Innovation in radioactive wastewater-stream management. Part II: theoretical model and experimental verification

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Abstract

The present work is the second part of the authors' innovative method for radioactive wastewater-stream management, by volume reduction, by a mutual heating and humidification of a compressed dry air introduced through the wastewater. In this part, to determine the optimal operating conditions, a theoretical model describing volume reduction of the radioactive wastewater stream is achieved. A set of first-order simultaneous differential equations describing the bubble humidity, temperature, liquid temperature, and mass diffusion to the bubbles variations, are obtained through the mass and energy conservations. A set of coupled first-order differential equations are used to solve for the humidity ratio, water diffused to the air stream, water temperature and humid air stream temperature distributions through the bubbling column. These coupled differential equations are simultaneously solved numerically by a developed computer program using the fourth-order Runge–Kutta method. Therefore, the behaviour of the air bubble state variables with column height can be predicted and optimised. Moreover, the design curves of the volumetric reduction of the wastewater streams are obtained and assessed at the different operating conditions. An experimental set-up was constructed to verify the suggested model. Comprehensive comparison between suggested model results, recent experimental measurements and the results of previous works was carried out and assessed. A good agreement between experimental and theoretical model is obtained. A semi-empirical correlation is obtained together with design curve of bubbling column.

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