Urban Strategy for Improving the Air Quality in Bucharest (Romania)

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Abstract. The paper presents an effective urban solution of update for the General Urban Plan (GUP) of Bucharest in order to reduce air pollution. The proposal presented is based on the good urban design planning practice offered by other cities that manage to preserve the air pollution level below an established limit. Firstly, the paper includes a literature review I carried out in order to study the latest scientific research papers related to the subject and the examples of good practice. Furthermore, the paper highlights the present situation in Bucharest generated by the high levels of air pollution and the need to reduce the toxic emissions. Romania has committed through Directive 2016/2284 of the European Parliament and of the Council to reduce the national emissions of certain pollutants. In addition, the proposal of update for GUP was developed according to the present national targets and to the specificity of the city, existing green space, tree density, small size surfaces. If the urban solution presented is applied through the General Urban Plan, the air quality in Bucharest will be considerably improved and the positive effects will not wait to appear in different perspectives, such as: inhabitants’ health condition, urban aesthetic, efficient use of the allocated budget for the improving air quality in the European capital. In order to successfully implement the urban solution, the present research has to be completed by an arboretum study in Bucharest. The topic of the paper is characterized by multidisciplinarity as it takes into consideration research information from Urban Design and Ecology.

1. Introduction
The lack of implementing adapted measures through the GUP to improve air quality in Bucharest led to a continuous boost of pollution that has had harmful effects, especially among the inhabitants.

The objective of this paper is to expose a potential update for the GUP that was drafted in accordance with the city’s needs, city’s lack of large sized green surfaces and the targets related to the sustainable development of the city.

The role of vegetation is crucial to purifying the air in urban environments playing the role of a sink for air pollutants. [1, 2, 3]

Vegetation can considerably reduce the need for air cooling, it can provide shade and preserve an urban water balance, diminish noise and contribute to "create a small ecosystem that offers refuge for a range of plant and animal species and the urban residents." [1, 4]

In the paper entitled "Air pollution removal by urban trees and shrubs in the United States", Nowak et al. (2006). mention that urban trees provide numerous benefits the cities inhabitants and explain that “urban forest and pollution literature, for example, has focused on the functional effects of
urban forest ecosystem structure, whereas the economic, ecological, environmental and natural resource literature has tended to directly link ecosystem functions to human well-being.” [1, 5]

Yang X. and Peter B. have observed a "focus on deposition of pollutants to vegetation frequent in the horticultural and architectural literature, while atmospheric scientists will often focus on issues related to dispersion." [1]

Paula Matos et al. (2019) suggest that urban management should concentrate efforts "on the smallest urban green spaces by increasing green space size or tree density." [6]

The first measure suggested is difficult to apply because increasing the size of urban space usually has juridical and lingering urban planning involvements whereas the second one can be conveniently implemented with a minor update of the general urban plan.

![Figure 1. Trees benefits](image)

In Asia – Pacific a new urban solution has been promoted to allow the coexistence of nature and architecture in urban settlements. This approach is dedicated to compact and green cities containing tall buildings surrounded by trees, flowering plants and shrubs. This urban concept takes into consideration the common existence of humans, birds and insects altogether in the city. This solution does not imply the expanding of the city’s surface. A relevant example of this concept can be observed in Tengah, Singapore, as the first Forest Town. [8]

On the subject of selecting the appropriate tree species to plant, it is highly recommended to look for the species that have a leaf surface which facilitates absorption of PM2.5 and other particles. Xinxin Z. et al. (2018) propose the tree species *Pinus tabulaeformis* and *Platycladus orientalis*, in order to improve the air quality in urban settlements. [9]

According to Emilia Grzedzicka (2018) research in the scientific paper concerning the contribution of trees to air filtration through summer and autumn seasons "The air quality was best in the neighbourhood of older specimens of beeches and European hornbeams". [10]

Furthermore, *Hibiscus taiwanensis* demonstrated to have the highest capacity to purify air in exposure with SO2 in high concentration. [11]

Although trees have a remarkable contribution in purifying air, reducing greenhouse gas emissions and balancing mental health, they have to be selected attentively as several species present severe allergenicity and may increase asthma hospitalization amongst the vulnerable inhabitants. [12]
In M. Fernández-González et al (2019) study in Porto city "the main airborne allergenic pollen come from trees (such as Betula or Olea), grasses or weeds (mainly Urticaceae)" [13]

However, if the species of trees are carefully selected in accordance with the urban needs and do not cause allergic reactions, they will represent the irreplaceable lungs of the cities.

2. Present situation in Bucharest, Romania
Bucharest has lost approximately 1,5 million trees since 1990, and the average of green space disappearing was estimated at 100 ha/year which stands for diminishing the green space with 50%. [15]

In the National Agency for the Environment Protection report (2013) concerning the environmental factors the forestry coverage in Bucharest – Ilfov is situated below the average of 27% recorded in Romania. Consequently, it is imperiously needed to afforest all of the degraded agricultural lands that cannot be used for agricultural production. In addition, it is highly required to redevelop the forest curtains and to expand the surface of forest vegetation in order to play the key role of the green lung of Bucharest. The most exposed area to aridity and drought is the southern part of Bucharest. [16]

The Bucharest city hall has finalised in 2011 the green cadastre of the city and the average of green space per capita was estimated at 23,21 square meters.
The green cadastre registered all the trees and green space from the public domain, considering green space, trees, grass and cemeteries, parks, squares etc.

The total number of trees is 1.7 million, from which 194,000 trees can be found in the forests. There are 110 legal protected trees. Therefore, the average number of trees per capita in Bucharest is estimated at 0.88 whereas the EU recommendation concerning this matter is of 3 trees/capita. [17]

The lack of green space and trees is reflected in the high level of pollution in Bucharest. The following table presents the classification of the pollution sources, according to the annual report of the National Agency for the Environment Protection for 2017:

| Types of sources   | Detailing of each type                                                                 |
|-------------------|---------------------------------------------------------------------------------------|
| Fixed sources     | Industrial sources represented by organic and inorganic particles containing metals such as: Fe, Al, Zn, Pb, Cu, Cr, Cd, Ni; gases and vapors – CO, CO2, SO2, NOx, HCL, NH3), soot, organic solvents, etc. The most important source is represented by electro thermal power stations. |
| Mobile sources    | Represented mostly by the traffic which generates the emission of inorganic gases (NOX, SO2, CO) and volatile organic compounds (benzene) or particulate matter containing metals (PM 10, PM 2.5). The most affected zones are the ones composed of constructions and very busy traffic arteries. |
| Surface sources   | These are the residential heating sources and other combustion sources lacking the relative advantage of the dispersion of emissions through tall baskets that public stations have. |
| Special sources   | This type of pollution source is defined by the construction sites. These sites can be enclosed in the fixed sources (the building construction sites) but also in the surface sources (reparation and modernisation traffic arteries). These sources produce high levels of toxic particles. |

In Romania the problem of poor quality air continues to persist as the European Agency for Environment estimated that in 2015, 25,400 premature deaths were caused by the high levels of particulate matters, 580 by the ozone concentrations and 1.300 by the nitrogen dioxide concentrations. The main air pollution source is represented by the transport and energy sectors. Moreover, serious structural deficiencies related to air quality measured by the Romanian monitoring system, which means that the situation can be more critical than the one reported. [18]

In order to improve the present situation concerning the level of pollution, the European Council has released the "Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants" which states that Member States have to reduce their emissions of SO2, NOx, non-methane volatile organic compounds, ammonia and fine particulate matter as specified in Annex II. Romania has committed to reduce national emission from 2020 to 2029 and from 2030 onwards as follows [19] in Table 2.

The objectives established for Romania concerning the emission reduction are hard to reach in the absence of integrated urban strategies.

Therefore, the following chapter suggests a potential urban solution that could correct the present situation related to pollution in Romania.

3. Urban solution proposed
The urban solution proposed takes into consideration the principle of sustainable development of the cities. Hence, it is connected with the urban concept presented in the Literature Review Chapter, applied in Asia. The concept applied for the compact cities can be successfully utilized in Romania as well as in Asia in pursuance of improving the air quality.
Table 2. Emission Reduction Commitment (Romania) [19]

| Type of emission reduction                  | Period of time             | Percentage |
|--------------------------------------------|----------------------------|------------|
| NH3 reduction compared with 2005            | For any year from 2020 to 2029 | 13%        |
|                                           | For any year from 2030      | 25%        |
| PM2.5 reduction compared with 2005          | For any year from 2020 to 2029 | 28%        |
|                                           | For any year from 2030      | 58%        |
| SO2 reduction compared with 2005            | For any year from 2020 to 2029 | 77%        |
|                                           | For any year from 2030      | 88%        |
| NOx reduction compared with 2005            | For any year from 2020 to 2029 | 45%        |
|                                           | For any year from 2030      | 60%        |
| NMVOM reduction compared with 2005          | For any year from 2020 to 2029 | 25%        |
|                                           | For any year from 2030      | 45%        |

The first step to develop such a concept in Bucharest would be to carry out an arboretum study in order to find out what species of trees respond best to the city’s problems and climate conditions.

After establishing the appropriate species of trees for the European capital the next step would be to enforce the increasing of the trees number through regulation. Consequently, the general urban plan for Bucharest should be updated with the new rules that compels the public and private land owners to plant the indicated species of trees.

The public land owners should identify the abandoned plots and plant an imposed number of trees depending on the size of the surface whereas the private land owners should have the obligation to plant trees when obtaining the construction permit. The construction permit can specify the number of trees they have to plant depending on the urban indicators. Therefore, another step in updating the general urban plan would be to attentively reconsider the values related to urbanistic indicators – percentage of land occupation and land use coefficient.

4. Research methods

The research methods that I applied were the documentary analysis, benchmarking and the observation.

I used the first method by analysing the specialty literature in urban design and ecology domains. Hence, I reviewed over 50 articles found on the Internet and scientific databases, such as: Elsevier, Emerald Management Journals 200, Web of Science, Scopus and others.

Furthermore, I extrapolated the use of benchmarking from my experience in business to the present scientific research. Therefore, I assessed the quality of national policies and strategies concerning the improvement of urban design planning and I compared them to the similar ones applied by other countries that offer a good practice example in this matter in order to develop a solution that can improve the present situation related to pollution in Bucharest, Romania. [20]

Another method I used was the observation when I examined the situation in Bucharest and in other foreign cities during work travelling from a scientific and practical point of view.
5. Conclusions
The urban design solution I presented in this paper would contribute to improve the air quality in Bucharest, to accomplish Romania’s commitments related to emission reduction and also to sustainable development that "aims to meet the needs of present generations without jeopardising the ability of future generations to meet their own needs." [21.] This approach brings together economic, environmental and social aspects so that they reinforce each other [21].

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