Proceeding Paper

Architectural and Urban Methods of Preventing Smog in an Urban Agglomeration †

Zuzanna Siemieniuk 1 and Ewa Szatyłowicz 2,∗

1 Faculty of Architecture, Białystok University of Technology, Wiejska 45A, 15-351 Białystok, Poland
2 Department of Technology in Environmental Engineering, Faculty of Civil and Environmental Science, Białystok University of Technology, Wiejska 45A, 15-351 Białystok, Poland
∗ Correspondence: e.szatyłowicz@pb.edu.pl
† Presented at Innovations-Sustainability-Modernity-Openness Conference (ISMO’22), Białystok, Poland, 26–27 May 2022.

Abstract: Cities are indicated as areas contributing to the smog problem. Nevertheless, they can also be viewed as a source of solutions. In modern urban agglomerations, we can observe innovative solutions such as buses filtering the air and plant installations cleaning the air around buildings. Since more than half of the human population lives in cities, the air quality in these places is a crucial aspect of a functioning of society. This study characterized the phenomenon of smog and discussed its types as well as potential architectural and urban solutions to counteract this phenomenon in urban agglomerations.

Keywords: architectural methods; smog; city agglomeration

1. Introduction

More than half of the Earth’s population lives in modern urban agglomerations, which is why bad air quality in cities is such a serious concern for which a catalogue of solutions that can be implemented in cities to reduce emissions and improve air quality are required for approximately six billion people in the world [1]. Clean air improves health and overall quality of life, helps combat climate change, and protects the environment [2]. However, despite its many benefits, high pollution levels are a significant threat to the health and lives of the EU population. It is estimated that 400,000 premature deaths in the EU are directly related to air pollution [3]. The air does not meet the standards in 130 European cities. A severe situation is observed in Poland. In the European Environmental Protection Agency’s ranking of the most polluted European cities, six Polish cities are featured in the top ten, including Katowice and Kraków [4].

The link between urbanization and air pollution appears to be noticeable. Pollution accumulates around the places where it originates, which are mainly dense housing areas (cities). Architecture and urban planning as areas directly related to shaping the city significantly reduce air pollution [5]. Currently, many innovative solutions can be observed in cities related to architecture, landscape architecture, spatial planning, means of transport or the method of supplying heat to buildings. All these solutions contribute to limiting and reducing the amount of air pollution in urban agglomerations. Thanks to the interdisciplinary cooperation of engineers, sociologists, local government officials and residents, this phenomenon may be limited or eliminated in the future. Instruments for combating air pollution are increasingly common, and the acquired knowledge and experience allow for the creation of a city free from air pollution [6].

Therefore, this paper defined air pollution in cities and the phenomenon of smog, which arises as a result of increased concentrations of certain substances in the atmosphere. In addition, the work aimed to classify activities and methods to counteract air pollution and indicate places in which they are directly related to architectural or urban design.
2. The Phenomenon of Smog

Smog is defined as an atmospheric phenomenon consisting of the coexistence of air pollution caused by human activity and unfavourable weather conditions—a phenomenon that results in temperature inversion and fog [7,8]. The word ‘smog’ derives from a combination of two words, namely smoke and fog and was used to refer to phenomena observed in London in the early 1950s. Today, under the name of smog, we most typically refer to above-average concentrations of air pollutants in cities resulting from emissions from heat sources and transport under specific meteorological conditions (especially temperature inversion) [7]. Figure 1 shows the types of smog and characteristic features such as the composition of pollutants and weather conditions.

![Figure 1. Characteristics of the types of smog. The figure contains information from the source: [7,8].](image)

Recently, three types of smog have been delineated in the literature, in addition to the two types of smog that have been described and characterized many times, which are Los Angeles and London smog. Polish smog is characterized by a different atmosphere and the conditions in which it arises. It also has a different composition than London smog, with a high concentration of sulphur dioxide, carbon monoxide, and PM10. All three types of smog are characterized by a smog life cycle, which begins primarily in sources of anthropological origin (furnaces, communications, industry), then continues in the air and ends with the transition from the air environment to water or land [7–11].

3. Architectural Methods of Smog Prevention

Architecture is one of the many areas influencing air pollution in an urban agglomeration. Ways to prevent poor air quality through architectural measures include the following [5]:

- Introducing elements of small architecture in urban spaces, such as anti-smog towers, exhaust screens, and anti-dust panels [1];
- Designing and promoting the construction of residential buildings based on environmentally friendly construction applications, such as so-called passive houses, modernization of heating systems, e.g., using a heat pump or solar panels [5];
• Implementation of materials in the design to absorb pollutants deposited on pavements and roads as a result of chemical reactions [1,5];
• Construction of public utility buildings based on the requirements of certificates that define ecological building standards, e.g., LEED27 [1] certificates;
• PV installations on public buildings, including offices or educational institutions, may also contribute to the improvement of air quality [1,5];
• Arranging green facades and roofs on both old and new buildings, as well as thermal modernization with pollution absorption systems [12,13].

4. Urban Smog Prevention Methods

The methods presented below are related to urban planning. Of the presented methods, the most effective is removing the pollution source from urban agglomerations. Still, at the same time, it requires application at the initial investment stage, and therefore the involvement of an educated investor and designing a building or city based on pro-ecological regulations. The urban methods of preventing poor air quality in an urban agglomeration include [5]:
• Identifying the existing and designation of potential paths of urban ventilation—ventilating wedges [1,14];
• Identifying prevailing winds likely to bring pollution to the site;
• Determining the location of urban layouts;
• Indication of objects that may constitute architectural barriers to airflow;
• Industrial locations suitable for emissions and wind rose;
• Planning protection zones in the form of green barriers;
• Including the ideas of energy efficiency, environmental friendliness and composition that do not constitute barriers to the development of the natural value of the city;
• Maintaining the principles of airflow by arranging new urban structures to regulate the urban fabric;
• Eliminating the formation of the so-called city gates—complexes of high-rise office buildings on city limits—constituting barriers to air exchange;
• Filling gaps in buildings, creating an opportunity for the formation of air vortices;
• Integration of the urban structure with downtown and non-urban greenery [15];
• Arranging tall buildings in round shapes, so they do not constitute a barrier to winds moving in the higher parts of the troposphere, and dispersing tall buildings relative to each other [14];
• Eliminating the formation of heat islands in the city, which sucks in cold and cool air from the periphery—the situation of weakened air convection creates conditions for the emergence of smog [16].

5. Conclusions

The introduction of all the recommendations mentioned above in the field of architecture and urban planning into the urban structure may take years. However, it is worth planning and implementing methods of combatting smog because, in the future, this organic action will reduce the concentration of individual air pollutants that contribute to smog formation in urban agglomerations. It is also worth mentioning that architecture and urban planning are crucial technical fields because the visualization of such objects makes them apparent to society more efficiently, which increases environmental awareness in the field of atmosphere protection. In addition, the completed architectural design is the final testimony to the seriousness of the problem and proof of the legitimacy of the actions taken to combat the smog phenomenon.

Author Contributions: For Conceptualization, E.S. and Z.S.; methodology, Z.S.; formal analysis, E.S.; investigation, Z.S.; resources, Z.S.; data curation, Z.S.; writing—original draft preparation, Z.S.; writing—review and editing, E.S.; visualization, Z.S.; supervision, E.S.; project administration, E.S.; funding acquisition, E.S. All authors have read and agreed to the published version of the manuscript.
**Funding:** The research was funded by The Scientific Subvention of the Bialystok University of Technology, Poland as part of research project no. WZ/WB-IIS/2/2021.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

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