Evaluation of the effect of Solid Waste leachate on Soil at Hilla City

Suad Mahdi Glewa *College of Engineering University of Babylon*

Mustafa Al-Alwani *School of Architecture Design and Environment Plymouth University*

Abstract

The present investigation was carried out to evaluate the effect of solid waste Leachate of unlined dumping site on soil at study area which located at the north of Hilla city . To assess soil contamination 6 bore holes were bring randomly at the site .Three samples were collected at 50, 100, 150 cm for each bore hole. For leachate the samples were taken randomly from three different locations and were mixed prior to its analysis. Concentration of various physico-chemical parameters including heavy metals (Cd, Cr, Cu, Fe,) were determined in soil and leachate samples. The presence of Cl ,NO_3 , Cd, Cr, Cu, Fe, in soil, likely indicate that soil is being significantly affected by leachate percolation. Further they proved to be as tracers for groundwater contamination.

الخلاصة

إن الدراسة الحالية تهدف إلى حساب تأثير المخلفات الصلبة على التربة في مدينة الحلة . ولتقييم تلوث التربة الناتج عن المخلفات الصلبة فقد تم حفر ٦ حفر اختباريه في منطقة الدراسة بصورة عشوائية وتم اخذ ثلاث عينات من كل حفرة ومن الارتفاعات ٥٠. ١٠٠. ١٥٠ سم .اما بالنسبة للمخلفات الصلبة فقد أخذت ثلاث عينات عشوائية للعصير الناتج عنها من ثلاث نقاط في الموقع وتم خلط العينات ومن ثم تحليلها .و لكل العينات المأخوذة سوء من التربة او من لعصير الناتج من المخلفات الصلبة فقـد تـم قيـاس لخصائص الفيزياوية والكيماوية ومن ضمنها العنصر الثقيلة

(Cd, Cr, Cu, Fe,) . ان وجود عناصر مثل NO_3 , Cd, Cr, Cu, Fe, في التربة كما تبين في الدراسة الحالية سيكون مؤشر مهم على تاثر التربة بالمخلفات الصلبة وبالتالي سيؤثر على المياه الجوفية ويسبب تلوثها .

1. Introduction

Due to several legislative, environmental, economic and social constraints, the identification of most sustainable disposal route for solid waste management remains an important issue in almost all industrialized countries (Adani et al. 2000)

Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearbysite. Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment.

The impact of solid waste leachate on soil has given rise to a number of studies in recent years.(Saarela, 2003; Abu-Rukah and Kofahi, 2001; Looser *et al.*, 1999; Christensen*et al.*, 1998; De Rosa *et al.*, 1996; Flyhammar, 1995). Many approaches have been used to assess the contamination of soil and groundwater . It can be assessed either by the experimental determination of the impurities or their estimation through mathematical modeling (Moo-Young *et al.*, 2004; Hudak, 1998; Stoline *et al.*, 1993; Butwa *et al.*, 1989).

Most solid waste disposal sites in Hilla city are illegal open dumps at numerous locations scattered inside and around the city with no infrastructure for environmental protection. It is usual to find uncovered solid waste. The rainwater runs off over the uncovered top of the waste dump. This water may contaminate the soil.

Some of the major problems that result from current solid wastes management are:

1. The unpleasant smells
2. The spread of insects that gather on these solid wastes
3. The emitted smoke from the burning of such wastes
4. The contamination of surface water and groundwater due to the decomposition of the solid wastes.

5. landscape damaging

Hilla is a city in central Iraq on the Hilla branch of the Euphrates River, 100 km (62 miles) south of Baghdad. The population is estimated at 524,000 . It is situated in a predominantly agricultural region which is extensively irrigated with water provided by the Hilla river, producing a wide range of crop.

Leachate by seepage and infiltration worsen soil quality . Open dumping is extensively practiced in Hilla city . The leachate generated from such sites pose serious environmental risks to the surroundings by causing contamination of soil and groundwater systems.. As the water percolates through the landfill, it contacts the refuse and leaches chemicals from the waste.

Leachate quality is greatly influenced by the length of time which has elapsed since waste placement. The quantity of chemicals in the waste is finite and, therefore leachate quality reaches a peak after approximately two to three years followed by a gradual decline in following years (FCSHWM, 1998). Leachate from a solid waste disposal site is generally found to contain major elements like calcium, magnesium, potassium, nitrogen and ammonia, trace metals like iron, copper, manganese, chromium nickel, lead and organic compounds like phenols, polyaromatic hydrocarbons, acetone, benzene, toluene, chloroform etc (Freeze and Cherry, 1979). The concentration of these in the leachate and water depends on the composition of wastes (Alker *et al*., 1995).
Some of the pollutants may be adsorbed on to the soil media during the flow of leachate through the soil.

Because of poor solid waste management and as the effects of solid waste on soil at Hilla city hasn't been studied yet including factors and its parameters. So the aim for this study is: evaluate the impacts of solid waste leachate on soil

2. Materials and methods

to assess soil contamination 6 bore hole were bring randomly at the site .Three samples were collected at 50, 100, 150 cm for each bore hole . Boring was carried out by using auger .Soil samples were tested against the following Physical properties
2.1.1 pH value : The pH was determined for the saturation paste extract using pH meter (APHA, AWWA,and WPCF 2002).

2.1.2 Electric conductivity: EC was measured as an indication of the total dissolve solids using EC meter after dilution with water at a ration of 1: 5 (soil : water) ,(APHA, AWWA,and WPCF 2002).
2.1.3 Bulk density: This was measured by putting a certain weight of soil in certain volume, where bulk density equal mass over volume.
2.1.4 Main particle size: by sieving analysis (Das, 1989).
2.1.5 Particle - size distribution: Soil samples, as received from the field, dried in air . The dried samples are taken in a tray, saturated with water and mixed with either 1g of sodium hydroxide and 1g of sodium carbonate per litre of water, which is added as a dispersive agent and put into a 1000 ml jar for hydrometer analysis.

2.2 Chemical properties

K, nitrite, and phosphorus,Na, Ca, Mg, Cl, Heavy metal that consists of Cd, Cr, Cu,Fe .

Soil Chemical analysis was conducted according to Method of Soil Analysis (Page *et al,* 1982). Chemical composition of Soil was determined by extracting it from the solid phase (soil) into a liquid phase (solvent). The extracting method differs from one element to another. However, many elements can be measured from the saturation extract.

2.3 Leachate

Since the site was not equipped with a leachate collector, the leachate collected at the base of the landfill was sampled randomly from three different locations and were mixed prior to its analysis including trace metals (APHA, AWWA,and WPCF 2002)

3. Study Area

Study area is located at the north of Hilla city, near Al mahaweel town . The disposal waste is fill a height varies from 1m to 4m . The waste disposal at this site includes domestic waste, e.g. kitchen waste; paper, plastic, glass, cardboard and cloths. Construction and demolition waste consisting of sand, bricks and concrete block are also dumped .

The site is non-engineered low lying open dump, looks like a huge heap of waste up to a height of 1 – 4 m. Trucks from different parts of the city collect and bring waste to this site and dump the waste in irregular fashion. The waste is dumped as such without segregation, except the rag pickers who look through the garbage and help in segregating it. They generally collect glass material, plastic and metals and sell this to the recycling units.

4. Results and Discussion

To understand the impact of leachate quality on the soil , characterization of leachate has been carried out and presented in Table (1).

Table (1) characterization of leachate quality

pH	6.8
EC (ms/cm)	4
TSS (mg/l)	525
TDS (mg/l)	3500
BOD5 (mg/l)	3750
Cl (mg/l)	1000
Alkalinity (mg/l)	1400
Hardness (mg/l)	700
Ca (mg/l)	190
Mg (mg/l)	48
SO_4(mg/l)	275
PO_4 (mg/l)	23
NO_3 (mg/l)	0.054
Iron (mg/l)	2.8
K (mg/l)	148
Na (mg/l)	147
Cd (mg/l)	0.014
Ni (mg/l)	18
Zn (mg/l)	91
Cu (mg/l)	0.23
Pb (mg/l)	0.19
Fe (mg/l)	17

Physico-chemical characteristics of the leachate depend primarily upon the solid waste characteristics and water content in total sold waste. The pH value of the collected sample was found to be 6.8 The relatively high values of EC 4 (ms/cm) and TDS 3500(mg/l) indicate the presence of inorganic material in the samples. The presence of high BOD (3750 (mg/l) indicates the high organic strength. presence of NO_3 0.054(mg/l) were also observed in the leachate samples.

The high level of Fe 17(mg/l) in the leachate sample indicates that Fe and steel scrap are also dumped in the disposal site. The dark brown color of the leachate is mainly attributed to the oxidation of ferrous to ferric formand the formation of ferric hydroxide colloids and complexes with fulvic/ humic substance (Chu et al., 1994).The presence of high concentration of Zn 91(mg/l) in the leachate shows that the disposal site receives waste from batteries and fluorescent lamps. The presence of Pb (1.54mg L−1) in the leachate samples indicates the disposal of Pb batteries, Pb-based paints and pipes at the landfill site (Moturi et al., 2004; Moret al., 2005a). Cr (0.29mg L−1), Cu (0.93mg L−1) and Ni (0.41mg L−1) were also present in the leachate samples. A variety of waste is dumped which likely indicate the origin of Zn, Cr, Cu and Ni in leachate (Moturi et al., 2004; Mor et al., 2005a).

pH values of the leachate 6.8 samples indicate presence of heavy metals like Cd, Cr, Cu, Zn, Pb and Fe. The presence of metals in the leachate shows the effect of unsegregated solid waste containing steel scrap, lead batteries, tins, cans etc.To avoid such heavy metal contamination source segregation of waste is a must.

leachates contain a variety of contaminants including heavy metals such as cadmium, nickel, zinc, copper. Usually these metals are found at moderate concentration levels in municipal landfill leachate According to Hem (1991),

For soil samples as they seem in figures 1 to figure 12 test results showed that soil was polluted with some contaminants like Cl,NO_3 ,and with heavy metals like Cd, Cr, Cu, Fe. High metal levels can adversely affect soil, including its ability to be farmed.(Hill, 2004). Growing of crop on contaminated soil may lead to serious health hazard because the crop may uptake heavy metals and other contaminants (Sidra, et, al ,2009) . So this soil is unfit to agriculture purpose.

morover excessive accumulation of heavy metals and other contaminant at study soil may eventually contaminate both human and animal food chain (Williams *et al.*, 1987; He *et al.*, 1992; Chukwuji *et al.*, 2005).

Table (2) grain size analysis of soil in study area

Clay (%)	48.6
Silt (%)	40.1
Fine sand (%)	5.0
Coarse sand (%)	6.3

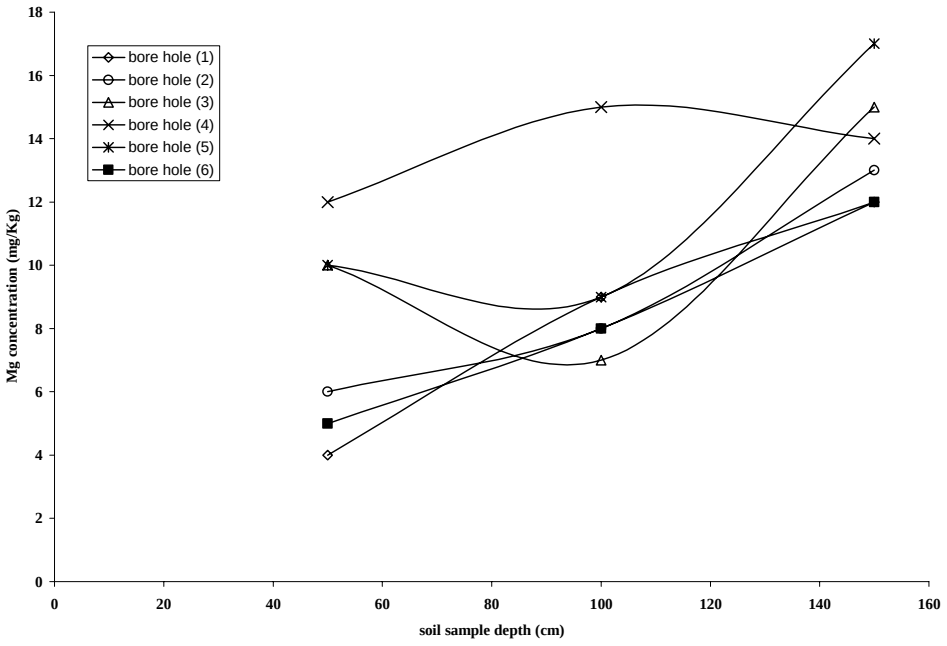

Fig (1) Concentration of Mg at various soil sampling depth

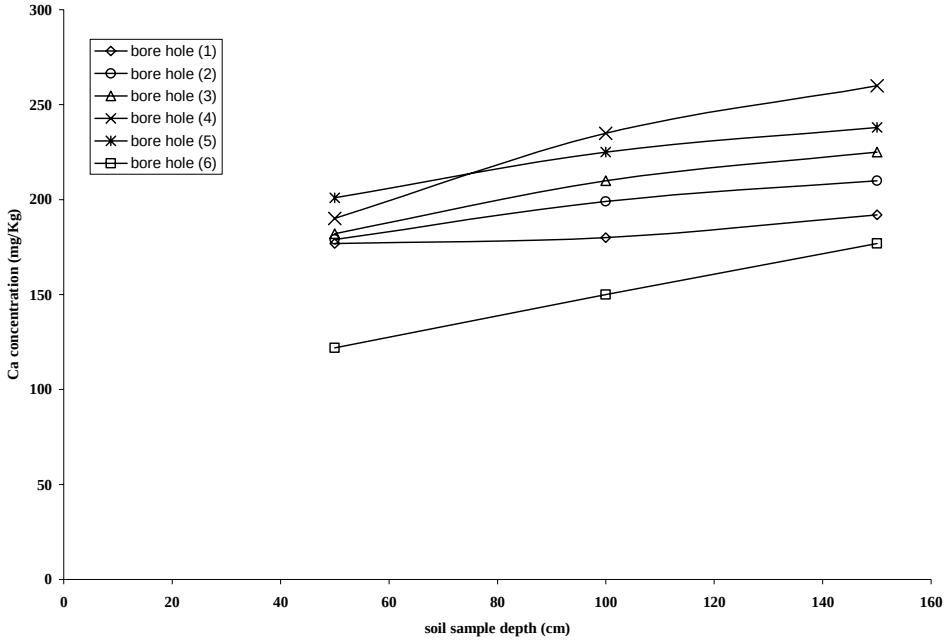

Fig (2) Concentration of Ca at various soil sampling depth

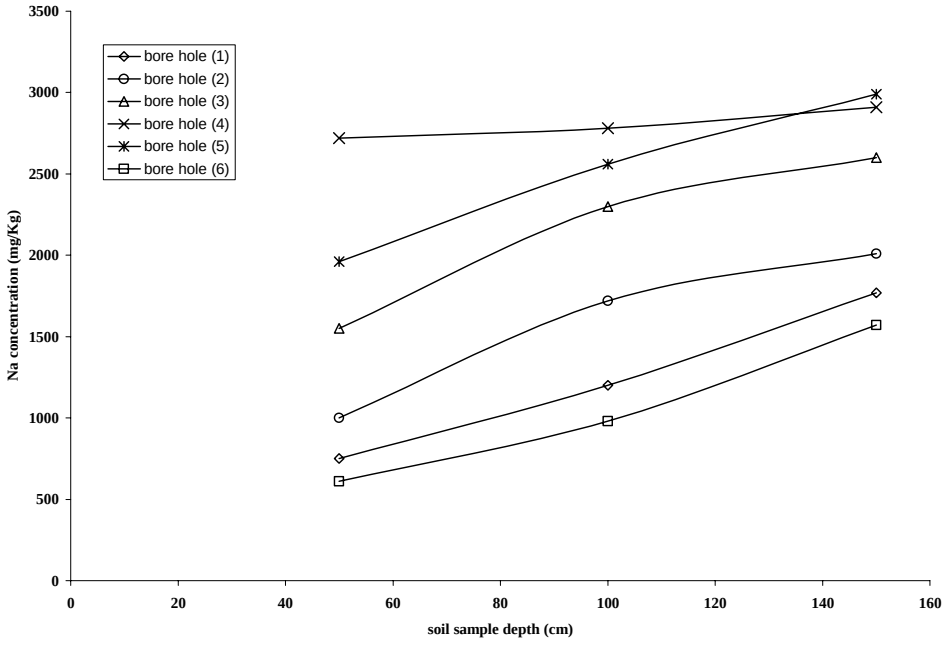

Fig (3) Concentration of Na at various soil sampling depth

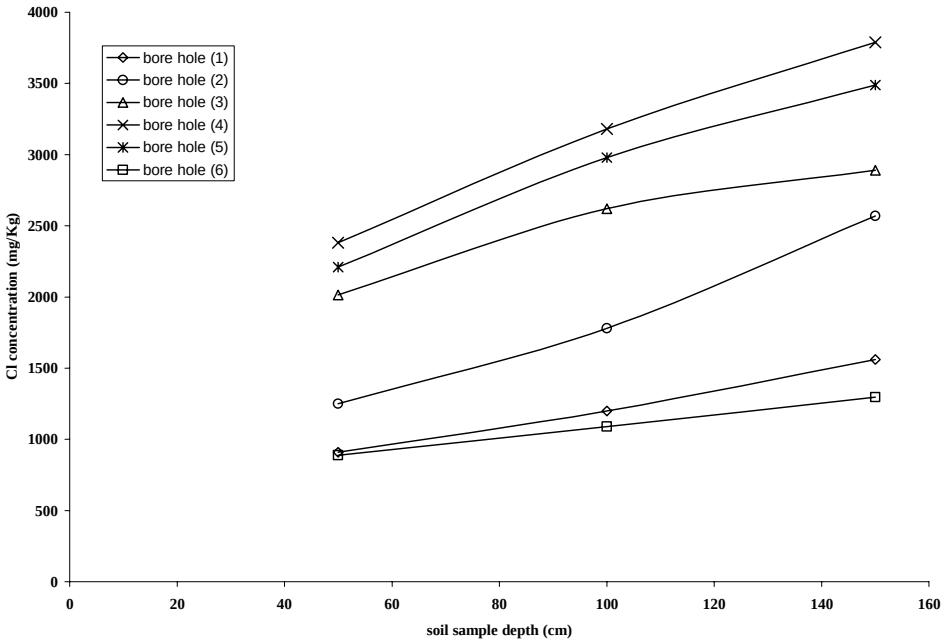

Fig (4) Concentration of Cl at various soil sampling depth

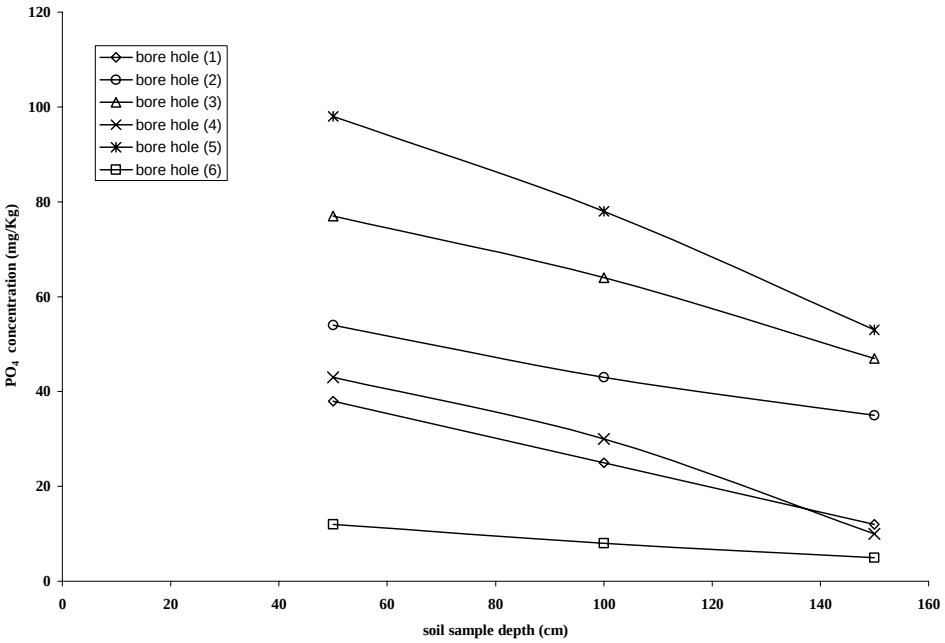

Fig (5) Concentration of PO_4 at various soil sampling depth

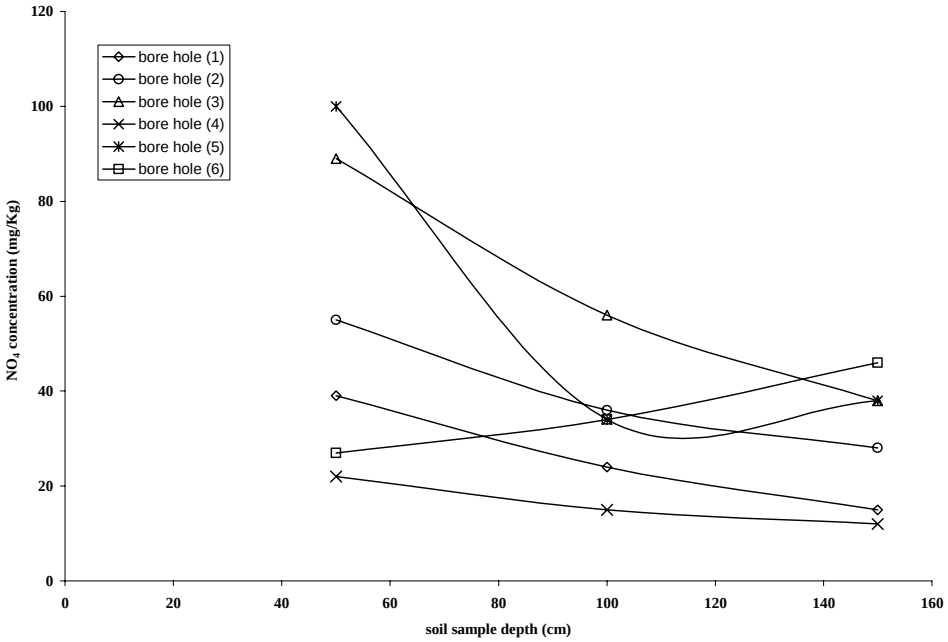

Fig (6) Concentration of NO_3 at various soil sampling depth

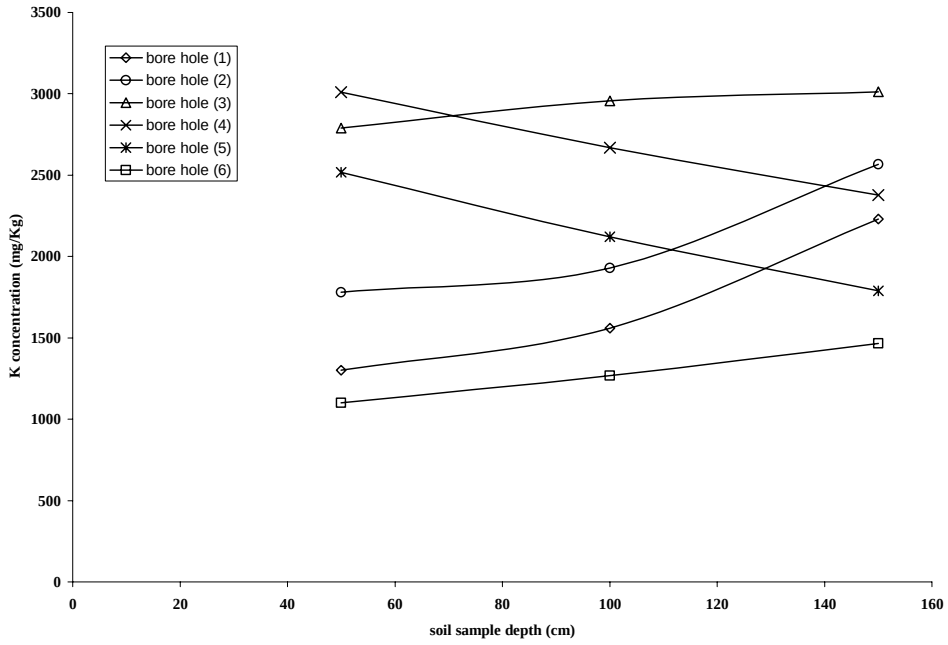

Fig (7) Concentration of k at various soil sampling depth

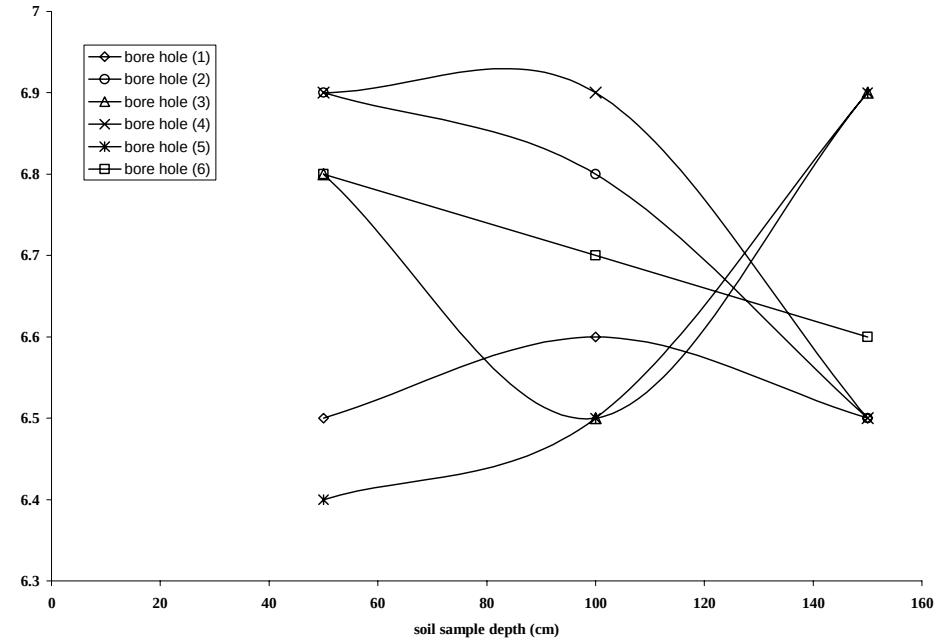

Fig (8) pH at various soil sampling depth

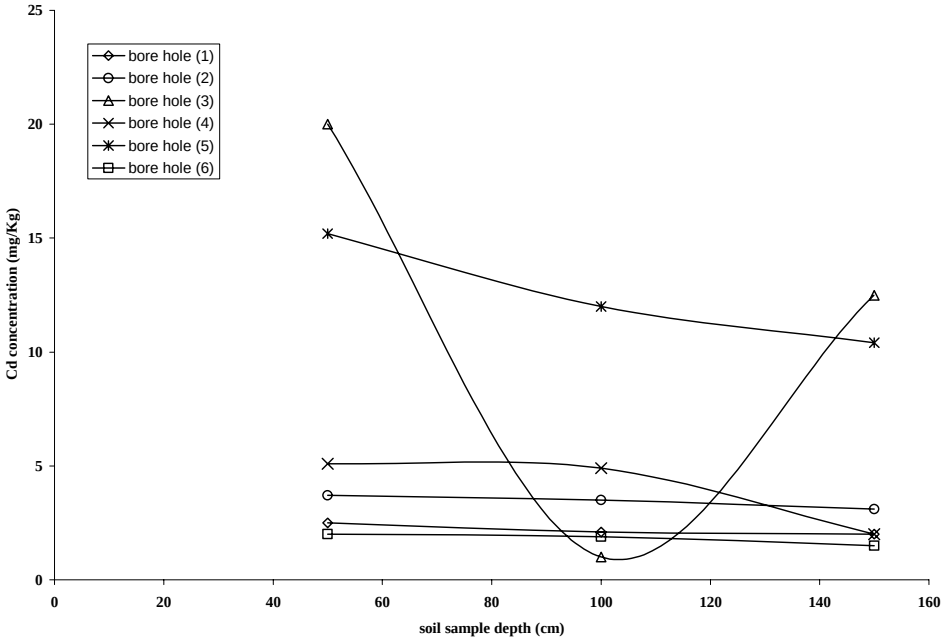

Fig (9) Concentration of Cd at various soil sampling depth

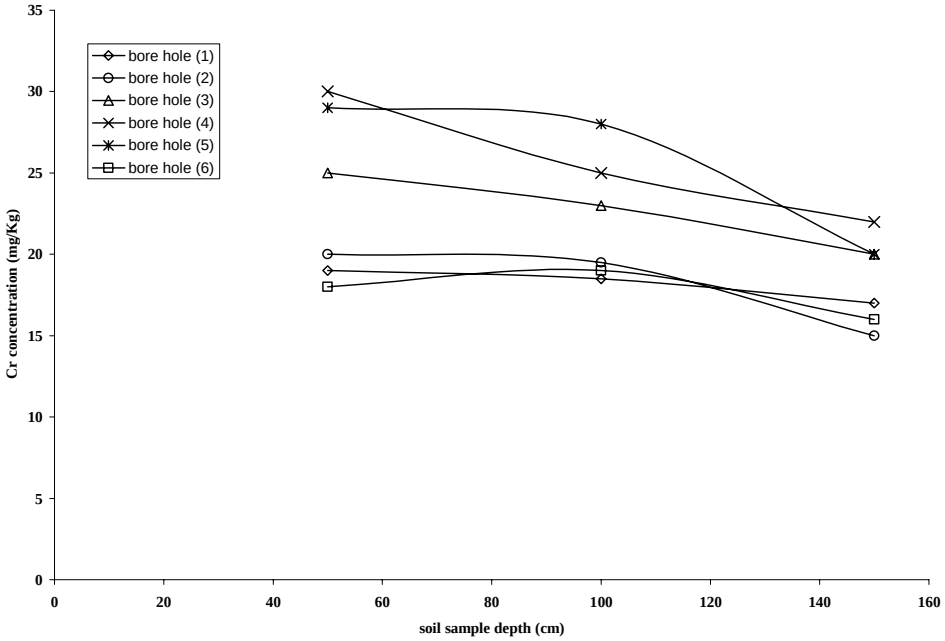

Fig (10) Concentration of Cr at various soil sampling depth

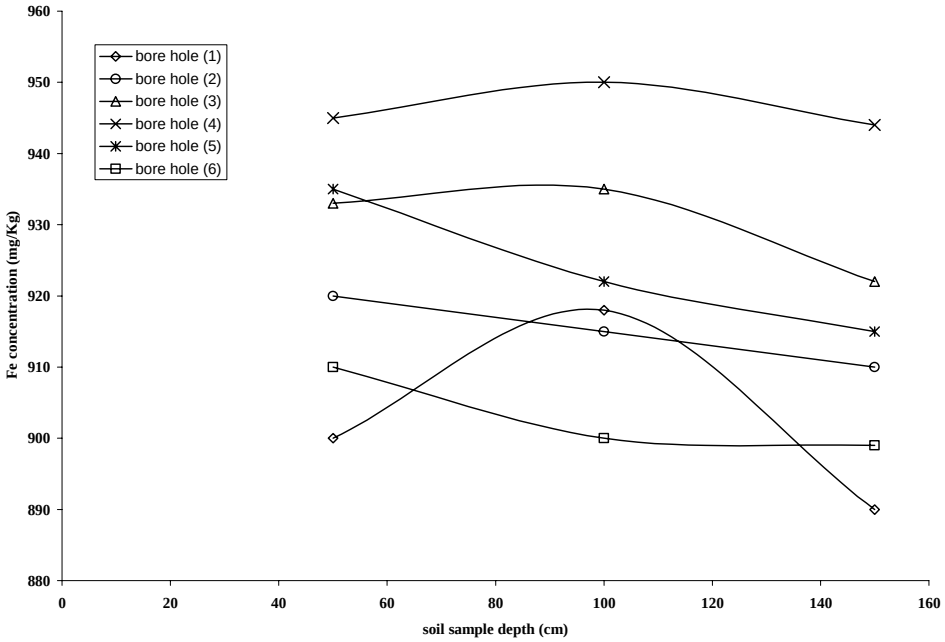

Fig (11) Concentration of Fe at various soil sampling depth

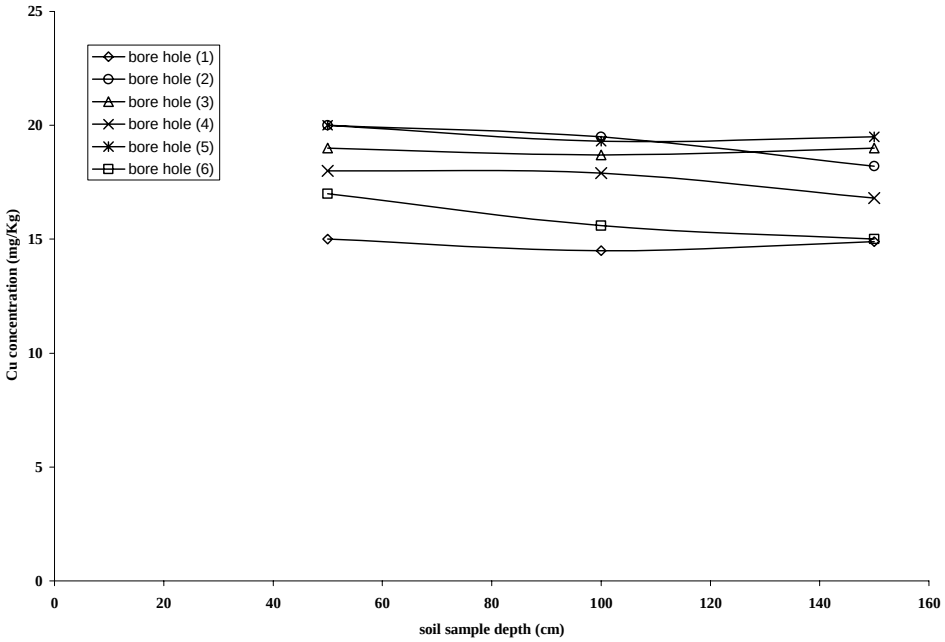

Fig (12) Concentration of Cu at various soil sampling depth

5. Conclusions

The analysis of soil has shown that soil is highly polluted and unfit for agriculture.. This has to be appropriately prohibited by engineering measures. Geo-synthetic liners can be provided to limit the percolation of leachate into the soil.

Concentration of various physico-chemical parameters including heavy metals (Cd, Cr, Cu, Fe,) were determined in soil and leachate samples. The presence of Cl ,NO_3 , Cd, Cr, Cu, Fe, in soil, likely indicate that soil is being significantly affected by leachate percolation. Further they proved to be as tracers for groundwater contamination, moreover high metal levels can adversely affect soil, including its ability to be farmed. Growing of crop on contaminated soil may lead to serious health hazard because the crop may uptake heavy metals and other contaminants. So this soil is unfit to agriculture purpose.

To minimize the impact of such landfills on soil properties and the environment in general, it is necessary to properly design and build these facilities to prevent pollution. Regular monitoring must be carried out over a large period, in order to verify the influence of seasonal variations on the contaminant concentrations with time. Developing countries should strictly implement integrated solid waste management approach to handle large volume of wastes and protect environment.

6. References

Abu-Rukah, Y. and Al-Kofahi, O.(2001), 'The assessment of the effect of landfill leachate on groundwater quality – a case study', *El-Akader Landfill Site – North Jordan, Arid Environ.* **49**, 615–630.

Adani F, Scatigna L, Genevini P (2000) Biostabilization of mechanically separated municipal solid waste fraction.Waste Manage Res 18:471–477.

Alker, S. C., Sarsby, R. W., & Howell, R. (1995) Composition of leachate from waste disposal sites. Proceedings, Waste Disposal by Landfill- Green'93 (pp. 215–221), Balkena,Rotterdam.

Angers, D. A. and Caron, J. (1998), 'Plant induced-changes in soil structure: Processes and feedbacks',*Biogeochemistry* **42**, 55–72.

APHA, AWWA, & WPCF (2002). Standard methods for the examination of water and waste water (20th ed.).

Butow, E., Holzbecher, E. and Kob, E.: (1989), *Approach to Model the Transport of Leachates from aLandfill Site including Geochemical Processes, Contaminant Transport in Groundwater*. Kobus

and Kinzelbach, Balkema, Rotterdam, pp. 183–190.

Christensen, J. B., Jensen, D. L., Gron, C., Filip, Z. and Christensen, T. H.: (1998), 'Characterization of the dissolved organic carbon in landfill leachate-polluted groundwater', *Water Res.* **32**, 125–135.

Chukwuji M. A. I.; Nwajei, G. E.; Osakwe, S. A., (2005).Recycling waste in agriculture: Efficacy of composting in ameliorating trace metal availability and soil borne pathogens. Eur. J. Sci. Res., 11 (4), 571–577.

Chu, L. M., Cheung, K. C. and Wong, M. H.: (1994), 'Variations in the chemical properties of landfill leachate', *Environ. Manage.* **18**, 105–117.

Das, Braja, (1989) Soil Mechanics Laboratory Manual, 3rd ed, California,Engineering.

DeRosa, E., Rubel, D., Tudino, M., Viale, A. and Lombardo, R. J.(1996), 'The leachate composition of an old waste dump connected to groundwater: Influence of the reclamation works', *Environ.Monit. Assess.* **40**(3), 239–252.

Flyhammar, P, (1995), 'Leachate quality and environmental effects at active Swedish municipal landfill', *Regulations, Environmental Impactand Aftercare*. Proceedings Sardinia '95, Fifth International Landfill Symposium. Vol. III, Sardinia,Italy, pp. 549–557.

Florida Center for Solid and Hazardous Waste Management "FCSHWM",Reinhart, Debra, and Grosh, (1998). University of Central Florida, Florida.

Freeze, R. A., & Cherry, J. A. (1979). Ground Water. Englewood

cliffs, NJ: Prentice-Hall.

Hem, J.D. (1991). Study and interpretation of the chemical characteristics of natural groundwater. U.S Geological Survey Water Supply 1473 p.

Hernandez, A. J., Adarve, M. J., Gil, A. and Pastor, J.(1999), 'Soil salination from landfill leachates :Effects on the macronutrient content and plant growth of four grassland species', *Chemosphere* **38**, 1693–1711.

Hudak, P. F.(1998) , 'Groundwater monitoring strategies for variable versus constant contaminant loading functions', *Environ. Monit. Assess.* **50**, 271–288.

Lapa, N., Barbosa, R., Morais, J., Mendes, B., Mehu, J. and Oliveira, J. F. S.(2002), 'Eco toxicological assessment of leachates from MSWI bottom ashes', *Waste Management* **22**, 583–593.

Looser, M. O., Parriaux, A. and Bensimon, M. (1999), 'Landfill underground pollution detection and characterization using inorganic traces', *Water Res.* **33**, 3609–3616.

Mace, J. E. and Amrhein, C.(2001) , 'Leaching and reclamation of soil irrigated with moderate waters',*Soil Sci. Soc. Am. J.* **65**, 199–204.

Menneer, J. C., McLay, C. D. A. and Lee, R.(2001), 'Effects of sodium-contaminated wastewater on soil permeability of two New Zealand soils', *Aust. J. Soil Res.* **39**, 877–891.

Mitchell, T., Desmond J., Wild, S. R. and Jones, K. C.(1992), 'Arrested municipal solid waste incinerator fly ash as a source of heavy metals to the UK environment', *Environ. Pollut.* **76**, 79–84.

Moo-Young, H., Johnson, B., Johnson. A., Carson, D., Lew, C., Liu, S. and Hancock, K. (2004), 'Characterization of infiltration rates from landfills: Supporting groundwater modeling efforts',*Environ. Monit. Assess.* **96**, 283–311.

Mor, S., Ravindra, K., Vischher, A., Dahiya, R. P. and Chandra, (2005), Municipal Solid Waste Characterisation and its Assessment for Potential Methane Generation at Gazipur Landfill Site,Delhi: A case study. Bioresource Technology, Communicated.

Mor, S., Vischher, A., Ravindra, K., Dahiya, R. P., Chandra, A. and Van Cleemput, (2005),'Induction of enhanced methane oxidation in compost: Temperature and moisture response',*Waste Manage.*.

Moturi, M. C. Z., Rawat, M. and Subramanian, (2004) , 'Distribution and fractionation of heavy metals in solid waste from selected sites in the industrial belt of Delhi, India', *Environ. Monit.Assess.* 95, 183–199.

Park, S., Choi, K. S., Joe, K. S., Kim, W. H. and Kim, H. S(2001), 'Variations of landfill leachates properties in conjunction with treatment process', *Environ. Technol.* **22**, 639–645.

Page, A., Millers, R., and Keeney, D., (1982) Methods of Soil Analysis Part 2.Chemical and Microbiological Properties, 2nd ed, USA, Madison

Wisconsin,.

Saarela, J.,(2003), 'Pilot investigations of surface parts of three closed landfills and factors affecting them', *Environ. Monit. Assess.* **84**, 183–192.

Sidra, K. Distribution and fractionation of heavy metals in solid waste from selected sites, *Journal of Science Technology and Development,* **28**, 14.

Stoline, M. R., Passerp, R. N. and Barcelona, M. J.(1993), 'Statistical trends in groundwater monitoring data at a landfill site – A case study', *Environ. Monit. Assess.* **27**(3), 201–219.

Williams, D. E.; Vlarnis, J.; Pukite, A. H.; Corey, J. E. (1987).Metal movement in sludge-amended soils: A nine-year study. Soil Sci., 143, 124-131 (8 pages).

Wiles, C. C.(1996), 'Municipal solid waste combustion ash: State-of-the-knowledge', *J. Hazard. Mat.***47**, 325–344.