Improvements of an Integrated Flow and Mercury Transport Model in East Fork Poplar Creek Watershed, Oak Ridge, Tennessee

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Introduction

The environment in the vicinity of Y-12 National Security Complex (Y-12 NSC), Oak Ridge, TN has been contaminated by mercury due to nuclear processing activities during the 1950s. The contamination exists within the soil, shallow groundwater beneath and adjacent to former process buildings, storm sewers, drains, stream sediment, and surface water. A significant reduction in mercury concentrations has been proposed in the area’s natural waters. In order to achieve a more effective clean up effort the Environment and Water Resources Group at Florida International University’s (FIU) Applied Research Center (ARC) has been tasked with developing a model for the site with the ultimate aim of assessing the impact of selected remediation scenarios.

Numerical Model

The model consists of MIKE 11, MIKESHE, and ECOLAB. These components are designed to couple the watershed hydraulics with mercury transport. MIKESHE describes the hydrologic processes using physical laws (conservation of mass, energy, and momentum). It is 2-D in the overland phase, 1-D in the unsaturated and 3-D in the saturated and vadose layers. MIKE 11 details the river flow and transport model through the hydrodynamic and advection modules. ECOLAB is an equations solver for the sedimentation and exchange of mercury within sediments, suspended particles, pore water, and dissolved mercury species.

Modifications

The following changes were made to the model:

- Van Genuchten’s hydraulic conductivity and moisture content parameters for the upper and lower portions of the aquifer
- ECOLAB created by the former nuclear complex containing high mercury concentrations (DOE/OR/01-02 or 03)
- Mercury concentration in the creek
- Mercury attenuates downstream of EFPC

Figure 5: Model layers and soil properties

Figure 6: OREIS database used for data extraction

Figure 7: Final stations added

Results

Simulations were executed for a series of scenarios to assess the impact of the hydraulic parameters (i.e. horizontal and vertical hydraulic conductivity, and Manning’s number were varied within accepted ranges) and determine the best fit with observed data. Drainage routing alternatives were also incorporated.

Conclusions

- Rainfall facilitates the exchange of mercury through hydrologic zones
- Mercury attenuates downstream of EFPC
- Sediment-mercury interactions significantly affect Hg transport
- High flow conditions re-suspend mercury particulates increasing concentration in the creek

Future Research

- Statistically determine hydraulic conductivity spatial distribution, porosity, and storage coefficients.
- Calibrate EFPC model using total suspended solids (TSS) and total mercury (TM) concentration timeseries at key stations.
- Incorporate sediment module
- Perform an uncertainty analysis and statistical tests

References

1. DOE, 2010. Remediation Effectiveness Report for the U.S. DOE ORR. DOE/OR/01-267/2601

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