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Nutrient Composition of Phosphorus Enriched Compost from Seafood Processing Unit Waste

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seafood is gaining in popularity because of its health benefits. At the same time, large amounts of fish waste are being generated, mostly from the industrial processing of fish. These large quantities of fish waste have not been utilized efficiently, and the disposal of fish waste can have large negative impacts on local environments. Unutilized fish waste is often disposed of by land fill or incineration, or by dumping into the sea. Therefore, there is an urgent need to find ecologically acceptable means for reutilization of fish waste. In this study, fish waste samples are collected and characterised. The fish waste was acidic in pH (6.1) with EC of 3.8 dSm^{-1}. The total N, P, K of the fish waste was 10.17, 0.20 and 0.74 % respectively. It also had an appreciable amount of organic carbon content 46.22%. Fish waste was mixed with saw dust (2:1) and Rock Phosphate - Phosphorus (RP-P) at the rate of 0, 2.5, 5, 7.5 and 10 % for enrichment of compost The results showed that the application of different levels of (RP-P) reduce the pH, slightly increased the EC, N,P,K and Organic carbon content. Thus, rock phosphate enriched fish waste compost could be an alternative and viable technology to manage the solid waste generated from the seafood industries as well as crop production.

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Keywords: Rock phosphate; fish waste; compost enriched rock phosphate; nutrient contents.

1. INTRODUCTION

"Application of organic manures as a source of macro and micronutrients and to give humus as a flavonic and humic acid contents in soil and also responsible for improving both the physical and the biological properties of the soil" [1]. "Compost has ability to improve soil properties by chemically (nutritionally). The usage of waste materials as organic manure has an economical value, its large disposal creates environmentally threatening operation" [2]. "In India many restaurants specialize in sliced raw fish, and large amounts (approximately 2100 t/day) of fish waste are generated every day" [3]. "The wastes generated by processing fish, crab and shrimp amount to 30% to 60%, 75-85% and 40-80% respectively. The trash fish manure has the high amount of minerals like nitrogen, phosphorous and potassium that are used as nutrients and growth promoters for plants" (Alarcon et al. 2002). "These wastes are dumped in the vicinity of the seafood processing plants and they lead to environmental pollution. Hence ways and means of utilizing these wastes for productive purposes need to be examined. In this background, the present study was therefore undertaken to manage the solid waste of sea food industries and explore the possibility of increasing the availability of macro and micro nutrient of fish waste compost by enriching the rock phosphate" [4].

"The seafood processing plant and capture fisheries produce huge amount of solid waste. The waste from fishes are viscera, offal, skin, scales, shells and other body parts are rich in variety of plant nutritive elements and devoid of hazardous contaminants and pathogens" [5]. "Disposal of solid waste generated from seafood processing plant has always been a problem for seafood processors. The inappropriate disposal of solid fish wastes may result in environmental problems, such as groundwater and surface water pollution through the leaching due to its high nutritive content. These wastes could be converted into eco-friendly compost through bioconversion process. Composting is a biotechnological process by which different microbial communities acted upon complex organic matter and convert it into simpler nutrients. Composting of fish waste is a relatively new, practical and an environmentally sound alternative to fish waste disposal. It is economical, fairly odourless and a biologically beneficial practice for seafood operations" [6].

2. MATERIALS AND METHODS

2.1 Collection and Characterization of Fish Wastes

"Fish wastes were collected from the Fish market and seafood processing unit, Thoothukudi District, which contains head, tail, shells, intestine, fins, dead fishes and etc. The collected fish wastes were cleaned and washed with water to remove dirt and slick. The sample was dried at 60^0C in oven followed by reduced into fine powder using pestle and mortar. It was sieved using a sieve with 0.2mm and stored for further analysis. The aqueous extracts (substrate/water 1:5 v/v) were used to determine the pH, electrical conductivity" [6]. "The pH and the electrical conductivity of the samples (EC) were measured using a combined electrode pH meter and Conductivity Bridge, respectively. After acid digestion with H_2SO_4 and H_2O_2 30% [7], Ca and Mg levels were determined by atomic absorption and Na and K by emission. Levels of P were analysed using colorimetry" [8]. "The C: N ratio of the compost were measured by the method followed by Knnunen, et al. [9]. Moisture was determined by drying the samples in oven at 105°C to constant weight" [10]. All parameters were determined in triplicate and the data shown are mean values. The characteristics of fish waste are presented in Table 1.

Fish waste was mixed with different materials such as farm waste, saw dust and coirpith (1:2) (Fish waste:carrier material) to select the suitable bulking material for composting and to increase the C:N ratio in the fish waste compost. These mixtures were composted aerobically. Water was sprinkled to maintain the moisture content of 60% level throughout the composting period. Finally after 60 days compost materials were harvested and used for analysis. The characteristics of different fish waste compost with different carbonaceous materials are presented in Table 2.

2.2 Composting of Fish Waste with Phosphorus

"Fish wastes were collected from the Fish market and seafood processing unit,

Fig. 1. Fish waste under drying

Fig. 2. Dried fish waste for analysis

Fig. 3. Fish waste in the compost bed

Fig. 4. Harvested fish waste compost

Thoothukudi District, which contains head, tail, shells, intestine, fins, dead fishes and mixed with cowdung. To increase the C/N ratio in the composting materials, saw dust (particle size 10-20mm) from local saw mill was added. These materials were spread in a compost pile 2 m wide at the base, 1 m high and 6 m long, with a total final volume of 10 m^3. To avoid nutrient washout, the pile was set on an impermeable base and sheltered above. The proportion of fishwaste, cowdung and saw dust was 1:1:2.The total duration of the composting process was four months" [6,11]. During decomposition, the Rock Phosphate - Phosphorus (RP-P) at the rate of 0, 2.5, 5, 7.5 and 10 % were applied for enrichment of compost. The compost pile was turned weekly during the first two months and every 15 days during the last two months. The temperature and O_2 levels were tested weekly to monitor the correct development of the process. Once the compost was considered mature, it was sifted using a 20- mm mesh screen and stored for further studies. Stepwise composting process is presented in Figs. 1 to 4.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Raw Materials Used for Composting

Different waste material such as saw dust, coir waste and farm waste were collected for composting experiment and characterized. The characteristics of fish waste and different waste materials used for composting are presented in Table 1.

The fish waste was acidic in pH (6.1) with EC of 3.8 dSm^{-1}. The total N, P, K of the fish waste was 10.17, 0.20 and 0.74 % respectively. It also had an appreciable amount of organic carbon content 46.22%. The calcium and magnesium content of fish waste were 1.86 and 0.15% respectively. The coirpith, farmwaste and sawdust were used for composting of fish waste. The pH of farm waste, coir waste and saw dust were 7.05, 6.5 and 7.50 with a EC of 0.57,0.62 and 0.78 dSm^{-1} respectively. Among the different materials, coir waste had the highest C:N ratio of 86:1 followed by saw dust 75:1. The total NPK content of all the waste used for composting is very low.

3.2 Composting of Fish Waste

As is shown in Table 2, the pH and EC of different fishwaste compost varied from 6.5 to 7.1 and 0.38 to 0.56 dSm^{-1}. Among the different fishwaste compost T_2 (farm waste) recorded highest organic carbon content of 36% followed by T_3 (coir dust) 32%. The NPK content of different fishwaste compost ranged from 1.19 to 1.64 % and 0.06 to 1.12% and 0.21 to 1.20% respectively. Among the different treatment, combination of fishwaste and saw dust (T1) composted rapidly. Based on maturity and duration of composting period saw dust was identified as an effective bulking material for further studies.

3.3 Nutrient Content of Phosphorus Enriched Fishwaste Compost

Application of different levels of RP-P in compost slightly reduced the pH value (7.96 to 6.92) and increased the EC content ranged from 1.05 to 2.86 dSm^{-1}. The total P content of harvested compost was ranged from 0.28 to 2.68% (Table 3). This increase might be due to the decomposition of organic materials released acids or acid forming compounds that react with sparingly soluble salts or at least increase their solubility.

The significant correlation between electrical conductivity and organic carbon content (R^2 = 0.897) is depicted in Fig. 5. The carbonic acid and organic acid produced during the decomposition of organic matter solubilised insoluble phosphate in the rock phosphate, resulting in the release of phosphate into the solution. Thus the preparation of rock phosphate enriched compost is based on the concept of solubilization of insoluble rock phosphate into plant available form during the process of composting.

The significant correlation between electrical conductivity and NPK content is depicted in Fig. 6. (N= R^2 = 0.9106; P=0.9653; K= R^2 = 0.9545). Application of different levels of RP-P in compost slightly increased the NH_4-N and NO_3-N content (Fig. 7). The NH_4-N and NO_3-N content of fish waste compost varied from 58.21 to 81.19 and 20.21 to 29.21 $mgKg^{-1}$ respectively. Irrespective of treatment, ammoniacal form of nitrogen was higher than the nitrate nitrogen. This might be due nitrogen is mainly present in ammonium form or relatives of ammonium such as amines in protein, urea and uric acid in fish waste compost.

Table 1. Characteristics of fish waste & different waste materials used for composting

S. no.	Characters	Fish waste	Farm waste	Coir waste	Saw dust
1.	pH (1: 5)	6.1±0.61	7.05±0.71	6.5±0.65	7.5±0.75
2.	EC (1: 5) (dSm^{-1})	3.8±0.38	0.57±0.06	0.62±0.06	0.78±0.08
3.	C:N Ratio	4.5±0.45	57.6±5.76	86±8.60	75±7.50
4.	Organic carbon (%)	46.2±4.62	40.3±4.03	30.1±3.01	31.5±3.15
5.	Total Nitrogen (%)	10.17±1.02	0.7±0.07	0.35±0.04	0.42±0.04
6.	Total Phosphorus (%)	0.2±0.02	0.08±0.01	0.01±0.1	0.06±0.01
7.	Total Potassium (%)	0.79±0.08	0.71±0.07	0.78±0.08	0.65±0.07
8.	Total Calcium (%)	1.86±0.19	0.62±0.06	0.4±0.04	0.31±0.03
9.	Total Magnesium (%)	0.15±0.01	0.46±0.05	0.36±0.04	0.29±0.03

Mean value ± Standard deviation

Table 2. Characteristics of different fishwaste compost

S. No.	Parameters	FW+ Saw dust compost	FW+ Farm waste compost	FW+Coir waste compost
1.	pH (1: 5)	7.1±0.71	6.5±0.65	6.8±0.68
2.	EC (1: 5) (dSm^{-1})	0.38±0.04	0.41±0.04	0.56±0.06
3.	C:N Ratio	17.1±2.80	30.3±3.60	25.8±3.20
4.	Organic carbon (%)	28±0.16	36±0.12	32±0.12
5.	Total Nitrogen (%)	1.6±0.02	1.19±0.21	1.24±0.01
6.	Total Phosphorus (%)	0.16±0.02	1.12±0.03	0.06±0.12
7.	Total Potassium (%)	0.21±1.71	0.25±3.03	1.2±2.58

Mean value ± Standard deviation

Table 3. Nutrient composition of the phosphorus enriched fish waste compost

S. No.	Treatments	pH	EC (dSm^{-1})	C:N ratio	Organic carbon (%)	Total N (%)	Total P (%)	Total K (%)
1.	FWC + 0 % RP-P	7.96	1.05	13.38	21.40	1.60	0.18	0.21
2.	FWC + 2.5 % RP-P	7.54	1.21	13.31	21.62	1.65	0.28	0.45
3.	FWC + 5 % RP-P	7.42	1.89	12.42	22.05	1.82	1.52	0.58
4.	FWC + 7.5 % RP-P	7.10	2.02	11.84	22.86	1.85	2.02	0.84
5.	FWC + 10 % RP-P	6.92	2.86	11.69	23.21	2.25	2.68	1.04

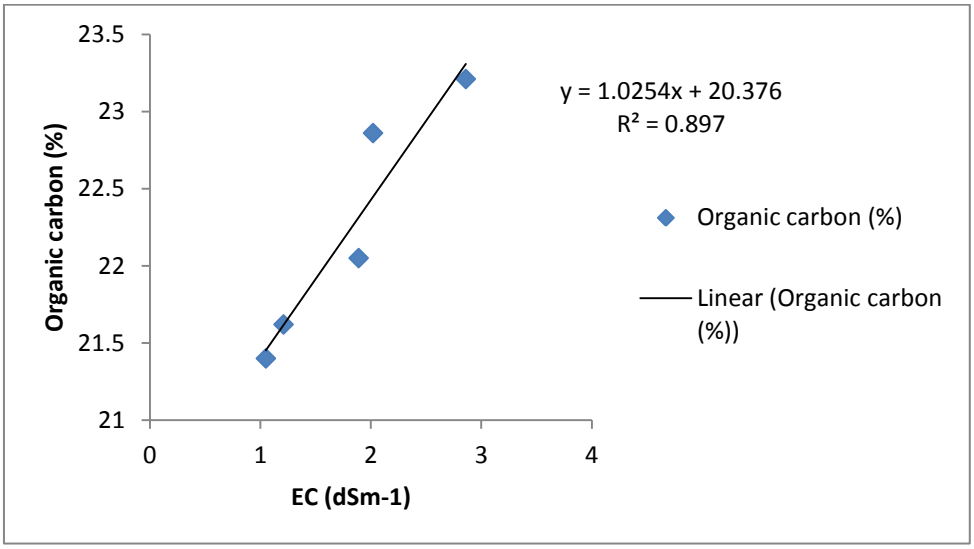

Fig. 5. Correlation between Electrical Conductivity and organic carbon content

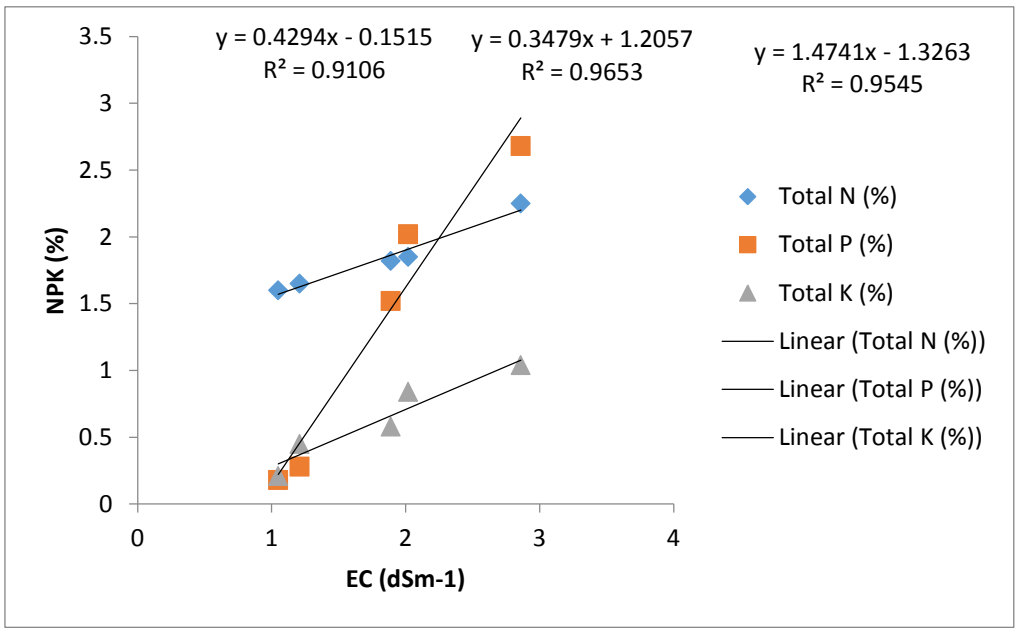

Fig. 6. Correlation between Electrical Conductivity and NPK content

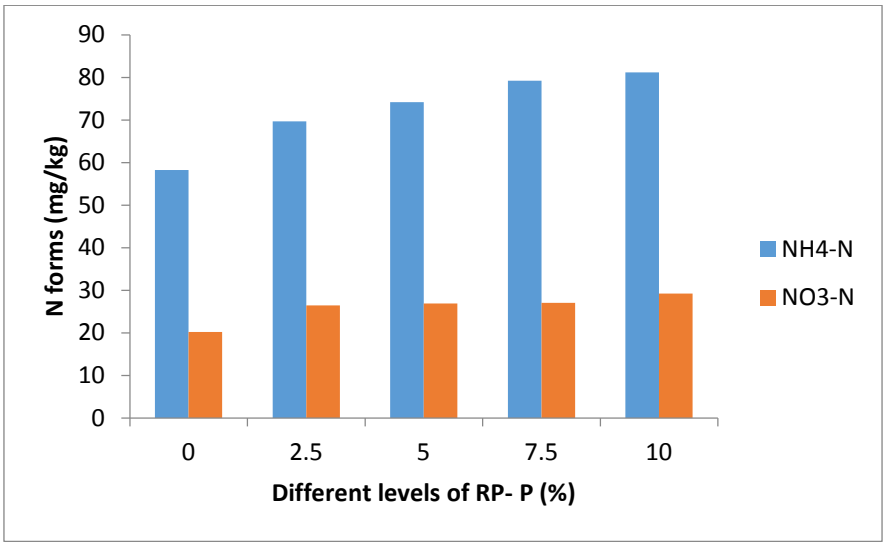

Fig. 7. Status of NH_4-N and NO_3-N content in enriched fish waste compost

4. CONCLUSION

Composting of fish waste with different carbonaceous materials allows reducing greatly the volume of fisheries byproducts. In the course of two months from the beginning of the experiment, a stable product is obtained. This product might be used as a fertilizer in ecological agriculture systems, as it is of natural origin and has no limitations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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