of organics that can deplete dissolved oxygen in the water which leads to environmental issues. Additionally, conditions such as the poor nutrient availability in leachate wastewater and biodegradability of the effluent could be the limiting

factor for the poor biological removal of the COD in this study (20). Although the use of EM mudball augments biological treatment in wastewater, it is not suitable to use as the primary component.

The value for both types of mudball is below the acceptable limit. Ammoniacal nitrogen is a toxic pollutant of nitrogenous organic matter in the form of ammonia which can disrupt the balance of water ecology systems (21). According to Apure (22), the increase of nitrogen in the form of free ammonia and ionic ammonium is mainly from the decomposition of nitrogen-containing organic matter in the leachate.

### Significance of The Use of Difference Type of Mudball in Treating Leachate Contaminated River Water

Based on the data in **Table III**, there was no significant difference in mean pH ( $p=0.544$ ), temperature ( $p=0.944$ ), turbidity ( $p=0.156$ ), chemical oxygen demand ( $p=0.700$ ) and ammoniacal nitrogen ( $p=0.533$ ) between conventional EM mudball and coconut-dreg based mudball. This is because of the small effect size, the difference between the means of the conventional EM mudball and coconut-dreg based mudball to the parameters is not large enough. Meanwhile, there is a significant difference in mean dissolved oxygen ( $p=0.011$ ) between conventional EM mudball and coconut-dreg based mudball because of the true observed difference between the type of mudball which is unlikely to have occurred by random chance alone despite the small sample size.

### CONCLUSIONS

The characterization of the leachate contaminated river water near the Jeram sanitary landfill which is a low level of dissolved oxygen and high-level chemical oxygen demand as well as ammoniacal nitrogen, a positive sign of leachate seepage into the water body. Generally, the coconut-dreg based mudball performed slightly better at pH stabilisation, water turbidity control, maintaining chemical oxygen demand, and ammoniacal nitrogen compared to conventional EM mudball. The mudball's functionality has slightly improved with the addition of coconut dregs, which have a fibrous composition and alkaline characteristics. However, the mudball application might not be suitable due to the characteristics of landfill leachate such as turbidity, dissolved oxygen, chemical oxygen demand, and ammoniacal nitrogen that acts as strong wastewater.

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