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Phthalate degradation in floor dust: mechanisms and requisite conditions

Sarah Haines (2,3), Ashleigh Bope (1,2,3), Bridget Hegarty (4), Charles Weschler (5,6), Jordan Peccia (4), Karen Dannemiller (1,2)

(1) Department of Civil, Environmental & Geodetic Engineering, College of Engineering, Ohio State University, Columbus, OH, United States, (2) Division of Environmental Health Sciences, College of Public Health, Ohio State University, Columbus, OH, United States, (3) Environmental Science Graduate Program, Ohio State University, Columbus, OH , United States, (4) Department of Chemical and Environmental Engineering, Yale University, New Haven, CT , United States, (5) Environmental and Occupational Health Sciences Institute, Rutgers University, Piscataway, NJ, United States, (6) International Centre for Indoor Environment and Energy, Department of Civil Engineering, Technical University of Denmark, Lyngby, Denmark

Background

Phthalate esters (phthalates) include some endocrine-disrupting compounds that are present at elevated levels in floor dust. Direct contact, ingestion and inhalation of this dust in the indoor environment is a major source of human exposure to these chemicals. Phthalates are degraded by microbes in water and in terrestrial environments in the presence of moisture, but this degradation has never been demonstrated in house dust. The goal of this work is to quantify phthalate degradation due to both biotic and abiotic mechanisms in the indoor environment at elevated ($\geq$80%) relative humidity conditions.

Methods

Previously used carpet was embedded with dust collected from the same home and incubated at equilibrium relative humidity (ERH) levels of 50, 80, 85, 90, 95 and 100% for 1-6 weeks. To determine abiotic versus biotic processes, collected dust was spiked with deuterated di(2-ethylhexyl) phthalate (d-DEHP), embedded into carpet from the same home and incubated at 100% ERH for either 1 or 3 weeks. After incubation, the samples were vacuumed, and dust was stored at -20 °C prior to analysis. Metatranscriptomic analysis was conducted to determine the expression of genes with phthalate degradation potential by the dust's microbial community.

Results

All nine phthalates considered were detected in the dust. When incubated at 100% ERH for three week we found significant removal of higher molecular weight phthalates DiNP and DiDP ($p<0.05$) and to a lesser extent BBzP ($p=0.055$) and lower molecular weight phthalate DMP ($p=0.048$) by abiotic/biotic processes. When d-DEHP was spiked into the dust, abiotic processes resulted in 10.1% ($\pm$1.1%, standard error) to 69.6% ($\pm$4.8%) decrease in total d-DEHP after 1 week ($p=0.03$) and a 27.2% ($\pm$1.4%) to 52.0% ($\pm$2.1%) decrease after 3 weeks ($p=0.008$). After one week, losses due to biotic processes ranged from 5.9% ($\pm$8.9%) to 8.5% ($\pm$1.7%) ($p=0.07$) and after three weeks, losses ranged from zero to 10.3% ($\pm$4.5%) ($p=0.044$). We identified the expression of genes that may potentially be associated with phthalate degradation.

Conclusion

Degradation of phthalates can result in the production of certain products that may be harmful to human health. To determine phthalate degradation at lower relative humidity levels this work should be repeated for extended periods of time. Overall, these results suggest that phthalates are degraded in house dust through both biotic and abiotic mechanisms when exposed to elevated relative humidity levels.