ODOR: QUANTIFICATION AND HEALTH IMPACTS

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Odor is an unwanted consequence of municipal waste processing and disposal of sludge. Anaerobic digestion of sludge generates a broad range of odorants during the treatment process. In the first stage (acid fermentation), sugars, lipids, colloidal solids, and dissolved carbonaceous matter are converted to organic acids with the evolution of H_2S and CO_2; pH drops during this stage. In the next stage (acid regression), the organic acids (formed in stage 1) along with some proteins are digested to acetate and ammonia compounds; pH rises slowly during this stage. In the third stage, pH rises to neutral ($pH \approx 7$) with the generation of large volumes of gases, especially methane, that can be used as fuel. The resultant humic mass has more odor if thermophilic digestion rather than mesophilic digestion is used. The sludge is then stabilized by chlorine or lime to render the material less suitable for microbial growth. It is also heated to reduce the quantity of moisture. Composing of the material and other forms of treatment byproducts can also generate odor.

Questions have been raised about the potential health effects of odors from wastewater treatment plants and the disposal of sludge. On April 16-17, 1998, a workshop sponsored by Duke University, the Environmental Protection Agency (EPA) and National Institute on Deafness and Other Communication Disorders (NIDCD) was held to examine the potential effects of unpleasant odors on health and well-being (Schiffman et al., 2000a). Complaints attributed to unpleasant odors from wastewater treatment (as well as other odor sources) include eye, nose, and throat irritation, headache, nausea, hoarseness, cough, nasal congestion, palpitations, shortness of breath, stress, and drowsiness. These health symptoms attributed to odors are generally acute in onset and self-limited in duration (Schiffman, 1998). Participants at the workshop attempted to determine whether these reported symptoms are caused by the odor (sensation) or the odorant (the chemical which happens to have an odor) or other causes.

Workshop participants concluded that there are at least three ways in which odors may be associated with health symptoms. First, a person may be exposed to an odorant (e.g. exposure to ammonia vapor) at levels capable of producing symptoms by sensory irritation (or other toxicologic mechanisms). In this case, the irritancy (or toxicity) occurs at a level above but within an order of magnitude of the odor threshold (concentration at which it is first detected). At concentrations above the irritation threshold, the experience of odor occurs simultaneously with the more relevant irritative process, but symptoms are caused by irritation rather than "odor-induced." Odor in this first case is simply a warning of potential health effects at elevated concentrations.

The second way in which odors may produce health symptoms is one in which the odorant is part of a mixture. In this case, a co-pollutant, which itself may have no odor, is responsible for the health symptom. An example of such a situation would be simultaneous exposure to odors from sludge and to bacteria. To the extent that symptoms/health effects are a result of bacterial exposure, odor is merely acting as a marker of exposure. That is, odor is a "potential cofounder."

The third situation involves exposure to odorants that are 3-4 orders of magnitude below the levels that cause irritation or classical toxicologic symptoms. Example of such odorant classes include sulfur-containing compounds such as, H_2S, mercaptans, and thiophenes. Empirically there is considerable evidence that exposure to such compounds at concentrations above threshold but below irritant levels is associated with increased symptom reporting. More research is required, however, to understand more fully the complex interplay between biological and behavioral/psychosocial factors on expression of health symptoms from odors. Objective medical tests such as pulmonary function studies must be correlated with objective measures of air quality. Methods for assessing health effects at specific odor/odorant levels will be discussed (see Schiffman et al., 2000b for a review of methods for measuring odor).

REFERENCES

Schiffman, S. S. Livestock odors: Implications for human health and well-being. Journal of Animal Science 76:1343-1355;1998.

Schiffman, S. S.; Walker, J. M.; Dalton, P.; Lorig, T. S.; Raymer, J. H.; Shusterman, D.; Williams, C. M. Potential health effects of odor from animal operations, wastewater treatment, and recycling of byproducts. Journal of Agromedicine, 7: 2000a, in press.

Schiffman, S. S.; Bennett, J. L., Raymer, J. H. Quantification of odors and odorants from swine operations in North Carolina. Agricultural and Forest Meteorology, 2000b, in press.