Discharging Microbeads to Our Waters:

An Examination of Wastewater Treatment Plants in New York

NEW YORK STATE OFFICE *of the* ATTORNEY GENERAL

April 2015

Acknowledgements

The Office of Attorney General Eric T. Schneiderman performed this study through its Environmental Protection Bureau. The study was led by Environmental Scientist Jennifer Nalbone. The Office of the Attorney General extends its appreciation to all participants who made this study possible.

The Environmental Protection Bureau of the New York State Attorney General's Office works to protect New York's environment and public health by vigorously enforcing both the State's and Nation's environmental laws. If you are aware of any activities or conditions which may violate environmental laws or significantly harm the environment, please call the New York State Office of the Attorney General's Environmental Protection Bureau at (518) 776-2400.

Executive Summary

In late 2014, the Office of the Attorney General ("OAG") initiated a study to determine whether plastic microbeads, small plastic abrasives commonly found in personal care products, are being discharged from sewage and wastewater treatment facilities ("treatment plants") into waters across the state.

Study Overview

34

Facilities Submitted Samples

25

Facilities Discharging Microbeads

With assistance from the State University of New York at Fredonia, the New York Water Environment Association, and operators at 34 municipal and private treatment plants located across the state, the OAG study confirms that microbeads are passing through treatment plants and entering New York waters.

The OAG detected microbeads in the effluent samples from 25 of the 34 treatment plants participating in this study, suggesting that microbeads are being discharged at the majority of treatment plants operating across New York State. As such, the study provides evidence that microbeads are released into numerous waterbodies across the state including the Great Lakes, the Finger Lakes, Lake Champlain, Hudson River, Mohawk River, Delaware River, Long Island Sound and the Atlantic Ocean.

An estimated six percent of plastic microbeads used in personal care products are easily-identifiable spherical or speckled microbeads, while the overwhelming majority are irregular microbeads. As this study used only spherical and speckled microbeads to verify microbeads in effluents, the results suggest that irregular microbeads are also passing through treatment plants. For this reason, the true contribution of microplastic pollution from personal care products to surface waters is likely under-represented by the abundance of spherical microbeads alone.

Treatment plants are not designed to remove microbeads from the wastewater stream, and treatments potentially effective at removing microbeads are unproven. Even if effective treatment technologies are found to be available, the potential cost and time necessary to retrofit wastewater treatment plants with such technology is likely to be substantial. Prevention of use in personal care products is a more efficient approach to address the emerging problem of microbead pollution in New York's waters.

What are Microbeads?

Microbeads are microplastic particles, usually less than one millimeter ("mm") in diameter, produced for use as abrasives in personal care products such as toothpaste and face and body scrubs. While the term "microbead" may conjure an image of a tiny, colorful, perfectly spherical plastic bead, the personal care product industry uses the term to describe any plastic particle, regardless of size, shape or color, added to personal care products for use as an abrasive. Microbeads vary in size, with a median ranging from 0.2 to 0.4 mm in scrubs,[1] while those found in toothpaste are about 100 times smaller, around 2 to 5 micrometers in size.[2]

Most of the microbeads used in personal care products are fragments, not easily identifiable spheres or speckled pieces. In fact, spherical or speckled microbeads averaged less than six percent of the microbeads found in 16 different personal care products examined, according to data from the State University of New York at Fredonia ("SUNY Fredonia").[3] Using data from these 16 products as an industry proxy, this means, of the 19 tons of microbeads washed down New York drains annually, about 1.1 tons (6%) are the easily identified spherical or speckled microbeads. The remaining microbeads in personal care products are the irregular microbeads (see Figure 1) resembling "angular quartz grains"[4] that are difficult to distinguish from microplastic pieces originating from the breakdown of larger plastic products. To date, the attribution of microplastic pollution to personal care products is based upon finding "multi-colored spheres" less than 1 mm in diameter in environmental samples.[5] The abundance, distribution, and fate of irregular microbeads in the environment has not yet been examined.

Figure 1: Types of Microbeads

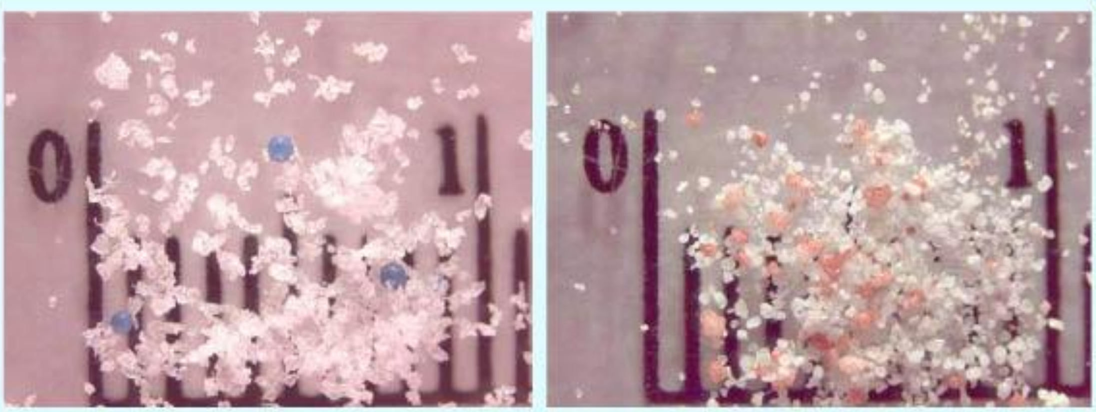

Photo Credit: OAG *Scale: 10 millimeters*

These photographs highlight two different facial scrubs with the three distinct types of microbeads commonly found in personal care products:
- *Irregular* – the irregular, opaque microbeads shown in both photos.
- *Spherical* – the larger, blue and round microbeads, as shown in the photo on the left.
- *Speckled* – the larger, pink and uniformly speckled microbeads, as shown in the photo on the right.

When personal care products containing microbeads are used by the consumer, microbeads are washed down bathroom drains into the sewage collection system on route to treatment plants. From there, the widely held assumption is that many pass through the treatment plants and discharge with the post-processing effluent into a receiving surface water.[6] These facilities are designed to capture and treat sewage, not microbeads. The OAG's 2014 report on microbeads – *Unseen Threat: How Microbeads Harm New York Waters, Wildlife, Health And Environment* – reviewed 610 New York State wastewater treatment plants and found only one-third employ advanced treatment technologies - tertiary screens and filters - that may be effective at removing microbeads, suggesting some microbeads were passing through most of the facilities across the state.[7,8]

When microbeads enter bodies of water, they can persist for decades, accumulating toxic chemical pollutants on their surface, and transporting pollutants as they float with currents. When mistaken for food by small aquatic organisms, microbeads may serve as a pathway for pollutants to enter the food chain and contaminate the fish and wildlife, including fish and wildlife we eat.[9] High counts of spherical microbeads were initially found in the New York open waters of Lake Erie[10] and Lake Ontario[11] in 2012 and 2013. They have subsequently been found in the open waters of Cayuga Lake, Oneida Lake, Erie Canal, and Mohawk River[12] and St. Lawrence River sediments.[13]

Wastewater Treatment Plant Effluent Sampling and Analysis Methods

In September 2014, the New York Water Environment Association[14] notified member treatment plant operators of the OAG study and asked them to participate. Operators from treatment plants supplied post-processing effluent samples for this study between October 2014 and January 2015. The range of volumes of wastewater treated and the types of advanced treatment unitized by treatment plants that participated in the study are similar to the range of facilities found across New York State as outlined in the 2014 OAG report. Ten of the facilities (29 percent of participants) use an advanced filter that may be effective at removing microbeads. The volume of wastewater treated at the facilities ranged, on average, from 30 thousand to 92 million gallons per day.

Photograph 1
Treatment plant effluent samples undergoing wet peroxide oxidation.
Photo credit: OAG

Dr. Sherri Mason, Professor of Chemistry at SUNY Fredonia, developed a sampling protocol based on a National Oceanic and Atmospheric Administration ("NOAA") sampling protocol entitled "Laboratory Methods for the Analysis of Microplastics in Wastewater Treatment Plant Effluent." In addition to the sampling protocol, participating treatment plant operators were also provided an eight-inch diameter, 0.355 mm Tyler sieve and three sample bottles. Participating operators collected between one and three post-processing effluent samples from a sampling port, or from an effluent pipe, well or flume using pump and tube equipment. Post-processing effluent is treated wastewater obtained after all processing has occurred, but just prior to being released into the receiving water body. Participating operators collected the samples through a sieve at a recommended flow rate of approximately 10 to 20 liters per minute, with the sieves left in place between 2 to 24 hours. For each sample, all contents collected on the sieve were transferred into one clean sample container.

Photograph 2
A small portion of treatment plant post-treatment effluent is sieved at the facility and sent to SUNY Fredonia for analysis.
Photo credit: OAG

The treatment plants mailed their samples to SUNY Fredonia for analysis. Under the oversight of Dr. Mason, the samples were processed and analyzed using an established laboratory methodology based on microplastic surveys conducted in the oceans and the Great Lakes.[15,16,17,18]

Photograph 3
SUNY Fredonia student technician looks for microbeads in a processed sample under a dissecting microscope.
Photo credit: Dr. Sherri Mason, SUNY Fredonia

Excess water and organic material in the sample was removed using wet peroxide oxidization. Microplastic pieces remaining in the sample were then removed physically with the help of a dissecting microscope. To confirm the passage of microbeads through treatment plants, this study only used spherical and speckled microbeads detected in effluent samples, rather than trying to also include irregularly shaped microbeads to avoid possible confusion with irregularly shaped fragments from other sources. Identification of spherical and speckled microbeads was performed by comparing size, texture and shape of microbeads removed from the effluent samples to microbeads obtained directly from various personal care products. Spherical and speckled microbeads collected from effluent samples were also verified as being of the same chemical composition (polyethylene) as those obtained directly from personal care products using a Bruker Alpha FT-IR spectrometer.

Study Results

The New York Wastewater Treatment Plant Microbead Study detected microbeads in samples of post-processing effluent from wastewater treatment plants located across New York State. Spherical and speckled microbeads, as shown in Figure 2 below, were detected in 25 of 34 (74%) of the sampled treatment plants. A map and full list of the studied treatment plants are found in Figure 3 and Table 3.

While collection and analysis of irregular microbeads was not a goal of this study, microplastics closely resembling irregular microbeads were detected in effluent samples.

***Figure 2*: Microbeads from Treatment Plants**

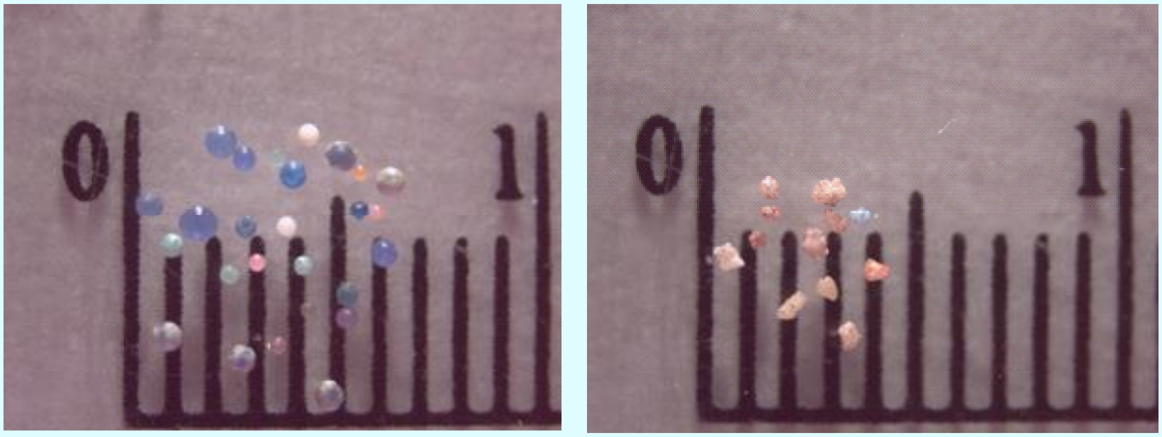

Photo Credit: OAG

Spherical (left) and speckled (right) microbeads were collected from the effluent samples of participating treatment plants and verified as the same size, shape and chemical composition as spherical and speckled microbeads removed from personal care products.

The study did not verify microbeads in the effluent at nine of the 34 facilities sampled. Of these nine facilities, six employ a form of advanced filtration that may increase efficacy of microbead removal from the wastewater stream. These include treatment units classified as membrane microfiltration, continuous backwash upflow dual sand (CBUDS) microfiltration, and rapid sand filters. The nine facilities were predominantly smaller in size, with the largest self-reporting an average annual flow rate of 16 million gallons per day. Of the 25 facilities where microbead release was verified, four did employ an advanced treatment unit that may increase efficacy of microbead removal, such as a rapid sand filter, continuous backwash sand filter, or unspecified type of tertiary filtration. See Table 1 below for an overview of treatment plant results and Table 2 for a list of results from facilities using advanced filters.

Table 1:
Treatment Plant Results by Size, Microbead Detection and Advanced Treatment Use.

Treatment Plant Design Size (Gallons/day)	Number of Treatment Plants in NYS[8]	Plants Participating in OAG Study	Plants with Microbeads Detected in Effluent	Advanced Filter in Use	Microbeads Detected in Effluent with Advanced Filter in Use
0 - 100,000	178	4	1	2	0
101,000 - 1,000,000	251	9	5	4	1
1,001,000 - 10,000,000	132	13	11	2	1
10,001,000 - 100,000,000	39	7	7	2	2
100,001,000 - 999,000,000	10	1	1	0	0
TOTAL	610	34	25	10	4

Table 2:
Filter treatment units as reported by participants of this study, as listed by categories defined by the NYS DEC report, *Descriptive Date of Municipal Wastewater Treatment Plants.*

Treatment Unit	Plants Sampled in OAG Study and Microbeads Detected	Plants Sampled in OAG Study and Microbeads not Detected
Filtration, unspecified	2	-
Microfiltration (CBUDS)	-	3
Microfiltration (Membrane)	-	2
Rapid Sand (High Rate) Filters	1	1
Continuous Backwash Sand Filter	1	-

Figure 3: Sampled Locations where Microbeads were Detected

Microbeads were detected in the effluent samples provided by treatment plants denoted by the green dots. Out of 34 participating facilities, a total of 25 had microbeads present in the samples submitted. The gray dots on the map are locations of over 600 untested treatment plants across the state.

The detection of microbeads in effluent samples from 25 treatment plants confirms that microbeads are being released into numerous waterbodies across the state, including into the Great Lakes, Finger Lakes, Lake Champlain, Hudson River, Mohawk River, Delaware River, Long Island Sound and the Atlantic Ocean. Refer to Table 3 for a complete list of results by facility, county and receiving waterbody.

Conclusion

The OAG study detected microbeads in small samples of post-processing effluent from wastewater treatment plants located across New York State. Microbeads were detected in samples submitted by 25 of the 34 participating treatment plants (74 percent), and suggests that microbeads from personal care products are passing through the majority of the additional 600+ untested wastewater treatment plants operating across New York State.

Microbead release was confirmed only if spherical or speckled microbeads were detected in treatment plant effluent. These easily identifiable microbeads make up only six percent of the microplastic particles used in personal care products. The discovery of spherical and speckled microbeads in effluent samples strongly suggests irregular microbeads from personal care products are also passing through treatment plants, and these products' total contribution of microplastic pollution to the environment is likely under represented by the abundance of spherical microbeads collected in open-water surveys.

The absence of spherical or speckled microbeads in the one-time samples from nine treatment plants is not conclusive evidence that all microbeads are captured at those facilities during wastewater processing. Factors such as possible temporal fluctuation in microbead concentrations in effluent, the potential for some specific primary or secondary treatments to capture microbeads, or samples taken at the bottom of effluent pools where microbeads may be floating at the surface, could contribute to the reasons why microbeads were not found. Our results also indicate the absence of microbeads in discharges from some facilities may be explained by the use of an advanced filter more commonly used by facilities treating relatively small volumes of water. This finding, however, is based on limited sampling and a small dataset and should be considered preliminary.

Treatment plants are not designed to remove microbeads from the wastewater stream, and treatments potentially effective at removing microbeads are unproven. Even if effective treatment technologies are found to be available, the potential cost and time necessary to retrofit wastewater treatment plants with such technology is likely to be substantial. Prevention of use in personal care products is a more efficient approach to address the emerging problem of microbead pollution in New York's waters.

Table 3: Results of Sampling from Wastewater Treatment Plants

Microbeads were detected in the samples submitted by facilities with a √ below.

Microbeads	Treatment Plant Facility	County	Receiving Waterbody
√	Albany County Sewer District	Albany	Hudson River
√	Mohawk View Water Pollution Control Plant	Albany	Mohawk River
	Village of Endicott Water Pollution Control Plant	Broome	Susquehanna River
√	Village of Silver Creek Treatment Plant	Chautauqua	Lake Erie
√	City of Hudson Wastewater Treatment Plant	Columbia	Hudson River
√	Village of Delhi Wastewater Treatment Plant	Delaware	West Branch of the Delaware River
	Town of Andes Sewer District	Delaware	Tremper Kill
	Village of Walton Sewage Treatment Plant	Delaware	West Branch of the Delaware River
√	Erie County Sewer District No. 3 – Southtowns Advanced Wastewater Treatment Plant	Erie	Lake Erie
√	Town of Grand Island Wastewater Treatment Plant	Erie	Niagara River
√	Erie County Sewer District No. 6 – Lackawanna Wastewater Treatment Plant	Erie	Smokes Creek, tributary to Lake Erie
√	Erie County Sewer District No. 2 – Big Sister Creek Wastewater Treatment Plant	Erie	Big Sister Creek, tributary to Lake Erie
√	Village of Lake Placid Sewage Treatment Plant	Essex	Chubb River, tributary to the Ausable River
√	Town of Westport Wastewater Treatment Plant	Essex	Lake Champlain
	Village of Chateaugay Wastewater Treatment Plant	Franklin	Chateaugay River
	Village of Hunter Wastewater Treatment Plant	Greene	Schoharie Creek
	Town of Windham Wastewater Treatment Plant	Greene	Batavia Kill
√	Village of Athens Wastewater Treatment Plant	Greene	Hudson River
√	Newtown Creek Water Pollution Control Plant	Kings	East River
√	Frank E. VanLare Wastewater Treatment Plant	Monroe	Lake Ontario
√	Northwest Quadrant Wastewater Treatment Plant	Monroe	Lake Ontario
√	Cedar Creek Water Pollution Control Plant	Nassau	Atlantic Ocean
√	Niagara County Sewer District No. 1	Niagara	East Branch of the Niagara River
√	City of Middletown Wastewater Treatment Plant	Orange	Wallkill River
√	Port Jervis Sewage Treatment Plant	Orange	Neversink River
	Villa Roma Resort & Conference Center	Sullivan	Jones Brook
√	Village of Potsdam Water Pollution Control Plant	St. Lawrence	Raquette River
√	Ithaca Area Wastewater Treatment Facility	Tompkins	Cayuga Lake
	Lake Mohonk Mountain House	Ulster	Tributary to Coxing Kill
	Pine Hill Wastewater Treatment Plant	Ulster	Birch Creek
√	City of Glens Falls Wastewater Treatment Plant	Warren	Hudson River
√	Village of Palmyra Wastewater Treatment Plant	Wayne	Erie Canal
√	Westchester County DEF- Yonkers Joint	Westchester	Hudson River
√	Westchester County DEF- Port Chester Wastewater Treatment Plant	Westchester	Long Island Sound

References

[1] Fendall, L.S. and M.A. Sewell (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. Marine Pollution Bulletin, 58(8): 1225-1228.
[2] Verschoor, A., Herremans, J.,Peijnenburg, W., and Peters, R. (2015). Size and amount of microplastics in toothpastes. National Institute for Public health and the Environment. Ministry of Health, Welfare and Sport, The Netherlands.
[3] Mason, S., unpublished data. (State University of New York at Fredonia), Personal communication, February 20, 2015.
[4] Smith, J.A., Ervolina, E. and Barry, B.T. (2015). "Investigating the Fate of Microplastic Particles in the Mohawk and Hudson Watersheds, New York State" Geological Society of America, 50th Annual Meeting (23–25 March 2015). Retrieved 3/26/2015 from: https://gsa.confex.com/gsa/2015NE/webprogram/Paper252541.html.
[5] Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. Marine Pollution Bulletin, 77,177-182.
[6] Microbeads were found in the effluent of wastewater treatment plants recently sampled by Mason, S., unpublished data. (State University of New York at Fredonia), Personal communication January 13, 2014.
[7] New York State Office of the Attorney General (2014). "Unseen Threat: How Microbeads Harm New York Waters, Wildlife, Health and Environment". Retrieved from: http://ag.ny.gov/pdfs/Microbeads_Report_5_14_14.pdf.
[8] New York State Department of Environmental Conservation. (2004). Descriptive Data of Municipal Wastewater Treatment Plants in New York State. Retrieved from http://www.dec.ny.gov/docs/water_pdf/descdata2004.pdf.
[9] New York State Office of the Attorney General (2014). "Unseen Threat: How Microbeads Harm New York Waters, Wildlife, Health and Environment." Retrieved from: http://ag.ny.gov/pdfs/Microbeads_Report_5_14_14.pdf.
[10] Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. Marine Pollution Bulletin, 77, 177-182.
[11] Mason, S., unpublished data. (State University of New York at Fredonia). Personal communication. February 8, 2014.
[12] Simon Wheeler, "We are probably drinking plastic," Ithaca Journal. Published January 13, 2015. Retrieved from: http://www.ithacajournal.com/story/news/public-safety/2015/01/13/microplastics-found-cayuga-lake/21695735/
[13] Castañeda, R.A., Avlijas, S., Simard, M.A., and Ricciardi, A. (2014) "Microplastic pollution in St. Lawrence River Sediments," Canadian Journal of Fisheries and Aquatic Sciences, 71(12): 1767-1771.
[14] NYWEA is a non-profit, educational organization promoting sustainable clean water management whose members include WWTP managers, operators, engineers, scientists, and academicians. A 2014 NYWEA letter in support of the Microbead-Free Waters Act can be found here: http://nywea.org/gac/MicrobeadComments0614.pdf.
[15]Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., Hafner, J., Zellers, A., & Rifman, S. (2013). Plastic pollution in the South Pacific subtropical gyre. Marine Pollution Bulletin, 68, 71-76.
[16] Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. Marine Pollution Bulletin, 77,177-182.
[17] Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., & Reddy, C.M. (2010). Plastic accumulation in the North Atlantic subtropical gyre.Science, 329, 1185-1188.
[18] Moore, C.J., Moore, S.L., Leecaster, M.K., & Weisberg, S.B. (2001). A comparison of plastic and plankton in the North Pacific central gyre, Marine Pollution Bulletin, 42,1297-1300.