Sorption of metals from low-iron acid mine drainage using agricultural waste materials

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Extended Abstract

The use of agricultural wastes for the biosorption of metals has become an emerging technique (Leong 2018) to address water pollution. Agricultural waste from plants, animals, and microbial biomass and their derivatives can serve as raw material for removing metals from low iron acid mine drainage (AMD). The biosorption technique has proven to be effective, inexpensive, and easy to operate for removing metal ions in solution (Agarwal et al. 2010), and aside from these advantages, raw waste required for the technique could be available, cheap, and accessible (Gupta et al. 2015) in AMD-prone environments. The technique also has the potential to remove contaminants from mine water even in dilute concentrations (Monachese et al. 2012), without necessarily requiring high energy input in the process. Due to limited information on the use of specific agricultural wastes to target specific metals, the goal of this study was to conduct experimental trials on selected agricultural wastes common and available in AMD-prone regions within the tropics. This study investigated the capacity of agricultural waste as low-cost sorbents to remove specific metals in lab-created artificial-mine water (AMW). It also examined the effect of solution pH and mass of the sorbent on sorption. Finally, the study analyzed the pH point-of-zero charge of the biosorbents.

The research followed a batch sorption experimental procedure by mixing different masses of biosorbents to remove metals from AMW, considering sorbent mass, pH, and initial concentration as the optimized adsorption parameters. Four masses from 0.1 to 5 mg each of plantain peel, banana peel, bamboo stems, coconut coir, sheep dung, and goat dung were mixed with 35 mL working volume of AMW containing cadmium, copper, lead, zinc, and mercury at different initial concentrations. The mixture was agitated for 24 hours at 150 rpm, and the metal-enriched sorbent was separated from the solution. An ICP-OES was used to analyze the final metal concentration in solution. The experimental procedure was repeated at pH 4 and pH 8 for two masses that achieved the highest removal per sorbent mass at pH 7 and the three biosorbents with the highest sorption capacity, sheep dung, coconut coir, and banana peel. For the pH-pzc determination, the salt addition method using a 0.1 M NaNO3 solution and 24-hour equilibration time was used.

This study showed that the sorption was successful for all the agricultural waste materials at pH 4 and 7. The removal per unit mass of sorbent for each metal and each sorbent at pH 4 and pH 7 is presented (tab. 2 and fig. 1 respectively). The coconut coir, sheep dung and banana peel proved to be the most effective sorbents for removing metals. At pH 8, the study indicated that sorption was not the mechanism for removing metals, but precipitation or co-precipitation drove the removal of the metals. Point of zero charge varied amongst materials (tab. 1), however, the two most effective sorbents, coconut coir and banana peel both had similar pH-pzc between 5 and 6.

***Table 1** pH-point-of-zero (pH-pzc) charge by salt addition method*

Biosorbent	pH-pzc	Standard dev.
sheep dung	7.15	±0.08
coco coir	5.25	±0.64
banana peel	5.8	±0.27

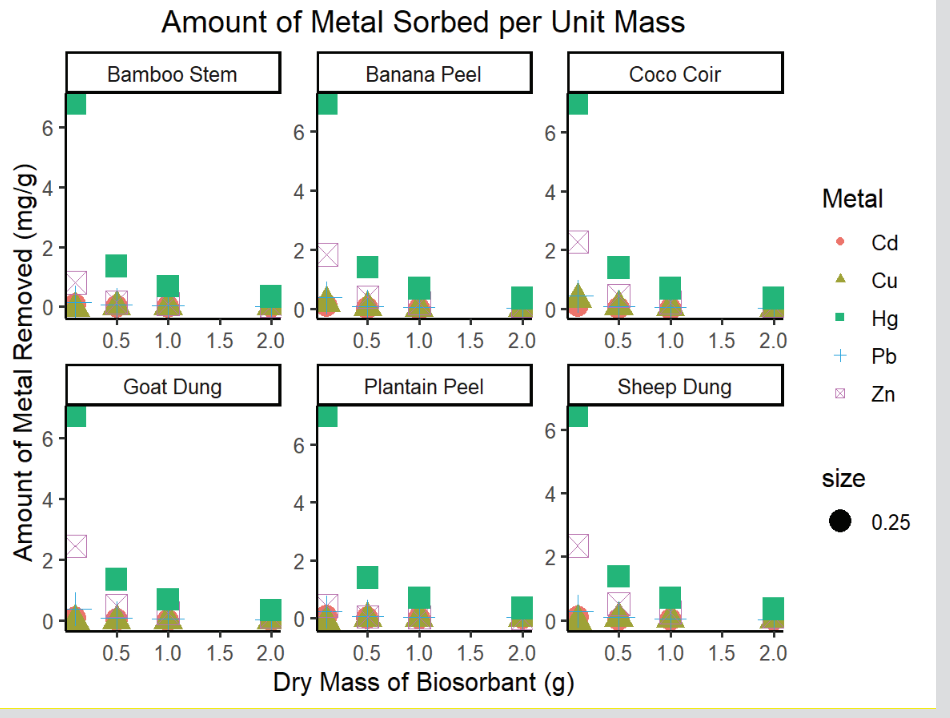

Figure 1 shows the amount of metal sorbed per unit mass of biosorbent at pH 7 at 24 hours at 150 rpm. The largest unit mass of biosorbent achieved the least metal removal

Table 1 Metal Sorbed per Unit Mass of Sorbent (mg/g) at pH 4, at 24 hours at 150 rpm

Metal Conc.	Mass of Sheep Dung		Mass of Coco Coir		Mass of Banana Peel	
	0.1 g	0.5 g	0.1 g	0.5 g	0.1 g	0.5 g
Cd (mg/g)	0.185	0.038	0.185	0.038	0.178	0.036
Cu (mg/g)	1.432	0.293	1.509	0.309	1.127	0.245
Pb (mg/g)	1.715	0.343	1.704	0.342	1.627	0.335
Zn (mg/g)	1.518	0.313	1.353	0.261	1.020	0.245
Hg (mg/g)	0.970	0.214	1.036	0.235	1.204	0.242

Keywords: Waste, low-cost-sorbent, biosorption, small-scale mining, mine water treatment

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