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RESEARCH ARTICLE

STUDIES ON THE PHYSIO CHEMICAL ANALYSIS OF THE INSTITUTIONAL SOLID WASTE FROM AVS COLLEGE OF ARTS AND SCIENCE, SALEM, TAMILNADU

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ABSTRACT

The present study was under-taken to assess the changes occurring during the decomposition of municipal solid waste, through the estimation of some typical physico-chemical, and biological characteristics. Changes in the composition characteristics of the compost over-time, included increased electrical conductivity, bulk density, water holding capacity and total soluble solids etc, during the decomposition process, where as the moisture content got reduced towards the end of composting (with final moisture content being around 27 %). The changes in these characteristics appeared to reflect the microbial activity and biomass present. The successive levels of composting process, pathogenic bacterial populations decreased, physico-chemical analysis of compost from the point of view moisture content, pH, chloride, organic matter, calcium, magnesium, total phosphorus, total nitrogen, C/N ratio, sodium and potassium agreed with recommended standards and higher heavy metals concentrations was detected at all the decomposition stages of composting and were found to be within the permissible limits of Ohai- EPA standards. From the results, it can be concluded that, Turned windrow composting and Aerated static pile composting, could produce acceptable quality of compost, which can be used as fertilizer or soil amendment.

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INTRODUCTION

Institutional composting is defined as "Institutions Process where Food scraps, paper and yard trimming viz., leaves, grass and brush, at an onsite composting operation". Institutions are uniquely suited to composting because they typically generate large quantities of above said organic material and also have enough land facility. In many universities the generation rates of these organic solid wastes have increased whereas, the capacity to handle these materials has declined. The safe and effective ways to manage these organic solid wastes, composting is becoming a more attractive management option when compared to land filling and incineration. Moreover onsite institutional composting is considered to be a key component of Integrated solid waste management and provides.

1. Reduction in the disposal cost of these organic solid wastes.
2. Opportunities for research and development of new composting technologies to the student/ teacher/ researcher.

According to WHO (World Health Organization), solid waste can be defined as useless, unwanted or discarded materials arising from domestic, trade, commercial, industrial and agricultural as well as from public services. At present municipal solid waste (MSW) management has become a serious environmental problem and one of the major growing concerns for urban areas all over the world. In the typical countries, the major portion of the total solid waste is biodegradable organic matter. The high content of these biodegradable organic matter and other inert material, results in high waste density and high moisture content. Theses physical characteristics significantly influence the feasibility of certain treatment options. Wastes with a high water or inert content will have low calorific value and thus may not be suitable for incineration (Gary *et al*., 1971; Marugg *et al*., 1993; Boni and Musmeci, 1998). However, composting technology seems to be a good alternative method for managing MSW. Composting is defined as the aerobic biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperature as a result of biologically produced heat. Compost prepared from different organic wastes differ in their quality and stability, which further depends upon the composition of raw material used for the compost production (Ranalli *et al*., 2001). Generally, successful composting depends on a number of factors that have both direct and

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indirect influence on the activities of the microorganism. They include the type of raw materials being composted, its nutrient composition, moisture content, temperature, alkalinity and aeration. The stabilized compost produced should benefit plant growth and be suitable for agricultural application (Magadi *et al*, 2003). Furthermore, compost stability relates to the degree to which the Organic matter (OM) has been stabilized during the composting process (Weppen, 2002). The chemical nature of compost organic matter changes throughout the composting process and can be useful indication of compost stabilization (Chen, 2002). To obtain a final product that is stable, free of pathogens, plant seeds can be beneficially applied to land (Komilis and Ham, 2003).

MATERIALS AND METHODS

AVS Institution, Ramalingapuram, Salem district, TamiNadu is a residential Institution with an area of 400hectare and with 48 departments and 14 hostels, presently, the Institutions generates about 30 tonnes solid wastes per day and the same is used for land filling and incineration. The Institutions is surrounded by many villages mainly with farming communities. So, AVS Institutions is being selected for the project and the technology development in composting process has given opportunities for research and development of new composting technologies to teacher/ researcher of the Institutions and also has a social impact on surrounding farming communities.

Collection of compost samples Individual degraded compost samples were collected for solid waste treatment plant at at AVS college of arts and science in Salem, during the months of June to July 2015. The description of the samples used for investigation are indicated below. 1st heap contains 10 days old compost sample, 2nd heap contains 20 days old compost sample, 3rd heap contains 30 days old compost sample, 4th heap contains 40 days old compost sample, 5th heap contains 50 days old compost sample and 6th heap contains 60 days old compost sample At each heap, five compost samples were taken randomly within a 0.5 meter quadrate and mixed in to a composite sample representative of that particular heap. The samples were then transported in sealed aluminum foil to the laboratory, where stones, plastic and metals were removed, oven dried at 700C and the compost is homogenized through a 2 mm sieve. The compost samples were stored in the dark bottles till further analysis.

Survey on the components and nutritional characteristics of organic solid wastes

The organic solid waste collected from various locations and seasons will be subjected to analysis for their components viz, organic, inorganic and inert fraction and the nutritional characterization of organic fraction viz, C: N, C:P and C:K will be determined according to Sharma *et al.* (1997) and Weie/a/. (2000).

Physico-chemical analysis

All experiments were carried out in triplicates. The collected degraded compost samples were analysed for various physico-chemical characteristics such as Moisture content (drying at 105 0C to constant weight by gravimetric method); Particle and Bulk densities (Pycnometric method); pH (1:5 water extract by pH meter); Electrical conductivity (1:5 water extract, conductivity meter); Total water soluble solids (1:5 water extract, gravimetric method); Calcium and Magnesium (1N ammonium acetate, EDTA method); Chlorides (1:5 water extract AgNO3 method); Calcium carbonate (1N HCl extract, titration method); Total organic carbon (cold oxidation with potassium dichromate Walkey and Black method); Organic matter (ashing); Total organic nitrogen (Kjeldhal method); Nitrate nitrogen (1N of CuSO4 and 0.6 % AgSO4 extract, Brucine sulphate method); Ammonia nitrogen (1:5 sodium acetate extract, Nesseler's reagent method); Soluble sulphate (1:5 water extract for BaCl2 method); Phosphorus (tri acid mixture with a aqua digestion); potassium and sodium (1N ammonium acetate extract using flame photometer method), soluble sulphate (1:5 water extract), Total nitrogen values used in C/N were calculated by adding the three forms determined (organic nitrate and ammonium) using standard procedures for analysis (Jackson, 1973; Saha Arun Kumar, 2008 and Mani *et al*., 2007).

RESULTS

Physico-chemical study in compost

Moisture content

Moisture content is a measure of the amount of moisture present in a compost sample and is expressed as a percentage of fresh weight. Moisture content of the composting blend is an important environmental variable as it provides a medium for the transport of dissolved nutrients required for the metabolic and physiological activities of micro-organisms (Elango, 2009). During the present investigation, the moisture content of compost samples varied from 29.8701 to 85.185 %. In comparison with recommended standards (Biotreat, 2003) except 60 and 50 days compost sample, in all the maturity stages, moisture content percentage was found to be high and during different degradation stages decrease in moisture content has been observed from 10 days to 60 days which can heat generated by biological metabolism and air flow increases the water evaporation in the bioreactor, consequently decreasing the moisture content. Decline in the moisture content percentage during the thermophilic phase of composting due to high evaporating rates has been recorded by Larney and Blackshow (2003).

Particle density

During the study period, the particle density range from 0.642 to 2.5 mg/m^3, in comparison with recommended standards(Bord na Mona, 2003), in all the degradation stages of compost samples. The particle density was found to be high.

pH

pH is a measure of acidic or alkaline nature of the compost as composting progresses. During the study period, pH values were found to be ranged from 7.13 to 8.76.

Table 1. Physico-chemical analysis of institutional solid waste

Sl. No.	Parameters	Units	10 days	20 days	30 days	40 days	50 days	60 days Final stage	Recommend standards
1.	Moisture content	%	82.448	85.185	86.29	61.29	42.857	29.870	45-65 [1]
2.	Particle density	mg/m³	2	2	2.5	1.9607	0.7099	0.642	0.25[2]
3.	pH	-	8.7	8.76	8.49	7.72	7.43	7.13	6.9-8.3 [3]
4.	Electrical conductivity	ds/m	2.4	4	4.5	5	7.2	7.7	2-6[4]
5.	Bulk density	mg/m³	0.631	0.654	0.7192	0.7625	0.789	0.872	0.12-0.369[5]
6.	Water holding capacity	%	16.334	25.63	42.1	51.6	75	80	NA
7.	Total water soluble solids	mg/g	22	22	24.5	25	210.62	517	NA
8.	Chloride	%	0.213	3.875	4.347	4.706	11.15	12.392	NA
9.	Total organic carbon	%	16.622	14.571	13.634	12.837	11.831	10.091	NA
10.	Organic matter	%	28.656	25.120	23.505	22.130	20.396	17.397	>30 [10]
11.	Carbonates	g/l	0.0222	0.0299	0.0699	0.1299	0.145	0.158	NA
12.	Bicarbonates	g/l	0..8875	0.993	1.1788	1.422	1.479	1.484	NA
13.	Calcium	%	9.545	12.035	14.03	16.65	17.63	61.2	1.0-4.0 [12]
14.	Magnesium	%	0.9996	1.5	3.13	4.7826	9.032	11.51	0.2-0.4 [13]
15.	Soluble sulphate	%	16.36	21.24	46.55	50	55	61.95	NA
16.	Calcium carbonates	%	9	13.8	14.4	14.7	22.999	25.66	NA
17.	Ammonia nitrogen	%	1.6956	0.184	0.219	0.345	4.2	1.601	0.05 [6]
18.	Nitrate nitrogen	mg/l	0.0514	0.936	3.204	5.616	6.048	9.072	240 [7]
19.	Total Phosphorous	%	1.43	4.012	5.21	6.23	6.292	13.871	0.4-1.1 [8]
20.	TKN	%	1.245	1.456	1.563	1.623	1.789	1.825	1.0-3.0 [14]
21.	C:N ratio	%	13.351	10.007	8.722	7.909	6.613	5.529	<25[11]
22.	Sodium	%	0.0275	0.0285	0.0303	0.0304	0.035	0.086	NA
23.	Potassium	%	0.06	0.071	0.082	0.084	0.091	0.138	0.6-1.7 [9]

In comparison with recommended standards (Bord na Mona, 2003), except 40, 50 and 60 days old compost samples, pH values were found to be higher than the normal range which implies that, during different degradation stages decrease in pH has been observed from 10 days to 60 days which can attributed to the produce CO_2 from organic acids and loss of nitrogen (Lugtenberg, 2009).

Electrical conductivity

Electrical conductivity is the measure of a solutions ability to carry electrical charge, that is, a measure of the soluble salt content of compost. The salt content of compost is due to the presence of sodium, chloride, potassium, nitrate, sulphate and ammonia salts (Brinton, 2003). The electrical conductivity of compost samples varied from 2.4 to 7.7 ds/m, in comparison with recommended standard in 50 and 60 days old compost samples the electrical conductivity found to be higher than the normal range (Table 1). These high values could be due to the effect of the concentration of salts as a consequence of degradation of organic matter (Campbell *et al*., 1997).

Bulk density

The bulk density of compost is defined as its weight per unit volume. During the present investigation the bulk density ranged from 0.6311 to 0.87206 mg/m^3. In comparison with recommended standard (Brinton, 2003) in all the maturity stages, of compost sample found to be higher than the normal range, which indicates that, during the composting process microbial activities break down the loosely combined raw materials into smaller pieces after degradation resulting in an increased bulk density (Hegarty, 1986).

Water holding capacity

Water holding capacity is the amount of water held into pores after gravitation loss for a specified time. The water holding capacity of compost samples varied from 16.334 to 80 % (Table 1). This test is assessed to find the utilization of compost for growing media. In the study carried out, water holding capacity got increased. This reveals that, the amount of water held in pores increases with days of composting.

Total water soluble salts

During the present investigation, the total water soluble salts varied from 22 to 517 mg/g. The maximum total water soluble salts concentration were recorded in 60 days old compost sample with 517 mg/g. Total water soluble salts have been found to increase in the case of all samples as the days of composting increased (Table 1).

Chloride

During the study period, the chloride concentration of compost samples varied from 0.213 to 12.3919 %. The concentrations of chloride for the samples are attributed to the dissolution of chlorinated soluble salts present in the solid wastes. The chloride concentration increased for each of the composting process.

Total organic carbon

During the present investigation, the total organic carbon varied from 10.0912 to 16.622 %. The total organic carbon content was found to be reduced in all the degradation stages of compost samples (Table 1). The losses of organic carbon were significantly affected by composting. It was found that, the percentage of organic carbon decreased, which shows the decomposition of waste by microbial population (Mondini *et al*., 2003). Part of the carbon in the decomposing residues evolved as CO_2 and a part was assimilated by the microbial biomass (Cabrera *et al*., 2005; Fang *et al*., 2001; Nakasaki *et al*., 1985). Fares *et al*. (2005) reported that carbon loss accounted for initial total carbon during the composting process.

Organic matter

Organic matter is the measure of carbon based materials in the compost. Organic matter is an important ingredient in all soils and has an important role to play in maintaining soil structure, nutrient availability and water holding capacity. The present investigation organic matter content of the compost samples varied from 17.397 to 28.656 %. In comparison with recommended standards (EPA waste-licensing system, 1996) in all the maturity stages, of compost sample found to be within the normal range. High quality compost will usually have a minimum of 50 % organic content based on dry weight.

Carbonates and bicarbonates

The concentrations of carbonates and bicarbonates of compost samples were found in the range of 0.0222 to 0.1582 and 0.8875 to 1.4837 g/l, respectively. The results shown that, minimum concentrations of carbonate and bicarbonate were recorded from 10 days old compost samples and maximum carbonate at 60 and bicarbonate at 30 days samples.

Calcium

Calcium and magnesium act as bases when they exist as oxides, hydroxides and carbonates. During the present investigation, calcium concentrations of compost samples varied from 9.545 to 61.2 meq/l. In comparison with recommended standards (Barker, 1997) calcium concentration was very higher in all the degradation stages of compost samples. Calcium has no hazardous effect on human health. In fact, it is one of the most important nutrient required by the organisms and can also aid in maintaining the structure of plant cells and soil condition. The main sources of calcium in the solid wastes are food and vegetable wastes, animal wastes, fine earth, organic wastes etc.

Magnesium

Magnesium concentrations varied from 0.996 to11.51 meq/l. In comparison with recommended standards (Barker, 1997) magnesium concentration was very higher in all the degradation stages of compost samples. The concentration of magnesium was found to be lower than calcium, which is regarded as, non-toxic to human health. The principal sources of magnesium in the solid wastes are domestic, food and vegetable wastes, fine earth and small scale industrial wastes etc. (Shivakumar *et al*., 2004).

Soluble sulphate

The present investigation on soluble sulphate varied from 16.36 to 61.95 %. The minimum percentage of soluble sulphate was recorded in 10 days old compost sample with 16.36 % and maximum for 60 days old compost sample with 61.95 %. The variation of sulphate concentrations mainly depends on the decomposition of organic matter present in the solid wastes. In anaerobic decomposition of solid wastes, sulphate is reduced to hydrogen sulphide, causing obnoxious odors and promote corrosion (Shivakumar *et al*., 2004).

Ammonia nitrogen

During the present investigate that, ammonia nitrogen ranged from 0.184 to 4.2 %. In comparison with recommended standards (Bord na Mona, 2003) the ammonia nitrogen were found higher in all the sample. Highest concentrations of NH4-N are produced in the first few weeks of composting. In fact, the ratio of organic and inorganic forms of nitrogen has been used as a maturity index. At the end of the process a concentration of NO3-N greater than the concentration of NH4-N would indicate that the process took place under adequate conditions of aeration and that mature compost was produced (Sánchez-Monedero *et al*., 2001). In this study concentration of ammonia nitrogen was lowest during initial stages, as the degradation proceeds, the concentration of ammonia nitrogen increases showing the lowest activity of urease in the degraded samples.

Nitrate-nitrogen

The nitrate-nitrogen concentration varied from 0.0514 to 9.072 mg/L. In comparison with recommended standards (Bord na Mona, 2003) the Nitrate-nitrogen were found higher in all the samples. Minimum concentration of nitrate-nitrogen was found to be in 10 days compost sample with 0.0514 mg/L and maximum 9.072 mg/kg for 60 days compost sample with 9.072 mg/L. The rise in nitrogen level during maturation phase could possibly be due to concentration effect caused by strong degradation of labile organic carbon compounds which reduces the weight of composting materials (Bermal *et al*., 1998).

Total phosphorous

Phosphorous is also an important nutrient for plant growth. Total phosphorous (TP) is usually expressed in terms of percentage concentration per dry weight. During the present investigation, the total phosphorous concentration varied from 1.43 to13.871 mg/kg. In comparison with recommended standards (Bord na Mona, 2003) the total phosphorous were found higher in all the samples. Total phosphorous content gradually increased during composting process and water solubility of phosphorous decreases with humification, so that, phosphorous solubility during the decomposition was subjected to further immobilization factor (Elango *et al*., 2009).

Sodium

The sodium concentration varied from 0.0275 to 0.086 %. Minimum concentration of sodium was found to be 10 day compost sample and maximum for 60 days compost sample. Sodium content in the waste was highly soluble and readily gets leached. Part of the sodium salt gets solubilized during decomposition. Up to moderate concentration, there was no adverse effect but the higher concentration of sodium may affect the soil structure as well as permeability resulting in alkaline salts and become toxic to plants (also corrosive).

Potassium

In the present study, potassium concentration varies from 0.06 to 0.138 %. Potassium is highly soluble in the wastes. Therefore, potassium is leached easily. The insoluble potassium salts can be solubilized by the decomposition of the wastes. Potassium increases during the period of composting and effective use of some fibrous materials like, straw or wood chips which can absorb relatively large quantities of water and still maintain structural integrity and porosity could prevent the loss of potassium from the compost formed (Gallardo-Lara *et al*., 1987). Potassium is not known to have harmful or toxic effects on human beings and it helps in plant growth as an essential nutritional element.

Total nitrogen

Total nitrogen (N) includes all forms of nitrogen, organic nitrogen, ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N). The measure of total nitrogen content includes both organic and inorganic forms of nitrogen in compost. In mature composts, most of the nitrogen is in organic form. The total nitrogen of all the compost samples varied from 1.245 to 1.825 %. The increase in total nitrogen concentration during composting will be caused by the decrease of substrate carbon resulting from the loss of CO_2 (because of the decomposition of the organic matter, which is chemically bound to nitrogen.

C/ N Ratio

C/N ratio is one of the most important parameters that determine the extent of composting and degree of compost maturity. Irrespective of the materials used for composting. The C/N ratio of all the compost samples varied from 5.529 to 13.351 %. In comparison with recommended standards (EPA waste management act 1996). It was reported that the C/N ratio narrow down as nitrogen remain in the system, while some of the carbon is released as CO_2 (Sadasivam and Manickam, 1993). Further nitrogen fixing microbes indirectly help in decreasing C/N ratio by making more nitrogen available from added Organic Matter (Rasal *et al*., 1988; Shinde *et al*., 1992). A ratio of >25 likely indicated stable compost.

DISCUSSION

The results of the study clearly indicate that, the biodegradation and recycling of solid wastes can transform garbage to enriched composts. Physico-chemical analysis of compost from the point of view moisture content, pH, chloride, organic matter, calcium, magnesium, total phosphorus, total nitrogen, C/N ratio, sodium, potassium agreed with recommended standards (Biotrate, 2003, Bord na Mona 2003, EPA Waste Management Act 1996 and Barker, 1997), The data presented in tables 1 showed that, the windrows system was more effective for nutrients marinating. Considering the high volume of garbage in institutional, aerobic composting may be considered as an important it could be concluded that element of Institutional waste management. In this regard, windrow composting system may be recommended for better method for recycling of Institutional waste, which can be used as fertilizer or soil amendment.

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