Modeling of Arsenic Transport in Groundwater at Sunland Park, NM

REU: Thomas Marrone, Undergraduate Student, State University of New York- College at Oneonta

Graduate Student Mentor: Gebregziabher Goitom, CE Department, New Mexico State University

Faculty Advisor: Dr. Salim Bawazir, Assoc. Professor, CE Department, New Mexico State University

Introduction and Background

Ground water and soil sample collected at ReNUWIt Riparian Rehabilitation Test-Bed site at Sunland Park, New Mexico indicated availability of arsenic (As). Arsenic is a naturally occurring element that is found in the environment (soil, groundwater, surface water, air) throughout the United States and other parts of the world. According to US Environmental Protection Agency (EPA), As combines with either inorganic or organic substances to form many different compounds. Inorganic arsenic compounds are found in soils, sediments, and groundwater. Extended exposure to these compounds can lead to cancer and affects major organs like lungs, kidneys, and the liver. Groundwater at the Test-Bed site is part of the Mesilla Bolson shallow unconfined aquifer. The aquifer consists of unconsolidated deposits of gravel, sand, silt, and clay. The quality of groundwater tested previously at the study site from 9 shallow observation piezometers varied considerably. Salinity of groundwater varied from less than 1 ppt to 18.20 ppt with pH ranging from 6.6 to 9, and the As ranged from 4.6 μg/l to 423 μg/l.

This study investigated the transport of arsenic (As) in groundwater at the Test-Bed using a finite element software known as FEFLOW (Diersch, 2014). The goal of the study is to better understand the direction and concentration of As leaching through the soil at the Test-Bed for riparian vegetation rehabilitation purposes. The Test-Bed is located on 10 hectares of riparian land in Sunland Park, New Mexico near the Rio Grande (river) and a drainage canal.

Methodology

Following are the steps taken to model As transport at the ReNUWIT Sunland Park Test-Bed:

Flow model setup: The data needed for flow model application included physical parameters such as hydraulic conductivity, aquifer thickness, and recharge. Topographic maps, hydrogeological formations, and maps with observation wells were also collected. The upper unconfined aquifer was considered for the model. The area of the site was delineated using ArcMAP. The model mesh was generated using the grid builder mesh-generation algorithm, with 2500 nodes and 1595 elements. The model boundary condition on the western side used a head contour line of 1141 m, the southern and eastern side used the first kind (Dirichlet) hydraulic head boundary conditions of 1139.9 m and 1139.89 m, respectively.

Model calibration: The model was calibrated by adjusting the hydraulic conductivities. Five observation points were loaded into the model in order to compare the simulated groundwater levels and the measured groundwater levels. A tolerance of 15 cm in groundwater levels between measured and simulated was accepted.

Transport model: For more quantitative estimation of arsenic transport, the developed flow model was extended to the transport model. The transport model used the flow model as its base. The flow model was initially run under steady-state condition. High concentrations of As at two piezometer locations were used as point source of contamination in the model. The transport model was then simulated to observe the arsenic transport distribution in the upper unconfined aquifer.

Results

The groundwater flow simulated by the FEFLOW is shown in **Figure 1**. Flow is moving towards the drainage canal and towards the Rio Grande. Similarly, the model show As leaching from natural alluvial deposits is moving slowly towards drainage canal and the Rio Grande (**Figure 2**).

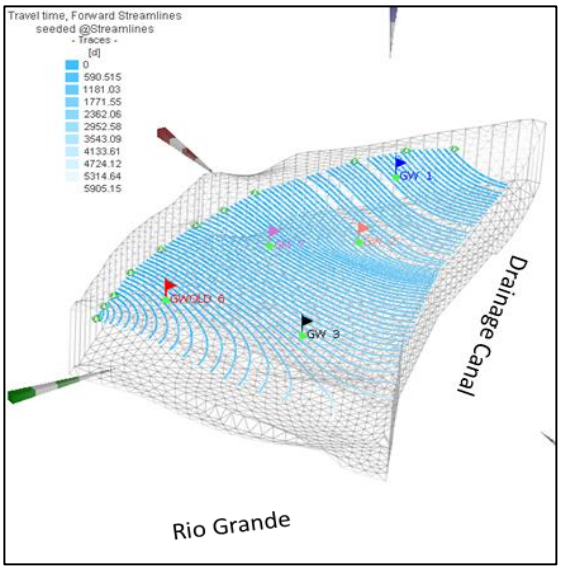

Figure 1. Flow streamlines simulated by FEFLOW

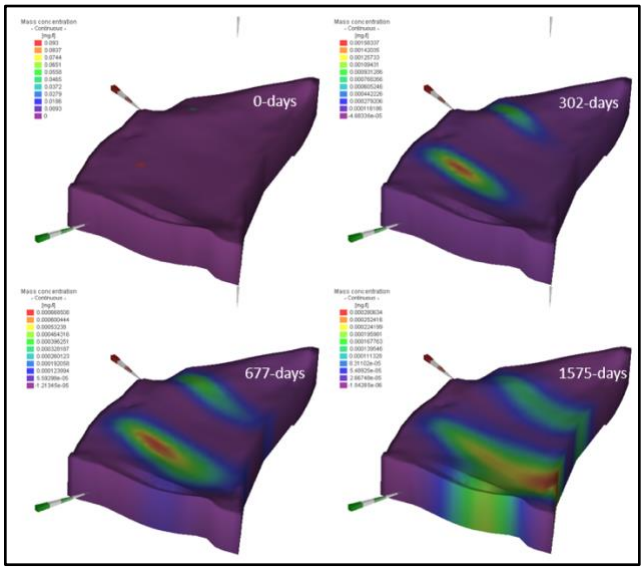

Figure 2. Simulated arsenic transport at Sunland Park, NM ReNUWIt Test-Bed

Conclusion and Recommendation

Arsenic transport at ReNUWIT Sunland Park Test-Bed was simulated using FEFLOW to better understand the direction and concentration of As leaching through the soil for riparian vegetation rehabilitation purposes. The study concludes that As is moving towards the drainage canal and Rio Grande. Arsenic adsorption by metal oxides was not considered in this modeling efforts and a further study is needed.

Reference

US EPA (Fact Sheet on Arsenic). https://www.epa.gov/north-birmingham-project/fact-sheet-arsenic

Diersch, H.-J. G. (2014). FEFLOW : finite element modeling of flow, mass and heat transport in porous and fractured media. Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-38739-5