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Study of Making Potassium Posphate from Seaweed Industrial Wastewater

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ABSTRACT

Seaweed industrial wastewater which contains 17.9% potassium can be used as a raw material for making multi-nutrient fertilizers. 1 liter of wastewater is reacted with 1 N phosphoric acid with a certain volume (15, 20, 25, 30, 35 ml) and 30 ml of aluminum sulfate (17,18,19,20,21%) stirred at a speed of 35 rpm for 25 minutes. The precipitate formed is dried. The results showed that the greater the volume of acid and the concentration of aluminum sulfate added with fertilizer obtained and the K, P, and S ion content was getting smaller. Fertilizer produced with the highest content of K ions (9.3%), P ions (9.7%), and S (9.295%) was obtained in the addition of 17% Aluminum Sulfate coagulant and 15 ml volume of H3PO4 (1N), and fertilizers produced weighing 4.0128 grams.

Keywords: Seaweed industrial wastewater, phosphoric acid, coagulation, multi-nutrient fertilizers

Introduction

Seaweed or algae is the largest part of the seaweed plant. It can be used for food, medicine, and raw materials for the domestic industry as well as non-oil and gas export materials. It is a low-level plant and does not have different skeletal structures such as roots, stems, and leaves. Although their appearance looks like there are differences, it is a form of the thallus. Every 100 grams of seaweed contains carbohydrates of 54.3 - 73%, protein 0.3 - 5.9%, and water content reach 80 - 90% besides that there is also calcium (Ca), sodium (Na), ester solutions, and vitamins A, B, C, D and E, and very high iodine (Winarno, 1996).

Seaweed industrial liquid waste has the potential as an ingredient for making fertilizer because it contains microelements for plants and is also a macronutrient that is needed for plant life and growth. Nutrients needed by plants include Carbon (C), Hydrogen (H), Oxygen (O) Nitrogen (N), Phosphorus (F), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulfur (S). (Saifuddin, 1986). This element of potassium is a microelement that is beneficial for plants, including affecting the speed of the photosynthesis process, affecting the resistance of plant stems from pest attacks (Alan & Surdianto, 2004), and increasing soil pH and phosphate uptake into peanut plants (Kaya, 2012).

Table 1. The potassium content of various types of fertilizers.

Fertilizer	Chemical Formulas	Percentage by weight of potassium
1. Potassium Chloride	KCl	48 - 60 %
2. Potassium Sulfate	$K_2 SO_4$	48 - 50 %
3. Potassium Nitrate	KNO_3	44 %
4. Potassium Magnesium Sulfate	$K Mg SO_4$	20 – 30 %

(Soepardi,1983)

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Phosphate substances are easily absorbed in the pH range 5.0 to 8.5 while potassium substances are easily absorbed in the pH range 5.5 - 9. The optimal limit for phosphates in the soil is at pH 5.5 - 7. (Mulyani, 1995). The need for potassium phosphate fertilizer nationally from year to year is increasing and this need still has to be met by importing from other countries. In Indonesia, many materials contain potassium which can be used as potassium phosphate fertilizer, for example, kapok peel ash extract processed with phosphate flour (Ariani, Cahyono, & Yuliastuti, 2015). The cooking process in the seaweed industry is by using potassium hydroxide so that industrial wastewater seaweed contains NaCl, Potassium, and Lignin.

According to Yustin, *et al.* 2005, the characteristics of liquid waste from seaweed processing are potassium, chloride, nitrogen as total N, and phosphorus as P_2O_5. This waste, if released or disposed of into the river, will cause environmental pollution. Therefore, seaweed industrial wastewater which contains potassium is combined with metal coating industrial pickling waste into inorganic fertilizers, namely potassium chloride fertilizer (Ariani, Cahyono, & Yuliastuti, 2015) and used for liquid organic fertilizer (Justus & Medan, 2017). In this research, seaweed wastewater is processed into potassium sulfate (multi-nutrient fertilizer) by adding aluminum sulfate and phosphoric acid. Besides being able to reduce environmental pollution, adding value-added from the seaweed industry is also expected to reduce fertilizer imports. Multinutrient fertilizers can also be made by processing bittern (Adi *et al.*, 2015, Nadia, Zainuri, & Efendy, 2015), from wastewater from geothermal power plants (Sumada, 2012).

The manufacture of fertilizers containing K, P, and S ions (multi-nutrient fertilizer) using wastewater containing KOH which is reacted with phosphoric acid and the addition of aluminum sulfate, follows the following reaction:

$$3\,K^{+}OH^{-} \;+\; H_3^{+}\,PO_4^{-} \;\rightarrow\; K_3^{+}\,PO_4^{-} \;+\; 3H_2O$$

$$Al_2^{+}\,(SO_4)_3^{-} \;+\; 6K^{+}OH^{-} \;\rightarrow\; 3K_2^{+}\,SO_4^{-} \;+\; 2Al^{+}\,(OH)_3^{-}$$

The addition of chemical elements such as phosphoric acid, aluminum sulfate will reduce the pH of the solution which will affect the formation of granules and the deposition process. The function of the addition of phosphate is as one of the macro elements needed to be absorbed by plants, namely its role in fertilizers is also to accelerate ripening (Saifudin, 1986).

The addition of Aluminum Sulfate as a binder and results in colloid destabilization to obtain suspended solids, which is the initial stage of clumping of destabilized particles (which have been stable), will bind with each other to become more stable particles and form precipitates quickly (Eckenfelder & Wesley, 1989). Multinutrient fertilizer from seaweed industrial wastewater is affected by stirring. The coagulation-flocculation process takes place in two stages, namely the fast stirring process and the slow stirring process (Ebeling, James, & Ogden, 2004):

1. Fast stirring process
   The fast stirring process is intended to even out the mixture between the coagulant and wastewater so that a homogeneous mixture is obtained. Negatively charged molecules and particles in water such as colloids will be seen by positively charged molecules and ions from the coagulant. In the fast stirring process, a strong stirring force and fast stirring time are required because the coagulation and particle destabilization processes occur in a very fast time. The time required for fast stirring is between 1 - 3 minutes at a speed of 100 - 150 rpm. The coagulation process requires fast stirring for several reasons, such as:
   a. To dissolve the coagulant in water.
   b. To distribute the coagulant sufficiently and evenly in the water.
   c. To produce fine particles in the coagulating agent before the coagulation reaction is complete.
2. Slow Mixing Process
   The slow stirring process aims to obtain larger and heavier flocculent particles to accelerate the deposition process. The time required for stirring is between 20-30 minutes at a speed of 30-50 rpm. The flocculation process requires slow stirring for several reasons including:
   a. Allows the coagulated particles (small floc) to combine into floc which size increases over time.

b. Makes it easy for the flocculants with its "threads" to tie small flocks into floc ties that are getting bigger and bigger over time.
c. Prevents the re-rupture of already formed flocks.

The purpose of this study was to determine the effect of the addition of aluminum sulfate and phosphoric acid on the processing of seaweed industrial wastewater into multi-nutrient fertilizers. The benefit of this research is to reduce environmental pollution caused by seaweed industrial wastewater, which is an alternative method of processing seaweed industrial wastewater into fertilizer.

Research Method

Research materials in the form of aluminum sulfate, phosphoric acid, and seaweed industrial wastewater from PT ACI. The most concentrated liquid waste that comes from processing or cooking seaweed. This waste is waste that is still original and has not been diluted so that it is more concentrated. The tools used are pH meter, thermometer, magnetic stirrer and glassware, and sedimentation tank/equipment. The conditions stipulated include the volume of seaweed wastewater 1 liter, stirring speed of 150 rpm for 5 minutes of stirring time, followed by a speed of 35 rpm for 25 minutes, the volume of $Al_2 (SO_4)_3$ 3 30 ml, and a concentration of 1 N phosphoric acids. Variables that are done:

- Volume of H_3PO_4 (ml) : 15, 20, 25, 30, 35

- Concentration of $Al_2 (SO_4)_3$ (wt%) : 17%, 18%, 19%, 20%, 21%

The research procedure starts by analyzing the K ion content in the wastewater first. The wastewater which has a pH of 14 is diluted to pH 12. Water. 1 liter of diluted wastewater is added with H_3PO_4 and aluminum sulfate according to the variables run and stirring is carried out at a speed of 150 rpm for 5 minutes and 35 rpm for 25 minutes. After the stirring is stopped and then allowed to stand until it settles completely for approximately 3-4 hours. The filtrate and sediment are separated. The precipitate (fertilizer) obtained is dried and the resulting fertilizer is analyzed for the K, P, and S content.

Results and Discussion

The results of the K ion content analysis in seaweed waste contained 17.9% potassium and a pH of 14. The effect of adding phosphoric acid and aluminum sulfate on ion levels in fertilizer can be seen in table 2.

Table 2. K, P, and S ion content in fertilizer (weight%) for various volumes of H_3PO_4 1 N and coagulant $Al_2 (SO_4)_3$ concentrations.

Volume	**K, P and S ion content (%) in various concentrations of $Al_2 (SO_4)_3$**														
H_3PO_4 (ml	**17 %**			**18 %**			**19 %**			**20 %**			**21 %**		
	K	**P**	**S**	**K**	**P**	**S**	**K**	**P**	**S**	**K**	**P**	**S**	**K**	**P**	**S**
15	0.93	0.97	0.929	0.12	0.11	0.13	0.14	0.13	0.16	0.15	0.16	0.15	0.16	0.17	0.18
20	0.79	0.92	0.924	0,12	0.10	0.13	0.13	012	016	0.14	0.14	0.15	0.16	0.16	0.19
25	0.76	0.68	0.926	0.10	0.10	0.12	0.12	0.11	0.16	0.14	0.13	0.14	014	0.15	0.19
30	0.74	0.52	0.859	0.83	0.08	0.11	0.09	0.09	0.14	0.13	0.12	0.13	0.14	0.15	0.19
35	0.6	0.40	0.788	0.69	0.06	0.10	0.08	0.07	0.13	0.12	0.11	0.12	0.12	0.14	0.18

The greater the phosphoric acid and aluminum sulfate added, the smaller the K ion concentration in the fertilizer. This is because H_3PO_4 is a strong acid and the more acid is added, the less floc is formed because the greater the concentration of phosphoric acid, the higher the solution viscosity, the lower the formation of floc (granules) (Iveson, 1996). The formed floc containing K, P, and S ions will dissolve again so that the smaller the ion that settles. With more acid added, the pH of the solution becomes smaller, it is less reactive to the added aluminum phosphate so that the bound S ions are also smaller.

Table 3. The resulting fertilizer weight in addition of $Al_2 (SO_4)_3$ was 30 ml

H_3PO_4 (ml)	The resulting fertilizer weight (grams) of various concentrations of Aluminum Sulfate is added				
	17 %	18 %	19 %	20 %	21 %
15	4.0128	3.6900	3.7586	3.8576	3.6500
20	3.4910	3.6510	3.6123	3.8121	3.3000
25	3.4270	3.5120	3.5980	3.6700	3.2900
30	3.3731	3.3250	3.4300	3.5210	3.2131
35	3.1920	3.1641	3.2121	3.3000	3.2000

The greater the concentration of phosphoric acid added, the smaller the floc formed because the more acid added, the floc formed will dissolve again. The amount of sediment which is fertilizer will be smaller. The resulting multi-nutrient fertilizer was 4.0128 grams with the addition of 15 ml of phosphoric acid and 17% concentration of aluminum sulfate and had a potassium content of 9.3%, P (9.7%), and S (9.295%), whose values met the value of SNI for fertilizer.

Table 4. K ion recovery besides of Al_2 (SO4) $_3$ with a concentration of 17% as much as 30 ml

Initial K ion content (gram)	H_3PO_4 (ml)	final pH	Product Weight (gram)	Potassium content in the product (%)	Potassium Taken (gram)	% Potassium Recovery
0,179	15	6	4.0128	0.9300	0.03732	20.8
	20	5	3.4910	0.7900	0.02758	15.4
	25	4	3.4270	0.7600	0.02605	14.6
	30	3	3.3731	0.7400	0.02496	13.9
	35	3	3.1920	0.6000	0.01915	9.5

The higher the concentration of phosphoric acid, the smaller the potassium that is taken. With the greater the acid concentration, the floc formed will decompose and dissolve back into the liquid, so that the fertilizer produced from the precipitation process will decrease. Thus the content of Potassium ions that react to form multi-nutrient fertilizers is also getting smaller. The smaller the potassium ion taken, the smaller the percentage of potassium ion recovery.

Conclusion

Fertilizer produced with the highest potassium ion content of 9.3%, P (9.7%), and S (9.295%) was obtained in the addition of 17% Aluminum Sulfate coagulant and 15 ml volume of H_3PO_4 (1N), and the resulting fertilizer weighing 4.0128 grams with a pH level of 6. Potassium phosphate fertilizer $(K_3PO_4)_3$ is good for use on Andosol soil and is very good for rice, potato (tuber), tobacco, sugar cane, and onions.

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