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Potential for Treating Sewage Wastewater Using Sewage Sludge Biochar

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Abstract: In this study, activated biochar from municipal sewage sludge was used for the treatment of sewage water. The sewage physicochemical parameters were measured before and after bio filtration with biochar applying the principle of adsorption using the standard methods. Biochar with 500 m2/g surface area at a loading of 2.5 g/L was employed. A reduction of more than 75% was observed for the total nitrogen, biological oxygen demand, chemical oxygen demand, total solids, electrical conductivity and the total phosphates. The sewage pH changed from alkaline to neutral after the adsorption process. Conversion of sewage sludge from biochar does not only present an opportunity for waste management but also effective water management.

Keywords— Biochar, bio contaminants, sewage water, sewage sludge

Introduction

Water is a scarce resource and its management for reuse is critical. Sewage water is generated every second and this results in the accumulation of sewage sludge in municipal sewage treatment plants which if not managed properly will result in environmental contamination [1]. This sewage sludge has potential to be converted to bio char, which is a good bio filter in wastewater treatment [1, 2]. Biochar is created by heating biomass to high temperatures under low oxygen conditions in a process known as pyrolysis [3]. The biomass remaining after pyrolysis becomes a fine-grained, highly porous charcoal-like material, rich in carbon [4]. Biochar's pores give the material extraordinary amounts of surface area,

often exceeding 400 m2/g [4]. This surface area makes biochar a highly adsorbent material. Biochar's high carbon content also makes the product highly resistant to decomposition [5]. In this study, biochar was made from sewage sludge and then evaluated for the potential of treatment of the sewage sludge.

I. Materials and Methods

A. Materials

Sewage sludge and sewage was obtained from a local sewage treatment plant. Filtered sewage water was used for determining the effect of biochar on bio contaminants removal whilst the sewage sludge was used for biochar production.

B. **Methods**

Biochar preparation

Biochar was made by slow pyrolysis of sewage sludge at 200-600 °C at a maximum heating rate of 1.0 °C/s. The pyrolysis products had 40% biochar and the rest were volatile gases and liquids. The biochar was ground to a particle size of less than 0.5 mm determined through sieve analysis. Biochar was loaded at 2.5 g/L in a batch filter at a retention time of 3 days.

Sewage treatment by adsorption using biochar

In order to study the bio contaminants removal efficiencies, batch experiments were conducted thrice. In each experiment, 100 mL of the sewage water was poured into 250 mL glass beaker. 2.5 g/L biochar loaded with sodium chloride as an activation procedure in order to increase the adsorption efficiency and porosity of the sewage sludge biochar. The activation was conducted in accordance to methodology described by Ahinduzzaman and Islam [6].

Sewage properties analyses

The raw sewage and the treated sewage's physicochemical characteristics were determined. The parameters determined included: total phosphates (TP), total Kjeldahl nitrogen (TKN), chemical oxygen demand (COD), biological oxygen demand (BOD5), total solids (TS), electrical conductivity (EC) and pH. The physiochemical parameters were determined in accordance to APHA (2005) [7].

Biochar characteristics

The biochar had a surface area of 500 m2/g determined in accordance to an earlier described method [8], organic carbon content of 72% and pH of around 8. The biochar used in this study is shown in Figure 1.

Figure 1: Biochar from sewage sludge used in this study

II. Results and Discussion

A. Effect on organic matter removal

The organic matter removal was measured through the behavior of the COD and BOD concentration after adding biochar over time. The COD and BOD significantly reduced by 91% and 95% respectively in the sewage water (Figure 2 and Figure 3). The reduction in the sewage COD and BOD is attributed to the adsorption of the bio contaminants. Dalahmeh *et al*. [9] also

reported a 99% efficiency removal in COD after using activated biochar for the treatment of grey water. The effective removal of bio contaminants as indicated by the COD and BOD reduction can also be attributed to the biological activity due biological action on the biofilm formed on the biochar [10].

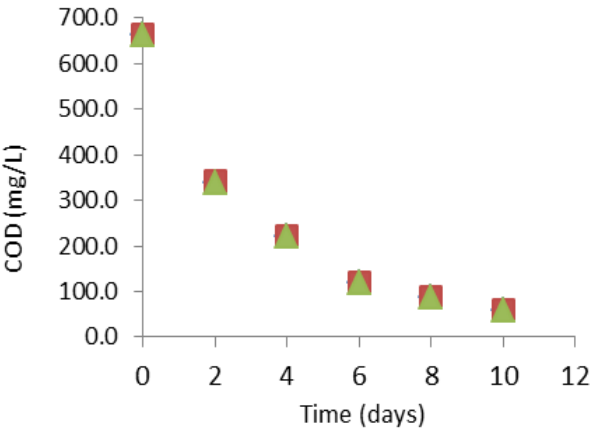

Figure 2: Effect of biochar on sewage COD

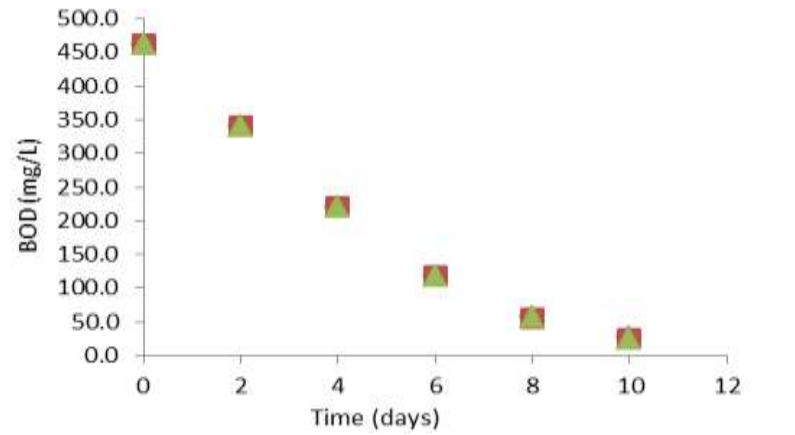

Figure 3: Effect of biochar on sewage BOD

B. Effect on total phosphorous removal

The sewage sludge biochar effectively removed total phosphorous from the sewage water by a total reduction of 78% as shown in Figure 4. Dalahmeh *et al*. [9] also reported an 86% reduction in total phosphates upon treating grey water with activated biochar. This shows that water treatment with biochar as bio filters is effective and must be considered for removal of phosphorous.

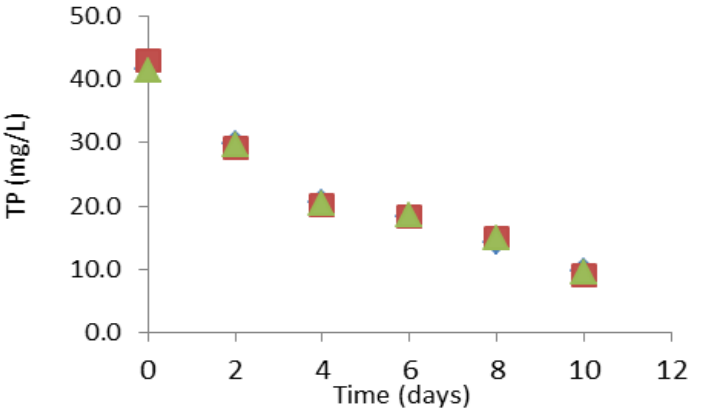

Figure 4: Effect of biochar on sewage water TP

C. Effect on total nitrogen removal

The treatment of sewage water with activated biochar from sewage sludge resulted in a total nitrogen reduction of about 86% as shown in Figure 5. In their study Dalahmeh *et al*. [9] reported a 97% decrease for total nitrogen when activated biochar was used in the treatment of grey water.

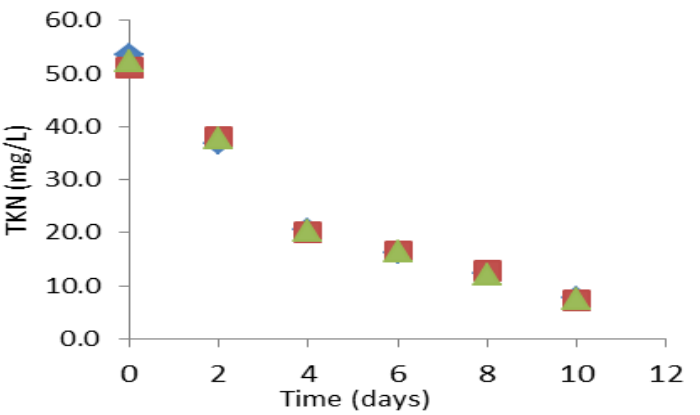

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Figure 5: Effect of biochar on sewage TKN

D. Effect on total solids removal

The total solids in the sewage water decreased upon bio filtration with activated by char from sewage sludge. A reduction rate of 94% was observed over a period of 10 days as shown in Figure 6. The reduction is attributed to the entrapment of solids on the biofilm that would have formed on the biochar during the adsorption process.

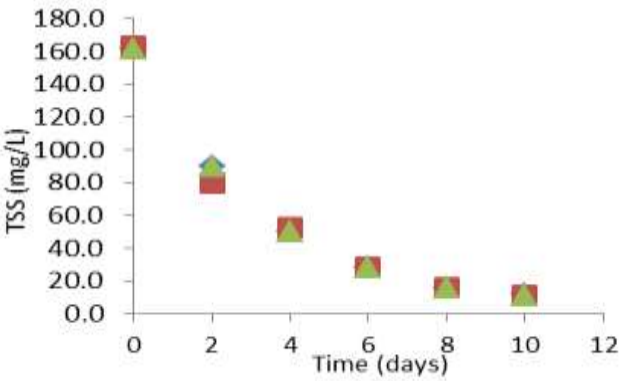

Figure 6: Effect of biochar on sewage total solids removal

E. EC Reduction

The electrical conductivity (EC) of sewage water reduced significantly upon bio filtration with sewage sludge activated biochar by 60% as shown in Figure 7. The reduction in EC is attributed to the reduction in total solids due to their adsorption on the biofilm.

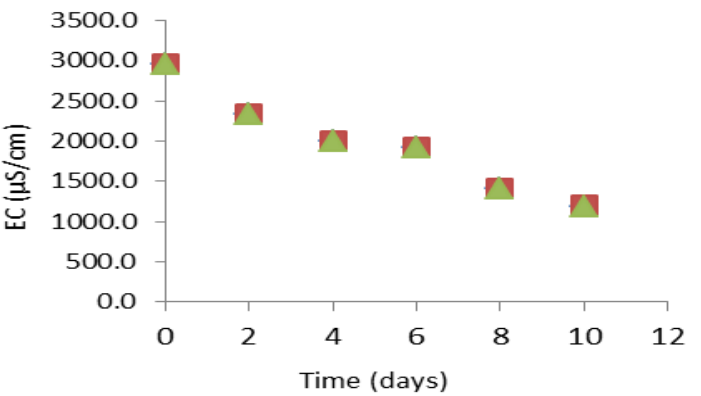

Figure 7: Effect on biochar on sewage electrical conductivity

F. Effect of biochar on pH

During the treatment of sewage water using activated sewage sludge biochar, the Ph changed from alkaline to neutral as shown in Figure 8. Liu and Zhang [11] reported that biochar has potential to neutralize the pH when 4-16g/kg of biochar was added for soil amendment.

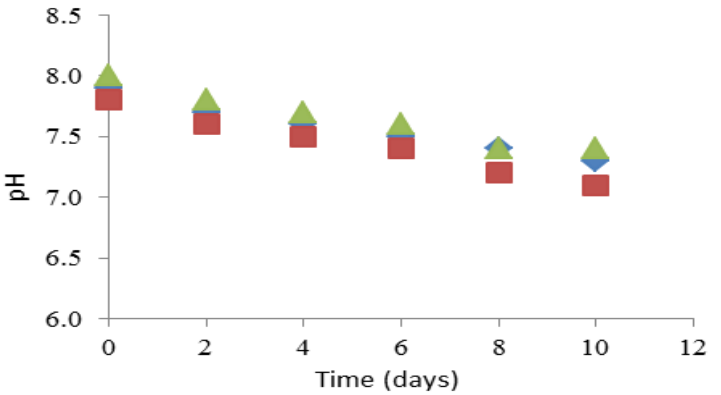

Figure 8: Effect on biochar on sewage pH

Table 1: Summary of Sewage Physicochemical Properties before and after Biochar Adsorption

Parameter	Before biochar filtration	After biochar filtration	%Reduction
pH	7.9	7.0	-
BOD	462	25	95
COD	661	59	91
TP	42	9	78
TKN	52	7	86
TSS	162	11	94
EC	2962	1193	60

III. Conclusion

Biochar effectively treats wastewater through adsorption of bio contaminants. Production of biochar from sewage sludge can be adopted as a waste management strategy. The spent biochar can be utilized as a source of bio fertilizer due to the enrichment of the nitrogen accumulated from the wastewater.

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