International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(2): 827-830
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Received: 01-12-2020
Accepted: 06-02-2021

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Bioconversion process for compost production from agricultural residue

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DOI: https://doi.org/10.22271/chemi.2021.v9.i2l.11923

Abstract
Bioconversion of agricultural residual wastes into value added compost for enhancing crop productivity and improving soil health and attaining popularity among the farmers. Therefore, in the present investigation was carried out microorganisms play an important role in the recycling of agricultural wastes for compost production. Cattle dung, biogas slurry and paddy straw had 14.35, 11.85 and 15.94% total solids with organic carbon 45.66, 40.12 and 50.76%, respectively. The C/N ratio was observed 35:1 in cattle dung, 34:1 in biogas slurry and 87:1 in paddy straw. The nitrogen content was 1.04, 1.0 and 0.62%, respectively in cattle dung, biogas slurry and Paddy straw. The C/N ratio dropped from 42.38 to 27.65 and maximum amount of humic acid was observed in T7 treatment after 60 days of composting. Volatile solids ranged from 60 to 67.7% of TS in all treatments after 60 days of composting.

Keywords: Bioconversion, composting, paddy straw, cattle dung

Introduction
In India, paddy is a major cereal crop that leads to the production of much larger quantity of straw. From such a large quantity of paddy straw, only a minor portion is used as animal feed and household fuel while the remaining paddy straw is disposed of by burning (Badarinath *et al.*, 2006) [3]. Approximately 75-80% of paddy straw is disposed of by burning which is a major source of environmental pollution which effect on human and animal health, huge loss of plant nutrients, organic matters and degrades soil properties. Moreover, use of chemical fertilizers may also contribute to environmental risks like increase in global warming, ground and surface water pollution etc. Subsequently crop yield goes down. Moreover, agricultural waste such as rice straw, wheat straw, corn Stover, sugarcane bagasse and weeds are composed of lignocellulose compounds such as cellulose, hemicellulose, and lignin (Perez *et al.*, 2002) [7]. In this direction, composting is one of the effective approaches for reducing the amount of disposed agro waste and produces value added products and transformation of these compounds for use in agriculture. It is cheaper and based on renewable energy sources. Use of compost is need for getting good quality of production and decrease the cost of cultivation, which will increase total income of the farmer. It liberates growth promoting substances and vitamins and help to maintain soil fertility. It is a decomposition process in which the substrate is progressively broken down by a succession of living organisms. The breakdown products of one microbial population serve as the substrate for the succeeding population. The whole process involves a heterogeneous population of microorganisms, bacteria, fungi and actinomycetes, and others. Straw decomposition increased amounts of soil organic carbon and changed microbial biomass (Yuli *et al.*, 2020) [11].

Composting arises as a safe option in this regard allowing for reusability of nutrients contained in these residues. Compost is a supply of macro- and micronutrients, which can substitute chemical fertilizers and suppressing plant diseases (Tahseen *et al.*, 2020) [10]. Composting can also provide nutrients that are suitable for agriculture and can be used as fertilizer to replace chemical fertilizer. Furthermore, compost can also be used as soil amendments as well as being eco-friendly, hygienic economical and toxic free. During the composting of agricultural wastes, the addition of animal manure, microorganisms can enhance the degradation process (Malik *et al.*, 2019) [6]. Compost is also minimizing the pesticides residue in soil (Kumar, *et al.*, 2018: Ahlawat *et al.*, 2019) [4, 6].

Use of microorganism may be cost effective method for bioconversion of crop residue (Maki *et al.*, 2012) [5]. No single microorganism has the capability to completely degrade the crop residue, there is dire need to use a microbial consortium of which can act synergistically for bioconversion of agricultural residues (Premlata, 2017) [8]. Therefore, the present paper would be an effort in the direction of developing sustainable, efficient, eco-friendly and economically feasible technologies for utilization of paddy straw into compost production. These technologies provide more sustainable, efficient, eco-friendly and economically feasible technologies for utilization of paddy straw into compost production using microbial consortia.

Materials and Methods

Paddy straw was collected from farmer's fields, Hisar (Haryana), India. Leaf litter were collected from different sites of CCS HAU, Hisar campus. Biogas slurry was collected from Modified Janta Biogas Plant, Deptt. of Microbiology, CCS HAU, Hisar. Cattle dung was collected from Animal Science department, COVS, LUVAS, Hisar.

Microbial consortia

Bacterial cultures (MC-2) namely *Bacillus* and *Pseudomonas* sp. and three fungal cultures (MC-1) namely *Aspergillus clavatus*, *Aspergillus* flavus and *Aspergillus niger* obtained from Biogas Lab, Microbiology department, COBS&H, CCS HAU, Hisar were used. About 10 kg of each substrate mixture was filled in the compost pit and inoculated with microbial consortium @1% (v/w) (1 x 106cfu/ mL) as per treatments. The microbial inoculum was mixed with the substrates and the mixture was allowed to decomposition for 2-3 months under natural conditions.

The treatments (T) were as follows

- T-1: Paddy straw +Cattle dung (2:1)
- T-2: Paddy Straw + biogas slurry + Microbial consortium (MC) 1
- T-3: Paddy Straw + Cattle dung + MC 1
- T-4: Paddy Straw + biogas slurry + MC 2
- T-5: Paddy Straw + Cattle dung + MC 2
- T-6: Paddy Straw + biogas slurry+ MC1& 2
- T-7: Paddy Straw (soaked) + Cattle dung + MC1& 2
- T-8: Paddy Straw (soaked) + Biogas slurry MC1& 2

The moisture content was maintained at 40–60% by sequential watering to replace any water loss. Initial C/N ratio was 50-55:1, turing of compostable material were done at 15 days' intervals. The compost samples were withdrawn at regular interval of time and analyzed for various parameters such as: pH, volatile solids (VS %), organic carbon (%C), nitrogen, phosphorous, potassium and C/N ratio (AOAC, 2000).

Results and Discussion

Analysis of compostable material

Initial analysis of paddy straw, cattle dung and biogas slurry was analyzed for pH, volatile solids, total solids, organic carbon, nitrogen and C/N ratio (Table 1). It was observed that cattle dung, biogas slurry and paddy straw contained 14.35, 11.85 and 15.94% of total soils where organic C, 45.66, 40.12 and 50.76%, respectively. The C/N ratio was observed in cattle dung (35:1), biogas slurry (34:1) and paddy straw (87:1). The nitrogen content was 1.34, 1.42 and 0.62%, respectively in cattle dung, biogas slurry and Paddy straw.

Table 1: Initial analysis of substrates

Component	Cattle dung	Biogas slurry	Paddy straw
pH	7.43	8.13	6.65
Total solids %	14.35	11.85	15.94
Volatile solids (% of TS)	88.0	65.0	88.2
Cellulose (%)	30.7	26.70	39.87
Hemicellulose (%)	17.3	14.91	23.9
Lignin (%)	13.23	11.14	10.31
Organic carbon %	45.66	40.12	50.76
Nitrogen %	1.34	1.42	0.62
C/N ratio	35:1	34.1	87:1

During the composting process, gradual changes of the textures of the raw materials were observed after 30 days (Table 2), followed by the appearance of a black colored humus-like substance which developed after 60 days of decomposition. Organic C of composting material decreased with time in all treatments. Combined inoculation of *E. fetida* and *Pseudomonas* sp. with poly lining in the pit significantly enhanced compost recovery (29.8%), cellulase activity (55.2%) and the C: N ratio (1.9%) as compared to control (Rajkhowa, *et al*., 2019). Minimum organic carbon (33.06%) was recorded in T7 treatment after 60 days of incubation. The nitrogen content was 1.10 and 1.19% in T7 and T8 treatments after 60 days (Table 3).

Table 2: Analysis of compost after 30 days

Component	T1	T2	T3	T4	T5	T6	T7	T8
pH	8.40	8.52	8.39	8.95	9.24	8.94	8.99	8.18
Volatile solids (% of TS)	76.0	84.0	68.0	74.0	70.0	89.0	84.0	84.0
Organic carbon %	44.08	48.72	39.44	42.92	40.60	51.62	48.72	48.72
Nitrogen %	0.92	0.93	0.91	0.94	0.93	0.90	0.96	0.94
C/N Ratio	47.91	52.38	43.34	45.65	43.66	54.33	50.75	51.82

Table 3: Analysis of compost after 60 days

Component	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
pH	8.42	8.13	8.87	8.10	8.20	8.00	8.03	8.10
Volatile Solids (% of TS)	64.9	65.4	67.8	64.5	62.3	62.1	57.1	60.1
Organic C%	39.24	37.70	46.72	38.57	40.77	36.02	33.06	35.38
Nitrogen %	1.22	1.44	1.35	1.28	1.26	1.36	1.10	1.19
C/N Ratio	31.87	32.68	32.05	30.2	29.0	30.62	27.65	28.60

As the decomposition progressed the organic carbon and volatile solids were decreased with time and nitrogen content increased which resulted in decrease in C/N ratio. C/N ration dropped from 42.38 to 27.65 in T-7 treatment after 60 d of composting. The application of effective microorganisms is suitable to increase the mineralization process in the composting process.

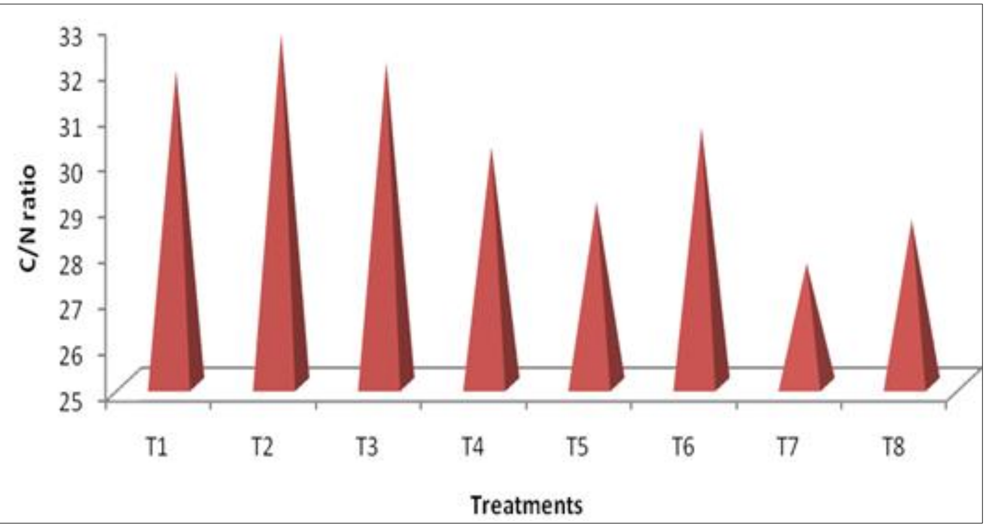


Fig 1: C/N ratio various treatments after 60 days of composting

The compost was further analyzed for humic substance. Humic acid in different treatments varied from 95.6 to 112.32 mg/g. Maximum amount of humic acid was observed in T7 (112.32 mg/g) after 60 days (Fig. 2). After 60 days of decomposition, the good quality of compost was prepared by agricultural residue (Fig 3).

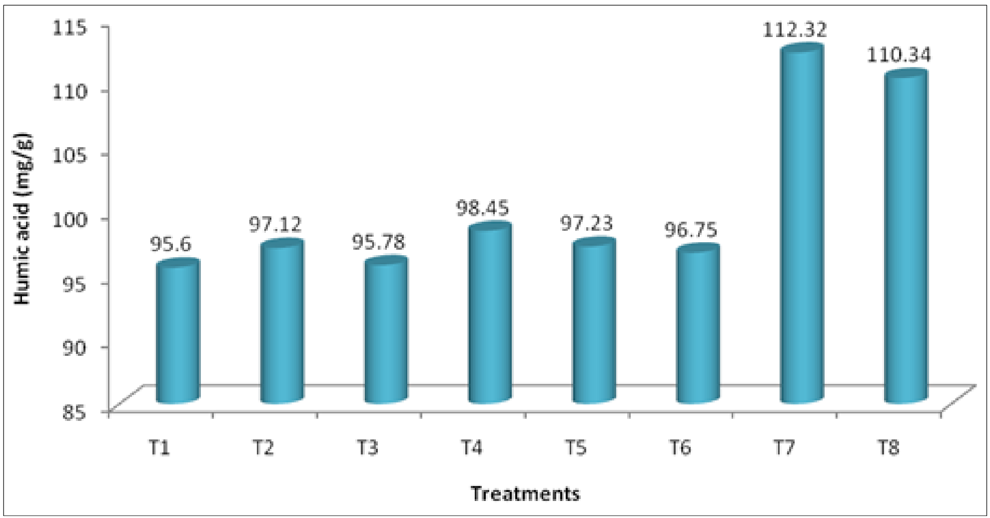
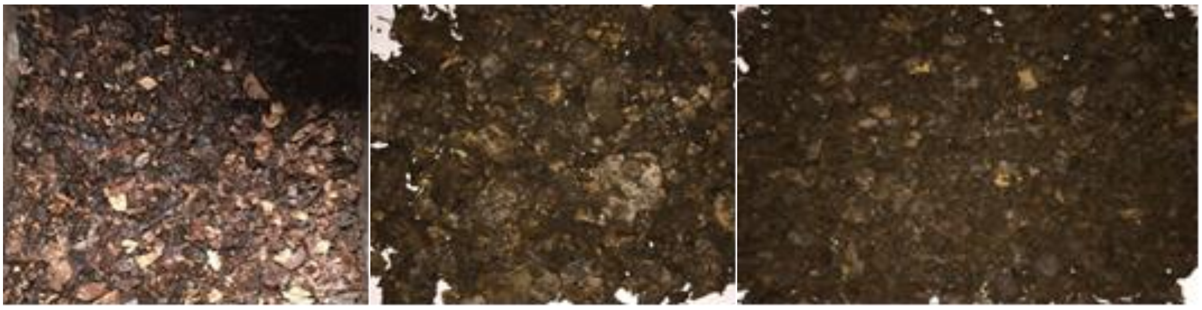


Fig 2: Humic acid of various treatments after 60 days of composting.



15 days **30 days** **60 days**

Fig 3: Bio-compost from agricultural residue at different incubation period

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