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Potensi Fosfat dari Tangki Septik di Kota Surabaya, Indonesia

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Abstrak

Kelangkaan fosfat terjadi jika manusia saat ini tidak mengelola fosfat yang tersedia di alam dengan baik. Batuan fosfor adalah sumber fosfat alami, yang ketersediaannya di alam berkurang akibat besarnya permintaan fosfat di dunia, terutama di bidang pertanian. Sehingga diperlukan suatu inovasi baru yang melibatkan *recovery* fosfat dari lumpur tinja. Lumpur tinja mengandung banyak nutrisi yang terakumulasi dari makanan yang dikonsumsinya. Selain itu, dengan rendahnya sistem pengelolaan air limbah di Indonesia, *recovery* fosfat dapt dilakukan menggunakan lumpur tinja dari tangki septik yang telah diangkut ke Instalasi Pengolahan Lumpur Tinja (IPLT). Hal ini merupakan salah satu sumber daya yang potensial. Tujuan dari penelitian ini adalah untuk mengukur potensi (keberadaan) fosfat dalam air limbah domestik di Kota Surabaya, Indonesia. Penelitian ini dilakukan dengan pengambilan sampel secara *accidental sampling* dan pengukuran total fosfat menggunakan spektrofotometer, sesuai standar APHA Metode 45001-P. Karakteristik awal sampel terdiri dari fase cair dan padatan yang berwarna hitam kecoklatan dan berbau. Konsentrasi fosfat dalam lumpur tinja berkisar antara 110,42 mg/L dan 4572,64 mg/L, dengan nilai rata-rata sebesar 1016,77 mg/L.

Kata Kunci : air limbah domestik, fosfat, lumpur tinja, tangki septik

Phosphate Potential from Septic Tank in Surabaya City, Indonesia

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Abstract

Phosphate scarcity will occur if humans do not currently manage the phosphates available in nature with good management. Phosphorus rocks are a natural source of phosphates, whose availability in nature is dwindling due to the large demand for phosphates in the world, especially in agriculture. It is necessary to launch a renewal that involves the recovery of phosphates from fecal sludge. Fecal sludge contains a lot

of nutrients that have accumulated from the food we eat. Due to the lack of sewage system distribution in Indonesia, phosphate recovery uses septic tank sludge that has been transported to the Fecal Sludge Treatment Plant. This is one of the potential resources. The purpose of this study was to see the potential (presence) of phosphates in domestic wastewater in Surabaya City, Indonesia. This research was carried out by accidental sampling and the measurement of total phosphate using a spectrophotometer, according to the APHA Method 45001-P standard. The initial characteristics of the sample consisted of liquid phases and solids that were brownish-black and smelly. The phosphate levels in fecal sludge are between 110.42 mg/L and 4572.64 mg/L, with an average value of 1016.77 mg/L.

Keywords : domestic wastewater, fecal sludge, phosphate, septic tank

INTRODUCTION

Phosphorus (P) is a nutrient needed in natural processes. Fosfor appears in natural waters in primary forms as ortho-, pyro-, and dissolved polyphosphates. Orthophosphates are naturally present in rivers and lakes that replenish aquifers, as well as those present in aquifers derived from rock erosion and the recycling of animal waste, plants, and animal tissues (Hem, 1985). However, phosphate rock, the source of phosphorus minerals in the fertilizer, has limited resources and is predicted to last less than a few hundred years at the level of current usage (Cordell et al., 2009).

Currently, some regions of the world overuse P fertilizers, which causes eutrophication in waters, while in other regions, limited access to phosphorus fertilizers leads to a decrease in crop yields (Baker et al. 2015). Some researchers predicted that with this current level of exploitation, phosphorus reserves around the world will be exhausted, and the production of phosphorus fertilizers will decrease drastically after 2033, which is referred to as "peak phosphorous" (Clabby, 2010). Because of the lack of nutrients that are important for plant growth, some argue that later most humans will face hunger (Grantham, 2012).

In nature, phosphorus goes through various associated cycles. Inorganic cycles describe cycles derived from erosion into the ocean, sedimentation, tectonic removal, and the change of phosphate-containing rocks into phosphorus available to plants in nature. Approximately 90% of society's use of phosphorus is for food production (including fertilizers, feed and food additives) (Cordell et al., 2009). The organic cycle describes phosphorus as part of the food chain. The cycle describes the passage of phosphorus in land (soil, plant, and animal organic soil waste) and in water (Emsley, 1980). Fecal sludge has a high solid, organic and nutrient concentrations compared to wastewater sludge (Gold et al., 2016). And the organic cycle can be disrupted when the amount of phosphorus in animal and human feces is not used in fertilizers. Phosphates contained in wastewater are partly transported into the ocean through the sewage system and partly released in the discharge of sludge deposited at the landfill site (Cornel & Schaum, 2009).

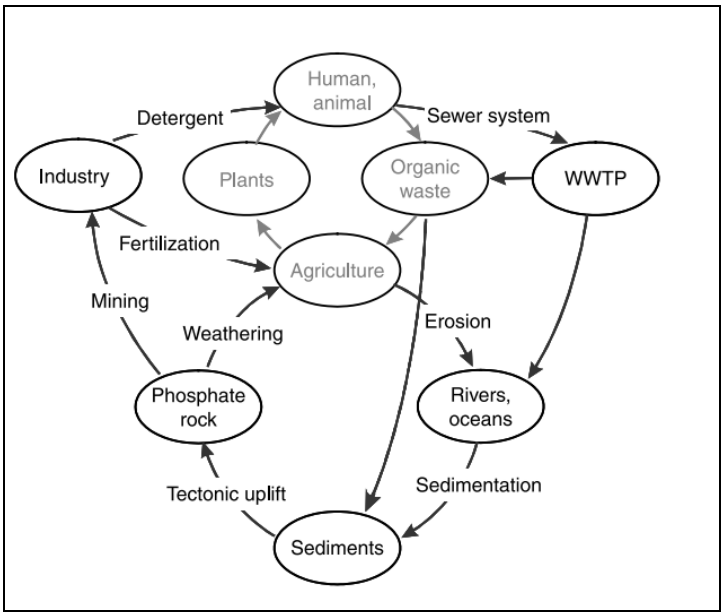

Figure 1. Phosphorus cycle in nature
(Cornel & Schaum, 2009)

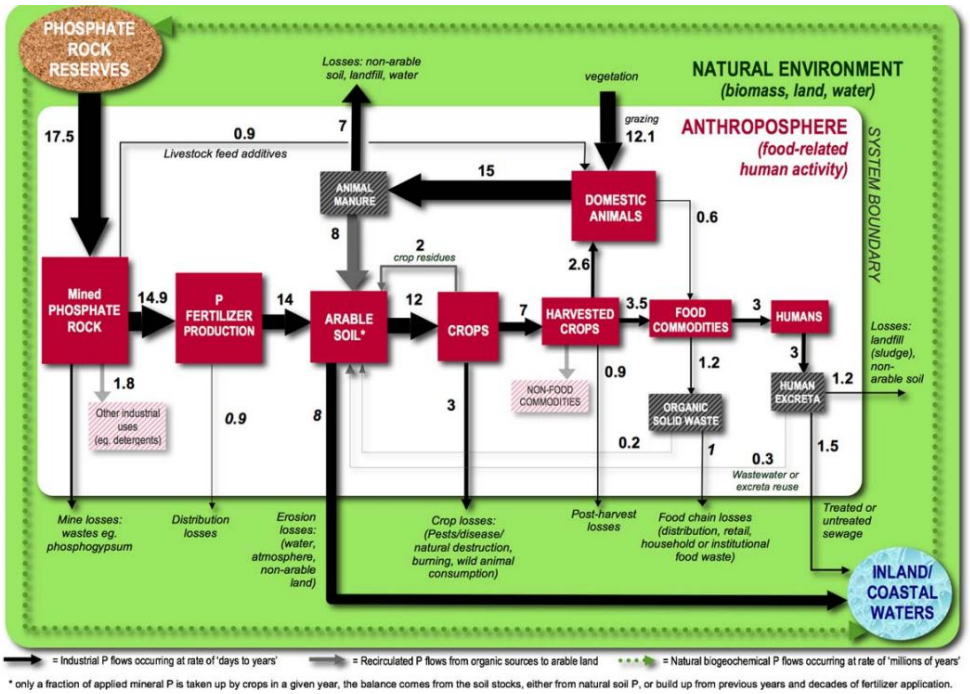

Figure 2. Phosphorus flows through the global food production and consumption system
(Cordell et al., 2009)

The implementation of phosphorus recovery in the wastewater management system is very useful to ensure that wasted phosphorus can be reused. Based on research conducted by Cornel & Schaum (2009) and Ronteltap (2009), phosphate removal in wastewater using the crystallization method can be recovered to an extent of 80–90%. Wu et al. (2021) obtained a recovery rate of 83.17% of the 318.64 mg/L PO_4^{3-} contained in it. The phosphorus recovery process for digested and thickened sludge achieves 80% PO_4-P removal in digested sludge, recovering 15% of the total P load from the treatment plant (Chrispim et al., 2019).

Based on the distribution of the percentage of households by region or city, the number of users of defecation facilities in Surabaya province is 72% (BPS Provinsi Jawa Timur, 2021). A septic tank is a waterproof space composed of one or more compartments that collect and treat household wastewater at a slow flow rate, allowing for the deposition of suspended solids and the decomposition of organic matter by anaerobic bacteria, resulting in the formation of water and gas-soluble materials (SNI, 2017).

Phosphorus (P) is an important nutrient for plants and animals. Phosphorus is a limited resource. Phosphorus is usually present in nature in the form of phosphates. Phosphorus is most commonly obtained through rocks located in several regions of the world (Cordel & White, 2015). Because the amount is limited in nature, this makes phosphorus needs vulnerable to food production systems and increases the need to encourage sustainable phosphorus production practices (Chrispim et al., 2019).

Phosphorus is widely used as a fertilizer in agriculture or as a food additive in animal feed. Other uses of phosphorus include being used as an ingredient in human food, drugs, detergents, and some chemical mixtures (DEFRA, 2008). Phosphorus in wastewater is present in three main forms: orthophosphate ions, polyphosphates, and organic phosphorus compounds (Özacar & Şengil, 2003).

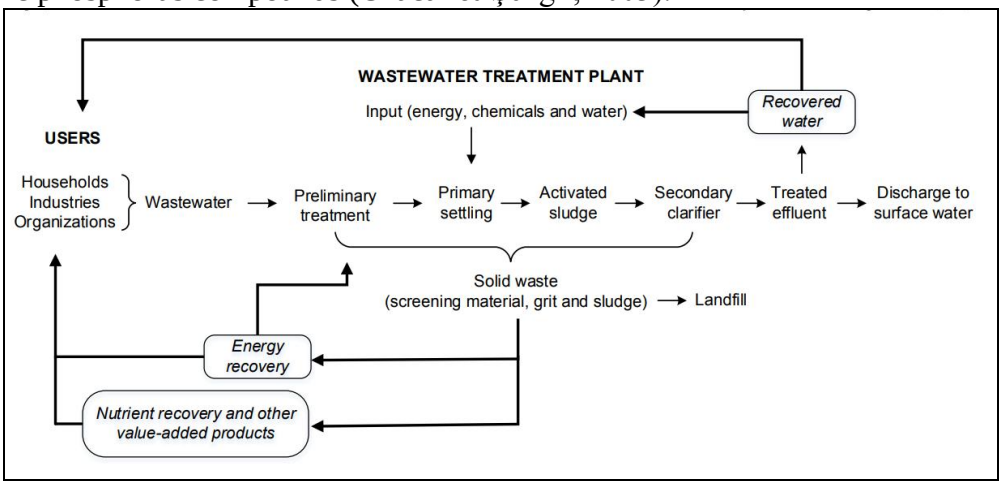

Figure 3. Major pathways in wastewater treatment in cities (Chrispim et al., 2019)

The excessive presence of phosphorus in bodies of water can lead to eutrophication since phosphates are a source of nutrition for the growth of aquatic plants in fresh water (Drever, 1988; Litke, 1999). Eutrophication has several negative impacts, namely a decrease in water quality (color, clarity, smell, and taste); bacteria consuming more oxygen and causing fish to die; loss of biodiversity; and a decrease in the aesthetic and recreational value of water bodies (Panasiuk, 2010). To make efficient use of limited resources, a process of recovery and recycling of nutrients contained in wastewater is carried out to be reused in the soil, increasing production in agriculture (Chrispim et al., 2019).

Phosphate recovery uses septic tank sludge that has been transported to the fecal sludge treatment plant, it is one of the potential resources. This is due to the lack of sewage system distribution in Indonesia. According to Soedjono et al. (2020), the most populous housing in Surabaya is currently underserved with a centralized wastewater disposal system; therefore, most of the household wastewater in Surabaya, especially blackwater, is treated in septic tanks or latrines. The purpose of this study was to see the potential and presence of phosphates in domestic wastewater in Surabaya City.

MATERIALS AND METHODS

This research was carried out by accidental sampling and the measurement of total phosphate using a spectrophotometer, according to APHA Method 45001-P. Acidental sampling is the appearance of sample respondents by chance, i.e., anyone who coincidentally meets a researcher can use a sample if the person being deemed suitable is a data source (Sugiyono, 2009). APHA Method 45001-P is a standard used to determine phosphorus levels in drinking water, water bodies, and wastewater. The principle of this method is that in an acidic solution, orthophosphate reacts with ammonium molybdate to form molybdophosphate acid, which is then reduced by stannous chloride ($SnCl_2$) to blue molybdenum. The resulting blue color concentration is directly proportional to the phosphate concentration. The measurement results are expressed in ppm (mg/L) of phosphate as PO_4 or P (CHEMetrics, 2017).

RESULTS AND DISCUSSION

Sampling Location

This study works with third-party providers of fecal suction services to collect data on stool suction requests. Fecal suction is generally done because the toilet cannot be used because feces can not flush. In fact, according to The Ministry of Public Works and Housing Regulation No.4/2017 for the septic tank system, it is inspected at least every 3 years and then disposed of using a fecal truck and transported to the Fecal Sludge Treatment Plant (IPLT). Sampling is carried out when a third party receives a request for fecal suction services from the people of Surabaya City. Population sampling for this study covers all users of private septic tanks. The sampling process uses accidental sampling techniques. The location of the sampling that has been carried out can be seen in Figure 4.

Figure 4. Sampling Point in Surabaya City

The samples to be tested for phosphate levels came from a fecal sludge truck after suctioning from a community-owned septic tank. Figure 5 shows the suctioning process performed by a third-party officer. The sample is put in a plastic bottle and pickled by putting it in a coolbox filled with ice crystals. The initial characteristics of the sample consisted of liquid phases and solids that were brownish-black and smelly (Figure 6).

Figure 5. Fecal sludge suction process from septic tank

Figure 6. Fecal sludge samples from septic tanks

Measuring Sample(s)

After sampling and curing the sample, it is immediately taken to the laboratory to perform phosphate measurements. APHA Method 4500-P (using Stannous Chloride) sample measure by spectrophotometric method.

APHA Method 45001-P is a standard used to determine phosphorus levels in drinking water, water bodies, and wastewater. The procedure will produce the total phosphate value in mg/L units; however, all samples need to be diluted first because the sample is so concentrated that it makes it difficult to measure the PO4-P value using a wavelength of 650 nm.

Phosphorus appears in natural waters in primary forms as ortho-, pyro-, and dissolved polyphosphates (Hem, 1985). While phosphorus is present in wastewater in three forms: orthophosphate ions, polyphosphates, and organic phosphorus compounds (Özacar & Şengil, 2003). The sample needs to be brought to a boil with acid to decompose organic phosphorus compounds into reactive (dissolved) phosphates. After measuring with the right procedure, the following data was produced as the total amount of phosphate in the fecal sludge of the people of Surabaya City (Table 1 and Figure 7).

Table 1. Total Phosphate (TP) Measurement Results

No	Sample Code	TP (mg/L)	No	Sample Code	TP (mg/L)
1	R3	866.20	13	R16	297.92
2	R4	286.22	14	R17	110.42
3	R5	1750	15	R18	2134.20
4	R6	3231.25	16	R7	4572.64
5	K8	901.81	17	R19	863.13
6	R9	550.44	18	R20	422.63
7	R10	412.50	19	R21	179.87
8	R11	2045.89	20	R23	1456.78
9	R12	410.72	21	R24	281.22
10	R13	194.18	22	R25	1169.96
11	R14	410.72	23	R26	783.08
12	R15	194.18	24	R27	876.47

It can be seen from the table above, that the value of the phosphate content (total phosphate) in fecal sludge from household septic tanks in Surabaya varies greatly. Phosphates derived from septic tanks in Surabaya City range from 110.42 mg/L (sample code R17) to 4572.64 mg/L (sample code R7). Figure 7 shows the sample data presented in a box plot. A box plot is a graphically presented summary of a sample

distribution that describes the shape of the data distribution, the size of the central tendency, and the size of the spread (diversity) of the data. Some statistical measures that can be read in the boxplot graph are the minimum value, Q1 (first quartile), Q2 (median), Q3 (third quartile), and maximum value.

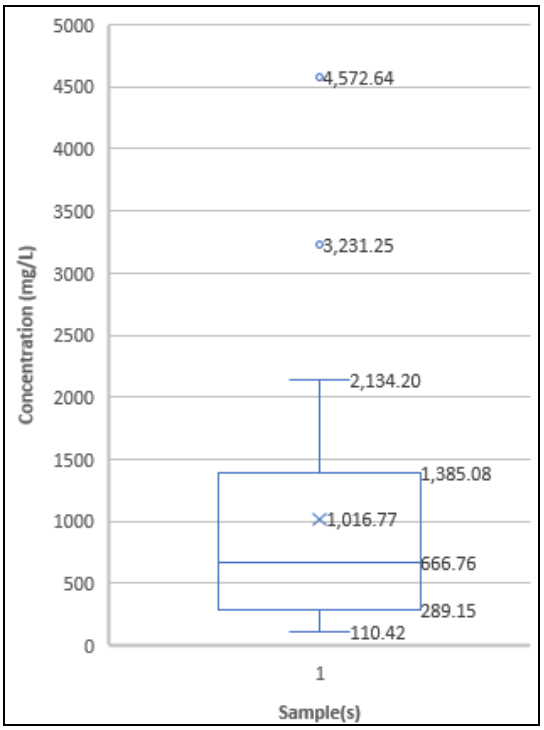

Figure 7. Box plot chart of phosphate concentration in fecal sludge samples

Figure 7 indicates that the minimum value of the concentration of the fecal sludge sample is 110.42 mg/L and the maximum value of the concentration of the fecal sludge sample from households is 2134.20 mg/L. The chart shows two values that are outliers in the measurement data. The average value of total phosphate concentration from 24 samples is 1016.77 mg/L. All of this wastewater will be disposed of using a fecal truck and transported to the Fecal Sludge Treatment Plant (IPLT) for treatment to decrease phosphate and organic concentrations. The excessive presence of phosphorus in bodies of water can lead to eutrophication since phosphates are a source of nutrition for the growth of aquatic plants in fresh water (Drever, 1988; Litke, 1999). This study shows that fecal sludge contains high levels of phosphate and has the potential to be recovered. In addition to preventing eutrophication, it can also be a source of raw phosphate in the future.

CONCLUSION

The initial characteristics of the sample consisted of liquid phases and solids that were brownish-black and smelly. The phosphate levels in household fecal sludge in Surabaya City are between 110.42 mg/L and 4572.64 mg/L, with an average value of 1016.77 mg/L. All of this wastewater will be disposed of using a fecal truck and transported to the Fecal Sludge Treatment Plant (IPLT) through the treatment process to decrease nutrient of phosphate concentrations.

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