

FISH WASTE COMPOST - A FERTILIZER FOR ORGANIC AGRICULTURE

ABSTRACT

Fish markets produce a large amount of fish waste such as fish head, gut, intestine, fines, bones and scales that are generally dumped in the river or land-filling areas. Such dumping of fish waste in larger numbers has scaled up in great intuitive pollution to the environment. Such impulsively growing contamination can be mitigated and checked through waste management in the form of organic composting that are environment friendly in nature. Adoption of fish waste compost will be a novel strategy and could have great implications to trigger a techno-green revolution. This approach will help in enhancing soil health and high food quality production.

KEYWORDS: Fish waste, composting, organic compost

INTRODUCTION:

Organic farming is a system of production that relies on animal, manures, organic wastes, crop rotations, legumes, pest control through biological measures. The essence of organic farming is to feed the soil rather than crops to maintain optimum soil health with its vibrancy and resilience and thereby making the soil capable of supplying all the essential nutrients to crop for its proper growth and development. It aims at sustaining and increasing the productivity by improving the soil health and overall improvement of agro-ecosystem. Applications of chemical fertilizers have robbed the soil fertility and have resulted in health

and environmental hazards. On the other hand, using of organic waste as fertilizers will improve the soil structure, water holding capacity, microbial biomass, and nutrient availability (Murthy *et al.*, 2018) and will pave the way for sustainable agricultural practices.

India is the second largest supplier of fish in the world after China, with a tremendous 11 fold leap from 0.75 million tonnes in 1950 to 9.6 million tonnes by 2012-13 (Spreij, 2004). Nearly 75% of the total weight of the fish is generated as solid waste in the form of gut, head, skin, bones, fins and frames after processing. Often, these wastes are not utilized further, but disposed off in landfills, by incineration, or dumping at river. Therefore, there is an urgent need to find ecologically acceptable means for reutilization of these wastes (Rosamond *et al.*, 2021). Composting has also been suggested as a viable solution (Liao *et al.*, 1997). Some fish wastes are also reutilized for the fish meal production (Hall, 1992; Keller, 1990). To date, only a few reports on reutilization of biodegraded waste products have been sighted. Fish wastes which are rich in nitrogen, potassium, phosphorus and trace minerals (Ghaly *et al.*, 2013) can serve as raw material for the production of many nutritive and non-nutritive products. The solid waste material of the fish will be transformed into compost for the improvement of soil fertility. With this background, the study was carried out in order to test fish compost may provide a viable solution for recycling and producing a quality organic fertilizer for organic agricultural systems.

MATERIAL AND METHODS:

PREPARATION OF FISH WASTE COMPOST:

Prior to compost preparation, the chemical composition of fish waste, saw dust, banana, jaggery were analysed as to check its nutrient contents (table 1). The solid fish waste namely gut, head, skin, bones, fins, scale and intestine were collected and chopped it into finer state. This chopped fish waste (w/w) 80% were mixed with 20% saw dust, whole

banana (12 nos.), jaggery (50g) and distilled water to soak. These percent contents were then placed layer by layer in the compost basket bin. The Basket bins were assembled using 10 ltr plastic basket, grommet, adapter and end-cap. Later the compost was stirred continuously in the interval of 3-4 days until the final fish waste compost was formed. It took 120-140 days to form complete mature fish waste compost (Plate 1 and 2). The mature fish waste compost was sieved using a 20 mm mesh screen and its analysis was done.

PLATE 1: Collection of fish waste from market



PLATE 2: Preparation of fish waste compost



MATURITY TEST OF FISH WASTE COMPOST:

Maturity test of the fish waste compost was done by physical and sensory, biological and chemical tests. The above test was done as prescribed by the Kristine and Daryl (2010).

Table 1. Fish waste compost maturity test (Kristine and Daryl (2010)).

Test category	Potential test for maturity
Physical and sensory test	Colour
	Odour
Biological test	Phytotoxicity (plant bioassay)
Chemical test	Carbon : Nitrogen ratio
	Organic matter
	Cation exchange capacity
	pH

	Electrical conductivity
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PHYTOTOXICITY TEST:

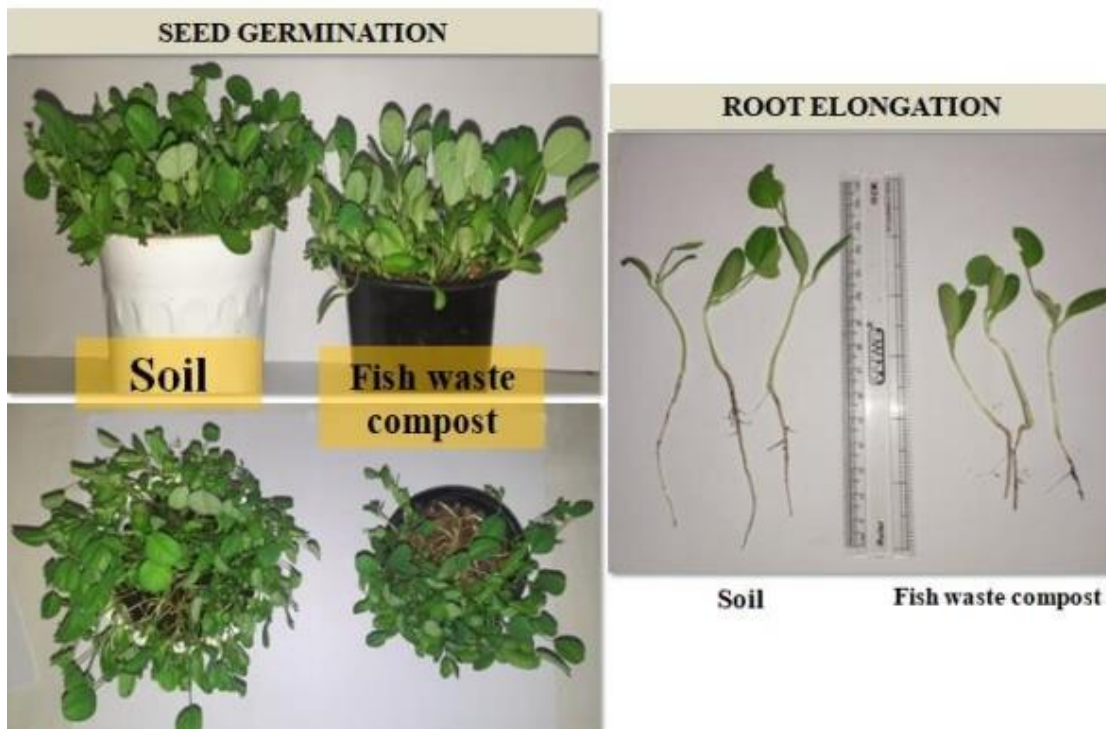
Maturity and toxicity of the compost were determined to establish its usability for agricultural purposes. The seeds of fenugreek (*Trigonella foenum-graecum*) were used in the seed germination experiment to assess the phytotoxicity of the final fish waste (Nazarath, 2004 and Zhang and Sun 2017) (Plate 3). For measuring germination index, seed germination and root elongation were firstly determined by using the formula given below.

$$\text{Seed germination (\%)} = \frac{\text{No. of seeds germinated in compost extract}}{\text{No. of seeds germinated in control}} \times 100$$

$$\text{Root elongation (\%)} = \frac{\text{Mean root length in compost extract}}{\text{Mean root length in control}} \times 100$$

$$\text{Germination index} = \frac{\text{Seeds germination (\%)} \times \text{Root elongation (\%)}}{100}$$

PLATE 3: Phytotoxicity (plant bioassay) Test: Fenugreek (*Trigonella foenum-graecum*)



STATISTICAL ANALYSIS

All the data of observations recorded in the experiments were statistically analysed and the critical differences (CD) were worked out at 5 per cent probability level (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION:

NUTRIENT CONTENT OF FISH WASTE, SAWDUST, BANANA AND JAGGERY

Fish waste compost was prepared by mixing fish waste, sawdust, banana and jaggery.

Before mixing it, each nutrient content of the component was analysed. Total major nutrient content in fish waste was 2.12 per cent of nitrogen, 0.82 per cent of phosphorus, 0.10 per cent of potassium and 10.55 per cent of carbon. (Table 2). The pH of the sawdust was found to be 5.9. The organic carbon of the saw dust was 25.58 per cent, 44 per cent organic matter, 2.18 percent nitrogen content, 0.71 percent of phosphorus, and 1.17 per cent of potassium (Table 2). The chemical composition of banana was analysed and their results were 3 per cent of phosphorus, and 8 per cent of potassium (Table 2). Chemical composition of jaggery were also analysed and were found to be as 0.35 per cent protein, 0.19 per cent phosphorus and 0.16 potassium (Table 2).

FISH WASTE COMPOST MATURITY TEST:

After 4.5 months of composting, the final product reduced to 70% of its volume. The fish waste compost was tested its maturity by physical and sensory test, biological test and chemical test (Table 3). Similarly Ieshita Pan *et al.*, 2012 observed that during the composting process, gradual changes of the textures of the raw materials were observed after 30 days, followed by the appearance of a black coloured humus-like substance which developed after 120 days of decomposition. Wheat straw (substrate C6) was converted into compost within 75 days (Ieshita Pan *et al.*, 2012). In physical and sensory test of the fish waste compost changes its colour and odour was observed as compost stabilizes and matures. Fish waste compost was earthy brown and odours become less offensive, changing from foul and

ammonia-like to rich and earthy. The similar way of testing physical and sensory test of the compost was reported by Kristine and Daryl (2010).

For biological test, mostly phytotoxicity (plant bioassay) was measured. The seed germination was (94.56%), root elongation (97.14%) and germination index were 91.86% (Table 3). This shows that the compost was non toxic to the plants and it can be further used for as compost for plant nutrient supplement. For biological test phytotoxicity test gives the best result of the maturity of the fish waste compost. Similarly result was obtained by María and Remigio (2011), Zucconi et al., (1981a) and Sullivan and Miller (2001) as germination index of the mustard seed was 81.1%, which shows the absence of phytotoxic substances in the fish waste compost. Many other species have also been used, among which it is worth mentioning horticultural species such as tomato (*Lycopersicon esculentum* Mill.), carrot (*Daucus carota* L.), cucumber (*Cucumis sativus* L.), cabbages (*Brassica oleracea* L. var. *italica*, *Brassica rapa* L. var. *pekinensis*, *Brassica parachinensis* B.), radish (*Raphanus sativus* L.), lettuce (*Lactuca sativa* L.) and beans (*Phaseolus vulgaris* L.); cereals such as barley (*Hordeum vulgare* L.), Italian rye grass (*Lolium multiflorum* Lam.), rice (*Oryza sativa* L.), wheat (*Triticum vulgare* L.), rye (*Secale cereale* L.), soya (*Glycine max.* L.) or corn (*Zea mays* L.), besides sunflowers (*Helianthus annuus* L.), petunia (*Petunia x hybrida*) or amaranth (*Amaranthus tricolor* L.), among others. References to various studies using these species can be found in Warman (1999). Also, an extensive experiment in terms of number of species tested has been carried out by Emino and Warman (2004). It should be noted that some protocols (ISO11269-2:2005) recommends use of at least one monocotyledonous and one dicotyledonous species in these tests by María and Remigio (2011). Zucconi et al. (1981b) described a germination test with cress seeds in contact with compost extracts, obtained by pressure from moistened compost, which determined the

relative seed germination and root elongation, as compared with that obtained in distilled water.

Germination index is considered the most sensitive parameter for identifying the phytotoxicity of compost and assess its suitability for use as soil amendment or growing media. It is an integrated parameter, which combines the relative germination and relative root elongation, although several authors (Emino and Warman 2004; Fuentes et al. 2004; Di Salvatore et al. 2008; Paradelo et al. 2008) have reported that root elongation is more sensitive to the presence of toxins than seed germination. According to Zucconi et al. (1981a, 1981b, 1985) and Emino and Warman (2004), Germination index values below 50% indicate high phytotoxicity; values between 50% and 80% indicate moderate phytotoxicity; and values above 80% indicate the absence of phytotoxicity. When the index exceeds 100%, the compost can be considered a phytonutrient or phytostimulant (Moldes et al. 2007 and María and Remigio (2011).

In chemical test, after the fish waste compost was fully matured, the nutrient content of the compost was analysed. The pH of the fish waste compost was 6.80. EC was 2.97(dS/m) (Table 3). Jagadabhi et al (2019) reported that initial pH of all the straws and saw dust was low ranging from 6 to 7 and this pH further dropped between days 1–10 of the composting process, i.e., when the temperatures in all the composting reactors were high because of increased microbial fermentation activity. During the fermentation process, degradation of readily available/soluble organic substances takes place and as a result pH decreases, due to the release of organic acids. The pH slowly rose to 8 and above after 10 days when temperature as well as thermophilic microbial activity started to decrease. By the end of the first month, pH ranged 7.5–8 indicating the completion of the decomposition process of readily degradable compounds and indicating the progress of maturity of the composted materials. The increased pH also indicates increase in ammonium contents in the

composted materials. Turning or aeration of the composting materials in the reactors during the first 10 days did not increase the pH significantly probably, due to the on-going thermophilic fermentation activity.

Electrical conductivity (EC) provides an indication of the amount of soluble ions (i.e., salts) in a compost product and hence its potential to be phytotoxic, as salts can damage roots, affect nutrient uptake, limit plant-available soil water, or cause seed germination to be inhibited (Avnimelech *et al.*, 1996). A decrease in EC over time as a municipal solid waste (MSW) compost matured, and observed that EC stabilization correlated well with the achievement of maturity. EC measurements were good predictors of plant growth in wheat-straw and manure composts, and recommended EC as a simple quality-control measure for on-site applications (Wang *et al.* 2004). Similarly Jagadabhi *et al.*, (2019) also observed that, as the composting time proceeded, electrical conductivity (EC) gradually increased with time in all the composting reactors (Mupondi *et al.* 2006; Manios 2004). This is due to the fact that as composting progresses, organic substances undergo loss of weight due to mineralization into soluble forms and subsequently become concentrated due to drying. The drying process enables accumulation of mineral salts such as phosphate and ammonium ions contributing to higher EC (Mhindu *et al.* 2013). Jagadabhi *et al.*, (2019) observed that EC of the compost materials increased from the initial 0.2–0.7 to final 0.8–1.2 mS cm⁻¹ which is still within the limits of favorable EC for enabling seed germination. Usually, high EC of composts (> 4 dS m⁻¹) was reported to inhibit seed germination and thus, seed germination assays are used as a means to test the maturity and phytotoxicity of the composts (Nakasaki and Marui 2011; Singh and Nain 2014)

Total major nutrient content in fish waste compost was 3.66 per cent of nitrogen, 1.03 per cent of phosphorus, 1.2 per cent of potassium, organic matter content was 18.70 per cent, cation exchange capacity was 119.6 (me/100 g) and C: N ratio was 28.6:1 (Table 3).

The C/N ratio of the composting substrates is an excellent indicator of maturity as it significantly influences the microbiological growth and thus the rates of decomposition (Chauhan and Singh 2013). High C/N ratio indicates the presence of unutilized complex carbon content, while a decrease in C/N ratio (<25:1) indicates efficient decomposition process (Pan et al. 2012). Substrates having higher carbon and nitrogen contents generally require more time for completion of the maturation phase. The completion of the composting process (compost maturity) is indicated when the C:N ratio reduces to between 25 and 30:1 (Hardy et al. 1993).

Cation exchange capacity'' (CEC), tends to increase during composting as organic materials are humified and carboxyl and phenolic functional groups are formed, therefore been investigated as an indicator of compost stability and maturity Butler et al. 2001). During the humification process, complexation and condensation reactions occur, producing high molecular weight, fairly stable compounds (Lax et al., 1986)

Table 2: Description of the materials used in preparation of fish waste compost and their values.

Constituents	Values
Chemical composition of fish waste	
1. Carbon	10.55%
2. Nitrogen	2.12%
3. Phosphorus	0.82%
4. Potassium	0.10%
Chemical composition of sawdust.	
1. pH	5.9
2. Organic carbon	25.58 %
3. Organic matter	44%

4.	Nitrogen	2.18%
5.	Phosphorus	0.71%
6.	Potassium	1.17%
Chemical composition of banana.		
1.	Phosphorus	3%
2.	Potassium	8%
Chemical composition of jiggery		
1.	Protein	0.35%
2.	Phosphorus	0.19%
3.	Potassium	0.16%

Table 3. Test category of the final fish waste compost and their results

Test category	Potential test for maturity	Remarks
Physical and sensory test	Colour	Earthy brown
	Odour	Odourless
Biological test	Phytotoxicity (plant bioassay)	
	Seed germination (%)	94.56%
	Root elongation (%)	97.14%
	Germination index	91.86%
Chemical test	pH	6.80
	Electrical conductivity	1.45(dS/m)
	Nitrogen	3.66%

	Phosphorus	1.03%
	Potassium	1.2%
	Organic matter	18.70%
	Cation exchange capacity	119.6 (me/100 g)
	Carbon : Nitrogen ratio	28.6:1

CONCLUSION:

It is important to use renewable resources to maximize crop yields and minimize the environmental hazards associated with chemical residues. Composting is an age old practice for the biological conversion of organic waste to a humus-like substance which can enhance physical, chemical and biological soil properties. Composting of fish waste with saw dust allows for a significant reduction in the volume of fisheries waste. The stability and maturity of the compost are essential for its successful application, particularly for composts used in agriculture. The conducted experiments indicate the compost product to be non-phytotoxic, mature, stable, and suitable for use in agriculture. The proposed fish waste compost can be a useful organic fertilizer in agriculture.

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