



SOLID WASTE MANAGEMENT USING COMPOSTING TECHNOLOGY

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Abstract- In developing nations like India there is a need to improve soil health as man-made disaster has mainly resulted in solid wastes problem and information on waste quantity and composition are limited that are strategic in order to devise effective waste management strategies. There is a need to study existing conditions and identify its associated problems and alternative solutions in order to shift from existing conditions to a more sustainable waste management practices. It is envisaged that solid waste compost prepared by organic matter composting can serve as a valuable organic nutrient source that can maintain long-term ecological health and simultaneously target short-term productivity gains. Also, the ill effects of chemical farming can be controlled. Moreover, in recent times India has faced rise in cost of labor, agricultural inputs and biological degradation of lands. The annual crop productivity has decreased and awareness of organic farming technology is lacking. Thus, keeping in view, the advantages of organic farming as well as its inherent limitations such as analysis and slow action, present studies had focused on domestic solid waste management by its conversion into enriched compost and to evaluate their nutritional quality. The experiments were conducted for a period of 12 months and it was concluded that during composting the E_4/E_6 ratio linearly increased till the 24th day and that suggests a reduction in density of organics. After this period starting from 25th day the ratio of E_4/E_6 subsequently reduced. This confirms that maturity had been attained between 24-32 days. Moreover, the chemical properties and micronutrient analysis conducted during experiments suggest that the obtained organic manure was qualitatively appropriate to be adopted as a cost effective fertilizer. Therefore, it can be envisaged that sustainability can be attained in agriculture by means of processed manure that are organic in nature.

Keywords- Solid waste management, Composting, Compost

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Introduction

With increasing urbanization and changing lifestyles, Indian cities now generate 8 times more solid wastes than they used to during the last decade. Generation of wastes per capita has increased from 1% to 1.33% per year. Throughout the country more than 1/3rd of all the wastes generated remains unclear on the streets and what is collected are finally dumped in insanitary dumpsites polluting groundwater and degrading the environment [1]. If at this point materials are recovered and processed into high quality compost than sustainable agriculture and environment management is feasible. Composting techniques have various advantages such as production of bio-fertilizers, organic manure, relatively low air and water pollution, low operational cost and has comparatively high income generation. The process of aerobic composting involves quick disposal of garbage and its immediate recycling as most of municipal solid waste fractions are biodegradable and have higher contents of moisture [2]. It is a biological process that is mainly aerobic and utilizes naturally occurring microorganisms that are responsible for the conversion of biodegradable organic matter into humus like

product [3]. The phenomena ultimately reduce volume of wastes by conversion of nitrogen from unstable ammonia to stable organic forms and also destroy pathogens in the waste. Thus, composting technology is strategic for solid waste disposal [4]. In India the municipal solid wastes generated constitute 35%–40% organic matters. The entities have the potential to be recycled by the process of composting. The final product by these natural processes is compost or manure that is obtained by the decomposition of organic wastes and is rich in nutrients. It is also high in carbon and nitrogen and is a good medium for plant growth. A classical example is re-use of kitchen wastes. The process of composting recycles the nutrients ultimately and revert them back to the soil as nutrients. Moreover, final product is cheap, safe and clean and the main advantage is that it reduces disposed garbage quantity. Organic manure can serve as ideal alternative to chemical fertilizers and can give better results when used for vegetables. They are responsible for water retention, make the soil cultivable and facilitate the soil to retain plant nutrients [3]. Thus, as composting is advantageous, such technologies must be encouraged.

Since long worldwide attempt have been done to optimize effective composting technologies for solid waste management. Researchers have developed organic waste composting methods that include chopping the organic wastes, adjusting water content of the chopped organic wastes to about 20%-40% by weight and then mixing an effective amount of fermented feed with the chopped organic wastes such that the fermented feed is substantially evenly distributed in the chopped organic wastes. Thereafter, the chopped organic wastes having the fermented feed can be stored in a closed container at suitable temperature at predetermined duration. Thus, chopped organics can be composted in closed container by fermentation [5]. Moreover, cultures of *Pheretima elongate* have been successfully used to convert organics to solid and fertilizer grade soil conditioners by reuse of water [6]. Nagavallema K.P. et al had studied on Vermi-composting as a tool for recycling wastes into valuable organic fertilizers. They had suggested that the utilization of Vermi-compost can help society as it will lessen the costs of production and will enhance the productivity of soils. Moreover, it can provide additional source of income generation for landless people. As far as the industries is concerned Vermi-composting can serve as cost-effective and pollution abatement approach. It can boost to rural economy and has benefits of less wasteland formation [7]. Hood Peter et al had developed technology to process organics wherein they are initially broken down to fine range of particles and then stored for sometime followed by subsequent breaking of particles to a defined size along-with mixing in rotary drums. These treated wastes than come out from the outlet provision. The biological decomposition occurs under aerobic conditions in the aerated storage bay and the rotating drum. The method can produce a sustainable, alternative fuel product specifically using a bio-drying process to treat biodegradable entities of the organics [8]. Several studies on processing organic wastes to compost in Iran have indicated that a sound quality compost can be produced when mixed raw materials are utilized that include organics from homes, cattle and agri-food industries. In Iran, majority of rural solid waste problem have been effectively tackled by the composting technology [9]. Researchers have even tried to dispose *Jatropha* wastes by aerobic composting methods wherein used manure from cattle can be mixed with the wastes at different levels and composted for thirty to sixty days that will result in a decrease in pH and increase in nutrients levels as days passes [10]. The composting systems can even sustain Mycorrhiza and this technology can be strategic to eliminate deforestation [11].

The most appropriate parameter to determine stability of the compost is to assess its E_4/E_6 ratio [12] and is advantageous in various aspects like it can ensure stable and sound quality of product and is environment friendly. But for the success of organic farming there is a need for the stakeholders' support, appropriate infrastructure and monetary assistance [13]. Manjula Gopinathan et al had conducted a study wherein they had used a combination of waste water from dairies and solid wastes from municipalities and allowed it to form compost. They had suggested that the co-composting of dairy waste water with municipal solid waste produces compost that is more stable and homogenous and can be effectively used as soil conditioner [14]. Moreover, Bio-humus can be produced by worms' composting of food wastes that can be adopted as fertilizer for the soil, in agriculture or flower cropping [15]. Also, researchers have developed anaerobic digesters as well as compost formation systems that can be best suited on average sized dairy farms. A saving of 6289 kg of fertilizer at a cost of \$17925 annually and additional

saving of \$20547 on energy use can be possible by installation of these systems on dairy farms [16].

Recently, Rajib Roy Chowdhury et al had studied on the aspects of agricultural productivity enhancement by farming in organic manner and had concluded that organic farming can be strategic and helps to attain sustainability in agriculture [17]. Moreover, agro-industrial wastes such as molasses, dairy waste, spent wash and bio-compost can be processed to high quality compost by the inoculation of consortium of phosphate solubilizing fungi [18]. However, proper collection to treatment model is inevitable for effective management of solid wastes [19]. A group of researchers in Bhopal had worked on the aspects of managing solid wastes and had suggested that biogas generation from wastes combined with a compost generation system can be effective in solving environment pollution issues [20]. Also, Manju Rawat et al had conducted studies on the characterization of compost from wastes collected in various metros of India and had recommended that there is need for periodic monitoring of heavy metals in municipal solid waste compost so that quality could be insured and contamination could be prevented. Moreover, the quality of compost may be improved by adding cowdung and garden wastes. Finally, it was envisaged that there is a need to make compost popular among the farmers for its sustainable utilization [21]. Also, in Nigeria researchers had worked on the determination of bacteriological quality of animal and municipal solid waste using windrow and open pile composting techniques and had recommended that a wide range of waste can be composted using these techniques, but regulations must be framed and implemented on scientific basis [22]. Thus, as per the prior art search, there was a need of further research on composting technology development for effective solid waste management and that had resulted the present studies to investigate the same.

Materials and Methods

The implementation of organic manure preparation was initiated with collection of solid wastes followed by selective segregation of plastics, metals, stones and glass. Thereafter primary shredding was carried out and the manure was prepared by composting. Also, Bio-culum culture and absorbing materials were added to shredded solid wastes and then the same was chopped and mixed thoroughly. Moreover, visual observations were continuously done to ensure process control. Thereafter, the processed mass was transferred, stored and allowed to mature in batches wherein moisture management was done by turning based on visual observations. Finally, homogenizing and screening were done before final storage that resulted in matured compost as end-result.

Estimation of pH in Soil-Water Suspension

Prepare standard buffer solutions having pH 4, pH 7 and pH 9 in Distilled Water (D/W), take a beaker of capacity 100 ml and add 20 g of soil sample, mix 50 ml D/W and churn it for six minutes and allow it to settle for 30 minutes, do the calibration with 3 buffers of pH 4, pH 7.0 and pH 9.2, immerse the electrodes with prior stirring and then measure pH.

Measurement of Electrical Conductivity

Prepare 0.01 N solution of Potassium Chloride: Weigh 0.7456 g of dry KCl and makeup volume by D/W. Thus, 1.41 ds m^{-1} conductivity will be given by the solution at 25°C. Then take a 100 ml capacity beaker and mix 20 g of soil sample, mix for 1 hour, add 50 ml D/W, allow till supernatant liquid is clearly visible, calibrate conductivity

meter with standard 0.01N KCl solution, estimate cell constant, use conductivity meter and estimate conductivity.

Estimation of % Organic Carbon

Prepare Potassium Dichromate solutions of strength 1 N, Concentrated (Conc.) Sulphuric acid, 0.5 N Ferrous Ammonium sulphate, Diphenylamine indicator and Orthophosphoric acid - 85%. Then take 500 ml volume conical flask and measure 1 g of 0.2 mm sieve soil sample, mix 20 ml H₂SO₄ (Conc.) and 10 ml 1 N Potassium Dichromate, mix and allow it for thirty minutes to settle on asbestos sheet, mix slowly 10 ml Ortho-phosphoric acid and 20 ml D/W in it, mix indicator of 1 ml quantity like Diphenylamine, take burette 50 ml quantity, add 0.5 N Ferrous Ammonium Sulphate, perform titration till appearance of green color, repeat with soil sample of 0.2 to 0.5 g if the titration readings appear less than six.

$$\text{The \% of Organic Carbon} = \frac{10 (B - S) \times 0.003 \times 10}{B \times \text{Sample weight}}$$

(Where, B = Reading of Blank, S = Reading of Sample)

Estimation of Available Phosphorus

The adopted approach was based on Olsen's method for slightly acidic, neutral and alkaline soil. The extracting reagent for Olsen's method had a pH of 8.5 and mainly of Soda bicarbonate - 0.5 M prepared by dissolving 42.0 g of NaHCO₃ (laboratory reagent) in D/W to give one liter of the solution. The pH is adjusted to 8.5 with small quantities of 10 % NaOH. The method has been found applicable in slightly acid, neutral and calcareous soils.

Extraction of Available Phosphorus

Take conical flask of 100 ml quantity and add 2.5 g of soil, add a little of charcoal powder (free of phosphorus) followed by 50 ml of Olsen's reagent, run the blank without soil, shake the flasks for 30 minute on shaker, filter the content immediately through dry filter paper into a clean and dry test tube, estimate the phosphorus calorimetrically.

Reagents

Take 250 ml of D/W and dissolve Ammonium Molybdate of 12 g i.e., Reagent 1 and separately take 100 ml of D/W and dissolve antimony Potassium Tartrate of 0.291 g i.e., Reagent 2, mix both solutions to 1000 ml i.e., Conc. H₂SO₄ 140 ml in one liter that is approximately 5 N H₂SO₄, thoroughly mix them and prepare 2 liters with D/W, prepare solution of Ascorbic acid by mixing 200 ml of reagent 1 and 2 by dissolving 1.056 g of ascorbic acid, ascorbic acid must be freshly prepared as per requirement.

Procedure

Prepare Olsen's extract aliquot of 5 ml into a volumetric flask of quantity 25 ml and carefully acidify with 5 N H₂SO₄ to pH 5. This can be easily done by taking 5 ml of the extracting reagent in a separate 25 ml flask and estimating acid volume essential to bring solution pH to 5 by p-nitro Phenol indicator, the yellow appearance of which disappears at this pH, after adjustment of pH, dilute the mixture with D/W of 20 ml, add 4 ml of reagent 2 and makeup to volume, shake the content well after 10 min, read the intensity of the blue color after waiting for 30 minutes in photoelectric colorimeter using red filter or 730-840 nm wavelengths, a blank must also be run (without soil) along with the sample.

Standard Curve for Phosphorus (P)

Take 0.439 A.R. grade Potassium Dihydrogen Orthophosphate dried for one hour at 600°C in oven and allow to cool in desiccators, dissolve in ½ liters of D/W, mix 7 N H₂SO₄ of quantity 25 ml and prepare 1 liter D/W, this gives a 100 ppm stock solution of P, from this prepare 2 ppm P solution (50 times dilution). For preparation of the standard curve with different concentrations of P, prepare in a volumetric flask of 25 ml quantity a one, two, three, four, five and ten ml of 2 ppm P solution and mix extracting reagent of 5 ml quantity and develop the color as described above by Dickman and Bray's reagent. In case of Ascorbic acid method develop the color after pH adjustment of the aliquot, take the colorimetric method and plot the curve.

$$\text{The available P}_2\text{O}_5 = \frac{R \times \text{Total Volume of the extract} \times 2.24 \times 2.29}{\text{Volume of aliquot} \times \text{Weight of soil}}$$

Estimation of Available Potassium (K)

Prepare 1 N solution of Ammonium Acetate by mixing Ammonium Acetate of quantity 77.08 gm in D/W and prepare one liter final volume, and with a pH meter set 7 and mix either acetic acid or solution of ammonia to neutralize it to pH 7.00. Also, prepare standard Potassium solution and stock solution by mixing potassium chloride of quantity 1.90 gm i.e., dried at 60°C for a duration of one hour in D/W, prepare one liter of final volume, this solution contains 1 mg K i.e. 1000 ppm of K. Finally, prepare a working solution by taking a volumetric flask of 100 ml quantity and prepare a stock solution of zero, one, two, three, four and five ml and prepare 1 N solution of ammonium acetate, they will possess zero, ten, twenty, thirty, forty and fifty ppm of potassium respectively.

Procedure

Weight 5 g soil in 150 ml plastic bottle, add mixture of 1 N Ammonium Acetate of quantity 50 ml, than for five minutes place it on a shaker and filter it with a paper, feed filtrate to nebulizer of Flame photometer and note blank reading, prepare standard curve for K by calibrating instrument with standard K solution of 10, 20, 30, 40, 50 ppm and do the necessary calculations.

Estimation of Available Nitrogen

Take 5 g of the given sample in the digestion tube and add little water, now add 25 ml of 0.32 % KMnO₄ solution to the sample and fit the tube in the distillation unit, add 25 ml of 2.5% NaOH solution through the distillation system-dosing pump, take a conical flask and pipette out 2.5% boric acid of 20 ml quantity and dip the receiving end, distill out ammonia gas from the tube and collect in the received acid, now perform titration with H₂SO₄ of strength 0.02 N after adding mixed indicator approximately five drops, do the necessary calculations.

Determination of DTPA Extractable Micronutrients (Fe, Mn, Zn, Cu)

DTPA can form soluble complexes when it mixes with free metal ions in solution and hence it is termed as a chelating agent. The simultaneous complexing of Zn, Cu, Fe and Mn can be facilitated by DTPA as it possesses combination of stability constants. Atomic Absorption Spectrophotometer (AAS), shaker, 0.005 M DTPA (Diethylene-Triamine Penta Acetic acid) solution, 0.1 M TEA (Triethanolamine) AR or extra pure, 0.01 M CaCl₂·2H₂O (A.R.) solution, micronutrient reference standard are the requirements. Also,

dilute HCl (A.R. HCl diluted with double distilled water 1:5, prepare DTPA extractant by taking 1.48 gm of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ and 1.98 gm of DTPA in a beaker and prepare extracting reagent, add doubled D/W of twenty to twenty five ml and TEA of quantity 13.3 ml, make final volume of one liter with doubled D/W after transferring it to one liter volumetric flask that had been washed thrice, adjust 7.4 pH of the solution with diluted HCl.

Procedure

Collect a plastic bottle and add soil in it of quantity 20 gm and add 40 ml DTPA reagent as an extractant and shake for two hours on mechanical shaker, the extract is filtered (Whatman No. 42) and micronutrients (Fe, Mn, Zn, Cu) can be estimated with the help of atomic absorption spectrophotometer, blank without sample is also to be run, calibrate the instruments using following standard solution (stock solution 1000 ppm). For Fe: Prepare 5, 10, 20, 30, 40, 50 ppm solution (using DTPA extractant) from stock solution, for Mn: Prepare 5, 10, 20, 30 ppm solution (using DTPA extractant) from stock solution, for Zn: Prepare 1, 2, 3 ppm solution (using DTPA extractant) from stock solution, for Cu: Prepare 1, 2, 3 ppm solution (using DTPA extractant) from stock solution, feed the standard working solution and prepare a standard curve by plotting reading against concentrations.

$$\text{ppm of micronutrient (Fe, Mn, Zn, Cu)} = \frac{(A \times (S - B) \times \text{DTPA extractant})}{\text{Wt. of Soil Sample}}$$

Where, S = Sample reading, A = Graph factor, B = Blank reading

Determination of Calcium and Magnesium

Prepare Ammonium Hydroxide and Ammonium Chloride buffer solutions by taking Ammonium Hydroxide of quantity 570 ml that is concentrated and mix Ammonium Chloride of quantity 67.5 g in it, make final volume of this dilution upto one liter, prepare 0.01 N solution of standard Calcium Chloride by taking HCL of quantity 10 ml and mix Calcium Chloride of quantity 0.5 g, prepare final volume of this dilution upto one liter, prepare indicator of Erichrome Black T by taking 95% ethanol solution of quantity 100 ml and mix Hydroxylamine Hydrochloride of quantity 4.5 gms and Erichrome indicator of quantity 0.5 g, prepare Ethylene Diamine Tetraacetic Acid (EDTA) of 0.01 N by mixing one liter water with EDTA of quantity two grams, take standard solution CaCl_2 of strength 0.005 M and use it for standardization.

Procedure

Take D/W of quantity 100 ml and mix sample of quantity 5 gm, take filter paper and perform filtration, take filtrate from it of quantity five ml, perform dilution upto 25 ml with D/W, add Erichrome indicator of quantity 100 μl and mix it with buffer solution of Ammonium Hydroxide and Ammonium Chloride, perform titration till blue color appears with EDTA of strength 0.01 N, repeat steps fourth, fifth and sixth after preparing a blank, the blank needs to be prepared from D/W of quantity 5 ml, express as meq/l i.e., the quantities of Magnesium and Calcium in the samples.

$$(\text{Ca} + \text{Mg}) \text{ meq/liter} = \frac{1000 \times (\text{ml EDTA used for soil extract} - \text{ml EDTA for blank})}{\text{Sample taken (ml)}}$$

Determination of Chloride

Prepare indicator of Potassium Chromate of strength 1.5% ($\text{K}_2\text{Cr}_2\text{O}_4$) by taking ninety ml of water and add $\text{K}_2\text{Cr}_2\text{O}_4$ of quantity 5 gm and prepare a solution of quantity 100 ml, prepare 0.05 M AgNO_3 standard by adding AgNO_3 0.8495 gm in D/W and make 1 liter of final volume.

Procedure

Take a cup and put soil in it of quantity 300 gm, slowly add distilled water to the sample, filter the paste that is mostly saturated in a Buchner funnel via a filter paper of Whatman No. 41. Connect this apparatus with a suction system, take receiving bottles of quantity 50 ml and allow the filtrate to settle therein after the application of suction, if filtrate is turbid, again filter, take 5 ml of aliquot of the sample or solution saved after the titration of carbonates and bicarbonates, add 5 drops of $\text{K}_2\text{Cr}_2\text{O}_7$ indicator in it, take standard solution of AgNO_3 and perform titration until brown to red color appears, take the reference of end point as the obtained red precipitates of Silver Chromate obtained equal to the level of used Ag^{+2} , and prepare the blank accordingly, at the end of titration the volume of unknown and solution must be equal.

$$\text{Cl (Meq) /liter} = \frac{1000 \text{ milliliter} \times \text{AgNO}_3 \text{ (ml) used} \times 0.005 \text{ M of AgNO}_3}{5 \text{ ml aliquot}}$$

Determination of Moisture content of sample

Dry an empty petri-dish with lid at $(65 \pm 1)^\circ\text{C}$ until constant in mass and keep it in a desiccators and allow it to cool until room temperature, measure the weight of the petri-dish, add minimum 10 g of the analysis sample into the petri-dish in an even layer and weigh the petri-dish with lid plus sample to the nearest 0.1 mg, heat the uncovered petri-plate and its lid together with the sample at $(65 \pm 1)^\circ\text{C}$ until constant in mass, constancy in mass is defined as a change not exceeding 1 mg in mass during a further period of heating $(65 \pm 1)^\circ\text{C}$ over a period of 60 minutes the drying time is required is normally for 5 hours, replace the lid while the petri-plate is still in the oven, transfer the petri-plate and its content to desiccators, let it cool to room temperature, weigh the precipitate with lid with the sample to the nearest 0.1 mg. Since small particle size are very hygroscopic it is important to weigh rapidly once the sample is cooled, a minimum of three determination must be carried out on the test sample, it takes 6 hours for one analysis, for each determination the moisture content, the sample analyzed is expressed as a percentage by mass and is calculated using the following formula:

$$M_{\text{ad}} = \frac{(m_2 - m_3) \times 100}{(m_2 - m_1)}$$

(Where, m_1 = Mass in grams of empty petridish plus lid, m_2 = Mass in grams of petridish plus lid plus sample before drying, m_3 = Mass in grams of the petridish plus lid plus sample after drying).

Determination of Carbonate and Bicarbonate

Prepare standard solution of H_2SO_4 that has strength of 0.01 M by mixing 1 liter of D/W and concentrated H_2SO_4 in it of quantity 0.56 ml. Also, prepare indicator of Phenolphthalein by taking alcohol of strength 60% of quantity 100 ml and mix Phenolphthalein in it of quantity 0.25 gm, prepare Methyl orange by taking H_2O of quantity 100 ml, mix methyl orange in it, quantity 0.1 gm, take a cup and put

soil in it of quantity 300 gm, slowly add distilled water to the sample, filter the paste that is mostly saturated in a Buchner funnel via a filter paper of Whatman No. 41. connect this apparatus with a suction system, take receiving bottles of quantity 50 ml and allow the filtrate to settle therein after the application of suction, if filtrate is turbid, again filter, take it for analysis, prepare a dilution with D/W in Erlenmeyer flask of volume 50 ml of extract i.e., quantity 5 ml, the final volume of dilution must be around 25 ml, now presence of carbonates is detected by the appearance of pink color when few drops of phenolphthalein indicators are added, perform titration by addition of H₂SO₄ drops 2-3 seconds till pink color vanishes in the flask that is placed on a magnetic stirrer, measure the utilized quantity of titrant i.e., Sulphuric acid (V_{ph}), add few drops of Methyl Orange indicator in this solution that is colorless, perform the same till pink color appears with no burette refilling, measure the quantity of used Sulphuric acid (V_t), the end point of Phenolphthalein is taken to calculate the concentration of CO₃²⁻:

$$\text{Meq/CO}_3^{2-} \text{ (liter)} = \frac{\text{Thousand ml} \times \text{M of H}_2\text{SO}_4 (V_t - 2V_{ph})}{5 \text{ ml aliquot}}$$

The end point of Methyl Orange is taken to calculate the concentration of HCO₃⁻:

$$\text{Meq/HCO}_3^- \text{ (liter)} = \frac{\text{Thousand ml} \times \text{H}_2\text{SO}_4 \text{ (M)} (V_t - 2 \times V_{ph})}{5 \text{ ml aliquot}}$$

Determination of Nitrate

Prepare Ammonium Hydroxide (NH₄OH–Sp. Gr. 0.90) by mixing H₂O and NH₄OH in equal amounts, Copper Sulphate (CuSO₄) solution (0.5 M) by dissolving 125 g CuSO₄.5H₂O per liter of D/W, prepare solution of Ag₂SO₄ strength 0.6% by mixing 1 liter of distilled water with Ag₂SO₄ of quantity 6 gm, thereafter till all the salt is dissolved thoroughly heat it and shake it. Also, prepare solution of extracting Nitrate by mix 20 ml of 0.5 M Copper Sulphate solution and 100 ml of a 0.6% Silver Sulphate solution and dilute to 1 liter with water.

Procedure

Take a flask and place 5 g sample in it, shake it for 12 minutes after addition of solution of quantity 25 ml that extracts Nitrate, shake it for 5 minutes after addition of Ca(OH)₂ of quantity 0.2 gm, filter through Whatman filter paper 42, add 10 ml aliquot from filtrate in sample and 10 ml extracting solution in Blank, keep a fume hood at low heat and perform evaporation till the solution becomes dry, add 2 ml Phenolsulfonic acid in both blank and sample, give incubation time of fifteen minutes, mix chilled water of volume 17 ml to both sample and blank, allow temperature to reach till normal, now to both sample and blank mix NH₄OH of volume 15 ml, now to both sample and blank mix chilled water of volume 17 ml, measure O.D at 415 nm.

$$\text{NO}_3^- \text{N in soil } (\mu\text{g/ml}) = \frac{\text{NO}_3^- \text{ in soil } (\mu\text{g/ml}) \times 50 \text{ ml} \times 25 \text{ ml}}{\text{Aliquot (ml)} \times \text{Oven dried sample wt (g)}}$$

Determination of CaCO₃

Weigh 5 gm of soil in 150 ml beaker and add exactly 50 ml 0.5 N HCL through measuring cylinder, cover the beaker with watch glass, boil gently for 5 minutes, filter it or directly take 5 ml superna-

tant in 50 ml conical flask, mix phenolphthalein in it but only few drops, till pink color appears perform titration by NaOH of strength 0.25 N.

Determination of Total Dissolved Solids (TDS)

Take a beaker of volume 250 ml and take sample of quantity ten gm, mix D/W in it of quantity 100 ml, now for half hour place it on a shaker, by a filter paper of Whatman no. 1 perform filtration of suspension, measure TDS with TDS meter, keep the records.

Determination of Sulphate

Weigh 5 gm sample in 150 ml beaker, mix [Ca (H₂PO₄)₂.H₂O] solution of volume 50 ml and place it on a shaker for half hour, perform filtration of the solution, take a flask of volume 50 ml and add extract of volume 5 ml in it, in Blank take 5 ml of D/W, follow same steps as that performed for sample after addition of standard solution in series of 1, 2, 3, 4, 5 ml in a volumetric solution of quantity 50 ml, perform addition of 5 ml, 1 ml, 1 gm of Acetic Acid, H₂PO₄ and BaCl₂ respectively that will decolorize Fe in solution, invert flask and mix it in a gentle manner, prepare D/W after addition of Gum Acacia solution of volume 2 ml, after mixing it in a gentle manner with the help of a spectrophotometer adjusted at 420 nm, measure the turbidity of BaSO₄, prepare a calibration curve with standard Sulphate and compare it with turbidity and in this manner estimate the sample concentration of SO₄.

$$\text{MgSO}_4/100 \text{ g soil} = \frac{\mu\text{g SO}_4/\text{sample (ml)} \times \text{ten}}{\text{Soil Weight (gm)}}$$

Results and Discussion

During the present studies collection of organic domestic wastes was done followed by its selective segregation wherein removal of plastics, metals and stones was done. The shredded organic wastes were than mixed with absorbing material of raw dust, Bioculum culture and thereafter thorough chopping and mixing of these wastes were performed in Organic waste converter (OWC). After the processing of the organic wastes in the OWC the final material obtained was used as source material to form the compost heap. The compost heap was then allowed to compost aerobically for 30 days. The analysis was carried out for a period of 12 months and was divided into 4 parts each of three months period. The results obtained were consistent for all the parts and that confirms the consistent quality of obtained compost. The results of a representative part are as mentioned below.

Constituents of Compost from Municipal Solid Waste

The constituents present in Compost obtained from municipal solid wastes and its residues were checked during every three months period. The results are shown in [Table-1] that indicates the presence of fair amount of plant growth nutrients in the Compost. However, as the requirement of each plant is different, the obtained compost along with only little fertilizer can be best suited for a variety of plant applications.

Moreover, measurement of trace minerals present in compost obtained from MSW and its residues were done. The result as represented in [Table-2] suggests that high levels of trace minerals were present in compost that can facilitate the growth of plants. However, the major factor affecting bioavailability of these trace minerals to plants is pH of soil where thumb rule is the more acidic the soil the more availability and solubility of these trace minerals to the plants.

Table 1- Chemical properties of compost and residue

S No.	Parameter	Result for MSW	Result for Compost
1	pH	7.74	7.04
2	EC (Qs/cm)	1442	1221
3	Organic Carbon (%)	36%	22%
4	N (%)	0.03%	1.04%
5	P (%)	0.0019	0.0216
6	K (%)	0.36	0.26
7	Na (%)	3.2	2.8
8	C:N ratio	952	22
9	Moisture (g/100g)	75.6	14.1
10	Chloride (%)	0.0016	0.0212
11	Carbonate (%)	0.04%	1.08%
12	Bicarbonate (%)	0.02%	1.04%
13	Nitrate (%)	0.06%	1.14%
14	CaCO ₃ (%)	0.0012	0.021
15	TDS	76	56
16	Sulphate (%)	0.0014	0.0214

The present studies had used spectro-photometric analysis and measured Optical Density (OD) to estimate whether the compost

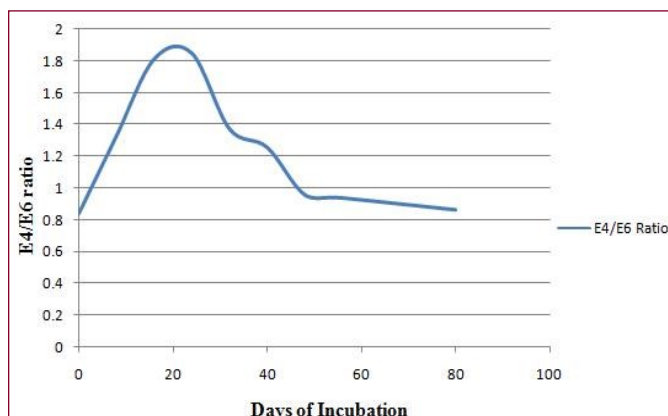
had attained its mature stage. The E_4/E_6 was calculated for this purpose. It was observed that this ratio showed linear progression for first 24 days during the incubation period and there was simultaneous reduction in mass of organic constituents present therein as represented in [Table-3]. Thereafter, ratio lowered in a linear progression. It can be envisaged that compost had matured within twenty four to thirty two days duration. Thus, ideal duration for composting should be thirty days to reduce the effects of any inhibition. The table 3 represents ratio of E_4/E_6 and the incubation days. The increment of E_4/E_6 ratio and its subsequent decrement after 24 days of incubation is also graphically represented in [Fig-1].

Table 2- Estimating trace minerals in MSW compost and residue

S No.	Trace Mineral	Result for MSW	Result for Compost
1	Fe (mg g ⁻¹)	0.17	0.89
2	Manganese (µg g ⁻¹)	15.7	34.9
3	Zinc (µg g ⁻¹)	0.34	101
4	Copper (µg g ⁻¹)	0.93	21.9
5	Ca (%)	1.6	2.6
6	Mg (%)	0.7	1.7

Table 3- Optical density, Chemical Properties of MSW compost

Parameter		Days of Incubation								
		0	8	16	24	32	40	48	56	80
Optical Density	E_{465}	0.0449	0.0681	0.1464	0.1638	0.1824	0.0823	0.0652	0.0582	0.0526
	E_{665}	0.668	0.0742	0.0815	0.0964	0.0987	0.0936	0.0724	0.0689	0.0598
	E_4/E_6	0.8369	1.3258	1.8095	1.8456	1.3695	1.2532	0.9542	0.9347	0.8605
Chemical properties	pH(H ₂ O)	7.76	7.96	8.24	8.46	8.64	8.78	8.52	8.24	7.02
	EC(µs/cm)	1445	1434	1424	1401	1396	1354	1320	1286	1223

**Fig. 1-** OD E_4/E_6 ratio vs days of incubation of compost heap

The present studies confirm that the approach of composting waste aerobically is dependent on certain parameters that are inter-linked to each other for instance nutrient availability, content of moisture and temperature on the basis of which the process can be divided into three phases. The first phase will involve heating by Mesophilic microorganisms followed by action of Thermophilic microorganisms and finally a phase where temperature is lowered at the end point of the process. The first phase will enhance degradation of organic constituents that result in increase in temperature due to oxidation reactions. The second phase can be observed at twenty to thirty

four days of incubation period. The process of further degradation will occur during this phase. The critical point during this phase is that if the temperature rises than sixty degrees Celsius than degradation is severely deteriorated as microbial community cannot be active at this temperature. Thus, optimum levels of temperature must be maintained during the entire process. The finally obtained compost can be used as soil conditioner. It has excellent values as organic manure. A variety of waste materials can be composted in this manner providing valuable products. Also, the application of compost obtained from municipal solid waste enhances the mineral levels in the soils that are beneficial for effective plant growth.

Conclusion

The present studies will serve as a classical example of solid waste management using environment friendly techniques. It is recommended that waste management strategies must include selective segregation process after collection of organic wastes wherein removal of plastics, metals and stones must be done. The shredded organic wastes should be than mixed with absorbing materials like raw dust, Bio-culum culture and thereafter thorough chopping and mixing of these wastes must be performed in OWCs and the final material should be used to form the compost heap. The current experiments indicate that compost heap must be allowed to compost aerobically for 30 days and proves that strategic constituents required by lands can be supplied in form of wastes that are organic in nature. The elemental analyses of the MSW compost indicated

that it had many essential constituents therein to ensure effective growth of plants. It is a common fact that each crop requires different nutrients. However, the compost obtained during the present studies can be used for a large range of crops and with very less fertilizers needs as the pH, EC (Q_s/cm), Organic Carbon (%), Nitrogen (%), Phosphorus (%), Potassium (%), Sodium (%) and C:N ratio, Moisture (g/100g), Chloride (%), Carbonate (%), Bicarbonate (%), Nitrate (%), CaCO₃ (%), TDS, Sulphate (%) were found to be 7.04, 1221, 22 %, 1.04 %, 0.0216, 0.26, 2.8, 22, 14.10, 0.0212, 1.08, 1.04, 1.14, 0.0210, 56, 0.0214 respectively that confirms its high merits. Also, micronutrient analysis suggested appropriate amounts of mineral nutrients in the developed organic manure. The obtained Iron, Manganese, Zinc, Copper, Ca (%), Mg (%) were 0.89, 34.9, 101, 21.9, 2.6, 1.7 respectively. Furthermore, the ratio of E₄/E₆ was assessed spectro-photometrically to estimate the compost Bio-maturity and that was found to be around 24-32 days. Therefore, it can be envisaged that sustainability can be attained in agriculture by means of processed manure that are organic in nature. Since the process uses raw materials that are mainly solid refuse its maintenance and operations costs are low and also no cost affair technology is required. These refuse need to be just compiled into stacks and allowed to decompose. The constituents of the obtained manure can be determined by the nutrients present in the refuse used and after entire decomposition the obtained mature compost can be applied for a variety of purpose like it can supply important essential nutrients to lands and for plant growth. It can serve as an excellent source of organic manure. Hence, the technology of processing waste to compost and its use as soil amendments must be practiced as it is a complete clean energy solution and causes less environment pollution. Thus, it is recommended that more and more development of such eco-friendly organic composting technology must be encouraged for effective solid waste management.

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