An investigation of heavy metal and migration through groundwater from the landfill area of Eskisehir in Turkey

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Abstract This paper was conducted in order to determine the groundwater and soil pollution within and around the landfill of Eskisehir, Turkey. In this paper, mud, leachate and groundwater samples were collected seasonally a year from near Eskisehir landfill-site to investigate the possible impact of leachate which affects soil and groundwater quality. Concentrations of various heavy metals (Fe, Cu, Zn, Mn, Co, Pb, Cr, Ni and Mo) were determined in mud, leachate and groundwater samples. In addition, the heavy metal transportation infiltrated from landfill through a porous medium into the groundwater was modelled in order to determine the potential groundwater pollution caused by the leachate of the landfill. The modelling of the contaminant transportation was carried out by using a multiflow computer programme which simulates the distribution of heavy metal concentrations. As a result of this study, the distribution of the contaminant concentration was modelled and determined with respect to time and distance. Hence, the contaminant concentrations were determined at any time interval according to distance. The heavy metal contamination in groundwater does not affect the wells found at far points from the source in a short time, e.g. 10, 20 and 30 days according to the obtained experimental results. When the time intervals extended more than 1 year, heavy metal concentrations decrease with distance but the concentration of the contamination increases when it gets closer to the pollution source. In this study, the potential contamination of groundwater was effectively estimated.

Keywords Contamination transport · Groundwater · Heavy metal · Landfill · Soil pollution

Introduction

The consumption of available resources has resulted in municipal solid waste (MSW) from industrial to domestic activities, which affect human health. Improper management of solid waste areas has resulted in serious ecological, environmental and health problems.

Such practices contribute to widespread environmental pollution as well as spread of diseases. Health deterioration, accidents, flood occurrences and environmental pressures are a few of the negative effects of MSW. Other environmental effects include pollution of surface and subsurface waters, unpleasant odors, pest infestations and gas explosions. Municipal solid waste is a major
environmental problem in Turkey and in many developing countries. The problem of solid waste management is an increasing issue in Turkey. Household solid waste generation is 1 kg day\(^{-1}\) per person in Eskisehir, also municipal solid waste generation is close to 1 kg day\(^{-1}\) where more than 25 million tons of municipal solid waste is generated every year in Turkey (TÜİK 2008).

Most of the solid waste is illegally dumped in the MSW dumping areas. If the solid waste generated from industrial and agricultural activities are included, this amount increases to at least 40–50 million tons per year in Turkey. Therefore, the management of solid waste, particularly MSW, has been one of the most important environmental issues of Turkey (Bakis et al. 1999). Municipalities are responsible from the domestic solid waste management including collection, transportation and final disposal according the Turkish constitution law. Solid wastes are generally dumped on the land without having any restrictions. In recent years, the situation of land filling has started to improve in some municipals by new valid laws called the Environmental Law 2872 (TME 2009) and related regulations of MSW which are conducted according to the standards.

Solid waste disposal methods are a major public concern in Turkey. Majority of the municipal solid waste disposal sites are still open dumps. Only seven cities have regular sanitary landfills used to dispose municipal solid wastes and more than 12 landfills are in the construction stage. The same situation of MSW environmental problems exists in the Eskisehir landfill where MSW is still disposed in open dumps. It is known that the composition of leachate is more important than the physical composition of wastes in landfills (Ahmed and Sulaiman 2001; Critto et al. 2003). Leachate consists of a more complex mixture of organic and inorganic composition.

The main source of leachate is liquid, which generally comes into existence during the organic dissolution in the landfill. The environment can be polluted by the leachates, which occurs at the end of decayed solid waste, mixed with precipitations of surface water. As a result, surface water collection system (rivers, creeks and lakes), subsurface collection system (groundwater reservoirs) and soil system (different soils layers) have been seriously polluted by this leachate during transportation. Hence, landfills are one of the sources of groundwater and soil pollution due to the production of leachate and transportation of the contamination to the far points (Howard and Livingstone 2000; Islam and Singhal 2004; Slack et al. 2004; Von Der Heyden and New 2004; Kacaroglu and Gunay 1997). Furthermore, different hazardous gases of the landfill also pollute the atmosphere.

**Research site and sample locations**

This study was mainly conducted to determine the extent of groundwater and soil pollution within and around the landfill of the city of Eskisehir, Turkey. In this study, the Eskisehir landfill has been selected as a research site. Location of the Eskisehir dumping area is given in Fig. 1. Eskisehir city is located at northwest of interior Anatolia region. The population of the city is approximately 750,000 people (TÜİK 2008). Residents, businesses and institutions produced more than 250,000 tons of MSW per year which was generated from approximately 1 kg of waste per person per day in 2008. This quantity indicates that the rate of generated waste (in kilograms per person per day) and total waste generation (in million tons) have increased from 1960 to 2008.

With these purposes, contaminated groundwater by waste disposal area in Eskisehir has been selected as a research site due to its adverse effect on the environment. The leachate samples have been taken to determine the amount of heavy metals in the area. This landfill, which contains a rather high concentration of contaminants, may pollute the rivers, lakes and aquifers in the Eskisehir region. Heavy metals may also seep and pollute the aquifers underneath the sites of disposal or agricultural usage.

The solid waste produced from the Eskisehir landfill is then transported to the soil layer consists of conglomerate–sandstone, tuff–marl–clay and limestone, old and young alluvium disposal site according to the geological deposits (DSI 2001). Thus, the amount of the toxic elements has to be known in order to take appropriate measurements to prevent groundwater contamination due to water flow through the fractures in formation.