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Contamination Transport Modelling of Leachate at Municipal Solid Waste (MSW) Sites

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ABSTRACT: Most cities in developing countries, Municipal Solid Waste (MSW) is dumped in open areas without proper lining. Now-a-days the generation of solid waste has increase, which leads to environmental problems, such as land pollution, air pollution and water pollution. Dumping of solid waste at open areas leads to formation of leachate during rains, which may seep and contaminate the ground water. This study is aimed to evaluate the hydraulic conductivity and geotechnical properties of contaminated soil and properties of leachate. Also to estimate and predict the fate of contamination that has occurred at MSW site

KEYWORDS: land pollution, water pollution, leachate, geotechnical properties, hydraulic conductivity and contamination

I. INTRODUCTION

India is a tropical county with a vast diversity of climate, topography and vegetation. Though blessed with fairly high annual rainfall, it is not uniformly distributed in time and space resulting in bulk of the rainfall escaping as runoff. This results in incomplete utilization of available surface water. The scarcity of surface water especially in the lean season in most parts of the country means that groundwater plays a decisive role. India has diversified geological, climatologically and topographic set up giving rise to divergent groundwater situations in different parts of the country. Groundwater may be considered as one of the most precious and one of the basic requirements for human existence and the survival of mankind providing him the luxuries and comforts in addition to fulfilling his basic necessities of life and also for industrial and agricultural development thus being a very important constituent of our eco-system.

MODFLOW is a computer program originally developed by the U.S. Geological Survey that simulates three-dimensional groundwater flow using a finite difference technique for solution of the governing flow equations. MODFLOW solves both confined and unconfined flow equations in an irregularly shaped flow system to simulate the behaviour of groundwater flow systems under several types of natural and artificial stresses. The flow region is subdivided into blocks in which the medium properties are assumed to be uniform. In plain view the blocks are made from a grid of mutually perpendicular lines that may be variably spaced. Model layers can have varying thickness.

A flow equation is written for each block, called a cell. Several solvers are provided for solving the resulting matrix problem. The user can choose the best solver for the particular problem. Flow-rate and cumulative-volume balances from each type of inflow and outflow are computed for each time step. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can be simulated. Hydraulic

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conductivities or transmissivities for any layer may differ spatially and be anisotropic, and the storage coefficient may be heterogeneous.

Specified head, specified flux, and head dependent flux boundaries can be simulated. Visual MODFLOW software package includes three main software and many support modules. MODFLOW software is used to calculate the volume, quality and distribution of groundwater flows. Function of MODPATH software is calculating the direction and speed of flow when it moves through aquifer system. MT3D software is used to calculate diffusion and transportation processes with chemical reaction of solutes in groundwater flow system.

Assigning initial and Boundary conditions

The boundary conditions allowed in Visual MODFLOW include constant-head, rivers, general head, drains, walls, recharge, evapotranspiration, constant concentration, (all are flow parameters for MODFLOW), and recharge concentration, evapotranspiration concentration, and point source concentration.

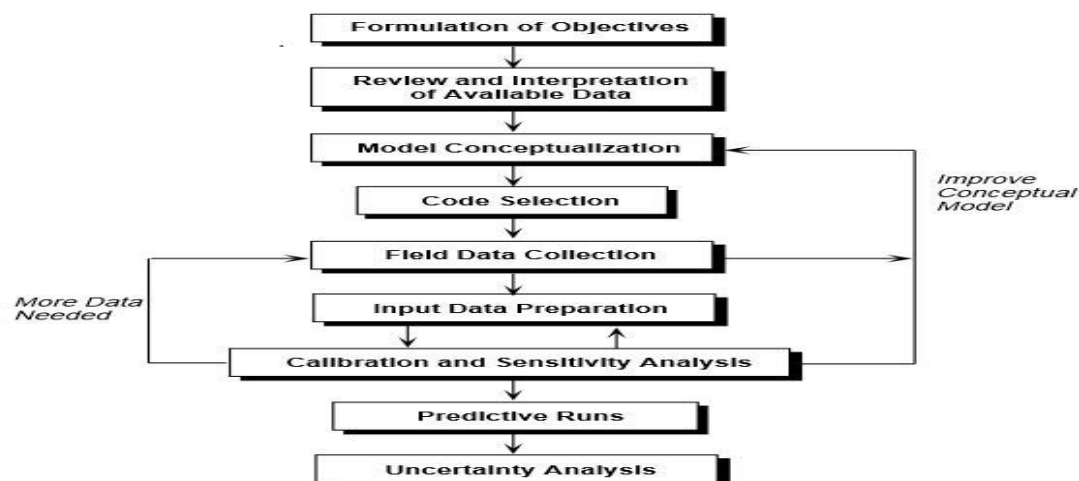


Figure 1 Flow chart of modelling of visual mod flow flex

This flow chart indicates that work pattern of visual mod flow flex software of conceptual model by assigning properties of hydraulic conductivity.

II. DESCRIPTION OF STUDY AREA

Geography

The study area is the lower part dundigal village of the Telangana in India. The area lies between 17030'01" N to 17032'03" N latitude and 78034'13" E to 78037'47" E longitude. The total area of the study is about 11.6 Km². The study area has an average altitude of 53.57 m in western part and gradually decreases towards the east. The area is located at Dundigal village and lies between Shameerpet and Kesara Mandal's of Ranga Reddy district, Telangana. There is a Greater Hyderabad Municipal Corporation solid waste dumping site in the study area. Groundwater in the study area occurs under water table to semi-confined conditions restricted to weathered and fractured formation. The study area contains granite rock formations. The samples are collected at the depth of 0.5 m and 1m.

The MSW site is classified as hard rock area where surface water resources are limited, with the result; groundwater has become a major source of supply to the village population. The problem connected with supply of safe water to rural communities from individual wells is often neglected. Added to this with rapid solid waste leachate

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pollution of groundwater due to rapid increasing of population, urbanization and industrialization, the available groundwater is rapidly getting polluted. Unfortunately the surrounding villages and catchment area aquifers affecting from this pollution has resulted mostly from urban human activities.

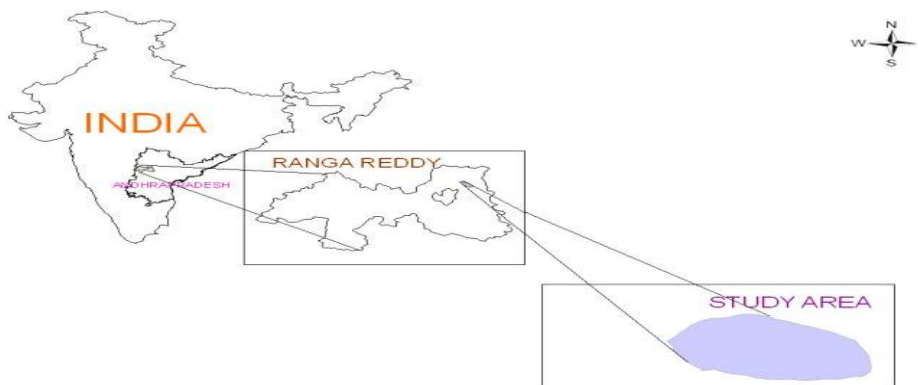


Figure 2 the study area

The soil samples are collected from the study area by using core cutter sample and the tests are to be conducted for the samples are collected from the study area

It can be seen from the hydrograph of the study area (Fig.3) that watertable fluctuations are influenced by the rainfall input during monsoon seasons. The hydrograph shows a good correlation between the rises in watertable the amount of rainfall and a month time-lag between rain fall and recharge. The watertable is increasing during September to December and start reducing from January onwards, indicating that recharge is mainly from rainfall infiltration during the monsoon periods [SW monsoon (July to September) and NE monsoon (October to December)]. The annual rainfall in the study area is 1347mm².

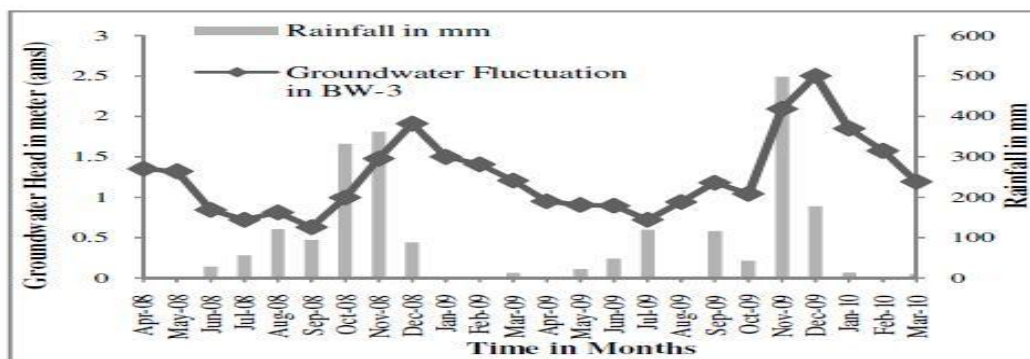


Figure 3 Rain fall data by hydrograph at MSW site

By using above rainfall data we can model the fate of contamination done at the respective data that to be analysed

III. MATERIALS

The soil sample is collected from the study area and soil is analysed for their index properties and geo-

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environmental properties and relevant test procedures have been included in the following.

The specific gravity of soil is conducted as per [4]. The sieve analysis is carried out to perform the particle size distribution of soil as per [5]. Liquid limit, plastic limit, and plastic index were performed as per [6]. The maximum dry density and optimum moisture content is performed of the soil sample collected at study area as per [7][8]. The permeability test is conducted for the soil sample from study area [9]. The soil has been tested for environmental properties such as pH, EC, organic content as per recommendations.

PROPERTIES	Virgin soil collected @500m radius	contaminated soil	
		Pit 1 @0.5m	Pit 2@1m
Specific gravity	2.45	2.27	2.24
Gravel %	0	0	0
Sand %	36	36	36
Silt %	44	44	44
Clay %	20	20	20
Liquid limit %	42	44	45
Plastic limit %	33	34	37
Plasticity index	09	10	12
Optimum moisture content (OMC) %	20	18	18
Maximum dry density (MDD) g/cc	1.86	1.48	1.52
pH	7.45	8.56	8.89
EC(s/m)	1	2	20
Organic content (%)	30	72	88.56
Permeability of soil (cm/s)	1.335×10^{-5}	1.726×10^{-8}	1.966×10^{-8}

Table 1 Index properties of virgin and contaminated soil

IV. MODELLING

The foremost step in modelling is to construct a conceptual model of the problem and of the related domain. The conceptual model consists of set of assumptions that reduce the real problem and the real domain to a simplified version.

- The domains hydrogeology and stratigrapher.
- The dimensionality of the model and the geometry of the boundary of the domain.
- The behaviour of the system: steady state or time dependent.
- The kind of soil and rock materials comprising the domain, as well as in homogeneity and anisotropy of the materials.

Modular Finite-Difference Ground-Water Flow Model (MODFLOW) simulates three-dimensional groundwater flow by using a cell entered Finite Difference Method. This program is used to trace the path lines, based on the assumption of advective transport only. The contaminant migration in the groundwater is mainly influenced by the groundwater

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flow direction and hydraulic conductivity in the aquifer underlying the MSW site, the volume of water entering the aquifer and the concentration of contaminant at the source and Hydraulic conductivity (K) is the measure of an aquifer’s ability to transmit water and is expressed as the rate at which water can move through a unit thickness permeable medium. K may vary by an order of magnitude or more, even in relatively homogeneous sites.

GRID DESIGN

The study area map was digitized using g the ArcGIS 9.2 software and imported into Visual MODFLOW as a shape file. The grid discretization was optimized to minimize numerical errors in the flow mo del. Based on the optimum grid size arrived, the model domain was discretised into 100 × 100 grids with cell dimensions of 35 m × 65 m. Further, finer grids were introduced around the well locations (Fig.4)

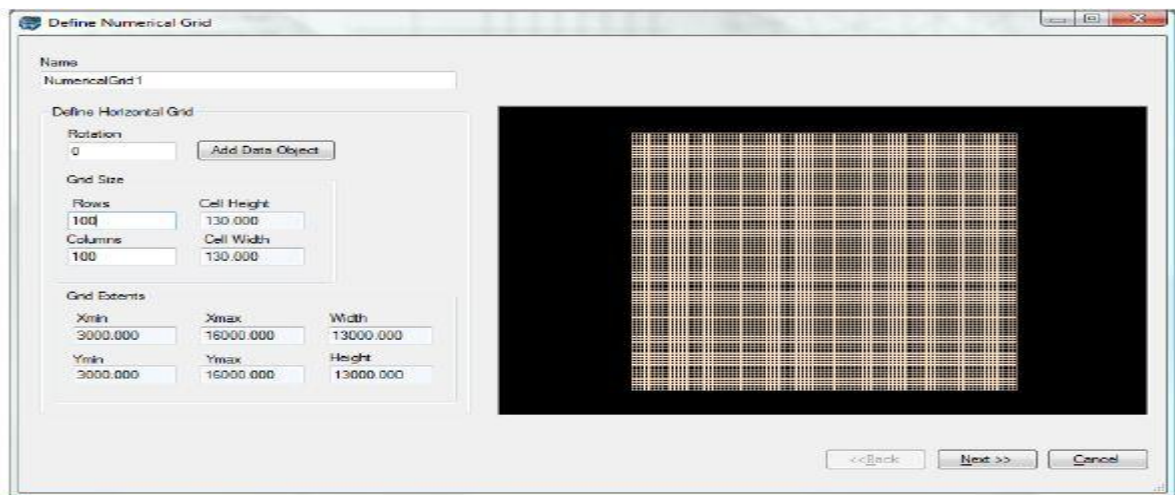


Figure 4 assigning numerical grids

To genetate the model the area should be discritised my meshing (grids)

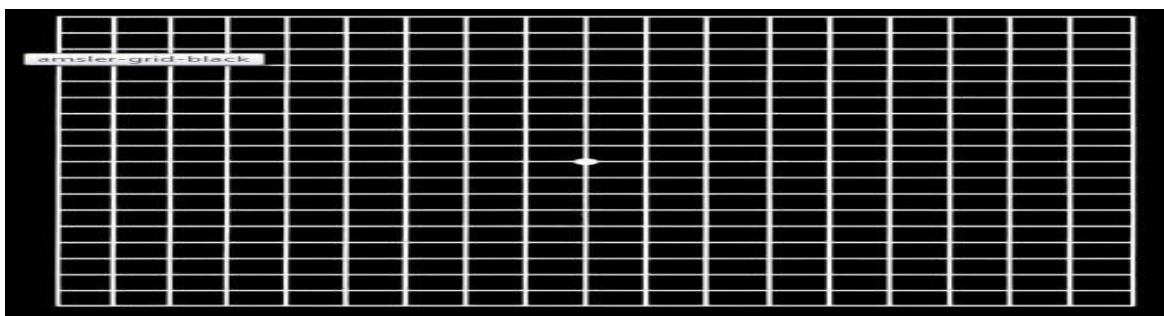


Figure 5 cell dimensiones

Asinning the cell dimension (width×height)

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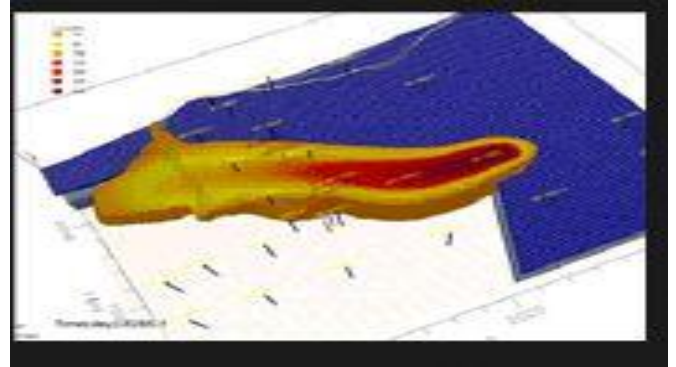
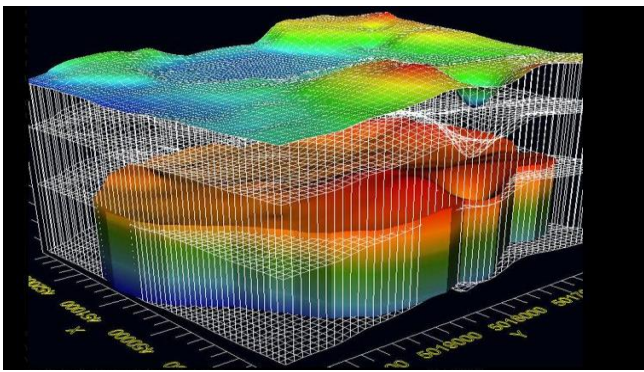


Figure 6 The distribution of leachate at the MSW in side view and top view

The amount of contamination done with respect to time, the taken to pollute the ground water is 20 years(7300days)

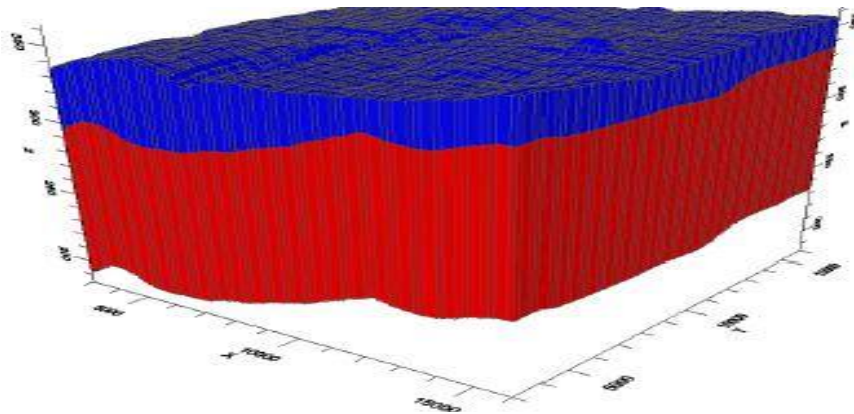


Figure 7 3D view of amount of contamination

The final 3D view of amount of contamination done in layers

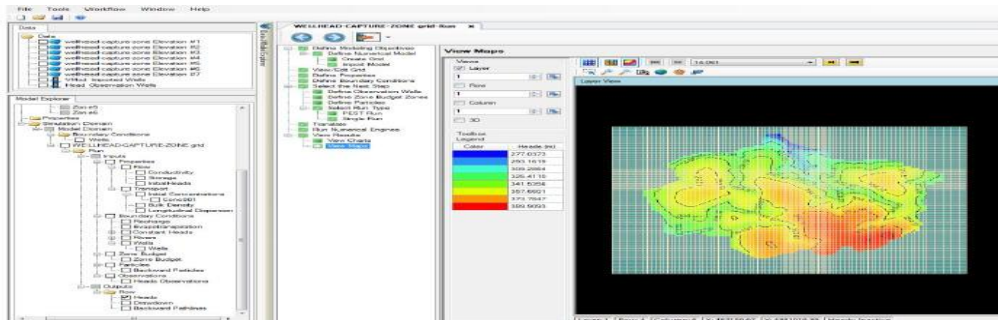


Figure 8 contour map

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The figure shows about the contour lines at the site at model is generated.

V.RESULTS AND DISCUSSION

Advantages of MODFLOW include numerous facilities for data preparation, the modular structure that allows it to be easily modified to adapt the code for a particular application, great flexibility in handling a wide range of complexity, easy exchange of data in standard form, extended worldwide experience, continuous development and availability of the source code. In addition to simulating groundwater flow, the scope of MODFLOW has been expanded to incorporate related capabilities such as solute transport and parameter estimation for 7300 days

VI.CONCLUSION

Sample collected from the site around 500 m radius the time taken to contaminate the soil is about 4.5 years(1645 days) it was estimated by using visual mod flow. The time taken to contaminate the same area in real time is about 5 years. The time take to contaminate the ground water from the height of soil samples collected is about 20 years(7300days).

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BIOGRAPHY



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