7 Mathematical Modeling for Assessment of Soil Pollution

J. G. C. Smits and N. M. de Rooij
Delft Hydraulics P.O. Box 177, 2600 MH Delft, The Netherlands

Abstract

Several mathematical models have been developed in the Netherlands for calculating the transport of pollutants into the environment of polluted sludge or soil. Applications of these models, CHARON in particular, have contributed to the setting of priorities for the cleaning up of polluted sites and to the assessment of alternatives for the storage of polluted sludge. CHARON is based on the principles of both equilibrium chemistry and process kinetics. The model applications in the Netherlands have focussed on the chemistry of heavy metals and organic micropollutants in chemically reduced systems. Adaptation of the input for the equilibrium chemistry may be necessary for application of the models to polluted sites with other (oxidized) soil systems in Central and Eastern Europe.

1 Introduction

The high level of industrial and agricultural activity in the Netherlands and its location downstream of important industrial regions in neighbouring countries have caused large scale pollution of the soil with heavy metals, organic chemicals and nutrients. The pollution problems concern the land as well as water bottom sediments. Consequently, the related environmental problems have been studied intensively, particularly in the past fifteen years. The assessment of the nature, extent and effects of the pollution requires, among other things, tools to quantify the transport of pollutants into the environment of polluted sites. These tools include chemical models as well as transport and hydrological models. The development of these models has reached the point where they can be used for the assessment of a broad variety of soil pollution cases.

This paper aims at presenting the possibilities and the significance of modeling for the management and control of soil pollution. An overview is given of management questions, which were raised in the Netherlands concerning soil and sediment pollution. A review of available models and some examples of applications follow a summary of important principles concerning the speciation, remobilization and fate of pollutants, heavy metals in particular. Finally, some conclusions are drawn.
regarding the use of these models for soil pollution assessment in Central and Eastern Europe.

2 Soil Pollution Problems in The Netherlands

A distinction can be made between the pollution of landsoils and of water bottom sediments. The former is usually caused by one local source, whereas the latter typically results from numerous industrial and domestic discharges along a river. The bottom sediments of estuaries and lakes are therefore usually polluted with a wide variety of substances in relatively small concentrations, whereas soil on land may be polluted with only a few substances in relatively high concentrations.

The pollution of the bottom sediments with heavy metals and organic substances has reached dramatic proportions in the Netherlands, especially in the estuary of the rivers Rhine and Meuse, but also in many canals. The presence of toxic pollutants in the bottom sediments has adverse effects on aquatic organisms, resulting in overall degradation of aquatic ecosystems. Due to dredging for maintenance of waterways and clean-up of the water bottom, large quantities of polluted sludge have to be stored in depots on land or in deep pits under water. Solid wastes from water treatment plants, drinking water plants and waste incineration plants must also be stored in depositories. When no precautions are taken pollutants can seep from the stored sludge and waste into groundwater aquifers, which in some cases may lead to the pollution of drinking water sources. The horizontal flow in aquifers transports the pollutants to upwelling regions where they may resurface and accumulate, a process which may last thousands of years.

Many sites on land have been heavily polluted by chemical plants, factories and other industries. Especially those sites that are destined for town expansion must be cleaned up in order to protect public health and to prevent the dispersion of toxic substances into surface water and groundwater systems.

The governmental policy is to prevent as much as possible the dispersion of pollutants into surface water and groundwater in order to safeguard the natural resources for future generations, and to allow sustainable development of the Netherlands. However, considering the number of polluted sites, priorities have to be set regarding the order in which sites are to be cleaned up or isolated. Alternative options for sludge depots and the storage of polluted soil also have to be assessed.