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Composting of Municipal Solid Waste Using Sericin Rich Wastewater from Silk Industry as an Additive

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Abstract

Huge quantity of solid waste majorly comprising of organic wastes produced by various anthropogenic activities causes severe problems pertaining to environment and human life. Composting is considered as one of the well known practices for management of solid waste. It is gaining augmented consideration as an environmentally sound approach to manage organic waste especially in countries like India, where more than 50% of solid waste comprises of organic/green waste. Municipal Solid Waste Processing Site of Mysore City was chosen for the present study. Different Organic Fraction of Municipal Solid Waste (OFMSW) was selected for present work. Sericin rich waste water from silk industry was used as a source of additive. Organic additives were mixed at the rate of 10- 60% of OFMSW inputs. Samples collected from different experimental set up were oven dried (100 -105°C), ground and used for chemical analysis.

Physico-chemical parameters such as pH, moisture content, electrical conductivity, organic carbon, total nitrogen & potassium, C: N ratio, phosphate, and ammonia were analysed periodically and optimum pH was observed between 7-8 and the pH values are relatively on higher side of OFMSW blended for 40% of total day's samples. Similarly moisture content in the range of 23.25 to 26.75- % was found as optimum for composting process. Physical parameters such as colour and odour were observed. The obtained results are in agreement with standards prescribed by Central Pollution Control Board for compost. Use of generally waste water, normal pollutant, sericin as additive in composting it can be one of the best eco friendly additive for solid waste management.

Keywords : Municipal Solid Waste (MSW); Compost; Additives; Sericin

Introduction

Increasing Solid waste generation and its management has been one of the key concerns for governing bodies around the world. Land filling is the only technique practiced majorly at present for solid waste disposal. However, most of the landfill sites are associated with numerous problems such open dumping, quick filling of landfills, availability of free land, causing severe environmental impacts like odor and pest problem, contamination by Leachate, health hazards to surrounding people etc. [1-3]. Yet another major concern with landfill sites is number of landfill sites are far lesser compared to actual amount of waste produced. Though there is an extensive interest on part of government and local bodies the disposal of MSW is major environmental problem which needs immediate thought as the existing disposal methods have failed to address the issue completely [4].

Organic component of solid waste majorly contributes to solid waste in common. Composting process for solid waste management in recent past has gained the attention of researchers and capitalists across the globe. This process has given rise to a concept of waste is money to entrepreneurs. Not only does this process ministers the reduction of waste disposal to landfills but also generates "compost", a product beneficial to agriculture resulting in enhancement of soil fertility [5]. Composting is now considered as one of the best options for solid waste management [2]. Presence of soaring level of biodegradable organic matter, C: N ratio etc. makes municipal solid waste suitable for composting. Municipal Solid waste generally consists of domestic and commercial waste that adds up to relatively lesser amount of total solid waste quantum in developed countries [6]. Though organic solid waste disposal through composting is gaining popularity all over the world as one of the effective natural methods, exhaustive labor processes and excess time consumption has made feasibility of this method impractical. These drawbacks can be overcome with use of additives which enhances the process time. Under control conditions, the composting process generally takes lesser time depending upon type of material used as waste along with type of additives selected during the process. However, development in various technologies for composting in recent past has renewed interest in composting as one of the most feasible waste management techniques.

Co composting using additives is one such technique which has opened up opportunities in modern waste management segment. Various additives like various microorganisms, mineral nutrients, enzymes, organic compounds, industrial waste etc. enhanced the composting process due to raise in microbial action during composting [7]. Recent studies on fly ash, phosphogypsum, jaggery, lime, and polyethylene glycol on green waste composting showed additives significantly improved the composting process [8]. Studies on use of indigenous microorganisms as an additive resulted in enhancement of composting process and better quality compost [3]. Yet another study on biomass ash reutilization as an additive demonstrated that composting process and quality of finished compost was improved by ash addition [9]. Various researchers across the globe have studies the use of chemical and mineral additives for co-composting of solid waste [10-12]. All these previous studies have indicated that co composting using additives could enhance composting processes significantly.

Sericin rich waste water generally waste by product from silk industry was used as organic additive in present study. Though it is very valuable source of raw materials for many of the industrial sectors such as food, pharma, cosmatics etc it has been discarded as waste in silk industry resulting in pollution [7,13,14]. Recovery and reusing of sericin typically discarded by the textile industry continues to be a major challenge around the world which would minimize environmental issues with a high scientific and marketable value. It is one of the good sources of sugar and sugar as carbon source results in growth of microbes that fasten the composting process. Most of the sericin is detached during degumming process which is discarded as wastewater, resulting in enhanced treatment cost and related issues. However there have been numerous proposals for sericin recovery from silk industry waste water and reutilization for various biomedical and tissue engineering applications [7]. Despite remarkable applications of sericin in various other industries like pharmaceuticals, cosmatics etc. its application in management of MSW is still limited and has not been explored so far as additive in solid waste composting [9]. However so far no studies pertaining to its role as additive have been reported. This is first study reporting the role of coconut water as additive in co composting for best of our knowledge.

Materials and Methods

Study Area

Current work was carried out in Mysore City using municipal solid waste generated in the city. The municipal solid waste samples were collected from aerobic compost plant situated in Vidyaranyapuram, Mysore.

Collection and Processing of Composting Material

The segregated solid waste rich in organic matter collected from the MSW Site was used as raw material for composting. Composting experiments were carried out at lab scale in 20litre cement pots. 5Kgs of organics fraction of MSW (OFMSW) was added to each pot. Coconut water which is used as organic additive was mixed at the rate of 10-60% of total municipal solid waste inputs respectively. The additives are mixed properly and temperature is monitored. Aeration is provided by mixing and turning the solid waste heaps on every 5th day. Excess water was drained out. Care was taken to minimize the external disturbance which would otherwise affect the process of composting. The compost samples were collected at different degradation stage from pots on 5th, 10th, 15th, 20th, 25th and 30th day. Thus obtained samples were oven dried at 100-105°C, ground to 2 mm particle size powder and stored until used for further analysis.

Analysis of Compost Samples

The finely ground, dried and powdered compost samples were analyzed for various physicochemical parameters such as pH, bulk density, conductivity, moisture content, organic carbon, C: N ratio, total nitrogen, potassium and phosphate. The pH of compost was determined in pH meter using deionized water with 1:10 w/v ratio of compost and water [15]. The organic carbon content of compost was estimated by combustion method [16,17]. Bulk density of composts was done by pycnometer method and calculated using the following formula [18,19].

$$Bulk\ density\ g/cm^3 = Weight\ of\ sample\ in\ gram / Volume\ in\ sample\ in\ cm^3$$

Electrical conductivity by instrument method (1:5 water extract) using conductivity meter, moisture content (%) by gravimetric method [20,21]. Phosphorous in the compost was determined through Olsen method, Total nitrogen by Kjeldahls method /phenol disulfonic acid method, total potassium by flame photometer (model no.) [22,23]. Total nitrogen in C/N ratio was calculated by adding the three forms determined (organic, nitrate and ammonium using standard procedures for analysis [24-26]. Heavy Metal Analysis was done using atomic absorption spectroscopy as per the protocol of Smith et al. [25] and Saha et al. [27].

Statistical Analysis

The data obtained from triplicates experiments were analyzed using Origin Pro Software, version 8 with average standard deviation of <5%. Graphical representation was statistically significant with error bars.

Results and Discussion

Processing of Raw Compost and Additive

The composting material used in the present study was segregated municipal solid waste from MSW Site of Mysore City which consisted of approximately 55% of organic matter. The sericin rich waste water procured from silk manufacturing industry was used as organic additive in the present study. It was mixed with balanced ratio of 10-60% of Organic fraction of MSW. The powdered finished additive aided compost samples are taken for physicochemical studies and heavy metal analysis.

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Effect of Additives on Temperature During Composting

Continuous monitoring of temperature in different compost pots using thermometer was done during the composting period. The temperature variation in control and additive based composting was recorded and is represented in Figure 1. The temperature shot to 54°C from 28°C after a day. Thermophilic phase lasted for 13 days with maximum temperature reaching upto 66°C. Temperature of 66°C lasted for 3 days that helped in quick destruction of all the microbes and weed seeds present in the compost. After thermophilic phase a phase of decline in temperature was seen.

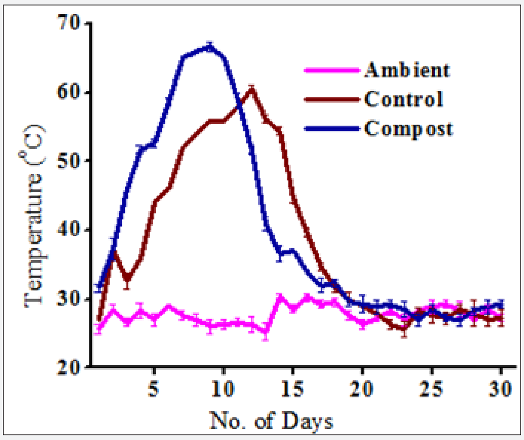

Figure 1 : Effect of Temperature on additive based composting Process.

The early set up and prolonged period of thermophilic phase in sericin rich waste water treated compost could be accredited to the immediate supply of sugars by sericin rich waste water to the composting medium which improved the microbial growth in due course leading to development of metabolic heat. Our observations are comparable to many earlier studies on similar line [28,29]. This phase was followed by cooling phase where in temperature began to decline and evened out on 23rd day. After 23rd day temperature of compost was equal to that of ambient with no noteworthy changes. Similar observations were made by studies carried out by Rynak et al. [30] & Hsu et al. [31] which reported that use additives in composting resulted early and extended duration of thermophilic phase that helps in speeding up the microbial metabolism leading to production of heat and killing of microbial mass resulting in better quality of finished compost. The existence of three phases during the composting stages showed that the pattern was distinctive to that exhibited by much different composting system.

Effect of Additives on pH During Composting

Figure 2 reveals the effect of additive on pH during composting process. The change in chemical composition leads to variation pH value during composting process. Formation of organic acids results in lower pH (less than 7) in the initial stage of composting which later rises above neutral because the formed acids are consumed and ammonium is produced [32]. Present study indicates that there is no much difference in pH pattern of control and additive based compost in different developmental phases. Bulk density is a measure of degradation of loosely arranged raw material into finer particles (Figure 3). Progressive increase in bulk density was observed in additive based composting and control compost. Current studies revealed range of bulk density to be 0.45 g/cm^3 to 0.87 g/cm^3 in additive based compost where as 0.46 to 0.78 g/cm^3 in control compost suggesting the bulking effect of additive rather than degradation effect. The range of bulk density is well within the standard range of Indian Fertilizer Control Order, 1985. Similar observations were done by Himanem et al. (2009) and Jagdish et al. (2012) [7,8].

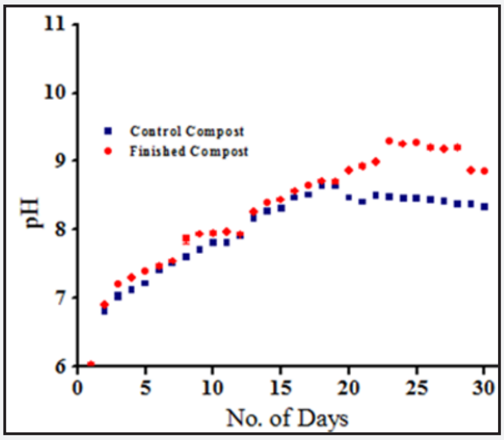

Figure 2 : Graph depicting effect of pH during composting Process.

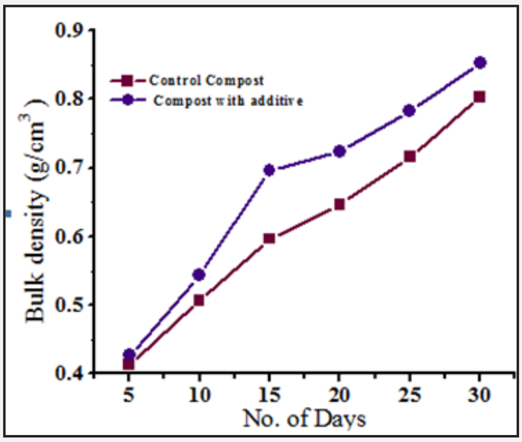

Figure 3 : Effect of Temperature on additive based composting Process.

Effect of Additives on Electrical Conductance / Total Conductance During Composting

The electrical conductance (EC) of compost is mainly depending on the amount of the soluble salts like, sodium, potassium, chloride, nitrate, soluble sulphate, calcium and magnesium present in the compost [33]. The range of electrical

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conductance varied from 1.45 to 7.1 ds/m in additive based compost and 1 to 5.5 ds/m in control compost (Figure 4). The higher electrical conductance compared to recommended standards in control and test samples may be attributed to increased salt concentration due to organic matter degradation [34].

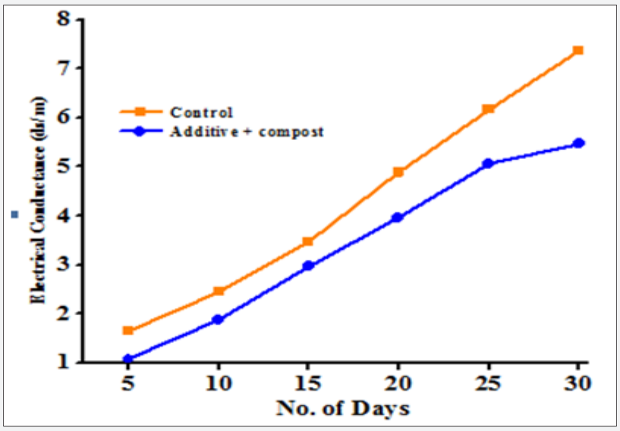

Figure 4 : Graphical representation of electrical conductance of control and additive based compost.

Moisture Content: Moisture content of compost is most vital environmental factor that transports nutrients for metabolic activities of microbes. With prolonged maturation, moisture content increased progressively. This might augment microbial and enzyme activity leading to rapid composting process [35,36]. In the present investigation, moisture content enhanced in the maturation phase of 15-25th day (Figure 5).

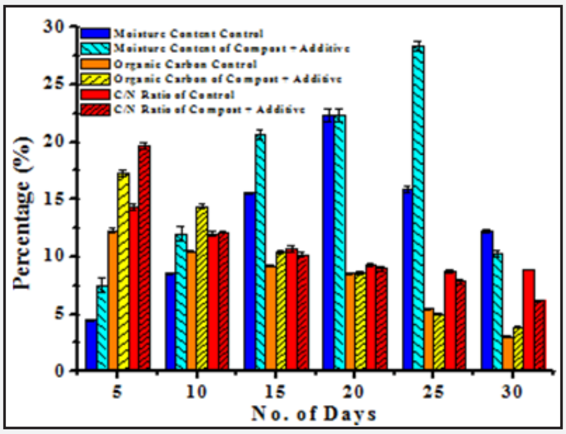

Figure 5 : Graphical representation of percentage moisture content, organic carbon and C/N ratio of compost.

Organic Carbon: Organic carbon content in the present study decreased with increasing maturation stages of composting. This decrease in percentage organic carbon can be attributed to waste decomposition by microbes to larger extent and CO_2 evolution partly [37,38]. In the present investigation, the total organic carbon percentage varied from 14.45 to 3.8 % and maximum reduction in TOC was observed on 25th day. In comparison to the recommended standards obtained values were well within the stipulated limits.

C:N Ratio: C:N ration signifies the stabilization and Organic matter decomposition during composting process and the present study of sericin rich waste water as additive on C:N ratio during composting process is presented in (Figure 5). There was significant reduction in C:N ratio during different maturation phase compared to control. C:N ratio of equal or less than 20 is considered as acceptable value for compost maturity [39]. Results obtained are well within the stipulated range of the recommended standard.

Analysis of Total Nitrogen, Potassium and Phosphorous During Composting Process

Total Nitrogen: Organic and inorganic forms of nitrogen in compost comprises of total nitrogen. The total nitrogen content in the additive based compost ranges from 0.16 to 0.54% as shown in (Figure 6). This indicates enhanced rate of organic conversion of the compost. The incremental augmentation in total nitrogen content during the composting can be attributed to decrease in carbon substrate due to decomposition of organic matter [40].

Total Potassium: Potassium which is highly soluble in is one of the indispensable soil nutrients that helps in plant growth and. The insoluble potassium can be solubilised by the disintegration of waste. The concentration of potassium in different maturation stages increased during the composting period. Variation of potassium concentration in control compost and additive based compost is presented in (Figure 6).

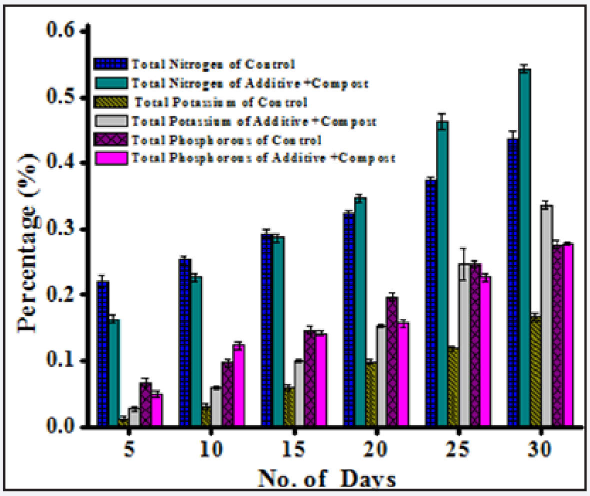

Figure 6 : Graph depicting % total nitrogen, phosphorous and potassium.

Total Phosphorous: Total phosphorous is one of the well-known plant nutrients among nitrogen, Phosphorous and potassium which assist in growth of plants. The concentration of total phosphorus in present study ranges between 0.026 to 0.33 % which is well within the stipulated range of recommended standard (Figure 6). The steady increase in phosphorus content is seen with progression of maturation phases of compost and any decreases due to humification. Similar observations were also noted in some of the earlier studies [24].

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Heavy Metal Analysis of the Compost: (Table 1): Heavy metal concentrations at different compost maturity phases, control MSW sample along with CPCB recommended standard for city compost. (Table 1): depicts the heavy metal concentrations at different maturity phases of additive aided composting along with control. The availability of heavy metals in all the maturity stages is well within the permissible limits of recommended standards by Central Pollution Control Board for the city compost. The concentration of heavy metals in additive based compost at different maturity levels were generally decreasing or below detectable limit suggesting compost toxicity to be low or negligible due to heavy metals presence which is also comparable to earlier studies by various researchers [7-9].

Table 1: Heavy metal concentrations at different compost maturity phases, control MSW sample along with CPCB recommended standard for city compost.

Parameters (mg/Kg)	Control (MSW Compost)	No. of Days						CPCB Standard
		5	10	15	20	25	30	
Arsenic (As_2O_3)	2.2	0.9	0.6	0.2	0.05	0.01	0	10
Mercury (Hg)	0.06	0.07	0.04	0.03	0.01	0	0	0.15
Cadmium (Cd)	1.6	1.5	1.2	0.6	0.3	0.1	0.1	5
Chromium (Cr)	3.8	3.4	2.9	2.7	2.6	2.1	2	50
Copper (Cu)	51	40.5	32	30.5	27.5	20.5	12.1	300
Nickel (as Ni)	39.1	38.2	36.1	30.5	23.2	20.2	18.5	50
Lead (As Pb)	9	6	5	4.2	3.4	1.7	0.6	100
Zinc (as Zn)	301	252	206	214	160	142	131	1000

Conclusion

Use of Sericin rich wastewater from silk industry as an additive in municipal solid waste enhanced the composting process which in turn was reflected by early degradation of organic matter and enhanced the quality of finished compost. Present study paves way for reuse of sericin rich waste water, usually an environmental pollutant, resulting in management of industrial waste and controlling pollution by reutilization of wastewater from silk industry and providing novel composting technology for management of municipal solid waste. Study further points toward use of simple and economical procedure for solid waste composting. These results have projected scope for additive based composting as new strategy for solid waste management.

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