CHAPTER 3

THE EFFICIENCY REMOVAL OF PHOSPHORUS BY USING RECYCLED CONCRETE AGGREGATE (RCA) AS FILTER

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3.1 INTRODUCTION

Phosphorus (P) is a main nutrient element plants growth in natural water system. However, excessive P loads to water bodies from industrial, agricultural, household wastes may cause the overgrowth of aquatic plants or algae which accelerate the depletion of dissolved oxygen (DO) in waters, and leading to serious eutrophication problems. In developing countries, approximately 75% of domestic wastewater is released to the environment without treatment (Rozari et al. 2016). Ayaz et al. (2012) reported that eutrophication in receiving water bodies may occur when concentration of phosphorus was 6 mg/L. Therefore, proper treatment to remove phosphorus from domestic wastewater to achieve the admissible level for natural systems is needed. Besides, construction and demolition (C&D) activities shows a growing trend for several years.

High cost waste disposal and pollution will occur if the management of solid waste in construction not disposed in a proper method. Thus, to promote sustainable of natural resources and reduced disposal of demolition waste, recycling of concrete is a significant alternative method. Recycled concrete aggregate that has been crushed for selected size was used in this study to investigate its performance as an effective filter for removal of P. According to (Nasir, 2016) the important factors that need to be considered in designing a filter are the selection of the filter material itself. The utilization of easily available and low cost materials has been widely demonstrated by previous study in removing phosphorus including limestone, fly ash, iron oxide, steel slag and blast furnace slag (Johansson, 2013). Therefore, a detailed study of filter media capabilities for the removal of phosphorus is essential.
3.2 EXPERIMENTAL

3.2.1 MATERIALS

The RCA was taken on thrown waste cubes produced from the Material Laboratory in University Tun Hussein Onn Malaysia. Initially, the thrown waste cubes outside laboratory were selected. Then the waste cubes were crushed by using the crushing machines in order to produce the aggregates. Next the all aggregates are being sieves into 5 mm to 30 mm by using sieve analysis process. The crushed samples was collected and sieve through a 5 to 30 micrometer test sieve using a shaker, Endecott Lambard Rd. London, model Sw193BR. The chemical microanalysis obtained from Energy-dispersive X-ray spectroscopy (EDX) test.

3.2.2 COLUMN STUDY

Lab-scale vertical column filters study was developed to investigate the difference between to size of RCA on the phosphorus removal efficiency using RCA as the adsorbent. Figure 3.1 shows the schematic diagram of lab-scale system Six column filters with the inner diameter of 150 mm, 6 mm thickness and total height 420 mm made from Perspex materials were set up with six different of concentration synthetic wastewater which is 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L, 50 mg/L which was prepared by dissolving KH2PO4 (Potassium Dihydrogen Phosphate) into distilled water. Synthetic wastewater was flowed via gravity from the influent tank located at the higher level and connected to the influent point of each column filter. The sampling was done weekly for influent and effluent to test for phosphorus removal.

![Figure 3.1 : Schematic diagram of lab-scale system](image)

3.2.3 ANALYSIS METHODS

The concentration of Phosphorus was measured by the ammonium molybdate spectrometric method using WESTCO Discrete Analyzer, model Smartchem 200, France. The efficiency of removal of phosphorus was observed by determining the removal percentage of the phosphorus using the following equation:

\[ \text{Removal percentage (\%)} = \left( \frac{\text{influent - effluent}}{\text{influent}} \right) \times 100 \]
in which the initial phosphorus concentration (influuent) in mg/L and the final phosphorus concentration (effluent) in mg/L.

3.3 RESULT AND DISCUSSIONS

3.3.1 (SEM) AND (EDX) TESTING OF RCA

SEM and EDX testing were used in this study in order to examine phosphorus distribution on the RCA surface and in sediment samples. SEM and EDX testing for fresh surfaces of the RCA samples are shown in Figure 3.2 while Figure 3.3 shows the SEM and EDX testing for RCA after treatment. The surface of the RCA sample is covered by loosely bonded cement paste and considerably amount of porous fine particles.

As we know, cement paste contains high amount of Calcium (Adnan et al., 2016). This is due to the higher calcium content, the higher the ability for removing phosphorus. Besides the RCA also contain aluminium and magnesium whereas this element enhance phosphorus adsorption. After two months in the filter system, phosphorus can be seen on the surface of RCA samples after being examined by SEM and EDX testing. Figures 3.3 show the presence of phosphorus on the surface of RCA through EDX mapping and the spectrum analysis of surface RCA samples after a two-month period of the treatment. Figure 3.4 shows the SEM and EDX test for Blast Furnace Slag (BFS) samples. The presence of phosphorus on the surface of RCA is 2.60%. It was similar result by Hamdan and Mara, for BFS sample which is 2.20% presence of Phosphorus which is illustrate in Figure 3.4. Hamdan and Mara, (2013) state that phosphorus rich oxides formed after the effluent from primary facultative pond underwent further treatment in the BFS filter. These findings demonstrate that BFS and RCA has a high capacity for adsorbing phosphorus from wastewater which same took place on the BFS surface and RCA surface.

![Figure 3.2: Energy-dispersive X-ray spectroscopy (EDX) test for fresh RCA](image)
3.3.2 PERCENTAGE OF PHOSPHORUS REMOVAL EFFICIENCY

Figure 3.5 shows graph of percentage of phosphorus removal with different concentration of synthetic wastewater for RCA size (5-10 mm) and (25-30 mm) with five different concentration of synthetic wastewater. For RCA size (5-10 mm), the percentage of Phosphorus removal in initial concentration 10 mg/L is 99.54%, then 76.92% for initial concentration 20 mg/L while 74.94% for initial concentration 30 mg/L, 69.91% for initial concentration 40 mg/L and lastly 67.60% for initial concentration 50 mg/L.

Next, for RCA size (25-30 mm), the percentage of Phosphorus removal in initial concentration 10 mg/L is 94.49%, then 68.95% for initial concentration 20 mg/L while 67.89% for initial concentration 30 mg/L, 66.42% for initial concentration 40 mg/L and lastly 66.25% for initial concentration 50 mg/L.
The highest percentage of Phosphorus removal is 99.54% which is in concentration 10 mg/L for RCA size 5 mm to 10 mm while the lowest percentage of Phosphorus removal is 66.25% which is in concentration 50 mg/L for RCA size 25 mm to 30 mm. Commonly it can be seen that the percentage of Phosphorus removal decreasing as concentration of synthetic wastewater increasing. From the graph, it defined that the percentage of phosphorus removal decreasing as initial concentration of synthetic wastewater increasing. It was similar due to the outcomes from Wood and Atamney (2016) where (80-90%) of initial Phosphorus where absorbed by Laterite when applying concentrations (10-25 mg/L) and 60% of initial Phosphorus absorbed when higher concentration applied. Regarding to Yihuan and Andrew (2018), the adsorption capacity increased linearly with the initial concentration from (5-30 mg/L), but the amount of Phosphorus removed reach maximum at an initial concentration of 15 mg/L. This suggest that removal of Phosphorus not suitable at higher initial concentration.

Percentage of P removal efficiency was predominantly affected by media size. This is because the smallest size of media, the greater surface available for Calcium Oxide dissolution (Chazarenz et al., 2017). Secondly is the Calcium (Ca) content in RCA. In EDX test it clearly shows to us in figure 2 that RCA contain 26.60% of Ca. Ca is one of the element for enhanced phosphorus adsorption. The porous surface structure of RCA also influenced the ability RCA for removing the P (Xiou et al., 2016). The larger the porosity, the larger the specific surface area where the adsorption mechanism can take place.
Figure 3.5: Graph of percentage of Phosphorus removal with different size of RCA versus different concentration of synthetic wastewater
3.4 CONCLUSION

This study showed the higher percentage of removal of Phosphorus at lower concentration synthetic wastewater which is 10mg/L is 99.54% which is RCA size 5 mm to 10 mm and it was proved that RCA is one of the absorbent that is good efficiency for removal of phosphorus.

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