TERRA SYSTEMS, INC. APPLICATION OF ESTCP SUBSTRATE ESTIMATING TOOL

Terra Systems, Inc. (TSI) uses the ESTCP Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents (http://www.serdp-estcp.org/content/download/8729/106124/file/ER-200627%20Substrate%20Design%20Tool.xls) to estimate the emulsified vegetable oil (EVO) demand for a particular site. The tool was developed by Parsons Infrastructure and Technology Group (2010) for ESTCP to estimate the substrate demands for sodium lactate, molasses, fructose, ethanol, whey, HRC, soybean oil, and emulsified vegetable oil.

The demand is based upon:

- the plume size (length, width, depth, and effective porosity)
- groundwater flow rate
- competing electron acceptors (dissolved oxygen, nitrate, sulfate, manganese, iron, and methane) and contaminant concentrations

The parameters that typically control the substrate demand are:

- the plume width (perpendicular to groundwater flow) and treatment thickness
- groundwater flow rate (GWFR)
- contaminant concentrations
- and sulfate concentrations

As an example, we ran the Substrate Estimating Tool for a template site with a plume of 100 feet wide, 100 feet long, and 10 foot thick with 10 mg/L tetrachloroethene (PCE), 1 mg/L trichloroethene (TCE), 1 mg/L cis-1,2-dichloroethene (cis-DCE), and 1 mg/L vinyl chloride (VC). We assumed that there was 1 mg/L dissolved oxygen and 1 mg/L nitrate and that 5 mg/L of manganese, 50 mg/L ferrous iron, and 10 mg/L methane would be produced from the metabolism of the EVO (this is based upon our experience at many other sites as it is difficult to know how much of these materials will be produced unless there has been a previous substrate injection at the site) and a design period of 3.0 years and a design factor of 3.0. We varied the groundwater flow rates between 0.1, 0.5, and 1.0 ft/day and sulfate concentrations between 50, 250, and 500 mg/L.

GWFR ft/day	Sulfate mg/L	EVO Demand pounds	GWFR ft/day	Sulfate mg/L	EVO Demand pounds	GWFR ft/day	Sulfate mg/L	EVO Demand pounds
0.1	50	1,663	0.1	250	3,998	0.1	500	6,982
0.5	50	4,921	0.5	250	12,300	0.5	500	21,524
1.0	50	9,060	1.0	250	22,679	1.0	500	39,702

The EVO demand increased from 1,663 pounds at a groundwater flow rate of 0.1 ft/day and sulfate concentration of 50 mg/L to 3,998 pounds at 250 mg/L sulfate and 6,982 pounds at 500 mg/L sulfate. At the 250 mg/L sulfate loading, the EVO demand increased from 3,998 pounds at a groundwater flow rate of 0.1 ft/day to 12,300 pounds at a groundwater flow rate of 0.5, and to 22,679 pounds at a groundwater flow rate of 1.0 ft/day. At the 500 mg/L sulfate loading, the EVO demand increased from 6,982 pounds at a groundwater flow rate of 0.1 ft/day to 21,24 pounds at a groundwater flow rate of 0.5, and to 39,702 pounds at a groundwater flow rate of 1.0 ft/day.

There is another factor that needs to be considered which is how much total organic carbon (TOC) is available from the substrate injection. From past experience, Terra Systems recommends that the minimum dosage of TOC from the EVO injection be at least 500 mg/L . to achieve adequate distribution of the EVO and longevity. One of the outputs from the model is the quantity of linolenic acid (the primary fatty acid in soybean oil) generated from the calculated quantity of EVO. To calculate the TOC, we multiply the concentration of linolenic acid by 0.769 (or the carbon content in linolenic acid). To determine the quantity of EVO to supply 500 mg/L of TOC, we divide 500 by the TOC from the model and multiply times the EVO quantity predicted by the model.

Reference

Parsons Infrastructure and Technology Group. 2010. The Substrate Estimating Tool for Enhanced Aerobic Bioremediation of Chlorinated Solvents. Version 1.1.