Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 1835 – 1847
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

Composting the Organic Fraction of Municipal Solid Waste and Fish Waste as Inoculum using Chrysomaya Megacepala

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Abstract

The organic waste can be handled by the process of composting as it will produce a useful by-product at the end of the process. In the present study, the organic fraction of municipal solid waste and fish waste were mixed in ratios like 99:1, 98:2, 97:3, 96:4 and 95:5 respectively. These ratios were handled with 0.25g and 0.5g larvae of Chrysomaya megacepala until the pupae stage arrives. The ratio 96:4 of the Organic Fraction of Municipal Solid Waste: Fish Waste could be taken as an optimum ratio by having the parameters under study. Carbon/Nitrogen ratio of the mix treated with 0.25g and 0.5g were found to be 26 and 19, the moisture content was 45% and 48%, total potassium was around 0.6 and 0.63 and total phosphorous was 0.69 and 0.7 respectively. This study aids to recognize the ability of Chrysomaya megacepala to handle the different combinations of the Organic Fraction of Municipal Solid Waste and fish waste.

Keywords: Chrysomaya megacepala; Fish waste; Organic solid waste; C/N ratio; Composting;

1. Introduction

The relocation of people towards cities has increased not only the population but also the generation of waste per capita, which led to the dumping in the outskirts of cities and towns leading to global warming (Karak et al., 2013a; Sarkar et al., 2016). Organic wastes like fish waste (Lanno et al., 2020; Isibika et al., 2021), poultry waste (Baba et al., 2018; Asses et al., 2019) market wastes (Lakshmi et al 2014; Jara-Samaniego et al., 2017; Tibu et al., 2019) create displeasing experiences to the surrounding environment and also lead to other kinds of pollution. When the heavy metals or the hazardous substances from these wastes enter the food chain they pose a serious threat to humans as well as other beings (Kadir et al., 2016; Wu et al., 2017). Hence it becomes necessary to treat such waste before they cause serious illness to the environment. Composting is one of the antique technologies for the treatment of such organic fraction of municipal solid wastes which can be done with the help of larvae (Fathi et al., 2014; Lohri et al 2017).

Chrysomaya megacepala commonly known as blowfly or greenfly is a significant insect in the forensic industry (Sukontason et al., 2008) that can also be helpful to treat rotten wastes. These larvae are attracted to the dead and rotten substances (Sukontason et al., 2007). They could be useful to handle the organic wastes with negligible bulking agents without much operating cost.

In the present study, Chrysomaya megacepala also knows as Greenfly (GF) was employed to treat the various mixes of organic fractions of the municipal solid wastes (OFMSW) and fish wastes (FW) to handle

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effectively and also generate the compost. The operating parameters like pH, moisture content, temperature, Electrical Conductivity (EC), Volatile Solids (VS), Total Organic Carbon (TOC), Total Kjeldahl Nitrogen (TKN), C/N (Carbon/Nitrogen) ratio, Total Phosphorous (TP) and Total Potassium (TK) were assessed for the waste till the larvae of the maggot convert to pupae. This work also intends to produce compost from the different mixes of the organic portion of the municipal solid waste and fish wastes using Chrysomaya megacepala.

2. Materials and Methods

2.1 Study area, sample collection and experimentation

The waste was collected from the dumpsite of Chidambaram Municipality, Chidambaram, Cuddalore District in February 2021. The latitude and longitude of the study area are 11.4°N and 79.7°E and it has a population of about 62153 as per Census 2011. The dump yard is situated at Omakulam of Chidambaram municipality area of about 4.8 sq. Acre is an open dump yard that contains composite wastes from the municipality. The temperature ranges from 24°C to 37°C, rainfall of about 1248 mm per year and 0.25kg per capita per day of waste is being generated. The sampling was done at a surface level using the quadrant method where the present-day samples were heaped together and one out of four quadrants were chosen. The collected waste was segregated for its organic fractions which contains much of market waste, paddy straw, paper and wood debris of about 2 kg in each tray and shredded manually to expedite the microbial process. The composting was administered for 15 days in durable plastic trays. The tray with only OFMSW is the control. The different fish percentages like 1%, 2%, 3% 4% and 5% were added with OFMSW making up to 100% as total in different trays using 0.25g of larvae to each tray. A similar kind of ratio of fish waste was mixed with OFMSW and 0.5g of larvae were added to each of them. The intrusion of other flies was avoided by covering the trays with mosquito nets. Until the larvae changed to the pupae stage, the waste characteristics were analyzed on alternate days. Manual stirring of the waste in trays was done twice a day to provide aeration. The operating parameters of the composting process like temperature, moisture content, pH, Electrical Conductivity (EC), Volatile Solids (VS), Total Organic Carbon (TOC), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), Total Potassium (TK) and Carbon to Nitrogen ratio (C/N ratio) were determined by APHA 2017. The parameters associated with the larvae like survival rate, waste reduction rate and eclosion rate of maggots were learnt to recognize the ability of the maggot to compost OFMSW and fish waste under study.

2.2 Morphological analysis

The larvae used for the study was captured from the nearby fish market and they were cultured in the laboratory for the same purpose. The morphology was studied with a scanning electron microscope and optical microscope.

2.3 Partial DNA Sequencing

The scientific name of the larvae was identified with the help of partial DNA sequencing. LCO and HCO primers were used for forward and reverse sequencing respectively. At pH 4.6, the mix of Ethylenediaminetetraacetic acid (EDTA), Sodium acetate and diluted water were prepared. In the sequencing plate, 50 ml of the above mix was added to the PCR product. The incubation was provided to the product at room temperature and rotation was provided for 30 min at 3700 rpm. The supernatant and 70% ethanol of about 50 µl was mixed and again rotated for 20 min at 3700 rpm. The supernatant was decanted and washed

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with 70% ethanol and air dry was provided to make it as a pellet. This air-dried and cleaned pellet was sequenced in ABI 3500 DNA Analyzer (Applied Biosystems).

3. Results and discussion

3.1 Morphological study

The physical features of the Chrysomaya megacepala were examined with an optical microscope. They are forensically significant flies where the mouth part was seen in the larval stage. The white larvae fed on the waste provided and its size increased every day. The insect reached the pupa stage with an outer black shell after which they did not feed on the waste. After the completion of the pupae stage, the green flies that emerged were also observed under the microscope. Redhead, two wings and legs were recognized. The optical microscopic image of Chrysomaya megacepala was shown in Figure 1. The Scanning Electron Microscope (SEM) image of Chrysomaya megacepala was shown in Figure 2. Anterior end, posterior end and full view of the larva were seen in SEM images. Figure 2a shows the mouth and eyes. Sukontason et al., 2008 discussed the analogous morphology.

Figure 1. Microscopic image of Chrysomaya megacepala a. Larval stage, b Pupae stage, c. Fly stage

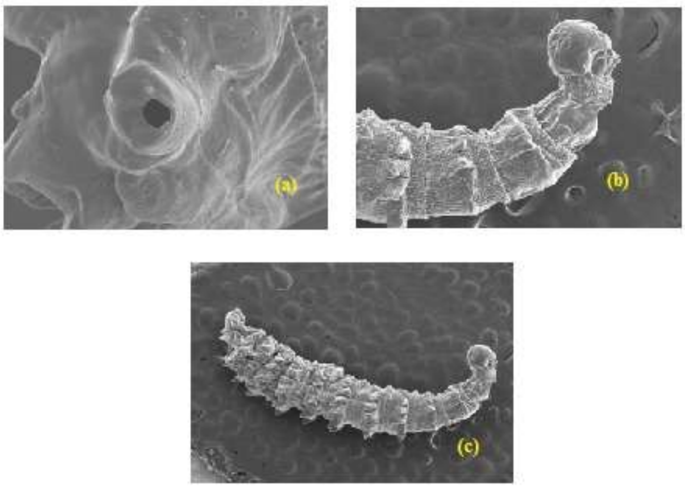

Figure 2. SEM image of Chrysomaya megacepala: a. Anterior end, b. Posterior end, c. Full view of the insect.

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3.2 Sequence

Mitochondrial COI gene analysis was done by the Sanger sequencing method and the base pairs of the sequence were 500. The accession number is MZ461937 to the sequence submitted in NCBI.

3.3 Outcome of physical and chemical parameters for OFMSW

The composting process was influenced by physical and chemical parameters of the different mix ratios of fish waste and OFMSW with the help of Chrysomaya megacepala shown in Figures 3 and 4. As it is an open composting process, the temperature maintained was much relatable to the ambient temperature and no major difference was observed. In the trays with 0.25g flies, the mix ratio of 5% fish waste with OFMSW shows the maximum temperature of about 31.3°C in Figure 3a. Similarly, in the trays with 0.5g of flies, the mix ratio of 5% fish waste with OFMSW shows the maximum of 31.6°C in Figure 4a. The temperature of the final compost was around the same value as in the current when swine manure was composted (Ravindran et al., 2019). The decreasing curve was seen in moisture content for all the trials with 0.25g and 0.5g of larvae. The moisture content of the 0.25g larvae with 4% and 5% fish waste were 45% and 47% respectively. On the other hand, the moisture content of the 0.5g of larvae with 4% and 5% fish waste was 48% and 49% respectively. The control had the final moisture content below 30%, which ceases microbial activity and makes it unfit to be valuable compost. The moisture contents for the final compost lie in the permitted range as mentioned by Lim et al., (2016). The initial pH of all the mix ratios measured on alternative days was in the acidic range. They gradually increased to the neutral phase. The final pH of the ratio with 0.25g of fly and 4% and 5% fish waste did not differ much and their values are 8.31 and 8.33 in Figure 3c. Likewise the ratios with 0.5g of larvae and 4% and 5% fish waste had their pH values as 8.19 and 8.21 in Figure 4c. The gradual increase in the pH may be due to the release of organic alkaline substances from wastes due to the employment of the larvae. A similar pattern was observed when swine manure was composted with house flies (Wang et al., 2016). The pH from acidic range was shifted to neutral range when agricultural wastes along with fish pond sediment were composted (Karak et al., 2013b). The fluctuations in the values of EC were observed during the entire process of composting in Figures 3d and 4d irrespective of the ratio mix. The fluctuation in EC values could be because organic salts would have been produced and a similar kind of pattern was obtained by (Liu et al., 2019). The decreasing trend was observed in volatile solids of all the mix ratios in 0.25g and 0.5g of fly. The increase in fish waste percentage also led to the decreased volatile solids in Figures 3e and 4e. A similar pattern was observed when food waste was composted with black soldier fly larvae there was a considerable decrease in the volatile solids content (Lalander et al., 2018). There was a visible change in the C/N ratio that the values diminish as the days increase. The final C/N ratio of the mix 4% and 5% fish waste treated with 0.25g of larvae were 26 and 25 (Figure 3f) and they were the least value compared with other mixes like 1%, 2% and 3% fish waste. Similarly, the mix ratio with 4 % and 5% fish waste treated with 0.5g of larvae were 19 and 18 (Figure 4f) and 1%, 2% and 3% fish waste mixed had 25, 25 and 23 respectively. This decrease in the C/N ratio indicates that the material is stably composted and similar results were obtained when food and sewage waste was composted (Liu et al., 2020). Arslan et al., 2011 found decrease in C/N ratio of optimum value when fruit and vegetable waste was composted.

The impact of parameters like pH, EC, temperature, C/N ratio, moisture content and volatile solids were significant for the trays with increased mix ratios like 4% and 5% fish waste inoculum which establish the relationship between the inoculum and the degradation of the wastes. On the other hand, there was not much

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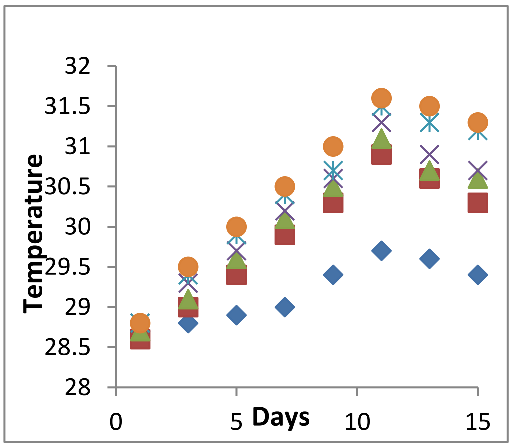
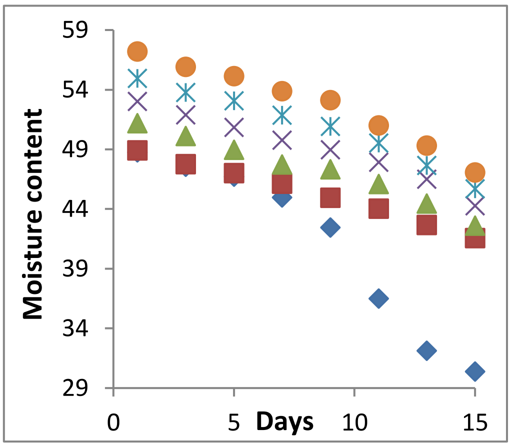
visible difference between the 4% fish waste and 5% fish waste in the trays treated with 0.25g and 0.5g of larvae, 4% fish waste mix could be chosen as an optimum mix.

3.4 Status of organic fertilizer obtained

The essential nutrients of the compost required for the plant to grow include organic matter, phosphorous, nitrogen and potassium and these parameters are displayed in Figures 5 and 6. The wastes treated with 0.25g and 0.5g of the larvae showed raise in the nitrogen content as the days pass by. The mix ratio with 4% and 5% fish waste treated with 0.25g of larvae had the maximum total kjeldhal nitrogen of 1 (Figure 5a). Similarly, in 4% and 5% fish waste treated with 0.5g of larvae had the highest total kjeldhal nitrogen of 1.12 and 1.13 respectively (Figure 6a). In the case of trays treated with 0.5g of larvae, all the mix ratios had the total kjeldhal nitrogen content of 1 and above. The increase in nitrogen value is due to degradation of organic substances and reduction in weight and a similar pattern was observed by Zhu et al., (2019) while composting different types of waste. Rawat et al., 2013 found alike nitrogen values in the final compost when municipal solid waste was composted. The total phosphorous value of the mix ratio with 4% and 5% fish waste treated with 0.25g of larvae was 0.69% and 0.7% (Figure 5b). The total phosphorous trend was increasing for all the mix ratios. Likewise, the mix ratio of 4% and 5% fish waste treated with 0.5g of larvae had the total phosphorous content of 0.7 and 0.71 respectively (Figure 6b). A similar kind of increasing trend was seen when different organic wastes were composted with the pile method (Al-Nawaiseh et al., 2021). Also, Ch'ng et al., 2013 found similar phosphorous values when composted pineapple leaves and chicken manure slurry. The total potassium content reached the maximum of 0.6% in trays treated with 0.25 g of larvae in Figure 5c. Likewise, the total potassium content was 0.63% in trays treated with 0.5g of larvae in figure 6c. All the mix ratios had an increasing trend of potassium content. Pathak et al., 2012 composted kitchen waste and found the potassium values in the similar range. The decreasing curve was observed in the total organic carbon for the mix ratios treated with 0.25g and 0.5g of larvae in Figures 5d and 6d. The decrease in the organic carbon values is due to the consumption of these substances by the larvae present and a similar drop was observed when earthworm was used for the composting process (Bhat et al., 2015).



(b)



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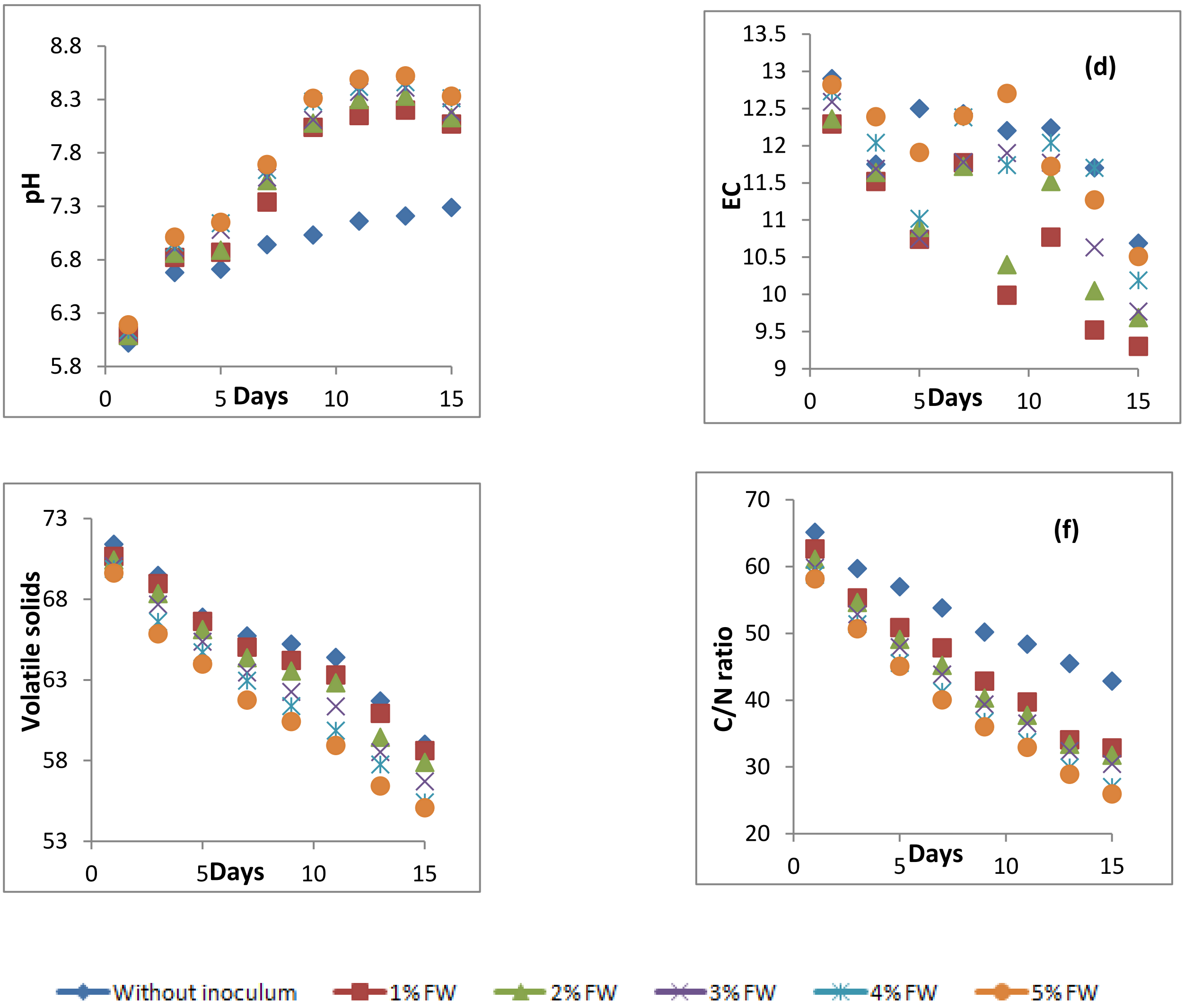
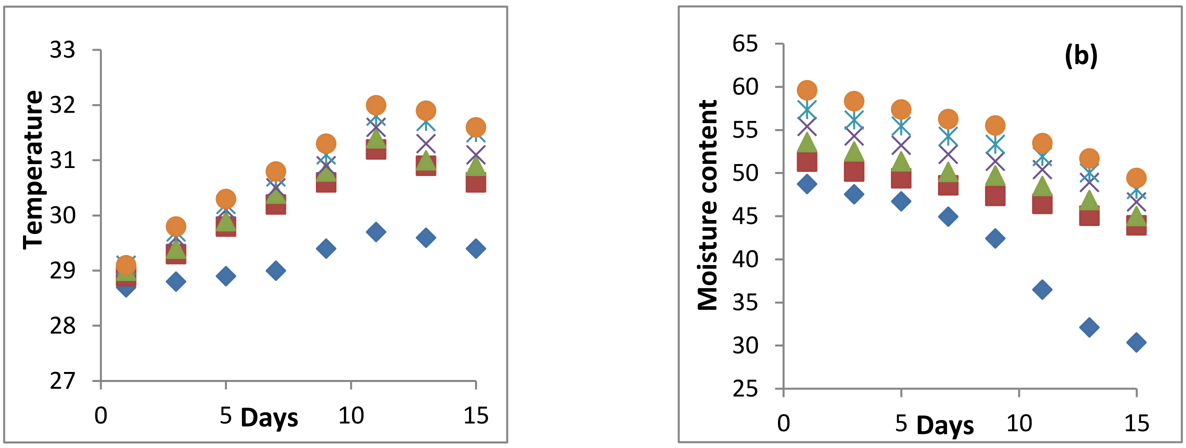


Figure 3. Changes in chemical and physical properties of OFMSW inoculated with different ratios of fish waste using 0.25g larvae. Effect of a.Temperture; b.Moisture content; c.pH; d.EC; e.Volatile solids; f.C/N ratio



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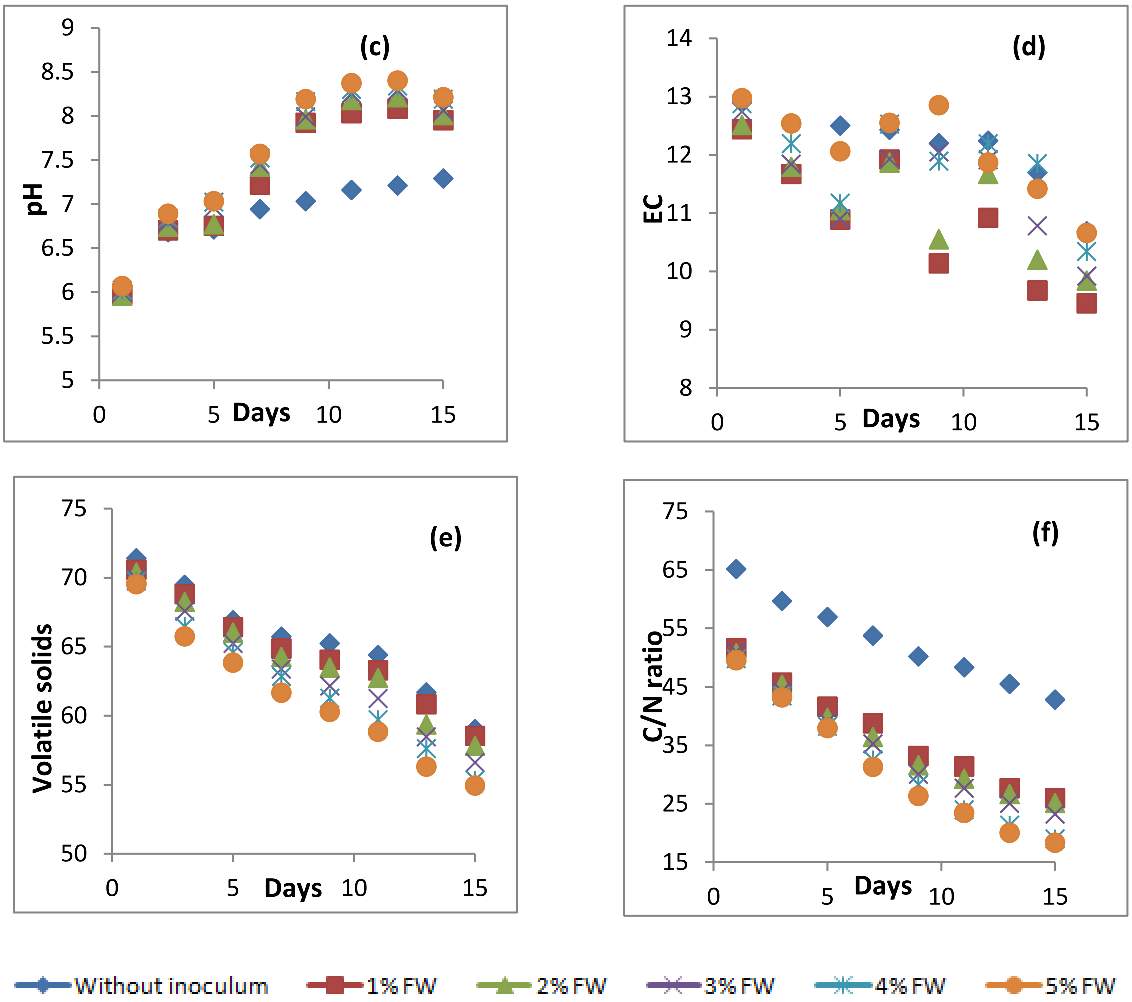

Figure 4. Changes in chemical and physical properties of OFMSW inoculated with different ratios of fish waste using 0.5g larvae. Effect of a.Temperture; b.Moisture content; c.pH; d.EC; e.Volatile solids; f.C/N ratio

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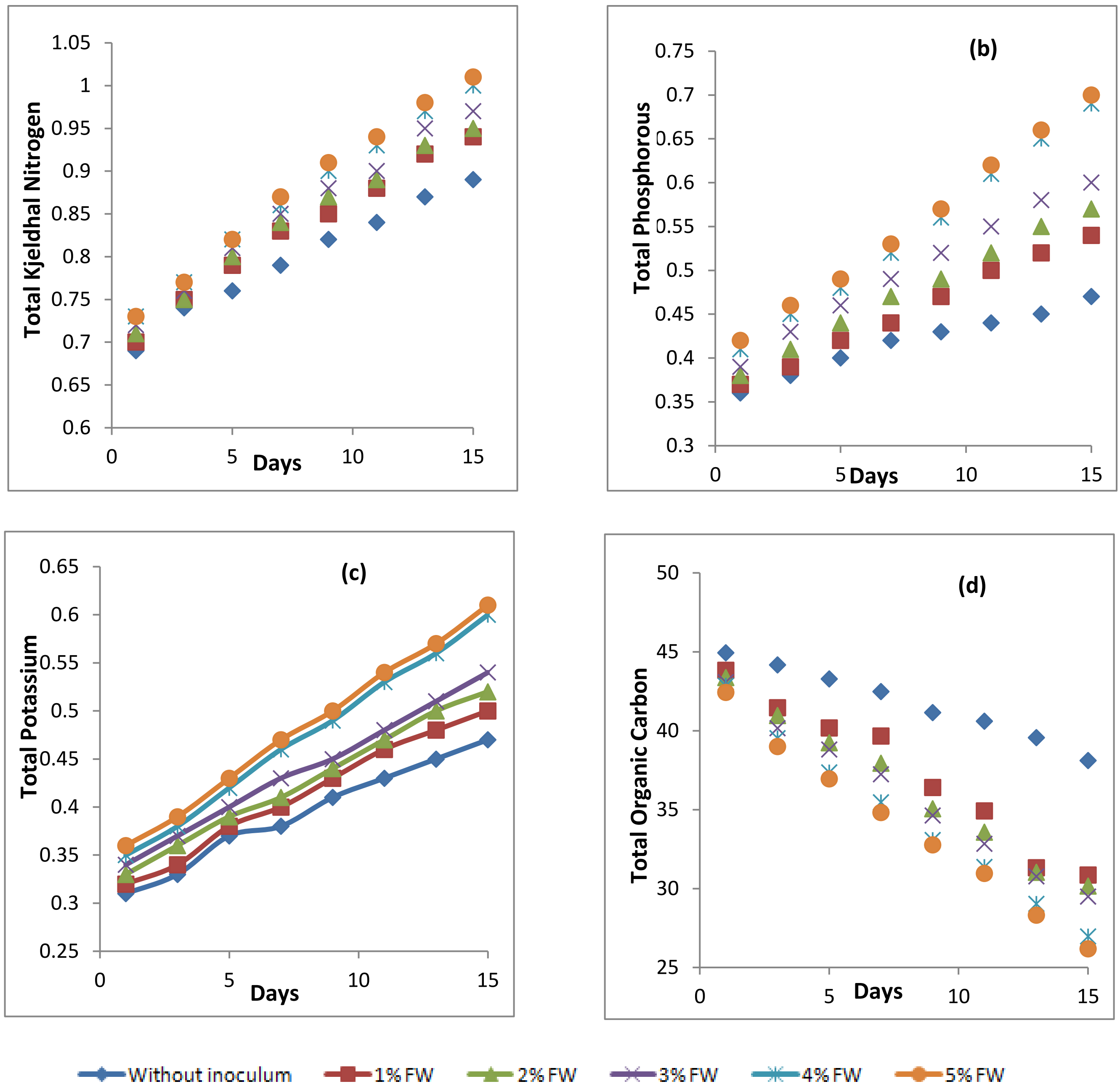

Figure 5. Changes in fertilizing properties of OFMSW inoculated with different ratios of fish waste using 0.25g larvae. Effect of a.Total Kjeldhal nitrogen; b.Total phosphorous; c.Total potassium; d.Total organic carbon

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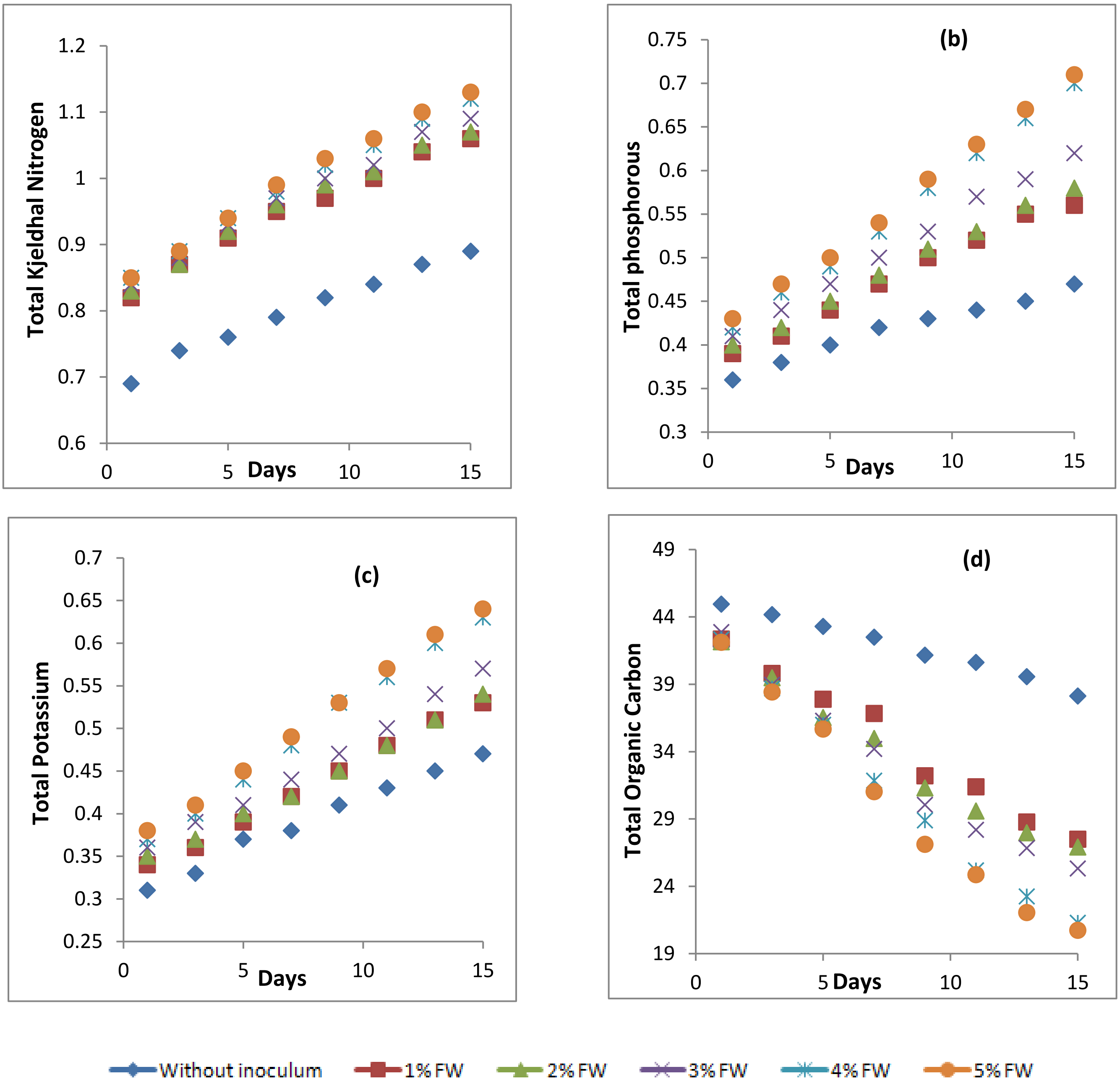

Figure 6. Changes in fertilizing properties of OFMSW inoculated with different ratios of fish waste using 0.5g larvae. Effect of a.Total Kjeldhal nitrogen; b.Total phosphorous; c.Total potassium; d.Total organic carbon

3.5 Role of Green flies

The survival rate, waste reduction index and eclosion rate of pupae for the different mix ratios treated with 0.25g of larvae were presented in Table 1a. The mix ratio with 4% fish waste had a waste reduction rate of 27%, after which there was only a mild increase. Likewise, the survival rate and the eclosion rate were good for the 4% fish waste mix compared with the remaining mix ratios. Also, the 4% mix ratio treated with 0.5g of larvae had a better waste reduction rate of 38%, after which 5% fish waste ratio did not have much

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increase (Table 1b). Other parameters like survival rate and eclosion rate of pupae were good for 4% of fish waste. The waste reduction rate was on par with the study that dealt with dairy manure and soybean residue using black soldier fly larvae (ur Rehman et al., 2017).

Table 1a. Role of Green Fly in composting OFMSW= 0.25g GF

Mix ratio= OFMSW:FW	Green fly (g)	Waste reduction rate	Survival rate	Eclosion rate
99:1	0.25	10.25	15.2	12.12
98:2	0.25	15.65	18.8	15.56
97:3	0.25	20.5	30	16.67
96:4	0.25	27.25	47.6	24.30
95:5	0.25	30.1	54.8	25.60

Table 1b. Role of Green Fly in composting OFMSW= 0.5g GF

Mix ratio= OFMSW:FW	Green fly (g)	Waste reduction rate	Survival rate	Eclosion rate
99:1	0.5	22.2	16.4	13.24
98:2	0.5	26.65	19.4	15.38
97:3	0.5	31.45	30.8	18.60
96:4	0.5	38.15	48.2	24.42
95:5	0.5	40.1	57.4	25.26

Conclusion

The organic fraction of municipal solid waste was inoculated with various ratios of fish waste were treated with Chrysomaya megacepala. The final compost attained a moisture content of above 3% and below 50%. The C/N ratio of the mix treated with 0.25g and 0.5g were 26 and 19 respectively. The waste reduction rate, eclosion rate and survival rate were better for 4% fish waste mix treated with both 0.25g and 0.5g of larvae. Hence 4% fish waste could be considered as the optimum mix treated with 0.25g and 0.5g of larvae by taking the parameters like C/N ratio, waste reduction rate, fertilizing properties and moisture content.

Acknowledgement

The authors would like to thank the Department of Civil Engineering, Annamalai University for providing us with the necessary laboratory facilities.

Conflict of interest

There is no conflict of interest.

Abbreviations

C/N – Carbon/Nitrogen
EC - Electrical Conductivity
EDTA - Ethylenediaminetetraacetic acid
FW - Fish Waste
GF – Green Fly
OFMSW - Organic Fraction of Municipal Solid Waste
SEM - Scanning Electron Microscope
TK - Total Potassium
TKN - Total Kjeldahl Nitrogen
TOC - Total Organic Carbon
TP - Total Phosphorous
VS - Volatile Solids

Orcid

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Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 1835 – 1847
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

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