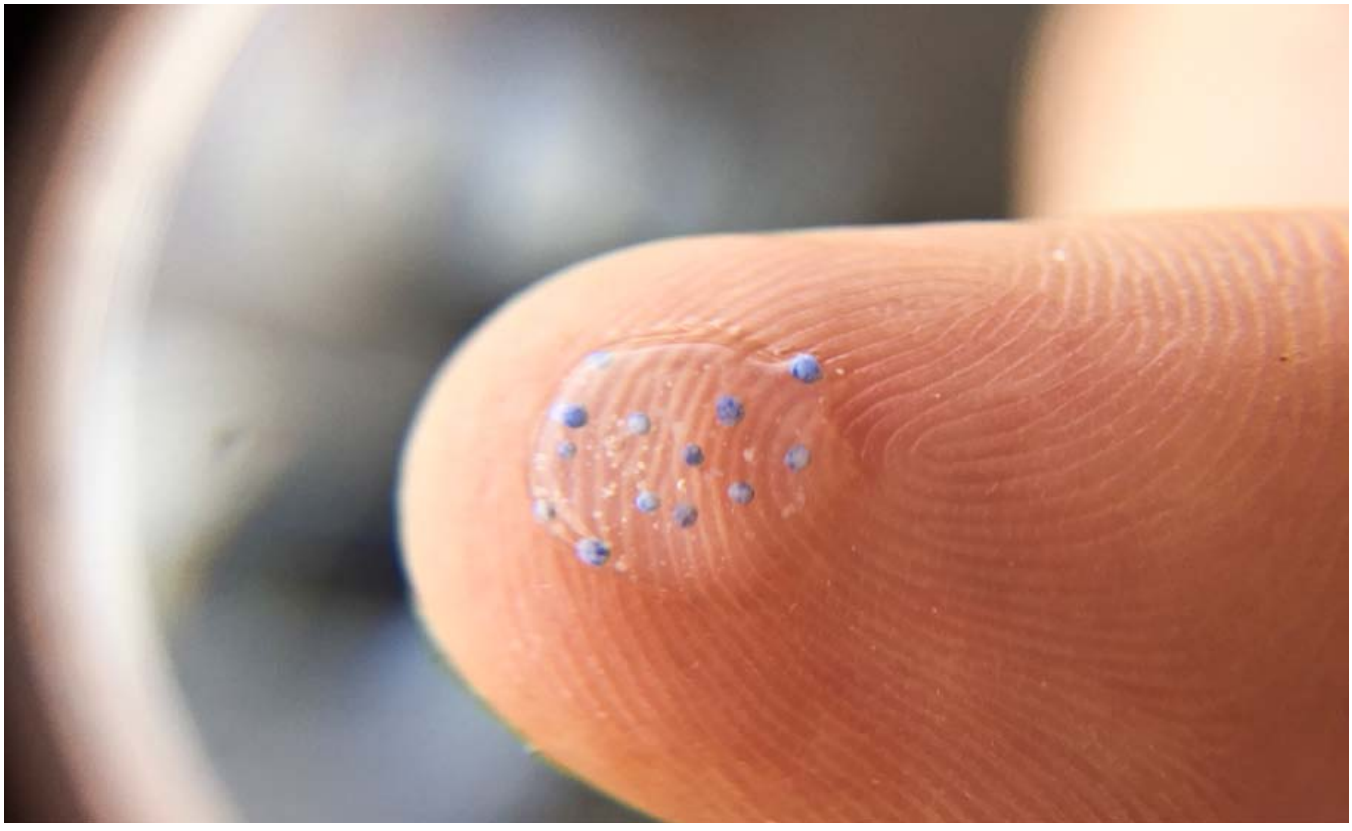
Plastic microbeads in Minnesota

Potential impacts of plastic microbeads, used in many consumer products, on environmental and human health



Minnesota Pollution Control Agency

December 2014

Legislative charge

The agency shall compile information on the presence of plastic microbeads in the state's waters and their potential impacts on aquatic ecosystems and human health, in consultation with the University of Minnesota. No later than December 15, 2014, the commissioner must present the information to the legislative committees with jurisdiction over environment and natural resources policy and finance and make recommendations.

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Minnesota Pollution Control Agency

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Introduction

Microbeads are small plastic pellets used in personal care products such as hand soap, exfoliating scrubs and toothpaste. When these products are used by consumers and are washed down the drains of sinks and showers, the microbeads end up in wastewater treatment systems. Depending on the type of wastewater treatment, some of the microbeads will be captured in the biosolids, or sewage sludge, but some will make it into the effluent and be discharged to Minnesota surface waters. Microbeads may also end up in the soil or groundwater from subsurface (septic) wastewater treatment systems. Since Minnesota wastewater treatment plant biosolids are typically land applied, it is possible that some of the microbeads reach surface waters via runoff from land-application areas as well.

Researchers have found a variety of microplastics, including microbeads, in surface waters in the United States. Although the MPCA has not identified any studies on microbeads in Minnesota waters other than Lake Superior, it is reasonable to assume that the use of microbead-containing products in Minnesota and wastewater treatment within the state is comparable to other states and will result in the same release of microbeads to Minnesota lands and waters. In May 2014, the Minnesota Legislature directed the MPCA to "compile information on the presence of plastic microbeads in the state's waters and their potential impacts on aquatic ecosystems and human health." This report fulfills this legislative requirement.

Definition of microbead

According to the *2008 International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris*[1], microplastics are plastics less than 5 mm in their longest dimension. Since the common mesh size for the nets used to collect surface water samples is 0.355 mm, that becomes the lower size limit of detection in surface waters. While many microbeads used in personal care products are spherical, some microplastics are more granular.

The composition of microbeads can vary and often includes polyethylene (PE) or polypropylene (PP), but may also be polyethylene terephthalate (PET), polymethyl methacrylate (PMMA) or nylon. Some microbeads found in the environment are "pre-production", meaning they spilled during transportation or manufacturing and made their way into surface water without first having been incorporated into a product. Microbead plastic powders are used to make many different plastic products, as well as printing and coatings. Other microbeads are used in various kinds of polishes and cleaning products, including personal care products.

For the purposes of this report, unless the source cited in the report is referring to microplastics in general, we are assuming that microbeads are plastic particles between 0.355 mm to 5 mm in size and that the source of these microbeads is personal care products.

[1] Arthur et al. (eds.). 2009. Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. National Oceanic and Atmospheric Administration Technical Memorandum. NOS-OR&R-30.

Potential impacts on aquatic ecosystems and human health

At the *2008 International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris*[2], participants agreed that microplastics may pose problems in the marine environment based on the following:

1. the documented occurrence of microplastics in the marine environment,
2. the long residence times of these particles (and, therefore, their likely buildup in marine environments overtime), and
3. demonstrated ingestion by marine organisms

The same issues exist in freshwater systems. Since the 2008 international workshop, a number of papers have been published on microplastics in freshwater, especially the North American Great Lakes. The State University of New York - Fredonia is working with partners on testing for microplastics in wastewater treatment facilities, food web assessment, sampling for presence in streams in collaboration with the U.S. Geological Survey and analyzing sediment.[3] The University of Michigan has also embarked on a multidisciplinary project to assess the impact of microplastics on the Great Lakes ecosystem health.[4] A University of Wisconsin-Superior researcher is also examining persistent organic chemicals adsorbed to microplastics and microbeads in Great Lakes fish.[5]

Surface waters

In the Great Lakes, researchers have conducted several studies counting the number of microplastic particles on the surface of the Great Lakes. According to Eriksen et al. (2013)[6], the average abundance for samples from Lakes Superior, Huron and Erie was approximately 43,000 microplastic particles per square kilometer, although four of the five Lake Superior samples were less than 10,000 and the fifth was 12,645 particles per square kilometer. Over half the particles from all three lakes that were between 0.355–1 mm were pellets. For particles between 1 and 5 mm, pellets (i.e., microbeads) were less than 5%. (Most of those larger plastic particles were fragments.) Additional sampling has been done or is planned in surface waters of the Great Lakes and their tributaries, but results are not published yet.

[2] Arthur et al. (eds.). 2009. Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. National Oceanic and Atmospheric Administration Technical Memorandum. NOS-OR&R-30.
[3] Mason, Sherri. 2014. State University of New York - Fredonia Department of Chemistry: Environmental Sciences Program Coordinator. Faculty directory.
[4] University of Michigan: Graham Sustainability Institute – Water Center. Microplastics in the Great Lakes: Towards Establishing a Longterm Multidisciplinary Research Platform to Assess the Impact of Microplastics on Laurentian Great Lakes Ecosystem Health.
[5] Rios-Mendoza, Lorena. 2014. University of Wisconsin – Superior Chemistry Department. Faculty directory.
[6] Eriksen, M., Mason, S., Wilson, S. Box, C., Zellers, A., Edwards, W., Farley, H., and S. Amato. 2013. Microplastic pollution in the surface waters of the Laurentian Great Lakes. Mar Pollut Bull. 2013 Dec 15;77(1-2):177-82.

Sediment

Microplastics are also found in sediments. Some plastics are denser than water and the particles sink. In other cases, the plastic particle is colonized by a bacteria that eventually weighs it down. Still other floating microplastics are "beached" when pushed up on the shoreline by wave action. In a study done on the St. Lawrence River, grab samples of surficial sediments were examined for microbeads between 0.40–2.16mm (Castañeda et al. 2014)[7]. The median abundance was 52 microbeads per square meter. The authors noted that they may have underestimated the densities because they did not count microbeads that were smaller than 0.5 mm.

Aquatic organisms

Few studies have yet been published on the occurrence of microplastics in freshwater organisms, but research is underway. Sanchez et al. 2014 found 12% of a small freshwater fish species from France had microplastic in their gut.[8] Similarly, microbeads were observed but not quantified in the guts of round gobies from the St. Lawrence River[9]. Dr. Lorena Rios-Mendoza from the University of Wisconsin – Superior examined 110 fish stomachs from Lake Superior fish, finding plastic filaments in 18% of the samples.[10]

Studies of the impact of ingested microplastics have been done on some marine invertebrates. Lugworms exposed to a mixture of sand and 5% microplastic were >30% more susceptible to damage from harmful chemicals called oxygen free radicals.[11] Another study of marine worms exposed to levels of PVC microplastic at levels that overlapped levels found in nature had significantly depleted energy reserves[12]. The researchers suggested that the results were from a combination of reduced feeding activity, longer gut residence times of ingested material and inflammation. (Note that PVC is not used to make microbeads in personal care products. However, the researchers suggested the impairments they observed are a result of the physical presence of the microplastic rather than their chemistry.)

Wastewater treatment plants

Several researchers have either tested wastewater effluent or sampled for microplastics above and below outfalls. A published study of water upstream and downstream from a wastewater treatment plant in Chicago found that plastic pellets between 0.333 – 2 mm increased from zero upstream to 0.45 pellets per cubic meter downstream[13]. However, pellets were not nearly as abundant as plastic

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[7] Castañeda, R., Avlijas, S., Simard, M.A. and A. Ricciardi. 2014. Microplastic pollution in St. Lawrence River sediments. Can. J. Fish. Aquat. Sci. 71: 1–5.

[8] Sanchez, W., Bender, C., and Porcher, J.-M. 2014. Wild gudgeons (Gobio gobio) from French rivers are contaminated by microplastics: Preliminary study and first evidence. Environ. Res. 128: 98–100.

[9] Castañeda, R., Avlijas, S., Simard, M.A. and A. Ricciardi. 2014. Microplastic pollution in St. Lawrence River sediments. Can. J. Fish. Aquat. Sci. 71: 1–5.

[10] Habermann, R. 2013. Readers Want to Know: Should we worry about microplastics in Lake Superior? Minnesota Sea Grant. Seiche newsletter. September 2013.

[11] Browne, M., Niven, S., Galloway, T., Rowland, S., and R. Thompson. 2013. Microplastic Moves Pollutants and Additives to Worms, Reducing Functions Linked to Health and Biodiversity. Current Biology. Volume 23, Issue 23, 2 December 2013, Pages 2388–2392.

[12] Wright, S., Rowe, D., Thompson, R., and T. Galloway. Microplastic ingestion decreases energy reserves in marine worms. Current Biology. Volume 23, Issue 23, 2 December 2013, Pages R1031–R1033.

[13] McCormick, A., Hoellein, T., Mason, S., Schluep, J. and J. Kelly. 2014 (prepublication). Microplastic is an Abundant and Distinct Microbial Habitat in an Urban River. Environmental Science and Technology. 9 pages.

fragments (6.65 particles per cubic meter) or fibers (10.57 particles per cubic meter). Preliminary findings from wastewater effluents from New York plants shows a similar pattern of most particles being fibers or fragments.[14]

Human health

One concern about the potential impact of microplastics to human health is the way that microplastics could introduce toxic chemicals into the food chain. A number of chemicals such as PCBs, DDT, dioxin and PAHs can be absorbed by plastic.[15] Microplastics contaminated by toxic chemicals could be ingested by aquatic organisms. If the chemicals are "desorbed" as the microplastic sits in the gut, then the organism will bioaccumulate them and pass them up the food web, into fish and eventually into humans. This may not be a significant route of exposure, however, since modeling suggests that the importance of microplastic as a vector of persistent bioaccumlative toxic (PBT) substances to aquatic organisms is likely of limited importance, relative to other exposure pathways.[16] Browne et al. 2014[10] found that although microplastic transferred contaminants into gut tissues of lugworms, sand transferred larger concentrations. Note: a study on plastic fibers in air is being conducted on the University of Wisconsin - Superior campus.[17]

[14] Mason, S. 2014. Unpublished. University of New York – Fredonia. Personal communication with Glenn Skuta.

[15] Rios LM, Jones PR, Moore C, Narayan UV. 2010. Quantitation of persistent organic pollutants adsorbed on plastic debris from the Northern Pacific Gyre's "eastern garbage patch. J Environ Monit. 2010 Dec;12(12):2226-36.

[16] Gouin, T., Roche, N., Lohmann, R. and Hodges, G. 2011. A Thermodynamic Approach for Assessing the Environmental Exposure of Chemicals Absorbed to Microplastic. Environ. Sci. Technol., 2011, 45 (4), pp 1466–1472

[17] Rios-Mendoza, L. 2014. Unpublished. University of Wisconsin – Superior. Personal communication with Carri Lohse-Hanson.

Actions to phase-out microbeads

There are a number of potential approaches to reduce the amount of microbeads released to Minnesota waters, including voluntary, regulatory and consumer actions.

Voluntary

In response to concerns raised by consumers and regulatory agencies, many personal care product manufacturers are taking steps to voluntarily phase-out microbeads in their products. Fortunately, alternatives to plastic microbeads are available and already in use in some products. Table 1 summarizes the actions taken or promised by a number of manufacturers who make personal care products for the U.S. market. While Table 1 only includes commitments that have a deadline currently posted[18] on the company's website, there are indications that other manufacturers (e.g., Proctor and Gamble[19]) intend to phase-out plastic microbeads in personal care products as well. Also, Table 1 is only a subset of all the possible personal care manufacturers whose products may be sold in Minnesota.

Table 1. Voluntary actions by some personal care product manufacturers to phase-out use of plastic microbeads

Company	Commitment
Beiersdorf	Beiersdorf has decided to discontinue using polyethylene particles in care products in the future. Their goal is to replace all polyethylene particles by the end of 2015.
Crest (a Proctor and Gamble company)	The majority of Crest's product volume will be microbead-free by March 2015. All Crest products will be microbead-free by March 2016.
Colgate Palmolive	The company is reformulating products that contain microplastics. Much of this work has already been accomplished, and the process will be completed by 2014.
Johnson and Johnson	Johnson & Johnson will phase out and will eliminate the use of polyethylene microbeads in personal care products by the end of 2017.
L'Oréal	L'Oréal has decided to no longer use microbeads of polyethylene in its scrubs by 2017. The phasing out will be first achieved for Biotherm (2014) and The Body Shop (2015).
Unilever	Unilever has decided to phase-out plastic scrub beads from personal care products. The company expects to complete this phase-out globally by January 2015.

Regulatory

In addition to voluntary phase-outs, several regulatory actions are being considered in North America. In the Great Lakes and St. Lawrence Cities Initiative, mayors in both Canada and the U.S. (including Duluth) have called on regulators and industry to remove microplastics from personal care products and clean up the microplastics already in the Great Lakes and St. Lawrence River.[20] In the United States, several states have investigated the possibility of banning personal care products that contain microbeads. Table 2 provides a summary of proposed and final legislation. At this point, only Illinois has passed phase-out legislation into law. Bills from a number of states have included language to differentiate plastic microbeads from non-plastic particles that are also called microbeads by manufacturers.

[18] As of October 2014 when this report was drafted.
[19] Elise Young. 2014. P&G dropping microbeads ahead of lawmaker action. Bloomberg News.
[20] Hobbs, K. 2013. Letter to EPA Concerning Microplastics in the Great Lakes. As viewed online October 2014.

Table 2. Status of proposed microbead bans as of October 2014

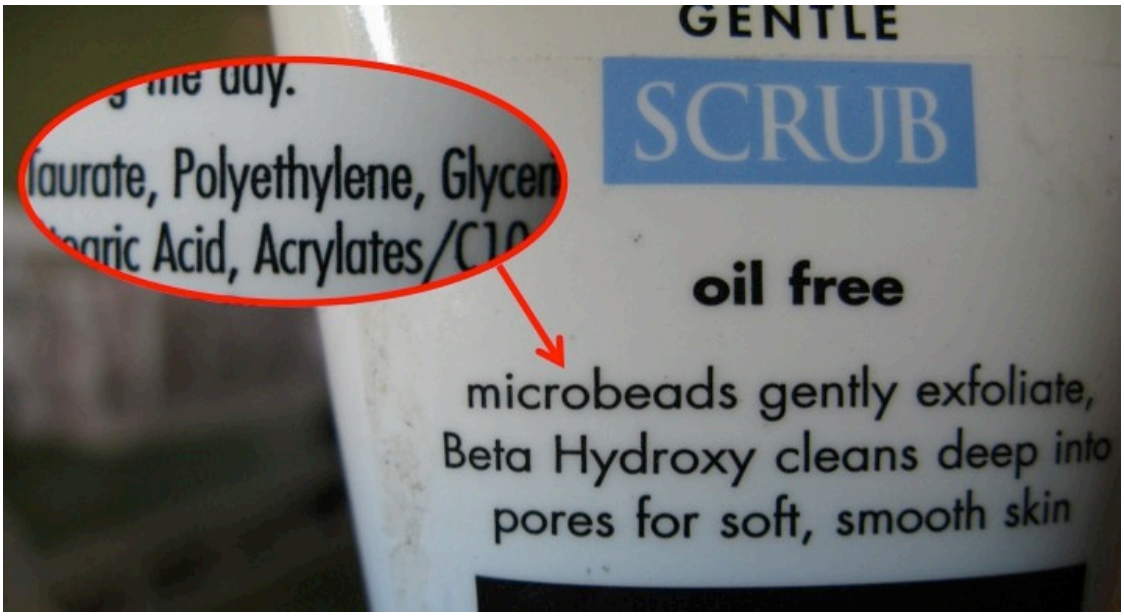
	Phase-out	Status[21]
California	AB1699 prohibits the sale of any cleaning product, personal care product, or both containing microplastic.	AB1699 was passed by the Assembly in May 2014 but failed by one vote in the Senate in August.
Illinois	SB2727 prohibits manufacturing and sale of any non-drug personal care product that contains synthetic plastic microbeads by 2018 and 2019, respectively. The law also prohibits the manufacture for sale and sale of any over-the-counter drug that contains synthetic plastic microbeads by 2019 and 2020, respectively.	Illinois became the first state to ban the manufacture and sale of products containing microbeads in June 2014.
Michigan	HB4994 prohibits intentionally adding plastic particles to the personal care products by January 2015 or selling such products by January 2016.	HB 4994 was referred to the Regulatory Reform Committee in September 2013.
Ohio	SB304 prohibits the sale of cosmetics or personal care products that contain synthetic or semi-synthetic polymeric microbeads.	This bill has yet to receive a hearing.
Minnesota	HF2414 prohibits sale after July 1, 2015, of a personal care product that contains microplastics with a diameter of five millimeters or less.	Referred to Environment and Natural Resources Policy Committee on February 27, 2014.
New Jersey	A3083 prohibits the production and manufacturing of all personal cosmetic products containing microbeads by January 2018 or selling such products by January 2019.	The Assembly unanimously passed A3083 in September 2014. The Senate version is expected to be on a subcommittee agenda in October.
New York	A08744A prohibits the manufacture, distribution and sale of personal cosmetic products containing plastic microbeads by 2017.	The Assembly passed A08744A in May 2015, but the state senate had not approved as of 10/10/14.
Wisconsin	NA	Legislation will be introduced in 2015.
U.S. Congress	HR4895(S2902) prohibits sale or distribution of cosmetics containing synthetic plastic microbeads beginning by January 2018.	HR4895 was assigned to a congressional committee on June 18, 2014.

[21] Sources (As viewed online October 2014):

- Associated Press. 2014. Senate rejects banning microbeads in cosmetics. Washington Times.
- Augenstein, S. 2014. Microbead ban passes N.J. Assembly, awaits Senate action. NewJersey.com.
- Professional Beauty Association. 2014. Michigan H.B. 4994 – Chemical Bans/Restrictions.
- Reich, A. 2014. Possible New State Legislative Trend: Bans on Microbeads in Cosmetics and Other Personal Consumer Products. Caveat Vendor Blog.
- Stewart, C. 2014. Ohio considers ban on microbeads found in toothpastes, beauty products. Dayton Daily News.

Consumer

From a consumer perspective, it is possible to avoid using personal care products that contain microbeads by reading the label. However, labels can be confusing since there are a number of possible plastic ingredients (i.e., polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polymethyl methacrylate (PMMA) or nylon). Furthermore, varying and unclear terminology is used on labels (e.g., "exfoliating microspheres"), some products contain natural agents in combination with plastic microbeads and are labeled as "natural", and the microbead ingredient may not be conspicuous on the label. The International Campaign Against Microbeads in Cosmetics has produced a smartphone app[22] that allows consumers to scan product labels and determine whether a personal care product contains microbeads. Rather than purchase manufactured personal care products containing microbeads, consumers can also make their own substitutes with commonly available ingredients. For example, consumers can make a facial scrub using sugar or salt and use baking soda for polishing teeth.



Consultation with the University of Minnesota

Fourteen researchers associated with the University of Minnesota were contacted for information on microbeads in Minnesota waters. While the University is not actively researching the issue, there is awareness of the issue among researchers from the Civil Engineering Department, Natural Resources Research Institute, Large Lake Observatory and University of Minnesota-Duluth. Several researchers expressed interest in research topics associated with microplastics and a number of them referred the agency to researchers outside Minnesota. We are grateful for the reviews of this report provided by these experts.

[22] http://beatthemicrobead.org

Other microplastics

Not all microplastics in Minnesota waters are microbeads from personal care products, and not all microplastics are delivered through treated wastewater. Examples of other kinds of microplastics include pre-production plastic pellets and powders spilled during transportation or manufacturing; fibers from synthetic fabrics; industrial and residential cleaners and polishes; fragments degraded from larger plastic products or coatings; and plastic flakes impregnated with insect pheromones.

As mentioned previously, analysis of microplastics in wastewater treatment effluent or downstream from wastewater discharges finds that most of the microplastic particles are fibers, followed by fragments.[23,24] Figure 1 is a "use tree" showing the many different commercial uses of microplastics. Microbeads used in personal care products are on just one branch on the use tree. Microplastics have many different uses and many different ways of getting into surface waters.

[23] McCormick, A., Hoellein, T., Mason, S., Schluep, J. and J. Kelly. 2014 (prepublication). Microplastic is an Abundant and Distinct Microbial Habitat in an Urban River. Environmental Science and Technology. 9 pages.
[24] Mason, S. 2014. Unpublished. University of New York – Fredonia. Personal communication with Glenn Skuta.

Recommendations

Given that plastic microbeads from personal care products pass through wastewater treatment systems into surface waters and soils, are not biodegradable, and may interfere with food chain dynamics, the MPCA makes the following recommendations:

1. While acknowledging the many different sources of microplastics in Minnesota waters, opportunities to replace microbeads in personal care products should be pursued since personal care products and the plastic microbeads they contain are essentially designed to be washed down drains into the wastewater system, and ultimately the environment. Wastewater treatment plants are not designed to remove microbeads and upgrading plants to address an easily avoidable contaminant is not an efficient and effective use of public resources. It is recommended that actions be taken to further incentivize and accelerate complete removal of microbeads from commercially available personal care products. While this will not remove all microplastics, it will at least remove one obvious source.
2. In addition, more natural, biodegradable alternatives to plastic microbeads are available and are already in use in consumer products. While some personal care product manufacturers are already replacing plastic microbeads with biodegradable microbeads, there is not an industry-wide commitment. Since plastic microbead bans in other states may have the intended effect nationwide, the urgency for a Minnesota ban has been lessened. However, a legislatively mandated phase-out similar to ones proposed by other Great Lakes states could be a helpful reinforcement.
3. The issue of microplastics in surface water bears watching. The MPCA and University of Minnesota (or other researchers) should continue to track developments in studies on abundance, type, ingestion and toxicity associated with microplastics in freshwater as well as uses and sources of microplastics. Several studies are underway, but not yet published. The MPCA should not invest resources in performing environmental monitoring or research on microbeads or microplastics, since adequate research is being performed elsewhere that applies to Minnesota and does not need to be duplicated. The MPCA should continue to stay in touch with lead researchers for work underway in other states to monitor data and analyses.

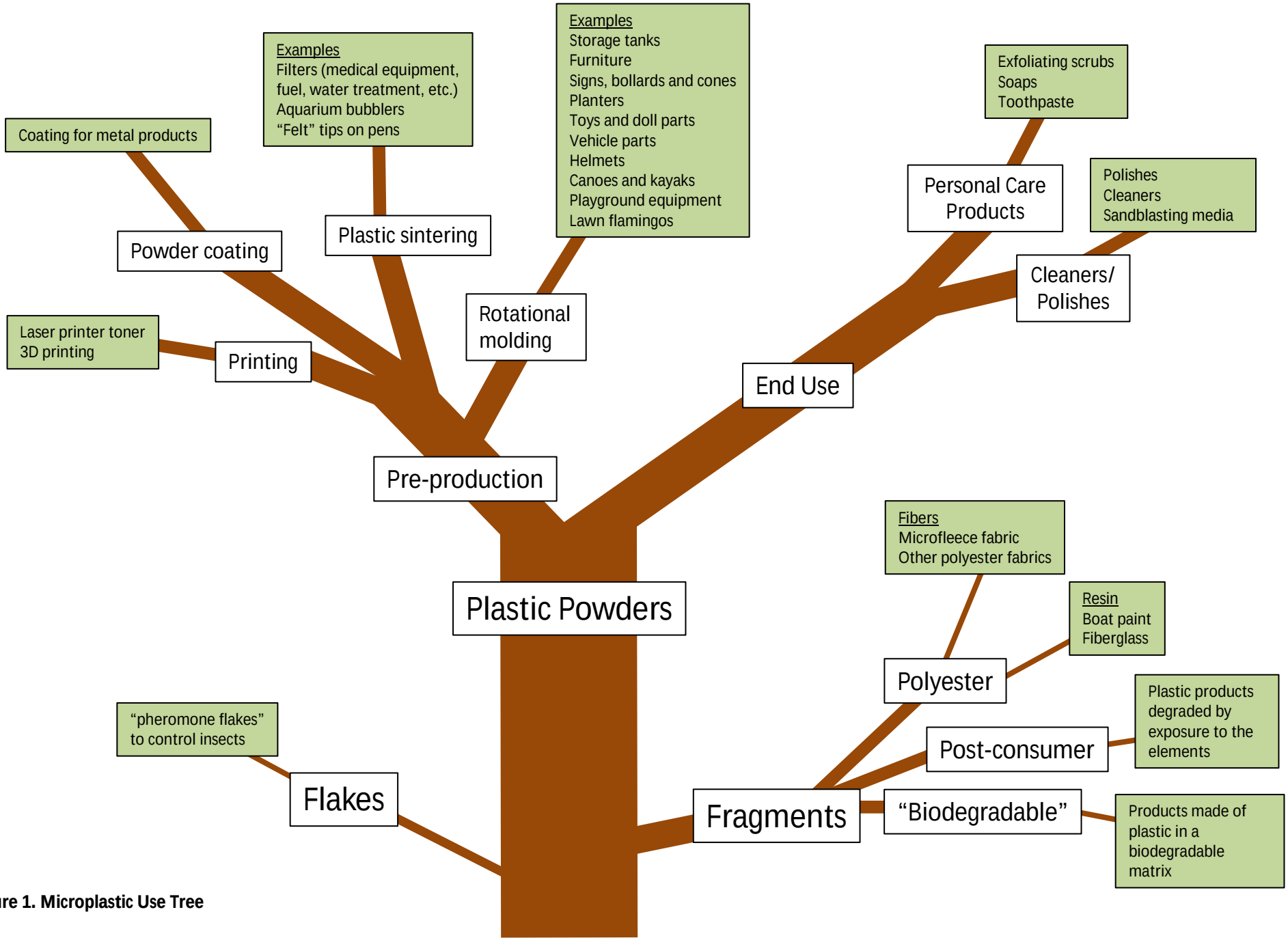


Figure 1. Microplastic Use Tree