# 1.0 INTRODUCTORY REMARKS

As a result of industrialization, the modern world has left a legacy of metal contamination throughout the environment. These industrial activities, such as smelting, foundries, and finishing, have introduced large concentrations of metals into many different environments, including aquatic systems (Nriagu, 1984). At present, the National Priorities List contains over 1350 superfund sites in the U.S. that the EPA lists as sites that contain significant metal contamination. In the Great Lakes region, there are 43 regions designated in the U.S. and Canada as Areas of Concern (AOC) by the International Joint Commission. Of the 26 AOCs in the U.S., nearly all of them report sediments contaminated by metals. These are just a few examples that show the widespread nature of metal contaminated environments.

The conventional clean up and remediation of these types of sites is estimated to take from 10 to 30 years to complete at an enormous cost. The design of appropriate clean-up actions rests on the detailed characterization of the fate of metals in the aqueous environment, so that educated choices can be made, *e.g.*, dredging and disposal or “intrinsic remediation”. The National Research Council reports that developing the knowledge in order to make accurate predictions of contaminant fate is an important tool in applying natural attenuation strategies.

For this purpose of "knowledge based remediation", one needs to assess the mobility, reactivity, and toxicity of these contaminants in the impacted environment. Despite the importance of sediments as a sink for metals, the processes that control the fate of such contaminants remain unclear. Consequently, the definition the different physical and chemical forms (*i.e.*, chemical speciation) of metals becomes a key issue. This speciation can be determined by performing thermodynamic calculations, coupled to an appropriate surface complexation model, relying on the analyses of the total dissolved metal concentration and estimates of adsorption sites (Westall *et. al.*, 1976; Allison *et. al.*, 1991). However, this approach can be misleading because natural systems are quite frequently out of equilibrium (Brezonik, 1994), and because biological systems have evolved a variety of mechanisms to respond to metal stress, some of which involve a re-speciation of the metals (Beveridge and Doyle, 1989; Nies, 1992; Kushner, 1993; Silver and Phung, 1996; Silver, 1997). One alternative consists of determining analytically the speciation of the elements of interest. This is more advantageous, as it is a procedure that directly examines the metal speciation, *i.e.*, it is an empirical observation rather than a theoretical calculation.

In addition, it has been shown that viable, active, microbial communities thrive in many types of metal contaminated environments (Roane and Kellogg, 1996; Kelly and Tate, 1998; Aceves *et. al.*, 1999; Kolensnikov *et. al.*, 1999). However, there is little information available about how these organisms cope with metal toxicity. In particular, there is little understanding of the influences of metal stress on bacterial populations present in freshwater, anaerobic systems such as sediments. Response to metal stress has been studied in more detail in aerobic systems (*i.e.* in bacteria and algae), but relatively little information exists on anaerobic bacteria and archaea. Even less is known about how the microbial communities in these systems respond as a whole to metal stress.

The primary goal of this research is to establish a better knowledge of the extent and properties of microbial control of metal speciation since it controls their availability and mobility in anaerobic freshwater sediments. In order to examine these questions, this work will examine the biogeochemistry of a contaminated lake system. The field site chosen is Lake DePue, IL. The lake has been impacted over the last century by the influence of a zinc smelter and chemical fertilizer manufacturing plant. As the bulk of the contamination in relatively localized in one section of the lake, this provides an excellent opportunity to study both contaminated and uncontaminated sediments from the same system.