A Landscape Perspective on Antibiotic Resistance

David R. Bowne, Ph.D., Franklin and Marshall College, david.bowne@fandm.edu
Debra L. Wohl, Ph.D., Elizabethtown College, wohld@etown.edu

Abstract:
The rapid evolution of antibiotic resistance in bacteria is one of the most pressing public health problems in the nation. According to the Center for Disease Control, over 70% of the bacteria that cause hospital-acquired infections are resistant to at least one commonly prescribed drug. The fight against antibiotic resistance is primarily focused on clinical settings. Antibiotic resistant bacteria are, however, found in the environment as well. Intense use of antibiotics for livestock and other agricultural practices contributes to this pool of resistance. But not all cases of resistance are caused by direct use of antibiotics. Many metals, including mercury, lead, cadmium, cobalt, nickel, copper, and vanadium, are often correlated with antibiotic resistance. Naturally occurring resistance also stems from interactions between microbes in the environment. Recent research highlights the need to understand patterns of antibiotic resistance in the environment, as well as in clinical settings. Our research is one of the first to examine the large-scale distribution of antibiotic resistance in enteric bacteria inhabiting soil. We determine the relationship of antibiotic resistance in *Enterobacter aerogenes* in Lancaster County to variables such as land use, concentration of heavy metals, bedrock type, watershed, and elevation. From soil samples collected from 84 randomly selected sites, we found mean proportions of isolates resistant to ampicillin (0.50), chloramphenicol (0.49), trimethroprim-sulfamethoxazole (0.42), kanamycin (0.05), tetracycline (0.03), and multiple drugs (0.23). Levels of resistance were typically lower in forest versus residential, pasture, and crop land uses but resistance among land uses was only significantly different for ampicillin and kanamycin. Analyses of heavy metal concentrations did not fully explain antibiotic resistance patterns. Lead was significantly related to ampicillin resistance, copper was significantly related to kanamycin and chloramphenicol resistance, and nickel was significantly related to kanamycin resistance. Kanamycin resistance also significantly differed between watersheds. Our research documents current levels of antibiotic resistance in the environment and provides an initial assessment of variables affecting that resistance. We suggest a greater effort be made to understand the relationship between land use, heavy metals, and antibiotic resistance in the environment.

Dr. David R. Bowne is a landscape ecologist at Franklin and Marshall College, Lancaster, Pennsylvania. His ongoing research projects include an analysis of the spatial distribution of antibiotic resistant bacteria in Lancaster County, the use of ecological theory to analyze the insurgency in Iraq, and factors influencing the spatial population dynamics of painted turtles in an agricultural landscape. He earned a Ph.D. in Environmental Sciences from the University of Virginia, a M.S. in Conservation Ecology and Sustainable Development from the University of Georgia, and a B.S. in Natural Resource Management from Rutgers University.

Dr. Debra L. Wohl is an assistant professor of microbial ecology at Elizabethtown College, Elizabethtown, Pennsylvania. Her research focuses on microbial interactions in both aquatic and terrestrial environments, particularly on the relationship between species diversity and ecosystem function. Dr. Wohl is currently studying antibiotic resistant bacteria in the environment, gene transfer between microbes, and the natural reservoirs of pathogens such as *Agrobacterium tumefacians* and *Erwinia amylovora* (i.e., causal agents of Crown Gall and Fire Blight, respectively). She earned a Ph.D. in Ecology and a M.S. in Entomology from the University of Georgia and a B.S. in Biology from the University of Michigan.

The Relationship Between Channel Catfish Estrogenicity Index and the Density of Combined and Sanitary Sewer Overflows; Significantly Elevated Mercury and Selenium Concentrations in Channel Catfish Fillet From Kittanning PA Versus the Pittsburgh Pool

Conrad Daniel Volz, DrPH, MPH [1,2,3]

1. University of Pittsburgh Cancer Institute, Center for Environmental Oncology, Pittsburgh PA, USA. 2. University of Pittsburgh, Graduate School of Public Health, Pittsburgh PA, USA. 3. Scientific Director, Center for Healthy Environments and Communities, Pittsburgh, PA., USA.

Abstract 1:

Effluent from wastewater-treatment plants contains compounds that possess estrogenic activity. The southwestern Pennsylvania area has over 400 sewer overflows (SOs) that release untreated sewage. We sought to determine if the estrogenicity index (EI) of channel catfish from dense areas of SOs differed from catfish that are less impacted by SOs, using MCF-7 and BT-20 cell cultures. The MCF-7 human breast cancer line is estrogen receptor (ER) positive, while the BT-20 line is ER negative. The EI is based on the ratio of MCF-7 proliferation from application of fish extract to the response achieved from physiological levels of estradiol. Catfish caught near dense concentrations of SOs had significantly higher MCF-7 EIs than catfish from areas of less dense SOs, ($p=0.02$). The ER negative BT-20 cell line exhibited no proliferative response. We hypothesize that fish caught in concentrated areas of SOs have bioaccumulated more xenoestrogens than fish caught in less SO impacted areas. River water from SO contaminated areas is the primary source of drinking water for Allegheny County residents, potentially exposing large population groups to xenoestrogens. Our data suggest that evaluation of the estrogenicity of fish should be incorporated into risk assessment paradigms. Estrogen-screen evaluation of channel catfish is proposed as one model for further development.

Abstract 2:

Fish can serve as biomonitors (sentinels) for source identification of aqueous metallotoxins. Additionally, there is evidence that local fishers and their families are exposed to metallotoxins through the consumption of river-caught fish. Our Community Based Participatory Research Project recruited local anglers to catch channel catfish (n=63) in legacy metals industry and sewer overflow contaminated areas of the Three Rivers Area (TRA) of Pittsburgh PA and upstream in angler-defined "cleaner water" at Kittanning PA, proximal to power plants. We wished to determine if fillet concentrations of mercury (Hg), arsenic (As), and selenium (Se) varied significantly by location of river catch as compared to store-bought.

There were no significant differences in Hg, As, or Se concentrations among the TRA catch, thus we combined these data. Unexpectedly, significantly higher levels of Hg and Se were found in Kittanning-caught catfish compared to those caught in the TRA (both $p<0.0001$). The store-bought fish were significantly lower in mercury and selenium than those caught in the TRA (both $p<0.0001$). Kittanning and TRA fish had 19 and 3.1 times, respectively the mercury as store-bought fish; 23% of samples from Kittanning had mercury levels over the 0.3-ppm EPA flesh criterion. The As concentrations from the TRA and Kittanning catches were significantly higher than store-bought (both $p=0.0001$). Contaminant levels in catfish from Pittsburgh rivers varies significantly by location and can aid in identifying sources of pollution particularly deposition of emissions from coal-fired power plants. Fish consumption advisories should be based on location-specific fish concentrations and actual consumption rates.

Dr. Conrad Daniel Volz has 30 years of experience in water, air and soil environmental contaminant human and ecological exposure and risk assessment, fate and transport analysis, environmental remediation projects and hazard communication. Dr. Volz has performed environmental consulting services for private industry, the federal government, foreign governments and NATO in 24 different countries on 5 continents. Dr. Volz is on the faculty of the University of Pittsburgh, Department of Environmental and Occupational Health. He is the Scientific Director of the Center for Healthy Environments and Communities at the Graduate School for Public Health (GSPH); he is also Co-Director, Division of Environmental Assessment, Monitoring and Control at the University of Pittsburgh Cancer Institute's, Center for Environmental Oncology.

Dr. Volz's research interests are primarily focused on how point and non-point source water toxins and carcinogens are taken up in fish and eaten by humans and what risk of disease this poses to the population. He is especially interested in how contaminants move through the environment to surface and ground water and how to block this movement. Dr. Volz is the Principal Investigator for projects to measure the amount of heavy metals, including mercury, as well as estrogenicity in fish in the Three Rivers Area. He was Director of the 2004 Amchitka Expedition in the far western Aleutian Island Chain to determine radionuclide concentrations in marine plants and animals and the risk to commercial fishing operations from underground nuclear test shots fired on the island during the Cold War. At GSPH he is also a Co-Investigator in the new Centers for Disease Control, Environmental Public Health Tracking-Center of Excellence.