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Characteristics of the leachate produced during nutrient recycling of food and poultry slaughter wastes by fly larvae

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Abstract

Biowaste management is a pertinent problem and nutrient recycling utilizing fly larvae is an emerging solution. The leachate produced during biowaste management has potential implications for the environment but studies on this issue are scanty. This study was conducted to assess the characteristics of leachate produced during the bioconversion of food (BW-I) and poultry slaughter waste (BW-II) by natural fly larval activity. The results showed that total volumes of 2.2 L and 1.1 L leachate were produced for BW-I and II respectively. The highest pH in BW-I leachate was 7.43 ± 0.01 and the lowest pH in BW-II was 3.30 ± 0.12. The highest levels of BOD in BW-I and II were 36733.33 ± 430.63 mg/l and 2800.000 ± 999.50 mg/l. The highest level of COD in BW-I was 52575.000 ± 1076.86mg/l while in BW-II it was 4316.67 ± 790.45 mg/l. The high BOD and COD values of the leachate indicated that they needed to be pretreated before being released into the environment.

Keywords : *Food waste, poultry slaughter waste, leachate, BOD, COD*

Management of biowaste is a pertinent problem today. Several decentralized management options are available to overcome this issue, but the impact of these options on the micro environment, fauna and flora have not been fully assessed. Decomposition of solid biowastes, result in the release of part of the moisture as leachate endowed with several potential environmental implications. Leachate has been described as the liquid that is produced by the degradation of

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waste and is stored along with the percolation of rainwater (Hernández-García *et al.,* 2019). The irrational management of solid waste results in a significant wastage of resources and this is further precipitated by the release of a large amount of polluted leachate which has a significant effect on the environment (Feng *et al*., 2019). Reduced space for waste disposal due to the increased human population was a cause for contamination of water resources (Latha *et al.,* 2003). The pH of leachate, BOD and COD could have implications on the soil and immediate surroundings of where it is generated or drained. Food waste recycling has been found to produce leachate of acidic nature due to fermentative reactions. Solid biowastes with high moisture content produce a significant quantity of leachate and hence, appropriate knowledge of the characteristics of the leachate produced is essential to initiate measures to reduce environmental and public health issues associated with bio waste handling and management. Nutrient recycling utilizing fly larvae is an emerging technology for biowaste management; this technology helps to reduce the loop of recycling to a circular economy. Hence, the present study was taken up to analyse the characteristics of the leachate released during the bio-conversion of food and poultry slaughter wastes by fly larvae.

Materials and methods

The study was conducted at the Eco-farm unit under the Department of Livestock Production Management, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Thrissur, Kerala. The study was conducted for a period of one year from November 2017 to December 2018. The study period was divided into three seasons as categorised by Joseph (2011) namely;

(i) Summer months (February-May) - S-I
(ii) Monsoon months (June-September) - S-II
(iii) Post-monsoon months (October-January) - S-III

Experimental setting

The poultry slaughter waste (BW-I) was collected locally from Mannuthy market, and this included the digestive system and associated wastes, excluding feather, head and feet**.** Food waste (BW-II) consisted of household and hostel food waste collected from Mannuthy campus. Five kilograms from each source were placed in 25 L bins with six replicates and a total of 12 bins were set. Containers (five liter) were kept below the bins to collect the leachate and further studies on the characteristics of the same. The experiment was conducted for 30 days during each season. The total period of 30 days was divided into five phases of six days each. The five phases were designated with identifying numbers from P-I to P-V. Flies were allowed to arrive naturally and ovulate on the biowastes and their larvae were allowed to convert the biowaste.

Physicochemical changes of the leachate

The physical and chemical changes in the leachate including the volume and pH, were recorded daily. The volume of the leachate was noted using a 1 L graduated measuring jar (Sarpong *et al.,* 2018). The pH of the leachate was recorded using PCSTestr 35 (Eutech, Thermo Scientific) (Oviedo-Ocaña *et al*., 2015).

Biochemical Oxygen Demand (BOD)

The samples of leachate that were collected were subjected to analysis for biochemical oxygen demand (BOD) (APHA, 2012), at weekly intervals.

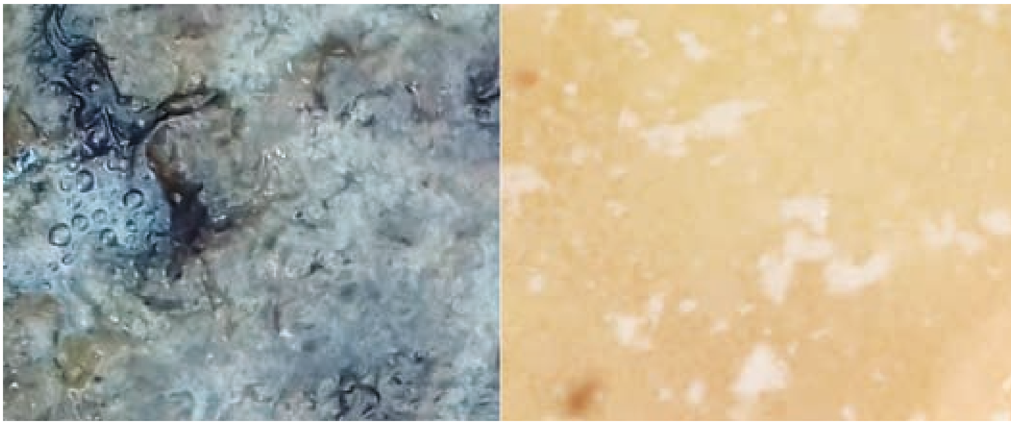
Chemical Oxygen Demand (COD)

Samples from the collected leachate were taken for estimation of chemical oxygen demand (COD) at weekly intervals. COD was done using the COD Cell Test kit Spectroquant 1.01797.001 (Merck) with a measuring range of 5000 to 90000 mg/L COD (Marcheggiani *et al.,* 2019).

Results and discussion

Physicochemical changes in the leachate

The BW-I had an initial moisture content that ranged from 73 to 76 per cent, and finally reduced to a level of 41 to 48 per cent. The BW-II had an initial moisture content that



BW-I leachate **BW-II leachate**

Fig. 1. Colour and nature of leachate from BW-I and II

ranged between 75 and 79 per cent, which reduced to a final moisture level that ranged from 70 to 76 per cent. The loss in moisture was a factor that mainly contributed to the formation of leachate.

The volume of leachate produced is given in Table 1. Leachate production occurred only during the first two phases. The BW-I leachate had pungent smell with a fat layer, and was dark red to dark brown in colour (Fig. 1). The BW-II leachate was cream or light brown in colour with an alcoholic smell and a watery consistency. The highest total volume of leachate produced was 2.2 L in BW-I in S-I, while for BW-II, it was 1.1 L in S-III. The maximum volume of leachate produced from BW-I (1.99 ± 0.045) was observed during P-I of S-II and from BW-V (0.52 ±0.03) during P-I of S-III. This is in agreement with the report of USDA (2004), where it was reported that more than 50 per cent of the available volume of fluid would leach out in the first week of degradation. Ghanem *et al.* (2001) reported that the maximum leachate production from food waste occurred by 10 days, which was in agreement with our findings. Means having same superscripts (small letter a-e, h-l, v-z within columns, capital letters A-E, H-L, V-Z within rows) did not differ significantly at 5 per cent level. The pH changes observed during the experimental period in all the leachates are given in Table 2. The highest pH in BW-I leachate (7.43 ± 0.01) was observed in P-I of S-II, similar to that reported for poultry slaughter waste water by Rajakumar *et al.* (2011), which was 7 to 7.6. But the value reported by Chavez *et al.* (2005) was 6.6 which was lower than that obtained in the present study. The lowest pH of BW-II leachate was 3.30 ± 0.12 and it ranged between 3.3 and 4.65, which was lower than that reported by Wang *et al.* (2013) and Zamri *et al.* (2016) for landfill leachate for which the pH was 8-8.1. But the value was closer to that reported by Sall *et al.* (2019) in studies on vegetable and fruit compost leachate (5.4). This may be because, in landfill leachate, the leachate had already undergone a maturation phase with a stabilisation of pH, whereas the leachate from vegetable and fruit compost produced an acidic leachate.

Table 1. Average volume (L) of poultry slaughter waste and food waste leachate

Season	Phase	Poultry slaughter waste	Food waste
Summer	I	1.89 ± 0. 04^{bB}	0.41 ± 0.04^{bA}
	II	0.11 ± 0. 02^{aA}	0.12 ± 0.02^{aA}
Monsoon	I	1.99 ± 0.05^{iI}	0.39 ± 0.05^{iH}
	II	0.21 ± 0.01^{hH}	0.19 ± 0.01^{hH}
Post-monsoon	I	1.73 ± 0.03^{wW}	0.52 ±0.03^{wV}
	II	0.31 ± 0.04^{vV}	0.19 ±0.04^{vV}

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Table 2. pH of poultry slaughter waste and food waste leachate

Season	Phase	BW-I	BW-II
Summer	I	7.00 ± 0.18^{bB}	3.30 ± 0.12^{aA}
	II	6.17 ± 0.03^{aA}	4.08 ± 0.02^{bB}
Monsoon	I	7.43 ± 0.01^{hI}	3.71 ± 0.01^{hH}
	II	7.34 ± 0.06^{hI}	4.65 ± 0.06^{iH}
Post-monsoon	I	7.02 ± 0.03^{vV}	3.78 ± 0.03^{wW}
	II	7.11 ± 0.02^{wV}	3.53 ± 0.02^{vW}

Means having same superscripts (small letter a-e, h-l, v-z within columns, capital letters A-E, H-L, V-Z within rows) doesn't differ significantly at 5 % level

Table 3. Estimated BOD (mg/l) of poultry slaughter waste and food waste leachate

BOD (mg/l)			
Substrate	**Phase**	**BW-I**	**BW-II**
Summer	P-I	36733.33 ± 430.63^{bB}	2033.33 ± 430.63^{aA}
	P-II	23300.00 ± 999.50^{aB}	2800.00 ± 999.50^{aA}
Monsoon	P-I	22433.33 ± 835.95^{hI}	1850 ± 835.95^{hH}
	P-II	34700 ± 606.81^{iI}	2566.67 ± 606.81^{hH}
Post-monsoon	P-I	25466.67 ± 636.77^{vW}	2050.00 ± 636.77^{vV}
	P-II	36350.00 ± 300.42^{wW}	2800.00 ± 300.42^{vV}

Means having same superscripts (small letter a-e, h-l, v-z within columns, capital letters A-E, L, V-Z within rows) doesn't differ significantly at 5 % level

Table 4. Estimated COD (mg/l) of poultry slaughter waste and food waste

COD (mg/l)			
Substrate	Phases	BW-I	BW-II
Season1	P-I	$41975.000 \pm 585.50^{aB}$	3400.000 ± 585.50^{aA}
	P-II	$52575.000 \pm 1076.86^{bB}$	$4283.333 \pm 1076.86^{aA}$
Season 2	P-I	40000 ± 358.17^{hI}	3258.33 ± 358.17^{hH}
	P-II	48933.33 ± 505.66^{iI}	4116.67 ± 505.66^{hH}
Season 3	P-I	$41716.667 \pm 625.72^{vW}$	3433.333 ± 625.72^{vV}
	P-II	$52250.000 \pm 790.45^{wW}$	4316.667 ± 790.45^{vV}

Means having same superscripts (small letter a-e, h-l, v-z within columns, capital letters A-E, H-L, V-Z within rows) doesn't differ significantly at 5 % level

Biochemical Oxygen Demand (BOD)

The BOD of the leachate collected during the experimental period is given in Table 3. In BW-I leachate, the highest BOD was found to be in P-I (36733.33 ± 430.63 mg/l) of S-I. The BOD of poultry slaughter waste water reported by Al-Yaqout (2005), Chávez *et al.* (2005) and Wu and Mittal (2012) ranged between 1320 - 5500 mg/l which was very less than that observed for BW-I in the present study, probably because of the dilution with water in poultry slaughter waste water. Wu and Mittal (2012) reported that beef slaughter waste water had a BOD of 14545 mg/l which could be due to the increased content of blood and manure.

The highest BOD for BW-II leachate was during P-II, (2800.000 ± 999.50 mg/l) of S-I. Kylefors (1997) had reported that the BOD of landfill leachate ranged from 49 to 24000 mg/l. Lee *et al.* (2010), reported that young landfill leachate had a BOD of 6350. The present findings were within the range reported by Kylefors (1997) but lower than that reported for young landfill leachate by Lee *et al.* (2010). The difference could be due to the variation in the organic content.

Chemical Oxygen Demand (COD)

The COD of the leachate collected during the experimental period is given in Table

4. The highest COD was found in BW-I leachate was during P-II, (52575.000 ± 1076.86mg/l). The COD observed was similar to that reported by Yuan *et al.* (2012), 40000 to 65000 mg/l for carcass leachate but higher than that reported by Rajakumar *et al.* (2011), 3000-4800 mg/l and Chavez *et al.* (2005), 5800-11600 mg/l for poultry slaughter waste water. This could be due to the fact that the leachate from the slaughter waste had higher level of organic constituents when compared to waste water.

The BW-II leachate showed the highest COD during P-II (4316.67 ± 790.45 mg/l) of S3. Kylefors, (1997) reported that COD of the landfill leachate ranged between 668 and 35000. According to Zamri *et al.* (2016), the COD for stabilised MSW leachate was 3127mg/l. Wang *et al.* (2013) reported a COD of 6200 for raw landfill leachate. In the current study, the COD of BW-I was more than that reported by Zamri *et al.* (2016) but less than that mentioned by Wang *et al.* (2013); values were however within the range reported by Kylefors (1997). In studies by Cruz (2020), the high COD of leachate was attributed to the accumulation of carboxylic acid intermediates. In the current study due to the presence of larva in substrate, part of the intermediates could have been utilised which could be the reason for the lower COD values.

Conclusion

The present study revealed that significant quantities of leachate were produced during the larval bioconversion of food and poultry slaughter wastes. The chemical properties of the leachate revealed that depending on the source of the leachate and age, it could be either acidic or basic and thus could significantly affect the soil chemistry. The high BOD and COD values of the leachate indicate that they need to be pretreated before being released into the environment. The results of this study could form the basis for utilizing the leachate as soil amendment or for use in biomethanation and energy production.

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Conflict of interest

The authors declare that they have no conflict of interest.

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