ABSTRACT

Phosphorus is an important element for the plant growth, and it is used as a fertilizer. It is a limited and non-renewable resources in the earth. But when the excessive amount of phosphorus goes into waterbody, it works as a nutrient for aquatic plants and algae and causes eutrophication. So, the recovery of the phosphate from water is very important to avoid eutrophication and recover phosphate to use as fertilizer.

Phosphate recovery using adsorption is a very attractive and effective method. Nowadays different types of natural bio waste material are used for phosphate recovery. Using biochar only is not suitable for phosphate adsorption because of the negative surface charge of the biochar. But metal modified biochar has good phosphate adsorption capacity. Sometime the adsorbed material could not be used as fertilizer because of presence of heavy metal in modified adsorbent.

Eggshell decorated biochar exhibits excellent phosphate adsorption capacity than only biochar. Moreover, calcium is not toxic. That's why current study was intended to recover the phosphate from wastewater using a most convenient procedure and available materials. Bamboo and eggshell were used as an available natural ingredient which was not used for phosphate recovery before. Since bamboo char is the source of carbon and eggshell as the resource for $CaCO_3$, would be used as a metal cation which has great affinity for phosphate. So, the combination of pure biochar with calcite could be a good adsorbent material to recover phosphate from wastewater. Another objective of this study was to examine the phosphate desorption using DI water at different temperature and the effectiveness of the phosphate loaded materials as P fertilizer on Japanese mustard spinach cultivation for the sustainable management of the P adsorbed material.

Bamboo and eggshell adsorbent were prepared for different mixing ratio and temperature (600, 700, and 800°C) to find out effective ratio and calcination temperature. To investigate the feasibility of calcined bamboo and eggshell for phosphate removal, different calcination temperature, initial concentration, temperature, time, dose rate, pH, and presence of different ions was examined. Adsorption mechanism was understood by adsorption isotherm, thermodynamics study, and adsorption kinetics. Morphological changes and characterization of the adsorbent after calcination and adsorption were identified by the SEM image, EDX spectra and FTIR analysis. The maximum P adsorption capacity of the BE 1:1 and BE 2:1 was found 95.14 mg/g and 98.40 mg/g respectively. For CE, BE 1:1 and BE 2:1 adsorbent, the data

were well fitted by Langmuir model, and it indicates the monolayer adsorption on the homogenous surface of the adsorbent. Thermodynamics results revealed that the Gibbs free energy ΔG of the BE 1:1 and BE 2:1 at 298 K, ΔG was positive indicates the process was not spontaneous. But after increasing temperature the reaction was spontaneous. Langmuir separation factor (R_L) value indicates the favorable adsorption conditions for phosphate.

Characterization of adsorbent was identified by FTIR, and SEM image. From FTIR analysis the formation of the band at 1021 cm^{-1} was observed, which clearly indicated the presence of phosphate after adsorption on BE 1:1. From kinetic study it has been found that the experiment data were better fitted the pseudo second order model which explain that adsorption procedure was chemisorption process. Presence of different ions (anions and organic acids) and pH of the solution also influence the phosphate adsorption mechanism. But calcined BE 1:1 is not effective for the organo-phosphorus herbicide glyphosate removal which is beneficiary for this research because it will not compete with phosphate for active sides and don't make contamination in application of phosphate adsorbed material as fertilizer.

In this study phosphate desorption in Milli-Q water and NAC extraction method was examined. Then phosphate dropped biochar was applied on pot experiment for Japanese mustard spinach cultivation. From the experiment it was found that phosphate desorption in Milli-Q water was very low. Because the bonding between calcium and phosphate is very strong. So, the reuse of the adsorbent is not a good option. But the phosphate loaded eggshell modified bamboo char was effective as slow-release fertilizer for the Japanese mustard spinach cultivation. So, the phosphate loaded eggshell modified bamboo char has potentiality to use in plant cultivation as a phosphorus fertilizer.