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Analysis of the Quality of Fermented Compost from Malapari Seed Cake (*Pongamia pinnata* L.)

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Abstract

Background: Biodiesel production from malapari seeds generates waste in the form of seed cake that can still be utilized. This seed cake can be processed into compost because it contains various essential minerals for plant growth. This study analyzes the quality of compost made from malapari seed cake based on the SNI 19-7030-2004 standard. **Methods:** The compost fertilizer was fermented for 31 days using four treatments. (P1) malapari cake 1kg + Orgadec 2g; (P2) malapari cake 334g + goat manure 333g + burnt rice husk 333g + Orgadec 2g; (P3) Malapari cake 200g + goat manure 400g + burnt rice husk 400g + Orgadec 2g; (P4) Malapari cake 400g + goat manure 200g + burnt rice husk 200g + Orgadec 2g. **Results:** Water, phosphorus, and potassium content tests in treatments P1, P2, P3, P4 met specifications. pH tests in treatments P1, P2, P4 met specifications, P3 did not meet specifications. Nitrogen tests in P1 and P2 met specifications, but P3 and P4 did not. The organic C test in P1 did not meet specifications, while P2, P3, and P4 met specifications. The electrical conductivity test in P1 met specifications, while P2, P3, and P4 did not. Color and odor in P1 did not meet specifications, while P2, P3, and P4 met specifications. **Conclusions:** Compost from malapari seed cake has met the compost quality specifications according to SNI 19-7030-2004 for P2, so it is suitable for plant application.

Keywords: Bungkil; Malapari; *Pongamia pinnata* L.

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Introduction

Malapari (*Pongamia pinnata* L.) is one of the sources of raw materials for making biodiesel (Arpiwi et al., 2018). Biodiesel production from malapari seed oil produces waste in the form of cake after oil extraction from the seeds. Malapari seed cake needs to be processed to obtain added value. One form of processed malapari cake is organic compost fertilizer (Susilawati, 2015). Malapari cake can be used as compost because it contains minerals including potassium, sodium, calcium, zinc, iron, copper, manganese, phosphorus, and sulfur which play a role in stimulating plant growth (Priantik et al., 2022) while the nutrients contained in the cake are nitrogen (3.2-3.7%), phosphorus (0.22-0.23%), and potassium (0.65-0.68%) (Usharani et al., 2019). Various types of compost are used to increase agricultural productivity. Industrial waste compost (Gonfa et al., 2018) evaluated the use of filter pulp and sugarcane ash pulp to grow wheat (*Triticum turgidum* L. var.durum) production. The results of the study showed that application at a dose of

100 tons/ha significantly increased plant growth parameters such as plant height (72.0 cm), number of tillers (2.7), panicle length (4.4 cm), number of spikelets per panicle (8.8), and number of seeds per panicle (17.2). Household waste compost (Olivera et al., 2020) conducted a study by applying almond skin substrate to *Phaseolus vulgaris* L. (cv.Saxa) to determine changes in plant growth, physiological properties, and biochemistry. The highest growth and significant physiological and biochemical changes were seen in plots given almond skin substrate. Agricultural waste compost has excellent potential to be recycled to improve soil quality. Studies show that the application of grapefruit waste (Bayoumi et al., 2019), olive tree waste (Riaz et al., 2015), tomato waste, turkey tailings, licorice (Kanaan et al., 2018), water hyacinth waste (Iriani et al., 2020) have a significant effect on increasing soil fertility and plant productivity. Vermicompost from earthworm waste such as *Eisenia foetida* and *Lumbricus rubellis* shows that worms can improve soil fertility better than other composting processes (Chattopadhyay). Livestock waste compost in the form of chicken waste and chicken waste biochar in the application of water spinach (Ipomoea aquatica) at a dose of 4.0 t/ha produces better plant growth (Sikder et al., 2019) and compost from brown algae (*Stoechospermum marginatum*) at a dose treatment of 1.5% increases the growth of eggplant plants (*Solanum melongena* L.) (Ramyah et al, 2015).

Based on the description above, research on using malapari seed cake as a raw material for compost has not been explored. However, this plant is known to have great potential as a raw material for biodiesel (Arpiwi et al., 2015). Malapari seed cake, a by-product of the seed oil extraction process, is rich in nutrients and nutrients needed to improve soil quality. However, this potential is not widely known, so there has been no specific research on the potential of malapari seed cake as an effective compost material to improve soil fertility and support advanced agriculture. Using malapari seed cake raw materials in composting can contribute the greatest to soil productivity (Kusmiyati, 2013; Ushaerani et al., 2019). Traditional composting involves mixing raw compost materials with animal manure and soil and spraying with sufficient water. The mixture is piled on the ground, and bamboo is stuck in with gaps for air circulation. However, this method takes 50-70 days (Razita, 2020). Therefore, a method is needed to shorten the composting time and improve the compost quality. One way to accelerate composting is using a bioactivator, or Orgadec, a microbial starter. Orgadec is a composting bioactivator with original Indonesian microbial materials produced by the Indonesian Plantation Research Institute (LRPI). The microbes in the Orgadec bioactivator used in composting are *Trichoroderma pseudokoningii* and Cytophaga sp. These microbes can simultaneously produce lignin and cellulose-destroying enzymes (Didik et al., 2008). Based on research conducted by (Alfiani, 2018) shows that organic accelerates the composting process of livestock manure into organic fertilizer, as seen from the parameters of N-total, P_2O_5, K_2O, and water content, but only the C/N ratio after meeting the standards according to Permentan No. 70/Permentan/SR.140/10/2011. In addition, research conducted by (Trivana et al., 2018) showed that the analysis of manure with the Orgadec bioactivator was more effective and required a faster time to decompose organic matter in a period of <20 days. This study aimed to analyze the quality of compost fertilizer from malapari seed cake (*Pongamia pinnata* L.) produced according to SNI 19-7030-2004. The benefits of this study are developing the potential of malapari seed cake waste as a raw material for making compost.

Methods

Tools and Materials

The equipment used in making compost is a measuring cup, spoon, tissue, label paper, and compost bag. The research materials are malapari cake obtained from seed extraction using a screw press machine, Orgadec starter, and compost bag obtained from

Toko Sehat Probiotic Surakarta, burnt rice husks and goat manure obtained from Toko Mulia Denpasar.

Research Location

Composting was conducted in the Plant Physiology Laboratory, Biology Study Program, FMIPA, and UNUD. The compost quality testing in the form of color, odor, pH, water content, organic C, electrical conductivity, nitrogen (N) nutrient content, phosphorus (P) nutrient content, and potassium (K) nutrient content was carried out in the Soil Biology Laboratory, Faculty of Agriculture, UNUD.

Research Procedure

The compost made from malapari seed cake used the Orgadec brand starter, which consisted of 4 treatments. Treatment 1 (P1): 2g of Orgadec starter was dissolved in 200ml water. The starter solution is slowly poured evenly onto 1kg of malapari cake and then put into a compost bag. Every week, the mixture is turned over. After 31 days, the mixture is fermented and ready to be used as organic fertilizer.

Treatment 2 (P2): 2g of Orgadec starter is dissolved in 200ml water. 334g of malapari cake, 333g of goat manure, and 333g of burnt rice husks are mixed evenly. The Orgadec starter solution is slowly poured onto the mixture evenly and then put into a compost bag. After 31 days, the mixture is fermented and ready to be used as organic fertilizer.

Treatment 3 (P3): 2g of Orgadec starter is dissolved in 200ml water. 200g of malapari cake, 400g of goat manure, and 400g of burnt rice husks are mixed evenly. The Orgadec starter solution is slowly poured into the mixture evenly and then put into a compost bag. After 31 days, the mixture is fermented and ready to be used as organic fertilizer.

Treatment 4 (P4): 2g of Orgadec starter is dissolved in 200 ml water, 400g of malapari cake, 200g of goat manure, and 200g of burnt rice husks. Mixed evenly. The Orgadec starter solution is slowly poured into the mixture evenly and then put into a compost bag. After 31 days, the mixture is fermented and ready to be used as organic fertilizer.

Compost Quality Test

The compost quality test includes color, odor, pH, electrical conductivity (EVC), organic C, water content, nitrogen, phosphorus, and potassium. The method used for characterization refers to the Soil Biology Lab guide, Faculty of Agriculture, UNUD.

Color and Odor

Color and odor testing is done by visual observation of the compost preparation.

pH and Electrical Conductivity

Ten grams of compost are weighed and then put into a bottle. 25ml of distilled water is added and then shaken for 30 minutes. pH is measured using a pH meter; the solution is filtered to obtain the EVC value. The filtrate is measured using a Conductivity meter. Electrical conductivity is calculated using the formula:

$$percent\ total\ gram\ content = (0.109 \times E.C) + 0.01$$

Organic C

One gram of compost is weighed and put into a 50ml Erlenmeyer flask. Potassium dichromate ($K_2Cr_2O_7$) 10ml and concentrated sulfuric acid (H_2SO_4) 10ml are added, shaken, and left for ± 30 minutes until cool. Phosphoric acid (H_3PO_4), as much as 5ml, 1ml Diphenylamine (DPA), and distilled water are added and then shaken until homogeneous. The mixture is left for 30 minutes until it settles, then the clear solution is pipetted as much as 5ml, then put into a 50ml Erlenmeyer flask. Aquades as much as 15 ml is then shaken and titrated with 1N FeSO4. Organic C is calculated using the formula:

$$C = (b - a)N\ \mathrm{FeSO4}\ x\ \left(3\ x\ \frac{100}{77}\right)\ x\ \left(\frac{100+KU}{100}\right)$$

Water Content

The water content of the compost is measured by taking a 10-gram compost sample. The empty cup is weighed first to get the initial weight (a1), then the cup is given 10 grams of material, and the results of weighing the cup and material are recorded (a2). Then, the cup and material are ovened for 48 hours at 105 ° C until the water content is constant. Cool in a desiccator, then weigh (a3). The water content is calculated using the formula:

$$KU = \frac{(a2 - a1) - (a3 - a1)x\ 100\ \%}{a3 - a1}$$

Nitrogen (N) Nutrient Level

One gram of compost fertilizer is put into a kjeldhall flask, and 1 gram of selenium mixture (1.55 grams of anhydrous CuSO4 + 96.9 grams of anhydrous Na2SO4 + 1.55 grams of selenium) and 3 grams of concentrated sulfuric acid. The kjeldhall flask is placed on the stove in the acid room and heated for 30 minutes until it turns white. The mixture is cooled, then 100 ml of distilled water is added. Next, add 20 ml of 30% sodium hydroxide (NaOH). Install the distillation apparatus and collect it with an Erlenmeyer flask containing 15 ml of 1% boric acid (H3BO3). Count 10 minutes after the first drop / collect up to 50 ml. The mixture is titrated with 0.05 N sulfuric acid (a), then a blank is made (b). Nitrogen is calculated using the equation:

$$N\ total\ (\%) = (a - b)\ x\ N\ H2SO4\ x\ 1{,}4\ x\ \frac{100 + KU}{100}$$

Phosphorus (P) and Potassium (K) Nutrient Levels

One gram of compost is put in a shaker bottle, and 15 ml of PA solution (a mixture of HCL and ammonium chloride) is added. Shake using a shaker for 15 minutes, then filtered into a test tube. 5 ml of filtrate is put into a new test tube. The standard solution of the dilution series 0.1,2,3,4,5 is pipetted as much as 5 ml each, then 5 ml of PB solution (a mixture of HCL, boric acid, molybdate acid) and five drops of PC solution (dye indicator) are added and left for 30 minutes and measured on a 660 wavelength spectrophotometer that has been previously heated for 30 minutes. For K analysis, 1 ml of filtrate is filtered, then diluted to 10 ml and set on a flame photometer. Calculate the absorbance using the following formula:

$$P\ kompos\ (ppm) = P\ dalam\ larutan\ (ppm) x\ \frac{15}{1{,}5}\ x\ \frac{10}{55}\ x\ \frac{100 + KA}{100}$$

$$K\frac{me}{100g} = kdr\ K\ dalam\ Iar.\left(\frac{me}{I}\right) xf.p.\frac{15}{1{,}5}\ x\ \frac{10}{55}\ x\ \frac{100 + KA}{100}\ x\ 100 - 1$$

Data Analysis

Data analysis in this study was conducted descriptively, which includes observations of maturity seen from the physical and chemical quality of the compost. The data and results obtained are presented in tabular form and will be compared with the requirements for compost from organic waste according to the reference SNl 19-7030-2004.

Result

Compost Quality Requirements Test Based on SNI

The laboratory analysis results of pH, water content, nitrogen, phosphorus, potassium, organic C, DHL (electrical conductivity), color, and odor in each compost treatment, including P1, P2, P3, and P4, are presented in (Table 1). pH in treatments P1, P2 and P4 meet specifications, P3 does not meet specifications. Water content meets specifications. Nitrogen in P1 and P2 meet specifications, while P3 and P4 do not. Phosphorus and potassium meet specifications. Organic C in P2, P3, and P4 meet specifications, but P1 does not meet specifications. Electrical conductivity in P1 meets specifications, while P2, P3, and P4 do not. In P2, P3, and P4, color and odor meet specifications, while P1 does not.

Table 1. Results of compost quality tests from malapari cake

No	Test Parameters	P1	P2	P3	P4	SNI 19-7030-2004
1	pH	6,850	6,980	6,040	7,210	Minimum:6,80 Maximum:7,49
2	Water Content	15,450	19,200	19,380	17,690	Maximum: 50
3	Nitrogen	0,910	0,920	0,280	0,340	Minimum: 0,40
4	Phosphorus	822,850	990,920	931,100	1040,970	Minimum: 0,10
5	Potassium	863,440	903,770	936,690	1115,070	Minimum: 0,20
6	C Organic	49,480	27,870	13,950	27,510	Minimum: 9,80 Maximum: 32
7	Electrical Conductivity	8,200	19,990	26,000	25,300	Minimum:6,5 Maximum: 8,88
8	Color	Grayish yellow	Black	Black	Black	Black
9	Aroma	Smells like malapari	Smells of earth	Smells of earth	Smells of earth	Smells of earth

Discussion

pH

The degree of acidity (pH) is essential in the growth of microorganisms in compost. The function of this pH measurement is to determine the condition of the reactor in an acidic, alkaline, or neutral state. Changes in pH in compost indicate the activity of microorganisms in degrading organic matter (Priyambada & Wardana, 2018). Based on the results of the compost research obtained, it showed that the pH value of P1 was 6.850 (neutral), P2 6.980 (neutral), P3 6.040 (slightly sour), and P4 7.210 (neutral). P1, P2, and P4 have met the pH specifications, while P3 does not meet the pH specifications of organic waste according to SNL 19-7030-2004, namely a minimum of 6.80 / maximum of 7.49 (SNI, 2004). The decrease in pH in P3 occurs because active acid-forming microorganisms convert organic matter into organic acids so that the compost is more acidic (Suwatanti & Widiyaningrum, 2017). Meanwhile, the increase in pH in P4 is caused by the activity of microorganisms that convert organic nitrogen compounds such as amino acids, amides, ammonium compounds, and nitrates into ammonia so that many cations are released, such as K+, which then bind the acids formed in the composting process and form KNO3 which causes the pH to rise (Hapson & Yusuf, 2015).

Electrical Conductivity

The soil fertility level is measured from the soil water content because it accurately represents the effect of salinity on plant roots. Conductivity is measured in millimhos per centimeter (mmhos/cm), which is related to the ability of the soil to absorb water, namely, the soil's electrical conductivity (DHL). DHL is the ability of the soil to conduct electric current. DHL occurs due to the free salt content in the soil water and the ion content on the surface of soil particles (Aji et al., 2021). Based on the results of the compost study obtained, it shows that the DHL value of P1 is 8,200 (very high); P2 19,990 (very high); P3 26,000 (very high); and P4 25,300 (very high) mhos/cm. P1 has met the DHL specifications, while P2, P2, and P3 do not meet the DHL specifications for composting from organic waste according to SNI 19-7030-2004, namely a minimum of 6.5/maximum 8.88 (SNI, 2004). The increase in DHL is caused by net weight loss, release of soluble salts through decomposition activities, and degradation of organic matter during the composting process (Mohamed et al., 2021). Compost with high DHL values can be very rich in nutrients because nutrients are responsible for most of the measured conductivity, where all charged ions entering the soil solution contribute to DHL measurements. Some of them, such as nitrate, ammonium, and potassium, are essential macronutrients whose presence in compost reduces the need for additional fertilizers (Crohn, 2016).

C Organic

Organic carbon is one of the critical indicators of compost quality; organic C is a source of energy for soil organisms and a catalyst for the availability of nutrients for plants (Nopsagiatri et al., 2020). Adding organic matter to the soil is very important in maintaining soil quality because it provides nutrients to improve soil conditions that are poor in nutrients (Mekki et al., 2019). Based on the results of the compost study obtained showed that the organic C value of P1 was 49.480 (very high); P2 27.870 (very high); P3 13.950 (very high); and P4 27.510 (very high) %. Overall, organic carbon has exceeded the specified standard: a minimum of 9.80/a maximum of 32%. The increase in organic C occurs due to decreased microorganism activity and death of microorganisms. The death of composting microorganisms causes increased biomass, increasing organic C levels (Muhammad et al., 2017).

Nitrogen

Nitrogen is one of the essential nutrients classified as macronutrients that plants need to grow. Nitrogen is absorbed by plants in the form of nitrite and ammonium, accelerating carbohydrate synthesis. Some of the functions of nitrogen for plants include increasing plant growth, increasing protein levels in plants, improving plant quality, increasing the development of microorganisms in the soil, improving vegetative plant growth and protein formation in tissue (Arisanti, 2021). Based on the results of the compost study obtained showed that the total N value of P1 was 0.910 (very high), P2 0.920 (very high), P3 0.280 (moderate), and P4 0.340 (moderate)%. Overall, the total N value has met the specifications for compost from organic waste according to SNI 19-7030-2004, namely a minimum of 0.40% (SNI, 2004). The increase in nitrogen content in P1 and P2 occurs due to the nitrogen mineralization process in the early stages of composting. Nitrogen mineralization is the process by which organic nitrogen is converted into inorganic nitrogen that is available to plants and is the result of the activity of microorganisms. Meanwhile, the decrease in nitrogen levels in P3 and P4 is caused by the lifting of nitrogen in the form of nitrogen gas or ammonia gas, which is formed during the composting process and packaging before the analysis of nutrient content (Muliarta & Suanda, 2021). The higher the nitrogen content, the faster the organic matter will decompose because microorganisms that decompose compost materials need nitrogen to grow their cells (Sofa et al., 2022).

Phosphorus

Phosphorus (P) nutrient level testing aims to determine the total P content of organic fertilizer after composting. As an organic material, phosphorus is essential in soil fertility, photosynthesis process, and plant chemical physiology. Phosphorus is also needed in cell division, tissue development, and plant growth points (Widarti et al., 2015). Plants that lack phosphorus will cause cell division to be delayed, so cell growth is inhibited, the color of the leaves becomes yellowish, and the plants become stunted. In contrast, excess phosphorus in plants can stimulate premature fruit ripening (Nurhayati & Andayani, 2016). Based on the results of the compost research obtained, it shows that the phosphorus value of P1 is 822.850 (very high); P2 990.920 (very high); P3 931.100 (very high); and P4 1040.970 (very high) %. Overall, the phosphorus value has met the specifications for compost from organic waste according to SNI 19-7030-2004, namely a minimum of 0.10% (SNI, 2004). Overall, the phosphorus content has exceeded the specified standard. This is due to adding water during fermentation, which results in higher results. In addition, due to the high total N content, the number of microbes will increase. The more microbes there are, the higher the phosphorus converted (Budirman & Andi, 2019).

Potassium

The purpose of testing the potassium (K) nutrient content is to determine the total K content of organic fertilizer after composting. Potassium in plants plays a role in physiological functions such as carbohydrate metabolism, enzyme activity, osmotic regulation, water use efficiency, nitrogen absorption, protein synthesis, and assimilation translocation. Potassium is needed by plants in the generative phase in the formation and development of flower buds, flowers, fruits, and seeds (Yusuf et al., 2023). Based on the results of the compost study obtained showed that the potassium values P1 863.440 (very high), P2 903.770 (very high), P3 936.690 (very high), and 1115.070 (very high) %. Overall, the potassium value has exceeded the specifications for compost from organic waste according to SNI 19-7030-2004, namely a minimum of 0.10% (SNI, 2004). The increase in potassium levels is caused by the activity of microorganisms that decompose organic matter. The variation in potassium values is caused by differences in the speed of microorganisms in the decomposition process of organic materials during fermentation (Mulyadi & Yuvina, 2013). Compost materials containing fresh organic materials contain potassium in the form of complex organics that plants cannot use directly for their growth. Decomposition activity by microorganisms changes complex organics into simple organic materials that produce potassium elements that plants can absorb (Widarti et al., 2015).

Water Content

Water content plays a vital role in composting because the decomposition of organic matter depends on it. During composting, water content plays a crucial role in transporting dissolved nutrients needed for microorganisms' physiological and metabolic activities (Guo et al., 2012) because it supports microbial activity and the transport of nutrients microorganisms need (Suhartini et al., 2020). Based on the results of the compost study obtained it showed that the water content value (P1) was 15.450; (P2) 19.200; (P3) 19.380; and (P4) 17.690%. Overall, the water content value did not exceed the specifications for compost from organic waste according to SNI 19-7030-2004, which is a maximum of 50% (SNI, 2004). The results showed that it had reached ± 15% in all treatments. The decrease in water content during the composting process is caused by an increase in temperature due to the heat of microorganisms during the composting process, which causes evaporation, thus reducing the water content value in the compost pile. In addition, it is caused by the consumption of microorganisms in water and the presence of turning or stirring activities (Priyambada & Wardana, 2018).

Color

Color testing of compost is one of the physical properties observed visually to determine the level of compost maturity (Khair et al., 2015). P1 is grayish yellow; P2, P3 and P4 are blackish. In terms of compost color, the waste color is still the same as the color in the initial phase, but in the second week, it begins to change to slightly blackish. This blackish color is an indicator that the composting process is complete. The complete blackish color was obtained starting on the 12th day. These results show the same perspective as the theory that good compost should have a color range from dark brown to black-like soil (Amien et al., 2023). The composting process will gradually change the color of the compost material towards blackish brown due to the ongoing transformation of organic matter and the formation of humus substances (Kusmiyatri, 2013). Color changes occur due to the decomposition process by microorganisms that convert organic matter with complex C chains into simple C forms. The decomposition process will cause the composted material to lose its color pigment so that its color changes to black according to the color of its constituent elements. In the composting process, organic material will be decomposed by microbial activity. Namely, microbes will take water, oxygen, and nutrients from organic material, decomposing and releasing CO2 and O2 (Fahruddin et al., 2013; Dewantari et al., 2023).

Aroma

Aroma is a stimulus produced from compost that is known using the sense of smell. The sense of smell is the instrument that plays the most role in learning the aroma of a product. Aroma testing aims to determine the level of maturity of a compost. The aroma produced in the composting process indicates that microbes have activated the decomposition of materials (Suwatanti & Widiyaningrum, 2017). The P1 compost produced has a distinctive malapari smell because the main ingredient in its manufacture is only malapari cake. Meanwhile, the P2, P3, and P4 composts produced the smell of soil, and this is due to the presence of lignolytic bacteria that function as lignin bond breakers and can separate the carbon components C, Hydrogen (H), Oxygen (O2), Nitrogen (N) and Sulfur (S) which are waste components so that they can convert the stench into an earthy smell (Dewantari et al. 2023).

Conclusions

Based on the results of the research conducted, it can be concluded that pH test P1 6.850; P2 6.980; P3 6.040; P4 7.210. P1, P2, and P4 have met the SNI specifications: not less than 6.80 and not more than 7.49. Water content tests at P1 15.45, P2 19.20, P3 19.38, and P4 17.69 meet the SNI specifications, namely a maximum of 50. Nitrogen test P1 0.910; P2 0.920; P3 0.280; P4 0.340. P1 and P2 have met the SNI specifications, namely a minimum of 0.40. Phosphorus tests P1 822.850, P2 990.920, P3 931.100, and P4 1040,970 have met the SNI specifications, a minimum of 0.10. The potassium test P1 863,440, P2 903,770, P3 936,690, and P4 1115,070 meet the SNI specifications, a minimum of 0.20. Organic C test P1 49,480; P2 7,870; P3 13,950; P4 27,510. P2, P3, and P4 met the SNI specifications, which were not less than 9.20 and not more than 23. The DHL (electrical conductivity) test P1 8,200; P2 19,990; P3 26,000; and P4 25,300 mmhos/cm. P1 meets the SNI specifications, which are not less than 6.5 and not more than 8.88. The color and odor tests on P2, P3, and P4 met SNI specifications, namely that they were blackish and smelled of earth.

Declaration statement

The authors reported no potential conflict of interest.

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