Keep it Clean: Using Biochars to Treat Industrial Wastewater

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INTRODUCTION

- Lead is a common contaminant in industrial wastewater and a health hazard to both humans and the environment (Pacyna et al., 2007)
- Biochar is a natural product that can be used to effectively remediate the contaminated water through adsorption while avoiding the creation of other contaminents (Sukmana et al., 2021)
- Adsorption is the adhesion of molecules, atoms, or ions to the surface of an adsorbent
- Biochar is the solid byproduct of pyrolysis
- Pyrolysis is the thermal decomposition of a biomass at high temperatures without the presence of oxygen

Figure 1: the Workplace Hazardous Materials Information System symbol for a health hazard

OBJECTIVES

- To evaluate how effectively biochar removes heavy metals, specifically lead (II), from synthetic wastewater

MATERIALS

1. Peat biochar (fig 2)
2. Synthetic wastewater, a lead (II) nitrate solution at a concentration of 50 mg/L (fig 3)

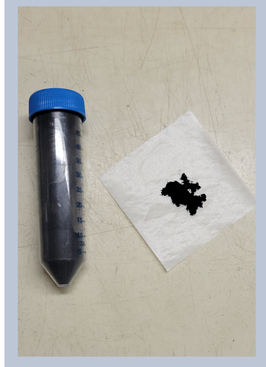

Figure 2

figure 3: Transfering the lead (II) nitrate solution to a large Erlenmeyer flask

- Blanks were double deionized water
- Three replicates were used

METHODS

1. 0.020 g of biochar was measured into Falcon tubes (fig 4)

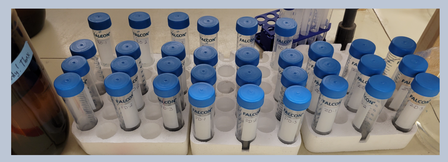

figure 4

2. A solution of lead (II) nitrate at a concentration of 50 mg/L was prepared by dissolving 0.020 g of lead (II) nitrate into 250 mL of double deionized water

3. 20 mL of the lead (II) solution was transfered into the Falcon tubes using a pipette (fig 5)

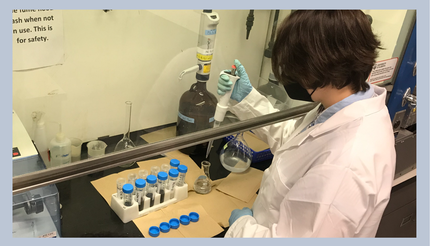

figure 5

Figure 6

4. The tubes were placed in the shaker at 180 rpm for 24 hours. This is to ensure that the biochar and lead (II) solution have reached an equilibrium (fig 6)

5. Using syringes and syringe-filters, 15 mL of each solution was placed into 15 mL falcon tube for lead analysis. Each tube was immediately acidified with 1-2 drops of 70% HNO_3

figure 7

6. With the remaining 5 mL of solution, pH was tested (fig 8) using a pH-meter (fig 7)

figure 8

7. Remaining solution was filtered using filter paper to separate the remaining biochar (fig 9)

8. Filtered biochar was dried at 105 degrees Celsius for 24 hours then stored for Fourier transform infra-red spectroscopy (FTIR), a test that shows the surface functional groups of the biochar

figure 9

RESULTS

The biochar removed over 99% of the lead present in the solution (fig 10)

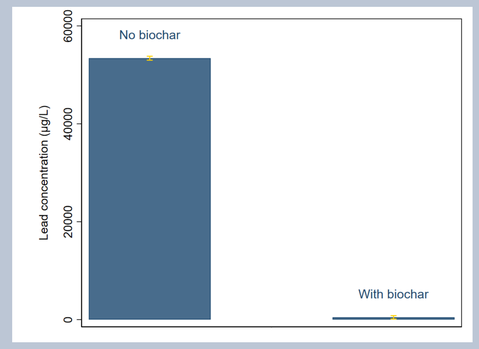

figure 10

The concentration of lead (II) averaged at 53400 µg/L in the solution without biochar while the concentration in the solution with biochar had an average of 462.3 µg/L. The error bars represent standard deviation and are 400 µg/L for the no biochar solution and 348.4 µg/L for the solution with biochar

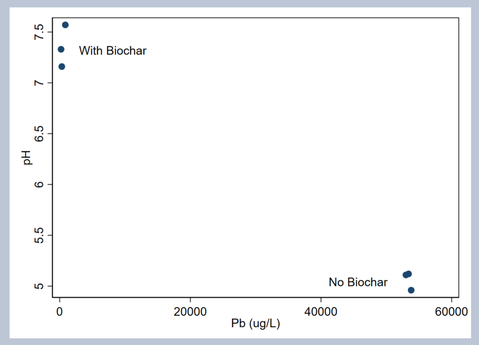

figure 11

The pH of the solution with biochar was always significantly higher, around 7.5, than that of the solution without biochar, which was always around 5.0 (fig 11)

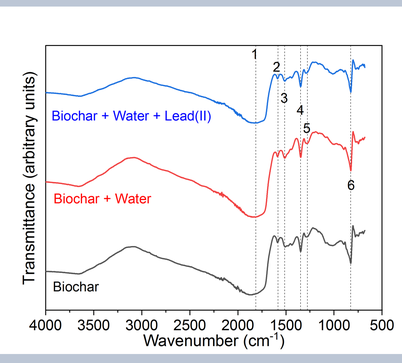

figure 12

The FTIR spectra (fig 12) showed very little change in the surface functional groups of the biochar in any situation

CONCLUSIONS

- Since biochars are alkaline in nature, the higher pH of the biochar solution could have caused the lead to precipitate, making adsorption onto the biochar happen at a very high rate
- Another factor that could explain the 99% removal rate is the negative net charge of biochars which could have caused bonding with the positively charged Pb^{2+} ions
- Finally, the similar peaks of the FTIR spectra might indicate that the surface functional groups did not participate in the lead removal

APPLICATIONS

- Lead (II) is a common contaminant in the water used to extract bitumen from oil sands. Adsorption using biochar is a way to remediate the billion cubic meters of this water that is stored in tailings ponds in Alberta so it can be reused both in the oil and gas industry and beyond

FUTURE DIRECTIONS

- To test more biochars, such as those made from different biomasses, those with different activation processes, and those that underwent pyrolysis at different temperatures
- To test different concentrations of lead (II)
- To test different lengths of reaction time

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CITATIONS

Pacyna, E. G., Pacyna, J. M., Fudala, J., Strzelecka-Jastrzab, E., Hlawiczka, S., Panasiuk, D., Nitter, S., Pregger, T., Pfeiffer, H., & Friedrich, R. (2007). Current and future emissions of selected heavy metals to the atmosphere from anthropogenic sources in Europe. *Atmospheric Environment*, *41*(38), 8557–8566. https://doi.org/10.1016/j.atmosenv.2007.07.040

Sukmana, H., Bellahsen, N., Pantoja, F., & Hodur, C. (2021). Adsorption and coagulation in wastewater treatment – Review. *Progress in Agricultural Engineering Sciences*, *17*(1), 49–68. https://doi.org/10.1556/446.2021.00029

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