

Gabrielle Westhoff
Beckman Catholic High School
Dyersville, Iowa, United States of America
Bangladesh, Water and Sanitation
April 3rd, 2025

Bangladesh: Fungal Remediation for PFAS Water Pollution

Bangladesh is a country in Southern Asia that shares borders with India and Malaysia. It is currently experiencing a water crisis in part due to the practices of the textile industry, which the nation relies on. In this paper, I will discuss the potential development and implementation of fungal remediation on PFAS chemicals and other wastewater contaminants, and its role in solving the ongoing water crisis in Bangladesh.

With an area approximately the size of Iowa, Bangladesh has a population of more than 168 million, 56 times that of Iowa. This has made it one of the most populous countries in the world (CIA, 2025). This comes with its own set of issues. Political and economic strife led to a famine in the 70's. However, according to the Global Hunger Index, an annual report tracking hunger globally, Bangladesh's rates of hunger have been improving for a number of years. As of 2024, Bangladesh has reached a 19.4% GHI score, classifying it as a low hunger country. This is down from the medium hunger, 24.7% GHI score, it received back in 2016 (Global Hunger Index, 2024). Economic and political stability have allowed the country to make great strides in growth.

Like Iowa, the Bangladesh economy was built around agriculture. The primary agricultural products in Bangladesh are rice, starchy vegetables, and tropical fruits. Nowadays, the country's economic focus has shifted towards ready-made garments, of which it is the second largest exporter in the world (CIA, 2025). These two industries have become the backbone of the Bangladesh economy, and thus the standards they set have implications on the entire country.

In Bangladeshi culture, the family is the highest priority, even above work. In the workplace, there is a strong organizational hierarchy and respect for authority that feeds directly into professional interactions. Communication relies heavily on the shared cultural understanding, non-verbal cues, and context clues rather than explicit verbal instruction (Rivermate, n.d.). This allows for expedient and precise communication, but the strict hierarchical structure can limit the interaction and create a disconnect between lower-level workers and management.

While Bangladesh's economic growth has greatly improved food security in the country, it has had negative impacts on the water quality. According to an article by the European Parliament, approximately 20% of the world's freshwater pollution comes from dye and finishing products (2024). Some chemicals used in fixing and finishing are known carcinogens and mutagens. Because these chemicals are released into the environment, they place not only the workers but also the general public at risk.

One particularly harmful category of these chemicals are PFAS chemicals. Within the textile industry, Per- and polyfluoroalkyl (PFAS) are used primarily in the finishing of fabrics to give them a variety of qualities such as stain resistance or fire retardancy. However, their resistance to degradation has made them incredibly environmentally persistent, giving them the name 'forever chemicals', (Hossain et al., 2024). They are unable to degrade by natural means and can thus make their way into the water, soil, air,

plants, food supply, and animals, including people. Knowledge of their effects on health and the environment has increased the urgency with which this situation must be addressed.

There has been much testing done on the effects different PFAS chemicals have on the environment and humans, but because there are thousands currently in use, a comprehensive knowledge is realistically unattainable. In tests of commonly used chemicals, PFAS have been linked to harm in fetal development, fertility, and thyroid hormone function; some have even been connected to a weakened immune system, liver damage, and cancer (Hossain et al., 2024). These effects are felt even more acutely by the community surrounding production facilities, as they face the most direct risk of exposure and contamination.

I am choosing to focus on the issue of water quality in Bangladesh due to my recent research project on the use of fungal remediation for dye wastewaters. The production processes of the textile industry allow contaminants to enter the environment in a multitude of ways. When the wastewater is not properly treated, the contaminants, like PFAS, are released into the environment. Fungi have already been shown to grow off of plastics, and recent developments in fungal remediation show that they have the potential to remediate dye wastewater. This makes them a very promising candidate for remediating this hazardous wastewater containing PFAS. Bangladesh's prominence as the second largest exporter of ready-made textiles means that the way the industry operates has a substantial impact on the nation.

Alternatives to commonly used PFAS chemicals and processes are available, but manufacturers have not chosen to use them. Instead of using the explicitly banned chemicals, they have likely shifted to using unregulated fluorinated polymers that can degrade into PFAS chemicals, including the globally banned PFOA (Hossain et al., 2024). This can be for a number of reasons, but in the end, the manufacturer's actions ignore the reason they are so heavily regulated and needlessly endangers human lives.

There are some limitations to the existing alternatives currently in the market. Alternatives are widely available for many PFAS chemicals and the processes that they are used for. Some specialized textiles, such as flame retardant cloth, have viable alternatives while others do not, and more research is needed to show if they are feasible in the industrial supply chain (European Environment Agency, 2024). Increased dedication by companies is needed to fully determine whether these alternatives are viable, but even if the current methods are not, then companies should be invested in the search for other options.

As of now, there is still a need for some of the PFAS chemicals in textile manufacturing. Alternatives are not yet available for Flame-retardant and medical-grade textiles needed for personal protective equipment (European Environment Agency, 2024). These materials are essential to the health and safety of many and thus cannot be substituted until alternatives have been thoroughly tested. However, these materials account for only a small portion of total manufacturing and thus have little bearing on the overall advancements that can be made towards sustainability in the textile industry.

Earlier this year, I ran a research project testing the efficacy of fungi in the remediation of commercial dyes. In this project, I explored the effectiveness of living and non-living fungi in the remediation of dyes by the use of mycoremediation. Mycoremediation is the process of using fungi to remove, degrade, or remediate pollutants, and it is now being explored as a way to decompose industrial dye effluent. In my

research, I focused on the effects of the digestive enzymes and absorptive hyphae in removing and degrading dye.

In my testing, I discovered that there was a notable difference in the absorbance and transmittance of light before and after treatment. It was not my goal to completely eliminate the presence of dyes at the time of testing, merely to test whether the fungal strains used would have an effect. The results of these tests provided promising results for the remediation of commercial dye. I believe that similar processes can be applied to the treatment of PFAS chemicals.

I am not the first to consider biological processes as a method for solving these issues. An article in the *Asian Pacific Journal of Environment and Cancer* reviewed many of the current biological techniques using fungi, bacteria, and algae for the removal of PFAS chemicals. While many other methods are only moderately effective and still produce toxic byproducts, biological treatment methods are cost-effective, simple, and do not produce the same toxic byproducts (Douna & Yousefi, 2023, pg 55). There are some conditions that must be met for them to work, but once they are, there are numerous benefits over alternative methods of remediation. The solution that I have proposed here would not solve the already existing pollution, but it would reduce the rate at which the water crisis is worsening and improve the health of the communities production facilities operate in.

There are some challenges that arise with this solution due to the cultural context in which it would be used. Because of the strongly hierarchical nature of companies in Bangladesh, any major change such as this would likely need to be initiated in a place of authority. It would be difficult for this change to get started in lower levels of the command structure and make a strong impact because the employees have little authority on how the company is run despite being the ones facing the highest risk. However, an employee in a high-level position would be further removed from the processes occurring and their effects on the general populace, and thus less likely to act.

The most likely way for there to be such a shift in processes is through increased government regulation and incentives. Government regulations regarding PFAS chemicals and wastewater disposal are in place, but would need to be tightened and enforced. Manufacturers could be incentivised to employ safer dyeing processes through government programs and widespread social pressure. These would be hard to ignore and have lasting positive effects on the environment, sanitation, and public health.

In addition to social pressure, there are monetary incentives as well. The high production within Bangladesh's agriculture industry results in readily available agricultural crop waste, which can be used as a low-cost substrate for bioremediation. Rice straw, wheat straw, rice husk, jute stick, and sugarcane bagasse, in combination with other forms of waste, are already being investigated as a source of biofuel, so pathways are partially in place for supplying these materials to the industrial market (Islam et al., 2021). The lowered waste management cost using local materials in combination with the positive PR of lowered pollution and tightening restrictions on PFAS chemicals and production processes would incentivise companies to consider bioremediation as a potential solution.

Through the development and implementation of disposal processes like fungal remediation, the textile industry can make progress towards solving the water crises happening in Bangladesh and countries around the world. Governmental regulation and aid will likely be necessary for any industry-wide change,

but there is hope for many current and developing alternatives to enter the global market, especially in countries with high levels of organic agricultural byproduct. Bangladesh's prepared garment industry is the backbone of its economic stability, so reducing water contamination will have national and international benefits.

References

- Barois, Z. O., Hasan, M. M., Ahmed, F., Rozario, S. R., Islam, M. A., Kazal, M. M. H., Shaheen, N., & Dengerink, J. (2024, May 6). *An Overview of the Bangladesh Food System: Outcomes, Drivers & Activities*. Foresight4Food. Retrieved April 1, 2025, from https://foresight4food.net/wp-content/uploads/2024/05/Bangladesh-May-2024_final_V2_cleanversion-002.pdf
- CIA (2025, March 25). *Photos of Bangladesh - The World Factbook*. CIA. Retrieved April 1, 2025, from <https://www.cia.gov/the-world-factbook/countries/bangladesh/#geography>
- Douna, B. K., & Yousefi, H. (2023). Removal of PFAS by Biological Methods. *Asian Pacific Journal of Environment and Cancer*, 6(1), 53-64. <https://waocp.com/journal/index.php/apjec/article/view/1030#sec-1-4>
- European Environment Agency. (2024, September 17). *PFAS in textiles in Europe's circular economy | European Environment Agency's home page*. European Environment Agency. Retrieved April 1, 2025, from <https://www.eea.europa.eu/en/analysis/publications/pfas-in-textiles-in-europes-circular-economy>
- European Parliament. (2024, March 21). *The impact of textile production and waste on the environment (infographics) | Topics*. European Parliament. Retrieved April 3, 2025, from <https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics>
- Global Hunger Index. (2024). *Bangladesh*. Global Hunger Index. Retrieved April 1, 2025, from <https://www.globalhungerindex.org/bangladesh.html>
- Hossain, S., Strakova, J., Sultana, S., Alam, S.F., Trisha, T.H., Rabbani, G., Brosche, S., Howard, R., & DiGangi, J. (2024, May). *Persistent Threat: PFAS in Textiles and Water in Bangladesh*. ESDO and IPEN. Retrieved April 1, 2025, from <https://ipen.org/sites/default/files/documents/pfas-textiles-water-bangladesh-v3.pdf>
- Islam, M. K., Khatun, M. S., Arefin, M. A., Islam, M. R., & Hassan, M. (2021). Waste to energy: An experimental study of utilizing the agricultural residue, MSW, and e-waste available in Bangladesh for pyrolysis conversion. *Heliyon*, 7(12), 1. ScienceDirect. <https://doi.org/10.1016/j.heliyon.2021.e08530>
- Rivermate. (n.d.). *Bangladesh Overview*. Rivermate. Retrieved April 1, 2025, from <https://www.rivermate.com/guides/bangladesh/overview>