Connecting the Connecticut Coastline to the Arctic: Pollutants Know No Boundaries

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One of the humbling truths of how our world works is that our local actions influence the environment on a planetary scale. Once a chemical that we use enters the atmosphere it takes only days to deliver it thousands of kilometers away. Exchange between air currents continues over months and the entire atmosphere is mixed within a year! This means that a compound released at the equator (or Groton, CT) will make its way to the Arctic as long as it is not completely degraded in the atmosphere within that year. Also, the break-down products of compounds that are transported will continue this global journey. Many of these compound classes have been identified by the United Nations Environmental Program (UNEP) 2001 Stockholm Convention as persistent organic pollutants (POPs). These are the chemicals that we use in our gardens, that coat our electronics that are used because of their unique properties. Sometimes, the properties that make these chemicals so useful are also the reason they build up in the environment and are not broken down easily. They are of world-wide concern.

Per-fluorinated compounds are used in non-stick surfaces on cookware, waterproof clothing, fire fighting foams; personal care and cleaning products; and oil, stain, grease, and water repellent coatings on carpet, textiles, leather, and paper. Certain forms of per-fluorinated compounds should, based on their chemical properties, last long enough in the environment to make their way to Arctic and Antarctic regions. Once there, they could be altered into per-fluorinated...
carboxylic acids (PFCAs). PFCAs have been measured in large concentrations in polar bear tissue and polar fish populations. Tim Wallington, an atmospheric chemist with the Ford Motor company who collaborates with the University of Toronto, predicted in 2006 that these compounds could be transported to the poles and lead to Arctic air concentrations of up to one-fifth of polar air concentrations. This prediction had not been confirmed, so we set out to test it.

During July 3 to 27, 2005 we had an opportunity (thanks to the graciousness of Professor Annelie Skoog) to join the Swedish Polar Secretariat’s Beringia Expedition on Board Sweden’s largest Icebreaker, the Oden, along with Prof. Skoog’s (UConn, Marine Sciences) group. The transect began in Gothenburg Sweden and ended in Barrow, Alaska following the Northwest Passage through Peel Sound in Nunavuk Canada. This was an exciting opportunity to sample air and water over the North Atlantic, areas partially covered with ice along the passage, areas of complete ice coverage and areas where there were rivers flowing such as the Mackenzie River plume.

“This was a unique opportunity to collect air samples in a region where no previous date for these chemicals existed,” said Dr. Tom Haner, a research scientist with the Science & Technology Branch of Environment Canada and a collaborator on the study. “The findings confirmed Wallington’s predictions and showed that many classes of fluorinated chemicals are prevalent in the arctic atmosphere during the summer,” he said.

“Some of the chemicals we detected are precursors to PFOS and PFOA, the main contaminants detected in arctic marine mammals. These findings will help resolve the current debate regarding the relative importance of the oceanic versus atmospheric pathway for delivering these chemicals to the Arctic region.”

The experience was amazing and the views breathtaking! Our first polar bear sighting was a mother and her two cubs just west of Greenland. The work was often interrupted by calls to gather on the deck during polar bear or whale sightings. During the transect we came across some multi-year ice that slowed down the icebreaker (almost stuck) for a couple of days, while we waited for downloaded satellite images of ice coverage so that our meteorologist could determine our next move. Those of us who were novices were baptized when crossing the Arctic Circle in a surprise ritual and throughout we enjoyed the hospitality aboard this Swedish vessel.
where the air we sampled came from we put together a six day wind history with help from meteorologists at Environment Canada. These plots show where our sampled air came from so we can figure out where the POPs may have been carried from. The wintertime sampled air was mostly from within the Polar cell air at least over the six-day time averages.

Fluorotelomer alcohols (FTOHs) and perfluoralkyl sulfonamide ethanolos (PFASs) are used commercially in paints, coatings, polymers, adhesives, waxes, and electronics. They are believed to break down into per-fluorinated compounds that accumulate in animals, fish, and the environment. We found that the concentrations of these compounds are as high as one-third of concentrations in urban air samples (from Toronto) and offer the first evidence to support the Wallington model. These findings are summarized in a recent edition of Environmental Science & Technology.

Pesticides and herbicides were also measured by the sampler. More than 20 herbicides and pesticides including: Dacthal, Linadane, Malathion, Atazine, Alachlor and Hexachlorohexane were detected in Arctic air. These compounds are also known to build up in animal and fish tissue and persist in the environment. The results show relative agreement in other air concentrations reported and contribute to our understanding of the accumulation and persistence of these chemicals in remote environments.

A third component of this study was to investigate structural changes in dissolved organic carbon (DOC) along different water masses along the cruise transect. 6 L samples of water were filtered using 0.2 micron filters and then passed through a series of discs that would extract the organic material from the water. These samples were analyzed by Dr. Elizabeth Kujawinski an assistant professor at the Woods Hole Oceanographic Institute (WHOI) by using a very sensitive mass spectroscopy method (electro-spray ionization Fourier-transform ion cyclotron resonance mass spectrometry) to evaluate the changes in DOC structure in different Arctic water types (land, snow melt, open-ocean etc). These results are also new for this region and we are working away at synthesizing the data with hopes to find a change in the relative

Strange and memorable rituals sometimes take place aboard ocean-going vessels as they reach major milestones such as the poles or equator. Here the Oden’s Head of Crew and Cook are King and Queen Neptune, presiding over a traditional ceremony and determining what each rookie’s initiation will be as the ship crosses the Arctic Circle.
reactivity of DOC across these zones. By keeping the material intact while it is analyzed we are able to evaluate its carbon to nitrogen and carbon to oxygen ratios to infer how chemically different the DOC seems to be and how this changes for different water types. Understanding how the DOC changes structurally helps us understand how long this carbon can be preserved or recycled and could have important implications for DOC cycling and carbon transport.

Our team will have an opportunity to evaluate these parameters in the Southern Ocean in the Spring of 2008, working with Professor Jim Edson’s marine meterology research group (UConn Marine Sciences) and we look forward to making a comparison of these two extreme environments.

On a local scale, our group will be evaluating the concentrations and persistence of these and other target compounds including polybrominated diphenyl ethers (PBDEs) which have widespread use as flame retardants. PBDEs are sprayed on electronic equipment and even children’s flame resistant clothing, among other things. Tiffany St. George, a Masters student in our department, is working on the design of special samplers to measure PBDEs in the bottom waters and sediments of the Thames River Estuary as part of her graduate research. Her work will be a piece of the puzzle linking local and global scale contaminant transfer as we realize how connected our planet truly is.

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**About the Author**

Penny Vlahos, Assistant Professor of Marine Sciences at UConn, is a chemical oceanographer interested in the geochemistry of carbon and nitrogen, and persistent organic pollutants in the environment.