Conversion of Municipal Organic Waste into Agricultural Product

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Abstract – In India, Kolhapur is one of the most advanced districts of Maharashtra state. Rapid development in city is causing increase in MSW generation of city resulting into degradation of environment. Kolhapur city has 11 vegetable and fruit markets and the waste generation of the city is around 200 TPD. Around 60-65% of waste is organic waste from the total generated municipal solid waste. This organic waste fraction has tendency to decompose which leads to odor problems and other problems like GHG emissions. Due to mixing of vegetable market waste with MSW and directly dumping it on landfill sites, it is causing scarcity of land and increasing GHG emissions. So this experiment of composting on vegetable market waste i.e. organic waste was carried out, in order to reduce the organic fraction at source itself, in Kolhapur city. The composting was carried out in plastic tray type bin. The vegetable market waste was collected from the four markets in the vicinity of city Centre. Water was sprinkled to maintain the moisture and the waste was turned frequently to keep aerobic conditions. Bio-culture was added as a seeding material to composting. The composting process required total 50 days to form the compost. Then the final product was analyzed for physical and chemical properties of compost. The results have shown that the compost has sufficient amount of nutrients and can be used as fertilizer. Only C/N ratio was less than required, which can be increased by adding the external carbon sources into compost. As composting requires less space, it was suggested that each vegetable market of Kolhapur city shall set up a small composting plant within the market or in a nearby area, in order to minimize the problem of waste disposal to a great extent.

***Key Words*: Vegetable market waste, Composting, Organic Waste, Kolhapur, Bio-culture, Nutrients.**

1. Introduction:

Kolhapur city is located at south-west part of Maharashtra, in India. The city is situated on the banks of river Panchaganga. Latitude and longitude co-ordinates of Kolhapur city are 16° 42′ N and 74° 14′ E and its elevation was 607 meters above mean sea level. Population of Kolhapur is 5, 49, 283 according to census 2011. Area of the city is around 66.83 sq. km. The city has abundant natural resources like water, soil, natural vegetation, animal wealth and minerals. As a result, Kolhapur is one of the most advanced districts of state Maharashtra, in India. One of the negative impacts of city's rapid development is increase in MSW generation of city which has resulted in environmental degradation. The factors such as rising urban population, economic development, institutional framework, climate and consumption patterns and climate were contributing in generating higher amount of MSW.

Vegetable waste is non-edible part of vegetables that are discarded during collection, handling, transportation and processing. Presently, those wastes have been mixed into municipal waste streams and sent to landfills for final disposal. As landfills are closing at an alarming rate, the disposal of vegetable waste becomes a serious problem in many cities. Many vegetable markets, supermarkets and wholesales markets are thinking to find substitute for management and disposal of solid waste generated.

Kolhapur also consists of many vegetable and fruit markets. Kolhapur city generates around 200 TPD of waste. It includes food waste, vegetable waste, yard waste, leftovers, containers, product packaging and other miscellaneous inorganic waste from residential, commercial and institutional agencies, etc. From total generated solid waste, it has been observed that around 60-65% of waste is organic waste in Kolhapur. This organic waste fraction has tendency to decompose which leads to odor problems and other problems like GHG emissions. The extensively used technique for treating organic waste fraction is "composting" and it results into the organic compost, which could be used as a manure and soil amendment on agricultural farms. Composting is a natural process and results in conservation of natural resources. If the organic fraction of the MSW is converted into compost then a very little amount remains, the inorganic one, which can be recycled. Using this method volume of the MSW discarded into the landfill can be minimized to a greater extent.

Composting is a low cost method of diverting low cost materials from landfills while creating a product for agricultural purposes (Saha et al., 2010). It is an aerobic biological process that uses the innate microbial to convert degradable organic matter into humus like product. Presently only 8-9% of the waste generated is used for compost production by

various public or private enterprises. There is a wide variation among the compost manufacturing agencies with respect to the different methods and technologies being used. The quality of compost depends upon the source and nature of waste, the composting facility design, composting procedure and length of maturation (Hargreaves et al., 2008). Composting offers several benefits such as enhanced soil fertility and soil health, increased agricultural productivity, improved soil biodiversity, reduced ecological risks and a better environment. It destroys pathogens and reduces the volume of waste. Furthermore, composting transforms unstable ammonia to stable organic forms of nitrogen (Zhu, 2006).

Kolhapur city has 11 vegetable and fruit markets, their contributions to total waste generation per day is significant. High amount of biodegradable waste is generated. Around 1 ton of organic waste generates daily in all these four markets and it can be reduced at the source itself, if treated scientifically. So, keeping this in mind, it was decided to conduct an experiment on treatment of vegetable market waste of Kolhapur city by composting, in order to reduce this extra load on the landfill.

Literature Review:

Saha et al., 2010, conducted a study to examine the physico-chemical properties, fertilizing potential and heavy metal polluting potentials of MSW composts produced in 29 different cities of the country. 36 MSW compost samples were collected from 29 different cities and from 13 different states of India. The samples were collected once from each place by standard USEPA part 503 rule (USEPA, 1995). The compost samples were analyzed for various physical and chemical characteristics such as moisture content, bulk density, pH, Electrical conductivity (EC), Chlorine, nutrient analysis as Oxidizable Organic carbon, Total Organic Carbon, Total Nitrogen, Phosphorus, Potassium; C/N ratio, respiration and heavy metal analysis like zinc, copper, cadmium, lead, nickel and chromium content. Also, the effect of segregation of wastes on the physical and chemical properties of compost was determined. From the results it was observed that except very few samples, other samples have shown normal pH and EC. Organic matter and major nutrients (N and P) contents in MSW composts are low as compared to the rural waste compost. Heavy metal contents in composts from bigger cities were higher by about 86% for Zn, 155% for Cu, 194% for Cd, 105% for Pb, 43% for Ni and 132% for Cr as compared to those from smaller cities. . The composts prepared from source separated biogenos wastes contained high organic matter (by 57%), total N (by 77%) and total P (by 78%), but lower concentrations of heavy metals Zn (by 63%), Cu (by 78%), Cd (by 64%), Pb (by 84%), Ni (by 50%), and Cr (by 63%) on average, as compared to the compost prepared from mixed wastes. From the partial segregation at source of composting no any significant improvement in quality of compost was observed in terms of fertilizing parameters and heavy metal contents. Most of the MSW composts did not match the quality control guideline of 'The Fertilizer (Control) Order 1985' with respect to total organic C, total P, total K as well as heavy metals Cu, Pb and Cr.

Mali et al., 2011, conducted the characterization study of Municipal Solid Waste in Pune city. Main of study was to characterize the MSW at a landfill site in Pune city and suggest the appropriate MSW management system. Monthly sampling from January to November 2008 was done to study the seasonal variations and representative characteristics of MSW. Physical and chemical analysis was carried out with total 25 no. of samples. Coning and quartering method has used for sampling. Sorting of MSW was done into seven categories named as, plastic, paper, cloth (rubber, leather and synthetics), metals, stone, glass and organic matter. These sorted samples were analyzed for parameters such as pH, organic matter, moisture content, total solids, volatile solids, fixed solids, density, organic carbon and total kjeldahl nitrogen (TKN). The results have shown that MSW of Pune landfill contains a high percentage of organic matter 69.3%, organic content of 32.83%, and average moisture content 48.08%. As MSW contains high organic matter and moisture content, biological treatment of MSW will be feasible. If solid waste treatment facilities were provided at source, it would help to divert 70% of the total waste leading to enormous cost savings of waste collection, transport and disposal.

Kanimozhi and Jayakumar, 2015, conducted a study on conversion of vegetable market waste into compost (Vermicompost) by using earthworm species Eudrilus eugeniae. Vermibeds were prepared by using plastic troughs and are maintained in triplicates. ½ kg of Eudrilus eugeniae earthworms were introduced in each of the Vermibed. The mixture of vegetable waste and cow dung at different ratios 20:80, 40:60, 60:40 and 80:20 (vegetable waste: cow dung) were prepared and used for the study. Different field experiments were conducted by using different treatments to determine the effect of vermicompost on growth and yield of okra plant. For the study, six different treatments were used as V1V, V2V, V3V, V4V, C1V and C control with three replicates each. Measurement of plant height, number of leaves, flowering days and yield of every plant was done. The results have shown maximum plant height (117.33 ± 2.08 cm), number of leaves (12 ± 2), early flowering (38.33 ± 1.15 day) and yield (446.93 ± 5.94 g) in V4V treated okra plants as compared to other treatments and control. The growth (biomass) of earthworm species Eudrilus eugeniae was measured at 10^{th}, 20^{th}, 30^{th} and 40^{th} days; to study the influence of vegetable waste with cow dung using different feeding mixture. The maximum growth of earthworms was recorded in V3 (1028.33 + 3.05 g) treatment.

Londhe and Bhosale, 2015, carried out research study on recycling of different types of organic solid wastes into fertilizer by using Vermicomposting method. The study was conducted in the area of DOT College and Shivaji University, Kolhapur. Eisenia Fetida, species of earthworm was used for study. The vermicomposting was carried out for total 45 days. The waste material collected for study was spread into layers and kept under sunlight for pre-composting for 5-10 days, to remove the pathogenic microbes and unwanted gases. Four different types of substrates were prepared using different types of wastes. For vermicomposting, 4 different plastic boxes were used and kept under shed. To maintain the moisture and temperature under these beds, water was sprayed frequently and wet gunny bags were kept on these beds. The parameters like pH, N, P, K, C/N ratio; OC and EC etc. were analyzed before and after treatment. The analysis was carried out in two sets, after 20 days and after 45 days. The results have shown that 2nd substrate (vegetable + fruit waste) has better results than other three substrates. Increase in parameters as N, P, K and C/N ratio was observed in all the substrates. Significant increase in nutrients was observed after 45 days.

Vanlalmawii and Awasthi, 2016, studied and discussed various treatments of MSW. Composting process was discussed in detail and the factors affecting composting process are given in detail. According to authors, waste management at source was more important than the conventional waste management practices. And Composting was one of the ways to treat MSW at source efficiently. The standard values of some factors affecting the composting process are given in paper, as follows:

Table-1: Composting standards

Factors	Standard Value
pH	6.5-7.5
Temperature	50 º C- 60º C
C/N Ratio	25 to 30
Moisture Content	Beginning- 60 to 70 Later Stages- 50 to 60

Roy et al., 2017, carried the experiment on decentralized composting by using vegetable market waste through Pit composting in Guwahati city. As the city generates high amount of organic waste (@78%), hence this study has been carried out. Pit composting was carried out on wooden pits (2m*1m*0.8m), as wooden pits are handy, cheaper and requires less space. To maintain the aerobic condition in pits, the perforated pipe wrapped with net was inserted through wooden pit and bottom was sealed with concrete to protect the seeping of nutritious compost (liquid form). In order to maintain the C/N ratio required for faster decomposition, the waste was mixed with dry leaves and dry wooden chips in 4:1 ratio (by weight). Total 353 kg of waste has been dumped into this pits and left for total 2 months for composting. Temperature was measured daily. After 2 months when compost became dark brown in color and smelled earthy, the sample was taken out and analyzed for physico-chemical characteristics i.e. measurement of pH, moisture content, EC, TOC, TP, TKN, Na, K, Ca and volatile solids. The results of the analysis have shown that the compost can be used as manure in agriculture for enhancing soil properties. It was suggested to set up small pit compost in or near all Vegetable Markets of Guwahati city, as it requires less space and to minimize the waste disposal problem of city.

2. Methodology:

Methodology adopted for the present study is described below:

Source of Waste:

The vegetable market waste was collected from total 4 different markets of Kolhapur city. The waste was collected from markets named as, (1) Kapil Tirth Market, (2) Runmukteshwar Market, (3) Shingoshi Market, and (4) Mahalaxmi temple area. These four markets were selected as they are close to each other and it has made the collection of sample of vegetable market waste easy for the study. These markets are selected as they generate high amount of organic waste daily, in form of green waste, rotten fruits, vegetables, flowers, leftovers etc. These markets are situated around 1.5 km periphery.

Experimental Procedure:

Vegetable market waste was collected from the above mentioned markets. Then it was segregated to remove the unwanted inorganic matter. Figure 2 shows the vegetable market waste used and segregation of waste done for composting process. Before adding the wastes to composting, the wet waste was shredded from Organic Waste Converter (OWC) machine. OWC takes total 10 minutes for cutting and mixing the vegetable market waste. Then this shredded waste was kept in a plastic bin for decomposition i.e. for composting. Figure 3 shows the plastic bin used for

composting process.

The size of plastic bin used for the experiment is 115cm X 90cm X 30cm (1.15m X 0.9m X 0.3m).Volume of bin used is 0.3105m^3. In this volume of bin total 110 kg of weight of wet sample was accumulated. To maintain the moisture content in the waste sample, water sprinkled daily over it and to provide adequate oxygen in the sample and maintaining aerobic conditions, the waste was turned from top to bottom after every 5 days. This waste then kept for composting. Bio-culture was added in organic waste as a seeding material to compost bin only once while starting the experiment. The bio-culture used for seeding is shown in figure 4. It was observed that after 50 days compost became ready. The ready compost analyzed for various parameters such as moisture content, TP, TKN, K, and C/N ratio. The conversion of vegetable solid waste into compost is shown in figure 5, where the pictures were taken during various steps of composting process; first at start day 1, then after 15 days, after 30 days, after 40 days and after 50 days, are shown. When the waste became dark brown in color and smelled earthy, then the sample was taken out and analyzed for physical and chemical parameters. After composting process of 50 days, the ready dry compost was taken out from bin and sieved to get the fine product of compost in dry powder form. This final compost product is shown in figure 6.

Figure 1: Bio-culture and Plastic bin (Tray) used for the compost

Day 1 After 15 Days After 30 Days

After 40 Days After 50 Days

Figure 2: Photos of compost taken at different period of time during the experiment

3. Result and Discussion:

The vegetable market waste collected from selected four markets of Kolhapur city was kept in bin for decomposition. The process of composting was required total 50 days. Daily observation of the compost was done. Water sprinkling was done to keep sufficient moisture in compost. And the seeding of bio-culture was adopted to aid the composting process. After 50 days of complete composting process the compost sample was analyzed for parameters such as pH, conductivity, TKN, TP, K, TOC and moisture content. The results of the same are given in Table 2.

Sieving of Compost Final Compost

Figure 3: Final Product as a Compost after 50 days of experiment

The results have shown that pH of the compost was alkaline in nature. Very less conductivity was observed in compost as 2.41 ms/cm. Lower conductivity shows significant reduction of salinity in compost. And according to Londhe and Bhosale, 2015, lower level of salinity in compost was essential characteristic of good compost. And the low conductivity shows better decomposition rate.

TKN measured was around 13.88 mg/L. It was higher than usual readings observed in literature. The nitrogen content of compost depends upon the nitrogen content of solid waste used. This means that either the vegetable waste used has higher nitrogen or the addition of bio-culture caused the increase in nitrogen of compost. Whereas, the values of potassium and phosphorus content in compost were observed to be as 0.8 and 0.08 mg/L, respectively. The moisture

content of the compost was 12.67 %. The moisture content was also lower than normal composts. The carbon content of compost was measured in terms of TOC. The TOC of compost sample was 46.37 mg/L. Whereas the C/N ratio of the compost was 3.34:1.

Very less C/N ratio was observed in the compost. The optimum C/N ratio of good compost varies from 25 to 30. This sample shows lower carbon content in compost compared to nitrogen. In order to get the C/N ratio near to optimum external carbon source addition was required.

Table 2: Characteristics of the compost from vegetable waste

Sr. No.	Parameters	Value
1	pH	8.24
2	Conductivity	2.41 ms/cm
3	Total Kjeldahl Nitrogen (TKN)	13.88 mg/L
4	Phosphorus (P)	0.08 mg/L
5	Potassium (K)	0.8 mg/L
6	Moisture Content	12.67 %
7	Total Organic Carbon (TOC)	46.37 mg/L
8	C/N Ratio	3.34:1

4. Conclusions

Kolhapur city generates considerably high amount of organic waste. This can be treated at source itself with the help of compost process. From the present study of selected vegetable market waste it can be concluded that,

1. It was found that the compost produced from vegetable market waste contains sufficient amount of nutrients like N, P and K.
   N=13.88mg/lit, P= 0.08mg/lit, and K= 0.8mg/lit
2. pH found is alkaline in nature so it will be of good quality soil conditioner.
3. Moisture content found was very low.
4. Total time required for conversion of vegetable and fruit waste to compost was around 50 days.
5. The C: N ratio of the compost found is 3.34:1 which was very low than standard optimum value of 25:1. To increase the amount of carbon, carbon source can be added in form of straw and saw dust.
6. All other physical and chemical parameters found within limits according to CPHEEO manual on Municipal solid waste Management (2000).
7. It was a simple and effective process which converts vegetable and fruit waste into nutrient rich fertilizer.
8. Compost from vegetable market waste was a good alternative for chemical fertilizers.
9. The results of compost analysis show that the compost can be used as manure in agriculture for enhancing the soil quality.
10. It was suggested to Kolhapur Municipal Corporation, to set up small compost pits in or near all vegetable markets of Kolhapur city, as it requires less space. This will not only reduce the volume of waste in landfill but also can contribute towards the requirement of bio-fertilizer in the city. Such type of decentralized systems will work as integrated solid waste management systems for Kolhapur city.
11. Using an appropriate composting technology in combination with a sound financial management, it will ensure production of good quality compost and constant sales throughout the year.

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