SOIL CONTAMINATION CAUSED BY URBAN SOLID WASTE LEACHATE

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SUMMARY: Almost 60% of waste disposal sites in Brazil are open dumps with no infrastructure for environmental protection. It is usual to find uncovered waste. The rainwater runs off over the uncovered top of the waste dump. This water may contaminate the soil. This paper discusses the contamination values in the soil from toxic metals, caused by the contact of the soil with this leachate. Soil samples were taken from six holes near the waste dump at six different depths. Two sampling jobs were undertaken during a dry and a wet season. Relatively high values of soil contamination near the open dump can be noted from the soil contamination profiles.

1. INTRODUCTION

In Brazil about 60% (ABRELPE, 2005) of domestic urban solid waste produced, that is, about 96 tons a day, is inadequately disposed of in waste dumps or flooded areas. In many cases the percolate drains directly into the soil or to lakes or rivers near the open dump. There are risks of pollution of natural resources.

The Paracambi open dump is such an example. It is an open dump about 50-70m away from the Macacos River close to the town centre. Macacos River is part of the Guandu river basin, which is the water supply to the city of Rio de Janeiro

2. METHODS AND MATERIALS

Two samples were taken and a conceptual model of the hydrological dynamic from the case study (Schueler, 2005) was developed, using the program H.E.L.P (Hydrological Evaluation of Landfill Performance).

2.1 Conceptual model of the open dump

During heavy rainfall, part of the water seeping through the landfill tends to drain out in preferential routes. This water together with some of the water run-off over the landfill surface (part of it with uncovered waste) accumulates in the study area to form a pond (Figure 1). Part of this liquid evaporates and part seeps into the ground. This percentage of seepage seems to be responsible for the soil contamination discussed in this paper. The pond shown in Figure 1 occurred for almost two months.

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Figure 1. Pond formed by the leachate from the open dump.

The rainfall in the area under study is considered high and there are some periods when the monthly effective precipitation (precipitation minus evapotranspiration) is 190mm, measured in January 2003, when the pond formed by the run off (figure 1) was detected. The rainy periods normally occur in December, January and February.

The water volume of the effective rainfall over the Paracambi landfill is divided so that approximately 14% is the runoff over the landfill (1.7% runoff on uncovered waste) and 86% seeps into the top layer.

The fraction of water percolated through the landfill may go directly to the base or is drained by preferential ways and accumulated in the soil. The total of both is equal to approximately 60-68 % of water seepage (52-59% of effective precipitation).

Figure 2 presents the dynamics of the water flow and leachate in the Paracambi landfill during the season of heavy rainfall.

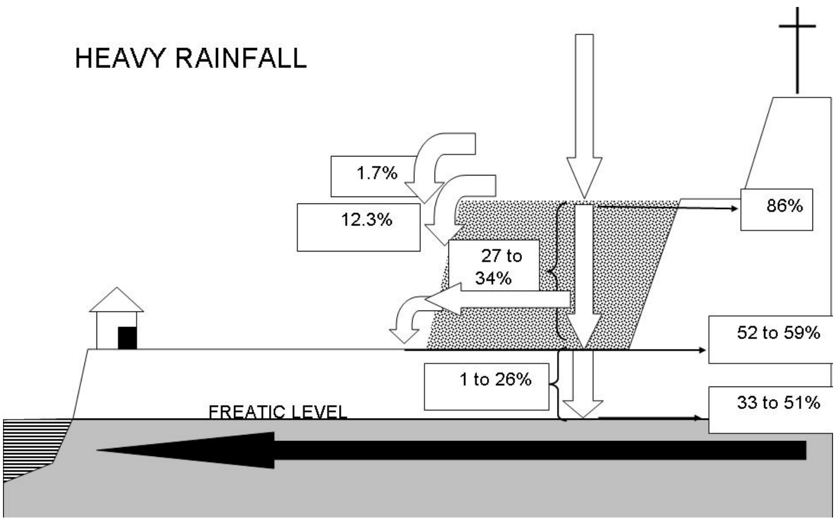

Figure 2. Scenery during the season of heavy rainfall

Table 1: Annual volume of leachate produced and leachate runoff over the open dump.

DRAINAGE (m3/year)	Leachate fraction
Effective precipitation (Precipitation less evapotranspiration)	10,596.4 m3/year
Volume of leachate produced in the open dump	7,462.4 m3/year
Runoff over uncovered waste	141.3 m3/year

It can be considered that the average precipitation in periods of heavy rain in the area under study is 10,596.4m^3 of the annual average value of effective precipitation.

In the periods of average and low rainfall in the region – between March and November – there is little runoff.

During percolation through the landfill, approximately 31-39% of liquid is stored in the waste (27-34% of effective precipitation).

After reaching the base soil, the leachate percolates through the non-saturated zone and around 55-97% reaches the aquifer (33-51% from effective precipitation). Approximately 1-26% of leachate remains stored in the soil in the non-saturated zone.

Figure 3 shows the results of the chemical analysis in leachate samples in the pond.

2.3 Soil Samples

Figure 3 shows a schematic diagram of the points where the samples were taken.

Soil samples were collected from six holes situated between the open dump and the river, into which drains the liquid runoff over the waste.

Three to six samples were collected from each hole at different depths, with a distance of 20cm between them, as shown in table 2.

Concentrations of Fe, Mn, Cd, Cr, Cu, Pb, Zn and Ni were measured to check the effects of contamination by the contact with the liquid runoff over the uncovered waste, and to check the difference in concentration of the chemical substances in the soil, at different depths.

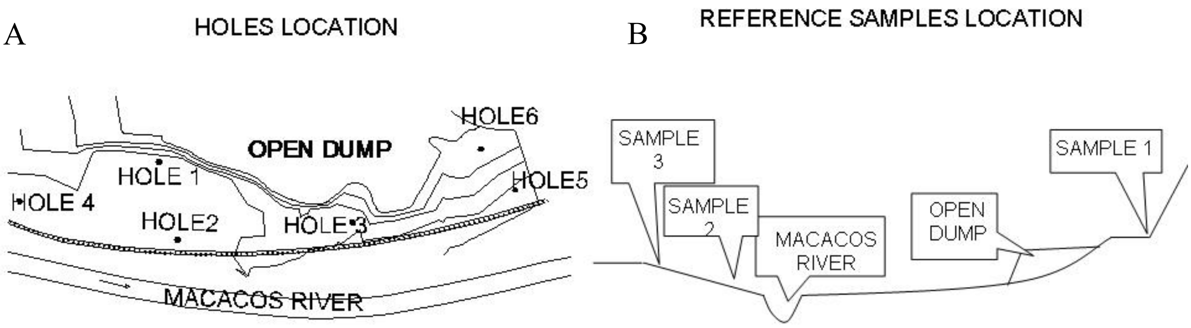

Figure 3. Location from where the soil samples were taken and B situation of points where the reference samples were collected.

Table 2. Depth of samples collected

Depth (metres)	1st sampling				2nd sampling				
	2	3	5	6	1	2	3	4	5
0					x	x	x	x	x
0.2					x	x	x	x	x
0.4	x	x	x	x	x	x	x	x	x
0.6					x	x	x	x	x
0.8	x		x	x	x	x		x	
1.0	x	x	x	x	x	x		x	

Table 3. Results of chemical analysis in reference sample.

Substance g/kg	Samples			CETESB reference values		
	1	2	3	Ref.	Alert	Interv. *
Fe	46.6	19.9	18.0	---	---	---
Mn	0.744	0.318	0.163	---	---	---
Zn	0.063	0.1	0.066	0.06	0.3	1.0
Cu	0.014	0.023	0.014	0.035	0.06	0.5
Cr	0.062	0.038	0.03	0.03	0.075	0.7
Cd	0.001	0.001	0.001	0.001	0.003	0.015
Ni	0.04	0.022	0.013	0.013	0.03	0.2
Pb	< 0.011	0.017	0.015	0.015	0.1	0.35

* Intervention values for residential areas

2.3.1 Sample Background

Soil samples that did not have contact with leachate were analysed and used as reference values (background).

Three soil samples were collected:

- Sample 1: upstream from the open dump
- Samples 2 and 3: on the other side of the river

Table 3 shows the values found in the samples and reference values established by Cetesb for soils in Sao Paulo State.

Sample 1 shows a very high concentration of iron, manganese, chromium and nickel in comparison to samples 2 and 3, collected on the opposite bank of the river Macacos, with no contact with the leachate from the waste dump. This difference may indicate a variation between the geochemical characteristics of both sites. It could also indicate contamination from an external source. This is a likely hypothesis since sample 1 was collected near the highway with heavy traffic. In addition, it is located at the foot of a slope from which it receives water and sediment.

3. RESULTS AND DISCUSSION

Figures 4 to 9 give the metal contents found in the soil samples. Figures 10 to 15 present the soil contamination profiles in each hole.

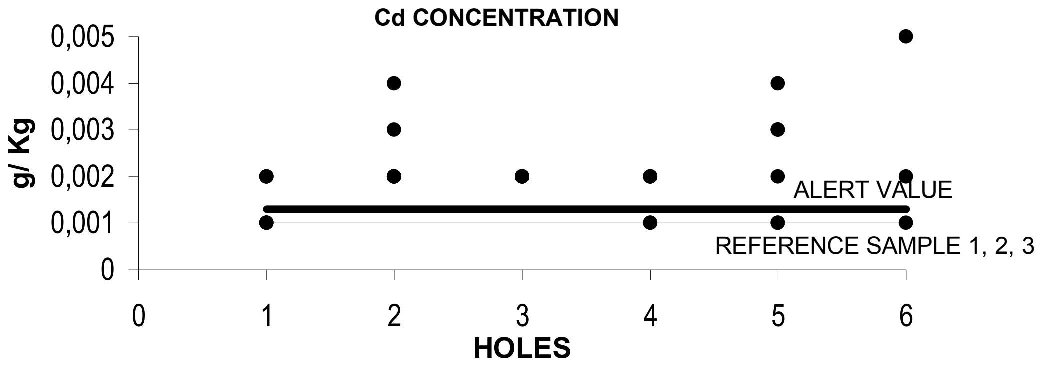

Figure 4. Cadmium concentration in soil samples

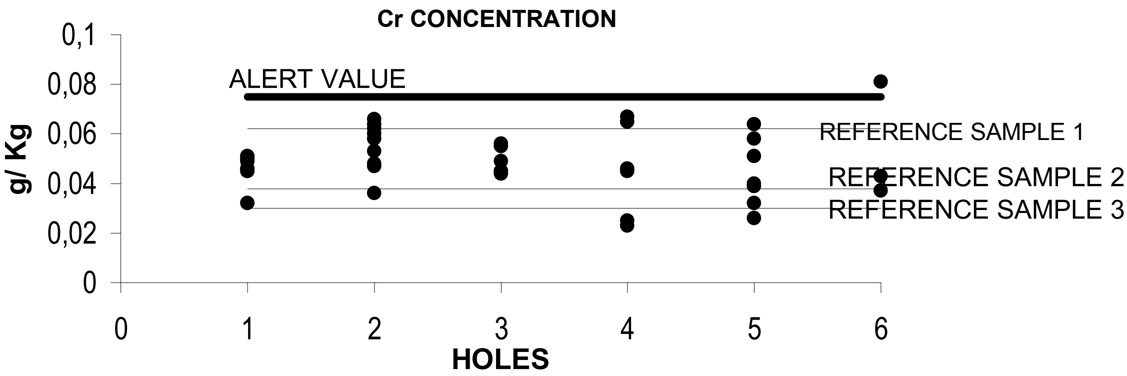

Figure 5. Chromium concentration in soil samples

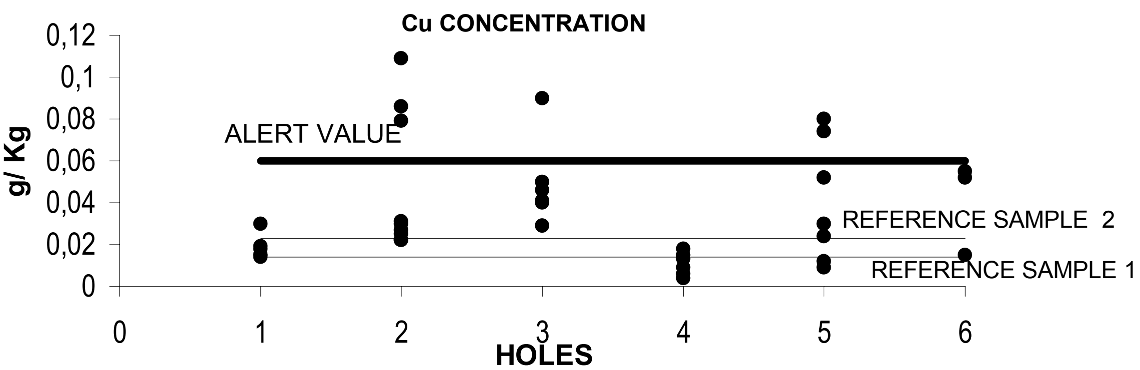

Figure 6. Cupper concentration in soil samples

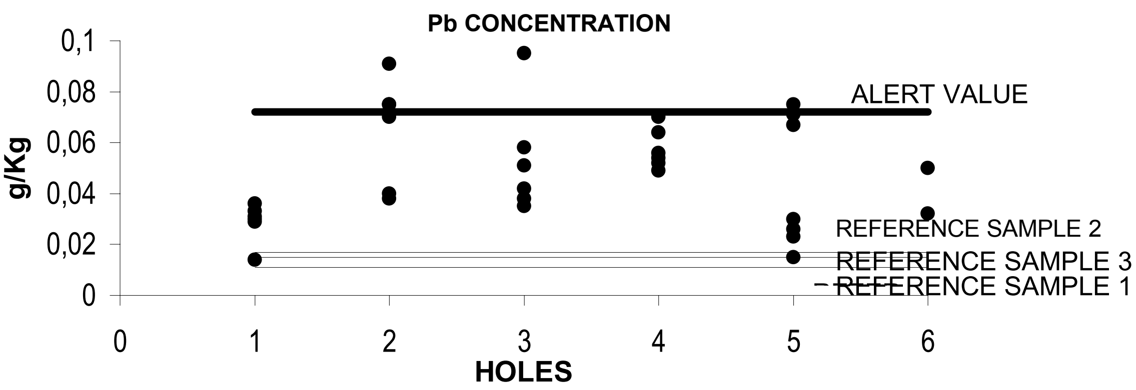

Figure 7. Lead concentration in soil samples

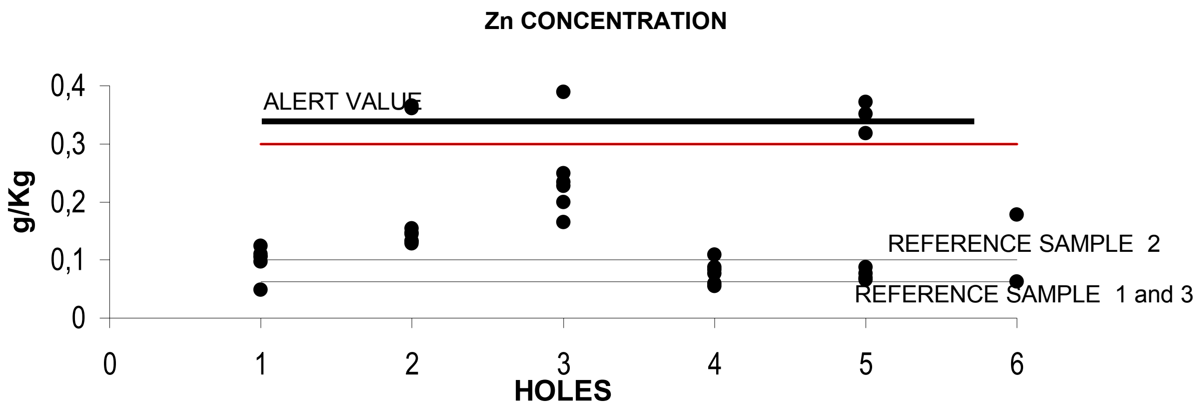

Figure 8. Zinc concentration in soil samples

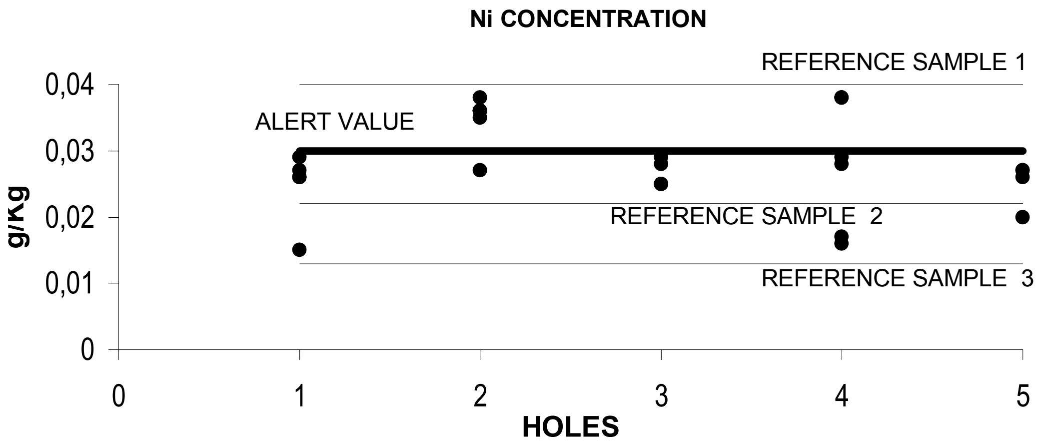

Figure 9. Nickel concentration in soil samples

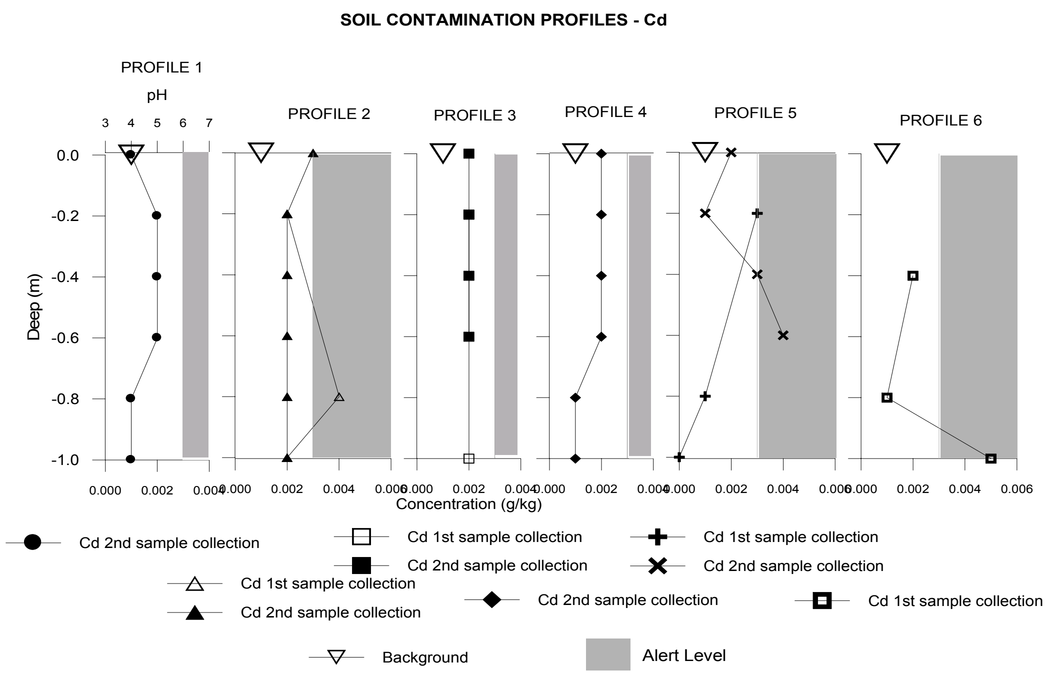

Figure 10. Soil contamination profiles with cadmium

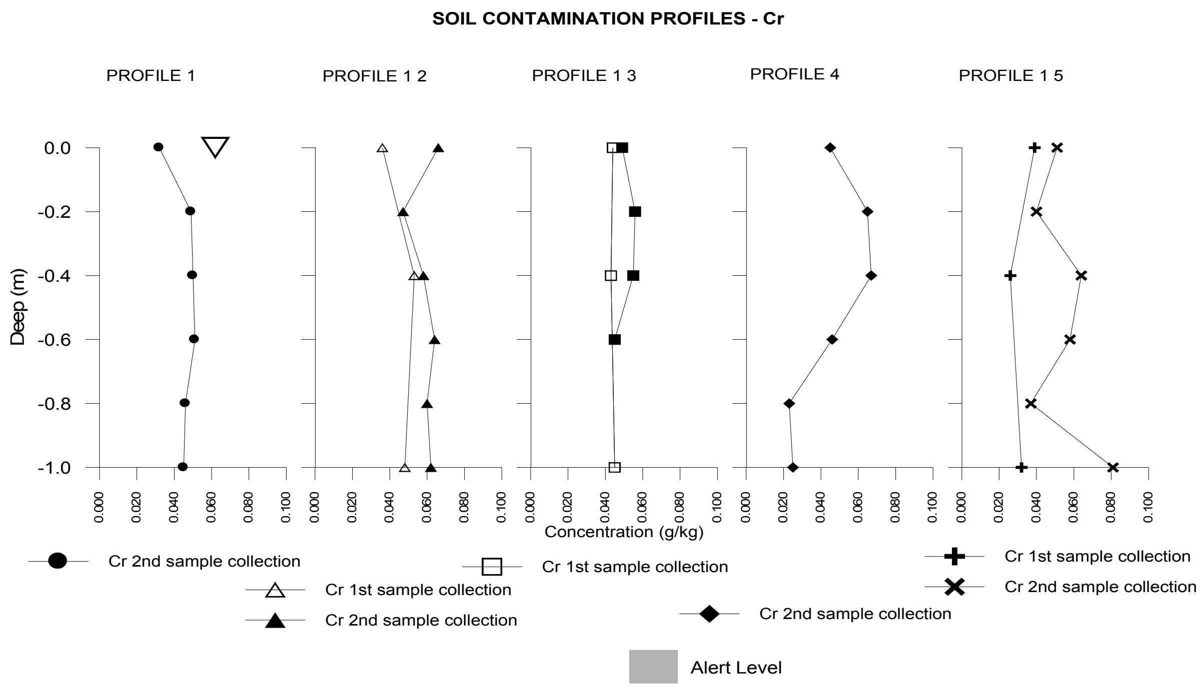

Figure 11. Soil contamination profiles with chromiu

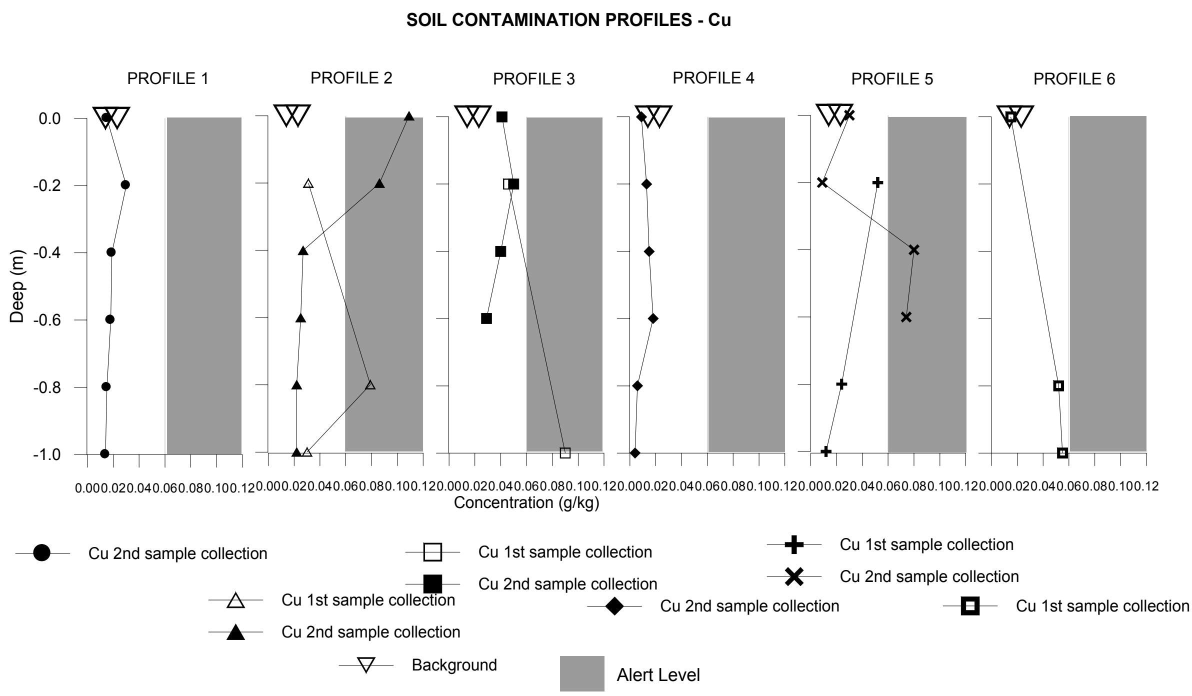

Figure 12. Soil contamination profiles with cooper

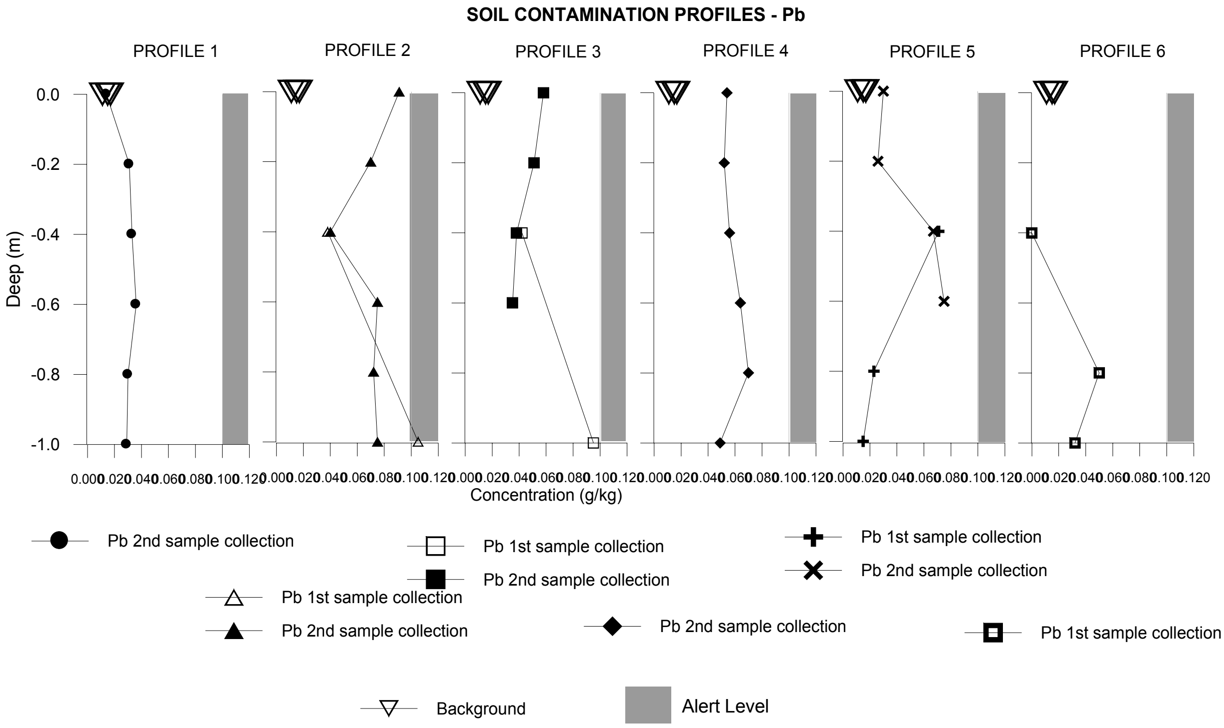

Figure 13. Soil contamination profiles with lead

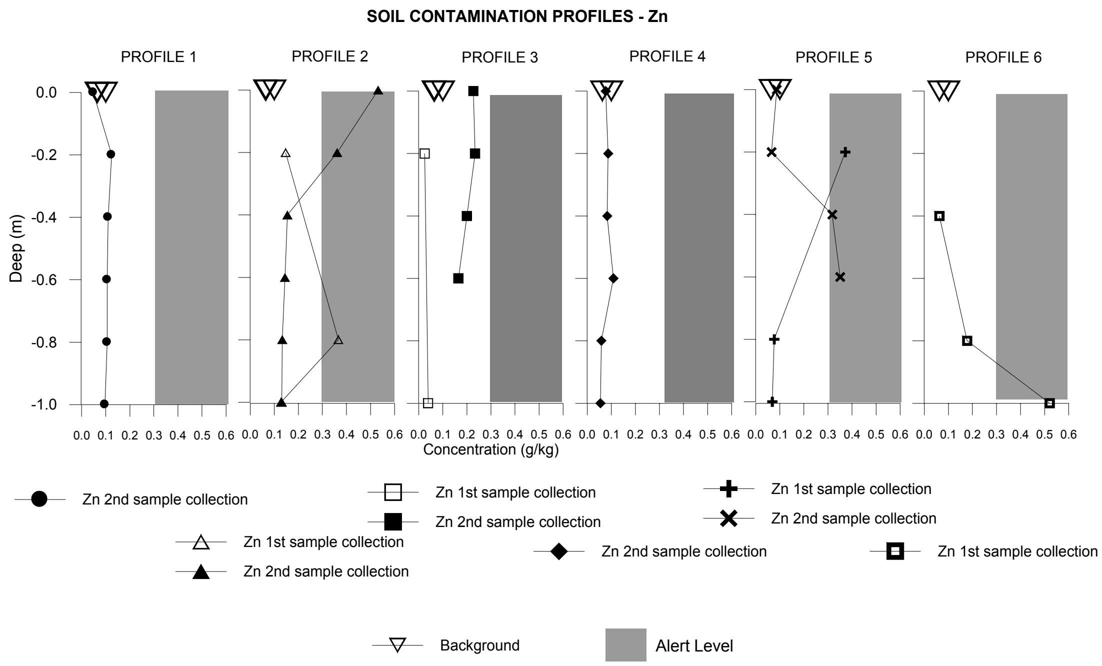

Figure 14. Soil contamination profiles with zinc

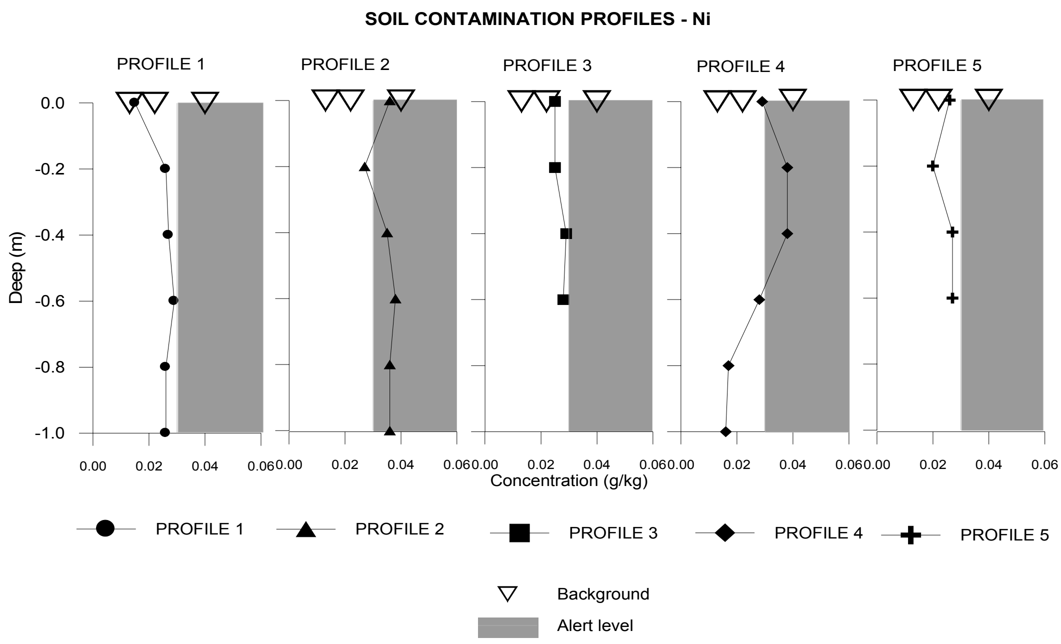

Figure 15. Soil contamination profiles with nickel

The most or least water presence for the period when the samples were taken does not seem to have interfered in the concentration of contaminants in the soil. This already was expected because a wide variation would occur if at the time the underground water layer had influenced the survey to humidify the deepest samples. This did not occur.

It can be seen from the contamination profiles (see figure 10 to 15) that there is a similar trend of different metal variation in the same hole. This does not occur between the profiles of the same metal, which can be justified by the geochemistry metal behaviour.

In relation to cadmium cooper, lead, and zinc, the three samples collected as reference present similar values of concentration. The majority of the samples collected downstream from the landfill in the area under study show a higher content of those metals, which characterises ground contamination of the area under study by the leachate from the waste landfill.

Reference sample 1 shows a very high iron, manganese, chromium and nickel content, in relation to reference samples 2 and 3. As none of them had contact with the waste leachate this difference may indicate a geochemical variation in the places where the samples were collected. It may also indicate contamination from a source outside the landfill, which is probable since the sample was collected next to the highway with heavy traffic. Moreover, it is located at the foot of a slope and receives water and sediments from it.

4. CONCLUSIONS

Brazil has around 60 tons of waste, with no or almost no care taken with its disposal in dumps, nor any environmental protection infrastructure.

The dumps are totally or partially uncovered, which means that the occurrence of contaminated surface runoff is normal.

When this type of disposal dump is closed down, special attention should be given to the cover systems, since these sites did not receive a protective layer at the landfill base. In such cases, the cover is now the only protective layer against the water seeping into the waste mass and against gas going into the external environment.

It is also important to rehabilitate the area that receives the surface runoff, since the runoff, as shown, is responsible for high contamination content of the soil.

It should be stressed tha t the leachate fraction responsible for contamination was produced by leachate formed by a relatively rapid contact between the runoff and waste, which happened in two months of the year.

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REFERENCES

ABRELPE (2005). Panorama of the solid residues in Brazil. Available in www.abrelpe.com.br

CONAMA - National Council for the Environment (2005). Resolution no. 357, 17 March 2005;

Health Department (2004). Administrative Rule no. 518, 25 March 2004.

Schueler. A.S. (2005). Study of case and proposal of evaluation of areas degraded for disposal of urban solid residues. Thesis of doutorado. Coppe - UFRJ. River of January-Rio de Janeiro 122p; available in http://www.coc.ufrj.br/teses/doutorado/inter/2005/Teses/SCHUELER_AS _ 05_t _ D_int.pdf