CHAPTER 1

INTRODUCTION

Acid mine drainage (AMD) is a man-made phenomenon that represents a persistent and destructive environmental problem. The heavy metal concentrations present in the effluent are toxic to all biota and the acidic pH disturbs the ecological systems maintained in the receiving waters (Figure 1.1 and 1.2) (Gray, 1997). If left untreated, the acidity and metal content of AMD flowing into the environment can have a devastating effect on terrestrial and aquatic ecosystems. Therefore, AMD is categorized as a multifactor pollutant (Figure 1.3) (Gray, 1997). AMD is caused by chemical and microbiological factors (Atlas and Bartha, 1993; Brierly and Brierly, 1997). The product is a leachate resulting from the oxidation of sulfide containing minerals exposed to water, air and bacteria.

Because of the biological entities involved in AMD formation, preventative control efforts have been developed that specifically target this component (Ledin and Pedersen, 1996). Surfactants and slow release biocides become diluted after time and thus proved ineffective. The financial costs involved in controlling the microbiological origin of the problem are daunting. The only really effective means of preventing AMD will be to separate the sulfide-bearing rocks from air and water (Brierly and Brierly, 1997; Ledin and Pedersen, 1996). Although this seems impossible to achieve, new approaches toward waste management have been implemented. These include covering the rocks with air and water repulsing clay, vegetating waste piles, and placing the rocks on specially engineered sites that allow capture and treatment of the effluent (Brierly and Brierly, 1997).

Sulphate is an important component of acid mine drainage because it causes the formation of sulphuric acid in the receiving waters. The chain of chemical reactions that lead to the formation of sulphuric acid can be interrupted with the removal of sulphate. Financial constraints prevent the widespread application of demineralization processes such as reverse osmosis and electrodialysis that may be applied for sulfate removal (Maree and Strydom, 1987). The drainage water itself can be treated by the addition of alkaline chemicals or by constructing artificial wetlands (Ledin and Pedersen, 1996). An inexpensive, low maintenance, on-site treatment process is greatly desired because of the large volumes of AMD that must be treated. The biological treatment of AMD using sulfate-reducing bacteria is a possible alternative to chemical treatment.

Tuttle *et al.* (1969) studied a stream that was impeded by a dam wall composed primarily of wood dust, a waste product from a small log-cutting mill. The stream contained ferric, sulfite and hydrogen ions that were produced from pyritic minerals associated with coal. The retarded flow of water resulted in a pond behind the dam (the upper pond) and another pond (the lower pond) was formed due to uneven terrain downstream. The porous quality of the wood dust allowed the water to permeate through at a very low rate, thereby enriching it in organic nutrients as the water entered the lower pond. The degradation of wood dust was required to establish an anaerobic microflora in order for sulfate reducing bacteria to utilize the sulfate present in the medium. It appeared as if the rate of wood dust degradation determined the initiation and rate of sulfate reduction. Partially degraded wood dust contained fermentation products that could be utilized by the sulfate reducing bacteria.

Previous studies have indicated that substrate availability became the limiting factor in terms of sulfate reduction in pilot plants operated at an AMD affected site after a period of approximately 9 months. A similar observation was made during the development of a mixed aerobic-anaerobic microbial treatment process for acid-mine drainage using straw as a substrate (Béchard *et al.*, 1994). The authors assumed that the biodegradation of the straw would provide organic carbon necessary to sustain the treatment process. However, the long-term stability of their bioreactors could not be maintained and supplementation with urea and sucrose was required. Carbon was the primary limiting factor in the treatment process.

Lignocelluloses are the building blocks of all plants. Physical barriers and the chemical recalcitrance of the lignocellulose substrate can prevent its complete utilization by microorganisms. Exposing complex lignocellulose materials to white-rot fungi facilitates preferential delignification of the lignocellulose matrix (Lee, 1997). The result is the release of cellulose and hemicellulose fibers previously shielded by lignin polymers. This increased digestibility provides organic carbon that can be fermented to organic acids in an anaerobic environment (Müller and Trösch, 1986). If the purpose of biological pretreatment of lignocellulose is to obtain a cellulose-enriched substrate, then the ideal microorganism will cause accurate lignin degradation without severe polysaccharide loss. Therefore, pretreatment of the complex carbon sources by white-rot fungi may be necessary to enhance the biodegradability of the lignocellulose substrate. The biologically modified carbon source, or its by-products, should be able to enhance sulfate-reducing bacterial activity.

The objectives of this study were to investigate:

1. The biological pretreatment of *Cenchrus ciliaris* cv. Molopo (Buffelsgrass) with *Phanerochaete chrysosporium, Pleurotus ostreatus* and *Schizophyllum commune* as well as the fungal community structure of the decaying grass.

2. The effect of lignocellulose leachate, produced during hydrolysis of Buffelsgrass by *Phanerochaete chrysosporium*, *Pleurotus ostreatus*, *Schizophyllum commune* and natural fungi, on sulphate reduction by sulphate reducing bacteria.

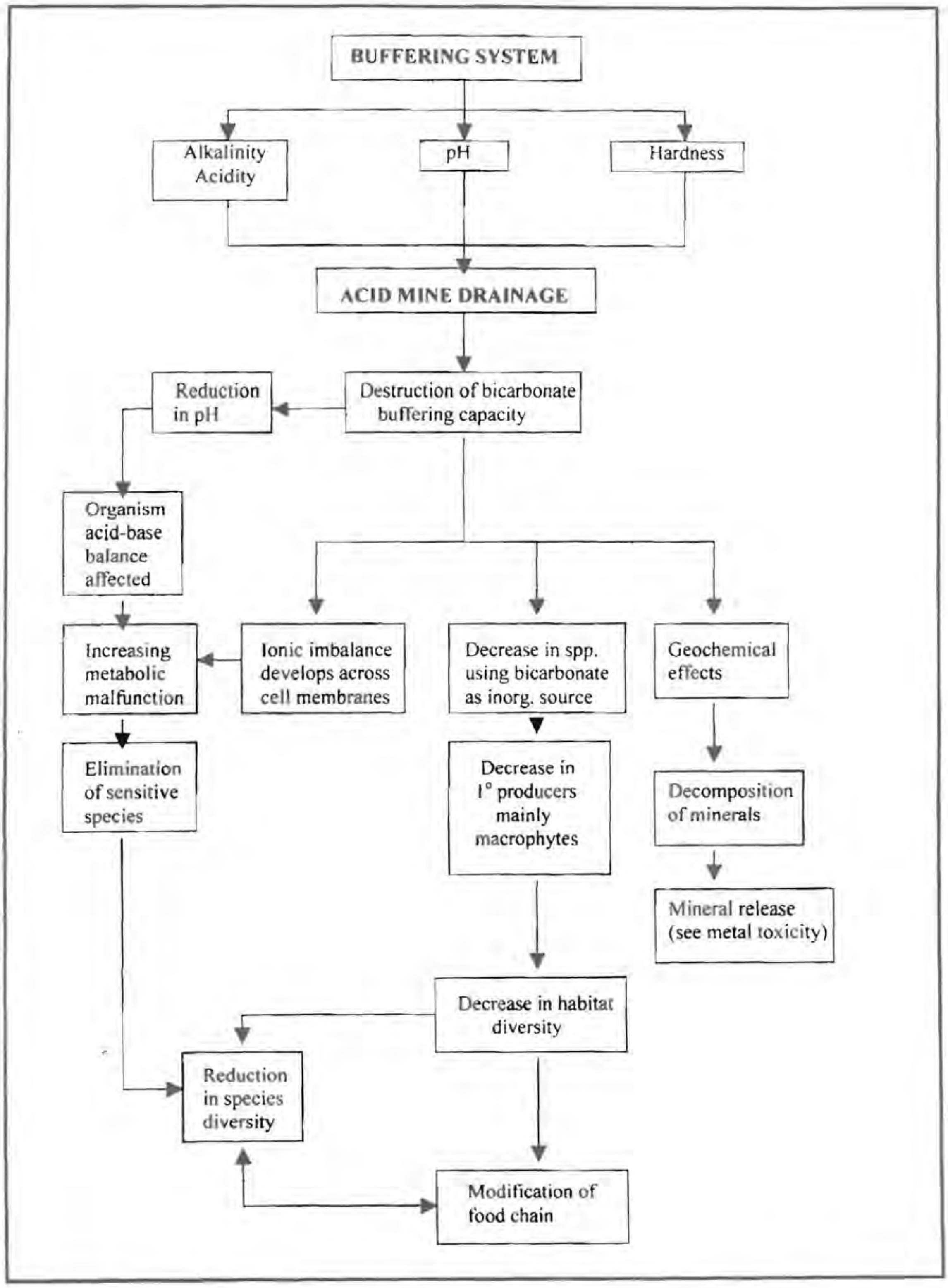

Figure 1.1: Effects of acidity originating from AMD in river systems (Gray, 1997).

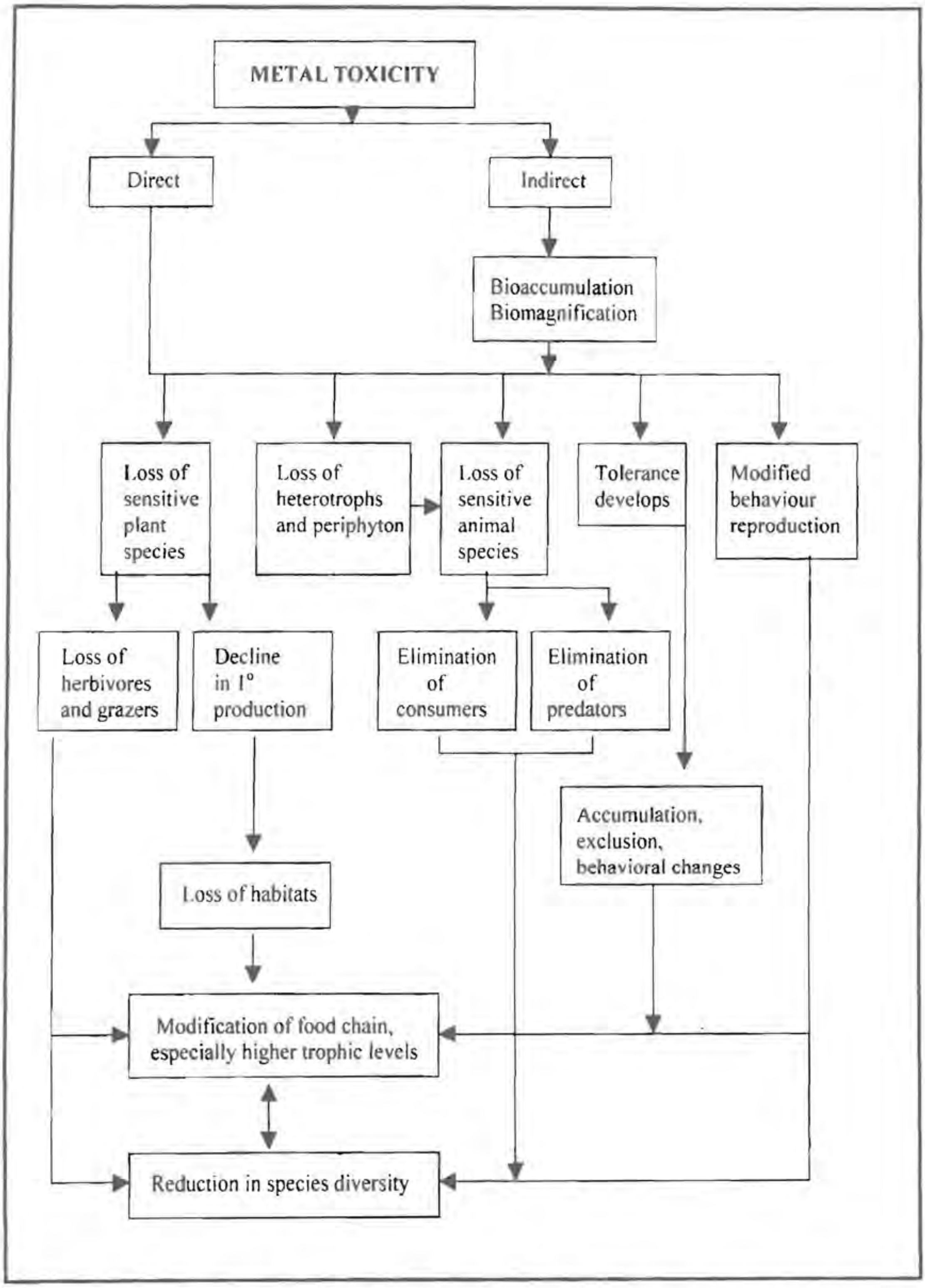

Figure 1.2: Effects of heavy metals originating from AMD in river systems (Gray, 1997).

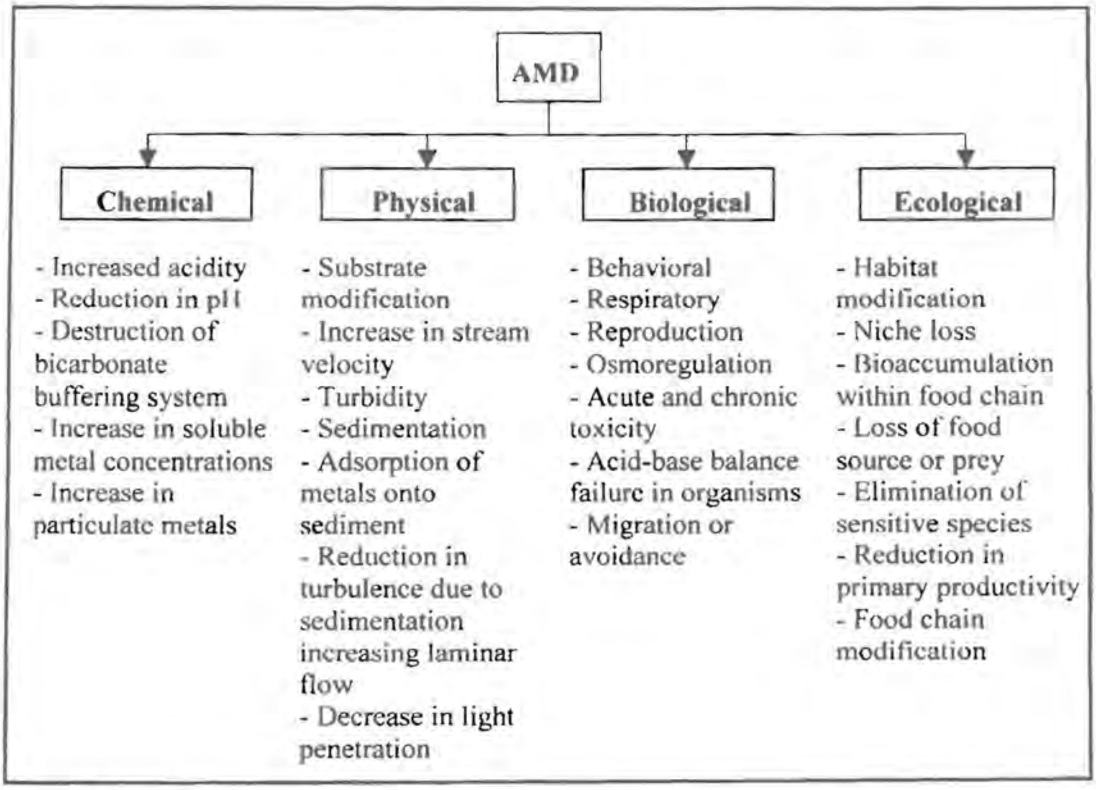

Figure 1.3: The major effects of AMD on a river system (Gray, 1997).

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