TECHNIUM

Romanian Journal of Applied Sciences and Technology

ISSN: 2668-778X

vol. 16 / 2023

The 7th International Conference on Science Technology

organized by
Faculty of Social Science and
Law Universitas Negeri Manado and
Consortium of International Conference
on Science and Technology

The Innovation Breakthrough in Digital and Disruptive Era

PLUS COMMUNICATION

International Communication & PR

Technium: Romanian Journal of
Applied Sciences and Technology
Vol. 16, 330-333, October, 2023
ISSN: 2668-778X
www.techniumscience.com

Phosphate removal from wastewater for the manufacture of struvite fertilizer

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Abstract. One of the non-renewable natural resources is phosphate rock. Phosphate is currently a lot necessity, while the need for phosphate is estimated to last within 30 to 300 years. Therefore, it is necessary to strive for the development of new sustainable sources of phosphate to maintain phosphate stability. Stirring is an efficient method in the crystallization process where the stirring speed affects the growth of struvite crystals. The purpose of this study was to study the growth of struvite crystals with the struvite crystallization process with the influence of stirring rotations of 100, 150 and 200 rpm at a temperature of 30^{o}C. The experiment was carried out by mixing the two solutions in a 1000 ml glass beaker. The reaction time and pH of struvite crystallization were evaluated in this experiment. The crystals obtained were characterized using a scanning electron microscope (SEM) with energy dispersion x-ray (EDX) and x-ray fluorescence (XRF). From the results of the study, it was found that the highest P_2O_5 content at a stirring speed of 100 rpm and a temperature of 30^{o}C was 47.5%, and was included in the quality of triple superphosphate fertilizer.The morphology of the irregular flake crystals was a typical form of struvite crystals with a size of 20 μm.

Keywords: Phosphate, struvite, SEM-EDX, XRF

1. Introduction

One of the natural resources that cannot be repaired is phosphate rock. Phosphate is currently needed a lot, while the need for phosphate is estimated to last within 30 to 300 years. Therefore, it is necessary to strive for the development of new sustainable sources of phosphate to maintain the sustainability of pospos. Phosphate is the main source of phosphorus (P) generally used as fertilizer, detergent or insecticide. Struvite is an effective phosphate fertilizer as an alternative source of rock phosphate to maintain agricultural production systems.

Most of the laundry waste comes from fabric softeners and detergents, which are non-biodegradable (non-biodegradable) materials, so they must be treated before being discharged into water bodies [1]. The increasing use of detergents will have a negative impact on the accumulation of surfactants on aquatic materials, causing problems with silting of waters, inhibition of oxygen transfer and others. In aerobic conditions, LAS can be degraded well, but if under anaerobic conditions, LAS removal is still not good. To overcome this problem, a waste treatment system is needed that is able to reduce levels of surfactants and phosphates as pollutants [2].

Struvite precipitation is a deposition process through a chemical reaction with the help of chemical precipitates containing Mg^{2+} and $PO3^{-}$ so that a precipitate is formed in the form of struvite crystals ($MgNH_4PO_4.6H_2O$) [3]. This method has the advantage of re-forming compounds from PO^{3-}, Mg^{2+}, and $NH4^{+}$ as struvite which can be used as a slow-release fertilizer [4].

Stirring is an efficient method in the crystallization process. Phosphate and ammonium removal will increase as the stirring speed increases. The higher the stirring speed, the lower the induction time and the faster nucleation will occur, so that the ammonium and phosphate removal can decrease because they are at high agitation. The stability of struvite crystals also decreases and causes the crystals to break. So that the optimum stirring speed in this study occurred at 158 rpm with a stirring time of 60 minutes [5]. Stirring speed affects the growth of struvite crystals, the higher the stirrer rotation speed results in an increase in struvite crystals at 50, 100 and 120 rpm [6].

Likewise, there will be an increase in crystals at a stirrer rotation of 70 and 100 rpm [7]. The solubility of struvite increases in the temperature range of 25-35^{o}C and then decreases at 40^{o}C [8]. The purpose of this study was to study the growth of struvite crystals by means of struvite crystallization process with the influence of stirring rotation of 100, 150 and 200 rpm at a temperature of 30^{o}C in laundry wastewater.

2. Research Methods

The solution for the experiment was prepared separately by dissolving a predetermined amount of $MgCl_2$ and $NH_4H_2PO_4$ crystals in laundry wastewater namely, Mg^{2+}, $NH4^{+}$ and $PO4^{-3}$, with a Mg:N:P molarity ratio of 1: 1: 1. The pH of the initial solution was ±9.0 with the addition of KOH. The reaction time and pH of struvite crystallization were evaluated in this experiment and carried out at a temperature of 30^{o}C and stirring cycles of 100, 150, 200 rpm.

The experiment was carried out by mixing the two solutions in a 1000 ml glass beaker. The glass beaker is equipped with a magnetic stirrer. At the beginning of the run, the solution in the glass beaker was stirred at high speed so that it was quickly homogeneous. Then, the stirring speed is adjusted according to the desired variable. The crystallization process continues to be observed by measuring changes in the pH of the solution. At the end of the experiment, the solution was filtered and the crystals obtained were dried in free air.

3. Result and Discussion

The content of P_2O_5 (%) is affected by the stirring speed at a temperature of 30^{o}C as shown in the following figure 1.

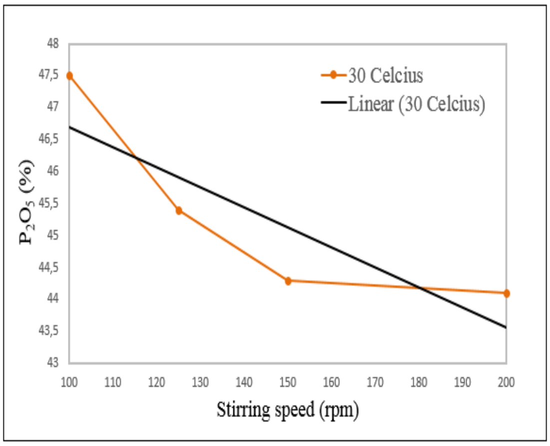
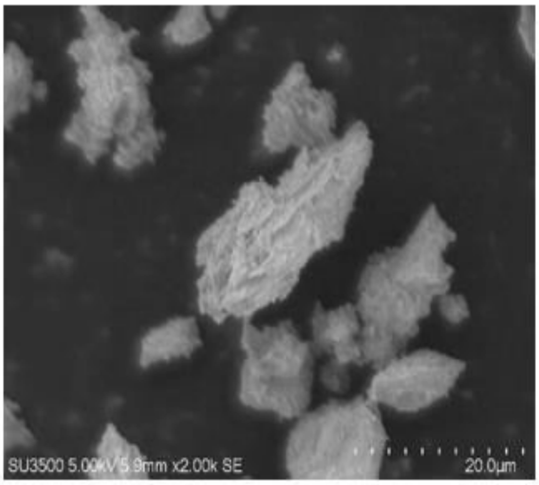


Figure 1. Relationship between Stirring Speed (rpm) and P_2O_5 content (%) at 30°C.

Figure 1 shows that at a temperature of 30°C with different stirring speeds, the highest P_2O_5 content was obtained at a stirring speed of 100 rpm of 47.5%. The higher the stirring speed, the smaller the P_2O_5 content, causing a drastic decrease of up to 44.1% at a stirring speed of 200 rpm. . This decrease is due to an increase in stirring speed that is too high which can cause the struvite crystals to break which can cause a collision between crystals [5]. High agitation also results in an increase in energy consumption. The morphology of struvite crystals from laundry wastewater can be seen in the image below. Struvite crystallization has been found to be a promising recovery technique because the precipitate obtained can be used as a slow-release fertilizer or raw material for the chemical industry [9].



Element	Weight %	Atomic %	Error %
161221 | 25,150 | Area 1 | Full Area 1			
C K	40	50.81	8.54
O K	40.59	38.7	9.02
NaK	0.56	0.37	12.99
MgK	7.99	5.02	5.16
AlK	0.17	0.1	19.72
SiK	0.41	0.22	8.66
P K	7.28	3.58	2.96
S K	0.32	0.15	11.84
ClK	0.25	0.11	16.57
K K	1.9	0.74	4.43
CaK	0.51	0.2	12.91

Figure 2. Results of SEM and EDX analysis of Struvite crystals.

The morphology of struvite crystals from laundry wastewater was obtained using SEM-EDX analysis.The morphology of irregular flakes is a typical form of struvite crystals with a size of 20 μm [10] . The structure of the struvite produced can be predicted from the presence of K, Mg, N, O, P ions which can be used as slow release fertilizers and the presence of Ca ions which function as root formation and growth in plants.

4. Conclusions

The results of the study of taking phosphate from laundry wastewater with the struvite crystallization process obtained the highest P_2O_5 levels at a stirring speed of 100 rpm and a temperature of 30°C, namely 47.5% and included in the quality of triple superphosphate fertilizer. The morphology of the irregular flake crystals is a typical form of struvite crystals with a size of 20 μm. The crystals obtained were characterized using a scanning electron microscope (SEM) with energy dispersion x-ray (EDX) and x-ray fluorescence (XRF).

5. Acknowledgments

The authors would like to thank the LPPM UPN “Veteran” of East Java who has financed the implementation of the internal research program of the Advanced Basic Research Scheme (RISLA) in accordance with the contract number: SPP/37/ UN.63.8 /LT/ IV/2022.

Technium: Romanian Journal of
Applied Sciences and Technology
Vol. 16, 330-333, October, 2023
ISSN: 2668-778X
www.techniumscience.com

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