ABSTRACT

This work has been carried out with an objective to study the impact of landfill leachate on groundwater quality and simulation of contaminant transport in the adjoining groundwater aquifer system. The systematic sampling of groundwater has been carried out in different seasons (May 2003, September 2003, January 2004, May 2004, September 2004 and January 2005) around all the three landfills (Bhalswa, Okhala and Indraprastha landfill) covering an area of about 28 sq. km. each, to infer the influence of municipal/industrial waste dumping landfills and other anthropogenic sources on the groundwater quality/chemistry of the Delhi region. Simulation of the contaminant transport has been carried out for a 300 km² area in south-central Delhi by using Visual MODFLOW/MT3D.

Most of the groundwater samples are colorless, odorless and alkaline; however some often shows light yellowish color with salty taste e.g. in Bhalswa Dairy Village. Few groundwater samples around Bhalswa landfill shows high values of TDS i.e. ~3500 mg/l and EC value up to ~5000 µS/cm. Most of samples around all three landfills are slightly basic (pH > 7.0), but few samples of groundwater collected around Bhalswa Landfill are slightly acidic (pH < 7.0) in nature. High concentration of Chloride, Nitrate and Sulphate were observed in almost all groundwater samples, with some exception in groundwater samples collected from Narendra Dev College, Govind Puri, Nehru Place etc. due to their longer distance from the all these landfill sites. High concentrations of chloride in groundwater indicate anthropogenic input in groundwater system. Swami Shridhdhanad Park, Badali industrial area, J.J. Colony, Bhalswa Dairy Gaon etc. groundwater samples shows high concentration of nitrate. The spatial distribution of nitrate, fluoride, chloride and heavy metals around landfill indicate leaching of contaminants from landfills, while Kalimata Colony, Chiriya Ghar etc groundwater samples shows much higher values of nitrate concentration in groundwater due to human as well animal wastage contribution along with the leaching of fly ash dumping from the Indraprastha landfill site (now closed). The groundwater samples around Okhala landfill shows less contamination because of geomorphological setup of this area showing domination of quartzite as well the water table is quite deep below the surface in comparison to other region of Delhi. But fluoride concentration in groundwater samples collected around Okhala landfill is high due to the geogenic weathering input. The spatial distributions of heavy metals concentration (mg/l) in groundwater around landfill indicate leaching of contaminant from the landfill sites. The Bhalswa landfill leachates
contain high concentration of heavy metals (Fe (20 mg/l), Mn (20 mg/l), Pb(1.8 mg/l), Cu(9.8 mg/l), N (2.8 mg/l) and Zn (9.8 mg/l)), while Okhala landfill leachates contain heavy metals (Fe (18 mg/l), Mn (17 mg/l), Pb(1.7 mg/l), Cu(9.6 mg/l), Ni (2.8 mg/l) and Zn (9.6 mg/l)). The study of the hydrogeochemistry of all landfill indicates anthropogenic input to the groundwater system. The speciation studies of heavy metals and other element has been carried out with PHREEQC, indicating the major role of anthropogenic input into the Delhi groundwater system. Water quality classification based on: Eton, Wilcox, Sawyer and McCarty, Lloyd, Schoeller etc. indicate contamination of groundwater due to anthropogenic input. Most of the groundwater samples are brackish and hard in quality. Hydro-chemical facies classification has been carried out based on Schoeller, Piper and Durov diagram. The 90.91 % groundwater samples collected around Bhalswa landfill shows Calcium-Sodium type of cation hydrochemical facies and Chloride type of anion hydrochemical facies in winter and pre-monsoon, while 9.09 % groundwater samples shows Calcium-Sodium type cation hydrochemical facies and Chloride-Sulphate-Bicarbonate type of anion hydrochemical facies in both winter and pre-monsoon. In post monsoon only 87.88 % groundwater samples shows Calcium-Sodium type of cation hydrochemical facies and Chloride type of anion hydrochemical facies and 12.12 % groundwater samples shows Calcium-Sodium type cation hydrochemical facies and Chloride-Sulphate-Bicarbonate type of anion hydrochemical facies due to addition of various ions from rainwater and dilution in various proportion. Okhala and Indraprastha landfill shows domination of calcium-sodium type of cation hydro-chemical facies and chloride type of anion hydro-chemical facies.

Simulation of different hydro-geological data sets shows that the groundwater is flowing from northwest to southeast of Okhala landfill. The path line of contaminant is also towards the northwest to southeast with the flow of groundwater. The rates of discharge with time simulated for 11 years shows negative values some times, may be due to persistence of long stress period, since rainfall is the major source of recharge in that area. The groundwater flow directions indicate that very less recharge takes place through the river Yamuna. But in this model, the river Yamuna is used as constant head boundary. The model is calibrated for 146-stress period with 95 % confidence interval. The fluoride and other heavy metals contaminate the groundwater up to Lodhi Garden, AIMS, Hauz Khas and surrounding area within 365 days after the release of contaminants in ground water system. This indicates that the movement of plume within groundwater system is quite fast. All, these heavy metals contaminates are at different rate due to adsorption / desorption and other geochemical process/salvation of these metals in various
proportions. The results of simulation indicate that along with the Okhala landfill Phase II, Indraprastha landfills also indicate leaching of contaminant in the groundwater.

The study of Hydrogeochemistry and simulation of contaminant transport in groundwater aquifer system indicate all three landfill acts as a point source of contaminant. Working landfill should be closed and alternative landfill should be developed. The transport of contaminant from landfill can be checked by putting bore well inside the landfill so that contaminant pumped out before being spread along with plume of groundwater. Further industrial and municipal solid waste material should be segregated and processed before being dumped into landfill.