Variation in soil heavy metal concentrations around and downstream of a municipal waste landfill

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Abstract

Municipal waste landfills are sources of groundwater and soil pollution due to the production of leachate and its movement through refuse. The aim of this study was the determination of soil pollution in the downstream area of the landfill, in relation to changes in soil chemical characteristics and heavy metals concentrations. The landfill was located in the southwest of Babol, North of Iran. Soil samples were taken at three depths (0-30, 30-60, 60-90 cm) from different locations; upstream (control), around and downstream of the landfill, also in two seasons of the year (dry season and wet season). Samples were analyzed by atomic absorption spectrophotometery for Cd, Ni, Pb, Fe and Mn concentrations. Although in the soil vadose zone, heavy metals were found to be in their typical and normal ranges and within the background concentrations, by comparison their concentrations were higher in wet season. Variation in the concentration with depth suggests movement of the heavy metals either from the leachate or from naturally present sources of minerals in the soil.

Key Words

Soil pollution, heavy metals, municipal waste landfill.

Introduction

Modern civilization is completely dependent on a large range of metals for all aspect of daily life. There is a long history association between metals and human development. Heavy metal pollution not only affects the production and quality of crops, but also influences the quality of the atmosphere and water bodies, and threatens the health and life of animals and human being (3). Almost any material will produce leachate if water is allowed to percolate trough it. The quality of leachate is determined primarily by the composition and solubility of the waste constituents. If waste is changing in composition, for example due to weathering or biodegradation, then leachate quality will change with time. This is particularly the case in municipal waste landfills containing municipal waste (5). The main routes of human exposure to soil metals are ingestion, inhalation and skin contact. Since soil is the major sink for airbone metals, the measurement of their levels in this media is useful to establish trends in abundance and their consequences because of natural and anthropogenic changes (4). This study was conducted to analyze soil in a municipal waste landfill and its downstream area at Babol, the north of Iran. We collected soil samples in two different seasons of the year(dry season and wet season) to compare the heavy metal concentrations and potential for presentation future pollution.

Methods and materials

Site description

The landfill and compost company of Babol, lying 40 km southwestern of city center of Babol, Iran on latitudes 65° 21' 63" and longitude 40° 19' 59". Covering an area of 30 ha. This waste facility started operation in 1999 and the compost factory started to produce of compost fertilizer in 2004(received 220 ton/per day for both the landfill and compost factory). Elevation of this area is approximately 650-800m and is located in forestry part. It is 5 km far from the nearest residential area of the village of Hally Khal. Leachate produced from the landfill in east and west directions enters to forest although north direction is directly in contact to ground water. Major agricultural crops in downstream of this area are rice and citrus which use river drills and low depth wells. The source of drinking water in official, commercial and residential parts of downstream substantially is low depth wells. The climate of the area and is characterized by uniform temperature and high rainfall with mean maximum annual temperature varying 14-16 °C and mean annual rainfall varying 1000-1100 mm.

Sample analysis

The soil samples were taken from 5 points in downstream area based on land use : paddy and forest , the soil samples were taken down stream and also one soil sample was taken in landfill(pollution source) and another upstream as a control and the samples were taken from three depth (0-30, 30-60, 60-90) . After preparation of soil samples and extracting by DTPA extractor, leachate was analyzed by (Cd, Ni, Pb, Fe and Mn) using a Perkin- Elmer 403 furnace spectrometer (atomic absorbtion spectrometer analysis) . the calibration of the spectrometer for each metal was performed according to its wavelength and standard solution. For Ni , Pb three standard solutions(1 and 2 ppm and 5ppm) was prepared, for Cd four solutions(0.1 and 0.5 ppm and 1 and 2 ppm),for Mn and Fe four solutions(1 and 2 ppm and 5 and 7 ppm).The spectrometer re-calibrated after each group of 10 successive measurement. The initial solution of samples was 1:2 while samples for Fe and Mn were diluted to 1:11 , in order to fit within the linear region of all the calibration curve . water samples also were analyze in the same way as soils.

Table 1: soil samples

Soil sample	Land use
P1	Forest
P2	Forest
P3	Paddy
P4	Paddy
P5	Paddy

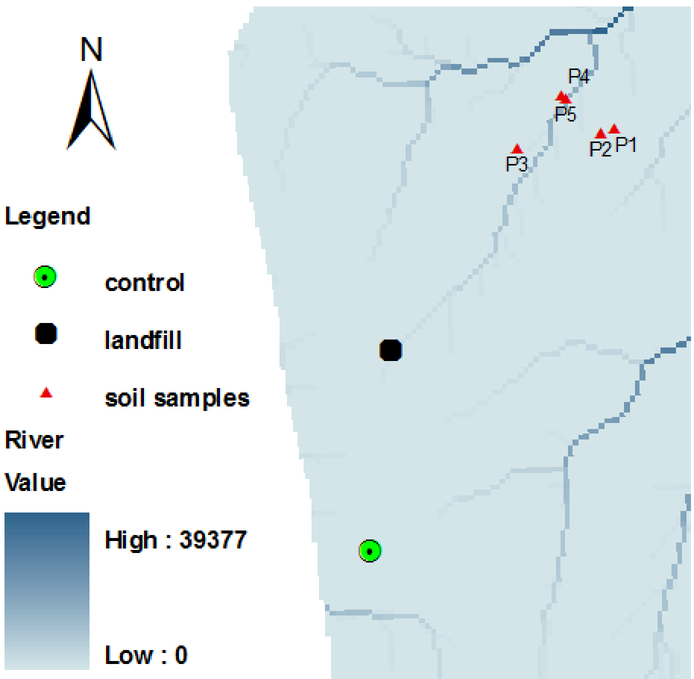

Figure 1. location of landfill, soil samples and control.

Result and discussion

Fe and Mn concentrations in two sampling times indicated an increase of these metals in 0-30 and 30-60 cm depths in all soil samples. the amount of increase for Fe in 0-30cm was higher than 30-60cm but Mn concentration was also noticeable in 30-60cm depth. The Pb concentrations showed a slight fluctuation in surface depth between two sampling times of except in P4, and these fluctuations were more in 30-60 cm depth. the outcome in all sampling points as compared to landfill and control pointed out that the landfill existence accumulated Ni and Fe in surface depth and the their amount decreased compared to control ; this decrease is also includes the down stream samples. Difference between control and the landfill samples in 30-60 cm depth generally decreased, although there was an increase of concentration in some samples in wet season. The main factor of the variation in the metal concentrations is due to the kind of solid organic compounds in the landfill and their ability for stabilization of metal elements. The amount of rainfall is believed to be the controlling factor in movement of elements through depth specially for Fe and Mn.

Table2. Changes in Heavy metal concentrations in soil samples between wet and dry season

Depth(cm)	Soil samples	ΔcMn	ΔcFe	cPb Δ	cCd Δ	ΔcNi
	P1	30	18	-0.09	-0.006	0.92
	P2	80	25	0.04	0.044	0.12
	P3	30	19	-0.044	0.024	0.04
	P4	26	15	0.942	0.082	2.23
0-30	P5	35	7	0.052	0.188	1.6
	landfill	20	-6	-0.04	0.026	0.21
	check	19	44	0.288	-0.024	-0.67
	P1	19	15	-0.7	0.004	0.96
	P2	49	-13	0.24	-0.02	2.39
	P3	21	3	0.52	-0.01	-0.11
	P4	13	-15	0.31	0.06	1.3
30-60	P5	31	5	-1.09	0.27	1.3
	landfill	-5	-6	-0.6	0.04	0.66
	check	26	-68	0.27	0.01	-0.07
	P1	55	2	-1.31	-0.13	0.13
	P2	56	-22	-0.91	0.02	1.87
	P3	13	-8	0.05	-0.01	-0.05
	P4	28	-2	-0.04	0.01	1.13
60-90	P5	37	-35	-0.42	0.3	0.26
	landfill	10	-17	0.64	0	0.47
	check	27	22	-0.57	0.03	0.88

Δc= the difference between wet and dry samples for each element

Conclusion

Differences between samples specially in Fe, Mn and Ni and the comparison of samples in two land uses indicated that land use has effected the heavy metal concentrations in 0-30, 30-60 cm depth; this differences in forest were higher than paddy and showed a reverse trend in case of Pb and Cd. A more precise investigation of the results will be possible with more sample analysis. The values obtained for heavy metal concentrations of soil in this experiment do not exceed the limits for soil quality standards normally stated in the literature , however ,the DTPA method of Analysis may not be a suitable estimate for this purpose.

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