Despite a huge technological advancement, air pollution remains one of the major problems in today’s world. Atmosphere is polluted by different gaseous species such as NOx (NO & NO₂), SOx, CO and volatile organic compounds (VOCs) etc. VOCs (e.g. benzene, toluene, xylene, ethylbenzene etc) have recently received greater attention in the field of environmental control due to its primary as well as secondary harmful effects on ground air quality and human health. VOCs are the chemicals that have high vapor pressure at room temperature. Most of the VOCs are emitted from process industries into the atmosphere and they generally have very low concentration i.e. in ppm or in ppb level. Even at that low concentration they are very harmful to health and environment. As most of them are carcinogens and they react with nitrogen oxides in sunlight to form ozone and photochemical oxidants, which contribute to ozone formation and photochemical smog. Hence there is a need to control them. There are various control techniques available like absorption, condensation, adsorption, thermal oxidation, catalytic oxidation, membrane separation etc. It has been found that oxidation (catalytic) is a good option when VOCs recovery is not important (both in terms of efficiency and cost), whereas, if VOCs recovery is important, adsorption is the best alternative. Since the concentration of VOCs found in the environment are generally low so catalytic oxidation would not be the right option as it requires higher temperature, more quantity of auxiliary fuel resulting in higher operating cost. The condensation technique will also be very energy intensive as temperatures below 0°C is required to condense the VOCs due to their low concentration. Compared to these techniques, adsorption has been found out to be a good alternative for the removal of VOCs as it can be easily carried out at room temperature making this technique economical in terms of energy. Activated carbon has been considered to be one of the promising adsorbents for controlling VOCs at low concentrations due to its high BET surface area. The VOCs chosen for the present study are toluene and xylene. An experimental set-up was designed and developed to carry out separate adsorption studies for the removal of toluene and xylene on granular activated carbon. Breakthrough times were found out with the help of breakthrough curves under varying operating conditions such as bed height and inlet VOC concentration. A mathematical model was also developed to predict the time-dependent (unsteady state)
concentration profiles of the adsorbing species (VOCs) on a solid adsorbent under isothermal conditions. The mathematical model developed takes into account both external and internal mass transfer resistances as well as non-ideal plug flow along the column. The model equations obtained were non-linear coupled partial differential equations which were discretized by using orthogonal collocation technique and the resulting ordinary differential equations were solved by using Gear’s method. Mathematical model was found to be robust and experimental and model predicted results were found to be in good agreement. After validating the model with the experimental results, simulations were carried out to predict the behavior of breakthrough curves for toluene and xylene on granular activated carbon under varying operating conditions such as flow rate, particle diameter, pore diffusivity, bed height and inlet concentration. Further sensitivity analysis was done to find the most sensitive parameter with respect to breakthrough time, and flow rate was found to be the most sensitive parameter with respect to breakthrough time for both toluene and xylene. Also the concentration of VOC in the pores of the adsorbent particle and in the bulk phase was found out with the help of a mathematical model with respect to time, along the radial position of the adsorbent particle and along the axial position of the column for better understanding of the adsorption process within the pores of the adsorbent particle and in the bulk phase of the bed. Finally the performance of granular activated carbon was found to be better in adsorbing xylene in comparison to toluene when breakthrough curves were drawn for same input parameters.