Waste utilization of red snapper (*Lutjanus* sp.) fish bone to improve phosphorus contents in compost

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Abstract. The purpose of this research is to get the idea that bone waste will be the P content enhancer in compost so that the compost produced meets the standard P levels specified in SNI 19-7030-2004 which regulating compost quality standard. Nutrient levels were obtained in fish bone meal (FBM) are C (3.35%), N (0.48%), P (30.90%) and K (0.02%). Effects of fish bone meal to the rising levels of P in the compost has been known. P levels of compost B, C, D, and E increased at 428.57; 542.85; 657.14 and 914.28% against the compost A (blank). FBM ideal addition indicated in compost B, as much as 15 gr, with a P content of 0.37% and has been passed according standards (0.10% for P). C/N ratio decreased over the 21 days period of composting, with the greatest decline was compost E with a ratio of 16:1. Highest nitrogen (N) levels recorded respectively in compost B and C with value of 1.09% and the lowest of recorded N content was compost A, D and E (1.08%). N content in all samples of compost were eligible minimum N of 0.40%. Carbon (C) is the highest recorded in compost B; 20.20% and the lowest in the compost E; 17.34%. Highest and lowest C levels on the compost has met the minimum C of 9.80%. Composting is done in a bucket as an aerobic composter (with air holes), compost pile turnover for each sample is controlled as much as once/2 days. Mesophilic period (23-45^{0}C) occurs during the 21-day period of composting. Compost B has P content of 0.37%, so it has fulfilled the provisions of SNI 19-7030-2004 about the recommended compost standard.
Keywords: compost, fish bone meal, phosphorus

1. Introduction

In the processing of red snapper fillet (*Lutjanus sp.*) the fish bone with the proportion of 13.70% of the total body of fish has not been widely used [1].The company's red snapper fish fillet produces a lot of fish bone waste, which until now has not been well utilized [2]. Marine fisheries production for the snapper species increased in volume from 91339 tons in 2004 to 130301 tons in 2014. In 2014 demersal fish captured reached 1557261 tons/year and red snapper volume contributed 130301 tons/year, the first place after jack trevallies fish (109441 tons/year) and giant catfish (Ariidae family)(102111 tons/year), [3] then it is estimated that the potential of red snapper fish bone waste generated can reach 17851.23 tons/year. Fish bone waste includes solid waste types generated from small-scale production to large fish farming as well as from marine catches. Bone is rich in phosphorus, while phosphorus is commonly known as one of the components of NPK (Nitrogen-Phosphorus-Potassium) fertilizer. As a fertilizer, the ratio of NPK in bone meal is generally 4-12-0 and in steamed bone meal of 1-13-0 [4]. The content of calcium (Ca) in fish bone is 20-35 mg, phosphorus (P) 190 mg, iron (Fe) 1.0 mg and potassium (K) 250-350 mg [5]. An increase in phosphorus content reached about 278.4; 251.3; 278.4 and 819% in tempe factory wastewater which added 10% of phosphorus isolate from red snapper fish bone waste [6].

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Biological treatment can be described as biological decomposition of organic waste under controlled conditions, for composting the condition to be in aerobic state and rise of temperature achieved by an exothermic process catalyzed by microbial enzymes. The C/N ratio is an important factor affecting the performance of microorganisms. The carbon element (C) is used as an energy source in the metabolic process of cell multiplication by bacteria. While the element of nitrogen (N) is used for protein synthesis or the formation of protoplasm, optimum pH range for bacterial growth is 6.0-7.5 while fungi prefer an environment in the range of pH 5.5-8.0 [7]. The purpose of this research is to get the idea that bone waste will be the P content enhancer in compost so that the compost produced meets the standard P levels specified in SNI 19-7030-2004 which regulating compost quality standard.

2. Research Method

2.1. Mass Balance

The mass balance is intended to find out how much incoming, recyclable, compostable and residual waste [8]. To know the percentage of garbage composition can be calculated by using formula :

$$\% \text{ Component} = (\text{weight of component/total weight of waste}) \text{ kg x } 100\% \quad (1)$$

The data obtained from this calculation is used to compile a mass balance equilibrium and analyze the potential utilization [9].

2.2. Decomposition Rate

The rate of substrate decomposition can be facilitated by simplifying it using the rate of first order reactions as is often the case in nature [10]. First order reaction rate is widely used in describing biological oxidation processes. The equation of the first order reaction rate can be written as follows :

$$\frac{d(C)}{dt} = -k_d(C)$$

$$\int_{BVS_0}^{BVS} \frac{d[C]}{[C]} = -k \int_0^t dt \quad (2)$$

$$\ln \frac{[C]}{[C_0]} = -kt$$

$$\ln[C] - \ln[C_0] = -kt$$

$$\ln[C] = -kt + \ln[C_0]$$

C = amount of carbon (unit weight), T = time (day), Kd = decomposition rate (per day)

If the equation is represented by a graph, then ln (C) will be on the y-axis, while time is on the x-axis, with the slope being the rate of decomposition. The value of negative decomposition rate indicates that the substrate will decrease over time [10].

2.3. Research Design

Prepare 10 pieces of fermentation equipment, each filled with mixture of 200 ml groundwater, 2 ml EM4 (bioactivator), 2 g sugar and fish bone meal (Table 1). Preparing 10 composter, each filled with leaf waste, sawdust and mixed samples of fermented A to E' and analyzed levels of C, N, P, K, C/N ratio and water content on day 10, 15, and 21. Here are the composting preparations shown in the experimental design form in Table 2.

Table 1. Research design 1.

Treatment	Groundwater (mL)	Sugar (gr)	EM4 (mL)	Fish bone meal (gr)
A & A’ (duplo)	200	2	2	0 (blank)
B & B’ (duplo)	200	2	2	15
C & C’ (duplo)	200	2	2	20
D & D’ (duplo)	200	2	2	25
E & E’ (duplo)	200	2	2	30

Table 2. Water content addition.

Treatment	Groundwater (mL)	Sugar (gr)	EM4 (mL)
A & A’ (duplo)	400	4	4
B & B’ (duplo)	400	4	4
C & C’ (duplo)	400	4	4
D & D’ (duplo)	400	4	4
E & E’ (duplo)	400	4	4

EM4 bioactivators and sugar were used to accelerate the maturation of compost with a concentration of (1:1:100) EM4 : sugar : water, while the water content used was the optimum range of 56-57% for the starter of composting process. Effective moisture content for composting is 55-65% [11]. After the mixture in Table 1 and Table 2 is stirred 15 minutes and left for 24 hours, this mixture is fed into the waste of dried leaves and sawdust in Table 3.

Table 3. Research design 2.

Treatment	Leafwaste (gr)	Sawdust (gr)	Mixtures	C/N
A & A’ (duplo)	900	200	Table 2.1 & 2.2	30:1
B & B’ (duplo)	880	200	Ditto	30:1
C & C’ (duplo)	870	200	Ditto	30:1
D & D’ (duplo)	860	200	Ditto	30:1
E & E’ (duplo)	850	200	Ditto	30:1

The mixture in Table 3 was composted and measured for daily parameters such as temperature, pH, humidity and weight reduction, and measurements of C, N, P, K, C/N and water content were performed on days 10, 15 and 21. The dried leaves used are trembesi tree leaves from Univ. Trisakti garden waste, while sawdust is a mixture of sengon and coconut trees obtained from the janitor of Univ. Trisakti. The use of one type of leaf litter aims to make the compost mix more homogeneous. Leaf waste is first chopped up with a blender and compost chopper machine because the smaller the particles, the larger the amount of surfaces that the microorganisms digest [12], then the sawdust is used for compost bulking. Waste weight adjustment is performed to adjust the optimum C/N ratio in composting, ie 30:1. This composition is consistent so that composting can be more effective at a C/N ratio of 30% to 40% [11].

2.4. Measurement of Water content, N-Total Content, Organic Carbon Content, Phosphor and Kalium
Measurement of water content was done by Gravimetry method, ie the water in the compost sample was evaporated by drying at 105^0C for 16 hours.Measurement of total N-content was done by using Kjeldahl method. The N-organic and $N\text{-}NH_4$ contained in the examples are decomposed with sulfuric acid and selenium mixture to form ammonium sulphate, distilled by addition of the excess base and finally the distillate is titrated, nitrogen in the form of nitrate is extracted with water, reduced by alloy devers, distilled and ultimately titrated.Measurements of organic carbon content were carried outusing Walkley & Black method. The organic carbon in the sample is oxidized by dichromate in an acidic atmosphere. The chromium III formed is equivalent to the oxidized C-organic and measured by spectrophotometry. The measurement of P and K content was done by using Spectrophotometry and Flamephotometry

(AAS) method. Samples were oxidized wet with HNO_3 and $HClO_4$. The extracts obtained were used to measure P elements Spectrophotometrically and K with AAS [13][14].

3. Results and Discussion

3.1. Results of Processing Snapper Fish Bone into Bone Meal

60 kg of processed wastes have been processed to produce three types of derivative waste, namely fish bone waste of ± 5 kg (8.33% of total waste weight), meat and fin waste of 45-46 kg (75-76.67% of Total weight of the waste) and the residue about 9-10 kg (15-16.67% of total waste weight) in the form of water content in the form of fish blood, ice and bone remnants and fish fins removed during the process, as shown in Figure 1.

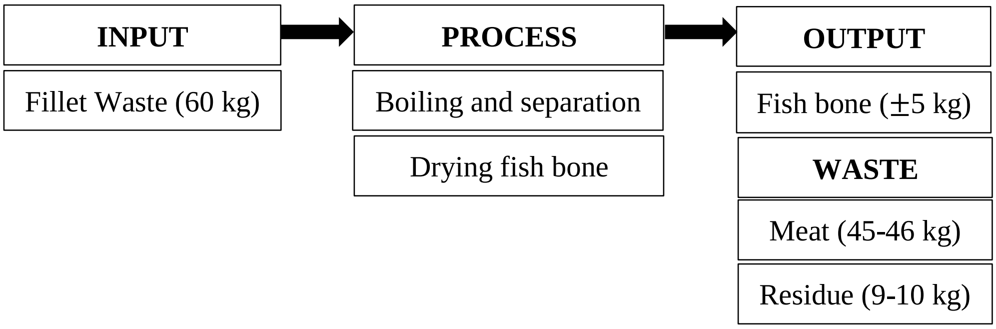

Figure 1. Mass balance of snapper fish fillet.

The fish bone in Figure 1 which has been separated from the meat and fins is taken as many as 10 samples for flouring process. The weight of fish bones in the flouring process decreases due to residue filtering, protein and fat dissolution, and decreased moisture due to the drying process in the oven. Depreciation of snapper fish bone weight can be seen in Table 4.

Table 4. Depreciation of snapper fish bone weight

Sample	Initial weight of bone (gr)	Bone meal (gr)	Weight reduction (%)
1	110[*1]	75,51	31,35
2	137[*1]	90,80	33,72
3	132[*1]	89,54	32,16
4	145[*1]	104,00	28,27
5	143[*1]	91,54	35,98
6	127[*1]	81,68	35,68
7	142[*1]	95,38	32,83
8	152[*1]	108,42	28,67
9	122,60	96,00	21,69
10	130,03	99,48	23,49

[*1]Bone weight weighed with Ohauss manual mechanical balance

In Table 4 the mean values were taken from the samples, so that the average value of fish bone weight reduction was 40.82 gr and for the mean weight reduction percentage was 30.38%. From fish bone meal (FBM) produced is taken as many as 391.73 gr FBM for sieves with sieve shaker. The weight of the largest sieve resulted was a sieve of 170 mesh, weighing 85.26 grams or 21.76% of the total FBM sieved for 60 minutes with 90 amps of vibration. The temperature reached at the end of composting (day 21) is; compost A (32.75^{0}C), compost B (33.25^{0}C), compost C (33^{0}C), compost D (32.75^{0}C) and compost E (32.75^{0}C). This shows that the addition of FBM in the composting process does not affect the composting temperature. The humidity of the 21st day compost sample on a consecutive basis is as follows; Compost A (51.50%), compost B (52.75%) compost C (54.50%), compost D (49.25%) and compost E (51.50%).

In the results obtained, the addition of FBM did not affect the water content of compost.The weight reduction of the compost sample is as follows; compost A (17 g/day), compost B (16 g/day), compost C (14 g/day), compost D (14 gr/day) and compost E (12 gr/day). So it can be concluded that the addition of FBM has no effect in compost weight reduction. The value of compost pH on the 21st day is as follows; Compost A (6.81), compost B (6.66), compost C (6.60), compost D (6.73) and compost E (6.64). In SNI standard 19-7030-2004, minimum pH value is set at 6.80 and a maximum of 7.49. This shows that only compost A samples have met the standard compost pH, whereas compost B, C, D, and E are still slightly below the recommended pH value because of the remaining formation of organic acids by microbes. In composting conducted for 21 days calculated from the 10th day to 21st day there is a decrease in the level of C in compost with the following values; Compost A (16.98%), compost B (14.53%), compost C (23.53%), compost D (20.67%) and compost E (19.95%).The rate of carbon degradation is as follows: compost A (0.14/day), compost B (0.12 /day), compost C (0.16/day), compost D (0.17/day) and compost E (0.16/day).

In composting conducted for 21 days calculated from the 10th day to 21st day increment of nitrogen levels in the compost among others ; Compost A (11.63%), compost B (5.53%), compost C (-1.38%), compost D (12.96%) and compost E (12.50%). Total increase in N is due to the loss of C-organic dry mass as CO^2 during the composting process. In addition, N values may also increase due to nitrogen-wearing bacteria that are generally active at the end of composting [15]. N levels in the compost sample from day 10 to day 21. On the 21^{st} day of composting, the percentage of compost B, C, D and E is bigger than compost A (blank), that is 428.57% (compost B), 542.85% (compost C), 657.14% (compost D) and 914.28% (compost E) to compost A (blank). P levels on all compost samples from day 10 to day 21.

The addition of fish bone meal (FBM) gives significant value to the increase of P content in the compost so that it can fulfill the requirements of SNI 19-7030-2004 which determine the minimum compost P level of 0.10%. The decrease in P content in the composting process is due to the dissolution of P in dissolved organic solution. It is also supported by the addition of EM4 containing phosphate solubilizing bacteria or Phospate Solubilizing Bacteria (PSB). In solubility P bound to Ca, microorganisms through secretion of various types of organic acids such as carboxylic acid and rhizospheric have a mechanism for lowering pHthat separates phosphate bond forms such as $Ca_3(PO_4)_2$ [16]. However, medium buffer capacity reduces the effectiveness of PSB in releasing P from $Ca_3(PO_4)_2$ [16]. The decrease percentage in C/N ratio is as follows; Compost A (27.08%), compost B (19.57%), compost C (21.43%), compost D (29.79%) and compost E (28.89%). Decreasing of C content is because carbon is a basic element of living things that is needed in large quantities by microbes rather than other elements [11].

Based on SNI 19-7030-2004 standard, the minimum value of C/N ratio in compost is 10:1 and maximum 20:1, so it is concluded that the ideal composting time is 21 days because the average C/N ratio of 5 compost samples has value of 17:1. The addition of water made to all compost samples is the same, ie with 300 ml of ground water/compost using sprayer on the 11th day. The upper limit of moisture content is between 60 and 80%, depending on the composite material [11]. Water is added for moisture content reaches 60% (wet base) in the compost mixture[15], then the percentage increase in moisture content in all compost samples from the 10th day to the 21^{st} day is as follows; Compost A (12.53%), compost B (9.70%), compost C (18.07%), compost D (12.16%) and compost E (11.22%). Based on the standard specified in SNI 19-7030-2004 the maximum water content allowed for compost is 50% so it can be concluded that all compost samples that have not met this requirement because the value of water content is still above 50%, this can be overcome by drying the compost pile in hot weather for 1-2 days so that the water content decreases.

4. Conclusion

Compost B (FBM 15 gr) has P content of 0.37%, so it has fulfilled the provisions of SNI 19-7030-2004 about the recommended compost standard of 0.10%, the increase of P content on compost B reached 428.57% compared to the blank (compost A) with P levels of 0.07%. The rate of organic carbon degradation is: compost A (0.14/day), compost B (0.12/day), compost C (0.16/day), compost D

(0.17/day) and compost E (0.16/day). The average calculation of residual weight of bone fish processing into bone meal form is 30.38% so that the percentage of FBM mass balance is 5.22-9.53% from total weight of whole snapper fish.

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