CHAPTER I

INTRODUCTION

In Thailand, the population has increased resulted the demand for resources increases. Therefore, consumer products are manufactured by agriculture, industry; mining activity caused effect of the environment in many aspects. However, the most important problem was the mining industry releasing toxic chemicals into environment, such as a cyanide, arsenic, lead, mercury, and chromium. Hence, heavy metals are very problem for environment and ecosystems although it has low concentrations in wastewater. Whereas, the mercury and chromium are envenomed lower than cyanide, arsenic, and lead. Hence, in this study has been interested for the removal of arsenic, lead and cyanide. Among these, lead (Pb) is generally used in several industries of wastewaters containing high concentrations. It has been released and dispersed to the groundwater and surface water in wastewaters through effluents from several manufacturing activities for instance metal plating, ore mine, paint manufacturing and battery industrial (Axtell, Sternberg, & Claussen, 2003). Lead is concentrations approach 200-500 mg/L in the industrial wastewaters (Özcan, Gök, & Özcan, 2009) but the World Health Organization (WHO) has set a drinking-water standard for lead concentration of less than 0.01 mg/L (WHO, 2012). Lead cannot biodegradable which it accumulated in organism tissues, and food chain. Later, it was absorbed into the human (Kul, & Koyuncu, 2010). Lead compound was found in drinking water which caused of diseases such as anemia, cancers, hepatitis and nephritic syndrome (Setshedi, 2012). Likewise, arsenic is a toxic and carcinogenic metalloid distributing in the environment through a combination of natural processes for example weathering reactions, biological activities and volcanic emissions as well as through a range of anthropogenic activities (Chang, Lin, & Ying, 2010). Thus, contamination of arsenic in drinking water causes the risk to human health (Aredes, Klein, & Pawlik, 2012). The WHO has set a contamination limit for arsenic in drinking water 10 μg/L. Arsenic in nature shows organic and inorganic forms which inorganic arsenic are frequently found more than organic in nature. Inorganic form has the toxic more than organic forms because organic forms can degradation in environmental. Normally, inorganic arsenic display two oxidation states, that is, +3 and +5, in water systems (Jeon, Baek, Park, Oh, & Lee, 2009). Arsenate (As^{5+}) has form as $H_2AsO_4^-$ and $HAsO_2^{4-}$ and arsenite (As^{3+}) has form as H_3AsO_3 ions. The dominant species of arsenic in water depends on solution pH. In general, As^{3+} is more toxic than As^{5+} (Guo, Stüben, & Berner, 2007).

In water, arsenic and cyanide usually find together because of mineral friend. The cyanide is an extremely toxic species. It is produced from gold refining, metal plating, chemical manufacturing and finishing industries which was released into wastewater (Saxena, Prasad, Amritphale, & Chandra, 2001). Cyanides are generally classified as free cyanide and metal cyanide. The free cyanide famous as the best toxic species causing toxic to microorganisms and human consequent to short or long-term exposure (Do, Jo, Park, & Kong, 2012). The cyanide has low biodegradation rate. Thus, many countries have intended standards for discharge of cyanide wastewaters by set the effluent standards of cyanide concentration in wastewater to below 0.2 mg/L in the environment (Moussavi, & Khosravi, 2010).

The mentioned above data has been extensively recognized the importance of education in the treatment of arsenic, lead and cyanide because they are toxic and widespread contamination in the environment. Therefore, the removal of pollution from drinking water and wastewaters are important in terms of protection of human health and environment. Many methods have been developed to remove arsenic, lead and cyanide such as precipitation, adsorption, membrane processes, and ionic exchange (Bessbousse, Rhlalou, Verchère, & Lebrun, 2008; Liao, Chung, Chen, & Kuo, 2007; Rakhshaee, Khosravi, & Ganji, 2006). However, these techniques have native limitations, such as poor efficiency, sensitive operating conditions, the production of a sludge and high cost. Nowadays, a nano scale zero-valent iron (nZVI) can remove contaminants in wastewater such as organic dyes, and inorganic pollutants (Bhowmick et al., 2014; Dorathi & Kandasamy, 2012; Kim et al., 2013; Qiu, Fang, Liang, Gu, & Xu, 2011). Since nZVI particles have a nanoscale dimensions, large active surface area and high adsorption capacity.

However, nZVI is usually agglomerated in systems resulting in a significant loss of reactivity; mechanical strength including fixed bed columns inevitably results in high pressure drops in systems. In recent years, porous-based materials, including zeolite (Kim et al., 2013), kaolinite (Zhang, Lin, Chen, Megharaj, & Naidu, 2011), activated carbon (Dou, Li, Zhao, & Liang, 2010) and pumice (Liu, Wang, Yan, & Zhang, 2014) have been commonly used as supports to improve the distribution and stability of nZVI particles. Diatomite ($SiO_2 \cdot nH_2O$) is a kind of natural amorphous siliceous mineral in the clay which is soft and lightweight with porous structure that composed of aquatic unicellular alga. It is suitable to be supporting material due to its property of catalysis and compositions. According to, the cheap and easily purchased material, diatomite is suitable to be supported material. Nevertheless, a few studies have interested on using the diatomite as the support material for nZVI which could potentially be used as a porous-based materials to support nZVI for the removal of metal ions from wastewater. Therefore, in this study has been used the nano-scale zero valent iron coated on diatomite (nZVI-D) removal arsenic, lead and cyanide and interested to study the mechanisms of nZVI-D in the removal.

The objectives of this work are: (1) to prepare nZVI-D and analyze its characteristics; (2) to study the effect of initial concentration, pH, adsorbent dose and contact time; (3) to determine the adsorption isotherms, the kinetics adsorption and (4) to propose the mechanism for removal contaminant from aqueous solution by nZVI-D. In conclusion, the results of this work can improve knowledge on nZVI-D provide information for process design and operation in wastewater treatment.

The thesis consists of nine chapters. Chapter 1 presents the overall introduction to the study; Chapter 2 displays the significant of literatures review; Chapter 3 shows the preparation and characterization of nZVI-D; Chapter 4 illustrate the equilibrium, kinetics, and mechanism of lead adsorption using nZVI-D; Chapter 5 indicate parameter screening for the important factors influencing the As(V) adsorption using a plackett–burman design; Chapter 6 present rapid adsorption of arsenic from aqueous solution using nZVI-D: mechanism, kinetics, and response surface methodology; Chapter 7 show kinetics, and isotherm of cyanide adsorption using nZVI-D; Chapter 8 illustrate fixed-bed column of arsenic removal from aqueous solution using nZVI-D and Chapter 9 displays the overall discussions and conclusions.