Innovative Uses of Recycle Waste Materials as an Artificial Concrete Reef for Estuarine Ecosystem

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Abstract. This study enveloped an innovative uses of banana peel particles (BPP) incorporated with recycle aggregate concrete (RAC) from construction waste as an artificial concrete reef for estuarine ecosystem. An artificial reef concrete composites were made of using BPP reinforced RAC as a matrix. The concretes composite cube were prepared in a percentages of 10%, 20% and 30% of BPP to RAC respectively. The concrete cubes without BPP was used as control cubes. The compressive strength of an artificial reef concretes composite s were carried out at 28 days. The total nutrient dispersed were determined using total nitrate (TN), phosphorus (TP) and organic carbon (TOC) test of the water samples in 6 days. The results showed that the averages compressive strength were 26.8 MPa for 10% of BPP, 18.3 MPa for 20% of BPP and 11.4 MPa for 30% of BPP, respectively. The concrete cubes without BPP was used as control cubes. The compressive strength of an artificial reef concrete composite increased gradually with time as more percentages of BPP added to concrete composites and on the contrary, the compressive strength indicated decreases with the increased of BPP.

Wet can be concluded that, BPP from the agriculture wastes could be used as potential nutrient sources of nitrogen, phosphorus and organic carbon for an artificial concrete reef in estuarine ecosystem with some further study on mechanical properties to increase the compressive strength of an artificial reef composite concretes.

1. Introduction
The by-product of human and industrial activity that has no residual value is defined as the waste [1]. Malaysians produce an average of 30,000 tons of waste every day and only 5 percent of it is recycled. These two statistics were recently revealed by the national Ministry of Urban Wellbeing, Housing and Local Government in 2017 and they’re causing enormous problems for Malaysia. The waste can be processed to produce recycled materials which is usable in the household applications to a variety of
industries. It is important that these wastes are recycled and reused or turned into highly beneficial outputs in order to sustain the renewable resource, safe ecological damage, bring economical profit and develop a sustainable civilization. Numerous studies have been done towards utilising by-products [2-6] and [7] thus, the goal of this research to investigate the mechanical properties and leaching behaviour of concrete composites structures for artificial reef made by construction and plantation solid waste.

In Malaysia, artificial reefs are referred to as any man-made structures or natural objects placed in marine water body to provide new habitat for fish and other flora and fauna, and at the same time prevent the encroachment of destructive gears such as trawls into protected areas [8], and some researchers like conclude that, an artificial reefs either aggregate existing scattered fish or allow secondary biomass production through increased survival and growth of new individuals as a result of the shelter and food resource provided by an artificial reef [9]. The artificial reef composite concretes for this research made of using construction waste as recycled aggregate concrete reinforced with banana peel particles from banana by-products or classified as agriculture waste. Artificial reefs can be defined as the human-made structure or natural object placed in water that can be used as the habitat for the flora and fauna. Artificial reefs have been placed in the marine environment since at least 1655, which is apparently the date of the first recorded deployment [8]. However, it is likely that their habitat providing function was recognized by fishermen long before that. Currently, artificial reefs are used worldwide for diverse functions: primarily to enhance fishing and recreational diving, but also to prevent trawling, provide beach protection, mitigate marine construction, etc. The different type of artificial reef can affect the attraction of fish. The most optimal shape of the artificial reef that can be used to attract the fish to come and build its colony at the reef is largely voided space. Concrete has been found to be very favourable for artificial reef construction. However, pure concrete materials can be expensive and may later leach elements which can be toxic to marine organisms and hence destructive to the environment. In order to provide the habitat for the aquatic flora and fauna, the aim of the artificial reef is to maintain the ecosystem structure and functions. Therefore, organic materials are added to the concrete reef mixture to promote aquatic organism growth. This organic material release usable nutrients to microorganisms in the vicinity of the artificial material. Some of the suitable organic materials may include agriculture wastes, animal by-products, and other waste materials from plant or animal origin.

2. Materials
Materials used in this research were banana peel particles from an organic waste and recycled aggregate concrete from construction waste.

![Figure 1](image)

(a) Banana peels and (b) Banana peels dried under sunlight.
2.1 Banana Peel Particles
Banana or *Musaceae sp* is one of the world’s most important fruit crops that is widely cultivated in Malaysia and other tropical countries for its valuable application [2]. Its enormous by-products are an excellent source of highly agriculture waste [4]. Banana by-products such as peels, leaves, pseudo stem, stalk and inflorescence. Banana peel collected from the garbage bin at local fruits and food stalls. Banana peels are chop into a particles and dry under a sunlight until it dry for two (2) weeks.

2.2 Recycle Aggregate Concrete
Concrete is one of the most used materials in construction [6] and at the same time, one of the materials with the higher contribution to construction and demolition (CDW) waste generation [10]. In this study recycled aggregate concrete used, were collected from construction wastes then grinded into a small particles. Figure 2 depicted the figure of control cube concrete with 0% BPP reinforced RAC and b) BPP reinforced RAC concrete cubes immersed in water.

![Figure 2](image1.jpg)  
Figures 2. (a) Control cube concrete with 0% BPP reinforced RAC and (b) BPP reinforced RAC concrete cubes immersed in water.

3. Methodology
3.1 Preparation of An Artificial Reef Cube Concretes
Recycled aggregate concrete (RAC) uses as matrix and banana peel particles (BPP) used as reinforcement to fabricate an artificial reef cube concretes. A cube concretes are dried in a room temperature for 28 days. There were different compositions in a weight percentage; 10%, 20% and 30% used to determine an optimum composition of BPP reinforced RAC cube. Test cube concretes were prepared by using hand mixing and the mould casting dimension is 150 mm x 150 mm x 150 mm.

3.2 Compressive Test
The compressive tests were conducted to determine the compressive strength of an artificial cube concretes at 28 days of age. The correlation between weight percentages of BPP to RAC towards compressive strength then analysed. There were six (6) cube concretes tested for each different compositions of BPP to RAC cube.

3.3 Determination of Organic Compounds Leached
The water sample before the cube concretes are put inside was taken as a control cube. The constant wave parameter was applied in this test using small scale wave simulation tank. Then, the water sample after the cube concretes were put inside was taken again to determine the total amount of organic compounds leached. The total amounts of an organic compounds leached into a water were
observed for each days after immerse in a 6 days. The spectrophotometer was used to record the reading of organic compounds leached into a water.

4. Results and discussion

4.1 Compressive Strength

As report by Noridah et al., [3] 2016 the compressive strength of the reef can be influenced by the properties and the amount of the agricultural waste used and the properties of the recycled aggregate. In their study, it has been reported that increased percentage of peanuts shell in the concrete resulted with decreased strength of the concrete. This study revealed that the highest compressive strength of BPP reinforced RAC are 26.8 MPa of 10% BPP to RAC, 18.3 MPa of 20% BPP to RAC and 11.0 MPa of 30% BPP to RAC, respectively. The compressive strength for control cube with 0% BPP to RAC is 43.0 MPa. It can be concluded that the compressive strength are decreased with the increased of weight percentages (wt %) of BPP. This is happen may be because some manufacturing defects as has been occurred. As reported by Suriani et al.[11, 12] defects typically occur during the commercial production of composites and can be caused by batch to-batch variations in the prepreg and sometimes by the manual construction known as a ‘lay-up’. In composite materials, variability could arise from differences in the prepreg tack level during lay-up as a result of variable resin content. Composites can contain a number of defects introduced during manufacturing such as, voids, resin-rich zones, pockets of undispersed cross-linker, misaligned fibres and regions where resin has poorly wetted the fibres which can considerably increase the likelihood of composite failure [17]. While in this study, with the increasing of BPP weight percentages had decreased the compressive strength because of the lesser bonding between interfacials adhesion may also cause by the defects occurred [13]. Naidu et al., in their study on characterisation and mechanical properties of banana peel reinforced composite reported on the same trend of decreasing on the mechanical properties caused by voids occurred [14, 15].

![Percentage of BPP (wt%) vs Compressive Strength (MPa)](image)

**Figure 3.** Compressive strength properties of banana peel particles (BPP) reinforced recycle aggregate concrete (RAC) at different weight percentages.

4.2 Total Organic Carbon, Phosphorus and Nitrogen Leached

Figure 4 shows the total organic compounds leached into water sample after 6 days immersion. It can be concluded that the amounts of total organic compounds released into water increased with the increased of amount of BPP. The total amounts of organic compounds also increased with the period of immersion from day 1 to day 6.
Figure 4. Total amount of nutrients (a) Total Nitrate (TN), (b) Total Phosphorus (TP) and (c) total organic Carbon (TOC) leached from banana peel particles (BPP) reinforced recycle aggregate concrete (RAC).
As depicted in Figure 4 a), b) and c) the amounts of total nitrate (TN) released into a water is 34.3% to 41.5%, the amounts of total phosphorus (TP) released into a water is 58.2% to 70.3%, and the amounts of total organic carbon (TOC) released into a water is 7.2% to 10.6%, respectively. This is similar to the finding of research did by Jiang et al., (2012) on leaching behaviour of total nitrogen, total phosphorus and total organic carbon from banana peel [16].

5. Conclusion and recommendations
This research has approved the use of BPP reinforced RAC concrete as an artificial reef with the present of organic compound leached to the water that provided a direct or indirect impact to estuarine ecosystem. Therefore, this research is significantly solved one of nation issues on solid waste management and pollution, contributes to a green and sustainable estuarine ecosystems, enhances health and safety lifestyle to community and gives the good economic impact as well. Further study on the surface morphology of the artificial reef manufacturing defects may resulted a better understood on compressive strength of the artificial reef concretes.

6. References
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