Using GeoStudio Model For Assessment of Leachate Migration Through Soil in Hushangabad-Azizabad Landfill of Tehran

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Abstract— The storage of any waste material in a landfill poses potential problems. One problem is the possible contamination of soil, groundwater and surface water. In recent years, the use of simulation software as a tool for the design, operation and monitoring in the field of environmental engineering including solid waste landfills is widely spread. Capability of these softwares in quick and precise calculation expands their application. More recently, integrated models have appeared that combine the several phenomena the previous models have tackled individually. One of the integrated models is GeoStudio that has several tools to model the water seepage, contaminant transport, particle tracking in response to the movement of water, diffusion, dispersion, adsorption, radioactive decay and heat transfer through soil. In this study, in first stage, SEEP/W, a part of GeoStudio, has been used to determine the path of leachate movement. Results of previous stage and CTRAN/W, a part of GeoStudio, has been used to assess contaminant transport by Advection-Dispersion mechanisms at the bottom of a new solid waste landfill in vicinity of Hushangabad-Azizabad, Tehran.

Keywords—Leachate, Water Sources, Modeling, GeoStudio

I. INTRODUCTION

The storage of any waste material in a landfill poses potential problems. One problem is the possible contamination of soil, groundwater and surface water that may occur as leachate produced by water or liquid wastes moving into, through and out of the landfill, migrates into adjacent areas [1],[2]. In order to assess the pollution by landfill, either experimental determination or estimation through mathematical modelling can be followed [3],[4]. In recent years, the use of simulation software as a tool for the design, operation and monitoring in the field of environmental engineering including solid waste landfills is widely spread. Capability of these softwares in quick and precise calculation expands their application. In the case of landfill process modeling, the significance of local factors such as the waste composition, disposal method and protection systems against potential impacts, the heterogeneity of the medium, as well as the several physical and biochemical phenomena that need to be considered (meteorology, liquid and gas movement, biological and chemical degradation of the waste, aging of materials), makes the development of models applicable to different landfill facilities difficult [5].

Since the 1970s a number of empirical expressions of gas generation have been developed to assess the economics of gas harnessing systems. These sorts of models do not represent the biological degradation processes, but only one of their consequences, which is gas generation. Their calibration is based on data observed in a specific landfill or similar facilities, which does not give rise to actual prediction tools. Nonetheless, these models are still used for approximate estimations when more refined tools are not available [6].

Subsequently, models have also appeared to support the study of the possible impacts of the leachate in the surrounding land. HELP, among the programs developed with this aim, became of widespread use in facilities all over the world, but nowadays its use is questioned as a number of shortcomings have been detected. On the other hand, several authors have reported modeling approaches that focus on the biological and/or chemical degradation of waste that generates gas and leachate pollutants [7],[8].

More recently, integrated models have appeared that combine the several phenomena the previous models have tackled individually. These models consider both the leachate pollution and gas, simulating jointly the hydrological and degradation phenomena, and can include settlement and heat transfer as well. When adapted to the simulation of real facilities, these models will make possible the “a priori” study of the different effects of design and operation measures such as leachate recirculation. Furthermore, the results from such
simulations could constitute the input for other models, such as those of leachate underground transport, making it possible to estimate the impacts on the landfill environment and, in combination with probabilistic models, form part of other complex tools for environmental risk assessment [9],[10].

One of the integrated models is GeoStudio that has several tools to model the water seepage, contaminant transport, particle tracking in response to the movement of water, diffusion, dispersion, adsorption, radioactive decay and heat transfer through soil. In this study, SEEP/W, a part of GeoStudio, has been used to determine the path of leachate movement and CTRAN/W, a part of GeoStudio, has been used to assess contaminant transport by Advection-Dispersion mechanisms at the bottom of a new solid waste landfill in vicinity of Hushangabad-Azizabad, Tehran.

II. REGION SPECIFICATIONS

The landfill is 50 km far from the south of Tehran. The borders of the landfill area is shown on the base map of the region in Fig. 1. As topographic characteristics, the area has an incline from north west to south east. The maximum altitude is 1110 m in the west and the minimum altitude is 950 m in the east of the region. On this basis, the region has a mean slope of less than %2 [11].

Shur river, the only surface water source in the region of the solid waste landfill, has 2 km distance from the landfill that can be contaminated by the leachate migration and lack of management systems [12].

As shown in Fig. 2, considering the 2 km distance between Shur river and the landfill and elevation difference about 50 m between the lowest altitude of the area and the river bed, the probability of contamination of the river by flowage is negligible, but it is important to assess the contamination migration through soil to the river bed.

Due to the limitations of GeoStudio 2004 software and to simplify the data as input, the characteristics of soil of the region is considered like the bore BH-A3. The depth of this bore is 30 m that is maximum among the others. Considering the elevation difference of 50 m between the lowest altitude of the area and the river bed, soil characteristics for the depth more than 30 m is chosen like the last layer of BH-A3 for modeling. The Specifications of this bore is shown in Fig. 3 and table I.

III. SEEP/W AND CTRAN/W MODELS

Ions that exist in leachate migrate through soil by various mechanisms and reach water sources and pollute the sources. Advection is a transport mechanism of a substance or conserved property by a fluid due to the fluid's bulk motion. The fluid's motion is described mathematically as a vector
field, and the transported material is described by a scalar field showing its distribution over space. Advection requires currents in the fluid, and so cannot happen in rigid solids. It does not include transport of substances by molecular diffusion.

The term seepage usually refers to situations where the primary driving forces is gravity controlled, such as establishing seepage losses from a reservoir, where the driving force is the total hydraulic head difference between the entrance and exit points. Another cause of water movement in soils is the existence of excess pore-water pressure due to external leading. This type of water flow is usually not referred to as seepage, but the fundamental mathematical equations describing the water movement are essentially identical. As a result, a software formulation for the analysis of seepage problems can also be used to analyze the dissipation of excess pore-water pressures resulting from changes in stress conditions. In this Study, the term seepage is used to describe all movement of water through soil regardless of creation or source of the driving force or whether the flow is through saturated or unsaturated soils.

Diffusion is one of several transport phenomena that occur in nature. A distinguishing feature of diffusion is that it results in mixing or mass transport, without requiring bulk motion. According to Fick's laws, the diffusion flux is proportional to the negative gradient of concentrations. It goes from regions of higher concentration to regions of lower concentration.

For one-dimensional flow, the hydrodynamics dispersion coefficient $D$ is defined above as:

$$D = \alpha v + D^*$$ (1)

Where $\alpha$ is dispersivity (material property), $v$ is D'arcian velocity divided by volumetric water content, and $D^*$ is coefficient of molecular diffusion. Dispersion in the direction of the water flow is usually higher than dispersion perpendicular to the flow direction. Two dispersivity values are therefore required to define the spreading process. Dispersivities in the flow directions are designated as the longitudinal dispersivity $\alpha_L$ and the transverse dispersivity $\alpha_T$. The content of $\alpha$ is %10 of system scale. For example, if modeling a contamination migration in an aqueous layer with 1 km width, the content of $\alpha$ will be 100 m.

According to (2), the software uses finite element method for analyzing the contaminant migration. The finite element equation can be written as:

$$[K][C] = [Q]$$ (2)

Where: $[K]$ the element characteristics matrix, $[C]$ the vector of nodal concentrations, $[Q]$ the mass flux entering or leaving the element [17]. There are three main parts to a finite element analysis. The first is discretization: dividing the domain into small areas called elements. The second part is specifying and assigning material properties. The third is specifying and applying boundary conditions.

GeoStudio 2004 uses SEEP/W and CTRAN/W calculations simultaneously for assessment of leachate movement. In this study, analysis of SEEP/W is in steady state and two-dimensional. CTRAN/W analyzes the contaminant transport by advection-dispersion mechanisms. The time period is 3750 days equal to 10.3 years. It is assumed that the soil layers are saturated and hydraulic conductivity of the soil layers are constant and equal to saturated hydraulic conductivity. The concentration of the pollutant is considered 1000 mg/L.

IV. RESULTS

In fig. 4, different layers of the soil are shown with distinct colors and divided to square shaped elements. Boundary conditions are contamination accumulation in the river bed ($q_m=0$) and consideration of advection and dispersion for nodal concentrations at output ($Q_d>0$). In fig. 5, the amount of leachate permeation in the bottom of the landfill is shown. The leachate migration is less than 1 m that shows there are impermeable and low permeable soil layers in the region. In conclusion, leachate permeation in the soil is not a threat for Shur river. This is shown in fig. 6.
REFERENCES