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The Food-Water Nexus: Irrigation Water Quality, Risks to Food Safety, and the Need for a Systems-Based Preventive Approach

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In this column, EHSB and guest authors from across CDC will highlight a variety of concerns, opportunities, challenges, and successes that we all share in environmental public health. EHSB's objective is to strengthen the role of state, local, and national environmental health programs and professionals to anticipate, identify, and respond to adverse environmental exposures and the consequences of these exposures for human health. The services being developed through EHSB include access to topical, relevant, and scientific information; consultation; and assistance to environmental health specialists, sanitarians, and environmental health professionals and practitioners.

The conclusions in this article are those of the author(s) and do not necessarily represent the views of the CDC.

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This year's World Water Day focused on the food-water nexus with the theme "Water and Food Security: The World is Thirsty Because We are Hungry." While much of the emphasis under this theme focused on the quantities of water used for food production, the quality of water is also important to that function. Water quality can also have significant effects on health. In this context, the quality of irrigation water can have profound impacts on the microbiological integrity of food. Irrigation water has been implicated as a possible source of pathogens in produce linked to major disease outbreaks in the U.S. and Europe. Many sources of irrigation water are subject to inputs of pathogenic loads from point and nonpoint sources stemming from multiple land uses in watersheds (Pachepsky, Shelton, Mclain, Patel, & Mandrell, 2011). Research on the potential effects of irrigation water quality on food safety therefore requires a systems-based environmental assessment on the watershed scale that accounts for various factors that may influence irrigation water quality.

Two nationwide disease outbreaks linked to fresh produce in the U.S. illustrate the concept of a watershed scale systems-based environmental assessment for investigation of potential effects of irrigation water quality on food safety.

In the first, fresh bagged spinach from a single farm in California was implicated as the source of a 2006 *E. coli* O157:H7 outbreak that caused over 200 illnesses and five deaths. The environmental investigation to determine how the spinach became contaminated included a watershed scale assessment of the farm's surroundings to identify factors related to irrigation water that may have contributed to that contamination. Based on the available information, groundwater used as irrigation water and its potential contamination by surface water recharge were identified as the most likely water-related contributing factors involved in this outbreak.

Because of the seasonal climate in this region of California, winter rains are stored in reservoirs and then released during the dry summer season to recharge aquifers used for irrigation. Analysis of water samples from a river flowing through the farm found a bacterial strain matching the outbreak strain found in patients as well as the bagged spinach. Analysis of the hydrogeologic conditions at the farm indicated that pathogens in surface water could potentially have reached wells on the farm and contaminated irrigation water. Those conditions included a groundwater table that dropped below the level of the river during the growing season, allowing surface water to recharge groundwater on the farm. High rates of irrigation well pumping and layers of coarse-grained soils would also have contributed to creating the conditions under which contamination from the river could have reached the irrigation wells (Gelting, Baloch, Zarate-Bermudez, & Selman, 2011).

In the second example of a systems-based environmental assessment, iceberg lettuce served in chain restaurants was identified as the vehicle of transmission for a different *E. coli* O157:H7 outbreak in 2006. Samples from an initial environmental investigation revealed a genetic match between the outbreak strain and environmental samples from a single farm in a different region of California, leading to an in-depth systems-based analysis of the irrigation water systems on that farm. Three sources of irrigation water were used on the farm: groundwater pumped from on-site wells, surface water delivered through canals by a local water management agency, and effluent from wastewater lagoons on nearby dairy farms. The wastewater effluent was blended with water from the other sources and used only to irrigate animal feed crops. Water management on the farm, including control of the wastewater blending process, however, appeared to create the potential for cross contamination. Backflow prevention between piping networks used to convey blended wastewater and water from the other two sources was insufficient. In addition, the hydraulics in the combined piping networks were such that either high or low pressure situations could create the potential for cross contamination (California Food Emergency Response Team, 2008). The irrigation network on the farm had evolved over time to attempt to meet various needs, without an overall analysis of how that evolution created possibilities for contamination of irrigation water.

One implication of the results of these assessments is that the scope of produce-related outbreak investigations and potential prevention measures need to be conceptually broadened to include factors beyond those actually found on the farms identified as sources of produce involved in outbreaks. A systems-based, watershed scale analysis is necessary for comprehensive identification of factors potentially contributing to irrigation water contamination. A dimension of time also needs to be added; such environmental variables as water quality are dynamic, with seasonal or other variations influencing the quality of irrigation water. Irrigation systems themselves also evolve over time to meet varying needs, and those incremental changes may lead to unintended vulnerabilities. A preventive approach such as that contained within the Water Safety Plan process for drinking water may also be useful in managing irrigation water quality (Davidson et al., 2005). Such an approach would include a systematic identification of risks to irrigation water quality, both within an irrigation system as well as in the broader watershed environment, and could help to identify and prevent contamination of produce from irrigation water.

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