Trace Element Concentration at Sanitary Landfill Sites in Parts of Delhi

Sirajuddin Ahmed
Department of Civil Engineering
Jamia Millia Islamia, New Delhi 25

Prof. S. S. Nabi
Department of Civil Engineering
Jamia Millia Islamia, New Delhi 25

Dr. S.G.V Subramaniam
Center for Environmental Studies, Anna University, Chennai

Dr. Inamul Haq
Central Pollution Control Board, New Delhi

Abstract

The sanitary landfill sites have occupied a considerable area especially the depression zones in parts of Delhi. Unfortunately, till date Delhi doesn't have any exclusive hazardous tracts landfill site. The municipal solid waste are mixed up with hazardous waste e.g hospital waste, industry waste and other toxic waste and deposited at different sanitary landfill sites. Thus the leachate forms from these site are toxic in nature occurred and contribute the physical, chemical and biological contaminant by their movement to the shallow ground water level. It is found that the of leachate at Bhalswa landfill sites contain the heavy metals like Iron, Manganese, Cadmium, Lead, Copper, Chromium, Nickel and Zinc.The study indicates that the leachate when mixed with rainwater then it infiltrates more and mixed up with ground water. However the movement of trace metals sets restricts by the impervious geological formation as quartzite rocks at Okhla within 3 meter depth and a impervious clay at Ghazipur at 5 meter depth.The infiltration of trace metals is recorded more at Bhalswa Sanitary Landfill Site because of pervious sandy beds at shallow depth of 4 meter clay. It is recommended that the farther site may be explored in the western part of Delhi or location having shallow clay formation in order or restrict the movement of trace metals to contaminate the ground water. Apart from these more suggestion have been given for engineers, scientists and research workers in this direction.

Keywords: Sanitary landfill at Bhalswa, Okhla Sanitary Landfill Site, Sanitary landfill at Pkhla

I. INTRODUCTION

Waste are generated in enormous quantities with municipal solid waste volume approaching to 150-200 Gega (it is not a standard term, being ambiguous) tons per year. Where the hazardous waste contribution has been estimated at 50-100 mega tons per year including the industrial wastes, hospital wastes, toxic wastes and chemical wastes.

The basic problem arises from the movement of trace metals, which migrates slowly from the base of disposal facility through the soil beneath to ground water resources. One of the major concerns in ground water contamination is the pollution by trace elements present in landfill. Their transport is influenced by the type of its soil, pH, presence of Carbonates, and Oxides of Iron, Aluminium, Silica, Soil moisture. Depth of ground water table also effect their movement.

The generation of trace metals from landfills is a well documented phenomenon and the real issue with respect to the containment of waste material will move through clay layer over a given period. Well-designated facilities are provided with several systems, which control the movement of trace metals and minimize its release into the sub-surface.

Engineered clay liners having low hydraulic conductivity and high adsorption capacity are generally used for controlling the migration of trace metals. Important physic-chemical properties that affect the suitability of a particular clay soil for use in an engineered clay liners are compaction parameters, hydraulic conductivity, cation exchange capacity and specific surface area.

The present study deals with the concentration of trace metals like Iron, Manganese, Cadmium, Lead, Copper, Chromium, Nickel and Zinc in the ground water at three almost saturated sanitary landfill sites at Bhalswa, Ghazipur and Okhla.

The entire area of Bhalswa was covered with the eight bore holes water sampling as indicated in the table 1 as BS1, BS2…BS8. These bore holes were drilled upto a depth of 10 meters below ground level.

The Ghazipur landfill site was covered with seventeen-bore hole water sampling station with a depth of 10m below ground level. These bore hole are marked as GS1, GS2…GS17.

The Okhla sanitary landfill site was covered with 10 bore hole water sampling station upto a depth of 10m below ground level. These bore hole are marked as OS1, OS2…OS10.

II. AIMS AND OBJECTIVES

1) To analyse and study the movement of trace metals in vadose zone.
2) Impact of trace metals on the ground water.
3) To develop an impirical relationship between the time, depth of soil and heavy metals concentration.

III. SITE DESCRIPTION

Solid waste collected from the city is disposed off by landfilling at three sites. Preliminary investigations have been done to assess the degradation of quality of environment in and around landfill areas requiring immediate improvement. These studies will help in delineating future investigations on the effect of landfilling practices on environment like air, water, land and ecology.

Presently landfill sites at Bhalswa, Ghazipur, and Okhla are used for disposal of solid waste in Delhi (fig. 1)

A. Sanitary Landfill at Bhalswa

The area of this site is about 16.2 ha having average depth of four meters. The height of this site is about two meters from the ground level. At present about 2200 MT/Day solid waste is being received at this site.

The entire area of Bhalswa was covered with the help of eight bore holes water sampling as marked as BS1, BS2…BS8 in the (table 1). These bore holes were drilled upto a depth of 10m below ground level.

B. Sanitary Landfill at Ghazipur

This site is about 28.3 ha with an average depth of 3 ha. At present about 2000 MT/ day of solid waste including slaughter waste and poultry waste is being received here.

The Ghazipur landfill site was covered with seventeen-bore hole water sampling station of depth 10 m below ground level. These bore hole marked as GSI, GS2…GS17.

C. Sanitary Landfill at Pkhla

The area of this sanitary landfill site is about 1.5 ha having an average depth of 3mm and the height of this sanitary landfill site is about 3m from ground level. At present about 1200 MT/ day of solid waste is being received.

The Okhla sanitary landfill site was covered with 10 bore hole water sampling station upto a depth of 10m below ground level. These bore holes are denoted as OS1, OS2…OS10.

IV. ANALYSIS AND DISCUSSION

Controlled placement of solid waste in sanitary landfills drastically reduces the number of rodents of insects, and greatly contribute to major aesthetic improvements in waste disposal. The facility revolves around how much waste material in trace metals will be released from the containment facility over given period of time and what the environmental impact of the release will be.

After solid waste is placed in the landfill the trace metals move gravitationally downward until it reached the soil. When a rock or soil material is saturated the pressure head will either be zero or a positive value. All the void spaces in saturated material are usually filled with water.

In an unsaturated material the pressure head will have a negative value. Void spaces in an unsaturated material will often be filled with both water and gases. In an unsaturated zone ground water does not flow to an opening at atmospheric pressure because the capillary forces hold the water molecules to the soil particles.

The movement of water in unsaturated zone occurs in response to suction forces and the gravity. The suction forces consist of adhesion, where water molecules are attracted to rock or soil particles and cohesion where water molecules are attracted to other water molecules. Collectively these forces are referred to as capillary forces. Capillary force dominate in dry soil, however as the soil wets, gravity becomes the more dominant force. As the moisture content increases, small pores are filled with water before larger pores, the number and volume of potential flow paths increase and thus overall hydraulic conductivity of the unsaturated material increases.

The mathematical representation of unsaturated flow on a macroscopic scale is derived from D' Arcy's law and the continuity equation. This equation known as the Richards equation is expressed below.

$$\frac{\delta}{\delta x}\left(K\psi\right) + \frac{\delta}{\delta x} + \frac{\delta}{\delta y}\left(K\psi\right) + \frac{\delta}{\delta y} + \frac{\delta}{\delta z}\left(K\psi\right) + \frac{\delta}{\delta z} = \frac{\delta}{\delta t}$$

where $K\psi$ is the hydraulic conductivity that varies with respect to pressure head(ψ).h is total hydraulic head and θ is the moisture content of soil at a given pressure head.

The present study deals with the concentration of trace metals like Cadmium, Lead, Copper, Chromium, Nickel and Zinc of three almost saturated sanitary landfill sites at Bhalswa, Ghazipur and Okhla in the ground water.

The entire area of Bhalswa was covered with the eight bore holes water sampling as indicated in the table 1 as BS1, BS2…. BS8. These bore holes were drilled upto a depth of 10 meters below ground level.

The Ghazipur landfill site was covered with seventeen-bore water sampling station with a depth of 10 meter below ground level. These bore holes are denoted as GS1, GS2… GS17.

The Okhla sanitary landfill site was covered with 10 bore hole water sampling station upto a depth of 10 meter below ground level. These bore holes are denoted as OS1, OS2… OS10.

A. Concentration of Trace Metals at Shallow Groundwater of Bhalswa Sanitary Landfill Site

1) Concentration of Iron: The iron concentration was recorded varying from 4.3 mg/l to 0.14 mg/l. (table l). According to Indian standard code (IS) 10500 the highest desirable and maximum permissible limits of iron are 0.3 mg/l and 0.1 mg/l. according to World Health Organization (WHO) standards the highest desirable and maximum permissible limits of iron are 0.5 mg/l and 1.0 mg/l.
2) Concentration of Manganese: The manganese concentration recorded was varying from 2.20 mg/l to 0.06 mg/l. According to Indian standard code the highest desirable and maximum permissible limits of manganese are 0.1 mg/l and 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of manganese are 0.05 mg/l and 0.5 mg/l.
3) Concentration of Cadmium: The cadmium concentration recorded was nil or not detectable. According to IS code the highest desirable and maximum permissible limit of cadmium is 0.01 mg/l. According to WHO standard the highest desirable and maximum permissible limit of cadmium is also 0.01 mg/l.
4) Concentration of Lead: The lead concentration recorded was varying from 0.2 mg/l 0.02 mg/l. According to IS code the highest desirable and maximum permissible limit of lead is 0.01 mg/l. According to WHO the highest desirable and maximum permissible limit of lead is 0.01 mg/l.
5) Concentration of Copper: The copper concentration recorded was ranging from 0.01 mg/l to nil. According to IS code the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l.
6) Concentration of Chromium: The Chromium concentration recorded was ranging from 0.36 mg/l to nil. According to IS code the highest desirable and maximum permissible limit of Chromium is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of chromium is 0.5 mg/l.
7) Concentration of Nickel: The nickel concentration recorded was ranging from 0.12 mg/l to nil. According to IS code the highest desirable and maximum permissible limit of nickel is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of nickel is 0.5 mg/l.
8) Concentration of Zine: The Zine concentration recorded was ranging from 1.68 mg/l to 0.06 mg/l. According to IS code the highest desirable and maximum permissible limits of zine are 0.5 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of zine are 0.5 mg/l and 1.5 mg/l.

Table - 1
Heavy Metal Concentration of Water, Landfill Sites

Sample No	*Iron As Fe*	*Manganese As Mn*	*Cadmium As Cd*	*Lead As Pb*	*Copper As Cu*	*Chromium As Cr*	*Nickel As Ni*	*Zinc as Zn*
Bhalswa Sanitary Landfill Site								
BS1	*4.30*	*2.20*	*ND*	*0.08*	*0.08*	*0.36*	*0.12*	*0.26*
BS2	*0.62*	*0.28*	*ND*	*0.04*	*0.01*	*0.07*	*0.05*	*0.34*
BS3	*0.34*	*0.17*	*ND*	*0.02*	*0.01*	*ND*	*ND*	*0.23*
BS4	*0.27*	*0.30*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.06*
BS5	*1.29*	*1.61*	*0.01*	*0.06*	*ND*	*ND*	*0.03*	*0.50*
BS6	*0.14*	*0.06*	*ND*	*0.07*	*ND*	*ND*	*ND*	*1.34*
BS7	*0.35*	*0.39*	*ND*	*0.01*	*ND*	*ND*	*ND*	*1.68*
BS8	*2.60*	*0.25*	*ND*	*0.2*	*ND*	*ND*	*ND*	*0.09*
Ghazipur Sanitary Landfill Site								
GS1	*2.92*	*0.36*	*0.01*	*0.03*	*0.01*	*ND*	*ND*	*0.29*
GS2	*7.35*	*0.44*	*0.01*	*0.07*	*ND*	*0.04*	*0.05*	*0.47*
GS3	*0.55*	*0.09*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.05*
GS4	*0.54*	*0.10*	*ND*	*0.05*	*0.01*	*ND*	*ND*	*5.08*
GS5	*4.01*	*0.43*	*ND*	*0.05*	*ND*	*ND*	*0.03*	*0.44*
GS6	*0.16*	*0.81*	*ND*	*ND*	*ND*	*0.03*	*ND*	*0.26*

GS7	*0.76*	*0.96*	*ND*	*0.01*	*ND*	*ND*	*ND*	*0.02*
GS8	*1.64*	*1.14*	*0.01*	*0.01*	*ND*	*ND*	*ND*	*0.30*
GS9	*0.14*	*0.10*	*ND*	*0.02*	*ND*	*ND*	*ND*	*0.04*
GS10	*1.66*	*0.58*	*ND*	*0.06*	*ND*	*ND*	*ND*	*0.96*
GS11	*0.04*	*0.13*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.06*
GS12	*0.18*	*1.02*	*0.01*	*0.07*	*0.04*	*ND*	*ND*	*0.13*
GS13	*0.38*	*0.20*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.03*
GS14	*0.50*	*0.69*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.09*
GS15	*6.50*	*1.15*	*ND*	*0.05*	*ND*	*ND*	*ND*	*1.71*
GS16	*ND*	*0.22*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.11*
GS17	*5.75*	*0.50*	*ND*	*0.50*	*ND*	*0.02*	*ND*	*0.01*
Okhla Sanitary Landfill Site								
OS1	*0.05*	*0.04*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.03*
OS2	*0.07*	*0.04*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.04*
OS3	*0.08*	*0.05*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.11*
OS4	*0.02*	*0.05*	*ND*	*0.01*	*ND*	*ND*	*0.03*	*0.02*
OS5	*1.77*	*0.03*	*ND*	*0.02*	*ND*	*ND*	*ND*	*0.44*
OS6	*0.17*	*0.02*	*ND*	*0.05*	*ND*	*ND*	*ND*	*0.31*
OS7	*0.01*	*0.03*	*ND*	*0.4*	*ND*	*ND*	*ND*	*1.77*
OS8	*0.21*	*0.01*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.11*
OS9	*0.18*	*0.01*	*ND*	*0.10*	*0.01*	*ND*	*ND*	*2.09*
OS10	*0.54*	*0.22*	*ND*	*ND*	*ND*	*ND*	*ND*	*0.19*

All the Values are expressed in mg/l.
ND – Not Detectable.

B. Concentration of Trace Metals at Shallow Groundwater of Ghazipur Sanitary Landfill Site

1) Concentration of Iron: The iron concentration was recorded varying from 7.35 mg/l to 0.16 mg/l. (table 1). According to Indian standard code (IS) the highest desirable and maximum permissible limits of iron are 0.3 mg/l and 0.1 mg/l. According to World Health Organization (WHO) standard the highest desirable and maximum permissible limits of iron are 0.5 mg/l and 1 mg/l.
2) Concentration of Manganese: The manganese concentration recorded was varying from 1.14 mg/l to 0.09 mg/l. According to Indian standard code the highest desirable and maximum permissible limits of manganese are 0.1 mg/l and 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of manganese are 0.05 mg/l and 0.5 mg/l.
3) Concentration of Cadmium: The cadmium concentration recorded was nil or not detectable. According to IS code the highest desirable and maximum permissible limit of cadmium is 0.01 mg/l. According to WHO standard the highest desirable and maximum permissible limit of cadmium is also 0.01 mg/l.
4) Concentration of Lead: The lead concentration recorded was varying from 0.07 mg/l to 0.01 mg/l. According to IS code the highest desirable and maximum permissible limit of lead is 0.01 mg/l. According to WHO the highest desirable and maximum permissible limit of lead is 0.01 mg/l.

5) Concentration of Copper: The copper concentration recorded was ranging from 0.01 mg/l to nil. According to IS code the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l.
6) Concentration of Chromium: The chromium concentration recorded was ranging from 0.04 mg/l to nil. According to IS code the highest desirable and maximum permissible limit of chromium is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of chromium is 0.5 mg/l.
7) Concentration of Nickel: The nickel concentration recorded was ranging from 0.05 mg/l to nil. According to IS code the highest desirable and maximum permissible limit of nickel is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of nickel is 0.5 mg/l.
8) Concentration of Zinc: The zinc concentration recorded was ranging from 5.08 mg/l to 0.02 mg/l. According to IS code the highest desirable and maximum permissible limits of zinc are 0.5 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of zinc are 0.5 mg/l and 1.5 mg/l.

C. Concentration of Trace Metals at Shallow Groundwater of Okhla Sanitary Landfill Site

1) Concentration of Iron: The iron concentration was recorded varying from 1.77 mg/l to 0.01 mg/l. (table 1). According to Indian standard code (IS) the highest desirable and maximum permissible limits of iron are 0.3 mg/l and 0.1 mg/l. According to World Health Organization (WHO) standard the highest desirable and maximum permissible limits of iron are 0.5 mg/l and 1 mg/l.
2) Concentration of Manganese: The manganese concentration recorded was varying from 0.22 mg/l to 0.01 mg/l. According to Indian standard code the highest desirable and maximum permissible limits of manganese are 0.1 mg/l and 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of manganese are 0.05 mg/l and 0.5 mg/l.
3) Concentration of Cadmium: The cadmium concentration recorded was nil or not detectable. According to IS code the highest desirable and maximum permissible limit of cadmium is 0.01 mg/l. According to WHO standard the highest desirable and maximum permissible limit of cadmium is also 0.01 mg/l.
4) Concentration of Lead: The lead concentration recorded was varying from 0.10 mg/l to 0.01 mg/l. According to IS code the highest desirable and maximum permissible limit of lead is 0.01 mg/l. According to WHO the highest desirable and maximum permissible limit of lead is 0.01 mg/l.
5) Concentration of Copper: The copper concentration recorded was ranging nil. According to IS code the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of copper are 0.05 mg/l and 1.5 mg/l.
6) Concentration of chromium: The chromium concentration recorded was ranging nil. According to IS code the highest desirable and maximum permissible limit of chromium is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of chromium is 0.5 mg/l.
7) Concentration of Nickel: The nickel concentration recorded was ranging from 0.03 mg/l to nil. According to IS code the highest desirable and maximum permissible limit of nickel is 0.5 mg/l. According to WHO standard the highest desirable and maximum permissible limit of nickel is 0.5 mg/l.
8) Concentration of Zinc: The zinc concentration recorded was ranging from 2.09 mg/l to 0.02 mg/l. According to IS code the highest desirable and maximum permissible limits of zinc are 0.5 mg/l and 1.5 mg/l. According to WHO standard the highest desirable and maximum permissible limits of zinc are 0.5 mg/l and 1.5 mg/l.

V. RESULTS AND DISCUSSION

The movement of trace metals depends upon the soil beneath the earth surface and the leachate characteristics. In case of pervious to semi- pervious layer such as sand and silty sand, the movement of trace metals occurs enormously. On the other hand the movement of trace metals also enhanced when the leachate mix with rainwater and reduces its viscosity. However in this case the concentration of trace metals reduces.

It would be desirable to first present comparative geology of these sites of help interprets the results. A sketch of substance zones would be make things self-explanating.

In case of impervious layers such as clay the accumulation of heavy metals restricts within the clayey strata and the clay becomes lining materials with low hydraulic conductivity and high adsorption capacity. The sanitary landfill site of Delhi, the Bhalswa and Ghazipur falls in the alluvial zones of the Delhi city. Ghazipur has thick clay formation at a shallow depth of about 5 meter below the ground level by virtue of which the rate of penetration of trace metals is low as compared to Bhalswa.

In case of Bhalswa there occurs the sandy formation at shallow depth by virtue of which the movement of trace metals below the ground level up to 10 meter is significant as takes place. During the rainy season when the rain mixed up with the leachate the movement of trace metal decreases more prominent.

Rocky areas formation has been encountered at shallow depth of about 3 meters below ground level at Okhla Sanitary Landfill site. Hence the movement of trace metals has occurred through fractured zone which is considerably in proportion.

VI. CONCLUSION AND RECOMMENDATION

On the basis of this study should be considered for site selection of Sanitary Landfill site particularly in Delhi.

1) The western part of Delhi is occupied by rocky formation with deep ground water table and hence scientifically very feasible areas because the movement of trace metals can be blocked by sealing the fractured rocks through grouting metals.
2) The alluvial zone of Delhi may be investigated and shallow with thick clay layer areas may be chosen in order to restrict the movement of trace metals and control the ground water pollution by formation of sanitary landfill sites.
3) Apart from these the recirculation of leachate and their treatment may be done in order to avoid the contamination of water due to movement of trace metals.
4) Trace metal compound are not at all soluble in probable water having pH range of 6 to 8 or 9.0. Trace metals are present in solid wastes either as legends or compounds improve in normal meters unless the pH is to low in the range of 0.5 to 1.5.

REFERENCES

[1] Karanath, K.R: 1987 Ground water and management, Tata McGraw Hill Publishing Company Limited, New Delhi.
[2] Raghunath, H.M : 1992 Ground water, Willy Eastern Limited, New Delhi.
[3] Roscoe Moss Company : 1990 Hand Book Of Ground Water Development, John Willy & Sons, New York.
[4] Baweja, B.K. and Karanath, K.R : Ground water recharge estimation in India Tech. Series. H. Bull. C.G.W.B (1980).
[5] Jacob(1940): Ground water hydrology, D.K. Todd, 2nd Edition.
[6] Pathak, B.K: Hydroleology and ground potential of U.P.(1978).
[7] Pathak, B.D: Ground water in India and scope or future development, Curren trends in geology VII-VIII P 573-577 (1985)
[8] Thesis (1985): Ground water hydrology, D.K. Todd, 2nd edition.
[9] W.C. Walton (1962): Ground water and tube-wells sites investigation, U.S.G.S. publication.
[10] C.P.C.B (March, 1996): Ground water quality in flood affected areas of Delhi (1995).
[11] N.L. NEMEROW: Scientific stream pollution analysis.
[12] Metcalf and Eddy: Waste water engineering.
[13] Walton: Ground water resource evaluation
[14] Wiener: The role of water in development: An analysis of principles of comprehensive planning.
[15] Gehm, Harry W. & Bregman, Jacob I (Edtrs): 1976 Handbook of water resources and pollution control, Van Nostrand Reinhold Co. New York, (SPA Planning Lib).