

# Reclaiming Phosphorus from Wastewater Effluents including Renewable Biochar

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## Abstract

The use of renewable biochar for the recovery of phosphate has great potential for environmental and socio-economic benefits. The low cost, renewable agriculture and animal waste biochar can be used for beneficial application such as pollution remediation as an adsorbent, catalyst, soil fertility improvement etc.

**Keywords:** Biochar; Phosphate adsorption; Agriculture waste etc

## Introduction

Phosphates are essential nutrients for plants and other biological organisms. So far, this element is one of the fundamental building blocks which mainly constitute nucleic acids (DNA and RNA), complex carbohydrates and phospholipids [1]. In order to feed rapidly increasing human populations, more lands need to be cultivated and crop yields should be increased. For this purpose, we require P-based fertilizers which are going to replenish. Also, the global phosphate rock reserves are complicated and depleting. It is due to exploitation of environmentally and culturally areas where phosphates are found [2]. Therefore, recoveries of phosphates from environment is very important to concurrently reduce the negative impacts of eutrophication as well as helping to transform P from a limited source into a more renewable resource. Similarly, intensive concentrated animal feeding operations (CAFOs) system is currently an important part of agricultural economy. On the other hand, this kind of practice usually generates a great deal of wastewater, which mostly contain high concentration of phosphorous. If this wastewater is not treated reasonably, it can also facilitate mosquito breeding and the spread of bacteria in rural areas when it is exposed

to air. Also, these kinds of increasing discharges from human industrial activities, mostly phosphorus pollution become global environmental problem. Even small amounts of phosphate on surface water can enhance algal blooms and cause eutrophication. In fact, eutrophication leads excess algae overgrowth, which can threat aquatic systems as well as human health. Eutrophication has serious economic impacts as the aesthetic and recreational qualities of the water bodies as well as industrial use. More serious impacts may also occur due to eutrophic conditions causing cyanobacteria species, some of them produce toxins that can cause harm to humans and domesticated animals. Once a lake has become eutrophic, it could take several years or more to remediate [3]. Regarding all these scenarios, eutrophication has been identified as a major threat that needs to be addressed as soon possible.

In the past, most studies were focused on powdered activated carbon (PACs) which can effectively remove organic micro pollutants from wastewater. However, PAC production is energy intensive, time consuming and expensive [4]. In literature, some studies have shown that biochars, which are solid products,

generally produced from the thermochemical treatment are capable of adsorbing various species including phosphates. Bio-chars can be obtained from any waste biomass which mostly includes (saw dust, bagasse, corn stalks, tomato tissues, orange peels etc.) [5]. Recently, it was studied municipal waste biochar in wastewater treatment for nutrients recovery [6,7]. In these studies, the municipal waste biochar successfully used for nutrient recovery in the wastewater. This allows not only removal of potential pollutants in wastewater but also promoting sustainable agriculture through the use of nutrient enriched biochar in soil amendment. To improve the adsorption capacity of biochars in aqueous phase, nowadays several attempts have been conducted to synthesize engineered biochars with unique structures and surface chemistry properties [8]. In fact, engineered Mg-biochar nanocomposites with nano-sized magnesium oxides (Mg-O) reported higher adsorption capacity of phosphate in aqueous phase [9] studied chemically modified biochars for the phosphate recovery. The studies concluded that biochar phosphate intake capacities can be improved by chemical activation of biochars (post-treatment) and biomass (in-situ treatment) with metal salts, KOH and acids. However, the phosphate adsorption observed was minimal.

Recently, there has been a significant interest in converting agricultural and forest biomass into value-added products, mostly adsorbents for the mitigation of environmental pollutants. Several researchers proposed agricultural/ fruits waste as precursors for synthesis of activated carbons for the removal of contaminants in water. Additionally, removal efficiencies were dependent on pyrolysis process temperature and pH of the system. Since biochar is a generic term, its characteristic solely depends on its composition of the source biomass and pyrolysis conditions. Different feedstock has different proportions of element composition, and thus exhibits different properties as well as various performance. For example, straw derived biochar had a higher potassium content and pH than the wood biochar. Moreover, the straw derived biochar had higher volatile content, which can be more easily removed than non-volatile content during the pyrolysis process. Also, manure from pig and cow showed different proportions of element composition. Therefore, the types of feedstocks have significant effects on the physiochemical properties of biochar. The biochar converted from anaerobically digested sugar beet tailings demonstrated great ability to remove phosphate from water [10]. In future, renewable resources should be considered as adsorbents. In fact, protein containing waste biomass are good choice. The high content of terminal amino groups are effective adsorbents for all kinds of organic and inorganic pollutants. Furthermore, biochar obtained from renewable wastes could synergistically improve water and air quality, carbon sequestration, greenhouse gas emissions mitigation etc. Furthermore, biochar can also be used as catalyst in wet air oxidation process.

## Biochar as a Universal Sorbent

Biochar is not only used for phosphorus reclamation, but it also has capacity to serve green environment sorbent. The use of carbonaceous materials has been reported elsewhere as sorbents for organic and inorganic contaminants in soil and water [11,12]. Mostly, the use of biochar to remove most persistent organic contaminants such as pesticides, herbicides, poly-cyclic aromatic hydrocarbons, dyes and antibiotics are of great interest. Only limited studies are available in literature to remediate soil contaminants. Therefore, future studies should focus on the use of renewable biochar from waste biomass to treat soil contaminants. Although biochar can have a different effect on the mobility of contaminants such as metal, the use of diverse agriculture products biochar can be used for specific purpose. For example., biochar derived from soybean stalks work better for phenanthrene and (Hg II) adsorption [11]. Furthermore, the use of magnetic biochar from waste biomass has remarkable application in various industries [13].

## Concluding Remarks

Mountains amounts of dairy manure, wastewater, other industrial and agriculture by products are responsible for environment pollutions. However, combined modifications of these waste resources in the form of biochar exhibited high adsorption ability for phosphate and other contaminants at low cost. Undoubtedly, the use of biochar from waste biomass have great implications. Converting waste lignocellulosic biomass into biochar will offer effective solution for the safe and beneficial disposal. On the other hand, it can be used as adsorbents, renewable energy, remediate contaminated soil etc.

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## Conflict of Interest

No conflict of interest.

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