CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water is the biggest component in the earth surface (70%) that is used for several goals by living organisms and agriculture. Generally the sources of water are groundwater, rivers, and the ocean. Nowadays the level of purity of the water is decreasing and it is very risky that could affect our health due to diseases like guinea worm and bilharziasis. At present, 1.1 billion people don't get to use fresh water and 2.6 billion general public are uncovered with sanitation facilities. According to the World Health Organization (WHO), more than three billion people of the world population will not have access to safe water by 2025 (United Nations, 2015). Therefore, water pollution is a vital issue for developing countries to save their life.

Water pollution containing toxic metals is very dangerous due to its toxicity (Ozmen et al., 2010). There are twenty metals that are considered as heavy metals in the environment. Some of them are harmful such as lead, nickel, copper, cadmium, chromium due to their poisonousness and some are non-hazardous (Amuda et al., 2007). Nowadays, the world is tackled with the challenges of water pollution by industrial activities such as mining, tannery, textile, electroplating, and others (Radhakrishnan et al., 2016). Heavy metals accumulate in human body, leading to various diseases and disorders such as damage the liver, kidney, brain, and central nervous system, even abortion and neonatal death can be occurred by the severe attack of these metals. The main sources of heavy metals are battery manufacturing, ceramic, and metal plating industries which produce large quantities of wastewater (Naiya et al., 2009). Many heavy metals are released from paint, ceramics, and dyes industries (Abdel-Ghani & Elchaghaby, 2007). The acceptable limits for toxic metals in industrial pollutant release set by the World Health Organization (WHO) are 0.05-1.5 (copper), 0.1 (cadmium), 5-15 (zinc), 0.1 (lead), 0.1-1 (iron), and 0.05-0.5 (manganese), 0.02 (nickel), in ppm.

The common methods used for wastewater treatment are restricted because of technical problems, producing more sludge, disposal and financial barriers. Furthermore, it is mainly due to low concentration of toxic metals in aqueous solution (<100 ppm). Some common methods used for removing heavy metals from wastewater are ion exchange, adsorption, precipitation and membrane separation. Among those processes, adsorption is one of the efficient methods to remove contaminants from wastewater (Anirudhan et al., 2008). Adsorption process is a promising method because of its cheap, simplicity and effectiveness compared to other methods. Precipitation methods produce a huge amount of precipitate sludge and need further treatment while reverse osmosis and ion-exchange can successfully remove metal ions from wastewater. However, the operational cost is very high and also has a limited pH range. Recently, biosorption has become a popular method due to their availability, cheap and recycling process (Bhatnagar et al., 2013). Two types of biomass are responsible in adsorption methods which are living biomass and non-living biomass. *Moringa oleifera* bark, coconut coir, rice husk, neem bark and corn cobs are used as a non-living biomass, in contrast, fungi, yeast and microbial cells are used as a living biomass (Chen & Wang, 2008).

Agricultural waste materials are cost effective adsorbents and easy to handle disposal problems. It can solve the disposal problem of agricultural waste by converting to activated carbon (Rafatullah et al., 2010). Natural products like rice husk, coconut coir, corn cobs, neem bark and *Moringa oleifera* bark can be used as an effective adsorbent for purifying wastewater. These types of agricultural waste fulfil two purposes, firstly unusable waste is converted to efficient adsorbent and secondly it can solve wastewater treatment problems in many countries (Tan et al., 2008). The adsorbents can be used not only for wastewater purposes but also air, and gas streams to eliminate contaminants and to reduce the treatment cost (Nguyen et. al.; 2013; Jain et. al., 2016; Alslaibi et. al., 2012; Al-Qodah & Shawabkah, 2009). The heavy metals chelation property can be developed by chemically activated adsorbents. It also can develop pore size and surface area of activated carbon. The activity of adsorbent is dependent on its pore volume, surface area, and pore size. Agricultural waste adsorbents possess high porous structures and contain large surface area from 1000 m^2/g to 2800

m^2/g (Ahmad et al., 2012). Activated carbon was very effective in removing organic elements (methylene blue) from wastewater (Rafatulla et al., 2010). It is also effective for removing inorganics and heavy metal pollutants. There are several agricultural by-products like *Moringa oleifera* root which show good antimicrobial activity (Raj et al., 2011).

Activated carbon derived from Agricultural wastes have lignocellulosic compounds as major constituents. They also have other polar functional groups such as alcohols, aldehydes, carboxylic, ketones and ether groups. These functional groups can bind toxic metals by donating an electron pair to complex form in solution (Demirbas, 2008). Most of the plants such as neem, rice, turmeric, coconut, corn cobs, and *Moringa oleifera* are reported to have binding properties.

The commercially activated carbon is in the form of powder and granular. Powdered form is applied to liquid media with the sizes of 15-25 μm. On the other hand, granular adsorbents are mostly applied for both in liquid and gas media. Those type of activated carbon can be used in medicine (Ilomuanya et al., 2017) pharmaceutical (Jodeh et al., 2016) wastewater treatments (Bonvin et al., 2016) but it is very costly process and not halal for Islamic religious because it is produced from animal bone (Nwankwo I H et al., 2018) (Jabar & Odusote, 2020). So, recently researchers are looking for a cost effective alternative adsorbents derived from agricultural waste to easily remove heavy metals and dyes from wastewater (Abad et al., 2002; Bello et al., 2017). Some researchers have used activated carbon as an adsorbents from agricultural waste but they could not successfully remove heavy metals and dyes from wastewater with cost effective process (Abad et al., 2002; Bello et al., 2010; Han et al., 2008; Jabar & Odusote, 2020). For this reason, the several activated carbons may be used to get better removal efficiency of waste from wastewater and it must be cheaper.

1.2 Problem Statement

Water is important for humans, animals and plants. But nowadays, water is contaminated by many sources such as household, hospital or industrial wastes etc. The fast growth in agriculture and industry sectors are the main cause of pollution such as heavy metals, and dyes in the water system. Toxic Metals (lead, nickel, cadmium, copper, and chromium) can reduce mental and central nervous system as well as decrease function of lungs, kidneys and liver (Azeh Engwa et al., 2019). Alzheimer's disease and Parkinson's disease are due to long term exposure of heavy metals (lead, cadmium, and manganese) (Bakulski et al., 2020). Synthetic dye is used in many manufacturing industries for colouring their products such as textile, paper, and paint. Mostly 50% of total dyes are released from textile industries (Sharma et al., 2010) where mostly synthetic dye (Cheng et al., 2015). Methylene blue consists of heterocyclic aromatic compounds which can cause irritation of mouth, throat, and jaundice (Shakoor & Nasar, 2016). It can also cause breast and skin cancer for humans.

There are several common methods for eliminating pollutants from water such as reverse osmosis, adsorption (Tang et al., 2014), assimilation (Chatterjee et al., 2010; Hu et al., 2010) precipitation, coagulation, and ion exchange (Pathania et al., 2017; Babu & Gupta, 2008). Among all methods, adsorption is the best process for wastewater treatment (El Haddad et al., 2013). Generally, commercial activated carbon is used as adsorbent in adsorption processes due to high capacity, environmental-friendly and nontoxic (Salleh et al., 2011) but it is a costly process (Jabar & Odusote, 2020). Therefore, third world countries would not make an effort for the high cost.

Researchers are now looking for cheaper technology as an alternative option from natural products which are absolutely *halal* for wastewater treatment. Many natural plants had been used as adsorbents for the removal of dyes and heavy metals from wastewater such as oil palm (Jabar & Odusote, 2020), groundnut shell (Bayuo et al., 2019), *Moringa oleifera* leaf (Bello et al., 2017), rice husk (Han et al., 2008) and coconut coir (Abad et al., 2002). However, no research has been conducted for the comparison on the efficiency of the activated carbons produced from rice husk, coconut coir, corn cobs, neem bark, and *Moringa oleifera* bark on heavy metals (lead, nickel, copper, and cadmium), and dye (methylene blue) simultaneously.

The main aim of this study was to prepare, characterize, and evaluate activated carbons produced from five waste of agriculture products (rice husk, coconut coir, corn cobs, neem bark, and *Moringa oleifera* bark) using heavy metals and dye. The cheaper raw materials used are available redundantly in Malaysia, Bangladesh, south–east Asia, and have no side effects for humans.

1.3 Significance of Study

Water is very essential for human life but it should be fresh water not contaminated water or wastewater. Wherever humans live, fresh drinking water is constantly required and wastewater is constantly produced. The provision of drinking water and the management of wastewater have thus been crucial to the success of human civilization, with the ancient Roman aqueducts and modern giant dam projects providing impressive examples of the success of humankind in ensuring the former is achieved. However, when it comes to the purification of sewage water, microorganisms are superior to humans; their abilities to degrade the most diverse of organic substances and to cycle elements such as nitrogen, phosphorus and carbon are unmatched in nature. The use of natural products as adsorbent material to filter heavy metal contaminated water has become gradually more popular due to having less expensive, biodegradable, abundant and efficient. Instead of activated carbon, this study can be focused on inexpensive materials such as agricultural and forest waste. It may show that these alternative adsorbents can be sufficient binding capacity to remove heavy metal ions, and dye from wastewater.

However, the effectiveness of the adsorption depends not only on the properties of the adsorbent, but also on various parameters (pH, temperature, initial concentration, contact time, etc.) used for the adsorption process. The basic components of the agricultural waste materials include hemicellulose, lignin, lipids, and starch, containing variety of functional groups (acetamido, alcoholic, carbonyl, phenolic groups). The functional groups present in agricultural waste biomass have affinity for heavy metal ions to form metal complexes that stop the contaminants through reactions of complexation, adsorption on surface, diffusion through pores and ion exchange. Agricultural waste materials being economic and eco-friendly due to their unique chemical composition, availability in abundance, renewable nature and low cost are viable options for water and wastewater remediation.

1.4 Objectives of Research

a) To prepare activated carbons from five agriculture waste products (rice husk, coconut coir, corn cobs, neem bark, and *Moringa oleifera* bark).

b) To evaluate the adsorption efficiency of prepared activated carbons on heavy metals spiked in aqueous solutions using AAS.

c) To characterise the high efficiency of activated carbons in (b) using FTIR, BET, SEM, and proximate analysis.

d) To evaluate the adsorption efficiency of dye using prepared activated carbons.

1.5 Scope of Research

Agricultural by-products such as rice husk, coconut coir, corn cobs, neem bark, *Moringa oleifera* bark were used to produce activated carbon. The produced activated carbons were characterized using Scanning Electron Microscopy (SEM), Brunauer-Emmett-Teller (BET), Fourier-Transform Infrared (FTIR) techniques. The absorption capacity of activated carbons were determined using prepared metals and dye solution. Methylene blue and heavy metals (copper, cadmium, lead, and nickel) were determined using UV Spectroscopy and Atomic Absorption Spectroscopy (AAS), respectively.