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### Pollution in Guanabara Bay

The last half of the 20th century and the early 21st have seen a dramatic increase in pollution and degradation of the planet. One of the most pressing problems is plastic and human waste pollution of the world's oceans, bays, and freshwater rivers. Currently, there are 150 million tons of plastic and other waste in the world's oceans with 8 million more tons entering every single year, or the weight of 90 aircraft carriers (NOAA). The majority of this trash and sewage is found in the open ocean, negatively affecting sea life; however, one place where it is most visible due to ocean currents and large populations is near coastal beaches and urban centers.

Perhaps the most heavily polluted coastal area in the world according to trash and sewage per square foot would be Rio de Janeiro's Guanabara Bay (Waldek). Historically, Guanabara Bay was one of the most beautiful places in the whole South American continent and a hotspot for tourists. This rampant pollution only started occurring in the late 1950s as the population of the city and the nation itself exploded along with many other countries in the Southern Hemisphere. The rapidly expanding population led to the government not having enough funds to build new infrastructure for the larger amount of residents. Pre-World War I sewers and

housing are still used in many parts of the city today. This housing shortage caused the expansion of the infamous slums in the central part of Rio de Janeiro. This lack of sewers in these poor regions has led to individuals dumping trash and human waste wherever they can, primarily on the tributary rivers that run right into Guanabara Bay. An estimated 4.5 million of Rio's inhabitants are not connected to any proper sewage system, nearly half of the individuals live within the city's limits (Branch). For the statistics of the bay itself, an estimated over 100 liters of raw sewage flows into the bay every single second (Alderton). The bay is so toxic with waste, trash, and bacteria that after ingesting only a few tablespoons, a person can inherit parasites and diseases that can lead to permanent damage to the heart and brain or even death (Alderton). According to a study published in Science Direct, not one of the five main regions of the Guanabara Bay watershed scored above 70% on the water quality grade scale, and three of the five scored below 40%, resulting in a grade of an F (Fries). A similar result was found for the water quality of the bay itself (Fries).

This dramatic change has occurred because, for almost the past seventy years, the amount of sewage entering the bay has been nearly five times the amount that has been properly treated and transported elsewhere (Fries). For the first 40 years of its existence, the problem was mostly ignored by the Brazilian government and the international community at large. However, this changed when Rio de Janeiro hosted the United Nations Conference on Environment and Development in 1992. Having representatives from all over the world gather to speak about the importance of our environment in the middle of perhaps one of the most polluted cities in the world resulted in more coverage of the environmental issues in the city. When Rio bid on the 2016 Olympics, the Brazilian government promised that they would clean, dispose of, and

reduce sewage output into their bay and city by up to 80% (Branch). As of the writing of this in 2022, the government hasn't come close to meeting these goals as the sewage output into their bay only has increased in the past few years.

The impact on the average person living in and around the Guanabara Bay watershed has been extremely negative. The urban center of Rio itself has consistently scored a grade of F with an overall score of 4% on various water quality tests which have been performed in the area (Fries). The most unsanitary and dangerous neighborhood in Rio is Senador Camera. This neighborhood is almost completely controlled by violent gangs and drug dealers. Camera is one of more than 600 shantytowns, or favelas, in Rio which is overcrowded, polluted, poorly ventilated, where gangsters and sexual diseases run rampant (Fraser). More than 1.2 million residents live in these favelas where the infant mortality rate sits at 54.8 per 1000 births (Fraser). This mortality rate is comparable to war-torn nations like the Democratic Republic of the Congo. These problems highlight that the pollution issue is so crucial because it also is exacerbated by various other crime and infrastructure problems. All of these factors come together to lower the life expectancy in these favelas to 13 years lower than the national average (Szwarcwald).

However, the main cause for these horrifying statistics is the lack of proper sanitation. Young children regularly play a stone's throw from pits of raw sewage. When it rains, the sewage flows into the streets and people's homes. Just breathing in the air can lead to diseases such as gastroenteritis which can cause symptoms such as fever, vomiting, and even death if left untreated. Along with very little basic sanitation, poor infrastructure limits access to the few hospitals that surround the slums and has led to epidemics of diseases like E. coli, Typhoid fever,

Salmonellosis, Hepatitis A, and others in the area. Moving out of the favelas isn't an option for 1.2 million who live in Rio's slums, as the average wage is £1 per day (Loewenburg).

Along with the lack of clean food that comes with poor sanitation, the pollution in Rio has other unforeseen effects on food distribution. For much of its history, fishing has been a huge industry for the people around Guanabara Bay. The fish are either sent to far-off domestic or foreign markets, or they are sold in local markets to help feed the growing population. However, as a direct result of the bacterial count in the bay, fishery yields have declined by as much as 10% in the last 30 years (Fistarol). The Brazilian government's attempts to mitigate the issue of trash and waste floating into the bay have also hurt subsistence fishermen. City officials have strung filters and nets across tributaries feeding into the bay in an attempt to keep trash out. However, this blocks fishermen from accessing the bay to get to their source of food and profit. All of this means that thousands of families in the city are going with less food, leading them to have less time to put toward acquiring good sanitation. This has become a deadly positive feedback loop.

As mentioned before, there have been some attempts by the Rio de Janeiro officials and the Brazilian government to rectify the issue, however, they have all fallen short in some critical way. For example, as recently as 2020 the government has put forth a program that would upgrade the sewers in Rio's Military District which has infrastructure dating back to as early as 1908 (Alderton). With very few maps of the actual pipes running under the area, the city employed Building Information Modeling (BIM) technology. BIM is an artificial intelligence-powered three-dimensional modeling program that helps architects more accurately and

efficiently construct their projects. This process has yielded some success as the once common flooding of sewage in the district, has stopped. However, the district is just a small neighborhood and this more efficient building technology will not be fully incorporated into the daily Brazilian infrastructure planning process until 2028 (Alderton). This is not an immediate solution or one that is making rapid progress in solving the issue.

Another proposed solution by philanthropists is the device known as a biodigester. A biodigester is a piece of technology made of brick and cement that collects all of a neighborhood's or town's waste into itself, where anaerobic bacteria will feed on and break down the waste until it is 99% less hazardous to people or the environment (Khazan). Then the waste is further sanitized by passing through a natural filtration system of plant roots. It also costs as much as a sixth of installing a new sewer system. There are many critical setbacks, however. Each biodigester is about the size of an apartment, so implementing them into the crowded slums of Rio de Janeiro or any other poor urban area is impractical. Most biodigesters also rely on a complex system of pumps to keep the sewage flowing which is not simple by any means. Also, these biodigesters provide few economic or job opportunities for the locals in the region. Finally, the Brazilian government has shown little interest in this project as it has mostly been funded by small private organizations in the region. This proposed solution's practical issues highlight the inherent complexity of the problem in general.

One of the most efficient processes that will improve the situation greatly has already been implemented elsewhere in the world. While it may not resolve the big picture problem of government intervention to stop all pollution in the entire region, it will still make a dramatic

difference in how much waste is put into the surrounding area. In Nairobi, Kenya, a small organization with only about 400 employees combats a similar problem. According to how much the population continues to grow and the government budget for new sanitation projects, it will take almost 150 years to provide adequate sewage coverage to the whole country (Otiento). However, the company Sanergy has come up with a solution that costs one-fifth of building regular sewage infrastructure. Their approach was launched on November 19th, 2011, or World Toilet Day (Otiento). Their business ideas were originally pitched at MIT's business plan competition and beat out 280 other projects to gain \$100,000 in funding (Shields). Step #1 of the process is to install small, port-a-potty-like bathroom units in highly populated areas such as Nairobi's slums and employ locals in the area to remove the waste and keep the unit in good shape. Even though they are only operating in Kenya, so far they remove an estimated 13,000 tons of waste that would have polluted the cities and rivers of Kenya (Otiento). In 2015, Sanergy had implemented 615 toilets which accommodated 32,000 people (Shields). Step #2 is to convert the waste into fertilizer to then be sold at an affordable price to local Kenyan farmers resulting in a 30% increase in crop yields (Otiento). Their novel solution includes collecting the waste in a central facility and introducing black soldier flies (Maguom). These flies feed on the waste and their larvae and the waste are sold as fertilizer to local farmers at an affordable price. Their goal was to expand the amount of treated waste given to farmers to 40,000 tons per year (Shields). In 2021, Sanergy's stations reached a capacity of 72,000 per year. In 2022, they received a \$2.5 million donation from the Japanese International Cooperation Agency to continue expanding so it could provide more fertilizer (Maguom). Step #3 is to use the money earned by selling it to the

farmers to pay the local caretakers of the bathroom units and to expand operations to new cities and locations.

I propose to place a model similar to Sanergy's in the heart of a neighborhood like Senador Camera. While the Brazilian government works with BIM technology and gets the funding to modernize their infrastructure, Sanergy's method could be used in the short term to give desperately needed proper sanitation to the people of Rio. This would allow for a clean place for people to relieve themselves, while also keeping the waste out of the river system and bay. The cleaner water would allow inhabitants to gain higher fish yields and possibly make the water of the bay's tributaries drinkable, offsetting both thirst and hunger in those areas. It would provide a consistent wage to hundreds of local employees, leading to fewer people turning to organized crime out of desperation. Finally, and most importantly, it would decrease child mortality and increase life expectancy. Cholera kills tens of thousands of people every year through the ingestion of water contaminated with fecal matter. It is common in crowded urban areas like Rio.

Safely disposing of the sewage which spreads these diseases would save countless lives. Each toilet costs anywhere from \$290 to \$500 (Mlambo). They aren't cramped, being 8 feet tall, 4 feet wide, and 6 feet long (Mlambo). They're open-top to allow for maximum ventilation to reduce the buildup of airborne diseases while being emptied often enough to prevent the buildup of flies. Soap, water, and toilet paper are provided and replenished at each toilet station. The waste is emptied by wheel barrow by an employee frequently and then carted to the facilities where the flies feed on it.

While from a sanitation perspective the Sanergy solution would be a success, would it be an economic success as well? The profit which allows Sanergy to pay the local employees is made from selling the fertilizer to local farmers. The main expenses are the above-mentioned installations of the toilets and the salaries of the hundreds of maintenance workers. However, the revenue far outweighs the issues of cost for two reasons. The method of using black soldier flies to make fertilizer is incredibly cheap and is less expensive than other forms of waste sterilization. Also, fertilizer is in incredibly high demand currently. Due to the recent Russian-Ukrainian crisis, global fertilizer prices have risen dramatically due to sanctions preventing the export of Russian fertilizers (Polansek). The price of fertilizers has increased in the US by as much as 12% in the last few months (Polansek). In Brazil, this shortage has resulted in a 60% increase in overall farming costs (Freitas).

The Sanergy method would provide desperately needed fertilizer to struggling Brazilian farmers. It would not only increase food security by increasing fish yields in Guanabara Bay, but it would also increase agricultural output during this global crisis and help put food on the tables of thousands throughout the whole country. The high prices would also ensure that they make a sizable enough profit to pay all of their local employees a healthy wage. While not bringing a complete end to the problem in Guanabara Bay, such a project could help the environment and thousands of people tremendously as similar processes have all across the world.



## Bibliography

Fraser, Barbara. "Growing up in Rio's Favelas." Define\_me, 21 May 2011, [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(11\)60717-4/fulltext?rss%3Dyes=](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(11)60717-4/fulltext?rss%3Dyes=). Accessed 13 February 2022

Fries, Alexandra S., et al. "Guanabara Bay Ecosystem Health Report Card: Science, Management, and Governance Implications." *Regional Studies in Marine Science*, Elsevier, 13 Dec. 2018, [www.sciencedirect.com/science/article/pii/S235248551830238X](http://www.sciencedirect.com/science/article/pii/S235248551830238X). Accessed 12 February 2022

Fistarol, Giovana O., et al. "Environmental and Sanitary Conditions of Guanabara Bay, Rio De Janeiro." *Frontiers*, Frontiers, 20 Nov. 2015, <https://www.frontiersin.org/articles/10.3389/fmicb.2015.01232/full>. Accessed 24 February 2022

Szwarcwald, Célia Landmann, et al. "Health Inequalities in Rio De Janeiro, Brazil: Lower Healthy Life Expectancy in Socioeconomically Disadvantaged Areas." *American Journal of Public Health*, American Public Health Association, Mar. 2011, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3036699/>. Accessed 23 February 2022

Shields, Ben, and Edward Ruehle. "The Sanitation Crisis and Social Media: Sanergy in Kenya." MIT Sloan, 9 July 2016, <https://mitsloan.mit.edu/teaching-resources-library/sanitation-crisis-and-social-media-sanergy-kenya#:~:text=Founded%20in%202011%20by%20three,fertilizers%20sold%20to%20Kenyan%20farmers>. Accessed 10 March 2022

Konkel, Lindsey. "What's in Rio's Bay and Beaches?" Science, National Geographic, 4 May 2021, <https://www.nationalgeographic.com/science/article/what-s-in-rio-s-bay->. Accessed 4 February 2022

Branch, John. "Who Is Polluting Rio's Bay?" The New York Times, The New York Times, 28 July 2016, [www.nytimes.com/interactive/2016/07/28/magazine/rio-sarapu-guanabara-bay-pollution.html](http://www.nytimes.com/interactive/2016/07/28/magazine/rio-sarapu-guanabara-bay-pollution.html). Accessed 1 February 2022

Alderton, Matt, et al. "Brazilian Army Battles Pollution in Rio's Toxic Guanabara Bay Using BIM." Redshift EN, 13 Apr. 2020, [www.autodesk.com/redshift/pollution-guanabara-bay/](http://www.autodesk.com/redshift/pollution-guanabara-bay/). Accessed 25 February 2022

Otiento, Michelle. "Home." Sanergy, [www.sanergy.com/](http://www.sanergy.com/). Accessed 27 February 2022

Mallon, Sandra Carnota. "Waves of Trash Expose Rio's Environmental Deterioration." Www.efe.com, 21 Apr. 2019, [www.efe.com/efe/english/business/waves-of-trash-expose-rio-s-environmental-deterioration/50000265-3957235](http://www.efe.com/efe/english/business/waves-of-trash-expose-rio-s-environmental-deterioration/50000265-3957235). Accessed 12 March 2022

Khazan, Olga. "The Cheap, Easy Fix to the Olympics' Sewage Problem." The Atlantic, Atlantic Media Company, 4 Aug. 2016, [www.theatlantic.com/science/archive/2016/08/a-cheap-easy-fix-to-rios-sewage-problem/494354/](http://www.theatlantic.com/science/archive/2016/08/a-cheap-easy-fix-to-rios-sewage-problem/494354/). Accessed 10 March 2022

Waldek, Stefanie. "5 Of the Dirtiest Beaches in the World - and Where to Go Instead." Business Insider, Business Insider, 9 July 2017, [www.businessinsider.com/5-of-the-dirtiest-beaches-in-the-world-and-where-to-go-instead-2017-7](http://www.businessinsider.com/5-of-the-dirtiest-beaches-in-the-world-and-where-to-go-instead-2017-7). Accessed 13 February 2022

Biller, David. "Brazil Privatizes Rio De Janeiro's Water, Sewage Utility." The Seattle Times, The Seattle Times Company, 30 Apr. 2021, [www.seattletimes.com/business/brazil-privatizes-rio-de-janeiros-water-sewage-utility/](http://www.seattletimes.com/business/brazil-privatizes-rio-de-janeiros-water-sewage-utility/). Accessed 23 February 2022

US Department of Commerce, National Oceanic and Atmospheric Administration. "A Guide to Plastic in the Ocean." NOAA's National Ocean Service, 20 Sept. 2018, [oceanservice.noaa.gov/hazards/marinedebris/plastics-in-the-ocean.html](http://oceanservice.noaa.gov/hazards/marinedebris/plastics-in-the-ocean.html). Accessed 3 February 2022

Loewenburg, Samuel. "Tackling the Causes of Ill Health in Rio's Slums." Define\_me, [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(05\)71062-X/fulltext#:~:text=Poverty%20is%20the%20root%20cause,new%20approach%20to%20health%20promotion](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(05)71062-X/fulltext#:~:text=Poverty%20is%20the%20root%20cause,new%20approach%20to%20health%20promotion). Accessed 28 March 2022

Carless, Will. "Rio's Water Cleanup Barely Works and It's Crimping Impoverished Fishermen." The World from PRX, 9 Feb. 2017, <https://theworld.org/stories/2017-02-09/rio-s-water-cleanup-barely-works-and-it-s-crimping-impoverished-fishermen>. Accessed 20 March 2022

Mlambo, Lynnet. "Sanergy Living up to Its Brand; Fresh Life, Live Fresh..." Kiva, <https://pages.kiva.org/blog/sanergy-living-up-to-its-brand-fresh-life-live-fresh>. Accessed 10 March 2022

Magoum, Inès. "Kenya: Sanergy Gets \$2.5 Million for Fertilizer and Protein from Waste." Afrik 21, 13 Oct. 2021, <https://www.afrik21.africa/en/kenya-sanergy-gets-2-5-million-for-fertilizer-and-protein-from-waste/>. Accessed 25 March 2022

Polansek, Tom, and Ana Mano. "As Sanctions Bite Russia, Fertilizer Shortage Imperils World Food Supply." Reuters, Thomson Reuters, 23 Mar. 2022, <https://www.reuters.com/business/sanctions-bite-russia-fertilizer-shortage-imperils-world-food-supply-2022-03-23/>. Accessed 28 March 2022

Freitas, Tatiana. "Brazil Farmers Caught in Wrong-Way Bet on Fertilizers as War Drives Up Prices." Bloomberg.com, Bloomberg, <https://www.bloomberg.com/news/articles/2022-03-21/ukraine-war-sours-fertilizer-bets-of-brazil-farmers-seeking-cuts>. Accessed 29 March 2022