Improving the Quality of Landfill Leachate by using Plant Leaf Extracts to Control the Odour at Karadiyana Site

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ABSTRACT

Karadiyana garbage dumping site is the largest dumping site in South Asia which faces garbage disposal issues on dumping of municipal wastes. Dumping of variety of solid wastes in landfills may cause severe environmental impacts if leachate and gas emissions are not controlled. As a biological treatment approach, plant leaf extracts of *Azadirachta indica, Plactranthus amboinicus, Oscimum sanctum* were used for the present study to treat the landfill leachate of Karadiyana dumping site as these are the common medicinal plants in all Asian countries and well known for their antimicrobial property. Each leaf extract was mixed with leachate samples separately at the ratio of 10:100, 20:100, 40:100, and 80:100. The wastewater quality parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), turbidity, pH, total dissolved solid (TDS), total suspended solid (TSS) and heavy metal analysis were used to determine the quality of leachate before and after treatment. The results showed that 40 mL pure modified neem extract, 40 mL pure *Plactranthus amboinicus* leaf extract, 80 mL mixture of modified neem extract with *Plectranthus amboinicus* leaf extract and, 80 mL mixture of modified neem extract with *Oscimum sanctum* had higher effectiveness of reduction in all the parameters such as turbidity, BOD, COD, TDS, pH, TDS, TSS and heavy metal analysis. However, further optimization is needed to recommend these extracts to apply to the dumping site to control the odour of Karadiyana site in the future.

KEYWORDS: Antimicrobial activity, Leachate, Modified neem extract, Odour, *Plectranthus amboinicus*

INTRODUCTION

Karadiyana site is a place situated in Western Province of Sri Lanka, which is the main dumping site where 37 acres of land is allocated for dumping purpose. Seven authorities and some public institutions dump their sewages in this site. The total wastes dumped in the site is nearly 575 tons per day (Monitoring Report, 2015). Together with the effects of temperature, time and rainfall the dump wastes undergo degradation with the help of the microorganisms. Due to their aerobic and anaerobic decomposition processes, majority of odourous gases (H_2S, SO_2, NH_3, and CH_4) come out from the wastes during either landfilled or composting (Mckendry *et al.*, 2002). This odour producing gasses are potential cause of air pollution, unhygienic conditions, many diseases, and it has become as a nuisance also to public surroundings of that area.

Wastes collected at this landfill site which come from households, industries and hospitals are more hazardous to the environment and as well as to human beings. The leachate is the major problem of municipal solid waste which causes significant threat to surface and ground water (Saffa *et al.*, 2013). The action of water on putrescible or organic wastes leads to the generation of liquid effluent termed as leachate and it is typically a black odourous liquid with high chemical oxygen demand (COD) and biological oxygen demand (BOD) (Mckendry *et al.*, 2002).

Currently the Western Province Waste Management Authority use odour controlling products such as Keeen Odour Neutralizer (ON), Odour Eliminator (OE) and Rydall Odour Eliminator (ROE) to control the odour in that area. As the Keeen ON and OE contains chemical substances which have been used in surfactants, detergents and disinfectants, it may have an impact on biodegradability and environment (Sewwandi, 2015). Therefore, it is essential to introduce an odour controlling product which is cost effective and eco-friendly. Many medicinal plants contain antimicrobial, antiseptic, antimutagenic, anticarcinogenic and antioxidant characteristics (Malini *et al.*, 2013).

Azadirachta indica (neem) belongs to Meliaceae family which is a traditional medicine for household remedy against various human ailments (Gavhane *et al.*, 2012), *Plectranthus amboinicus* (Indian borage) which has enormous potential to control pathogenic bacteria habited in highly polluted wastewater (Nagalakshmi *et al.*, 2012) and *Ocimum sanctum* (tulsi) which has strong antimicrobial characteristics to control the growth of *Escherichia coli* in wastewater (Rama *et al.*, 2012).

Therefore, use of these leaf extracts will improve the quality of the leachate of Karadiyana dumping site and this present study will provide a remedy for controlling the odour of leachate in future.

MATERIALS AND METHODS

Experimental Site

The study was conducted at Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka collaboratively with Waste Management Authority, Sri Lanka and Department of Forestry and Environmental Sciences, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka from December 2015 to June 2016.

Collection of Samples

Disease free leaves of *Azadirachta indica* (neem), *Plectranthus amboinicus* (Indian borage), *Oscimum sanctum* (tulsi) were collected and rinsed with tap water followed by distilled water to remove the dust and soluble impurities and air dried for 2 h.

Leachate sample was collected from Karadiyana dumping site in Western Province in a plastic cleaned water bottle and stored at -20 °C.

Preparation of Leaf Extracts

Leaf extracts were prepared by taking 2.5 g of thoroughly washed, air dried and finely cut leaves. For each leaf extract preparation, the cut leaves were boiled in 100 mL of distilled water for 2 min and the mixture was filtered by using gauze and then Whatman papers (De Silva *et al.*, 2013). The modified neem extract (MNE) was prepared according to the previous optimized protocol (Warusawitharana and Vivehananthan, 2010).

Application of Leaf Extracts to the Leachate Samples

Different volumes of leaf extracts of all three types of leaves and the mixture of each leaf extract with MNE were added into 100 mL of leachate samples separately. The control was used only with the leachate sample without adding leaf extracts. All the treated samples were stored in the amber color bottles separately and kept on a flat surface for incubation for 5 days.

Determination of Wastewater Quality Parameters

The parameters which are used to detect the wastewater quality such as turbidity, BOD, COD, pH, TDS, TSS and the presence of heavy metals were tested for all the treated samples and controls.

Turbidity

Turbidity of the treated samples and control was measured by using UV visible spectroscopy (model JENWAY 6305) at 600 nm wavelength to determine the microbial growth in the leachate samples. Distilled water was used as the blank.

Biological Oxygen Demand (BOD) Test

Dissolved oxygen was measured before and after incubation of 5 days. The amount of oxygen utilized by the microrganisms during decomposing process in leachate sample under aerobic conditions was measured by using Winkler's method (Sattar *et al.*, 1992). BOD was measured for treated samples and control. Indicator starch was used to titrate the I_2 released through the reaction and the titration was continued until the endpoint pale straw color obtained.

Chemical Oxygen Demand (COD) Test

The amount of oxygen required to oxidize the organic and oxidizable inorganic matters were measured by using COD reflux apparatus. During titration, added potassium dichromate was used for this oxidation. The excess dichromate was titrated against ferrous ammonium sulfate using ferronin indicator and the titration was continued until the endpoint reddish brown color reached. Chemical oxygen demand was measured for treated samples and control.

pH

The pH of treated samples was measured before and after application of leaf extracts and pH of the control was also measured by using pH meter (model-WTW 3110 SET 2) to determine the pH values of the samples.

Total Dissolved Solid (TDS)

Treated samples were measured to get the TDS values before and after application of leaf extracts and TDS of the control was also measured without adding leaf extracts by using TDS meter (model-WTW 3210 SET 1) to determine the organic matters dissolved in the samples.

Total Suspended Solid (TSS)

The treated samples and control were filtered through Whatman filter papers separately, then air-dried and weighed. The weight differences were calculated to obtain TSS (Anon, 1999).

Heavy Metal Analysis

The presence of heavy metals was analyzed in all the treated samples and the control by using atomic absorption spectroscopy (AAS) (model-GBC 932) by flame method with the help of air-acetylene gas (Michael, 1982).

RESULTS AND DISCUSSIONS

The initial screening experiments were carried out to evaluate the effectiveness of the Modified neem extract (MNE), Indian borage extract (IBE) and tulsi Extract (TE) to treat the leachate. Different volumes of each pure extracts and mixture of MNE with other extracts added separately to the leachate which found to be varied in improving the quality of leachate.

Most prominently when leachate treated with different volumes of MNE, all the parameters tested in this study showed reduction compare to control for the addition of 40 mL MNE. Even, the reduction was observed with the rest of the volumes for this extract to all the parameters except COD (Table 1). Therefore, the 40 mL volume of MNE extract plays a major role in this treatment process. In previous studies the effectiveness of MNE has been proved in reducing turbidity and microbial load in wastewater treatment (Srirathan *et al.*, 2011).

Treatment of leachate with different volumes of IBE was also tested as Indian borage contains good aroma (Ignatius *et al.*, 2014), so that it may provide better aroma to control the odour. The results of this treatment showed reduction for all the parameters compare to control for the addition of both 40 mL and 80 mL (Table 2). As this treatment improved the quality of the leachate as like the MNE treatment, further experiments were carried out with the mixture of MNE with IBE.

The treatment with mixture of MNE and IBE to leachate showed reduction for all the parameters compare to control. Among those, the 80 mL mixture showed reduction in all the parameters. However, there is a slight increase in the COD. Though all these treatments were repeated three times to confirm the results, the COD measurement was taken only once which can be improved in future treatments (Table 2).

Further, as tulsi also has the antibacterial property which was also tested to improve the quality of the leachate. So that the treatment of TE and the mixture of MNE with TE for the leachate samples were tested in this study which showed reduction on all the parameters especially for all the volumes. However the 80 mL mixture of MNE with TE treatment showed considerable reduction in BOD and even reduction in all other parameters as tulsi has strong antimicrobial activity which may control the growth of the microorganisms present in the leachate. The pH parameter values obtained in the neutral pH range (6.91) is also considered as an added advantage in this treatment (Table 3) compare to the treatments with other two types of extracts.

Other interesting aspects of all of these treatments are where atomic absorption analysis for heavy metals showed reduction for all the volumes compare to control (Table 1, 2 and 3). However prominent results showed with pure TE and the mixture of MNE with TE as there were no heavy such as Pb, Cd and Ni detected in these treated samples (Table 3).

Importantly, all three types of extracts showed reduction in all the parameters, for certain volumes of all these samples indicating the potential use of all three leaves used for the present study.

Table 1. Analysis of different parameters for the application of MNE to the leachate samples

WWQP	Volume of MNE (mL)				
	Control	10	20	40	80
BOD (mg/L)	13400	8300	8800	8800	11800
COD (mg/L)	308	320	336	288	316
Turbidity	0.192	0.122	0.108	0.116	0.162
pH	8.75	8.16	8.01	7.78	7.99
TDS (g/L)	113.7	20.92	19.53	17.80	14.59
TSS (g/L)	2.66	1.99	2.02	1.92	1.72
Heavy Metals (μg/mL)					
Pb	0.416	0.394	0.321	0.254	0.230
Cd	0.056	0.041	0.037	0.033	0.029
Sn	13.537	13.172	12.597	11.684	10.026
Ni	0.485	0.476	0.470	0.437	0.405
Cr	0.598	0.589	0.517	0.536	0.480

WWQP- wastewater quality parameters, BOD- biological oxygen demand, COD- chemical oxygen demand, MNE-modified neem extract, TDS- total dissolved solid, TSS- total suspended solid

Table 2. Analysis of different parameters for the application of IBE and the mixture of IBE with MNE to the leachate samples

WWQP	Volume of IBE (mL)					Volume of MNE with IBE mixture (mL)				
	Control	**10**	**20**	**40**	**80**	**Control**	**10**	**20**	**40**	**80**
BOD (mg/L)	13400	9200	8500	7200	9400	8800	4000	19200	11600	8800
COD (mg/L)	308	324	312	272	296	284	312	344	272	288
Turbidity	0.192	0.142	0.092	0.114	0.137	0.635	0.546	0.532	0.436	0.472
pH	8.75	7.97	7.65	7.38	7.82	4.9	4.6	4.7	4.4	4.5
TDS (g/L)	113.7	21.08	19.15	16.48	14.78	32.20	28.54	27.63	25.61	22.63
TSS (g/L)	2.66	2.17	2.09	1.74	1.58	0.78	0.76	0.79	0.73	0.74
Heavy Metals (μg/mL)										
Pb	0.416	0.253	0.206	0.223	0.382	0.416	0.431	0.363	0.353	0.212
Cd	0.056	0.022	0.024	0.039	0.046	0.056	-	0.037	0.041	0.024
Sn	13.537	-	12.513	10.372	9.743	13.537	-	-	6.248	6.002
Ni	0.485	0.345	0.341	0.256	0.278	0.485	0.473	0.423	0.252	0
Cr	0.598	0.470	0.461	0.427	0.412	0.598	0.350	0.272	0.311	0.274

WWQP- wastewater quality parameters, BOD- biological oxygen demand, COD- chemical oxygen demand, MNE- modified neem extract, TDS- total dissolved solid, TSS- total suspended solid

Table 3. Analysis of different parameters for the application of TE and the mixture of TE with MNE to the leachate samples

WWQP	Volume of TE (mL)					Volume of MNE with TE mixture (mL)				
	Control	**10**	**20**	**40**	**80**	**Control**	**10**	**20**	**40**	**80**
BOD (mg/L)	14000	12600	10600	8000	7200	14000	13100	11800	8300	6900
COD mg/L)	386	367	308	298	302	386	-	-	-	-
Turbidity	0.106	0.095	0.087	0.072	0.089	0.106	0.088	0.079	0.108	0.083
pH	7.89	7.31	7.71	7.50	6.32	7.89	7.20	7.22	6.97	6.91
TDS (g/L)	4.47	3.32	3.78	2.61	1.97	4.47	3.83	2.95	1.99	2.06
TSS (g/L)	0.63	0.47	0.40	0.35	0.39	0.63	0.48	0.43	0.39	0.41
Heavy Metals (μg/L)										
Pb	0.416	0	0	0	0	0.416	0	0	0	0
Cd	0.056	0	0	0	0	0.056	0	0	0	0
Sn	13.537	5.726	5.159	4.898	5.555	13.537	-	-	0	0
Ni	0.485	0	0	0	0	0.485	0	0	0	0
Cr	0.598	0.270	0.260	0.249	0.211	0.598	0.323	0.302	-	-

WWQP- wastewater quality parameters, BOD- biological oxygen demand, COD- chemical oxygen demand, MNE- modified neem extract, TDS- total dissolved solid, TSS- total suspended solid

Therefore, testing all three extracts together in the treatment protocols may lead to produce a product which may be a cost effective and ecofriendly to control the odour of leachate.

CONCLUSIONS

As present study yields an excellent results of treatments using pure extracts and MNE with other extracts, in future, the mixture of all three extracts can be used to make a product or provide an alternative methods to improve the quality of the leachate and it can be used to control the odour by optimizing the volume ratios appropriately. Further studies should be needed to confirm the significant reductions in all the parameters with these extracts.

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