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Research Article

Characterization of Physicochemical and Biological Properties of Household Food Waste Composting Using Actinomycetes Genus

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ABSTRACT

Household food waste, farmyard cow dung waste, sawdust waste are used as substrate mixture and converted into organic composting using soil culture Actinomycetes genus. Isolation, characterization and biochemical test were carried to identify the Streptomyces spp. These species were subculture using nutrient media for inoculum dosage. An experimental setup was conducted using 1kg capacity of Poly Vinyl Chloride with six different ratio composting types induced and maintained in the thermophilic phase condition. This research sourced to characterization the physiochemical properties and microbial influence, after the composting. The composting types, C1 and C4 attain rich in Nitrogen while C2 and C5 attain rich in potassium and phosphorus. Carbon content rich in C3 and C6 composting. The concentration of the microbial population for each formulated composting was found and estimated. According to seedling and plant growth of Raphanus Sativus, C1 and C4 types composting attain mature growth within a short period and other composting maintain a slow growth rate. This beneficial research potential has made an interest or motivates to develop terrace farming, vertical farming and organic farming by individual household members.

Keywords: *Food Waste, Cow dung, Sawdust, Plant growth, Streptomyces species.*

INTRODUCTION

Around 8700 tons of Food Waste (FW) produced in India and 32% contributed to Municipal Solid Waste (MSW). Apart from food industries, 34% FW generated from consumption level (Palaniswamy et al., 2016). Dumping FW into landfilling and garbage causing inconvenience, health risk problems and environmental pollution (Yoada et al., 2014).Household food waste consists both of the inedible and edible food. Edible FW is based on choice or over-taken which is discarded or throw away.

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Inedible FW can be unwanted parts, rodent or spoiled foods, meat bones etc. Household members were facing major difficulties with this food waste due to bad smell while keeping separately or improper disposal management. Composting is a better option to handle the household food waste management instead avoid the landfilling and part of MSW due to social concern (Saravanan et al., 2013). This study executes the main source for composting FW, cow dung binds co-composting substrate (Karak et al., 2014) and sawdust controls the moisture content (Huang et al., 2004). Research study on composting approaches that the Actinomycetes genus is accounted for wide distribution in the soil (Williams & Davis, 1965) favorable microbes for composting. Streptomyces suitable species for the thermophilic phase (Meghvansi & Varma, 2020) composting food waste (Al-Dhabi et al., 2019) which are the subculture and prepared as inoculum dosage and induced for better and faster degradation and composting. The objectives of this study indicate to optimize the six different formulated ratio composting types were prepared as substrate mixture and 5% inoculum dosage poured into each formulation. The experiment was set up using PVC plastic containers. After composting, evaluated the physio-chemical properties includes moisture content, porosity, water holding capacity, bulk density, electrical conductivity, pH, NPK content, Total Organic Content (TOC) and C:N ratio. The microbial log was calculated. *Raphanus sativus* seeds are using an attempt of seedling and maturation to test the better types composting inducing. Considering such facts existing in the fold, this research has been taken with the main successive to digest the food waste using cost less culture to make an odor-free environment by use of aerobic process and ensure easy maintenance and eco-friendliness. This recycling approach increases our social response such as concern over environmental management, terrace farming and organic farming.

MATERIALS AND METHODS

Collection of food waste

The Food and vegetable waste includes discarded uneaten parts, vegetable peels, fruit peels expert meat bone and sandstone were collected using polyvinyl chloride plastic box in a local residential area represented by (Fig 1). The digestive culture portion includes cow dung, soil sample, sawdust was collected in large-sized jute gunny bags in a local farm unit in Thanjavur district and stored at 5°C shows in (Fig 2).

Fig. 1: Collection of food waste

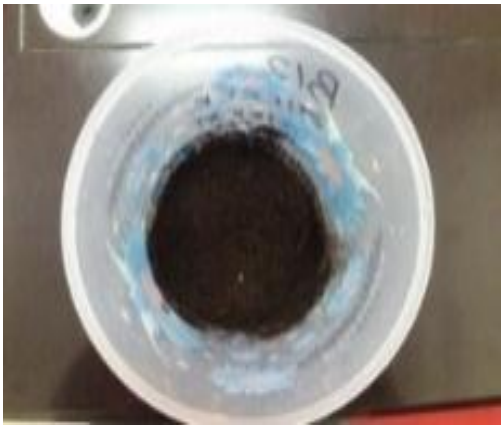


Fig. 2: Collection of culture

Isolation of Actinomycetes

The soil sample was serially diluted 10^{-3} to 10^{-10} by using Trypticase Soy Agar (TSA). Incubated at 28°C for 24-72 days. Spread Plate Count (SPC) and Coli form count (CFU) experimented. According to Bergey's Manual, the isolated microbes were under the morphological and cultural characteristics such as pigment, abundance growth, optimal characteristics, elevation, margin and microbe

sizes were studied on TSA plates.

Identification of Actinomycetes

Gram's staining technique and Hanging drop technique was applied to identify the gram-positive or gram-negative and mobility of microbes. Biochemical characteristics such as Triple sugar iron test, Methyl red test, Indole test, Voges - Proskauer, Endospore and starch hydrolysis were carried to isolated strain belonged to the genus Streptomyces in the growth culture. These species were subculture using nutrient broth were utilized to decompose the substrate (Indumathi, 2017).

Mixture Preparation

The experiment was conducted with a capacity of 1kg Polyvinyl chloride (PVC) Plastic box to make 6 different composting types. The collected sawdust, cow dung and food waste were dried at 105°C in the oven for 3hrs. Later, it was chopped into particle size. For 1kg formulation, different ratio substrate was prepared for composting types and an isolated genus was sub-culture using nutrient media and small quantity added together for faster microbial degradation. PVC boxes were closed with a portable plastic lid with a 1cm hole in three different places on it. The cow dung binds co-composting activity and booster of microbial load (Adegunloye et al., 2007). The sawdust maintains the moisture content of the sample preparation (Ogunwande et al., 2008) not above 80% and added subculture microbes increase the biodegradable rate with a short period. Composting types were agitated manually at the required interval and kept it composting about 25 to 30 days. The PVC box should be placed in a solar dryer to maintain the thermophilic phase and periodically adequate oxygen level. After composting, 50 g from each composting types were poured in a zip-seal pouch bags and allowed the conduct the physio-chemical and microbial log.

Formulation of sample

According to sample preparation, six different composting types run were prepared using the food waste + cow dung + sawdust substrate mixture and subculture inoculum dosage of 5ml added to composting types. The following six composting formulations are listed in (Table 2).

Table 2: Different Formulation of the composting sample preparation

Different Formulation of the compost sample					
C1	C2	C3	C4	C5	C6
(50:25:25)	(25:50:25)	(25:25:50)	(75:12.5:12.5)	(75:12.5:12.5)	(75:12.5:12.5)

Physio-chemical Properties of composting types

The bulk density (g/cm^3) was determined by using the pycnometer (Gabhane et al., 2012). Moisture Content (%) was measured by using hot air oven keeping at 105°C for 24 hrs (Khater, 2015). Water Holding capacity (g water/g dry sample) was calculated using principal of (Ahn et al., 2008). The porosity was followed by (Andrew and Leonard, 2003). pH value measured by ten grams of composting type samples were transferred into 100 ml of beaker and 100ml of distilled water added to it. Later, suspension centrifuge at 10,000 rpm for 30 minutes and analyzed by pH meter (Sasaki et al., 2003). Electrical Conductivity measured by 1 gram of formulated samples was allowed to keep in a hot air oven at 105°C for 24 hrs. Later, mashed with 10ml distilled water, shaken at 130 rpm for 24 hrs and then filtered it (Yaser, 2019). Total Organic Content was estimated by 5 grams of formulated samples were allowed to keep in a hot air oven at 105°C for 24 hrs. Then, dried sample was allocated to keep at 550°C for 2 hrs in a muffle furnace. The total N % and total C % were estimated by using high sensitivity analyzer (Nakhshiniev et al., 2014). The total P % was estimated by using ULR Colorimeter (Galvez-sola et al., 2010). The total K % was estimated by using flame spectrometry (Bar-Tal et al., 2004). Carbon/Nitrogen ratio was followed and calculated by (AZIM et al., 2014).

Biological properties

Microorganisms Colony Count

Composted samples were allowed to determine the total plate or colony count by using Spread Plate Counting Method. Actinomycetes were culture growth in strength of 0.4 % TSA, 10 mg Polymixin B, 70% Ethanol, 10.0 g Bacto Agar, 500 ml distilled water. Mix the first 3 ingredients, autoclave for 20 minutes, and cool to room temperature. Later, pour into sterile Petri dishes. Ten grams of composted samples diluted in 90 ml of distilled water and Perform serial dilutions to 10^{-10} and add 0.l ml of dilution to each plate. Incubate the plate at 28C for 14 days. The numbers of microbes were expressed as colony-forming units (CFU) per gram dry w.t of samples (Kazemi et al., 2017).

Seedling and plant growth

Composted type samples were allowed to check for the seedling germination and effect of plant growth using *Raphanus sativus*. The six portable trays length, width and height of 60×40×20 in Centimeter which is used to sow the six seeds with a spacing of 15×10 cm adopted for each. Drip irrigation method is done using an 8 hole drip emitters size of 4mm at an interval period and kept in the incubator chamber at 20°C (Warman, 2013). The seedling germination within 72 hours was observed and experiments conducted for every 14 days were analyzed parameters.

RESULT AND DISCUSSION

Biochemical characteristics of the Actinomycetes isolate

The following Actinomycetes species primary screening and isolation using the spread plate and streak plate method represented by (Fig 3). The Isolation and Screening showed in (Table 3) remains Streptomyces species and subculture using nutrient media shown in (Fig 4) (Dhananjeyan et al., 2010).

(a) Spread Plate

(b) Streak Plate

Fig 3 (a-b) Isolation and Screening of micro-organisms

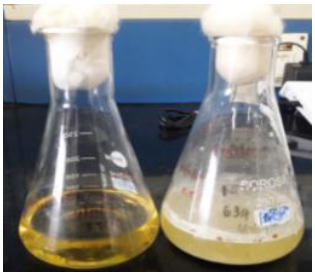


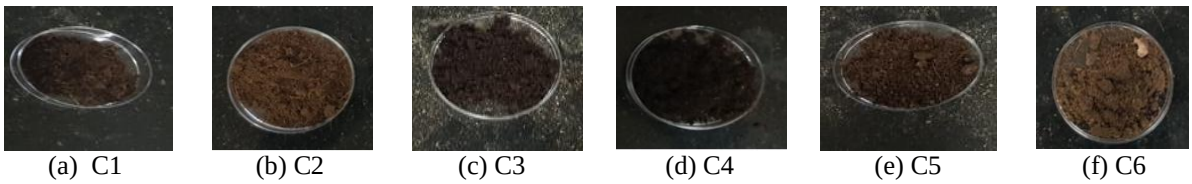
Fig 4 Growth of microbes in media

Table 3: Biochemical characteristics Streptomyces strain in the soil

S. No.	Characteristic Tests	Streptomyces Species
1	Gram Staining	+
2	Shape and growth	Filamentous aerial growth
3	Motility	+
4	Methyl red test	+
5	Indole test	+
6	Triple sugar iron test	+
7	Voges- Proskauer	+
8	Starch hydrolysis	+

Analysis of Physio-chemical properties

After composting, each composting type sample was showed in the (Fig 5) and analyzed for physio-chemical properties and resulted in (Table 4). Bulk density of the formulated compost types results in that range from 670 to 466 (kg/cm^{-3}). C4 types range of density 670 (kg/cm^{-3}) was found to be food waste proportion and C7 has the lowest range of density 466 (kg/cm^{-3}) due to high proportion of sawdust shows in (Table 4). The bulk density of increase and decrease range indication on the Total Organic Content of composting (Celik et al., 2004). MC of the formulated compost types ranges from 52 to 28 percentage. The highest value of 52 % on C1 types shows because FW contains maximum moisture content. Results show that C6 has the lowest of 28 % due to high-level presence sawdust is a dry matter which absorbs and maintains the MC of the compost. Thermophilic condition and microbial activity are a key factor for fluctuations (Manu et al., 2017) in the MC value for compost formulation According to Water Holding Capacity, data shows that value increase from 3.72 to 4.89 (g water/g dry sample). C6 attains 4.89% based on sawdust particle size which holds more water retention (Rizki et al., 2010) and low content attains the value of C4 type shows in (Table 4). Porosity increase with decrease depends on the MC and bulk density of composting. Porosity value ranges from 60.69 to 72.11%. C6 results in the highest range of 72.11% intended for particle size (Veeken et al., 2003). The lowest value attains with C1 formulation has a large particle size. pH value of the formulated composting types where shows variation from 6.8 to 7.7 based on the influence of H^+ ions. C4 type value based on a faster degradation rate while C6 depends on mediate degradation. This variation indication of organic acid formation (Yang et al., 2013). EC result shows that the C4 type value of 3.97 mS/cm indicates more phosphorus and potassium content during the decomposition of FW substrate. C6 represents the lower value imitates transmission of NH_4^+ ions rate. A better range of EC value of compost should be (2.5-3.5 mS/cm) gives a positive impact on plant growth (Lin, 2008). TOC of different formulated samples shows that the value range from 20.12 to 26.33% indicates C6 type attains high content of DM and ash (Rendek et al., 2006). Lowest value attains due to a lack of DM and volatile suspension. Composting type shows Nitrogen ranges from 3.88 to 4.56. C4 combination reaches higher content of 4.56 while C6 attains 3.88 due to high MC. Composting type shows P content ranges from 2.11 to 3.97%. C5 attains a high value of 3.97 to intended of nitrogen absorption. C3 attains the lowest range of 2.11% indicates a loss of minerals content and MC. Composting type K content observed to be shown (Table 4) resulted in that C2 has a high range of 2.68 due to cow dung substrate increase K level while C3 appears to decrease due to normal content of minerals. C/N ratio of the formulated compost sample ranged from 20.33 to 26.81 and showed in (Table 4). The optimum ratio lies in (25:1 to 30:1) for better composting. C4 combination attains a higher range of 20.81 due to adding more dry matter (Bazrafshan et al., 2009) while C3 attains the lowest range of 16.33.



(a) C1 (b) C2 (c) C3 (d) C4 (e) C5 (f) C6

Fig 5: (C1- C6) Six different formulation of compost production

Table 4: Analysis of physio-chemical properties data, after composting

Parameters	Compost Formulation					
	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Bulk density (kg/cm^{-3})	665	635	470	670	650	466
Moisture content (%)	52	44	35	60	52	28
Water Holding Capacity (g water/g dry sample)	3.13	3.87	4.37	3.07	3.43	4.89
Porosity (%)	60.69	62.53	69.77	63.45	66.59	72.11
pH	7.3	7.6	6.8	7.7	7.6	6.5
Electrical Conduct (mS/cm)	3.95	3.35	2.46	3.97	3.42	2.77
Total Organic Content (%)	20.12	22.83	26.30	20.77	24.22	26.33
Nitrogen Content (%)	4.13	4.01	3.97	4.56	4.23	3.88
Phosphorus content (%)	3.44	3.83	2.11	3.71	3.97	2.03
Potassium content (%)	2.56	2.68	1.03	2.60	2.65	0.97
C/N Ratio	18:19	20.3	16.33	20.81	23.77	18.37

Microbial Colony Count

To analyze the microbial population of the differently formulated compost sample after the predicted digestion duration, the colonies of Streptomyces strain were calculated by using a colony counter. Dilution factor 10^{-3} to 10^{-10} was carried out. During the incubator period, the colony-forming units per gram value ranged were too numerous to count in 10^{-3} to 10^{-5} while 10^{-7}, 10^{-8}, 10^{-9} and 10^{-10} were found to be calculated that shown in (Table 5).

Table 5: Microbial load for each composting types (Log $CFUg^{-1}$)

Formulated composting	Microbial Load							
	10^{-3}	**10^{-4}**	**10^{-5}**	**10^{-6}**	**10^{-7}**	**10^{-8}**	**10^{-9}**	**10^{-10}**
C1	TNTC	TNTC	8.139	7.806	8.732	9.681	10.414	11.113
C2	TNTC	TNTC	8.161	7.973	8.857	9.799	10.732	11.556
C3	TNTC	TNTC	6.982	7.892	8.799	9.748	10.556	11.342
C4	TNTC	TNTC	TNTC	9.130	8.944	9.832	10.716	11.556
C5	TNTC	TNTC	TNTC	8.892	8.779	9.732	10.556	11.414
C6	TNTC	5.963	6.924	7.799	8.748	9.623	10.518	11.361

Effect on seedling and maturation

The effect on seedling and maturation were resulted in (Table 6) using *Raphanus sativus* seeds shows the variation of growth stage for different formulation by calculating the root length and shoot length (Hameeda et al., 2006), promoting growth C4 reached higher growth of shoot and root size of radish due to high nitrogen fixation while C6 has less growth yield in size and leaves appears with white rust.

Table 6: Effect on root and shoot growth

Parameters in (cm)	C1	Different C2	Formulated C3	Composts C4	C5	C6
Root lenth on 14th day	1.8	1.5	1.2	2.2	1.8	1.5
Shoot length on 14th day	0.8	0.6	0.3	1.4	0.9	0.5
Root lenth on 28th day	3.7	3.4	2.8	4.9	3.8	2.5
Shoot length on 28th day	1.6	1.4	1.0	2.7	1.9	1.3
Root lenth on 42th day	6.6	6.0	4.8	7.6	6.8	4.6
Shoot length on 42th day	2.8	2.4	2.2	3.6	3.4	2.1
Root lenth on 42th day	8.8	8.1	6.4	10.2	9.4	6.0
Shoot length on 42th day	3.6	3.0	2.8	4.6	3.8	2.5

CONCLUSION

In this present study, it was observed that 30-35% compost degradation loss is on average due to digestion and recoverable compost around 65-70%. Analysis of parameters results for formulated composting types showed that C4 and C5 remain good nutrient matter. Microbial population value ranged showed that no significant variation associated with studies ($P<0.05$) and higher load concentration were attributes for all formulated samples. *Raphanus sativus* seeds for seedling and maturation experiment concludes that C1 and C4 types attain faster and better growth within a short period while C6 represents immature growth.

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