International Journal of Engineering Research and Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 21, Issue 9 (September 2025), PP 45-56

"Green Infrastructure and Technological Innovation: The Role of LIQUID 3 in Air Pollution Reduction in Bosnia and Herzegovina"

Emir Brulic
International Burch University, Faculty of Engineering, Natural and Medical Science, Department of Architecture, Sarajevo, Bosnia and Herzegovina

ABSTRACT
This research examines the potential of LIQUID 3, an urban photobioreactor with microalgae, as an innovative tool for mitigating air pollution and complementing traditional greenery in cities. Through photosynthesis, LIQUID 3 captures carbon dioxide and produces oxygen, supported by solar panels, built-in lighting, and a water-based system that enables year-round operation. Developed in response to Serbia's high pollution rates in 2020, LIQUID 3 serves as a case study for densely populated areas where green spaces are limited. Although critics stress that liquid trees cannot replace deforestation benefits or soil enrichment, designers emphasize their role in spaces unsuitable for traditional trees.The divided perspectives highlight the importance of recognizing LIQUID 3 as a complementary, not competing, approach. Integrating biotechnology, microbiology, and sustainability, such photobioreactors may shape future urban strategies for combating pollution and climate change, offering a technological path toward cleaner cities.

Key Words: *air pollution, greenary, liquid 3, bosnia and herzegovina*

Date of Submission: 02-09-2025 Date of acceptance: 11-09-2025

I. INTRODUCTION

Air pollution affects all humanity as a whole. It is one of the greatest social and environmental problems, with terrible consequences. In 1952, a large cloud of sulfate aerosols covered London for just 2 days, yet killed about 12 000 people. More recently, a 5 day smog period in 1985 in North-Rhine Westphalia put an estimated 4000 Germans in the hospital as a result of respiratory and cardiovascular failure. Unfortunately, these are not stand-alone incidents. Even by conservative estimations, air pollution reduces the average life expectancy in Europe by nearly a year (a total of 7 million life years are lost annually). With the rise in urbanization, the dangers of air pollution are increasing. Identifying the problem is easy, but treating it is much harder because air pollution is highly complex. In Figure 1 is shown that there are many types of pollutants, both anthropogenic and naturogenic. Moreover, quantifying the effects of specific pollutants is difficult because of periodical variations in pollution levels and correlation effects between pollutants. Choosing the right way to tackle air pollution is no mean task.

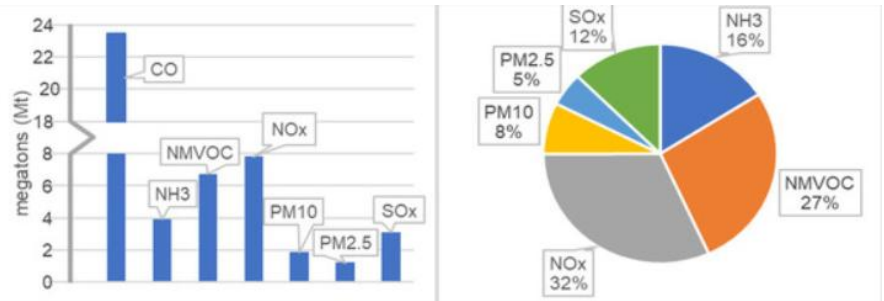


Figure 1: Column graph showing the estimated emissions in megatrons of pollutants in the EU28 in 2014 (left) and pie chart showing the corresponding vol % contribution of each pollutant if CO is excluded (right)Koolen, S. D. Prof.Dr.Rothenberg, G.(2018) –Air pollution in Europe

The significant relationship between the determined genotoxic activities and the PAHs pollution was also confirmed by a regression analysis. However, the correlations were not absolute because the observed genotoxic activity was also dependent on the presence of other organic pollutants than the PAHs. It concerns predominantly direct genotoxicity which is not related with the PAHs, but with their nitro-, oxi-, and hydroxy-derivatives and also other unknown polar organic pollutants. However, the concentrations of the direct genotoxins apparently correlated with the PAHs contents in the air. The study showed that screening genotoxicity tests, such as the SOS chromotest, could be effectively used for the identification of localities with increased genotoxic risks. In comparison with the health risk assessment which is usually based on the chemical analyses of only a small part of the pollution mixture, the bioassays enable us to evaluate the risks of all the mixture. The localities with the highest detected human health risks according to the screening bioassays may then be analyzed in detail with specific chemical methods to identify their causes.

Figure 2 and Figure 3 shows the data about PM10 in Sarajevo and Zenica, from 2014 up to the present day. Apparently, winter is especially problematic. In 2014 we reached 400, even 500 in the following years. Only in 2017 we had more luck thanks to the many windy days.

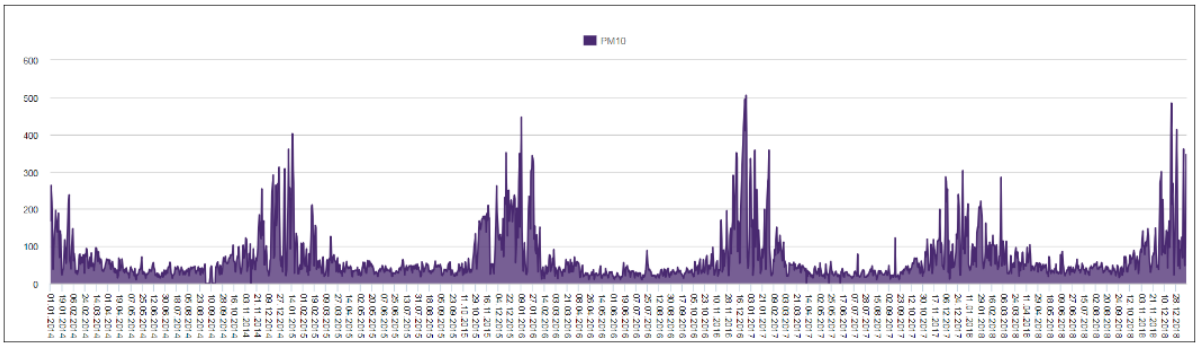


Figure 2: Sarajevo – average daily concentration of PM10 fine powders from 2014 to today, Podic, A., (2019) – Pollution in Sarajevo

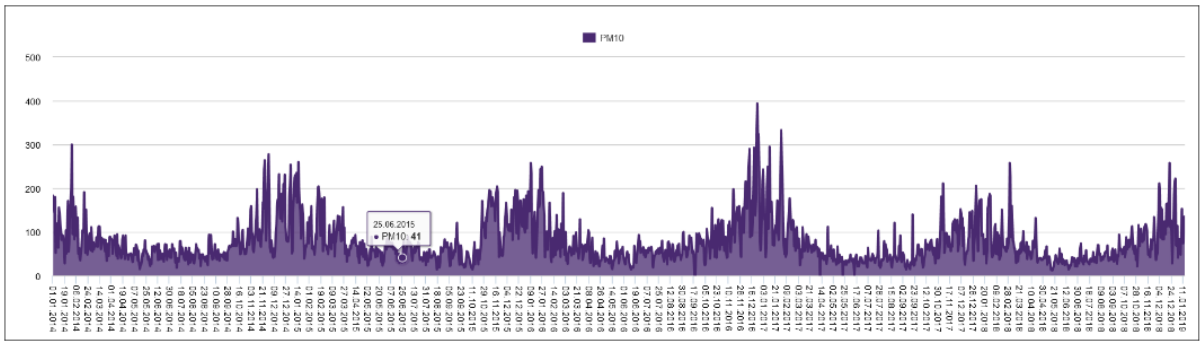


Figure 3: Zenica – average daily concentration of PM10 fine powders from 2014 to today, Podic, A., (2019) – Pollution in Sarajevo

One of the key challenges is the alert threshold for fine particles. Although these thresholds are not legally binding directives, several countries and cities in the region have implemented them in practice. Bosnia and Herzegovina has adopted European legislation selectively, prioritizing only those provisions that are considered convenient. While the legal framework may appear adequate on paper, significant components remain absent, limiting the overall effectiveness of air quality management.

II. MATERIAL AND METHODS

Taking into account the first part of our scientific research work as a research methodology, we chose two methods: Literature review and survey.We approach the aforementioned from two aspects, the first from the scientific knowledge of the already known literature on the topic, while on the other hand, we want to include public opinion in the research process itself in order to get a complete picture.

Through the literature review, we use the knowledge of people who were involved in the research of the liquid 3 project and their thinking about this project. Their knowledge and observation is important to us in the first part in order to explain the operation of liquid 3 and its advantages and disadvantages. After that, it is important for us to express in what percentage of respondents want something like Liquid 3 to be installed in their city and whether they even think that this could be one of the new air purifiers.

Hypotesis: LIQUID 3 can largely replace the role of trees in protecting the environment from air pollution in Bosnia and Herzegovina.

III. LITERATURE REVIEW

The "Liquid Tree," (Figure 4) often referred to as "LIQUID 3," is a new ingenious solution containing freshwater microalgae. It is an innovative photobioreactor containing microscopic fibers from plant cell walls, known as cellulose nanofibers. It has been introduced in Serbia to address the issue of air pollution. Photobioreactors are closed fermentation tanks containing numerous small photosynthetic organisms collected within a carefully controlled system that enables precise management of their growth. These algae absorb carbon dioxide from the environment, carry out photosynthesis, and release oxygen, offering an effective solution to air quality concerns.

Dr. Spasojevic, I.,(2020) exploited the Liquid Tree photobioreactor from the University of Belgrade. In 2020, Serbia attained the unenviable distinction of having the highest number of pollution-related facilities in Europe. This alarming situation prompted the development of the photobioreactor concept as a response to pressing environmental concerns.

Dr. Ivan Spasojevic, Ph.D. in Biophysical sciences, and one of the authors on the project from the Institute for Multidisciplinary Research at the University of Belgrade, developed an innovative tool for reducing greenhouse gas emissions and improving air quality: the liquid tree. Also dubbed LIQUID 3, the novel creation is Serbia's first urban photo-bioreactor, a solution in the fight for clean air. It contains six hundred litres of water and works by using microalgae to bind carbon dioxide and produce pure oxygen through photosynthesis.

The photobioreactor is equipped with a 600-liter water chamber housing a multitude of single-celled freshwater algae (Castim, 2021). These algae are native to ponds and lakes, making them resilient to both high and low-temperature stress, allowing them to thrive even during the winter season. Their primary function is the absorption of carbon dioxide from the atmosphere, conducting photosynthesis, and subsequently producing pure oxygen. After a month and a half, thebiomass of the algae is harvested, and the water is replenished with added minerals. The harvested biomass serves a dual purpose, as it is employed as a fertilizer for crops and plants.

Furthermore, the "Liquid 3" has a solar panel on the top using dead biomass of algae, that captures solar energy, converting it into electricity, which is then used to power a pump responsible for introducing air into the tank through small perforations (Kriegar, 2022).

This electrical supply also enables the tank to emit light, facilitating year-round, uninterrupted photosynthesis by the microalgae, even during the winter months when sunlight is less abundant.
In addition, this tank acts as a bench, the solar panel includes charging capabilities for mobile phones and provides light during the night.

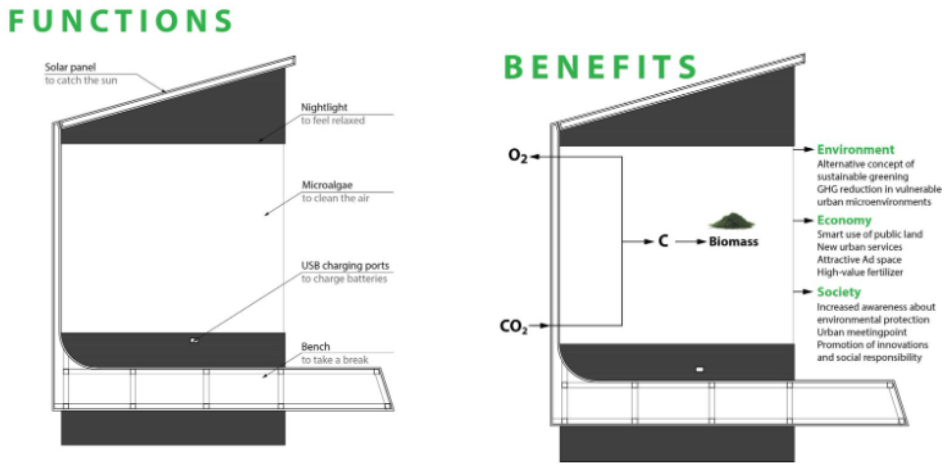


Figure 4: Functions and benefits of Liquid 3 in Public places and urban environments (Source: Singh and Dake, 2023)

(Anannya Dhar, Saikat Dei and Sukamal Sarkar, A Novel Approach for Air Pollution Mitigation,2023) scientists from India have given on this topic liquid 3 what all the benefits we can get from this project.

1. Carbon Dioxide Emissions Reduction: Liquid Trees play a crucial role in capturing and sequestering carbon dioxide from the atmosphere, serving as a pivotal solution in mitigating the greenhouse effect and addressing climate change.

2. Air Quality Improvement: Liquid Trees actively contribute to the enhancement of air quality by absorbing carbon dioxide and various pollutants from the atmosphere. Simultaneously, they release pure oxygen, fostering a healthier environment for inhalation.

3. Wastewater Treatment: In the innovative process of wastewater treatment, photobioreactors prove invaluable. As wastewater passes through these reactors, the enclosed algae act as effective filters, removing pollutants such as nitrogen, phosphorus, contaminants, and organic matter.

4. Medicinal Applications: Controlled bioreactor environments facilitate the cultivation of various microorganisms, including algae, capable of producing bioactive compounds with significant applications in the field of medicine. This controlled setting allows for the efficient extraction of these compounds compared to their natural habitat growth.

5. Utilization in Spacecraft: Photobioreactors hold tremendous potential for deployment in spacecraft for carbon dioxide removal and oxygen generation. Furthermore, they offer the exciting possibility of cultivating green salads to meet the dietary needs of astronauts.

6. Urban Greenery Promotion: Liquid Trees make a substantial contribution to enhancing greenery in dense urban environments. This not only provides an aesthetically pleasing effect to urban landscapes but also promotes a healthier and more vibrant city environment.

The microalgae within the bioreactor possess the ability to replicate and replace the carbon dioxide absorption equivalent to that of two ten-year-old trees or a lawn spanning an area of 200 square meters. Notably, microalgae demonstrate a photosynthesis-based carbon dioxide binding efficiency that is 10 to 50 times higher than that of trees, as demonstrated in a study by Singh and Dake (2023).

Furthermore, in situations where pollution levels are exceptionally elevated, trees often struggle to survive, whereas microalgae exhibit remarkable resilience, effectively continuing their air purification efforts. These algae exhibit resistance to heavy metals and can purify a substantial volume of air, ranging from 300 to 3000 cubic meters, as indicated by research conducted by Krieger (2022). Liquid 3 acts as an alternative to hedges, where there is not enough space to grow a woody plant. It can be installed anywhere around the city including parks, malls, cinema halls, and even multi-storeyed buildings.

IV. CASE STUDY

A survey was conducted through interviews with 61 individuals of varying ages and social backgrounds in Bosnia and Herzegovina. The purpose of this survey was to examine the stated hypothesis and to assess its validity. On the basis of the collected data, relevant conclusions were drawn.

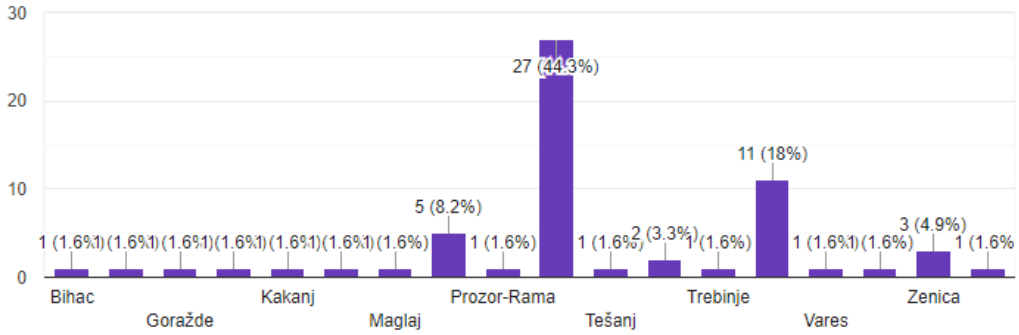


Figure 5: Where do you live in Bosnia and Herzegovina?

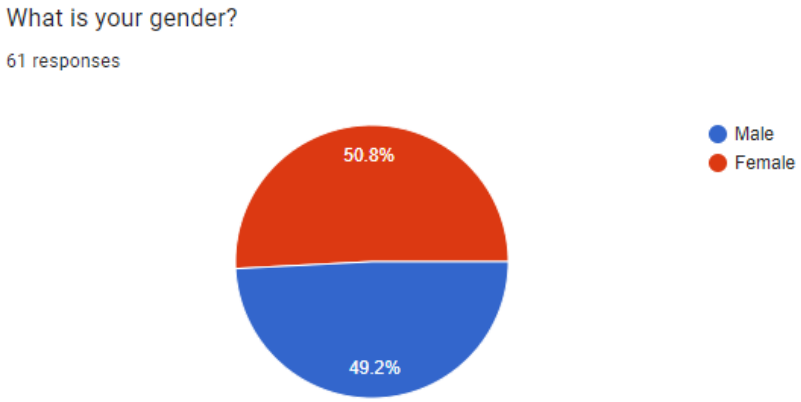


Figure 6: What is your gender?

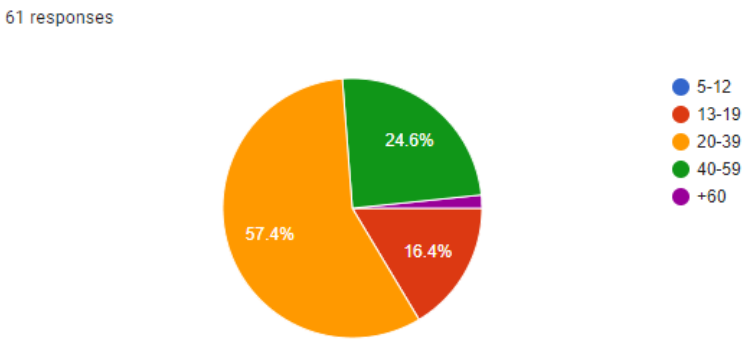
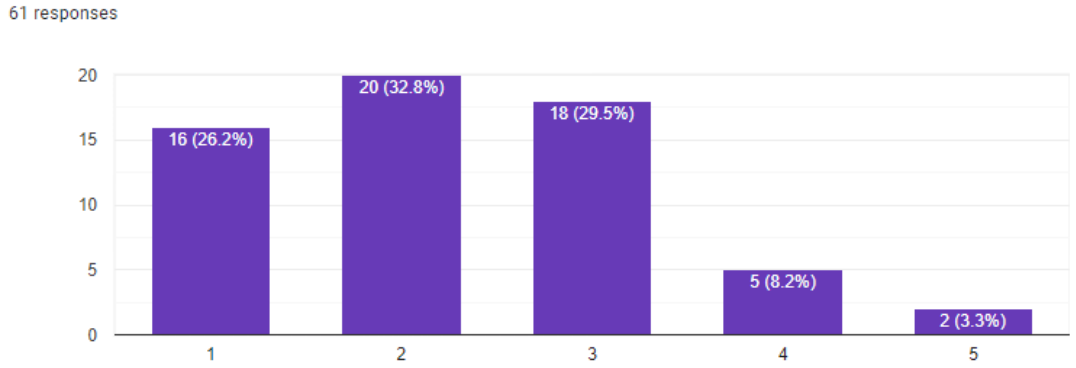
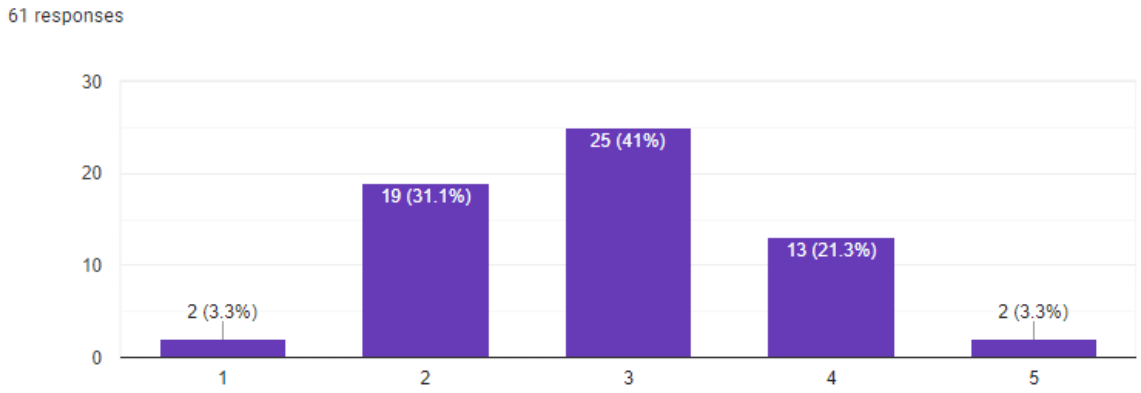


Figure 7: What is your age?



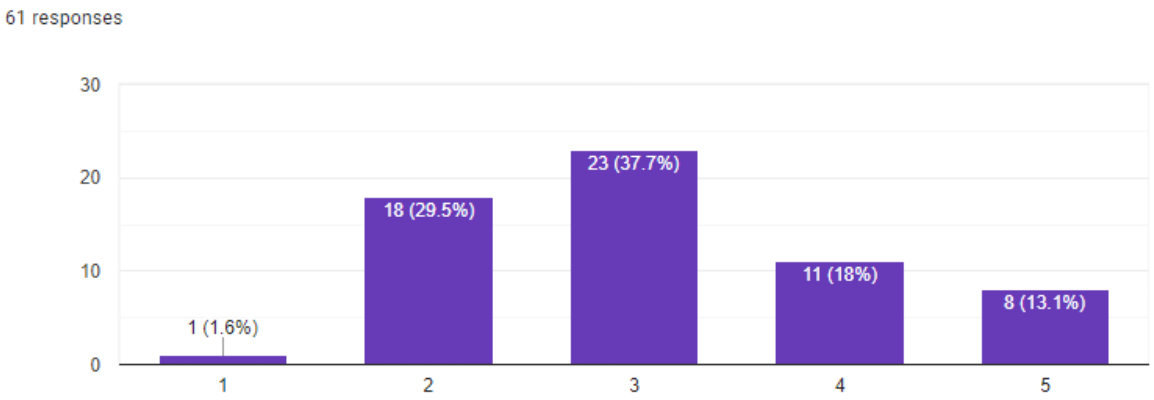
1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 8: Air quality in your city is at a satisfactory level?



1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 9: There is a lot of greenery in your city?



1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 10: On a scale of 1 to 5, how developed is the industrial zone in your city?

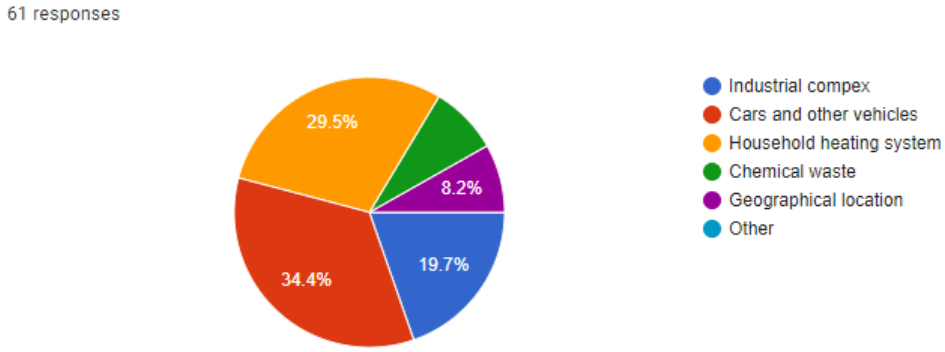


Figure 11: In your opinion, what is the main cause of air pollution in your city?

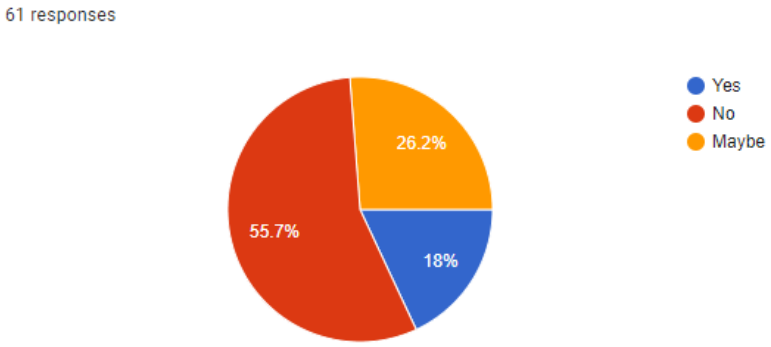


Figure 12: Are you familiar with other types of air purifiers?

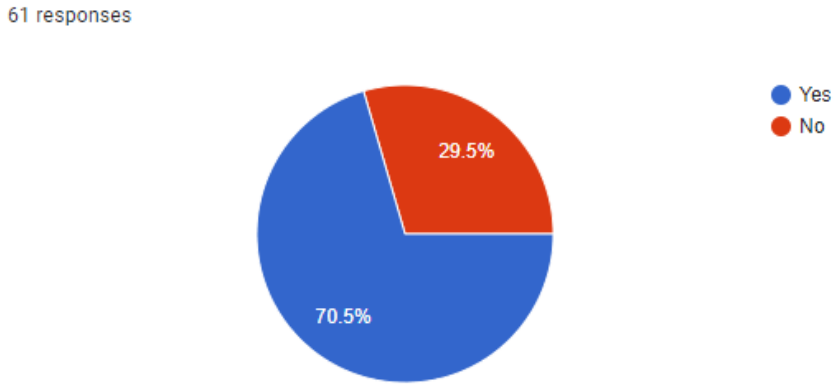


Figure 13: Do you think green is the only reliable producer of O2?

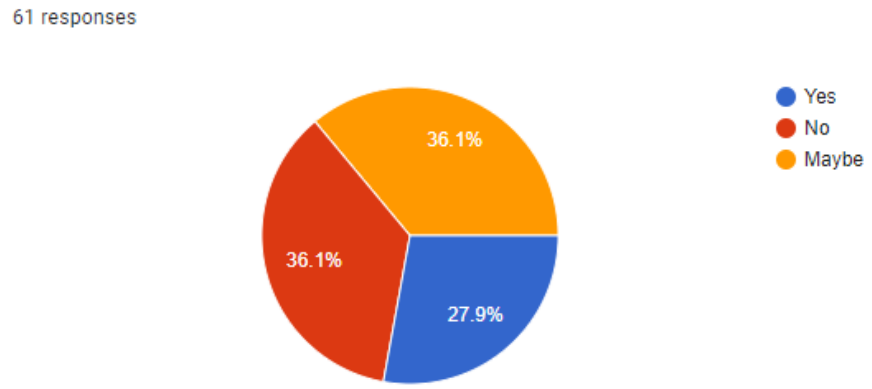
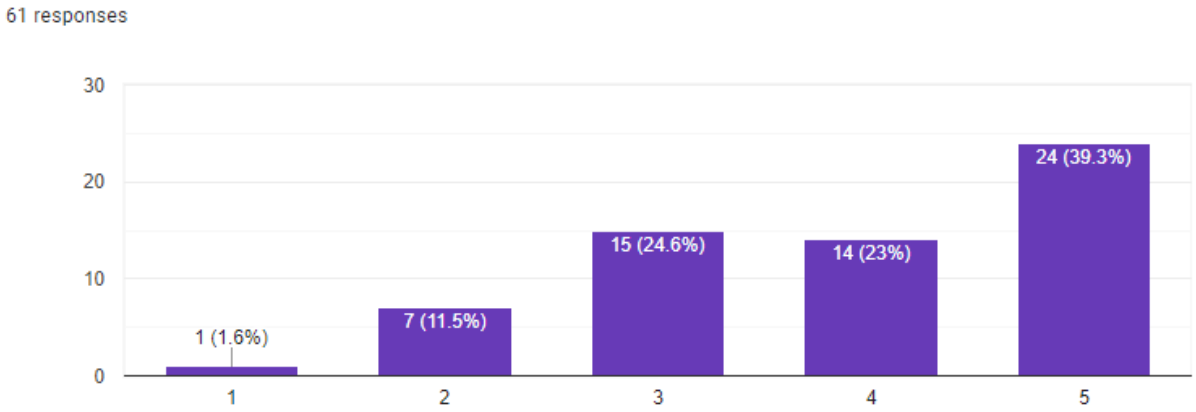
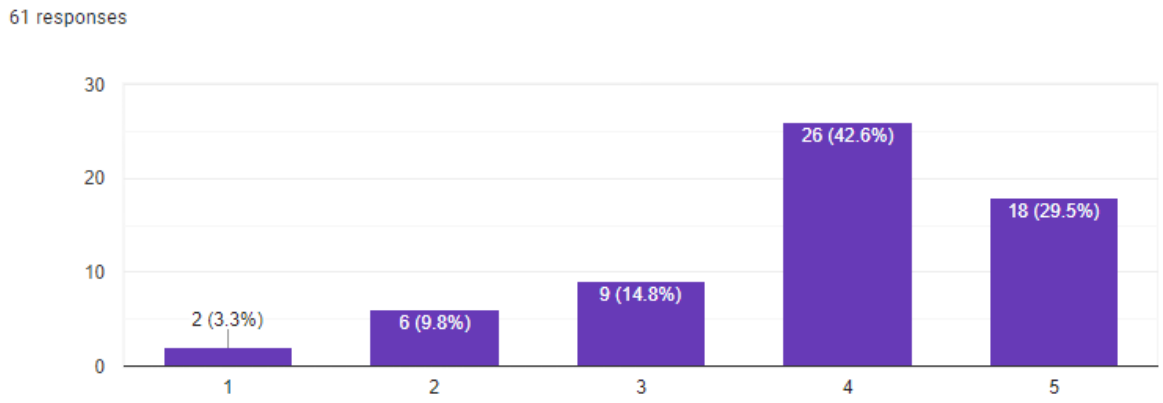


Figure 14: Are you familiar with the LIQUID 3 project?



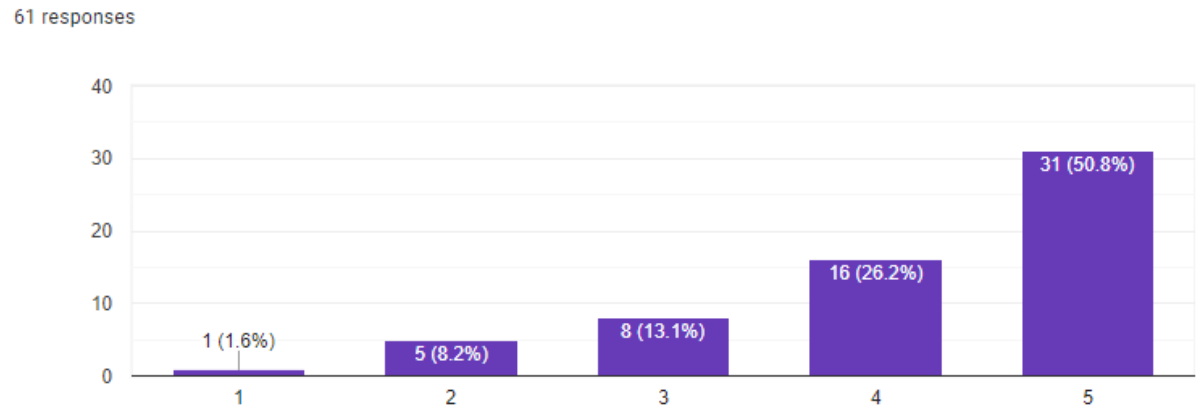
1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 15: On a scale 1 to 5 it is aesthetically acceptable to have this in your city?



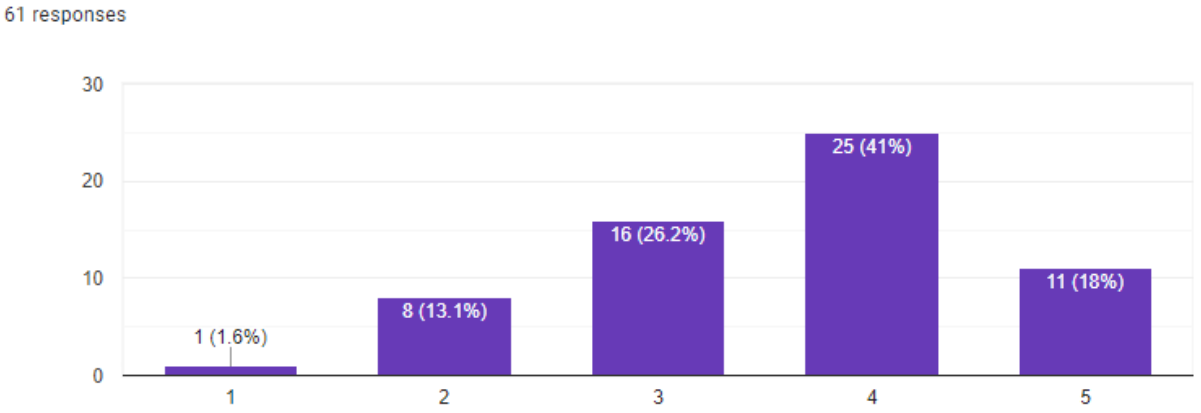
1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 16: LIQUID3 is an urban photo-bioreactor that uses the power of microalgae to efficiently remove CO2 and produce O2 and biomass.
On a scale of 1 to 5, do you like this kind of concept for prevention in air pollution?



1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 17: On a scale of 1 to 5, it is important for you to have an air purifier even during the winter period?



1 – Strongly disagree, 2 – disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree

Figure 18: On a scale of 1 to 5, do you think that this project can replace role of greenery?

V. RESULTS

In **Figure 5**, the survey identifies the origin of respondents, which serves as the basis for further research. The majority of respondents were from Sarajevo (44.3%), followed by Tuzla (18%) and Mostar (8.2%). This distribution enabled the determination of the target cities most affected by air pollution.

Figure 6 shows that both genders participated in the survey in nearly equal proportions, with women accounting for 50.8% and men for 49.2%.

As presented in **Figure 7**, respondents belonged to various age groups, with the largest share represented by those aged 20–39 (57.4%), followed by the 40–59 age group (24.6%). The inclusion of multiple age groups ensured a more comprehensive understanding of the problem.

Figure 8 illustrates the level of satisfaction with air quality in the respondents' cities. A considerable proportion (32.8%) expressed dissatisfaction, suggesting that an installation such as Liquid 3 could provide significant benefits in these areas.

Awareness of greenery as a major source of oxygen production was further investigated. **Figure 9** demonstrates respondents' perceptions of the presence of greenery in their cities. While 41% remained neutral, these results did not yield substantial relevance for the research itself.

The development of industrial zones was examined in **Figure 10** due to their role as major air pollutants. On a five-point scale, the largest proportion of respondents (37.7%) selected the neutral option, suggesting that while industrial complexes exist, they are not dominant in their cities.

In **Figure 11**, respondents identified the most common air pollutants in their cities. Vehicles were cited most frequently (34.4%), followed by household heating systems (29.5%) and industrial complexes (19.7%).

Knowledge of alternative oxygen production and purification methods was further assessed. As shown in **Figure 12**, 55.7% of respondents were not familiar with options other than greenery. Similarly, **Figure 13** revealed that 70.5% were unaware of other forms of oxygen generation besides photosynthesis.

The level of awareness regarding the **Liquid 3 project** was examined in **Figure 14**, which shows that knowledge of this initiative is limited, with a majority of respondents indicating unfamiliarity. For those unacquainted with the project, an image was provided to evaluate its aesthetic acceptability. **Figure 15** indicates that 39.3% of respondents considered the installation highly desirable in terms of appearance.

Following a brief explanation of the Liquid 3 concept, respondents were asked whether they perceived it as a viable air purification solution. As illustrated in **Figure 16**, 42.6% agreed that it could represent a potential method of combating air pollution.

Given that Liquid 3 functions year-round, a question was posed regarding the importance of air purifiers and oxygen generators during winter months. **Figure 17** shows that 50.8% of respondents regarded this feature as highly significant. Finally, the central hypothesis of the study was tested. In **Figure 18**, respondents were asked whether a project such as Liquid 3 could replace the role of greenery in mitigating air pollution. A total of 41% agreed with this statement, while only 1.6% completely disagreed, thus providing substantial support for the proposed hypothesis.

VI. DISCUSSION

The research methodology was structured around two complementary lines of inquiry regarding the Liquid 3 project and its potential to substitute greenery in urban air purification in Bosnia and Herzegovina. The first line of investigation was grounded in the literature review, which revealed a general acceptance of Liquid 3 as a promising alternative solution to the problem of urban air pollution. Scholars addressing this topic highlighted the advantages of the project in reducing harmful emissions and ensuring a continuous supply of oxygen, thereby offering a valuable expert perspective.

The second line of investigation consisted of an empirical survey involving 61 respondents of different ages and social backgrounds. The results demonstrated a high level of awareness among participants regarding the severity of air pollution in their cities. Nevertheless, a considerable number of respondents were initially unfamiliar with the concept of Liquid 3. Once provided with explanatory information, the overall perception shifted positively, and the project was increasingly recognized as a viable option.

Of particular importance was the recognition of Liquid 3's year-round functionality, especially during winter months when greenery cannot sustain its ecological role. Respondents emphasized that this capability provides Liquid 3 with a significant advantage over natural vegetation. Furthermore, the finding that 41% of respondents considered the project a revolutionary solution underscores its potential impact in urban contexts.

Overall, the discussion of findings suggests that while the project is still relatively unknown to the public, awareness campaigns and broader dissemination of scientific evidence could substantially increase public acceptance. The integration of literature-based expert opinions with survey-based community perspectives provides a holistic foundation for evaluating the relevance and applicability of the Liquid 3 initiative.

VII.CONCLUSION

The study examined the potential of the Liquid 3 project as a substitute for urban greenery in addressing air pollution in Bosnia and Herzegovina. Based on a survey of 61 participants, it was observed that 41% of respondents support the use of Liquid 3 in combating urban air pollution. Although many were unfamiliar with the project prior to the survey, the provision of additional information significantly improved perceptions, indicating that knowledge dissemination plays a decisive role in acceptance.

The survey further emphasized the importance of air purification technologies during winter months, when vegetation is unable to fulfill its ecological role. In this context, Liquid 3 was recognized as an ideal complement to natural processes, capable of operating continuously throughout the year.

The combined evidence from the literature review and empirical findings confirms the hypothesis that Liquid 3 can play a meaningful role in mitigating urban air pollution and preserving environmental quality in cities across Bosnia and Herzegovina. This conclusion highlights not only the scientific value of the project but also its potential to gain societal acceptance as an innovative and sustainable solution for improving air quality.

REFERENCES

[1] S. D. Koolen and G. Rothenberg, *Air Pollution in Europe*. 2018.

[2] A. Podic, *Pollution in Sarajevo*. 2019.

[3] I. Spasojevic, *University of Belgrade – Liquid Tree Photobioreactor Research*. 2020.

[4] Castim, *Liquid 3 Bioreactor Design*. 2021.

[5] M. Krieger, *Algae-based Urban Photobioreactors*. 2022.

[6] R. Singh and R. Dake, *Benefits of Liquid 3 in Urban Environments*. 2023.

[7] A. Dhar, S. Dei, and S. Sarkar, *A Novel Approach for Air Pollution Mitigation*. 2023.

List of Figures

[17] Figure 10 – On a scale of 1 to 5, how developed is the industrial zone in your city? (Survey result)

[18] Figure 11 – In your opinion, what is the main cause of air pollution in your city? (Survey result)

[19] Figure 12 – Are you familiar with other types of air purifiers? (Survey result)

[20] Figure 13 – Do you think greenery is the only reliable producer of O_2? (Survey result)

[21] Figure 14 – Are you familiar with the LIQUID 3 project? (Survey result)

[22] Figure 15 – On a scale 1 to 5, it is aesthetically acceptable to have LIQUID 3 in your city? (Survey result)

[23] Figure 16 – LIQUID 3 is an urban photo-bioreactor… do you like this kind of concept for prevention in air pollution? (Survey result)

[24] Figure 17 – On a scale of 1 to 5, it is important for you to have an air purifier even during the winter period? (Survey result)

[25] Figure 18 – Do you think that this project can replace the role of greenery? (Survey result)