National Marine Microbead Policy in Developed Nations: How Microbead Bans Have Influenced Microplastic Pollution in Waterways and Begun the Trend Towards International Collaboration

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National Marine Microbead Policy in Developed Nations: How Microbead Bans Have Influenced Microplastic Pollution in Waterways and Begun the Trend Towards International Collaboration

How have national microbead policies in developed nations influenced global microplastic pollution, and what further steps can be taken to end such pollution worldwide?

Abstract

Microplastics are a contaminant of emerging concern that have penetrated aquifers, surface waters, and even deep ocean trenches. Defined as particles less than 5mm in size, microplastics are pervasive and difficult to filter from water systems with current infrastructure. A common source of microplastics is cosmetic products containing microbeads, tiny balls of plastic between 1.5-3.5mm in size. As a byproduct of human consumption, microplastics come in varying forms. Microfibers, the most common marine microplastic pollutant, result from household laundry and commercial clothing production. Microbeads from cosmetics products are the second most common source of consumer microplastic pollution in waterways. Microbeads pass through municipal water filtration systems and are released into waterways, including rivers, lakes, and oceans at rates as high as eight billion beads per day. Several developed nations, including the United States, United Kingdom, France, New Zealand, and South Korea took action between 2015 and 2017 to mitigate microbead pollution in response to growing research and citizen concern. Each of these national laws prohibits microbeads in cosmetic products such as face-wash and exfoliant. Microbead-free acts have varying restrictions, timelines, and loopholes, resulting in inconsistencies on the global market. This study assesses and compares each of these national microbead bans, including the United States Microbead Free Waters Act of 2015 (MFWA), and their relative effectiveness. By individually assessing each of these policies, we can better understand our options for a global approach to the elimination of microbeads.

Introduction

Widespread production of plastics began in the 1950s, making them readily available for consumers in a variety of contexts.[1] This production was spurred by plastic use during World War II, when plastic production quadrupled in the United States. After the war, plastic transitioned to everyday use on the consumer market. 1950-2000 was a period for exponential growth of plastic production as a result of its affordability and convenience. As use of plastic

[1] Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017). Plastic as a Persistent Marine Pollutant. *Annual Review of Environment and Resources*, *42*(1), 1–26. https://doi.org/10.1146/annurev-environ-102016-060700

increased, so did its variations, spanning from cars to sandwich bags. Today, we produce over 300 tons of plastic each year, with over 5 trillion single-use plastic bags in circulation.[2] High consumption of plastic has resulted in massive waste, with an estimated 5,000 Mt tons of plastic discarded between 1950 and 2017.[3] The consequences of extraneous plastic waste are now well-researched and have motivated citizen action. Alarming reports of the high proportion of plastic pellets in beach sand, images of suffocated sealife, and trails of plastic straws in rivers have also prompted legislative action worldwide. The motivations of plastic prevention laws are clear; plastic use has become synonymous with pollution.

Microplastics are a particularly dangerous and pervasive byproduct of plastic consumption. Defined as plastic particles less than 5mm in size, microplastics are small enough to penetrate beaches, deep sea trenches, and even our own bodies. These pellets are split into two key classifications. Secondary microplastics are the result of photocatalytic degradation in the ocean, as macroplastics break down into smaller and smaller pieces.[4] This process results from zinc oxide nanorods within the plastics themselves, which interact with visible light and break down into smaller microplastic pieces. These microplastics are difficult to regulate, and mostly result from consumer or industrial waste released into waterways. Primary microplastics, on the other hand, are originally less than 5mm in size and result from plastic production or microbeads.[5] The size of these microplastics prevents them from being filtered out by wastewater treatment

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[2] *Our planet is drowning in plastic pollution. This World Environment Day, it's time for a change*. Retrieved February 12, 2020.

[3] Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, *3*(7), e1700782. https://doi.org/10.1126/sciadv.1700782

[4] Tofa, T. S., Kunjali, K. L., Paul, S., & Dutta, J. (2019). Visible light photocatalytic degradation of microplastic residues with zinc oxide nanorods. *Environmental Chemistry Letters*, *17*(3), 1341–1346. https://doi.org/10.1007/s10311-019-00859-z

[5] Sharma, S., & Chatterjee, S. (2017). Microplastic pollution, a threat to marine ecosystem and human health: A short review. *Environmental Science and Pollution Research International; Heidelberg*, *24*(27), 21530–21547. http://dx.doi.org.proxy.lib.umich.edu/10.1007/s11356-017-9910-8

plants, resulting in pollution of streams and residential water sources.[6] Primary microplastics are dangerous to wildlife and often pass through wastewater treatment systems. Bird species mistake bits of plastic for food and can suffocate from a high volume of plastic in their stomachs. Microplastic chemicals can also build up in fish membranes and harm their central functions. Despite these concerns, microplastics are an emerging issue that has not yet dominated the political playing field. As a result, literature on microplastic policy is limited, and research efforts have focused on the impacts of microplastics on marine and human health. By studying the regulation of primary microplastics, the issue of microplastic pollution can be addressed by a means that is tangible and all-inclusive.

The first major publication on "microplastics" was released by Thompson et. al (2004). This study assessed the abundance of microplastics and explored where they seemingly "disappeared" in the ocean.[7] Ultimately, they found that microplastics never disappear. From this pivotal point forward, microplastic studies have focused on discovering how prominent these contaminants are in major water bodies. Past studies have categorized them as contaminants of emerging concern, especially as attention was garnered from international organizations. In 2008, the National Oceanic and Atmospheric Association (NOAA) hosted their first workshop on microplastic pollution, gaining international awareness for the issue. These workshops focused on a wide variety of microplastic sources, but one source in particular began to stand out to legislators: microbeads.

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[6] Blair, R. M., Waldron, S., & Gauchotte-Lindsay, C. (2019). Average daily flow of microplastics through a tertiary wastewater treatment plant over a ten-month period. *Water Research*, *163*, 114909. https://doi.org/10.1016/j.watres.2019.114909

[7] Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., McGonigle, D., & Russell, A. E. (2004). Lost at Sea: Where Is All the Plastic? *Science*, *304*(5672), 838–838. https://doi.org/10.1126/science.1094559

Typically used for exfoliation in cosmetic products, microbeads are the most prominent type of primary microplastic in our waterways. Other sources of primary microplastic pollution in waterways are plastic pellets, also known as nurdles, which are released as a result of industrial plastic production and shipping.[8] While accidental releases of nurdles from ships are relatively rare occurrences, they are often blamed for marine microplastic waste. The real culprits of such widespread pollution are plastic plants and an influx of microbeads from consumer wastewater. The flow of microbeads into waterways is ongoing and numerous. Along with microfibers from household laundry, microbeads are also one of the most common sources of microplastic waste from a consumer source. Once they wash down the drain, microbeads often pass through wastewater treatments that are unequipped to handle such pollutants. They can clog and overload filters, pass through filtration into sewers, and leak into residential water sources. As a result, they often reach larger water bodies including lakes, rivers, and the ocean. With such destructive properties, microbeads are an example of plastic products whose costs far outweigh their benefits to consumers.

Popular face washes, toothpaste, and even lipsticks contain microbeads with few benefits to users. The first patents for microbeads were issued in the mid-1960s, as plastics gained popularity in products across the global market.[9] By the 1990s, use of microbeads in personal care products expanded significantly, despite uncertainty about their environmental impacts. Until the mid-2010s, these products were sold and used in abundance by average consumers. By 2013, social campaigns arose worldwide that advocated for banning the microbead, including the Plastic Soup Foundation's "Beat the Bead" campaign, and an adjacent campaign through the

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[8] Brown, Margaret. (2020, March 11). *Dirty Money,* season 2 episode 6, "Point Comfort." Netflix. I recommend watching this to learn more about nurdles and the corporate side of plastic production.

[9] Girard, N., Lester, S., Paton-Young, A., & Saner, D. M. (n.d.). *Microbeads: "Tip of the Toxic Plastic-berg"? Regulation, Alternatives, and Future Implications*. 40.

United Nations Environment Program (UNEP). These movements came in response to emerging scientific evidence of microplastic pollution since Thompson's article in 2004, including corporate research that prompted companies to voluntarily phase microbeads out of their products. However, nearly ten years of research was required before any governing body took official action. The state of Illinois passed the first microbead ban in 2014. California followed with a ban in early 2015, with a federal ban overruling its legislation later that same year.

The Microbead Free Waters Act of 2015 amends the Federal Food, Drug, and Cosmetic Act (21 U.S.C. ch. 9 § 301 et seq) to ban microbeads from consumer cosmetic products. Originally passed in 1938, the Federal Food, Drug, and Cosmetic Act (FDCA) gave authority to the United States Food and Drug Administration to oversee the safety of food, drugs, medical devices, and cosmetics.[10] Since its passing, it has guided issues spanning public and environmental health, including marine pollution related to consumer drugs and cosmetics. By amending the FDCA, the MFWA followed state efforts in California and Illinois. Creating a federal ban seemed like a progressive step against microplastic pollution, but many aspects of the Act are not as effective as lawmakers and environmentalists may have hoped. While previous studies have posed criticisms of the Microbead Free Waters Act, little research has been conducted on international microbead prevention and the effectiveness of recent laws.

Comparing this federal act to the California and Illinois laws that inspired it, I will assess whether federal protections take measures strong enough to prevent companies from bypassing the law or finding other loopholes. Additionally, I will assess the language of the law to assess how and why products such as pharmaceuticals and non-cosmetic products are not subject to the

[10] Commissioner, O. of the. (2018, November 3). *Federal Food, Drug, and Cosmetic Act (FD&C Act)*. FDA; FDA. https://www.fda.gov/regulatory-information/laws-enforced-fda/federal-food-drug-and-cosmetic-act-fdc-act

law. Microbead use in these products is just as prevalent, but the Act fails to prevent such products from using plastic ingredients. Moving beyond the United States perspective, I will compare the Microbead Free Waters Act of 2015 to other national laws, including the United Kingdom's 2017 Environmental Protection Act prohibiting the use of microbeads in UK cosmetic products. Determining whether other microbead prevention laws take more comprehensive action than the US can help determine next steps on the issue of microbead elimination, including additional US national legislation and expansion of microbead prohibition to other countries. Comparing these prohibitions to similar regulations in France, New Zealand, and South Korea helps build a greater understanding of their overlaps and faults. Studies considering the language of law in these microbead-free acts are relatively rare, as these laws have only gone into effect within the past year. Due to the new nature of these laws, some taking effect on January 1st, 2020, their effectiveness in preventing microbead pollution has not yet been assessed. Prior to 2014, no constituency had passed a microbead prohibition. Determining whether these laws have the appropriate scope, addressing the oceans as massive, international territories, is yet another means of determining whether these laws are effective in preventing microbeads from reaching the ocean.

Methods

To assess the effectiveness of the Microbead Free Waters Act and other legislation, I first conducted a literature review on microbead and microplastic pollution. Beginning with microplastic pollution, I focused my review on its prominence, makeup, and suggestions for solutions. Then, I gathered information regarding citizen action, support, and mobilization on microbead prohibition. I also connected this information with corporate information, such as

voluntary microbead elimination and worldwide cosmetic sales plans. Finally, for each national microbead ban, I assessed its origins, history, and current impact. Each of these reviews combine to create a comprehensive literature review to provide background and information about the legislation.

To analyze each microbead law I examined the exact language of the law, as well as its policy implications, partisan history, and perceived effectiveness. To better synthesize these results, I compared the provisions of each law in tables, including what the ban covers and when it went into effect. Table 1, "Implementation Timelines of National Microbead Bans" identifies the passing, "phase-in" period, and complete implementation of each law. Table 2, "National Microbead Ban Provisions" identifies the specific provisions of each national law. Finally, I examined the language of international laws including the United Nations Convention on the Law of the Sea (UNCLOS), the Honolulu Framework, and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) provisions to assess the impact of international law.

To provide suggestions for further international legislation and stronger regulations, I assessed the exact jurisdiction of each law, both national and international. Alongside this, I incorporated suggestions for plastic waste reduction taking place around the globe. Combining the language of current law with precedent of activism, I propose solutions to prevent microbead pollution on an international scale and begin reducing microplastic waste overall.

Modern Plastic: Production, Persistence, and Pollution

United States awareness of microbeads began, for the most part, following the publication of a study revealing high levels of microbeads in the North American Great Lakes in

2013. This study, "Microplastic pollution in the surface waters of the Laurentian Great Lakes," by Ericksen et al. gained local attention and inspired the passing of a state-level microbead ban in Illinois in 2014. Despite international attention, United Nations campaigns didn't emerge until legislation was already in progress in Illinois. These international campaigns focused their efforts more on consumer efforts than legislation. For example, UNEP partnered with the Plastic Soup Foundation in 2013, aiding in development of an app that informed consumers of the ingredients in their products. The app allowed average consumers to scan cosmetic products to see whether they contained microbeads. They primarily encouraged wariness of these products, and public awareness efforts to purchase products free of microbeads. UNEP did not take an official stance encouraging the banning of microbeads until 2015, after the United States passed a federal ban.

The US ban on microbeads was influenced by a growing wealth of research, including those that aided in the passing of bans in Illinois and California. A 2015 study tested nine of the top exfoliant products that listed polyethylene, a plastic polymer, in their ingredients. These included five Neutrogena, three Clean & Clear, and one L'Oréal product.[11] In this test, microbeads were small enough to pass through wastewater treatment facilities, posing a problem for water disposal and a route for microbeads to enter large bodies of water. About eight billion microbeads are estimated to enter the aquatic environment each day via wastewater.[12]

As marine pollutants, microbeads can have severe effects on the ecosystem. Oftentimes microbeads are ingested by marine biota, including zooplankton and bivalves, who mistake them for food. After ingestion, microbeads can translocate between tissues and remain within an

[11] Reducing microplastics from facial exfoliating cleansers in wastewater through treatment versus consumer product decisions | Elsevier Enhanced Reader. (Chang 2015). https://doi.org/10.1016/j.marpolbul.2015.10.074

[12] Rochman, C. M., Kross, S. M., Armstrong, J. B., Bogan, M. T., Darling, E. S., Green, S. J., Smyth, A. R., & Veríssimo, D. (2015). Scientific Evidence Supports a Ban on Microbeads. *Environmental Science & Technology*, *49*(18), 10759–10761. https://doi.org/10.1021/acs.est.5b03909

organism.[13] They can also chemically and physically disable organisms if consumed in high quantities. Plastic materials are absorbent, and can retain persistent organic pollutants (POPs) from the environment.[14] Beyond harming marine biota, some dense microbeads and other microplastics, they impact sea floor sediments. Once microbeads are embedded in corals and sediments, they blend with natural sediment and are irreversible. We lack the technology to separate microplastic materials from sediments and as a result of the non-biodegradable nature, they never disappear. There is even emerging evidence of plastics entering the geological cycle, and some scientists suggest they will become a stratigraphic indicator of human impact on the environment.[15] The scope of microbead and microplastic pollution even reaches to the deepest point on Earth. In 2018, researchers with the Institute of Deep Sea Science and Engineering in Hainan discovered microplastics in the Mariana Trench. Their samples reached a maximum of 2,200 plastic particles per liter of sediment and 13 pieces per liter of water.[16] The abundance of microplastics 11,000 meters below sea level indicates their devastating impact on the environment and a need for drastic change.

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[13] Auta, H. S., Emenike, C. U., & Fauziah, S. H. (2017). Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects, and potential solutions. *Environment International*, *102*, 165–176. https://doi.org/10.1016/j.envint.2017.02.013 ; Hall, N. M., Berry, K. L. E., Rintoul, L., & Hoogenboom, M. O. (2015). Microplastic ingestion by scleractinian corals. *Marine Biology*, *162*(3), 725–732. https://doi.org/10.1007/s00227-015-2619-7

[14] Chua, E. M., Shimeta, J., Nugegoda, D., Morrison, P. D., & Clarke, B. O. (2014). Assimilation of Polybrominated Diphenyl Ethers from Microplastics by the Marine Amphipod, Allorchestes Compressa. *Environmental Science & Technology*, *48*(14), 8127–8134. https://doi.org/10.1021/es405717z

[15] Zalasiewicz, J., Waters, C. N., Ivar do Sul, J. A., Corcoran, P. L., Barnosky, A. D., Cearreta, A., Edgeworth, M., Gałuszka, A., Jeandel, C., Leinfelder, R., McNeill, J. R., Steffen, W., Summerhayes, C., Wagreich, M., Williams, M., Wolfe, A. P., & Yonan, Y. (2016). The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene*, *13*, 4–17. https://doi.org/10.1016/j.ancene.2016.01.002

[16] Carrington, Daimian. (2018, December 20). Plastic pollution discovered at deepest point of ocean. *The Guardian*. https://www.theguardian.com/environment/2018/dec/20/plastic-pollution-mariana-trench-deepest-point-ocean

Plastics and Public Health

Once released into waterways, microbeads can take on more harmful properties than simply bits of plastic. They have been known to expand and absorb harmful chemicals, including flame retardants (PCBs), poly-aromatic hydrocarbons (PAHs), and bisphenol-A (BPA).[17] These beads are then consumed by marine wildlife, who mistake it for food, and absorb toxins in their body. Contaminated fish quickly become a potential hazard to human health. The contamination of fish within major fishing routes, that are then sold and eaten by the average consumer, has caused unhealthy consumption of plastic-related chemicals. Another means by which fish become contaminated is via bioaccumulation of toxins.

Bioaccumulation of plastic-related chemicals, the concentration of chemicals inside living organisms, has become common in sea life[18] In 2017, the United Nations Food and Agricultural Organization (UNFAO) released a briefing on the status of their knowledge of microplastics in fisheries and aquaculture, providing a comprehensive report on the number of microplastic particles in the average fish. Adjacent studies found that mussel and oyster species for human consumption had, on average, .36-.47 microplastic particles per gram of tissue, and dietary exposure of European consumers to microplastics exceeded 11,000 particles per annum.[19] A study by Rochman and colleagues in 2015 found that fish on both the United States and Indonesian markets were contaminated with microplastics.[20] The study included thirteen species at each marketplace, and their stomach contents were analyzed for plastic particles. While this

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[17] Conservation Education: http://www.conservationeducation.org/uploads/6/2/0/1/6201942/plastic_microbeads.pdf
[18] Yoksoulian, Lois. (2019, January 25). Microplastic contamination found in common source of groundwater, researchers report. Retrieved August 8, 2019, from phys.org/news
[19] Cauwenberghe, Lisbeth Van, Colin R. Janssen. Microplastics in bivalves cultured for human consumption. (2014). *Environmental Pollution*, *193*, 65–70. Doi.org
[20] Rochman, C. M., Tahir, A., Williams, S. L., Baxa, D. V., Lam, R., Miller, J. T., … Teh, S. J. (2015). Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific Reports*, *5*(1). Doi.org

study is only one in an emerging field of research, it suggests microplastics may be infiltrating our diets in unexpected ways. Fisheries are especially vulnerable to BPA contamination and they may be a public health concern for those who consume seafood on a regular basis. Debris levels in market seafood, as well as corals and shellfish, indicate a rise of microplastic contamination in sea life, which can be detrimental to human health when consumed. Many coastal communities rely on seafood as a source of protein, and these chemicals are disproportionately infiltrating their diets.

While the public health implications of directly consuming microplastics is still unknown, the risk from ingestion of chemicals in the plastics themselves is well-researched.[21] Plastic polymers, including BPA and di-(2-ethylhexyl) phthalate (DEHP) have endocrine-disrupting properties which, when consumed in high quantities or over long durations, can be harmful to fertility and hormone-producing functions. BPA was found to have 1,932 interactions with genes and proteins, resulting in a variety of inflammatory, prostatic, and ovarian diseases.[22] Most BPA is consumed via food, and is most dangerous in prolonged exposure. BPA has become common in the human diet, and the United States Center for Disease Control found BPA in 90% of urine samples from US adults.[23] Additionally, studies of mice found that even three generations after BPA introduction, offspring experienced reduced fertility and delayed sexual development.[24] The health risks associated with BPA make their presence in many fisheries, water sources, and food operations even more alarming. Knowledge that BPA

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[21] Halden, R. U. (2010). Plastics and Health Risks. *Annual Review of Public Health*, *31*(1), 179–194. Doi.org; Rist, Sinja. 2018, Elsevier Enhanced Reader. A critical perspective on early communications concerning human health aspects of microplastics. Doi.org

[22] Singh, S., & Li, S. S.-L. (2012). Bisphenol A and phthalates exhibit similar toxicogenomics and health effects. *Gene*, *494*(1), 85–91. Doi.org

[23] Center for Disease Control, 2009. Fourth Report on Human Exposure to Environmental Chemicals. Cdc.gov

[24] Yates, D. 2015. BPA exposure in pregnant mice affects fertility in three generations. Retrieved August 8, 2019, from news.illinois.edu

may be contained within microplastic particles makes them threatening to human health and stresses the need to eliminate them from the consumer market. In addition to direct consumption of BPA, chemicals from plastics can leach into our bodies and the environment via plastics. Even basic compounds, like chloride and ortho-phosphate found in plastics can negatively impact consumers. When consumed in excess, phosphate can create phosphine gas in the gastrointestinal tract and lead to potential death.[25] This is most threatening to humans when consumed via groundwater, where plastic chemicals can leach into drinking water.

Contamination of microplastics in groundwater, as a result of surface water waste, is a serious health concern. Karst aquifers, also known as fractured rock aquifers, constitute about 25% of global drinking water.[26] Embedded in soft rock, Karst aquifers are vulnerable to absorption of pollutants. In the St. Louis, Missouri metropolitan area, an early 2019 study found that 16 of 17 samples of groundwater contained microplastic particles, with a maximum of 15.2 particles per liter of water.[27] Other sources of groundwater microplastic pollution have resulted from the breakdown of litter, mismanagement of wastewater, and microfibers. Leakage of wastewater in particular has allowed microplastics to make their way into groundwater systems, as shown from to Karst aquifers in Illinois. Sixteen of seventeen samples collected from these aquifers along Illinois' southern border were found to contain microplastics. [28] Most of the microbeads found in this study were less than 1.5mm and could pass through filtration systems.

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[25] Pandya, S. N., Rana, A. K., Bhoi, D. K., & Thakor, F. J. (2013). *Asessment of Ground Water Quality of Rural Parts of Kapadwanj and its Impact on Human Health*.
[26] White, W.B. (1988). *Geomorphology and Hydrology of Karst Terrains.* Oxford University Press.
[27] Yoksoulian, Lois. (2019, January 25). Microplastic contamination found in common source of groundwater, researchers report. https://phys.org/news/2019-01-microplastic-contamination-common-source-groundwater.html
[28] Panno, S. V., Kelly, W. R., Scott, J., Zheng, W., McNeish, R. E., Holm, N., Hoellein, T. J., & Baranski, E. L. (2019). Microplastic Contamination in Karst Groundwater Systems. *Groundwater*, *57*(2), 189–196. https://doi.org/10.1111/gwat.12862

This further emphasizes the importance of microplastics as a contaminant of emerging concern, threatening water quality.

The Microbead-Free Waters Act

Environmental protection policies such as the Clean Water Act of 1972 and Safe Drinking Water Act of 1974 have played a pivotal role in United States water safety. These laws institutionalized water safety by supporting the drinkability of surface waters and banning chemical dumping and regulating amounts of contaminants such as lead in waterways. However, plastic is not regulated as a contaminant in either of these acts, even as its environmental impact on waterways becomes more well-known. Some chemicals within plastic, including chloride and ortho-phosphate are considered when testing water quality, but cannot be detected before they leach from their source. The failure of water quality legislation to prevent microplastic pollution resulted in a need for another approach.

The Microbead Free Waters Act (HR 1321), passed by US Congress in 2015, was a significant step towards microplastic regulation, as it banned microbeads in cosmetics on the consumer market. Microbeads are common in many face washes and body scrubs, and easily enter the ocean system through domestic wastewater. The Act was a direct result of citizen mobilization and growing scientific awareness of the impact of microbeads. Facing pressure from environmental groups like 5Gyres and increasing public awareness on issues of plastic pollution, a bill was presented to the House floor in 2014, later becoming the Microbead Free Waters Act.[29] The Act followed state action prompted by early microplastic studies. After the publication of microplastic pollution analysis in the Great Lakes region by Erickson et. al (2013),

[29] Pallone, F. (2015, December 28). H.R.1321 - 114th Congress (2015-2016): Microbead-Free Waters Act of 2015 (2015/2016) [Webpage]. https://www.congress.gov/bill/114th-congress/house-bill/1321

the state of Illinois took action to prevent microplastics from entering the Great Lakes.[30] Public act 098-0638 made Illinois the first state to ban microbeads in over-the-counter personal care products in 2014. This was in response to research that microbeads, defined as "intentionally added non-biodegradable solid plastic particles measured less than 5mm in size used to exfoliate or cleanse in a rinse-off product," were found in abundance in Lake Michigan.[31] Public opinion and citizen lobbying were integral to the passing of Illinois' microbead ban in 2014, initiating the federal conversation. The Alliance for the Great Lakes, Illinois Environmental Council, Shedd Aquarium, and other local environmental groups raised public awareness and encouraged state legislators to take up the issue.[32] Mobilization in California supported action as well, as their 2015 ban was the most restrictive, emphasizing that existing law preventing the sale of "marine degradable" plastics requires compliance with American Society for Testing and Materials (ASTM) International standards. Their restrictions went beyond banning microbeads and also prevented their "marine degradable" alternative, ending the sale of all microbead plastics by 2020.[33]

The Act is ultimately tied to the Federal Food, Drug, and Cosmetic Act, in the form of an amendment. Within the law, microbead is defined as "any solid plastic particle that is less than five millimeters in size and is intended to be used to exfoliate or cleanse the human body or any

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[30] Eriksen, M., Mason, S. A., Wilson, S., Box, C., Zellers, A., Edwards, W. E., … Amato, S. M. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. *Marine Pollution Bulletin*, *77*(1–2), 177–182. https://doi.org/10.1016/j.marpolbul.2013.10.007

[31] Illinois General Assembly—Full Text of Public Act 098-0638. (n.d.). Retrieved October 4, 2019, from http://www.ilga.gov/legislation/publicacts/fulltext.asp?Name=098-0638; Mason, S. A., Kammin, L., Eriksen, M., Aleid, G., Wilson, S., Box, C., … Riley, A. (2016). Pelagic plastic pollution within the surface waters of Lake Michigan, USA. *Journal of Great Lakes Research*, *42*(4), 753–759. https://doi.org/10.1016/j.jglr.2016.05.009

[32] Tiny Plastic, Huge Victory. (2018, June 29). Retrieved December 3, 2019, from Alliance for the Great Lakes website: https://greatlakes.org/2018/06/tiny-plastic-huge-victory/; Finishing What You Started: Important victory on plastic microbeads to take effect in 2018. (2018, January 4). Retrieved December 3, 2019, from Alliance for the Great Lakes website: https://greatlakes.org/2018/01/victory-microbeads-2018/

[33] Bill Text—AB-888 Waste management: Plastic microbeads. Retrieved October 4, 2019, from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB888

part thereof." This restricts the range of this law to cosmetic products. While Section 2(a)(2B) specifically declares that "rinse-off product" includes toothpaste, other products containing microbeads that aren't within the law's strict definition as intended for exfoliation or cleansing of the human body are still legal. Additionally, the applicability of the law declares "a rinse-off cosmetic that is a nonprescription drug, with respect to manufacturing." Prescription drugs are deliberately omitted, as subject to section 503(b)(1) of the Federal Food, Drug, and Cosmetic Act. Beyond these limitations, the Act further prohibits the continued implementation of state bans under section 2(c): "no state or political subdivision of a state may directly or indirectly under any authority or continue in effect restrictions with respect to the manufacture or introduction or delivery for introduction into interstate commerce of rinse-off cosmetics containing plastic microbeads." This language invalidates the bans established by Illinois and California and prevents introduction of further legislation that would have stronger restrictions than federal law. The purpose of the Act itself states that it will preempt state and local laws related to plastic microbeads, requiring overall national compliance with the ban. While this is beneficial to prohibit microbeads across the country and standardize regulations, it prevents states from establishing more strict bans at their discretion. Additional restrictions by states on nonprescription cosmetic products would therefore be prohibited by federal law.

When introduced to Congress, the bill had significant bipartisan support, gaining co-sponsorship from Congressmen on both sides of the aisle.[34] Introduced by Democratic Representative Frank Pallone from New Jersey, the bill moved from introduction to signing by the president in a matter of months. Within the Energy and Commerce Committee, the bill

[34] Pallone, F. (2015, December 28). Cosponsors - H.R.1321 - 114th Congress (2015-2016): Microbead-Free Waters Act of 2015 [Webpage]. Retrieved October 4, 2019, from https://www.congress.gov/bill/114th-congress/house-bill/1321/cosponsors

gained bipartisan support and was ultimately passed by the committee chairman Representative Fred Upton (R) from Michigan. Pushing the bill as an environmental win for both sides, it faced relative success in Congress with 37 cosponsors in the House and unanimous consent in the Senate on December 7th, 2015.[35] The federal ban went into effect in 2018, banning the manufacture of microbead-containing products, and prohibited retail sales on July 1st, 2018. Full implementation of the law, considering interstate commerce, did not go into effect until July 1st, 2019. Until this date, products containing microbeads were no longer manufactured, but could be sold across the country until stocks were depleted and the products replaced.

State-level microbead bans in states such as California posed a significant roadblock for cosmetics companies, who were unable to use the same formula across all their products on the US market. As a result, the federal ban was favorable to companies who sought standardization of their products. Inconsistent timelines, restrictions, and standards across states caused many cosmetic companies to voluntarily eliminate microbeads from their products prior to the passing of the MBFWA. A 2015 Greenpeace statement reported an uptick in voluntary efforts by global cosmetic companies to eliminate microbeads in 2014. Major producers such as Colgate-Palmolive and L Brands committed to eliminating microbeads from all their products by 2014 and 2016, respectively. These companies ranked among the top five on Greenpeace's corporate rankings in terms of microbead elimination and use. However, other major corporations, including Revlon and Amway, ranked low in their commitment to microbead elimination, and therefore were forced to comply with the MBFWA despite their resistance to changing the formula in their products. Their statements on the issue were narrow, for example

[35] 114th United States Congress, congress.gov: https://www.congress.gov/bill/114th-congress/house-bill/1321/actions?KWICView=false

limiting the definition of microbeads to "small plastic balls" as opposed to other shapes. Amway stated they planned to remove microbeads from personal care products but were not clear what products fell within this definition. Voluntary initiatives from most companies, however, were spurred by recommendations based on consumer interest and environmental standard compliance. For example, in 2015 Cosmetics Europe recommended the elimination of microbeads to its members in response to consumer surveys and shifts in regulations. Between 2012 and 2017, use of plastic microbeads in personal care and cosmetic products decreased by 97.6% in part because of these voluntary initiatives.[36] Many companies that instated voluntary microbead bans on the global market included only exfoliant products. For example, in 2016, Estée Lauder stated they were "in the process of removing exfoliating plastic beads in the small number of products that contain them."[37] While exfoliators are the most common source of microbeads, they also can be found in toothpastes, shaving creams, and other rinse-off products that aren't used for the sole purpose of "exfoliation." Narrow definitions in voluntary microbead eliminations further stressed the need for action on microbead prohibition, and elimination of microbeads from the market.

Statements from the Congressional Budget Office (CBO) estimated low costs to companies as a result of their voluntary removal of microbeads from cosmetic products prior to the Act. While some environmental organizations, such as the Plastic Soup Foundation have celebrated the passing of this law as a win for environmental causes, other environmentalists are skeptical of the Act as "low-hanging fruit" passed only due to its nonpartisan status. The bill

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[36] Over 97% of plastic microbeads already phased out from cosmetics—Cosmetics Europe announces. Retrieved November 24, 2019, from Cosmetics Europe—The Personal Care Association website: https://cosmeticseurope.eu/news-events/over-97-plastic-microbeads-already-phased-out-cosmetics-cosmetics-europe-announces

[37] Carrington, D. (2016, July 20). Microbeads report reveals loopholes in pledges by biggest firms. *The Guardian*. https://www.theguardian.com/environment/2016/jul/20/microbeads-report-reveals-loopholes-pledges-by-biggest-firms

passed unanimously in the House, a rare sight for modern environmental laws, and faced few lobbying efforts in opposition.

Criticisms of the Act

Based on evaluations of microplastic sources in oceanic waters, national microbead legislation is largely ineffective at preventing microplastic pollution overall. Estimates suggest that microbeads make up only 3-10% of all microplastic pollution in aquatic environments. For example, the percentage of microbeads within Japanese coastal waters was 9.7% of all microplastics.[38] Eriksen et. al (2013) found that 81% of their microplastic samples were between .35 and .99 mm in diameter, pointing to microbeads as their source. However, other sources of microplastic pollution, such as secondary microplastics and runoff from residential laundering, are not protected by the act. The Act also allows for several loopholes, as noted by McDevitt et al. (2017). Microbeads in non-cosmetic products, including prescription products, soap, and leave-on products such as lipstick and anti-wrinkle cream, are overlooked. Consumers are oftentimes unaware that these products may still contain microbeads, since ingredient labels include terms such as Polyethylene (PE), Polyethylene terephthalate (PET), Polypropylene (PP), and Polymethyl methacrylate (PMMA) that are unfamiliar to consumers.[39] The Act bans only rinse-off, over-the-counter products such as face wash and toothpaste, which are estimated to contribute to only 2% of all microplastic pollution.

Reflecting on these minimal regulations, some have criticized the Act, claiming politicians found an easy way out to show constituents their dedication to the environment. Large

[38] Isobe, A. (2016). Percentage of microbeads in pelagic microplastics within Japanese coastal waters. *Marine Pollution Bulletin*, *110*(1), 432–437. https://doi.org/10.1016/j.marpolbul.2016.06.030
[39] Plastic microbeads | Department of the Environment and Energy. Retrieved October 2, 2019, from https://www.environment.gov.au/protection/waste-resource-recovery/plastics-and-packaging/plastic-microbeads

corporations were beginning to phase microbeads out of their products prior to the Act in 2015 and were seeking non-plastic alternatives.[40] Additionally, state bans were barriers to business operations for companies who benefit from cohesive national legislation. Once introduced to Congress, then, there was little opposition to the bill from corporations who sought to standardize their production in compliance with state and national law. While this lack of opposition allowed for swift passing of the bill, it shows the lack of nuance in the legislation and its compliance with pre-existing changes on the cosmetics market. As consumer interest shifted towards strict regulation of consumer plastics, the Act seemed a natural progression to placate grassroots movements. With growing momentum, national microbead bans like the Microbead Free Waters Act were up for consideration in parliaments worldwide by 2016.

Microbead Bans Worldwide

After the passing of the US Microbead Free Waters Act, four countries quickly followed suit: The United Kingdom, France, New Zealand, and South Korea.[41] Canada and Sweden also took action on microbeads within this time period, with similar laws to the US and UK. The quick succession of these laws shows the effectiveness of social movements to influence national policy, as citizens brough microbead pollution to the global debate stage. Additionally, these laws acted in response to the World Trade Organization (WTO) agreement on technical barriers to trade (TBT). The TBT agreement aided in the prohibition of microbeads to set some level of standardization for the global cosmetic market. With the United States instating a complete ban

[40]Microbeads, Marine Debris Regulation, and the Precautionary Principle. Columbia University, 2015. https://blogs.ei.columbia.edu/2015/12/28/microbeads-marine-debris-regulation-and-the-precautionary-principle/

[41] Kentin, E. (2018). Banning Microplastics in Cosmetic Products in Europe: Legal Challenges. In M. Cocca, E. Di Pace, M. E. Errico, G. Gentile, A. Montarsolo, & R. Mossotti (Eds.), Proceedings of the International Conference on Microplastic Pollution in the Mediterranean Sea (pp. 245–250). Springer International Publishing. https://doi.org/10.1007/978-3-319-71279-6_34

on microbeads, manufacturers had to make the choice between standardizing their products or producing variable formulas for different markets. Some companies made the choice to eliminate microbeads completely from their products on all markets. Others adjusted formulas to serve US markets but resumed sales of microbead exfoliants in countries without the ban. However, the US was the top consumer of microbead products prior to the ban, followed by Germany, France, Spain, and China.[42] With the elimination of this massive market, it was only logical for corporations to edit their formulas and take action on other consumer markets. This precedent supported the passing of other national acts between 2015-2017. Each law includes its own implementation timeline, with a date of passing, a phase-in period, and full-implementation date. The date of passing is the date legislation was signed. Phase-in periods include any lapse between signing of and implementation of the law. Phase-in periods can also include, such is the case in the United States, levels of implementation that are not yet complete. Complete implementation is the final date of impact for the selected law. These dates are shown in Table 1 (Appendix). Additionally, Table 2 (Appendix) synthesizes the specific provisions of each national law. These include: rinse-off cosmetics, other cosmetics (non rinse-off), other cleaning products, bioplastic alternatives, and UNEP plastic components. By comparing current legislation, we can better assess the possibility of a cohesive international doctrine on microbeads.

[42] The power of environmental norms: Marine plastic pollution and the politics of microbeads: Environmental Politics: Vol 27, No 4. Retrieved January 22, 2020, from https://rsa.tandfonline.com/doi/full/10.1080/09644016.2018.1449090#.XihkYFNKhQJ

United Kingdom

In 2017, the United Kingdom passed a microbead ban as an amendment to the Environmental Protection Act, originally passed in 1990. The Act states that the "regulations come into force 21 days after the day on which they are made" (December 19th, 2017).[43] This makes it the quickest implementation period of the national microbeads bans passed between 2015-2017, as shown in Table 1 (Appendix). With virtually no "phase-in" period, the law stipulates that microbeads shall no longer be produced beginning in 2018. While this posed a challenge for companies, it was swift and necessary action to stop the flow of microbead pollution.

Citizen movements in reaction to other national microbead bans were a significant factor in the passing of UK legislation. Environmental organizations took action to inform consumers and prevent the sale of microbead exfoliants. For example, Greenpeace issued a petition in 2016 to ban microbeads, a partnership with the #BanTheBead campaign on social media.[44] The petition gained 350,000 signatures, making it the largest environmental petition to date.[45] Prior to a national microbead ban, strategies for reducing plastic waste during the 2010s focused primarily on changing consumer behavior.[46] After passing several consumer-focused bills, including a plastic bag tax in 2015, banning microbead products was a logical next step in the prevention of marine plastic pollution. National bans held more certainty than consumer awareness campaigns, and had a lasting impression on This legislation came during a wave of other plastic waste prevention policies. A bottle scheme to encourage recycling of plastic

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[43] *The Environmental Protection (Microbeads) (England) Regulations 2017*. 16.
[44] *Taking Microbeads straight to No.10!* (2016, June 9). Greenpeace UK. https://gparchive.wpengine.com/microbeads-no10-20160609/
[45] *We did it! Microbeads Ban Comes Into Effect*. (2018, January 11). Greenpeace UK. https://www.greenpeace.org.uk/news/we-did-it-microbeads-ban-comes-into-effect/
[46] McNicholas, G., & Cotton, M. (2019). Stakeholder perceptions of marine plastic waste management in the United Kingdom. *Ecological Economics*, *163*, 77–87. https://doi.org/10.1016/j.ecolecon.2019.04.022

containers has also been proposed. However, consumer action can only extend so far. Microbead bans resulted in changes at the company level, going beyond the actions of everyday consumers. As the UK joined multiple countries in banning microbeads, companies like Johnson & Johnson, who were originally resistant to microbead elimination, took steps to remove microbeads from all their products. Taking action on a global stage proved more effective for microbead prevention. Companies were now forced to comply with the law in order to succeed worldwide.

In addition to consumer action, other legal frameworks helped set the stage for the UK's 2017 microbead ban. Attempts to mitigate marine plastic pollution include the Integrated Maritime Policy for the European Union that makes the disposal of waste at sea illegal.[47] Additionally, bottle schemes and anti-litter laws have been beneficial for plastic regulation. Since most plastic waste originates on land, litter prevention regulations have been successful in preventing marine pollution.[48]However, with the separation of the UK from the EU, they will no longer be required to comply with EU environmental policy. This could be a positive development for environmental policy advocates, as the UK creates individually targeted policies, such as the microbead ban, that more strongly restrict plastic pollution. Despite these benefits, the diversion from international policy makes regulation of marine environments even more complicated. Without overarching international legislation, waterways are subject to inconsistencies and contradictions that make prevention of plastic pollution more difficult. Unlike most plastic pollution, microbeads were deposited directly into waterways and could not

[47] Galgani, F., Hanke, G., Werner, S., & De Vrees, L. (2013). Marine litter within the European Marine Strategy Framework Directive. *ICES Journal of Marine Science*, *70*(6), 1055–1064. https://doi.org/10.1093/icesjms/fst122

[48] González Carman, V., Machain, N., & Campagna, C. (2015). Legal and institutional tools to mitigate plastic pollution affecting marine species: Argentina as a case study. *Marine Pollution Bulletin*, *92*(1), 125–133. https://doi.org/10.1016/j.marpolbul.2014.12.047

be regulated by other plastic prevention measures. The national ban stopped microbeads at their source, benefitting international waterways even if it was small in scale.

France

France and the United Kingdom were the first European states to pass microbead bans, pre-empting discussions of an overall EU microbead ban. French legislation not only bands solid plastic microbeads, but also plastic cotton buds, or cotton swabs, used for personal hygiene. Passed in March 2017, the microbead ban went into effect beginning January 1st, 2018, followed by the plastic bud ban two years later, in 2020 (Table 1).[49] The law also included higher standards for cosmetic compliance, including stronger formula review, safety assessments, and cosmetic certification processes. The decree was part of a holistic strategy to begin reducing plastic pollution in the environment. As of January 1st, 2020, France has also begun a series of legislation to phase out single-use plastic by 2040. As a result, 2020 brings bans on plastic plates and cups, cotton buds, and still water bottles. Additionally, the law recognizes the fallibility of "biodegradable" plastic alternatives and encourages a 100% plastic recycling initiative. These laws follow the microbead ban in similar efforts to prevent plastic pollution from waterways and take immediate action on pollution. In 2019, the EU voted to phase out single-use plastics beginning in 2021, aligning with French policies to prevent plastic cups, straws, and other single-use items from harming the environment. Despite this large step in supranational action, the EU has yet to place a complete ban on microbeads.

The French microbead ban prohibits the use of bioplastic microbeads in cosmetic products, as shown in Table 2 (Appendix). Bioplastics are seemingly harmless, as they have the

[49] Banning microbeads in cosmetics in France by 2018 | Le blog EcoMundo. Retrieved January 13, 2020, from https://www.ecomundo.eu, blog, ban-microbeads-cosmetics-france-2018

ability to break down, unlike other plastic products. However, these beads can only be degraded in industrial compost facilities, which heat the plastics so they will break down as intended.[50] The marine environment cannot naturally break down bioplastic materials. Therefore, they have the same harmful impact as typical plastic microbeads in our waterways. The prohibition of these beads prevents yet another loophole to microbead prohibition that allows companies to continue polluting without the knowledge of their consumers.

As one of the top consumers of microbeads in the world, France's 2017 microbead ban influenced cosmetic companies in the EU to voluntarily remove microbeads from their products EU-wide. Similar to the impact of US legislation on global cosmetic markets, the banning of microbeads in France signaled a shift of European markets away from microbead particles and towards biodegradable alternatives, which were already in development at many university and corporate research institutions. Natural alternatives such as pumice, oats, sugar, and coffee were already being used on the US market and were similarly effective for exfoliation and intensive scrubbing, without the environmental cost. Additionally, exfoliation alternatives such as oats were shown to less frequently irritate sensitive skin compared to microbead products.[51] These alternatives were quickly popularized across the US and France and made consumers more conscious of their choice to support natural alternatives, as opposed to polluting products.

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[50] *Plastic Microbeads: They're Bad. But Together We Can Stop Them.* The Story of Stuff Project. Retrieved January 22, 2020, from https://storyofstuff.org/plastic-microbeads-ban-the-bead/

[51] O'Malley, K. (2018, January 9). 7 Alternatives To Microbead Exfoliators That Are Planet-Friendly. ELLE. http://www.elleuk.com/beauty/skin/articles/a31140/7-alternatives-to-microbead-exfoliants/

New Zealand

New Zealand microbead prohibitions, passed in 2017 as an amendment to the 2008 waste minimization regulations, ban microbeads in wash-off products like most other national bans. These include microbeads for the following purposes: exfoliation or cleaning of the body, abrasive cleaning of any area, surface, or thing, or the visual appearance of the product. This does not include medical devices or medicine. Similar to citizen response in the United States, the New Zealand regulation was passed after the release of an August 2017 impact assessment outlining environmental harms of the particles and their relative abundance in the environment. Similar to the United Kingdom, the law passed on December 7th, 2017 was quickly implemented by June 7th, 2018 (Table 1).[52] Unlike the United States, New Zealand law does not stipulate "rinse-off" or "cosmetic" products in their definitions. Although they create an allowance for medical products, there are far fewer exceptions to these broad definitions. The inclusion of products to wash any area, surface, or thing in this legislation extends microbead prohibition to non-cosmetic products, such as household washes, making it the most restrictive microbead ban in the world, as of current.[53] Additionally, the inclusion of non-rinse off products in this law also prohibits products such as glitter bubble baths and abrasive household cleaners, that release microbeads into wastewater facilities at similar rates as exfoliant face washes and other rinse-off products (Table 2).[54]This makes it the most expansive microbead legislation to be passed so far. Other legislation only takes rinse-off cosmetics into consideration, and specifically defines

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[52] *Plastic microbeads ban | Ministry for the Environment*. Retrieved April 23, 2020, from https://www.mfe.govt.nz/waste/waste-strategy-and-legislation/plastic-microbeads-ban

[53] New Zealand Legislature: http://www.legislation.govt.nz/regulation/public/2017/0291/latest/whole.html?search=ts_act%40bill%40regulation%40deemedreg_microbeads_resel_25_a&p=1#DLM7490703

[54] New Zealand Bans on Microbeads in Cosmetics Comes into Effect. Retrieved January 22, 2020, from https://www.sgs.com/en/news/2018/06/safeguards-08418-new-zealand-ban-on-microbeads-in-cosmetics-comes-into-effect

microbeads to not include products such as glitter, which are a similarly damaging source of microplastic pollution. Taking more extended action has more of an impact on the prevention of microplastics in our waterways, as fewer sources of plastic pollution are available on the consumer market.

South Korea

In 2014, the South Korean government announced its "Plan for Managing Marine Debris," targeted at limiting multiple forms of plastic pollution.[55] Following pressure from environmental groups, a ban of microbeads in cosmetics was passed in 2016. Legislators notified the WTO TBT on January 26, 2016. The law prohibits the sale of products containing microbeads beginning July 2017, and all previously manufactured products in 2018 (Table 1).[56] Groups including the Korea Women's Environmental Network expressed concern for the levels of microbeads in fish and waterways. 2.5 out of every 10 fish in the area were estimated to contain microbeads, presenting concerns for fish-heavy diets and unknown human consumption. [57] The 2014 framework was largely criticized for failing to include primary microplastics, including microbeads, in its regulations. Even with the passing of a microbead ban, environmental groups argued the law was too narrow, only covering 2.2% of all plastics. A more comprehensive plastic ban would address non-cosmetic products containing microplastics, as well as the extensive use of plastic in packaging. However, a 2018 survey of 400 respondents in the Seoul metropolitan area found that residents were not willing to pay for the price increases

[55] Choi, E. C., & Lee, J. S. (2018). The willingness to pay for removing the microplastics in the ocean – The case of Seoul metropolitan area, South Korea. *Marine Policy*, *93*, 93–100. https://doi.org/10.1016/j.marpol.2018.03.015

[56] Hurley, C., Janssen, J., Schreuder, M., Simonin, I., Zeng, J., & Zhong, W. *Memo on national legislation and initiatives banning microplastics*. 10.

[57] Microbeads to be banned in cosmetics products. *The Korea Herald.* Retrieved February 9, 2020, from http://www.kreaherald.com/view.php?ud=20160929000753

that would come with higher regulations. Despite general public support for a ban, the willingness-to-pay was unexpectedly low. Citizens supported microbead legislation in general, but were not willing to pay higher prices for cosmetic products.

Although China is one of the top consumers of microbeads, South Korea was the first Asian nation to take action on microbeads. Studies of Hong Kong waterways and Chinese mainland microbead pollution showed that microbeads were a significant pollutant of emerging concern in the Southeastern Asian region, and issues were quickly picked up by local environmental groups. For example, an estimated 306.9 tons of microbeads are emitted into the aquatic environment from mainland China, with more than 80% of these resulting from incomplete wastewater filtration.[58] Additionally, a 2018 study found that 60% of samples drawn from Hong Kong coastal waterways contained microbeads.[59] Studies like these provided evidence that microbeads were indeed a major environmental concern and a non-negligible proportion of marine microplastic pollution. Small countries including South Korea have been considered at risk of microbead pollution in groundwater, especially during rainy periods. Increased rainfall has been positively correlated with sewage effluent and runoff into coastal waters. Microbeads have become even more pervasive in Southeast Asia as they spread from the sewage system to major waterways, rivers, and even groundwater.

Despite criticism, the South Korean microbead ban takes considerably comprehensive action on the issue. The United Nations Environment Program (UNEP) identifies 22 ingredients that are excluded from the scope of "microbead." These include polyethylene, polypropylene,

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[58] Cheung, P. K., & Fok, L. (2017). Characterisation of plastic microbeads in facial scrubs and their estimated emissions in Mainland China. *Water Research*, *122*, 53–61. https://doi.org/10.1016/j.watres.2017.05.053

[59] So, W. K., Chan, K., & Not, C. (2018). Abundance of plastic microbeads in Hong Kong coastal water. *Marine Pollution Bulletin*, *133*, 500–505. https://doi.org/10.1016/j.marpolbul.2018.05.066

and acrylates.[60] Legislation in other countries does not stipulate which ingredients beyond "plastic" are impacted by their microbead ban. The South Korean law includes all 22 of these products, taking a more comprehensive approach to the prevention of microbeads in cosmetics than the US and UK (Table 2).

Broadening International Solutions

Of the microbead bans in place as of 2019, New Zealand's is the most restrictive. Other microbead bans in countries including the US and France only include cosmetic, toiletry, and sanitary products defined as "rinse-off." New Zealand's restrictions, on the other hand, restrict other home and industrial uses such as household cleaning products and heavy-duty cleansers.[61] Additionally, it prohibits the use of microbeads in cosmetics considered non rinse-off. More restrictive legislation is more effective in actively preventing microbeads from reaching waterways and harming wildlife. Beyond considering which products are affected by the ban, addressing biodegradable alternatives is a factor in strong legislation. Prohibiting the use of biodegradable plastic alternatives encourages companies to opt for non-plastic exfoliating alternatives such as oats and coffee. These restrictions also encourage scientific innovation. For example, scientists at the University of Bath developed cellulose microbeads following the UK microbead ban in 2017. These beads go beyond current bioplastic technology and serve as a feasible alternative for exfoliating beads.[62] These beads are made from plant material and can be digested by organisms in sewage treatment plants, preventing their release into the marine

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[60] Korea Bans Plastic Microbeads in Cosmetics. (2017, July 4). *Cosmetic News:* https://cosmetic.chemlinked.com/news/cosmetic-news/korea-bans-plastic-microbeads-cosmetics

[61] Plastic Pollution Coalition: UNEP 2018 https://plasticpollutioncoalitionresources.org/wp-content/uploads/2017/03/UNEP-2018-REVIEW-OF-NATIONAL-PLASTIC-REGULATIONS.pdf#page=74

[62] Scientists make biodegradable microbeads from cellulose. Retrieved November 24, 2019, from https://www.bath.ac.uk/case-studies/scientists-make-biodegradable-microbeads-from-cellulose/

environment. Even after reaching waterways, cellulose beads have the ability to biodegrade over time, unlike plastic microbeads.[63] Expanding these alternatives can make the transition to a worldwide microbead ban more feasible, especially using existing legislation as a framework for global collaboration.

Encouraging other nations to take more restrictive action can help create more cohesive international legislation on microbeads. Modern international shipping and globalization make it difficult for companies to comply with each country's individual laws. Similar to differing state regulations, the result of these discrepancies is often compliance with the most restrictive law. New Zealand's microbead ban extends to other non-cosmetic products, including household and automobile cleaning products that currently are not under the jurisdiction of any other microbead ban. Amending current microbead legislation in the United States and Europe to match New Zealand's restrictive ban will further prevent microbeads and provide standardization for the companies that produce these products. The voluntary elimination of microbeads from cosmetics in response to mismatching state-level bans is an example of how even minor legislation can impact the philosophy of major corporations. Despite the criticism that microbeads were an easy way out for environmental legislation, it was a movement that took root quickly and had a major impact on companies. Voluntary elimination of microbeads from products throughout the US in response to Illinois' regulatory statute kickstarted the path to federal legislation and made a permanent change. Preventing the sale of microbeads in one state, or several fragmented states, is much less effective than a federal ban that protects all US waterways and surrounding oceans. However, international collaboration is still a must for further microbead pollution prevention.

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[63] Coombs OBrien, J., Torrente-Murciano, L., Mattia, D., & Scott, J. L. (2017). Continuous Production of Cellulose Microbeads via Membrane Emulsification. *ACS Sustainable Chemistry & Engineering*, *5*(7), 5931–5939. https://doi.org/10.1021/acssuschemeng.7b00662

Collaborative Legislation

Considering the international nature of oceans and waterways as interconnected bodies, national policies and grassroots support are not enough to prevent plastic pollution from harming fish and other wildlife. With microplastics already penetrating deep ocean trenches, zooplankton, and fish for human consumption, the situation is only posed to get worse. While national microbead bans in North America and Europe are becoming more widespread, countries like India and China remain stagnant. As the first nation to take action on microbeads in Southeast Asia, South Korea's microbead ban stands out as inclusive of a variety of microbead products in cosmetics. While microbead bans may be effective in preventing contamination of inland waterways and groundwater in the countries that enact them, they are unlikely to prevent the continued pollution of marine environments with microplastics without implementation on a global scale.

Attempts to regulate marine plastic pollution at the international level include the Honolulu Framework, a collaboration between NOAA and UNEP, that considers prevention of marine debris on two main fronts: consumer-based levies and national bans.[64] While the Honolulu Framework doesn't address exclusively plastic pollution, it provides potential means by which plastic pollution could be prevented and explicitly outlines concerns regarding microplastics. Its assessment of microplastic contamination considers its effect on marine food-chains and exposure to chemicals absorbed in plastic particles. The framework failed to

[64] UNEP, Honolulu Strategy. http://wedocs.unep.org/bitstream/handle/20.500.11822/10670/Honolulu%20strategy.pdf?sequence=1&isAllowed=y

include integrated solid waste management and producer responsibility as part of their suggestion, requesting action on these issues be taken individually.

The United Nations Ocean Conference on marine plastics pollution in 2017 set 14 targets to reduce and prevent plastic pollution from entering the ocean, but these are not upheld by many national governments. These include conserving at least 10% of coastal and marine areas, strengthening environmental resilience, and enhancing implementation of the United Nations Convention on the Law of the Sea (UNCLOS).[65] UNCLOS is the primary legal code governing the global oceans. As a result of nearly ten years of negotiations, from 1973-1982, UNCLOS took on a global perspective on maritime regulations, anthropogenic activities, and ocean zoning.[66] Its global significance stems not only from its status as a universal legal code, but its recognition of the seas as interconnected entities in need of protection. Since its inception, the Convention has added three institutions to the list of United Nations commissions: The International Tribunal for the Law of the Sea, International Seabed Authority, and Commission on the Limits of the Continental Shelf. UNCLOS is placed under the jurisdiction of the International Union for the Conservation of Nature and works closely with non-governmental organizations to reach their goals. The International Union for the Conservation of Nature (IUCN) recently launched a campaign entitled "Close the Plastic Tap," addressing the massive amounts of plastic entering our oceans. While the UNCLOS provides provisions for the conservation and protection of the ocean as we know it, it presents little in the realm of pollution regulation and cleanup.

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[65] The Ocean Conference | 5-9 June 2017 | Oceans Plastic Pollution—Save Marine Life and Human Health. Retrieved October 12, 2019, from https://oceanconference.un.org/commitments/?id=32054

[66] UNCLOS - Table of Contents. Retrieved February 27, 2019, from http://www.un.org/Depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm

Regulating microbeads with the language of UNCLOS under Part XII Article 194 (Measures to prevent, reduce, and control pollution of the marine environment) would create standard global legislation. The Article regulates marine pollutants, including "toxic, harmful, or noxious substances," but does not list plastic. An addition of microbeads, microplastic, and plastic chemicals to UNCLOS could be beneficial for companies who struggle to comply with differing national laws, allowing them to choose one formula for their global market. Additionally, the doctrine recognizes the oceans as interconnected, global bodies that require blanket protections to prevent destruction of entire ecosystems. Completely eliminating microbeads from the stream of plastic pollutants entering the oceans could be a first step in solving widespread microplastic contamination.

Consumption and Waste Management

Proper waste management can help prevent the dumping of debris in waterways and decrease the flow of microplastic pollution. Today, the majority of plastic input to the oceans comes from rivers; over 90% of plastic pollution is sourced from the world's largest rivers.[67] Plastic runoff into rivers categorizes it as a non-point source pollutant, coming from various sources and making it difficult to prevent. The Yangtze River alone deposits about 1.5 million tons of plastic into the ocean each year, a result of mismanaged plastic waste on the mainland.[68] Whether sourced from personal litter to unprotected rubbish piles and landfills, aquatic plastic pollution quickly becomes widespread. Developing countries are more likely to lack necessary

[67] 90% of plastic polluting our oceans comes from just 10 rivers. Retrieved October 12, 2019, from World Economic Forum website: https://www.weforum.org/agenda/2018/06/90-of-plastic-polluting-our-oceans-comes-from-just-10-rivers/

[68] Patel, P. Stemming the Plastic Tide: 10 Rivers Contribute Most of the Plastic in the Oceans. https://doi.org/10.1038/scientificamerican0218-15a

infrastructure to manage plastic waste, develop recycling facilities, or handle the plastic per capita in their population. These issues are most concerning because they result in massive amounts of plastic waste in nearby waterways and can harm local communities that are already impoverished and struggling. Establishing proper recycling infrastructure worldwide has been suggested to reduce plastic mismanagement by 2025 and improve conditions in countries such as China and India that struggle with mismanaged waste.[69]

In 2018, China increased restrictions on imported recyclable materials to be managed in their facilities. China has been the final resting place of over forty percent of the US' recyclables, but with a desire to recycle more domestic waste, they stopped accepting most scrap plastic and cardboard from US sources.[70] Recyclables are now subject to a strict contamination rate of no more than .5%, meaning plastics tainted with food, beverages, or paint are no longer acceptable. This has seriously harmed American waste management abilities. Many cities are paying higher prices for recycling, dishing out high costs for a low environmental return. For example, the city of Fort Worth, Texas, was making approximately $1 million annually from their recycling facilities, but after regulation changes in 2019, they were projected to lose $1.6 million.[71] Movement away from plastic usage to non-plastic alternatives as a result of the recycling crisis has become more popular in public media. However, these alternatives require engineering and willingness to change from both corporations and consumers. Compostable plastics, with bases in corn instead of petroleum are a current alternative, but these containers are still only

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[69] Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*, *16*(6). https://doi.org/10.3390/ijerph16061060

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[71] CBS News: Recycling After China's Plastic Ban, America's Cities Face a Recycling Crisis. https://www.cbsnews.com/news/recycling-after-chinas-plastic-ban-american-cities-face-recycling-crisis/

compostable in commercial facilities. As a result, plastics are still reaching waterways, polluting rivers, and ending up in our oceans.

Even if we were to reduce plastic consumption at our current rate, the existing amount of microplastic debris in the oceans would require cleanup to restore the ecosystem. Skimming for plastic debris by ships is minimally effective due to the small range reachable by ships, and the potential for debris to continually spread. Efforts in the Great Pacific Garbage patch to clean up pieces of plastic debris have also had little impact on clean-up of the Pacific overall. Debris from these areas is spreading around the world, landing on beaches and being consumed by fish. Consumption of plastic debris by fish can result in starvation, as well as contamination of seafood stocks with chemicals such as BPA. Additionally, birds oftentimes view small plastic particles as food, due to their shape and color. Pollution prevention and litter pick-up efforts on beaches have become more widespread as beaches are the main connection people have with the oceans. In Hawaii, plastic debris from the Pacific Garbage Patch has begun washing up on beaches and required extensive clean-up. The impact goes beyond the ecosystem to the economy, as ugly, plastic covered beaches reduce tourism and have the potential to impact the housing market. Coastal residents around the world have joined clean-up crews to maintain clean beaches and prevent plastic buildup as a result of this massive destruction. Recently, the international community rallied together to establish an "international coastal clean-up day," on September 21st each year, during which citizens take action by cleaning litter on their local beaches. Over 6 million volunteers in 90 countries took action on clean-up day in 2018. This action is primarily motivated by environmental concerns surrounding plastic, which go beyond the destruction of beautiful beaches. These grassroots efforts have the potential to be impactful if

communities participate in a global effort, but without legislative support, they are unlikely to solve the issue of plastic debris.

Consumer Action on Plastic Pollution

In addition to a lack of international cooperation on microbead prohibition, long phase-out periods allowed for a continued flow of microbeads despite bans. As the first country to pass a microbead ban in 2015, the US instituted a timeline that completely eliminated microbeads from cosmetic products by 2019. However, different effective dates for interstate commerce, sale to stores, and shelf-life drew out the process. Stores with microbead products on their shelves did not face recalls, but rather sold these products despite the ban. As a result, consumer education and grassroots movements have become invaluable in the fight against microbeads since 2015.

Citizen mobilization has shifted towards strict regulation of consumer plastics. For example, in 2015 the United Kingdom passed a 5 pence plastic bag tax, requiring consumers to bring their own bags or pay extra. Similar bills have passed in the United States, where California became the first state to enact a plastic bag tax in 2014, charging 10 cents per bag. However, these policies vary drastically from state to state. In 2016 the state of Michigan prohibited local ordinances from prohibiting, restricting, or imposing fees on plastic items including bags, cups, and packaging after the city of Ann Arbor attempted to enact a 10-cent bag fee similar to California's. Other cities, including Washington, DC and San Diego, have lobbied for the regulation of single-use plastic items and begun pressuring businesses to focus on sustainability. Great Britain's Royal Statistical Society even made plastic their statistic of the year in 2018: 90.5%, the proportion of plastic that has never been recycled. These attitudes play

into the overall political climate and can have strong effects on how policy is considered, passed, and implemented. Political climate also plays an essential role in how nations interact with international governing bodies and legal codes.

Since 2017, the United States has been scaling back its environmental protections at both the national and international level. In late 2018, the Environmental Protection Agency (EPA) announced they were altering the definition of waterways in the United States, scaling back protections of the Clean Water Act in an effort to support private entities. Additionally, compliance with the United Nations Convention on the Law of the Sea (UNCLOS) and 2015 Paris Climate Agreement has significantly decreased. While the United States has not ratified UNCLOS, it has historically followed provisions set by its Seabed Authority and International Maritime Organization. Issues regarding ratification stem from the original 1982 convention, where they contested part IX of the treaty, which regulates seabed resources beyond national jurisdiction and have persisted with the growth of populism in the 21st century. Additionally, the US withdrew from the Paris Climate Agreement in June 2017, making a statement against the mitigation of climate change and global efforts. Unlike the United States, the UK has not only remained a signer on the Paris Climate Agreement, but in 2018 became the first developed country to create a comprehensive plan of how to meet the Agreement's provisions. With a goal of reaching net-zero emissions by 2050, the UK has taken steps towards sustainability. By taking legislative action to minimize plastic pollution, developed nations have set the precedent for future microbead minimization and prohibition.

Analyzing the creation and compliance with environmental policy across the globe can help us better understand the national attitude towards pollution prevention, and therefore microplastic regulation. However, knowledge of these laws, how they are being implemented,

and their impact on consumers is not yet widespread. Areas of future research would be re-examination of microbead levels in waterways that were studied before the passing of these laws. Additionally, further research could incorporate current negotiations regarding single-use plastic bans and how these impact microplastic production in waterways. Implementing an international microbead ban is the burden of lawmakers, not researchers, but possible iterations of these laws could extend to future study as well.

Conclusion

By enacting microbead bans between 2015-2017, developed nations including the United States, United Kingdom, France, New Zealand, and South Korea began a trend towards global awareness of microbead pollution. From 2018-2020, Sweden, South Africa, Italy, and India, among others, introduced microbead legislation. The growth of national microbead bans indicates a shift in attitudes towards the consequences of microbeads. As a type of primary microplastic, microbeads are on average 2mm in size and impossible to eliminate from the environments they pollute. Enforcing bans on microbeads in consumer products stops microbeads at their source and prevents them from flowing into our waterways at rates as high as eight billion beads per day. However, national policies do little to protect the global seas. With inconsistencies and varying timelines, microbead bans are not strong enough to curb microplastic pollution. International doctrines, like the Honolulu Framework and UNCLOS establish intent to reduce plastic pollution, but similarly do little to protect marine ecosystems. Incorporating plastic pollutants into existing international legislation is a logical next step in preventing the sale and use of microbeads. Additionally, establishing international microbead elimination goals can help developing nations establish their own guidelines and regulations. Including waste management

provisions in microbead bans is yet another step that can reduce plastic pollution and support national infrastructure.

Regardless of these solutions, policy is not the crux of the solution to our plastic addiction. Scientific innovation is integral to the clean-up of existing plastics and development of alternatives for plastic materials. Engineering ways to filter microplastics out of water systems and improve wastewater treatment can prevent microbeads from entering waterways. Utilizing alternatives to microbeads, such as biodegradable materials and organic products benefits both consumers and companies. These solutions allow us to consider methods that seem impossible, like "mutant enzymes" developed by scientists at the University of Portsmouth in the U.K. and the U.S. Department of Energy's National Renewable Energy Laboratory that can digest plastics and eliminate them from the ecosystem.[72] A holistic approach to mitigation of marine plastic pollution combines science with policy and moves us towards a plastic-free world.

[72] *This "Mutant Enzyme" Breaks Down Plastic | Smart News | Smithsonian Magazine*. Retrieved April 23, 2020, from https://www.smithsonianmag.com/smart-news/scientists-accidentally-create-mutant-enzyme-can-break-down-plastic-180968881/

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Appendix

Table 1: Implementation Timelines for National Microbead Bans

	Date Passed	Phase-In	Complete Implementation
USA	2015	2018	2019
UK	2017	2018	2018
France	2017	2018	2020
New Zealand	2017	2018	2018
South Korea	2016	2017	2018

Table 2: National Microbead Ban Provisions

	Rinse-Off Cosmetics	Other Cosmetics (non rinse-off)	Other Cleaning Products	Bioplastic Alternatives	UNEP Plastic Components
USA	**x**			**x**	
UK	**x**				
France	**x**	**x**		**x**	
New Zealand	**x**	**x**	**x**		
South Korea	**x**				**x**

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