Fumigation Monitoring and Modeling of Hopper-bottom Railcars Loaded with Corn Grits - Abstract

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Summary

Bulk railcars are a common method of moving commodities in the United States. Allowances are given for the practice of treating railcars with fumigates during transit because the routes are limited access and not on public roads. Recent technology has become available for monitoring phosphine gas (PH_3) fumigation on railcars which log the phosphine concentration and temperature of the test point in the railcars. Industrial cooperators allowed for the monitoring of fumigations for two shipments of corn grit, which were being transported in hopper bottom railcars. Several sensing units were used in each railcar and spaced across the top layer. Data were collected during the eight-day trip from grain mill to processor. The phosphine concentrations at the top varied with time with phosphine spiking over 1600 ppm and gradually settling to over 300 ppm at the end of the eight days. Total gas dosage was estimated as concentration*time (CT) over the eight days as 115,000 and 125,000 ppm*hr at the top of each railcar. Because access to lower depths in the railcar were not available, supplement experiments were performed with small columns of corn grits (2.5 m height x 0.55 m dia) to test for phosphine below the top surface. A higher and lower phosphine treatments were applied to the columns. These tests found significant phosphine penetration into the bulk at 2 m depth with ~380 ppm after two days and going down to ~260 ppm after eight days with the high phosphine treatment. Bioassays of both phosphine susceptible and resistant, adult *Rhyzopertha dominica* (F.), lesser grain borer, and *Tribolium castaneum* (Herbst), red flour beetle, were included at both the surface (0 cm), 25 cm and 60 cm below the surface. All insects, at all locations, were dead after eight days. The railcar and the fumigation treatments were additionally modeled with a CFD simulation approach. The simulation models were shown to provide estimates of the phosphine concentration and distribution which matched well the observed data, validating the CFD approach as an efficient tool for future planning and analysis of similar fumigations.

Keywords

phosphine, lesser grain borer, red flour beetle, computational fluid dynamics, wireless sensors, mathematical modeling

Acknowledgements

This research is part of the project «Management of entomological infestations in the stored products by using innovative technologies» (Project code: KMP6-0081034) that is co-funded

Proceedings of HAICTA 2022, September 22–25, 2022, Athens, Greece
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by Greece and European Union by the Action «Investment Plans of Innovation» in Central Macedonia under the framework of the Operational Program «Central Macedonia 2014 2020».