Modeling the Distribution of Phosphine and Insect Mortality on Cylindrical Grain Silos with Computational Fluid Dynamics: Validation with Field Trials - Abstract

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Summary

In the present work, the distribution of phosphine gas in six metal silos with wheat was modelled and compared with available distribution data from phosphine sensors. During the fumigation, a recirculation system was used to improve the diffusion of phosphine. Three different Scenarios of the recirculation system were used: (a) Scenario 1: the recirculation system was used for only 24 h in the beginning of the fumigation, (b) Scenario 2: the recirculation system was used for four consecutive days from the beginning of the fumigation and (c) Scenario 3: the recirculation system was used from the beginning of the fumigation for approximately 50 hours, the concentration reached over 300ppm and all sensors had gas equilibrium. In each silo, sensors were placed to monitor the concentration of phosphine, along with vials with phosphine-susceptible and -resistant insect populations. The insect species that were used were *Rhyzopertha dominica* and *Oryzaephilus surinamensis*. A Computational Fluid Dynamics (CFD) method was used for precision fumigation by using phosphine sensors with the OpenFoam software. Gas transport and sorption effects of phosphine into the grain was accounted through the CFD model. Simulation results were obtained for insect mortality as a function of their exposure to phosphine gas. CFD-based modelling was accurate in simulating and forecasting fumigation results and provided good predictions on each location inside the fumigated areas. Moreover, the fumigation applications resulted in complete control in all populations tested. The recirculation system improved the distribution of phosphine in the fumigated area. The most appropriate Scenario was Scenario 3, showing the least uneven distribution in the treated silo in contrast with the other two. These results indicated that CFD correlates well phosphine concentration with insect mortality and thus, a methodology for precision fumigation can be further established.

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