10.1. INTRODUCTION

Sediment removal by means of excavation and dredging can be an effective means of remediating contaminated rivers. The process, however, is not without its limitation, one of the most significant of which is the potential for sediment removal to negatively impact the short- to medium-term health of aquatic and riparian ecosystems. Biotic communities may be significantly disturbed or even completely erased during the removal process. Local communities are also subjected to the often annoying transport of contaminated sediment from the riverine environment, to sediment handling or treatment facilities, and finally to the disposal site. Compared to excavation and dredging, in situ remediation techniques offer alternatives to sediment removal as they are generally less invasive and are less likely to impact the local community. Costs of in situ treatments are highly variable, but in some cases, can be similar to or less than those associated with ex situ remedies. It should come as no surprise, then, that the application of in situ methods has increased over the past decade, and will continue to do so in the future with the development of several promising methods.

In this chapter, we will examine the most extensively utilized in situ remediation techniques for metal contaminated sediment and soils. In doing so, the various methods have been grouped according to whether they extract particulate-borne trace metals from the sediment or contain them in place. This classification system is not perfect in that some general techniques (e.g., phytoremediation) are used for both extraction (phytoextraction, rhizofiltration) and containment (phytostabilization). Nonetheless, it provides a framework that facilitates our discussion while describing the primary approach to remediation that is used by the in situ method.

While reading the following text, you will find that all of the in situ remedies have strengths and weaknesses. It follows, then, that the selection of an appropriate remedy represents a balancing act where the program manager, in cooperation with other stakeholders, must weigh the benefits and limitations of one method against those of another. Once more, what may serve as an entirely appropriate remedial alternative at one site may be entirely inappropriate at another, depending on the river’s characteristics, the physiochemical environment, the contaminant(s)
of concern, and various social and political constraints, among a host of other factors. It is therefore impossible to precisely define where and how an in situ alternative should be used. Thus, we focus on providing a brief understanding of how the various methods work, along with their uses, limitations, and costs, all of which represent important considerations in method selection.

Because of the variations observed between remediated sites, comparable cost data are difficult to obtain (NRC 1997b). Here we use data which are being compiled by the Federal Remediation Technologies Roundtable for remediated sites in the U.S. The advantage of using these data is that there has been an attempt to compile the information using similarly reported metrics and methods. It is important to recognize, however, that these data are provided only as a comparison of the costs associated with the discussed technologies as their actual costs will undoubtedly vary from location to location.

10.2. IN SITU EXTRACTION

10.2.1. Soil Flushing

In Chapter 9 we examined the process of soil washing as applied to dredged or excavated materials. Soil flushing is a similar process with the exception that the contaminated materials are not excavated from the site. Rather, contaminants are flushed from the sediment in place using water or some other aqueous solution. In general, soil flushing, which is sometimes referred to as in situ soil washing, usually involves a multi-step process (Fig. 10.1). The first step involves the application of an extracting solution consisting of water, acids, or chelating agents to the site. The solution can be applied using either injection or infiltration systems such as sprinkler networks, horizontal or vertical injection wells, or leach fields and basins. If applied to the vadose zone, the solution will migrate downward through the

![Figure 10.1. Schematic of the in situ soil flushing process (From USEPA 1991b)](image-url)