“Removal of Micro-plastics in Central New Jersey Freshwater Sources”

By Gorkem Yurekli

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Rutgers, The State University of New Jersey

RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

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December 11th, 2019

Catherine McCabe
Acting Commissioner
NJ Dept. of Environmental Protection
401 East State Street
Trenton, NJ, 08608

Re: Removal of Microplastics in Central NJ Freshwater Sources

Dear Mrs. McCabe,

A large population of NJ residents rely on resources from freshwater sources. It is imperative that the water in the area remains monitored for quality assurance on a constant basis. Microplastics have increased in statewide concern over the last several years for their detrimental threats to the aquatic life and to humans as well. The New Jersey Department of Environmental Protection organization understands the severity of this issue and how tackling the microplastics abundance in NJ freshwaters can hold the key to a healthier population of not only civilians, but animal life as well. After much research on foundations and organizations, I have found your organization to be the most suitable in funding research projects as well as creating a viable cleansing plan for environmental protection concerns in the state of NJ.

Central NJ and specifically the Raritan River has a dangerously high abundance of MPs which could directly affect the nearby residents around the lakes and rivers. I am highly confident that my plan of action would directly address the problem to the nearby public by educating them on the effects of MPs on animal life and our drinking water and reduce the amount of them to create a healthier environment for everybody living there. In this proposal, I will be directly addressing the problem of MPs in Central NJ as well as citing recent research that not only shows the effects of MPs on everyone, but different techniques we could use to tackle the issue head on. Please feel free to contact me at gty6@scarletmail.rutgers.edu or my phone number: 908-340-9965 in you have any questions or concerns. I sincerely thank you for your time and effort in reading my proposal.

Sincerely,

Gorkem Yurekli

Gorkem Yurekli

Removal of Microplastics in Central NJ Freshwater Sources

Submitted By:
Gorkem Taylan Yurekli

Submitted To:
Catherine McCabe
Acting Commissioner
NJ Dept. of Environmental Protection
401 East State Street
Trenton, NJ, 08608

Final Proposal for Scientific and Technical Writing
Prepared for Professor Caroline Marrone
Department of English
Rutgers University

Abstract

Microplastics have become a ubiquitous problem in both freshwater and marine environments over the last several decades. With cosmetic and plastic companies on every block, the accumulation of these small polyethylene substances inside a water habitat has been documented several times to be extremely damaging to our bodily systems as they can enter our enteric digestive system by consumption of food sources as well as drinking water. The WHO has conducted a plethora of studies accessing the potential hazards that Microplastics contain that can damage the chemically and physical nature of our bodies to such a degree, that it could be life threatening. The freshwater areas in New Brunswick and others around Central New Jersey are no strangers to the presence of these Microplastics. That is why the public in and around those areas will benefit greatly, if a viable cleansing plan were to take place via this proposal, to not only prove and educate the masses of these harmful plastics, but to alert the public that these substances exist in their potential drinking water and food sources.

Table of Contents

Table of Figure

Introduction

Microplastics are synthetic organic polymers with absorption capabilities. “Since the development of the first modern plastic in 1907, a number of inexpensive manufacturing techniques have been optimized, resulting in the mass production of a plethora of lightweight, durable, inert and corrosion-resistant plastics” (Cole et. al., 2017). This mass production has now shifted towards the freshwater environments of large lakes and rivers all over the nation and NJ is no exception to these recent phenomena. A research experiment conducted in 2017 sought out to identify the existence of microplastics in central NJ freshwater locations, some of which include Piscataway and New Brunswick. Researchers took in water using a manta trawl attacked to a flow meter that accurately calculated the density of microplastics in the targeted aquatic source. Figure 1 shows the discharge areas that the research time primarily conducted their research as well as a 5-mile radius circle enveloping the neighboring towns. To make the case more interesting, the research team specifically targeted areas near and around special locations. These include cosmetic companies and industries with the word “plastic” in their name. The researchers found that “Microplastics, whose densities ranged from ~28,000 to over

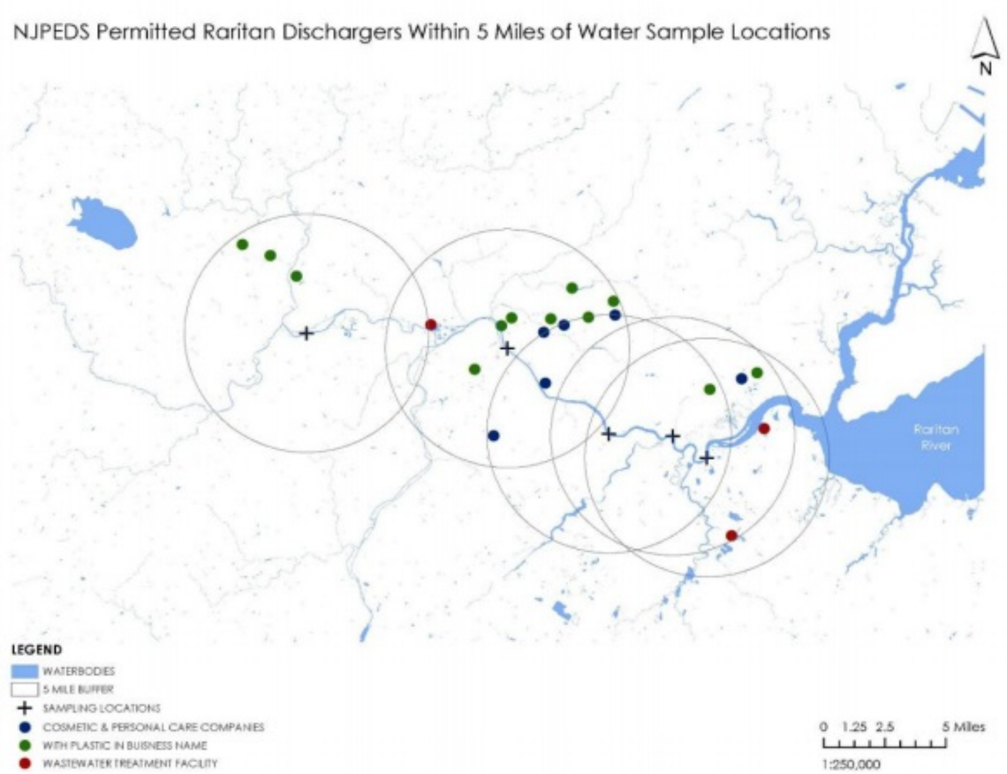

Figure 1: Locations of Testing Near Raritan River

Ravit et. al., 2017

3,000,000 particles km^{-2}, were observed in all sampled locations.” Figure 2, on the next page shows a graphical analysis of the resulting densities of the locations. As my target for this proposal is freshwater sources in Central NJ, it is imperative to take note that the locations in Piscataway and New Brunswick had densities up to and around 2.0 x 10^5 – 6.0 x 10 ^5 particles km^{-2}. The study will prove the existence of MPs (microplastics) specially in the Raritan River along New Brunswick which will serve as my targeted area for conducting a viable cleansing plan. These plastics can have absorptive qualities that allow them to take in any toxins in the water and condense them inside a sleek polymer coating. This is precisely why major companies and industries use MPs in their exfoliating gels and liquids as a business model to absorb facial toxins and promote healthier skin. Not only is this detrimental for nearby residents as a source of drinking water, the researchers also found the contaminants in a species of *larval fish* one of many food sources for humans as well (Ravit et. al., 2017). These factors contribute to the microplastics hazardous threats to animal life and water quality which can directly affect residents living around a MP abundant water source.

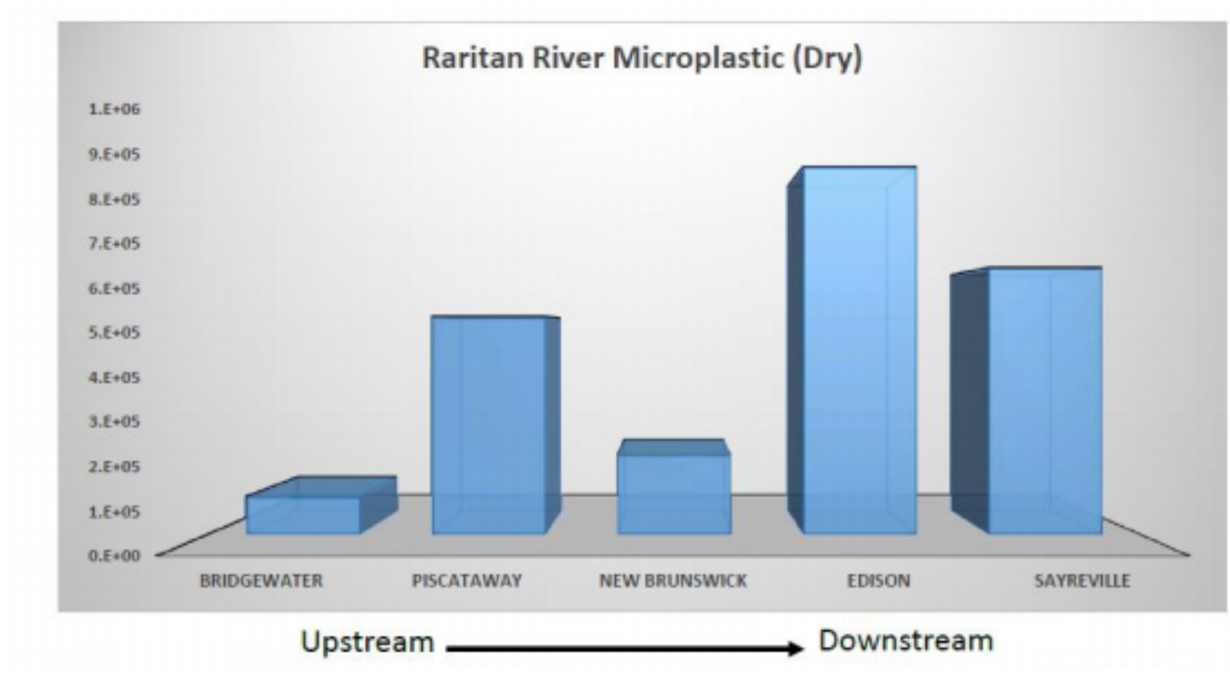

Figure 2: Density of Microplastics along the Raritan River
Ravit et. al., 2017

MPs Effects on our Internal Systems

Microplastics are small crystalline elements that exist, typically in facial scrubs and washers that get transported into the water system and have detrimental threats to both the water quality and the biodiversity of the source. Since their early onset in 1940, microplastics have exponentially grown in abundance both in retail scrubs and marine and freshwater density (Cole). In fact, research shows that the presence of microplastics present in freshwater sources like the Raritan River are "equal to or greater than those documented in the world's oceans with "thousands of microplastic beads are released by using as little as 5 mL of facial scrub exfoliates once each day" (Ravit). The World Health Organization claims that microplastics that enter our bodies from drinking water can damage our internal systems. They also claim that harmful microorganisms from freshwater and marine locations can latch onto these microplastics and thus attach to our organs when consumed (Newman).

Because of their compositions, MPs can render special proteins in our bodies useless. A study done in central India in 2019 conducted studies on individuals who consumed heavy amounts of polluted water across the coasts of rivers and lakes to access the problems they might face. "Blood was taken from five healthy males and then separated into plasma (protein portion of blood), white blood cells and red blood cells. Researchers then tested interaction between Nano plastics and plasma" (Jain 2019) Important proteins like albumins and globulins play pivotal roles in our bodily systems to maintain homeostatic within ourselves. Some of which control osmotic pressure, salinity, blood glucose level, etc. Once plastic particles are fully surrounded by proteins, the plastic-protein complexes are attracted towards each other resulting in aggregation of these complexes. In the study, "scientists say these aggregates in blood stream can block flow of body fluids. Also, this complex formation leads to structural and conformational changes in blood proteins rendering them non-functional" (Jain 2019). These blockages in the blood streams on individuals can later cause catastrophic damage to their internal systems. Respiratory problems, cardiovascular disease, reproductive inefficiencies, and even cancer are just a few results that could accumulate with the consumption of MPs from either food sources such as fish or from drinking water, taken up from freshwater environments.

Size and Science Behind Microplastics

Since their inception in the early 1900's, microplastics have been a global concern, not only for their relative size but their capabilities in water as well, most of which come from their very unique and critical composition. Plastics serve as transport vectors of a

Abbr.	Polymer	g cm^{-3}
PP	Polypropylene	0.85–0.92
EVA[a]	Ethylene vinyl acetate	0.92–0.95
LDPE[a]	High density polyethylene	0.89–0.93
HDPE[a]	High density polyethylene	0.94–0.98
(E)PS[b]	(Expanded) polystyrene	1.04–1.06
ABS[b]	Acrylonitrile butadiene styrene	1.04–1.08
PA	Polyamide	1.12–1.15
PMMA	Polymethylmethacrylate	1.16–1.20
PC[c]	Polycarbonate	1.20–1.22
PU	Polyurethane	1.20–1.26
PET[c]	Polyethyleneterephthalate	1.38–1.41
PES[c]	Group of polyesters	1.10–1.40
PVC	Polyvinylchloride	1.38–1.41
PTFE	Polytetrafluoroethylene	2.10–2.30

Figure 3: Major compositions of Microplastics
(Enders et. al., 2015)

various amount of persistent organic pollutants, many of which are already existing toxins residing in the water source already. A study done in 2015 where researchers conducted experiments in the coastal and central regions of the Atlantic Ocean, found that a majority of plastic type particles in both freshwater and marine environments show a large spectrum of polyethylene and petrochemical properties which contain high energy bonds that can easily take up other molecules in the water and be able to withstand breakage. This allows the microplastics (MP) to absorb toxins inside the water as well as condense them into a small pellet-sized sphere to which can easily be seen as food for aquatic organisms. The research them used various techniques to filter out plastics via their size in order to access their identification more clearly. Figure 3 above shows the major composition types of the results of the study. They show that most of the MPs in the water environment are composed of isomers of polyethylene and polyesters. The research team elaborated on the actual amplifications on their findings as well. Polyethylene and petrochemical properties allow the MPs to withstand acidic conditions inside a freshwater source. They are composed of double and triple bonds allowing them to create many enantiomers of themselves and shift their structure to acquire new and prevalent toxins in a water source. In additions, MPs can vary in size and thus, become very difficult to track and filter out. The researchers in this study found surprising evidence that certain patterns emerged to the nature of the movement of these particles.

Their “results show that, once a MP fragmented down to a certain size, rather dispersed distribution patterns can be observed, both horizontally as well as vertically” (Enders et. al., 2015). Specifically, they showed the researchers that larger microplastics tend to break off into fragments when being filtered out by humans still leaving them inside the body of water. These “MP fragments additionally have an increased risk due to their larger surface to volume ratio” which then in tune “results in higher adsorption capacities” (Enders et. al., 2015). This can be highly detrimental to the water as a majority of toxins in and around the microplastics can easily group together and become condensed in a single plastic. The fragments as described earlier still be filtered inside drinking water for residents in the area and won’t be detected by the filtration techniques due to their size and mobility.

Impact on Aquatic Organisms

Not only can microplastics become a hazardous component of drinking water, they can easily be digested by aquatic organisms affecting our potential food sources from freshwater locations. A study done in 2013 found that "a key factor contributing to the

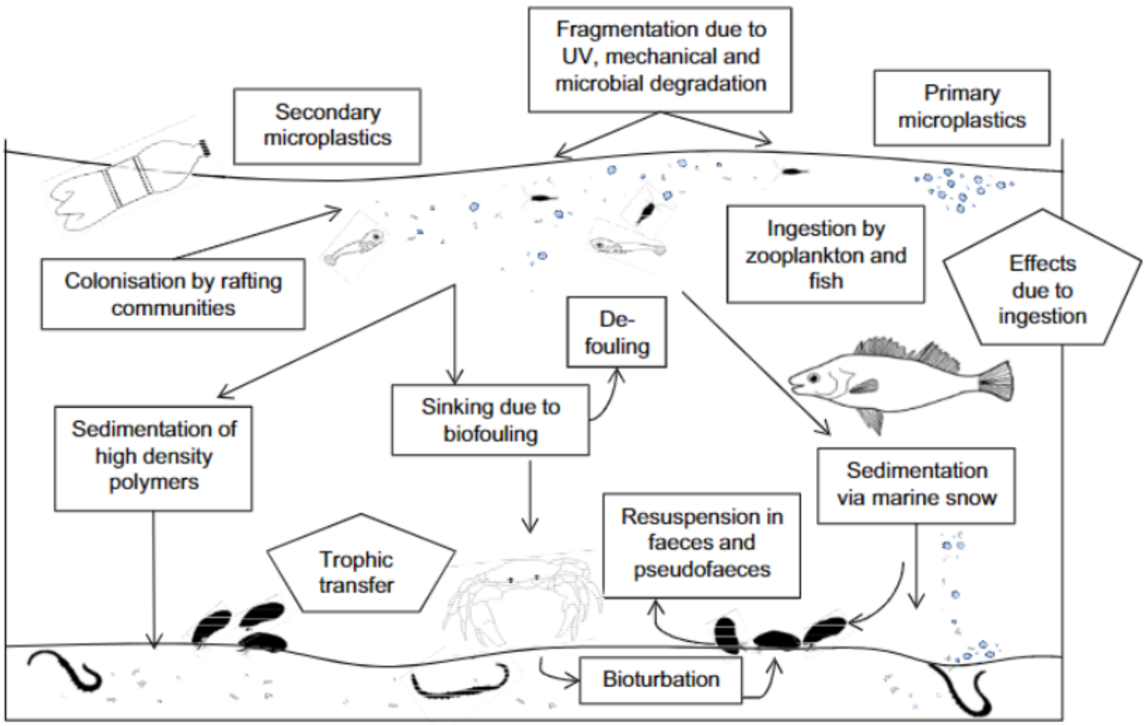

Figure 4: Flowchart of Microplastic movement to Aquatic Organisms
(Wright et. al., 2013)

bioavailability of microplastics is their small size, making them available to lower trophic organisms" (Wright et. al., 2013). This can easily be detrimental to the entire organism ecosystem as the plastics can move up through the food chain into the more heavily populated fish species that act as our primary freshwater food source. These researchers conducted various groups of experiments evaluating the organisms in the system of water and figuring out if any plastics have been identified within the population. One of the researchers found "reported microplastic (20-2000mm) ingestion in the omnivorous amphipod Orchestia *gammarellus* and the deposit-feeding polychaete A. *marina*", two highly common bottom chained organism and suspensions feeders that live in many freshwater and marine bodies of water. The figure below from the same study illustrates the flow

of MP movement inside a body of water. The journal also notes the difference between primary and secondary MPs as follows: primary MPs are particles already under 5 mm in size or less, but secondary MPs are ones that are created from the degradation of primary MPs. As aquatic organisms live near the bottom of a body of water, the MPs, because of their size and density, are allowed to wither down to the bottom and be mistakenly thought of as food for the bottom feeders and species of fish living there, as shown by the diagram. The trophic transfer of these MPs can travel through the levels of life inside a freshwater environment and can get inside a potential food source for humans living near that body of water. Rivers like the Raritan river are highly composed of these types of organisms, and if ingested with microplastics, can create terrible chain reactions that could potentially infect any food source for humans with toxins.

Successful Models and Techniques

In order to develop a viable plan to reduce the abundance of MPs in freshwater sources in Central NJ, we must first cite real research that has succeeded in the past with this very same topic. Fortunately, a research study done in 2017 successfully removed a majority of MPs from a nearby water source. Researchers in this study "investigated the removal of MPs from effluent (water moving out) in four different municipal wastewater treatment plants utilizing different advanced final-stage treatment technologies" (Talvitie et. al., 2017). The researchers used bioreactors and targeted effluent technologies as a mode of filtration for the study. The specific Membrane Bioreactor was deemed very useful for the removal of MPs for the researchers. In fact, The MBR removed 99.9% of MPs during the treatment (from 6.9 to 0.005 MP L^-1), rapid sand filter 97% (from 0.7 to

Table 1
Sample volumes (L = liters) before and after the treatments for each filter size. DF 10 = discfilter with pore size 10 μm, DF 20 = discfilter with pore size 20 μm, RSF = rapid sand filters, DAF = dissolved air flotation and MBR = membrane bioreactor.

	DF 10		DF 20		RSF		DAF		MBR		After CAS
	Before	After	Before	After	Before	After	Before	After	Before	After	
300 μm	50 L	6–50 L	17–50 L	50 L	650 L	1000 L	333 L	1000 L	140 L	140 L	500 L
100 μm	50 L	6–50 L	1–17 L	50 L	50 L	1000 L	50 L	300 L	4 L	140 L	50 L
20 μm	2 L	2 L	0.5–2 L	2 L	4 L	70 L	2 L	2 L	0.4 L	140 L	4 L

Figure 5: Sample Volumes before and after treatment with filters and Membrane Bio Reactors (Talvitie et. al., 2017)

0.02 MP L^-1), dissolved air flotation 95% (from 2.0 to 0.1 MP L^-1) and discfilter 40-98.5% (from 0.52.0 to 0.030.3 MP L^-1) of the MPs during the treatment" (Talvitie et. al., 2017). Figure 5 and 6 show the results of the mechanism used to filter out water sources using a membrane bioreactor. Figure 5 below shows a before and after table after using effluent filtration techniques combined with a membrane bio reactor. The after results show the amount of plastic volumes that were found using these techniques. Almost all of the techniques showed an increase in volume of the microplastics meaning the techniques used for this study proved to be very useful. In addition, Figure 6 on the following page shows a table that the researchers used in the same study to access the need of rapid sand filters. Likewise, the team also found incredible results showing an increase in volume of the plastics using membrane bioreactors coupled with rapid sand filters. This concluded the validity of bioreactors as a way to quickly and accurately take

Table 2
The 24-h composite sample volumes (L = liters) before and after the treatments for each filter size. RSF = rapid sand filters, DAF = dissolved air flotation and MBR = membrane bioreactor.

	RSF		DAF		MBR		After CAS
	Before	After	Before	After	Before	After	
300 µm	27.4 L	25.5 L	15.8 L	16.1 L	5.8 L	6.1 L	4.2 L
100 µm	27.4 L	25.5 L	15.8 L	16.1 L	5.8 L	6.1 L	4.2 L
20 µm	4.0 L	25.5 L	4.0 L	16.1 L	0.4 L	6.1 L	4.2 L

Figure 6: Table of Membrane Bioreactor results with rapid sand filters
(Talvitie. al., 2017)

of MPs from an area of water. In addition, another study done in 2017 found great results, using knowledge of WWTPs. The researchers in this study used a high-volume sampling device to capture MPs in a nearby aquatic environment. At the end, "the sampling device captured between 92% and 99% of polystyrene microplastics using 25µm-50µm mesh screens in laboratory tests" (Ziajahromi et. al., 2017). Figure 7 on the following page shows an analysis of the results from this study. The mesh screens with the high-volume sampling device deemed to be a very successful technique to find MPs in Waste Water Treatment Plants. The researchers used different sized mesh screens for this experiment ranging from 25- 500 µm. Primary and secondary MPS were documented to better access the validity of high-volume sampling devices as their size disparities could be difficult to track in further testing. The reseracher found that mesh screens between 25-100 µm had the highest particle density compared to the rest in charts A, B, C which were conducted in effluent water sources. Since the Raritan River is a major effluent freshwater source in Central NJ, this study will be pivotal to cite in order to use the correct mesh screens and necessary high-volume sampling devices to create a viable cleansing plan. In conclusion both the MBR and a high-volume sampling device were key in transition to tackle the issue of MPs by accurately taking them up from aquatic environments. I would personally love to use both these methods and create a viable plan to remove MPs from freshwater environments in Central NJ.

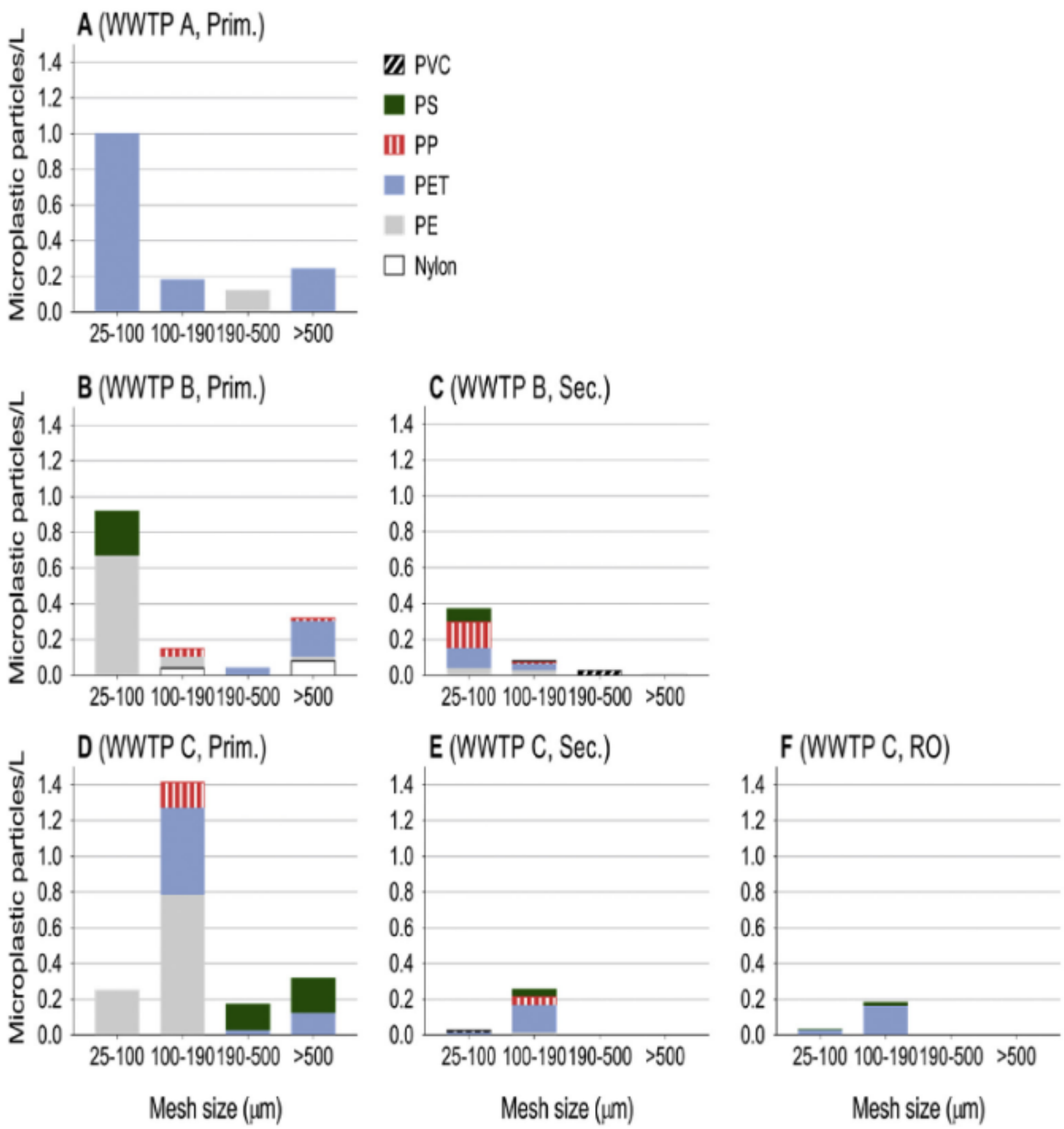

Figure 7: Number of Microplastics in Waste Water Treatment Plans using Effluent techniques and high-volume sampling devices with mesh screens
(Ziajahromi et. al., 2017)

Viable Cleansing Plan

Several organizations and areas have addressed the issue of microplastics in our environment and have also funded research to help tackle the issue. The National Oceanic and Atmospheric Administration has recently funded a large array of programs and universities to conduct research and create a viable cleansing plan. Among the successful attempts, they include the 30,000 pounds of marine debris in Alaska as well as funding Rutgers University to study how microplastics move from rivers to oceans as well as their path to our food chain. This model is great to reference as it shows the global scale of this problem in the United States as well as references Rutgers University and New Brunswick which is the targeted area for the

My main focus on removing MPs in freshwater environments is to create an urgent environmental call to all residents living in New Brunswick area. To tackle the issue of MPs in freshwater environments in Central NJ, I would first need to create a viable cleansing plan here in New Brunswick targeting the Raritan River. Mrs. McCabe, on your website, your organization has funded and created various modes of actions tackling environmental threats around NJ. Specifically, your Division of Water Supply and Geoscience has done incredible work to test drinking water in man locations in New Jersey. I would love for you to fund a cleansing plan for the Raritan River in New Brunswick to all the residents in the area. I would use multiple high- volume water sampler and create a team of researchers to conduct research into the Raritan River and take up as much MPs as possible. My plane will heavily revolve around high-volume sampling devices as the research has proven their validity in sampling primary and secondary MPs using mesh screens. As an added incentive for this cleansing plant, I would also open the doors as a potential volunteer initiative for New Brunswick residents and current Rutgers University students.

As my plan will focus on the Raritan River around the Rutgers University campus in New Brunswick, the team of researchers will be conducting their research in labs around the university, specifically in the school of Environmental Sciences. This sector of Rutgers is incredible passionate about many types of Environmental problems ranging from aquatic biology to freshwater biohazard. Rutgers has many labs available for research during the semester and the team of researchers will be able to safely transport the water samples from the river to the lab as they are in close proximity to each other. The manifolds for my plan have safe and rigid dents within them which will need multiple people to carry and navigate from the river to the lab.

The major purpose of the plan is to discover the amount of MPs that currently exist inside the river and create a motive to educate the individuals around the area to be aware of the dangers of these plastics. Flyers and presentational motives will be used to educate the people around New Brunswick and teach them the effects of MPs and urge them to help with this cleansing plan. As an added initiative to the plan, it will also serve as a volunteer aspect to the people of New Brunswick as well as be open to any current

Rutgers students. Current students in the school of environmental sciences will be very keen to help as their concentration in aquatic life resonates with my p

Budget

I would first need to obtain a multi-position manifold that would cost around $470 which would allow me to transport high volumes of water from the site into our buckets for testing and removal (Southern Labware). I would also need several buckets of water to collect for testing and removal. Judging from the size of the Raritan River, we would need just enough to test a small specific area along the coast meaning I would need around 500 buckets each around $3.25, totaling $1625 (Laine et. al., 2018). The high-sampling devices will cost around $589 for a commercial use, however to make this cleansing plan as effective as possible I will need 10 of these devices totaling $5890. The average salary for researchers tends to be around $70,000 or around $5833 a month. I would need a team of 5 researchers to conduct totaling around $29,167 for their time for a single month of study. Moreover, the estimated cost for creating an urgent notice for the volunteer ship would be around $500 including flyers and small table conventions around Rutgers-New Brunswick. Finally, I would need multiple high quality filtration systems. These ones, though used for homes can be transported to a location. Each costs around $1650 and I would need around 10 of these totaling $33,000 (Average Cost of Water Filtration System). The total budget for this plan equals $77,635.

Item	Cost	Amount	Total
Multi-Position Manifold	$470	1	$470
Buckets for Water Collections	$3.25	500	$1625
High-Volume Sampling Devices	$589	10	$5890
5 Researchers for 1 Month’s work	$5833	5	$29,167
Flyers/Presentation Tools	$1650	1	$1650
Filtration Systems	$1650	20	$33,000
Total for Cleansing Plan			**$77,635**

Discussion

Central NJ and specifically the Raritan River has a dangerously high abundance of MPs which could directly affect the nearby residents around the lakes and rivers. I am highly confident that my plan of action would directly address the problem to the nearby public by educating them on the effects of MPs on animal life and our drinking water and reduce the amount of them to create a healthier environment for everybody living there. Central NJ has been documented several times to have a large abundance of MPs in their freshwater environments. For over several decades the science has been crystal clear on the relative nature of these MPs and their detrimental and irreversible effects on not only aquatic life but the lives of humans living near the body of water as well. It is of utmost importance to filter out these harmful plastics and ensure a safe and viable way to maintain cleanliness in our food and water sources. My plan will indeed have the science-backed and necessary equipment to be able to filter out these plastics from the Raritan River and conduct research in the labs to figure out the sources of these plastic migrations. Mrs. McCabe, your donation will go far not only in the education of these plastics, but it will take the necessary first step in protecting our Central NJ Freshwater environments from these harmful plastics. I would like to thank you for attending my presentation on November 20th, 2019 and hope that you find all the necessary information about to fund my cleansing plan.

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