# CHAPTER I
# INTRODUCTION

Lead, nickel, copper, and manganese are classified as heavy metals and are commonly associated with water pollution. They contaminate water by way of leaching from rock and soil or from diverse commercial activities that can generate toxic wastes, including the industries that use or manufacture electronic components. Other sources include by-products of electroplating or pigments and paints, or as spent catalysts. They also can come from mining and other metallurgical related activities. These metals are very toxic; hence, their discharge into water affects human health and the environment. As a result, the removal of heavy metals from wastewater has become mandatory.

The method most employed for heavy metal removal is chemical precipitation which is simple and inexpensive. However, it has the disadvantage of generating a large volume of sludge for disposal. Alternative recovery methods are based on reduction, oxidation, coagulation, electrowinning, reverse osmosis, electrodialysis, solvent extraction, evaporation, and specific binding on ion-exchange supports.

Metal-ligand binding is a promising technology due to easy setup, requiring little maintenance and its recovery possibility. Another advantage is its minimal waste generation.

The concept of ligand-exchange-based separation is first introduced by Helfferich (1962). Polymeric ligand exchangers (PLE) are a class of promising sorbents that allow chemicals to adsorp on polymers based primarily on their ligand characteristics rather than ionic charges. PLE offers an easy route to the preparation of organic/inorganic hybrid materials and has becomes a most interest research theme (Bosco *et al.*, 2005, Du *et al.*, 2008). Generally, polymeric ligand exchangers (PLE) are composed of: (a) a cross-linked hosting resin that can firmly bind with a transition metal such as lead, nickel, copper, and manganese and (b) metal ions that are immobilized to the functional groups of the hosting resins. While sharing many common features with standard ion exchangers, a ligand exchanger employs transition metal ions as its terminal functional groups (An *et al.*, 2005).

A series of polybenzoxazine obtained by the ring-opening polymerization of cyclic monomer has been developed as a novel type of phenolic resin (Ishida *et al.*, 2000). The monomers can be prepared from phenols, amines and formaldehyde. The extensive variations of phenols and amines allows great molecular design flexibility. Polymerization proceeds through the ring-opening of the cyclic monomers only by heat treatment without the need of catalyst. Furthermore, the reaction does not give out any by-product or volatile; thus products with excellent dimensional stability can be achieved. Polybenzoxazine provides characteristics such as high heat resistance and flame retardance, low water absorption and relatively stable low dielectric properties.

The purpose of this study is to investigate the performance of polybenzoxazine-based aerogel (PBZ) as a polymeric ligand exchanger. The optimal condition for metal ions removal was determined as a function of pH, time, types of solutions, and temperature.