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ORIGINAL ARTICLE

Geochemical processes controlling the groundwater transport of contaminants released by a dump in an arid region of México

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Abstract The Vado Carranza dump, located in the Mexicali Valley, Baja California, northwest Mexico, was operated for more than 15 years receiving about 30 tons/day of solid wastes. The disposed wastes were periodically burned in open air. The presence of a shallow aquifer in the area makes the groundwater vulnerable to contamination processes. The purpose of this study was the evaluation of heavy metals content (Cu, Cd, Ni, Pb and Zn) in soil and groundwater in the vicinity of this dump. The results indicate high content of metals in soil, mainly at a superficial level, with the highest concentrations in the areas where burning of wastes occurred. Elevated concentrations of cadmium and copper were detected in groundwater with the highest concentrations occurring in monitoring wells located in the north side of the dump, downward of groundwater flow. Although the high content of metals in soil can be attributed to the burning of waste, other sources of pollution could be the agricultural irrigation in the vicinity of the dump. The program PHREEQC was used to model the geochemical evolution of groundwater. Results suggest that evaporation of the contaminated waters circulating below the landfill is one of the key processes that explain the increased concentration of contaminants in groundwater and its seasonal variations. As groundwater flows away from the dump, evaporation can concentrate the chemicals making the water more toxic. These results are important because they illustrate processes that are likely to occur in landfills located in other desert areas of the world.

Keywords Dump site · Groundwater evaporation · Semiarid zones · Heavy metals · PHREEQC · Mexicali

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Introduction

In most developing countries, solid wastes are being dumped on land surface without adopting any acceptable sanitary landfilling practices (Vasanthi et al. 2008). After the 1940s, Mexico has experienced a substantial increase in its generation of urban solid wastes (USW). In addition, a change in waste characteristics occurred mainly due to industrial development and a remarkable population explosion. These changes, combined with the common disposal practices, led to the unrestricted emergence of large open dumps that lack the structure needed to protect the environment. Currently, about 30 % of solid wastes generated nationwide are deposited in controlled and uncontrolled open dumps (INEGI 2005). In these sites, the burning of wastes is a common form of treatment, which increases their potential to contaminate the environment and affect human's health.

Areas located near landfills are largely exposed to groundwater contamination given the potential source of pollution that generation of leachate represents. The nature