5-1-2014

Micro-plastic Pollution: A Comparative Survey of Wastewater Effluent in New York

Elizabeth Chaskey
SUNY Plattsburgh, chas6970@plattsburgh.edu

Taylor Hirsch
SUNY Plattsburgh

Todd Drake
SUNY Plattsburgh, tdrak001@plattsburgh.edu

Karyn Ehmann
SUNY Plattsburgh

Yvonne Chu
SUNY Plattsburgh

Micro-plastic Pollution: A Comparative Survey of Wastewater Effluent in New York

Student Researchers: Elizabeth Chaskey, Taylor Hirsch, Todd Drake, Yvonne Chu, and Karyn Ehmann
Faculty Mentors: Dr. Danielle Garneau (SUNY Plattsburgh) and Dr. Sherri Mason (SUNY Fredonia)

Center for Earth and Environmental Science & Dept. of Biology
SUNY Plattsburgh, Plattsburgh, NY 12901

Abstract

Micro-plastics are hypothesized to be discharged into the waterways through wastewater treatment plant (WWTP) effluent. Students from SUNY Fredonia, jointly with students from SUNY Plattsburgh, have conducted a survey of regional plastic pollution at WWTPs in Chautauqua County, NY (Dunkirk and Fredonia) and Clinton County, NY (Peru and Plattsburgh) to explore this hypothesis. Samples of wastewater treatment effluent were collected using sieve arrays and materials were analyzed in the lab for any suspect micro-plastics. The suspect micro-plastics were placed into sample containers for future analysis. Preliminary results of this survey suggest suspect particles were present and discharged at rates of 109,556, 81,911, and 1,061,953 particles per day from Plattsburgh, Fredonia, and Dunkirk, respectively. Continued monitoring and dissemination of micro-plastic results to sewer facilities, may result in mitigation to reduce the amount of plastic discharge. These micro-plastics have become ubiquitous freshwater and marine pollutants, that are negatively impacting survival and fitness of aquatic species. Technological improvements to older facilities are likely to reduce micro-plastic waste and harm to the ecosystem.

Impetus for Study

- A plastic pollution survey was conducted by SUNY Fredonia and the 5 Gyres Institute during an annual Great Lakes Environmental Sciences Summer Field Course in July 2012.
→ N = 21 open water samples were collected from 3 of the 5 Great Lakes (Lake Superior, Huron, and Erie)

- Micro-plastics have been recently identified as marine pollutants of significant concern (Ng and Obbard, 2006; Cole et al., 2011).
→ Potential to act as vectors for the transfer of persistent organic pollutants (POPs) to marine organisms (Ng and Obbard, 2006; Andrady, 2011).

Hypothesis

- It was hypothesized that not all of the micro-plastics resulted from photo-degraded plastics .

- Postulated sources of these micro-plastics may be traced to skincare products that contain micro-beads, used for exfoliation, and/or from clothing, in the form of polyester and acrylic fibers (Thompson et al., 2011).

- It is believed that beyond their intended use, these micro-plastics are washed down the drain and directly released into the waterways by surpassing the wastewater treatment process (Fig. A).

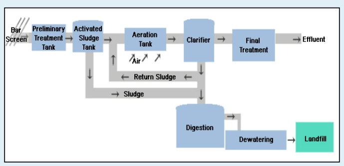

Fig. A. Multiple steps are taken to treat wastewater before it is discharged into natural waterways. Samples are to be taken of the final effluent after treatment.

Comparative Sites

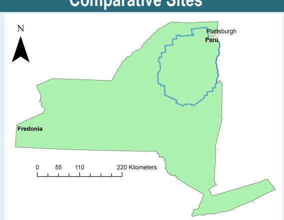

Fig. B1. Locations of wastewater treatment plants in the comparative study.

Local Sites

Plattsburgh:
Discharges to **Lake Champlain**
Max:16 MGD
Serves: 30,000 people
Built: 1973
Updated:1987

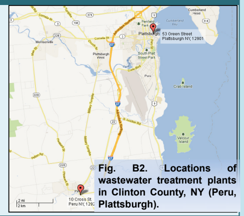

Fig. B2. Locations of wastewater treatment plants in Clinton County, NY (Peru, Plattsburgh).

Methods

WWTP- Sample Collection:

- A pump and hose were used to divert water from the open channel for sample collection and flow rate measurements.

- The hose was held in place over a stack of sieves with sizes of 1 mm (top), 355 um (middle), and 125 um (bottom) (Fig. C).

- 3 measurements of flow rate were taken using a 15 L bucket before and after each collection event (Fig. D).

Fig. C. Sieve set up at the Plattsburgh WWTP. Gives a view of the open channel at the end of the waste treatment process.

Fig. D. Yvonne Chu preparing to take 1 of 3 flow rates using a 15 L bucket.

Fig. E. Sieve samples put into two beakers (1 mm and 355 um combined). H_2O_2 and Fe^2 added and heated at 75°C. While stirring on hot plates.

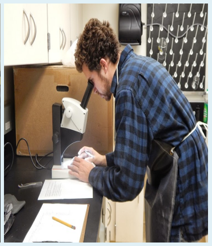

Fig. F. Todd Drake, finding micro-plastics by use of microscope, extracting them from the Petri dish and categorizing them based on their color and shape in a chart.

Laboratory analysis of samples:

- The samples collected in the 355 um, and 125 um sieves were stored in 50 mL test tubes (Fig. F).

- 20 ml H_2SO_4 and 20 ml of H_2O_2 were added to sieve samples.

- Acid digestion of samples occurred at 75°C on a heated stir plate.

- 20 ml of H_2O_2 were added as aliquots until all organic material was dissolved.

- The acid-peroxide digested samples were filtered through a 125 um sieve and washed with DI water.

- All samples were processed under a dissecting microscope for fine micro-plastic retrieval.

Results

- The goal of this survey was to develop a concise and repeatable way to measure real-time effluent wastewater samples and analyze them for potential microscopic plastic particulate.

- Each suspect plastic-like particle varied in size (all < than 1 mm in diameter) and color (from bright reds and blues to opaque).

- Plattsburgh WWTP→ abundant plastic-like particles.

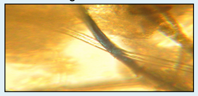

Fig. G. A blue tinted fiber that was found in a sample from Plattsburgh WWTP. This is 20x magnified under a compound microscope.

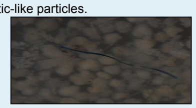

Fig. H. A blue tinted fiber that was found in a sample from Plattsburgh WWTP. This is 5x magnified under a dissecting microscope

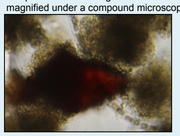

Fig. I. This red suspect particle was taken from a Plattsburgh WWTP sample. It is 5x magnified under the dissecting microscope and is surrounded by organic material also collected in the sample.

Fig. J. In order to show the average size of the suspect particles, a penny is used as reference scale.

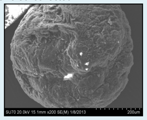

Fig. K. A 200 times magnified image of a suspect particle. Note of the spherical shape, but the intricate changes along the particle. UV-degradation can break down and soften suspect particles in the WWTP and in large waterbodies, such as the Great Lakes where 21 open-water samples were taken to analyze the system for plastic suspect particles.

Fig. L. Microplastics from post-treatment wastewater (courtesy of Dr. Sherri Mason- Fredonia).

Table 1. Site-specific daily particle rate (courtesy of Dr. Sherri Mason- Fredonia).

Location	Population Size	Facility Established	Average Particles/ Gal	Low Particles/ Gal	High Particles/ Gal	Std. Dev.	Flow Rate (mgpd)	Particles/ Day
Plattsburgh	19,750	1974, Updated 2012	0.0219	0.0043	0.0358	0.0110	5	109,556
Fredonia	11,047	--	0.0328	0.0058	0.1372	0.0365	2.5	81,911
Dunkirk	12,382	1926	0.1770	0.0321	0.4349	0.1446	6	1,061,953

Considerations for Future Methodological Modification

- Clogged sieves < 2 hrs following sample collection commenced (Fig. C)
- Duration of collection shifted short-term (2 hrs) to long-term (6 hrs) mid-semester.
- Some organics were not digested completely in the allotted time, despite the amount of H_2SO_4 applied.

Discussion

- The origin of micro-plastics in WWTP effluent was studied in a collaboration of SUNY Plattsburgh and SUNY Fredonia students.

- In recent years, organic exfoliating materials, such as apricot seeds, oatmeal, and pumice, have been replaced by easy to manufacture polyethylene micro-plastics (Fendall and Sewell, 2009).

- Suspect particles displaying bright colors were targeted.
  - A bright blue suspect fiber (Figs. G, H), as well as bright red suspect particles (Fig. I) were found in the effluent samples. While searching for suspect plastics, we noted particle softness and unevenness.
  - Each suspect particle (Fig. K) was not completely spherical due to erosion in the water system and UV-degradation. Coin used for reference (Fig. J).

- Macro- and micro- particles in any water system can be detrimental to the ecosystem. Polyethylene plastics will float on the water surface.
  - Since many organisms feed near the surface of the water and there is great potential for planktonic organisms to ingest micro-plastics; through ingestion, micro-plastics have the potential to bioaccumulate in higher trophic levels (Andrady, 2011).

- Dunkirk, simililarly populated as Fredonia, had 7.7% more particle yield per day→ likely the result of older infrastructure (Mason, 2014).

- Plattsburgh's population was 58% larger than the other 2 towns and produced 10% fewer particles per day than Dunkirk (Mason, 2014).

DMUR Collaborative Research Experience

Distance Mentoring for Undergraduate Research (DMUR) is an opportunity for undergraduate students to utilize new technology and collaborate between schools on unique projects. Dr. Sherri Mason began micro-plastic research in the Great Lakes and transferred what she learned to Academia by working with students. Through Skype and email, all of those involved were able to relay information between universities, SUNY Plattsburgh and SUNY Fredonia. Without the collaboration that DMUR brought to SUNY Plattsburgh, a project of this type and scope (Plattsburgh and Fredonia) would not have taken place. Students on our campus now have the opportunity to investigate research questions beyond the scope of Plattsburgh faculty.

Conservation Implications and Suggestions

The presence of plastic micro-particles in every day consumer products, such as facial cleansers, is cause for concern. Our research suggests that plastics in consumer products are not completely captured in the wastewater treatment process and are passing directly into our regional waterbodies. The effects on the aquatic ecosystem are still being studied, but numerous researchers have shown bioaccumulation of plastic in aquatic organisms. In order to prevent future degradation to aquatic ecosystems, consumers should limit their use of products containing plastic and manufacturers should utilize materials that will naturally decompose. Additionally, facilities should be upgraded to meet higher standards.

Acknowledgements

We would like to acknowledge the SUNY IITG (DMUR) grant and CEES for funding our research. Additional thanks to the many faculty members and students that have helped us throughout the process: Dr. Sherri Mason (SUNY Fredonia) for conducting this research project, Dr. Danielle Garneau for lending a helping hand as our on campus mentor, Dr. Robert Fuller for demonstrating safe practices in the inaugural run of the acid-peroxide digestion, as well as providing laboratory supplies and allowing us to use the Water Quality Laboratory, Dr. Tim Mihuc and the LCRI team for showing us microscopy techniques, and our student colleague Parker Fink (SUNY Fredonia) for his knowledge on sampling methodology. In addition, we would like to say thank you to the hardworking employees at the Plattsburgh and Peru wastewater treatment plants who were eager to assist us with our project.

Literature Cited

Andrady, A. 2011. Microplastics in the marine environment. Marine Pollution Bulletin 62(8): 1596-1605.

Department of Environmental Conservation. Descriptive Data of Municipal Wastewater Treatment Plants in New York State. Division of Water *Bureau of Water Compliance*. Jan 2004. Web accessed May 14,2013. http://www.dec.ny.gov/docs/water_pdf/descdata2004.pdf

Eriksson C. and Burton H. 2003. Origins and biological accumulation of small plastic particles in fur seals from Macquarie Island. *Ambio* 32: 380-384.

Fendall, L.S and Sewell, M.A. 2011. Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Science Direct: Marine Pollution Bulletin* 58: 1225-1228.

Johnston, P., Allsopp, M, Walters, A. 2005. Plastic Debris in the World's Oceans. *Greenpeace*. http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf

Thompson, R., Browne, M.A., Crump, P., Niven, S.J., Teuten, E.,Tonkin, A., Galloway, T. 2011. Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks. *Environmental Science and Technology* 45: 9175-9179.