Health Effects of Biosolids Odors: A Literature Review and Analysis

Wastewater treatment plants (WWTPs) can be sources of unacceptable odors even when their emissions fall below levels set to protect public health. What is not clear is whether the experience of odors (i.e., odors as sensations) cause illness. This project—the third in a series on municipal wastewater odors—refines the issues and terminology regarding whether biosolids odors, as sensations, might cause illness and reviews the evidence that biosolids odors do or do not cause illness. Furthermore, this project evaluates whether WWTP emissions cause irritation and explains why many symptoms attributed to biosolids odors fail to qualify as illness.

The project team surveyed literature on emissions from biosolids, giving special attention to quantitative estimations of concentrations of notable constituents and the connection between odors as sensations and illness. The survey revealed a general lack of attention to the question of whether odors per se cause illness but reflected appropriate attention to the objective toxicological effects of notable contaminants.

The project's methodology also entailed application of a quantitative structure-activity model to calculate chemesthetic potency and an atmospheric dispersion model to calculate ambient concentration away from a source.

The project findings led to the conclusion that:

- Odors as sensation do not cause signs of illness.
- The acceptability or unacceptability of odors varies systematically and predictably with circumstances of exposure.
- Below toxic levels of exposure, symptoms associated with odors involve no pathology.
- Removal of the source of odor leads to immediate reduction of symptoms.
- Mediating variables, such as anxiety, seem largely to account for symptoms from odors. The analysis does leave room, however, for a role for malodors in the exacerbation of both symptoms and signs in persons with certain chronic illness, such as asthma.

The objective of this project was to consider whether odors from biosolids cause illness and to make recommendations for work necessary to understand any effects.

Wastewater treatment plants should take the fifth point to heart—both for the responsibility it implies and for the opportunity it may present for understanding the expression of symptoms. Nothing will reduce symptoms better than control of emissions. WWTPs should, of course, seek to produce as little annoyance or anxiety as possible but should also recognize the mediating states as the source of symptoms.

Odors, Illness, Signs, and Symptoms

Illness is defined as impairment of normal physiological function, affecting part or all of an organism. In pursuit of its objective, this report includes information on how to view illness via symptoms (subjective) and signs (objective), how to define odors and thereby to clarify the question of whether odors may cause illness, how the sense of smell functions, how sensory irritation (chemesthesis) differs from smell, how acceptability of odors derives from a role in physiological

BENEFITS

- Refines the issues and terminology regarding whether biosolids odors, as sensation, might cause illness.
- Reviews the evidence that biosolids odors do or do not cause illness.
- Explains the functional origins of the acceptability of odors.
- Defines the difference between the sense of smell and the chemesthetic or irritation sense.
- Evaluates whether emissions from WWTPs cause irritation.
- Explains why symptoms attributed to biosolids odors fail to qualify as illness.
- Clarifies that the amelioration of such symptoms lies in reduction of anxiety and associated states.

RELATED PRODUCTS

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regulation, whether the medical community has recognized connections between odors and illness, how field studies have contributed to understanding, and how to study the problem in the future.

There exists no repository of information on the numbers of complainants with illness, their specific complaints, or the relationship between degree of exposure and complaints. Nevertheless, anecdotal reports imply a pattern much like that associated with other industrial malodors.

Any connection between odor and illness has received little attention in medical literature. This state of affairs presumably exists because odors per se generate no objective signs of illness in otherwise healthy persons. Rather, the symptoms associated with WWTP malodors seem to occur via intermediate variables, such as annoyance, anxiety, and frustration. Persons who experience no such distress experience no symptoms according to the researchers.

Acknowledgment that odors cause anxiety and the like should inform strategies for dealing with reports of symptoms. Research into the connection between the composition of the emissions from WWTPs and odor characteristics should seek to illuminate quantitative goals that engineers can seek to achieve. Finally, failure to respect the boundary between the subjective and the objective in discussions of the matter can invite incorrect conclusions about the relationship between odors and illness.

Malodors may, however, exacerbate both symptoms and signs of illness in persons with certain chronic disorders, such as asthma and migraine. Vulnerability to such effects varies considerably from person to person. The effects of malodors on the exacerbation of symptoms or signs in persons with existing illness should receive attention in the research laboratory where issues of dose and response and individual differences could elucidate the risk factors for claims of malodor-induced illness.

Research on the sensory consequences of WWTPs could profit from approaches taken in the sensory analysis of foods, for which odor quality receives as much attention as odor intensity and potency. Study of the "sensory anatomy" of odors from WWTPs might sharpen targets for control and might thereby give the engineer greater leverage to minimize annoyance.

Future Directions

Based on its findings, the project team formulated a list of four areas that merit further investigation. These projects would focus on identifying and controlling odors, rather than on additional health studies.

- *Collect data on the distribution of threshold sensitivity to the notable constituents of emissions from biosolids:* Databases on the thresholds for the odors of various volatile organic compounds often rely upon results collected almost a century ago. They also lack information about the relationship between concentration and probability of detection both within and across individuals. Of even greater concern, the databases have notorious levels of error, as high as orders of magnitude.
- *Supplement knowledge of thresholds for individual chemicals with those for mixtures:* There exist some results on the relationship between the detection of individual chemicals and the detection of mixtures. For emissions from biosolids, the questions of relevance concern a) whether chemicals with like functionality, e.g., sulfides, show any different rules of additivity than materials of unlike functionality, e.g., sulfides and amines, and b) whether the rules of additivity of complex mixtures differ from those of simple mixtures.
- *Above the threshold, perceived odor intensity increases nonlinearly with concentration, with different functions for different materials:* Simply put, for a given reduction in concentration, the odor intensity of one material can decrease more than that of another. Any effort to collect data on the distribution of threshold sensitivity could also collect data on supra-threshold odor intensity for the same materials and for some mixtures.
- *Research on the intensive properties of malodors needs to be supplemented with research on qualitative properties, such as the character and acceptability of the odors, particularly of blends:* This topic has received little attention in the small amount of research devoted to sensory analysis of malodors from biosolids.

Research on the four topics identified above should bring understanding that goes beyond the data. Some of the understanding might lie in discovery of physicochemical correlates of sensory phenomena, and some may lie in discovery of the neural "algebra" of olfactory processing. Research on the sensory properties of the odors of biosolids can set the stage for control. Actual control will give rise to its own needs for research, mostly on the chemistry of biosolids, though this could occur as understanding of the sensory properties unfolds.

There may be merit in studies of the effects of the odors on patients with asthma and perhaps with migraine. Such studies could take place in the controlled conditions of a laboratory and could thereby allow exploration of dose and response. These studies could tease apart issues concerning whether chemical agents themselves, their odors as odors, or the stress associated with stimulation govern effects. The studies could also address whether positive effects occur only in some persons and what might determine the extent of any individual differences.

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