ISSN 0251-1223

GEOBIOS

An International
Quarterly Journal of Life Sciences

Vol. 37, No. 4

October, 2010

GEOBIOS - ZION
P.O. BOX 14
JODHPUR - 342 001 (RAJ.)
INDIA

GEOBIOS 37 : 297-302, 2010

CHARACTERISATION OF TANNERY SOLID WASTES AT DIFFERENT STAGES OF LEATHER PROCESSING AND VERMICOMPOSTING AS A METHOD OF DEPOLLUTING THE WASTES

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(Received February 2; Revised June 1, 2010)

Key words : Vermicomposting, leather processing, tannery solid waste, depollution

ABSTRACT

Four types of wastes were collected from different stages of leather processing namely, LDB-BT, LDB-AT, PW-BT and CTW-ACR and mixed with equal amounts of vegetable wastes and vermicomposted using local species of earthworms and then analyzed. The results show an increase in pH, EC and decrease in COD, TDS, phosphorus, potassium, sodium, calcium, and magnesium in the vermicompost.

INTRODUCTION

Pollution is associated with the addition of foreign substances to the natural habitat. This affects the flora, fauna and human health. Industrial pollutants are known to contaminate the abiotic components of the ecosystem which pose threat to the sustenance of plant and animal kingdoms. Among the various pollution problems, the quality of water is of major concern as it is a vital ingredient of everyday life. The major sources of water pollution are the untreated or partially treated industrial wastes of which the tanning industrial waste is reported globally as a major industrial waste which contributes to water pollution (Karmegam & Daniel, 2009).

Tanning industry is one of the oldest in India, which produces a lot of pollution by disposal of wastes into aquatic environment, both solid and liquid wastes. Tannery wastes are highly polluting among all the other industrial wastes. They contain heavy metals, protein, chloride, nitrogen, sulphate and increased levels of COD, BOD and suspended solids which contaminate both water and soil (Ramesh et al., 2000).

Recycling of tannery wastes can be done by a technique called vermicomposting, which is used to compost the wastes using earthworms. This technique is more environment friendly and can convert the waste into nutrient rich products which are essential for plant growth.

MATERIALS AND METHODS

This study was undertaken in 3 phases.

In the first phase, tannery solid wastes from four selected stages of leather processing were collected [LDB-BT (Liming, Deliming and Bating-Before Treatment), LDB-AT (Liming, Deliming and Bating- After Treatment), PW-BT (Pickling Waste-Before Treatment) and CTW-ACR (Chrome Tanning Waste-After Chrome Recovery)]. They were then analyzed for various parameters like

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physico-chemical characteristics (pH, electrical conductivity, chemical oxygen demand (COD) and total dissolved solids (TDS) and minerals like sulphate, chloride, phosphorus, potassium, sodium, calcium and magnesium).

In the second phase, different proportions of tannery solid wastes from each stage of leather processing were mixed with equal amounts of vegetable waste in the ratios 2:100, 6:100, and 10:100 and vermicomposted using one local species of earthworm. After the completion of 45 days of vermicomposting, the vermicomposts were harvested from each vermibed.

In the third phase, the vermicomposts harvested were used for physico-chemical characterization like pH, electrical conductivity, chemical oxygen demand (COD) and total dissolved solids (TDS) and determination of sulphate, chloride, phosphorus, potassium, sodium, calcium and magnesium and the results were compared with those of raw (undecomposed) tannery waste (Ravindran et al., 2008).

RESULTS AND DISCUSSION

Table 1 records the pH, EC, COD, and TDS values of raw and vermicomposted tannery solid waste from different stages of leather processing. It can be observed that sample LDB-BT had the highest pH value among the raw tannery wastes. The pH increased in all the different types of raw tannery waste when vermicomposted with vegetable waste. The pH value of the vermicompost from control was found to be similar to other samples. The increase in pH after vermicomposting is due to the conversion of organic nitrogen to NH_4^+ with consequent consumption of H^+ ions, as material passes through the gut of the earthworms. Babu (1995) reported that the pH of the earthworm castings was higher than that of the surrounding soil. Das & Dash (1990) had reported that alkaline conditions were responsible for faster decomposition of organic matter. Thus, increase in pH favors the vermicomposting process. EC in sample PW-BT was highest among the raw tannery wastes. The EC values of the different types of raw tannery wastes increased only slightly when vermicomposted with vegetable waste. Kale et al. (1992) have reported higher EC in vermicomposts which denotes an increase in the levels of soluble salts as compared to the surrounding soil.

Among the raw tannery wastes, sample LDB-BT was found to have the highest COD followed by PW-BT. This may be due to the reason that these two wastes being not treated contain more pollutants than the treated ones. The COD values of the different types of raw tannery waste were found to decrease when vermicomposted with vegetable waste. The COD levels decreased in the vermicompost samples when compared to the raw tannery waste, probably due to the biodegradation of organic pollutants during the vermicomposting process (Ravikumar et al., 2009).

Samples LDB-BT followed by PW-BT was found to record highest TDS values. This may be due to the untreated nature of the wastes. These values decreased on vermicomposting with vegetable waste. The high TDS may be due to the addition of various chemicals and soluble salts during the processing of leather and it has been reported that tannery waste loaded with high total dissolved solids is highly toxic to plants. Arochiasamy (1982) has reported that tannery waste loaded with high total dissolved solids is highly toxic to plants.

Table 2 depicts the sulphate and chloride

Table 1. pH, electrical conductivity (EC), chemical oxygen demand (COD) and total dissolved solids (TDS) of raw and vermicomposted tannery solid waste (TSW) as compared to vegetable waste (VW) from different stages of leather processing.

Samples	Raw TSW				TSW+VW											
	pH	EC	COD	TDS	pH			EC			COD			TDS		
					T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
LDB-BT	9.4	0.09	5800	2017.5	9.8	9.6	9.5	0.12	0.13	0.13	2100	3000	3900	941	1049.5	1354.5
LDB-AT	8.6	0.13	3600	1228.5	8.7	8.6	8.4	0.14	0.14	0.13	2300	1900	2900	533.5	720	985
PW-ACR	6.1	0.14	5500	1784	8.1	8.0	7.9	0.16	0.13	0.16	2400	3500	3600	836	1096	2403.5
CTW-ACR	7.2	0.12	3300	1550	8.4	8.1	7.9	0.12	0.16	0.14	1200	2100	3000	624	807.5	1084.5

T_1, T_2 & T_3 – Different proportions of tannery solid waste.

Table 2. Sulphate and chloride (mg/100g) of raw and vermicomposted tannery solid waste from different stages of leather processing.

Samples	Raw TSW		TSW + VW					
	Sulphate	Chloride	Sulphate			Chloride		
			T_1	T_2	T_3	T_1	T_2	T_3
LDB-BT	224.26	1219.62	80.2	94.6	98.7	129.9	289.9	479.8
LDB-AT	187.23	1049.67	72.0	88.4	84.3	389.8	349.9	609.8
PW-BT	211.92	1189.63	67.8	100.8	92.5	149.9	349.8	509.8
CTW-ACR	104.93	979.70	61.7	78.1	80.2	159.9	399.8	329.9

T_1, T_2 & T_3 – Different proportions of tannery solid waste.

Table 3. Total phosphorus (TP), available phosphorus (AP), total potassium (TK) and available potassium (AK) (mg/l) of raw verrmicomposted tannery solid waste from different stages of leather processing.

Samples	Raw TSW				TSW+VW											
	TP	AP	TP	AP	TP			AP			TK			AK		
					T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
LDB-BT	2.01	0.01	0.26	0.14	0.07	0.13	0.11	0.02	0.02	0.02	0.24	0.27	0.27	0.05	0.05	0.18
LDB-AT	4.52	0.01	0.14	0.14	0.06	0.10	0.095	0.02	0.02	0.20	0.24	0.45	0.24	0.06	0.16	0.15
PW-BT	6.30	0.03	0.11	0.05	0.06	0.06	0.06	0.03	0.02	0.02	0.37	0.22	0.25	0.16	0.15	0.18
CTW-ACR	5.03	0.02	0.14	0.12	1.10	0.16	0.08	0.02	0.01	0.01	0.27	0.50	0.26	0.18	0.05	0.06

T_1, T_2 & T_3 – Different proportions of tannery solid waste.

Table 4. Sodium, calcium and magnesium (mg/l) of raw and vermicomposted tannery solid waste from different stages of leather processing.

Samples	Raw TSW			TSW+VW								
	Sodium	Calcium	Magnesium	Sodium			Calcium			Magnesium		
				T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
LDB-BT	2.65	11.40	37.80	0.15	0.20	0.15	3.83	8.11	2.62	7.76	20.8	15.75
LDB-AT	13.68	5.01	32.64	0.27	0.22	0.36	2.36	1.24	3.50	10.6	14.8	19.953
PW-BT	21.90	4.12	11.91	0.23	0.21	0.53	3.20	2.23	3.43	6.41	1.06	11.59
CTW-ACR	10.21	6.61	17.90	0.27	0.11	0.10	1.27	2.30	3.16	11.5	6.90	3.16

T_1, T_2 & T_3 – Different proportions of tannery solid waste.

values of different types of raw and vermicomposted tannery solid waste from different stages of leather processing. It is clear that among the raw tannery wastes, LDB-BT recorded the highest value followed by PW-BT. This may be because these wastes were not treated to reduce the sulphate levels. The treated samples, namely, LDB-AT and CTW-ACR exhibited lower levels of sulphate probably due to treatment. The sulphate values of the vermicomposted samples had significantly decreased when compared to their respective raw samples. The sulphate value of control revealed a significant decrease when compared to the other vermicomposted samples. Excess sulphate may be toxic since it depletes the dissolved oxygen rapidly and may be harmful to plant growth and human health (Kumar & Sharma, 1998). The presence of high amounts of sulphate in tannery solid waste in the present study agrees with the results of Balashouri & Prameeladevi (1994), who reported the presence of a high amount of sulphate in tannery effluents. The excess of sulphate present may be due to the addition of sodium sulphide, magnesium sulphate, ammonium sulphate and chromium sulphate during the processing of leather.

Among the raw tannery waste LDB-BT had the highest chloride content due to its untreated condition. A significant reduction in the chloride content of vermicomposted sample was found when compared to different raw tannery wastes. The control compost had the least values among all the samples which were found to be significant. The above results partly agree with those of Balashouri & Prameeladevi (1994), who found that tannery effluents show a high content of chloride. Similar results in tannery effluent have been stated by Sujatha & Gupta (1996). The excess of chloride present in the tannery waste may be the result of the use of sodium chloride and chromium chloride during the treatment of leather.

Table 3 represents the total phosphorus, available phosphorus, total potassium and available potassium of different types of raw and vermicomposted tannery solid wastes. It shows that PW-BT had the highest total phosphorus among the raw tannery waste samples. The total phosphorus levels of the vermicomposted samples showed significant decreases when compared to their respective undecomposed tannery waste. PW-BT was found to have the highest available phosphorus level as shown in Table 3. The available phosphorus of vermicomposts had increased though not significantly when compared to the respective raw tannery wastes. The available phosphorus level had increased in vermicomposts when compared to the raw tannery waste, since during the digestion process, the earthworm gut facilitates the conversion of total phosphorus to available phosphorus (Kale et al., 1992; Lavelle & Martin, 1992).

LDB-BT contained the maximum of total potassium level among the raw tannery waste samples. The levels of total potassium had significantly increased in the vermicomposts when compared to the different types of raw tannery samples.

Among the raw tannery wastes, LDB–BT was found to have the highest available potassium level. The available potassium levels exhibited significant increases in most of the vermicomposted samples when compared to raw tannery waste. Basker et al. (1993) who have reported that increase in both the total and available potassium levels of vermicomposted samples may be due to the release of potassium from the nonexchangeable potassium pool as soil material passed through the gut. Table 4 indicates that PW-BT had the highest sodium and chloride levels among the raw tannery samples. The levels of sodium had significantly decreased in the vermicomposted samples when compared to raw tannery waste. The control value was found to be similar to the other vermicomposted samples. The high sodium level in pickling waste may perhaps be due to the use of sodium chloride during the pickling process of leather tanning.

Among the raw tannery samples, LDB-BT revealed the highest calcium content. This may be due to the addition of lime during the liming process. Vermicomposted samples showed significant decreases in the levels of calcium when compared to the raw tannery waste samples. The control was found to be similar to other vermicomposted samples.

The raw tannery waste LDB-BT was found to contain the highest magnesium content. The magnesium contents of undecomposed tannery waste were reduced significantly on vermicomposting.

From the data of sodium, calcium and magnesium, it is found that raw tannery waste had the highest levels when compared to the vermicomposted samples and control. This is due to the reason that several chemicals like sodium chloride, sodium sulphide, sodium dichromate, sodium carbonate, calcium hydroxide and magnesium sulphate are generally used in the tanning of leather for different processes. Therefore, the tannery waste from this industry is reported to contain fairly good amounts of sodium, calcium and magnesium. It can, thus be assumed that tannery solid waste would also contain these elements and also vermicomposting could reduce the levels of element like calcium, magnesium and sodium of the raw tannery solid waste. Vermicomposting of sewage sludge was said to reduce the macro element contents like sodium, calcium and magnesium.

From the present study, it can be concluded that vermicomposting is an effective and simple technology to depollute tannery solid waste to some extent into compost instead of following the usual method of disposing the waste as landfills. The process also decreases the contents of sulphate, chloride, COD, TDS, calcium, magnesium and sodium, the excess of which could produce harmful effects on the environment.

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Human impacts on ecosystems

HUMAN SOCIETIES alter the productivity of natural ecosystems in myriad ways, be it by clearing forests to grow crops or by expanding grasslands to provide fodder for livestock. In a series of articles in press with the journal *Ecological Economics,* scientists associated with IGBP's Global Land Project elucidate the complex linkages between social and ecological systems.

More efficient agricultural practices can limit the human impact on ecosystems in spite of increasing populations. But as discussed in Annabella Musel's study of the human modification of ecosystems in the United Kingdom over the past two centuries, such practices tend to rely on extensive inputs of fossil fuels and fertilisers. This suggests that the burden of maintaining relatively stable ecosystems may be borne by other components of the Earth system.

Karl-Heinz Erb and colleagues analyse the ecological impacts of the global trade in biomass products. They elaborate on how ecological effects of consumption in one part of the world are often felt far away. This is because nations with low population densities – which include some of the most industrial nations such as the United States – tend to satisfy the biomass needs of densely populated countries. This finding is "counterintuitive in light of results indicating that industrialised countries increasingly rely on raw materials from developing nations", say the researchers. The flow of carbon associated with such trade in biomass is significant compared to major global carbon flows, for example, the amount of carbon released by industrial processes.

Future work of this kind is expected to help evaluate the ecological impacts and sustainability of socio- economic policies such as the reliance on biofuels.

Ecological Economics 69 (2): 250-334.

Source : *Global Change* 74, 2009, p. 6

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