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Microalgae Photo-Bioreactors (*LIQUID3*) as an Alternative to Counter CO₂ Air Pollution and Generate O₂ and Biomass in New Delhi, India.

Picture this, Among the most populated cities in the world, the headquarters of the executive, legislative, and judicial power of the entire nation; is a place where the sites and monuments that conform to the culture of the city are hidden under thick layers of smog, where kids regularly can't go to school due to the air condition, feeling shorts of oxygen when going outside, where pollution causing around 264930 deaths every year (*Air Pollution Deaths: What Troubles Delhi Today May Haunt Mumbai Tomorrow* / J. Basu, August 2022). That so, is the actual circumstances of New Delhi, India.



Figure 1. Photography of the smog and air condition in New Delhi, India.

Thomas, V., & Tiwari, C. (2022, March 9). Delhi, the world's most air-polluted capital fights back. *Brookings*.
<https://www.brookings.edu/blog/future-development/2020/11/25/delhi-the-worlds-most-air-polluted-capital-fights-back/>

New Delhi is amongst the most populated and air-contaminated cities on the earth, with a pollution concentration that is over 100 times more than the recommendation of the WHO (World Health Organization) (Martínez et al., 2016), breathing PM_{2.5} (Particulate Matter), a combination of solid and liquid particles on the air that when it's above a concentration of 35 µg/m³ during 24 hours-periods, it converts into a health-risking pollutant that can cause lung cancer and various lung-related diseases (Devadmin, 2021). This terrible air quality has

diverse factors, such as the growing overpopulation of the city, when at this moment, it's approx. to be around 3206600 people.

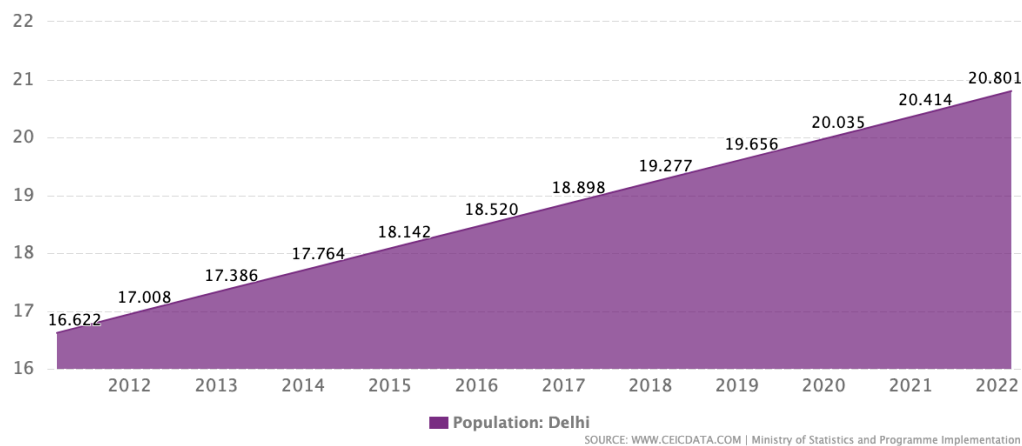


Figure 2. The demographic of the population in New Delhi.

CEICdata.com. (2022). India Population: Delhi. [www.ceicdata.com.](https://www.ceicdata.com/en/india/population/population-delhi)
<https://www.ceicdata.com/en/india/population/population-delhi>

This overwhelming growth of population that New Delhi has experienced directly correlates to other causes of pollution such as fossil fuels emissions (vehicular emissions) and the lack of an infrastructure that can hold all the urban and commercial needs of New Delhi. But interestingly, even when New Delhi has serious fuel emissions and population infrastructure problems that contribute to its dangerous PM_{2.5} levels, the city is not the most significant cause of its decay.

New Delhi is located next to Punjab and Haryana, critical countries for the plantation and cultivation of rice, which requires large amounts of water, so broadly, that the region's groundwater started to go low. As a precautionary measure, the Indian government passed an act in 2009 that states *"No farmer shall transplant paddy before 15th June of the year or such date, as may be notified by the State Government"*, This prohibits farmers from cultivating rice before the rainy season, that it's on the ends of July. Pushing harvesting later the same years, shortening the time that farmers have to prepare the fields for the new plantations, so to clear more efficacy and quickly, farmers burn their crops, all this air heads straight to New Delhi. This burning of crops, combined with geographical factors such as the fact that Delhi is located on a flat plain, where the Himalayan mountains block airflow on the city, creating the smogs and pollution just above the city, leaving no airflow to either the burning crops air and the urban pollution of New Delhi to spread away and that during winter, the air flows and directions that come from the mountains go down towards Delhi just beneath a warm lowland air, creating a barrier that doesn't let go the smog. (Vox, 2019)

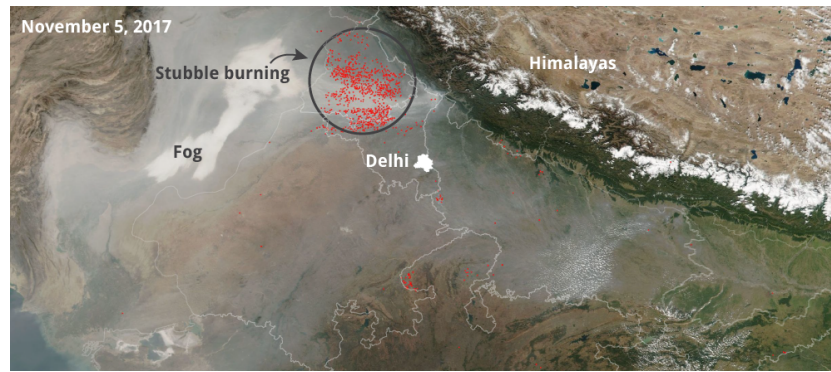


Figure 3. Geographical mapping of pollution flow in Delhi.

Katakam, A. (2018, November 8). Delhi could blame location, wind flow, and the Himalayas for its terrible air – or it could blame itself. *Scroll. in.* <https://scroll.in/article/901029/delhi-could-blame-location-wind-speed-himalayas-for-its-terrible-air-or-it-could-blame-itself>

As in culture, New Delhi families normally tend to extend the typical nuclear family unit and create large families that can provide economic security to individuals. Most of India is conservative when talking of gender and household roles, where the father, son, uncles, and men work and bring economic support to the family in general while the mother takes care of the daughters and babies at the house, with a big predominance of patriarchal structures. (*Indian Culture - Family*, 2018)

In 2019, New Delhi's average household size was 4.57 (*Average Household Size - Area Database - Table - Global Data Lab*, n.d.). According to Expatistan.com, a family of four estimated monthly costs: of Rs147,465 (1,778.13 USD), where the highest worker salary is around 20903 INR (252.21 USD). This has caused New Delhi streets and households to have poor infrastructure and be congested. This lack of infrastructure directly correlates with the economic growth and development of a city, which breaks the chain of production, lowering the standard of living in a country (Rw-Admin, n.d.). So to summarize, the poor infrastructure makes unachievable the use of expensive solutions in New Delhi, affecting directly the way of living and health of thousands of civilians. In a survey conducted by LocalCircles in 2022: "80% of families revealed that they are "facing multiple issues due to pollution" and 7% indicated that they have had "no issues at all due to pollution".

The survey showed that 18% of Delhi NCR families have had one or more members visit a Doctor or a Hospital for pollution-related ailments in the last few weeks." (Livemint, 2022)

The residents of New Delhi have witnessed the attempts of various solutions to reduce air pollution concentrations, most of them being politicized such as the rice crops law. The

extensive plantation of trees doesn't seem possible due to plants and trees dying around critical points of the city where there are high concentrations of pollution there's no appropriate area where a massive quantity of trees could be planted to balance CO₂ and PM_{2.5}. Lastly, the full maturation of the tree could take 20 years, while the consequences are immediate, making it impossible to counteract the consequences of pollution and lack of oxygen in the air. The lack of O₂ is the one that causes more than 30000 deaths annually, air-related diseases, and the impossibility of doing outdoor exercises and activities along the city; only in 2017, it was registered 1.24 million deaths because of air pollution. This also directly correlates with impacts on the economic and industrial growth of New Delhi, focusing on just the emissions is no longer a viable solution. (*Delhi Air Quality Index (AQI) and India Air Pollution* | IQAir, n.d.), t

One of the most prominent diseases in New Delhi is lung cancer, which is generated by almost 50% PM_{2.5} concentrations, Lung cancer treatments have the next costs according to *Adotrip, India (2022)*:

Table 1. Different lung cancer treatments and their costs in Delhi, India.

Treatments	Cost
Chemotherapy (per session)	Indian Rupees: 13000 to 30000 INR Dollars: 156.95 to 362.20 USD
Immunotherapy	Indian Rupees: 200000 to 400000 INR Dollars: 2414.64 to 4829.28 USD
Radiation Therapy	Indian Rupees: 60000 to 400000 INR Dollars: 724.39 to 4829.28 USD
City-wise lung cancer treatment	Indian Rupees: 100000 to 400000 INR Dollars: 1207.32 to 4829.28 USD

Table 2. Category of workers and their minimum wages in Delhi, India (Upadhyay D., 2023)

Category of workers	Minimum Wage (in Indian Rupees and Dollars)
Highest category workers	Indian Rupees: 20903 INR Dollars: 252.21 USD
Medium category workers	Indian Rupees: 18993 INR Dollars: 229.16 USD
Lowest category workers	Indian Rupees: 17234 INR Dollars: 207.94 USD

Comparing the table and the minimum wages, funding these treatments is hard labor for the workers of Delhi. The consequences of the pollution above them are prices that the citizens can't afford to pay, so the solution must be something that people can afford.

This is where I propose as a viable solution, the use of the recently popular “Liquid Trees”, part of the project *LIQUID3*, an urban photoreactor developed by the Institute of Multidisciplinary Research of Belgrade, Serbia; that uses cultivating microalgae to produce O_2 and biomass, countering CO_2 production. It is perfect for urban development with a lack of space, heavy air pollution, or no proper soil for tree plantations (*LIQUID3 - the Index Project*, 2023). It can produce over the same amount of O_2 as 2 adult trees or 200 m² of lawn. The cultivating microalgae have a useful life of approx. 20 years, and it can also work during the cold seasons, This is because the bio-reactor works by photosynthesis, with a light that is above the reactor itself that is working day and night, This light uses solar panels as energy to light the microalgae.



Figure 4. LIQUID3 Photo-bioreactor on the streets of Belgrade, Serbia

Riccio, G., & Riccio, G. (2023). LIQUID 3, un árbol líquido para producir oxígeno en nuestras ciudades. *FuturoProssimo*.

<https://es.futuroprossimo.it/2023/04/liquid-3-un-albero-liquido-per-produrre-ossigeno-nelle-nostre-citta/>

Another advantage of this project is it works 10 to 50 times better than normal trees. Normally because of the high concentrations of pollutants in their soil and air, they don't survive most of the time under this type of urban conditions, but the microalgae don't have a problem resisting those conditions. As a “life-quality” advantage, *LIQUID3* works also as a bench, and has USB ports that can charge civilian phones, all this working by the same solar panels that keep enlightening the microalgae (Castim, 2022).

The goal is to set this project in the city of New Delhi, first localizing where the busiest areas are, and where there exist the highest concentrations of CO₂ in the air. I haven't discovered the costs of the *LIQUID3*, so it is needed to look for the materials of the bioreactor to give out an estimated price, also the creation of a presentation or a lookout at the product can help governments and especially, the New Delhi government's interests in the product and its benefits and places *LIQUID3* all along the city. It has accessible prices, only on maintenance of the microalgae culture, that goes about 60 euros or 5370 Indian Rupees, making it more accessible to invest in lung cancer treatments, giving the option to people pay for it like a tax or the government investing on it. Also, the design could be (to a certain extent) modified (I will also search and "sketch" into that) so it can fit tighter spaces and bring other goods to civilians (such as instead of a bench, can work as streetlights, also being solar powered). This project isn't looking to replace trees because these play essential roles in species and nature development itself. But for locations of the city where the planting of trees is impossible due to the lack of space or the high pollution, this is an alternative source to combat CO₂, while bringing other goods and advantages for civilians. Civilians can take action by first educating themselves on the current situation they are living in, implementing easy, classic sustainable measures in their homes, and advocating for new renewable energies and eco-solutions in their cities, Citizen help is also required for any project to succeed, they can give data-information and take the initiative that is crucial for a solution like this to work.

As for how to sponsor this proposal, I have thought about several options for how *LIQUID3* could be funded. We could do it by contacting NGOs (non-profitable organizations) in Delhi and India, such as The *Centre for Urban and Regional Excellence* (CURE), a non-profit development association that operates near urban and low-income communities, to pledge and incorporate individuals into city strategies, which could support it.

CURE treats and mobilizes women and youth in lower-income districts, especially urban spaces, to access water supplies, sanitation, electricity, livelihoods, schooling, health care, and housing. It operates at all levels of governance – national, state, and local. (Seruds India, 2022). As the official website of CURE dictates, it is suitable and recommended to contact them via email or if possible, visit one of their different headquarters, located in New Delhi. As for delivering the idea, it is essential and I consider adequate the making of a presentation or meeting where it is demonstrated how *LIQUID3* works and its benefits on Delhi. CURE involves low-income communities in engineering solutions for city development, and has previously worked on projects regarding health, environment, and technology; so *LIQUID3* could be a fitting project for this organization, because it brings to citizens other urban goods such as benches, lights, and USB-ports chargers, while also

cleaning and counteracting the pollution, combining various factors that are similar to the goals and previous success stories from CURE.

As for international foundations, it could be applicable to contact and gain help from the *Bill & Melinda Gates Foundation*, which last year contributed around 1.661 Billion USD to charitable support in Global Health works and 1.890 Billion USD to Global Development works, whose target is the use of science and technology to transform the lifestyle poor communities (*About | Bill & Melinda Gates Foundation*, n.d.). Likewise, pursue the *Musk Foundation*, which concentrates its giving on a few distinctive areas that compromise around renewable energy, space exploration, pediatric investigation, and science and engineering schooling (*Musk Foundation: Should You Pursue Their Grants?* n.d.).

This work taught me about how *LIQUID3* can also be applied in other cities that suffer from the same crises around the world, and this process of work taught me about compromise and how important is it, to the point that I'm working separately on how this information can be applied in my hometown. The solutions are out there, and science and technology are advancing at a quick pace, so the conflicts and solutions shouldn't be taking baby steps, action is required now.

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