



Application of ^{13}C isotope and carbon geochemistry to identify impact from landfill on surrounding groundwater

Hossein Mohammadzadeh^{1,2}, Ian Clark²

¹Groundwater Research Center, Ferdowsi University of Mashhad, Iran

²Department of Earth Sciences, University of Ottawa, Canada

mohammadzadeh@alumni.uottawa.ca OR mohammadzadeh@um.ac.ir

Abstract

In this paper, the $\delta^{13}\text{C}$ values and concentrations of carbon pools (DOC, DIC, CH_4 and acetate) were used to recognize leachate impact on the surrounding groundwater and to evaluate carbon biogeochemistry within the Ottawa landfill plume. The enriched $^{13}\text{C}_{\text{DIC}}$ for groundwater (-6.4 ‰ to -1.0 ‰) confirm that the leachate (+8.8‰ to +10.7‰) has had an impact on aquifers. In addition, in proximal ground water, methane concentrations are high ($\sim 10 \text{ mg l}^{-1}$) and the $\delta^{13}\text{C}_{\text{CH}_4}$ values demonstrate reactive loss of acetate in the leachate plume by methanogenic fermentation, and methane oxidation in the plume fringe. Continued reaction of DOC in groundwater is confirmed by deviation from the mixing lines on diagrams of DIC vs. $\delta^{13}\text{C}_{\text{DIC}}$ and DOC vs. $\delta^{13}\text{C}_{\text{DOC}}$, and by the absence of acetate.

Keywords: Landfill leachate, ^{13}C stable isotopes, carbon pools (DOC, DIC, CH_4 , acetate)

1. INTRODUCTION

Leakage of landfill leachate pollutants from unlined landfill sites over time is a source of groundwater contamination and may pose a threat to groundwater resources. Leachate contains a mixture of labile dissolved organic constituents, the composition of which is very dependent on landfill refuse of the respective site [1, 2]. Decay and dissolution of these organic constituents through bacteria-mediated reactions will generate different major carbon pools, such as DIC, DOC, and CH_4 , within both the refuse pile and the leachate plume [3].

As demonstrated in earlier research [4, 5, 6], the biogeochemical processes associated with refuse decomposition within the landfill environment and outgassing of CO_2 not only can produce characteristic ^{13}C signatures in the major carbon pools, but also generate ^2H enriched of water in landfill leachate. The objective of this work is to identify unambiguous isotope signatures in the leachate carbon system that provides evidence of leachate contamination in marginally impacted groundwaters.

2. SITE SETTING, SAMPLING AND ANALYTICAL METHODS

The Trail Road Landfill (TRL) is owned and operated by the City of Ottawa and is located approximately 25 km west of the city (Figure 1). Based on the geological history of the study area, monitoring well logs, and observations, there are both a shallow and a deep aquifer in this area, separated by a discontinuous clay aquitard (Figure 2). The deep aquifer is confined where it is overlain by the clay-confining unit (northern and western portions of the site) and it is unconfined below the southern half of Stages 1, 2 and under most of Stages 3 and 4. Over the clay aquitard, shallow groundwater flows northward and follows the general slope of the underlying clay which varies approximately 20 m in elevation over the study area. In the deep aquifer, flow is toward the dewatering pond (DWP) located northwest of the TRL site. Several individual and nested piezometers representing more than 200 monitoring wells were installed by City of Ottawa to sample the groundwater (Figure 1). The nested piezometers were screened at different depths including the shallow aquifer, the upper deep aquifer, and the lower deep aquifer [8].

Leachate samples were taken from M32 monitoring well and groundwater samples were taken from multilevel monitoring wells located down-gradient and up-gradient of the TRL site. The detailed description of sampling procedures and analytical techniques is given by Mohammadzadeh et al. [7] and Mohammadzadeh and Clark [2].