Optoelectronic enzymatic biosensors (OEB) were constructed with immobilized whole cells of *E. coli* pGELAF+ and were used to sense dichloroethane (DCA) in concentrations of parts per billion. The sensor physical characteristics are well understood to be mass transfer limited; therefore OEBs of different volumes of immobilized matrices (0.5μL and 6μL) were constructed and tested. This work is the first step of a complete evaluation and subsequent formulation of an iterative experimental modeling approach for the sensing system used in the Reardon laboratory. Prior model formulation suggests mathematical forms for reaction and diffusion of substrate through the immobilized matrix and a pH dependant quenching mechanism of the immobilized fluorophore. Two modeling strategies are evaluated as an extension to prior modeling efforts; 1) mixed regression (i.e. predictor-response methodology) upon sensor response and 2) a mechanistic approach cast in a symmetric reaction-diffusion equation form. Mixed regression was performed with; optode sensitivity, matrix size, days after biosensor construction, and photomultiplier setting during sensor testing. The following sensing mechanism was formulated; diffusion through a stagnant boundary layer about the cell matrix (I), diffusion through the immobilization matrix to a dehalogenase active site (II), analyte reaction with the dehalogenase (III), diffusion of resultant protons from the dehalogenase to the immobilized fluorophore (IV) and fluorophore quenching (V). Mathematical analysis techniques were developed in Polymath and MATLAB (with the statistics and curve fitting toolboxes).