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Vertical Aerated Recycled Concrete Aggregate Filter for Removal of Phosphorus

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Abstract: This paper assesses a new design of recycled concrete aggregates as vertical aerated filter for removal of phosphorus (P). Recycled concrete aggregates (RCA) obtained from crushed concrete waste. In this study, RCA is used as an Aerated Filter for removal of P. A commercial concrete was crushed, and the RCA were sieving according to different sieve size. The highest percentage passing sieve size is size 5 mm to 10 mm is 99.54%. The pH value for RCA is 9.30 which is alkaline. RCA with smallest size and lowest initial concentration of P which is 5mm to 10 mm and 10 mg/L respectively has the lowest uptake capacity which 0.995 mgL-1/g. Moreover, the RCA also contain Phosphorus (P) element which is that it proven for us that RCA has a high capacity for absorbing phosphorus. After a few months in the aerated filter system, phosphorus can be seen on the surface of RCA samples after being examined by EDX test. The usage of RCA will ease the environmental problems that are currently perceived globally. RCA could also saves landfill space which helps reduce the needs for gravel mining and reduces pollution.

Keyword: Recycled Concrete Aggregates; Phosphorus; Aerated; Crushed Concrete Waste.

1.0 Introduction

Eutrophication of fresh water bodies is one of the main problems facing aquatic ecosystems. In developing countries, approximately 75% of domestic wastewater is released to the environment without treatment [1]. Ayaz *et al.* (2012) reported that eutrophication in receiving water bodies may occur when phosphorus concentrations of nitrogen (N) was 6 mg/L [2]. Therefore, proper treatment to remove phosphorus from domestic wastewater to achieve the admissible level for natural systems is needed.

Phosphorus (P) is an essential nutrient element for aquatic 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, greatly accelerating the depletion of dissolved oxygen (DO) in waters, even leading to serious eutrophication. The management of the collected debris and waste causes real problems at the environmental level. Apart from that, Recycled Concrete Aggregates (RCA) have choose as part of our commitment to helping the environment and being sustainable.

Recycling of concrete is important because it helps to promote sustainable development in the protection of natural resources, and reduces the disposal of demolition waste from old concrete. Crushed waste concrete was used in this study to evaluate its performance as an effective filter for phosphate reduction. Hence, in this study the RCA has been choose to be the materials for filters the removal of phosphorus. The growth of the world population, widespread urbanization and the economic condition of developing countries has remarkably increased the pace of development of the construction industry. As a result of these activities, old constructions are being demolished to make new buildings. Due to these large-scale demolitions, a huge amount of debris is generated all over the world, which causing serious environmental pollutions including a disposal problem. Therefore in this study, recycled concrete aggregates are chosen to be as a medium to filter the waste water for removal of phosphorus.

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2.0 Research Method

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.

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. 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 KH_2PO_4 (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 aeration was controlled to ensure tiny and uniform bubbles of air spread throughout the column filters. The sampling was done weekly for influent and effluent to test for phosphorus removal. Fig. 1 shows the schematic diagram of lab-scale of vertical aerated filter.

Analysis Method

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:

Removal percentage (%):

$$\frac{\text{influent}-\text{effluent}}{\text{influent}} \text{ x } 100 \quad (1)$$

in which the initial phosphorus concentration (influent) in mg/L and the final phosphorus concentration (effluent) in mg/L.

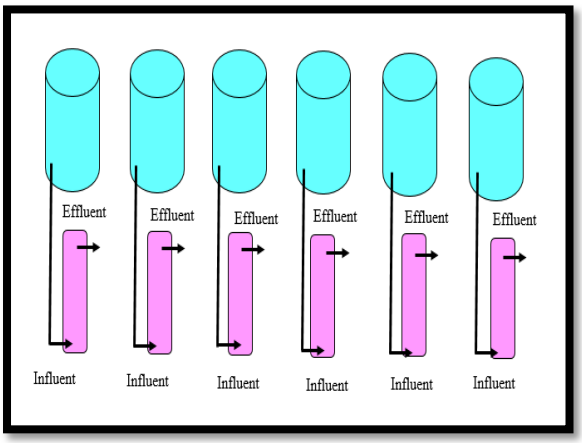

Fig. 1 Schematic diagram of lab-scale of vertical aerated filter.

3.0 Result and Discussion

Energy dispersiveX-ray spectroscopy (EDX) test

As we know, cement paste contains high amount of Ca. This could verify the highest dosage of RCA removed highest amount of P. This is because the higher the calcium content, the higher the ability for removing phosphorus. Besides the RCA also contain aluminium and magnesium which is this element enhance phosphorus adsorption. Moreover, the RCA also contain Phosphorus (P) element which is that it proven for us that RCA has a high capacity for absorbing phosphorus. After a few months in the aerated filter system, phosphorus can be seen on the surface of RCA samples after being examined by EDX testing. Fig. 2 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.

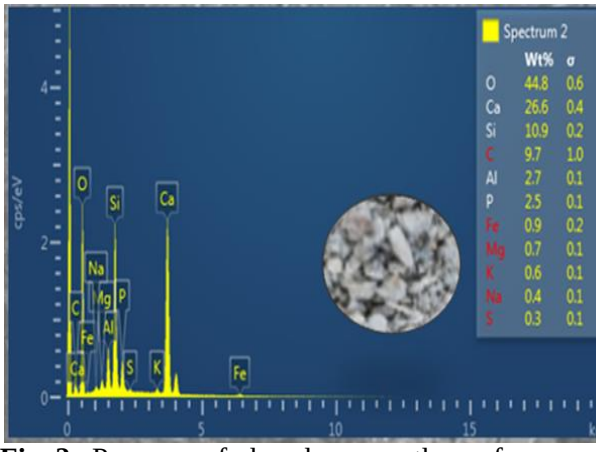

Fig. 2 Presence of phosphorus on the surface of RCA through EDX testing.

Percentage of phosphorus removal

Fig. 3 shows graph of percentage of Phosphorus removal with different size of RCA vs different concentration of synthetic wastewater for RCA size 5 mm to 10 mm and 25 mm to 30 mm with six different concentration of synthetic wastewater which is 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L, 50 mg/L and distilled water. The highest percentage of P removal is 99.54% which is in concentration 10mg/L for RCA size 5 mm to 10 mm while the lowest percentage of P removal is 66.25% which is in concentration 50 mg/L for RCA size 25 mm to 30 mm.

Generally it can be seen that the percentage of P removal decreasing as concentration of synthetic wastewater increasing. From the graph for different size of RCA which is 5 mm to 10mm and 25 mm to 30 mm, it is obvious shown that RCA which smallest size and lower concentration have the highest percentage of P removal. This results, shows the similarities finding with Akratos and Tsihrintzis (2007) found greater removal efficiency of P removal for fine gravel is 89%, followed by medium gravel with cattail 67% and cobbles (57%) [3]. 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 [4]. Secondly is the Calcium (Ca) content in RCA. In EDX test it clearly shows to us in in previous sub-chapter 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 [5]. The larger the porosity, the larger the specific surface area where the adsorption of mechanism can take place.

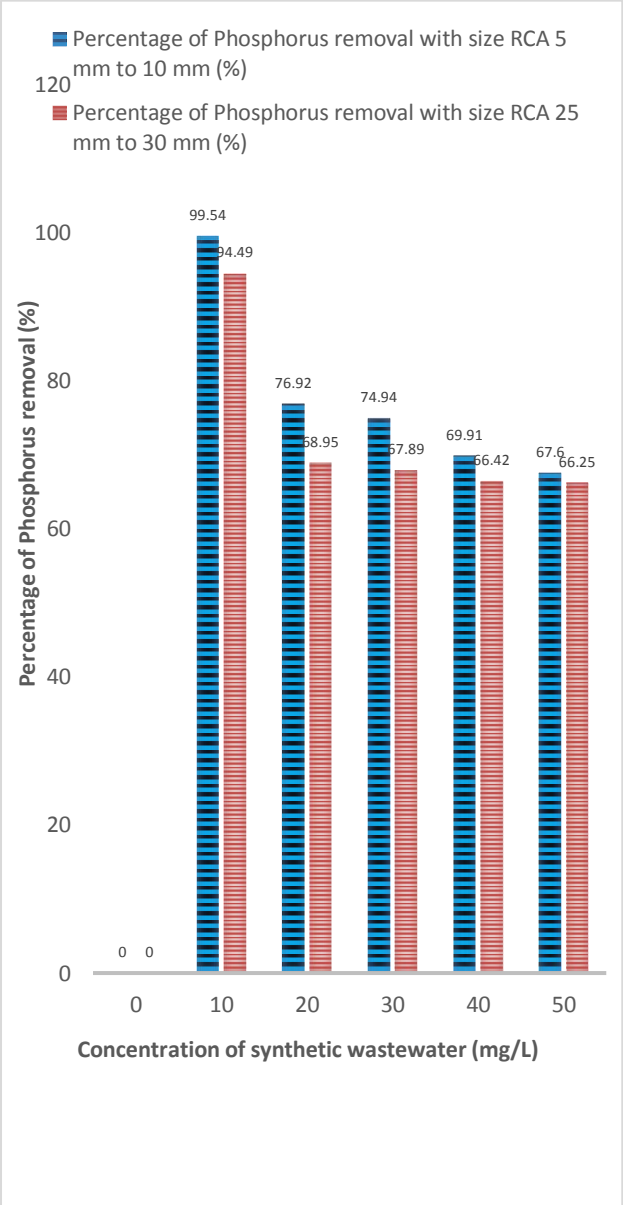

Fig. 3 Graph of percentage of Phosphorus removal with different size of RCA

The correlation uptake capacity on different size of RCA versus initial concentration of synthetic wastewater

Fig. 4 show the linear correlation coefficient uptake capacity on different size of RCA versus initial concentration of synthetic wastewater. The linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables.

From the graph we can see that the R^2 between the uptake capacities of Phosphorus is near to 1.00 which is 0.9916 for the RCA size 5 mm to 10 mm while for RCA size 25 mm to 30 mm the R^2 is 0.9929. Thus, the correlation coefficient the uptake capacity on different size have a strong positive linear correlation due to R^2 is close to +1.

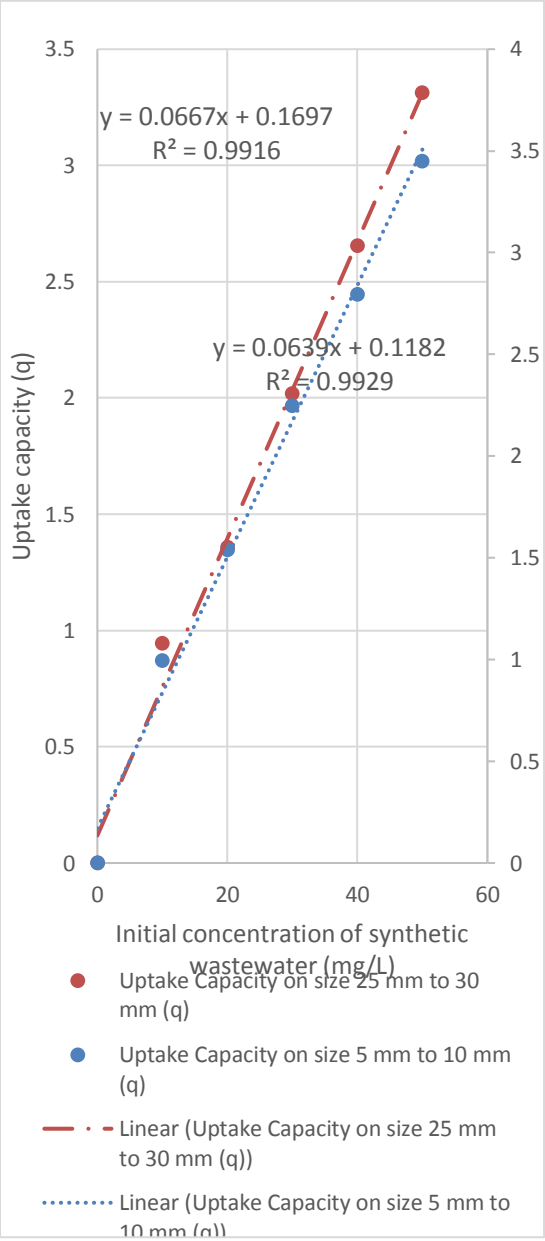

Fig. 4 The linear correlation coefficient uptake capacity on different size of RCA versus initial concentration of synthetic wastewater.

4.0 Conclusion

This study showed the higher percentage of removal of Phosphorus at lower concentration synthetic wastewater which is 10 mg/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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