One of the major environmental problems that the world is facing today is heavy metal pollution of water. It is reported in 1996 that the Philippine tanning industry had an estimated annual capacity 46 million square feet of finished leather, of which 60% went to leather footwear industry. A high toxic level of wastewater is produced from tanneries. In Philippine tannery plants, the major source of pollution is chromium compounds produced from retanning and dyeing processes. Various aquatic floras have been identified as organisms capable of sorbing toxic and heavy metals from wastewaters. One of the aquatic plants capable of removing heavy metals is water spinach (*Ipomoea aquatica*), which is available in tropical and subtropical countries such as Philippines. This study investigates the use of the dried biomass of water spinach in removing chromium metal by adsorption. The main advantage of using dead biomass instead of living biomass is the prevention of metal toxicity on plant metabolism, plant deterioration, odor liberation and insect proliferation. Batch sorption experiments were conducted in this study to determine the effect of initial metal ion concentration and pH on adsorption. Linear, Langmuir and Freundlich adsorption isotherms were also used to determine equilibrium adsorption data. Continuous sorption experiments were also conducted to establish the breakthrough curve. In addition, biochemical and physical characteristics of the biomass were determined.

Dried biomass was prepared through washing, drying, cutting and alkali treatment. The total chromium metal concentration of all samples were determined using Atomic Absorption Spectrophotometer (AAS) at a wavelength of 357.9 nm. K$_2$Cr$_2$O$_7$ solutions at an initial concentration of 200 mg/L were added to a fixed biomass of 200 mg at varying pH values of 1, 2, 3, 4 and 5. The flasks were agitated for 3 hours, and then the solutions were filtered. The adsorbed total chromium is calculated as the difference between initial total chromium concentration and the filtrate total chromium concentration. A plot of total chromium adsorbed per weight of biomass (mg Cr/g biomass) vs. pH shows that the maximum total chromium metal uptake was at pH 2, wherein the biomass adsorbed was 9.56 ppm Cr/mg biomass.
Aliquots of 50 mL K$_2$Cr$_2$O$_7$ solutions at varying concentrations of 10, 50, 100, 200 and 300 mg/L were added to flasks with a fixed biomass weight of 200 mg and fixed pH of 2. The flasks were agitated in a flask shaker for 3 hours. The solutions were then filtered. After the total chromium concentrations were measured using the AAS, the adsorbed chromium concentrations were also calculated. Linear, Freundlich, and Langmuir isotherms were the isotherms used for the sorbent. It was found out that the best fit isotherm is the Langmuir isotherm with a correlation coefficient ($R^2$) of 0.9993. The linearized form of the Langmuir isotherm is

$$\frac{1}{q} = \frac{1}{Kq_oC} + \frac{1}{q_o}$$

Where $q$ is the amount adsorbed (mg Cr adsorbed/g biomass); $q_o$ is the maximum adsorption capacity (mg Cr adsorbed/g biomass); $C$ is the equilibrium Cr concentration (ppm or mg/L); and $K$ is the adsorption equilibrium constant. The Langmuir plot ($1/q$ vs. $1/C$) yielded a slope and intercept of 12.282 and 0.0072, respectively. $K$ is calculated from the slope and was found to be 1705.83 L/mg. Maximum adsorption ($q_o$) is calculated from the intercept and was found to be 138.89 mg Cr/g biomass or 0.13889 kg/kg.

The physical properties that were determined include particle size (<4mm), bulk density (0.299 g/cm$^3$), apparent density (1.434 g/cm$^3$), water retention (2.583 g/g) and surface area (3.79 mm$^2$/mg). According to a study by Mandal, et al. (2008), the biochemical properties of the water spinach were protein (32.2%), carbohydrates (31.8%), ash (30.0%) and lipids (6%). Proteins and lipids have metal binding groups such as carboxyl and phenolic hydroxyl, which is behind the adsorption mechanism of water spinach.

Continuous sorption experiment was performed in a cylindrical column with 4 g biomass of water spinach. Around 7300 mL flowed in the column at a flowrate of 19.7 mL/min for 370 minutes. The kinetic behavior of the biomass showed increasing total chromium removal with time, and showed saturation in about 100-250 minutes with around 30-40% total chromium adsorption. The breakthrough curves showed that around 70% of total chromium is adsorbed during the first 20 minutes.