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Survey, characterization and composting studies of agricultural product producers and traders association market (APPTA) wastes of Kanyakumari District of Tamil Nadu (India)

C PrabakaranDOI: <https://doi.org/10.22271/chemi.2020.v8.i4g.10123>**Abstract**

Wastes generated in APPTA market in Kanyakumari district created the problems of disposal. Hence, an attempt was made for surveying, characterization and composting of APPTA market waste. From the survey, it was found that a quantity of 1200 tonnes of solid waste was generated every year in the APPTA market. Characterization for physical composition analysis recorded that major portion of the APPTA market waste was banana bunch stalks/peduncle (80%) followed by banana threshees with a wide C:N ratio (93:1). Compost of APPTA market waste matured within 90 days of initiation of aerobic heap composting process (after removal non-degradable waste followed by shredding, addition of 2 kg bio-mineralizer and 4 kg N per tonnes of APPTA market waste with frequent turnings at weekly intervals).

Keywords: APPTA market waste, survey, characterization, composting, maturity

Introduction

Market waste are produced in huge quantities and disposed along with municipal waste that created controversies between municipal workers and market managers in disposal of waste. It is known that the farmers are in great demand for fertilizer at the same time waste materials also accumulating. Since the majority of market waste are organic in nature, composting of the market waste will reduce environmental pollution and provide nutrient for the farmers towards crop production programmes. Several literatures revealed beneficial use of compost for crops. Application of compost as organic manure to crops improved physical properties of applied soil (Prabakaran, 2006)^[9], enhanced soil fertility (Prabakaran, 2003c.)^[8], improved soil quality (Prabakaran, 2008)^[14] enhanced enzymatic activity (Pitchai *et al.*, 2003)^[11], increased nutrient uptake of tomato (Prabakaran, 2003b: Prabakaran, 2008b)^[7, 15], improved micronutrient status of soil (Prabakaran, 2008)^[14] increased stress tolerant properties in banana (Udayasoorian and Prabakaran, 2010)^[21], increased the yield (Prabakaran, 2007)^[12], quality of tomato (Prabakaran and Pitchai, 2003)^[11] and banana (Udayasoorian *et al.*, 2007)^[22], higher biominerals of banana (Prabakaran, 2020)^[16], ground water quality under fertigation (Prabakaran, 2016)^[17], improved the economy of tomato cultivation (Prabakaran, 2003a), increased seed yield of green gram (Thavaprakash *et al.*, 2006)^[19], improved performance of vegetable based agroforestry based system (Rajalingam *et al.*, 2016)^[17]. APPTA market in Kanyakumari district is one the biggest market in South India where the commodities of horticulture from Kanyakumari district and different parts of Tamil Nadu are exchanged. The literature regarding quantity of waste generated in APPTA market, its characteristics and process of composting is scanty. Hence, this study was proposed.

Materials and Methods

Survey on the quantity of waste generated in APPTA market during the project period was estimated by multiplying the number of loads of waste disposed from the APPTA market with average waste holding capacity of the truck (volume) used for disposal multiplied by bulk density of APPTA market and expressed in tones.

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Homogeneous and representative sample were obtained by reduction method (mixing the waste thoroughly and dividing into four piles of same volume followed by removing two parts of waste at diagonal opposite ends and mixing the remaining amount till desired quantity is obtained). For the physical composition analysis, a representative sample of about 100 kg was obtained by reduction method. The samples were segregated into nine category and the composition ratio of each waste in wet weight base (%) was calculated. In addition to the above physical properties like bulk density and particle density were also determined by following standard procedures.

Compost yard experiment was conducted in Agricultural Research Station (ARS), Thirupathisaram. Compost yard was prepared by spreading water proof high density polyethylene (HDPE) sheet of 250 GSM thicknesses and size of 4m x 4m for each treatment. This acted as impermeable layer in compost yard to prevent leaching of nutrients to ground water. Buffer channel was created between each treatment to prevent mixing of waste between treatment. Required quantities of waste materials were collected from APPTA market of Kanyakumari district through market's regular disposal vehicle to ARS, Thirupathisaram. APPTA market waste was composted by following aerobic heap method. Size of the heap adopted for aerobic composting is 2m x 2m x 2m.

The following treatments were imposed for composting the APPTA market waste with four replications. Treatments consisted of T₁-Absolute control; T₂-APPTA market waste without segregation+2 kg bio-mineralizer+4 kg N tonnes⁻¹ of waste; T₃-APPTA market waste (compostable part only)+2 kg bio-mineralizer+4 kg N tonnes⁻¹ of waste; T₄-APPTA market waste (Shredded compostable part)+2 kg bio-mineralizer+4 kg N tonnes⁻¹ of waste + turning the compost at weekly interval.

To apply bio-mineralizer and nutrient N source equally to entire APPTA market waste aerobic heap, APPTA market waste were stacked in layers of 7.5 cm thickness on the impermeable HDPE sheet. About 8 kgs of N (17.4 kg urea) was divided into 13 equal parts and one part was sprinkled on the first layer. Similarly, 4 kg of bio-mineralizer (@ 2 kg tonnes⁻¹ of waste) was mixed with 40 litres of 2 per cent cow dung slurry. The cow dung slurry was divided into 13 equal parts and one part is sprayed in next layer above the first layer as microbial source. Application of bio-mineralizer followed by application of urea was repeated till it attained 2 m height. After this water was sprinkled to maintain a moisture content of 60 per cent. Then the heap was molded by using locally prepared mud slurry. Adequate aeration holes were provided. The maturity indices viz., temperature, pH, EC, total C, total N and C:N ratio were assessed at 30 days interval up to 60 days and there after it was measured at 10 days interval up to 120 days as per standard procedures. After maturity, the compost heap was disturbed and the compost was spread for curing. After about 24 hours the composted material was sieved through 4 mm sieve to get uniform compost material.

The data obtained from the yard experiments and field experiments were analyzed as per the procedure described by Panse and Sukhatame (1961) [5]. Critical difference was worked out at five per cent probability level and the results were interpreted.

Results and Discussion

The data on survey indicated that waste generation during project period ranged from 92-128 tonnes per month. The

average waste generation per year is 1266 tonnes with the highest generation during July- August (Table 1). Since it is a banana fruit-based market, increased banana production and decreased price during the rainy season may be the reason for increasing waste during July to August.

Table 1: Generation of waste in APPTA market of Kanyakumari District during the project period (September 2015 to August 2017)

Month	Quantity (in tonnes)		
	2015-2016	2016-2017	Average
September	128	124	126
October	104	96	100
November	93	87	90
December	96	92	94
January	88	84	86
February	96	92	94
March	104	100	102
April	124	104	114
May	120	104	112
June	112	96	104
July	120	112	116
August	132	124	128
Total	1317	1215	1266

It is estimated that about 1300 (rounded) tonnes of wastes were generated from the APPTA market every year. Highest waste generation was recorded during July and August. Since APPTA market waste was banana market, more production of banana during rainy season and damage due to wind that might have produced inferior products may be the reason for increased production of waste.

Table 2: Physical Composition analysis of APPTA market waste

No.	Name of the material	Composition	Average
1.	Banana bunch stalks/peduncle	75 – 95	80
2.	Banana threshes	8 – 12	10
3.	Banana fruits (Damaged/)	2 – 6	4
4.	Decayed other fruits and	2 – 6	4
5.	Packaging materials (soiled	0.5 – 2	0.8
6.	Recyclable plastics	0 – 1	0.2
7.	Non-recyclable plastics	0 – 1	0.2
8.	Leather, rubber and textiles	0 – 1	0.2
9.	Non-recyclable metals	0 – 1	0.2

Physical composition analysis of APPTA market waste (Table 2) revealed that the waste had more quantity of Banana bunch stalks or peduncle (80%) followed by banana threshes (10%), banana fruits (Damaged/ substandard) (4%), decayed other fruits and vegetables (4%). It also contained packaging materials (soiled card board, papers worn out jute bags etc.), recyclable plastics, non-recyclable plastics, leather, rubber and textiles, and non-recyclable metals.

Table 3: Physical properties of APPTA market waste

No.	Name of the material	Composition range	Average Composition
1	Bulk density (g/cm ³)	0.27-0.33	0.30
2	Particle density (g/cm ³)	0.45-0.55	0.50

The bulk density and particle density (Table 3) of the waste were 0.3 and 0.5 g cm⁻³, respectively. Analysis of physical properties revealed that it will occupy more area even it is land filled. Hence compost is alternate to land filling.

Table 4: Chemical Composition analysis of APPTA market waste of Kanyakumari district

No.	Particulars	Composition range (%)	Average composition (%)
1.	Moisture content	62 - 71	66
2.	Total Carbon	12 - 17	14
3	Total Nitrogen	0.1 – 0.2	0.15
4.	C:N ratio	80:1 - 100:1	93:1
5.	Total P	0.12 -0.18	0.14
6.	Total K	0.12-0.20	0.18

Chemical composition analysis (Table 4) revealed that it has appreciable quantities of moisture for microbial attack (66%). It had a carbon content of 14 per cent and total N content of 0.15 per cent. Wide C:N ratio of 93:1. Higher amount of banana stocks might be the reason for higher C:N ratio of the waste material. In order to bring the C:N ratio to around 30:1 required quantity N source has to be added. It had also appreciable amount of total P (0.14%) and rich in K content (0.18%).

Table 5: Changes in temperature ($^{\circ}\text{C}$) during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	42.3	45.2	47.3	48.5	49.0	50.0	55.3	58.2
T ₂	70.1	68.3	62.4	52.6	42.7	32.5	30.8	28.8
T ₃	70.0	68.4	62.5	52.6	42.8	32.8	30.9	28.7
T ₄	62.5	42.5	32.4	25.8	25.8	25.8	25.8	28.7
S.Ed	1.4	1.6	1.1	0.8	1.6	1.2	1.3	1.1
CD (5%)	3.0	3.4	2.4	1.7	3.4	2.6	2.8	2.4

Temperature is an important factor to be considered during composting process. This is one of the indicators of initiation, progress and maturity of composting. Compost heat is developed as a byproduct of the microbial breakdown of organic material. In general, higher level of temperature at 30 days of initiation of composting was observed (except control) then it decreased. The heat production depends on moisture content, size of the material/surface area of the material etc., In this present study, increased temperature (70.1°C) at 30th day of composting (Table 5) was recorded due to composting of APPTA market waste without segregation along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste (T₂). To preserve beneficial microbes the temperature should be below about 65°C because hotter temperatures may kill beneficial microbes.

In this experiment, composting of APPTA market waste after shredding along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste with turning the compost at weekly interval during composting (T₄) attained a safe temperature of 62.5°C at 30 days of composting is a sign of rapid initiation of composting process and it decreased gradually but remained in thermophilic range of more than 400°C up to 60 days. It further decreased and reached ambient level after 70 days of composting. Tiquia *et al.*, (1997) [20] reported that turning of pile, maintenance of moisture at optimum level and addition of easily available carbon sources are necessary to enhance microbial activity during composting. In the present study turning of compost might had released excess heat to the atmosphere. All the composting treatment except control has reached ambient air temperature at 120 days except control (Table 4). The compost is said to stable when temperature of compost approaches the ambient level (Satisa and Devaranjan, 2007) [18].

In the treatment, composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄), the temperature found to decreased due to increased surface area for microbial that might had increased the temperature attained at thermophilic phase before 30 days.

Thermophilic composting is the act of breaking down biological or organic waste materials with heat-loving bacteria. Compost that stays at 50°C for 24 hours will be safe to use to grow food. A temperature of 46°C will kill pathogens within a week. 62°C will kill pathogens in one hour

Table 6: Changes in pH values during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	7.88	7.89	7.89	7.91	7.88	7.87	7.86	7.87
T ₂	7.68	7.65	7.55	7.53	7.52	7.22	7.01	7.01
T ₃	7.67	7.64	7.54	7.52	7.51	7.21	7.01	7.01
T ₄	7.48	7.44	7.21	6.99	6.99	6.99	7.00	7.00
SEd	0.02	0.03	0.02	0.01	0.02	0.02	0.03	0.01
CD	0.04	0.06	0.04	0.02	0.04	0.04	0.06	0.02

Changes in pH of a substrate decide type of an organism to grow. Since it is almost neutral pH bacteria may dominate resulting in quick decomposition. The initial pH ranged between 7.88 to 6.90 (Table 6) for different treatments in APPTA market waste composting. During the initial phase of composting, the pH is slightly high later decreases as the material gradually decomposes and stabilizes, finally staying at 7.00. In this present study, composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄) recorded lower pH values and reached neutral after 80 days of composting. In general, control remained at high pH indicating that the compost processes is going on slowly (Table 5). At initial phase pH value decreased. The reason ascribed for decreased pH was that the fermentation of carbohydrate that released the organic acids. At the thermophilic period the pH began to rise and reached 9.02. This might be due to release of NH_3 due to break down of protein. During the maturity stages the pH drop to a neutral value. This study indicates that pH may not be considered a right parameter to assess compost maturity as its overall trend is not describable by a monotonic function.

Table 7: Changes in EC values (dS m^{-1}) during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.09
T ₂	0.41	0.63	0.82	0.93	1.12	1.12	2.61	2.61
T ₃	0.42	0.62	0.82	0.93	1.12	1.82	2.61	2.61
T ₄	0.81	1.11	1.82	2.61	2.61	2.61	2.61	2.61
SEd	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.03
CD	0.02	0.04	0.02	0.02	0.01	0.02	0.04	0.06

The EC is the measure of a solution's ability to carry out electrical changes that is the measure of a soluble salt content of the compost. It is reported that the salt content of the compost is due to the presence of Na, Cl_2 , K, NO_3 , sulphate and ammonia salts (Brinton, 2003) [4]. In general, EC values tend to increase during the process of composting whereas the

control treatment had shown lower values of electrical conductivity during entire process of composting (Table 7).

Table 8: Changes in total C content (%) during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	29.1	28.2	27.3	26.7	26.1	25.8	25.5	25.3
T ₂	27.2	26.8	26.1	25.2	23.6	22.4	20.4	20.1
T ₃	27.2	26.7	26.2	25.3	23.4	22.4	20.5	20.1
T ₄	25.2	23.6	22.4	20.4	20.4	20.1	20.1	20.1
SEd	0.01	0.02	0.05	0.04	0.04	0.03	0.03	0.03
CD	0.02	0.04	0.11	0.09	0.09	0.06	0.06	0.06

Decrease in total C (Table 8) was observed during the process of composting in all the treatments (Table 8). In this present study, composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄) recorded higher loss of organic carbon than any other treatment. The total organic carbon got stabilized at 80th day of composting due to composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄). Higher organic carbon content was noticed in control. The carbon present in waste material is the source of microbial respiration and growth. The organic matter loss increased with composting time in all the composts due to greater availability of easily biodegradable substances to microbes (Benito *et al.*, 2003) [1]. Highest losses of organic matter were observed during first 60 days of composting in all the composts which slowed down thereafter. The reason ascribed that the incorporation of bio-mineralizer, frequent turning of compost at weekly interval, shredding of APPTA market waste and maintenance of adequate moisture content that provided optimum condition for the growth of micro-organism to utilize the organic carbon available in the waste material. The organic matter loss more than 42 per cent may be accepted as an index value to get mature compost. The breakdown of complex organic compounds into simpler compounds due to microbial bio-degradation and conversion of carbon into CO₂ and release of other by products that might had increased the total N content in the final matured compost in case of all the above four treatments.

Table 9: Changes in total N (%) during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	0.31	0.33	0.35	0.38	0.39	0.41	0.43	0.44
T ₂	0.71	0.73	0.75	0.78	0.81	0.82	0.91	0.91
T ₃	0.71	0.73	0.75	0.78	0.81	0.82	0.91	0.91
T ₄	0.73	0.74	0.78	0.81	0.91	0.91	0.91	0.90
SEd	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.02
CD	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4

N is an essential nutrient required for the growth and development of plants and micro-organisms. The matured compost obtained due to composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄) had a total N content of 0.91 per cent at 90 days after initiation of composting (Table 9). The reason ascribed may be that the bacteria present in the

bio-mineralizer might have played an effective role in the decomposition process and release of N as nitrate.

Table 10: Changes in C:N ratio during composting of APPTA market waste

Treatments	Sampling period (Days)							
	30	60	70	80	90	100	110	120
T ₁	93.87	85.45	78.00	70.26	66.92	62.93	59.30	57.50
T ₂	38.31	36.71	34.80	32.31	29.14	27.32	22.42	22.09
T ₃	38.31	36.58	34.93	32.44	28.89	27.32	22.53	22.09
T ₄	34.52	31.89	28.72	25.19	22.42	22.09	22.09	22.33
S.Ed	1.24	1.46	1.36	1.14	1.24	1.22	1.31	0.91
CD	2.63	3.07	2.85	2.45	2.63	2.63	2.82	1.95

C:N ratio is then widely used as an indicator of compost maturity (Bernal *et al.*, 1998) [3]. The C:N ratio recorded during the composting of shredded APPTA market waste along with addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste and turning the compost at weekly interval during composting (T₄) decreased till 90 days and stabilized thereafter (Table 10). As the decomposition progressed due to losses of organic matter mainly as carbon dioxide, the carbon content of the compostable material decreased with time and N released per unit material increased might be the reason for decrease of C:N ratio of the composted waste material. A C:N ratio below 20 was assumed to be indicative of maturity compost and a ratio of 15 or less is preferable (Bernal *et al.*, 2009) [2].

Conclusion

Waste generated in APPTA market is huge. It had wide C:N ratio. Hence it needs composting prior to soil application for crop production. Compost maturity test *viz.*, temperature and total C reached stable value at 80 days onwards; total N and C:N ratio stabilized at 90 days onwards of aerobic composting initiation indicated that the treatment of composting the APPTA market waste after removing non-compostable material followed by shredding, addition of 2 kg bio-mineralizer and 4 kg N tonnes⁻¹ of waste with turnings at the rate of weekly intervals reaches maturity at 90 days of initiation of composting process.

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