A description of the study, and why it matters, by the authors-

The spread of antibiotic resistant bacteria in the Hudson: one more reason to care about reducing sewage pollution in our waterways

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The waterways of New York City are a valuable natural and recreational resource (Figure 1) and their health depends on responsible stewardship. While conditions have improved greatly in the Hudson River and New York Harbor over the last 30 years, the release of sewage into our waterways continues to threaten ecosystem health and optimal water quality. Perhaps the problem that presents the most immediate heath threat to those who contact river water is the billions of gallons of combined stormwater, mixed with raw human sewage, that are expelled into the Hudson River each year. This happens when rain water enters our sewer system via storm drains and mixes with sanitary sewage. The combined volume can overwhelm the capacity of the pipes leading to our wastewater treatment plants. To avoid sewer backups, a portion of this combined stormwater and sewage is sometimes diverted into our waterways before it has been processed in a treatment plant to remove bacteria and other contaminants. This process of releasing stormwater mixed with sewage is referred to as a "combined sewer overflow" (CSO). While we know that untreated sewage can contain disease-causing organisms, we don't always know what kinds of potentially dangerous organisms are actually present. **A recent study by our laboratory group, published in 2013, confirmed that the abundance of antibiotic resistant bacteria in Hudson River Estuary (HRE) water is connected to sewage pollution and found that levels of these resistant bacteria in the HRE increased following rainfall, presumably due to CSO contamination (Figure 2).** In addition, many of the resistant bacteria detected in HRE water, especially following rainfall, were similar to bacteria found in the human intestine and in some cases were similar to groups of bacteria that have been associated with antibiotic resistant infections.

Samples for this study were collected in parallel with the monthly water quality monitoring program conducted by Riverkeeper, in collaboration with Queens College and the Lamont Doherty Earth Observatory of Columbia University (Figure 3 and 4). The Riverkeeper sampling program determines the level of *Enterococci*, commonly measured sewage-indicating bacteria, at seventy-five Hudson River locations spanning the entire tidal portion of the HRE (www.riverkeeper.org/water-quality). Our recently published study demonstrates a clear connection (correlation) between the level of *Enterococci* and the level of antibiotic resistant bacteria in HRE water samples (Figure 2). This is a significant finding since it demonstrates that the commonly measured sewage indicator, *Enterococcus*, also represents the abundance of other microbes of concern, such as antibiotic resistant bacteria. **This provides additional support for the use of *Enterococci* as a valuable indicator in water quality monitoring programs.**

Antibiotic resistant infections are growing as a public health crisis, with new "superbugs" emerging and effective treatments often eluding physicians. The spread and transmission of resistant bacteria through environmental pathways is an important component of understanding the problem and taking steps towards implementing preventative measures to protect the public. **Polluted waterways contain resistant bacteria, with greater levels of sewage pollution resulting in more resistant bacteria in our waterways and perhaps greater susceptibility for infection of the public.**

More thorough epidemiological study is necessary in order to quantify and fully assess the risk that this issue poses to the public. **However, this recent study illustrates one more reason to care about Hudson River water quality and to reduce sewage pollution via improved management and upgrades to wastewater infrastructure in our communities.** This study was the first to directly measure antibiotic resistant bacteria in the urban Hudson River Estuary and was the first study to demonstrate a clear connection of the number of sewage indicating bacteria with the levels of antibiotic resistant bacteria in an estuary.

You can learn more about the research described above by reading the full scientific paper: *"Antibiotic-resistant bacteria in the Hudson River Estuary linked to wet weather sewage contamination"* 2013. Journal of Water and Health, Volume 11, Number 2, pages 297-310. Doi:10.2166/wh.2013.131

If you have questions about the study you should contact the corresponding author for the study: Dr. Gregory O'Mullan from Queens College; 718-997-3452; gomullan@qc.cuny.edu

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Figure 1: Kayakers enjoying the Hudson River, with Manhattan in the background, on a warm summer day.

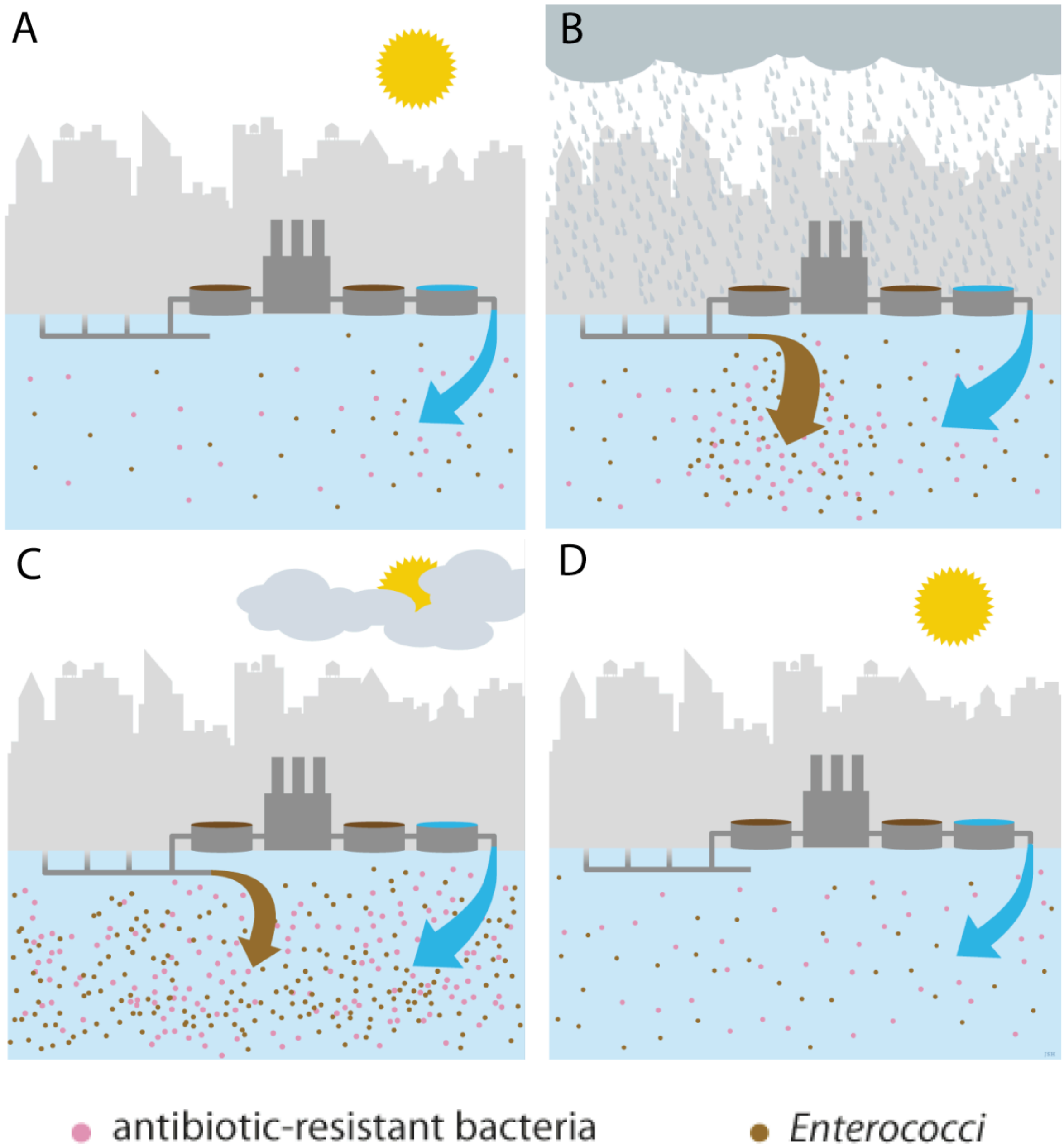

Figure 2: Illustration of combined sewer overflow (CSO) in New York City and the connection between levels of sewage indicating bacteria (*Enterococci*; brown dots) and Antibiotic Resistant Bacteria (ARB; pink dots). Panel A- During dry, sunny weather sewage is delivered from the city to waste water treatment plants, and treated effluent (blue arrow) is released into the estuary. Panel B- Rainwater from street drains combine with sanitary sewage and overwhelms the capacity of pipes delivering sewage to treatment plants, causing CSO to release untreated sewage into the estuary (brown arrow) from approximately 500 locations in New York Harbor. CSO discharge contains both *Enterococci* and ARB. The levels of these bacteria are correlated, demonstrating that *Enterococci* is a very useful indicator of other microbes of concern including antibiotic resistant bacteria. Panel C- In the hours and days immediately following rainfall and CSO discharge, the levels of both *Enterococci* and ARB are elevated, often hundreds to thousands of times higher than during dry weather. Panel D- After several days of dry weather the levels of *Enterococci* and ARB decrease to background levels.

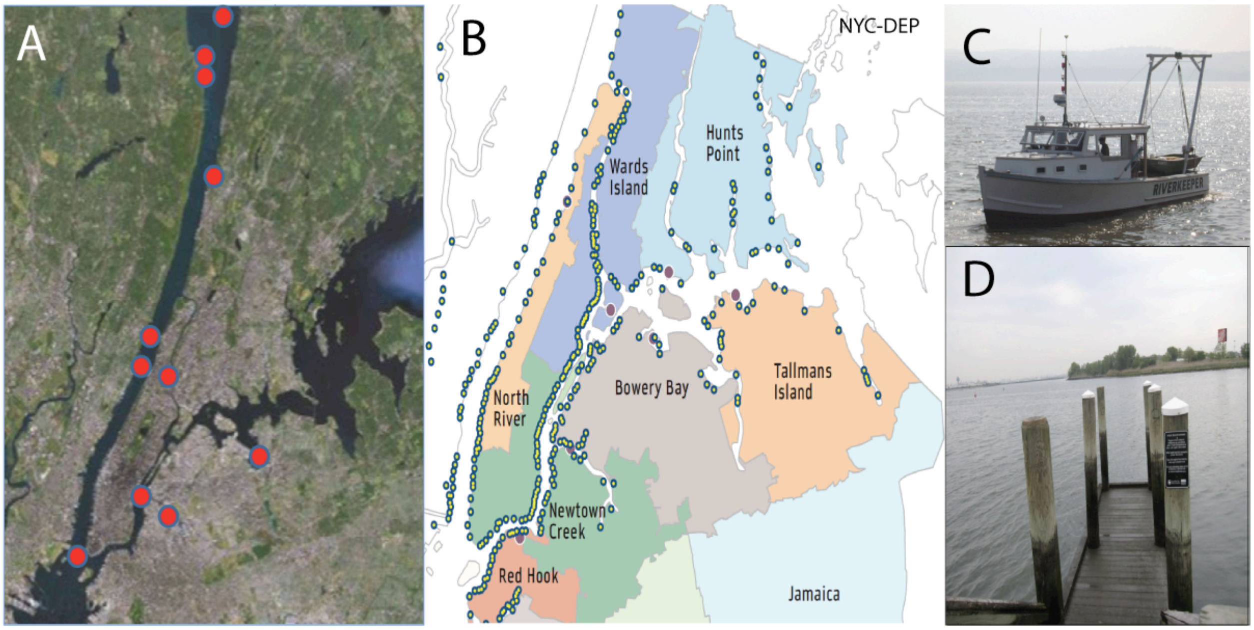

Figure 3: Field sampling. Panel A- Red dots identify sampling sites around New York City and the Tappan Zee used in the study. Panel B- New York City Department of Environmental Protection map with dots showing the location of more than 400 CSOs in New York Harbor. Panel C- The Riverkeeper patrol boat, used to collect samples for this study. Panel D- Public dock in Flushing Bay used for high frequency sampling in this study.

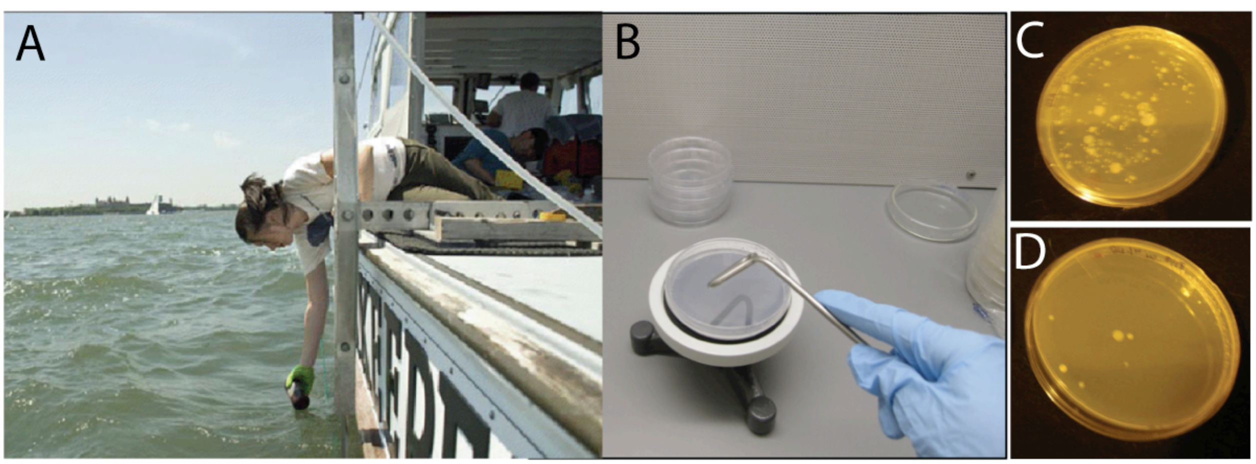

Figure 4: Collection and lab processing of samples. Panel A- Water samples were collected from the Hudson River Estuary in sterile bottles and transported to the laboratory at Queens College for processing. Panel B- In the laboratory water was spread on to media plates, with and without antibiotics, to grow bacteria collected from the estuary water. Panels C and D- Media plates were incubated in the laboratory and then the number of bacteria that grew were counted. Media plates without antibiotics (Panel C) had far more growth than plates with antibiotics added (Panel D) but antibiotic bacteria were detected at every sampling site tested and increased after rainfall.