The phenomenon of radioluminescence (RL) has been reported in a number of materials including Al2O3 : C, which is one of the main dosimetric materials. In this work, we study RL using a kinetic model involving two trapping states and two kinds of recombination centres. The model has been previously used to provide a quantitative description of the thermoluminescence and optically stimulated luminescence processes in Al2O3 : C. Using appropriate sets of trapping parameters for the kinetic model, the RL signal along with the occupancies of the relevant traps and centres are simulated numerically. The set of differential equations is also solved analytically by assuming dynamic balance during sample irradiation. Analytical expressions are obtained for the concentrations of traps and centres in the material during irradiation with short irradiation pulses, by assuming that quasi-steady conditions hold during irradiation. Several experimentally observed characteristics of the RL signals are explained by using the model. Good quantitative agreement is found between the analytical expressions and the numerical solutions of the model for short irradiation pulses.