Green Warsaw – the future of green vegetation

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1. Green vegetation on the buildings and its impact on the city

Living in a big, well developed city may be fascinating, but may also lead to a lot of health issues as well as other uncomfortable consequences for the life of its inhabitants.

The city, exposed to a quick, high level development in a very short time is facing problems of Modern civilization, causing around 3000 people dying untimely in Warsaw per year. Trying to solve the problem of the urban heat islands and air pollution taking as example the city of Warsaw I came up with a solution available for new developed buildings as well as a solution easily applicable for already existing buildings. Although green roofs and vertical gardens are artificially created by humans, they can be considered as patches and corridors necessary to achieve landscape continuity in heavily urbanized areas. Vegetation can be used to mask fragments or entire buildings for better correspondence with the surrounding landscape[1]. The research has been focused on 3 main problems in the modern city: How to reduce stress of habitants; How to reduce air pollution in the city; How to solve the problem of urban heat islands.

1.1 How to reduce stress of habitants

Reducing stress of habitants can be achieved by making space not feel overcrowded. Crowding - not density - is the reason of urban stress. With the proper urban planning the space can be designed in such manner that even the most dense areas are not going to feel overcrowded and not being a cause of stress for its inhabitants. Open spaces and park systems applied into the dense area can strongly minimize the stress and raise the livability level. Additionally, green cities equal good health: incite people to practice sport, increasing the possibilities to be close to nature, keep calm, restore the body, mind and soul; incite people to have social interactions. The research proves that green eliminates stress and high level of aggression, soothing the senses[2]. Emotional balance affects employee performance, which is why increasingly green roofs and living walls are used in buildings in which people work.

High density spaces can still remain dense, with the green elements designed on the pieces of architecture, which are not evident and very often forgotten. Top roofs, walls, balconies or terraces should be effectively used as green areas which are able to fulfill at least some of the functions the traditional gardens has.

Figure 1: Overlay on green balconies visualization

Overlay on green balconies have the advantage on green roofs and green walls, that does not necessarily has to be expensive. As an element of a private apartment is extremely easy to implement by independent private customer as much as the building developer. It interacts with the closest environment of the habitant, changing the view but also the air quality and temperature in the apartment. It does make the owner of the balcony feel responsible for his own prosperity and allow him to improve the life quality without necessary contracts, agreements, respecting building law and a structure requirement, which are very often a problem to implement a green walls or green roofs on already existing buildings.

1.2 How to reduce air pollution in the city

Air pollution is an environmental and social issue and, at the same time, it is a complex problem posing multiple challenges in terms of management and mitigation of harmful pollutants. Air pollutants are emitted from anthropogenic and natural sources; they may be either emitted directly (primary pollutants) or formed in the atmosphere (as secondary pollutants). They have a number of impacts on health, ecosystems, the built environment and the climate; they may be transported or formed over long distances; and they may affect large areas. Effective action to reduce the impacts of air pollution requires a good understanding of its causes, how pollutants are transported and transformed in the atmosphere, and how they affect humans, ecosystems, the climate, and subsequently society and the economy[3].

As we can read in the report written by the European Environment Agency (EEA), the air quality in Poland is not very satisfying. Many stations, also in Warsaw are reporting concentration of PM10 and PM2.5 above the EU annual limit value. That means that most of the habitants in big cities are very often exposed to pollutants in and around their homes, which may have very bad effect on their health.

Poland belongs to the countries with the most polluted air. In Europe every year, 45,000 Poles die prematurely due to air pollution, as carcinogenic and mutagenic substances enter the air. Breathing air contaminated with sulfur compounds, dust, benzo (a) pyrene and other harmful substances causes deadly diseases: lung cancer, chronic obstructive pulmonary disease and asthma. Health costs resulting from air pollution estimated for only city of Warsaw is from 6 billion - 18 billion PLN annually.

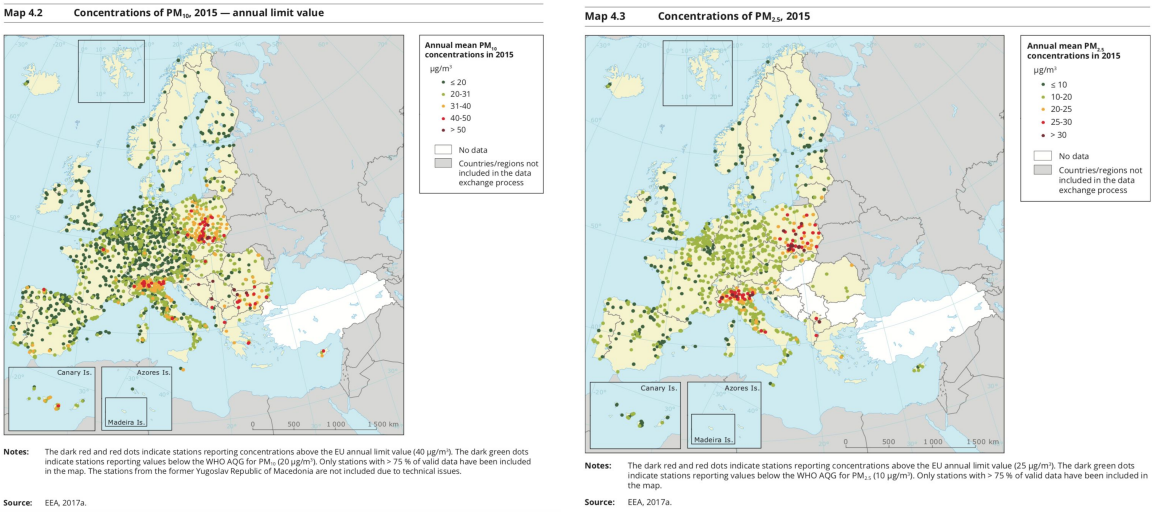

Figure 2: Concentration of PM10 and PM2.5 in Europe[3]

Green areas are not only useful as a space which brings people closer to the nature. It is also a place with plants. And those exact plants may be the solution for the air pollution. The research states that plant leaves as well as certain microbes are able to absorb air pollutants or transform them in less or nontoxic substances.

The average tree produces oxygen of an estimated value of over 30,000 dollars during the 50 years. Depending on the age and species of the tree, these benefits are different - for egzample 60-year-old pine can produce enough oxygen for 3 people, and 100-year-old beech can produce enough oxygen even for 10 people. The work of such a single tree is compared to the work of even 4-5 large air conditioners for 20 hours a day. Therefore, trees can be considered as friends of our wallets - they allow to save up to 30% per year on air conditioning, while in winter they can reduce heating costs by 20-30%[2].

Green infrastructure can directly influence air quality in three main ways: Increase in deposition of pollutants; Altering the wind flow; Emitting biogenic volatile compounds and pollen. Every one of these ways can influence air quality on different scales. The first and the third influence the air quality on a city scale, while the second influences the air quality on a local scale. In addition, there are also indirect side effects.

Studies assume that the deposition of a pollutant depends on the deposition velocity, the well mixed height of the pollutant and the concentration of the pollutant. The deposition velocity of green is in general higher than that of other urban surfaces due to the metabolic uptake by plants, the “stickiness” of the leaf surface, the large surface area of green, and the aerodynamic properties of green. The higher the deposition velocity, the lower the concentration of the pollutant will be and the more deposition.[4]

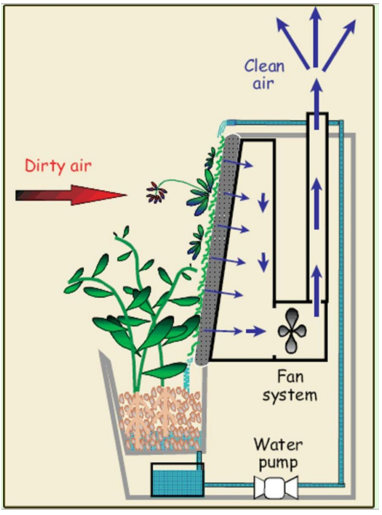

Figure 3: Scheme of cleaning the air by green walls

During past years several studies have been done to understand the impact of plants on the quality of the air. Two different consequences emerged: Phytoremediation and Biofiltration. Phytoremediation can be defined as the use of plants to remove pollutants from the air, water and soil. There are various techniques to do this process. Phytoextraction: the use of plants to clean up pollutants via accumulation in harvestable tissues; phyto(rhizo)filtration: the use of plants in hydroponic set-up for filtering polluted water; phytostabilisation: the use of plants to stabilise pollutants in soil by preventing erosion, leaching, or runoff, or by converting pollutants to less bioavailable forms; phytodegradation: the breakdown of pollutants by plant enzymes, usually inside tissues; rhizodegradation: the degradation of pollutants in the rhizosphere due to microbial activity and phytovolatilisation: the release of pollutants by plants in volatile form.
Biofiltration is defined as the process of drawing air into an organic material, such as soil or plants and removing in that way the gases.[5]

1.3 How to solve the problem of urban heat islands

The Urban Heat Island effect describes the tendency of urban areas to experience higher outdoor air temperature levels compared to their contiguous rural periphery. This phenomenon is mainly attributed to the special characteristics of the urban landscape, including building density, size and orientation, open space configuration, and the use of heat absorbing construction materials, irrespective of global warming. The design of urban landscapes and buildings, including intensive development leading to massive loss of vegetation and pervious surface cover, might increase the intensity of the Urban Heat Islands effect and thus compromise the thermal comfort of people at street level, exacerbate discomfort caused by the overheating of indoor spaces, and increase energy consumption resulting from cooling energy demand in buildings.[6]

Urban Heat Islands are present mostly in metropolitan areas, and are created by energy from people, cars, buses, and trains and other places which have lots of activity and lots of people. It is also connected to the crowding - density problem. Skyscrapers and other high density constructions tends to create a lot of heat which bypasses insulations and having nowhere else to go, ends up between the buildings creating a urban heat island. Again plants are the solution: they help to cool things down. Plants absorb carbon dioxide, a leading

pollutant. They also produce a cooling effect on the environment thanks to the process of evapotranspiration: heat energy is lost as water evaporates and transpires from vegetation.

Thanks to the greenery we can lower the temperature in the closest area as a result of the evapotranspiration process in the summer even 2-11oC[7]. In winter, the construction of the vertical garden protects the façade against the impact of wind power, reducing energy consumption for heating. The research shows that green elements installed on the facades of the buildings improves also the microclimate inside the rooms. In rooms with green walls, the temperature is reduced by an average of 5oC, which significantly reduces the energy consumption for cooling by means of air conditioning[8]. Analysis of energy consumption in buildings with green roofs and walls indicates that this type of development allows reducing the cooling load costs in the range of 17-79% per year and 0.6-19.5% in the total energy consumption calculation in the building[9]. A 20 cm layer of soil substrate and 20-40 cm of plant cover has the same insulating properties as 15 cm of mineral wool.[9]

The sources emitting heat radiation are mostly the sun and the surroundings (buildings and ground surface). Some of the sunlight falling on plants and substrate are absorbed and some is reflected and transmitted[10]. The proportion of solar radiation absorbed, reflected, and transmitted varies across type of plants, their different leaf density and colors. Approximately half of solar radiation is absorbed in the plant and the amount of radiation reflection is nearly equal to that of transmission, which mostly ranges from 20 to 30% of solar radiation. The absorptance of plant leaves is strongly dependent on water content, leaf hairs and leaf thickness. Thick and waxy-leaves, such as conifer needles, absorb up to 88% of solar radiation[11]. Plants are an effective reflector and transmitter in long-wave radiation from their ability to reflect 50% of near infrared radiation and they are effective absorbers in the short-wave radiation, particularly photosynthetically active radiation (PAR), which can be absorbed up to 85%.[12] Additionally, heat transfer in the Living Walls is a result of heat exchange by convection between plants and air in the surroundings, plants and air in the canopy, plant and substrate, and substrate and air in the canopy. Conductive heat transfer mainly occurs between plants and substrate and also through the leaf. It is noted that the amount of heat exchanged from leaves to leaves is usually negligible. Apparently, substrate depth is one of the key factors in impeding conductive heat exchange.

Evaporation and transpiration are the important mechanisms to cool down the leaf due to the use of considerable heat absorbed in a leaf[10]. About 60% of the heat accumulated in a leaf can be dissipated by transforming it into latent heat. However, this ratio of latent heat dissipated from the plant to total absorbed radiation by the plant can be highly varied according to wind speed and moisture content of the air. [13]

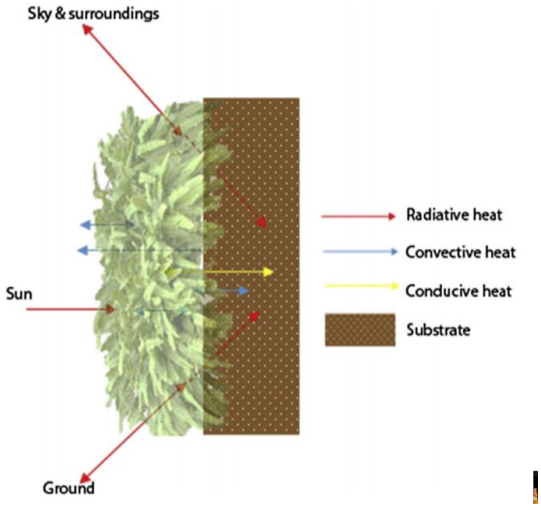

Figure 4: Radiative / Convective / Conductive heat[14]

2. The vision of green balconies as a future of modern cities

Taking into the consideration all the positive impacts of the green walls on the environment but also inhabitants the idea has been proposed to be implemented in some areas of buildings. Green balconies seems to be a great solution independently - or together with green roofs and green walls. It can be implemented by a private investor, which is willing to purchase a plants just for his own balcony, but also by a developer of the building which is willing to implement it to all existing balconies in the building.

Figure 5: Before and After - Ursynów visualisation

2.1 Technological solutions

Currently on the market available are three different systems which can be used for the construction of overlay on green balconies. Each of the solution is different and can be choosen respectively to the expectation of the client and his budget.

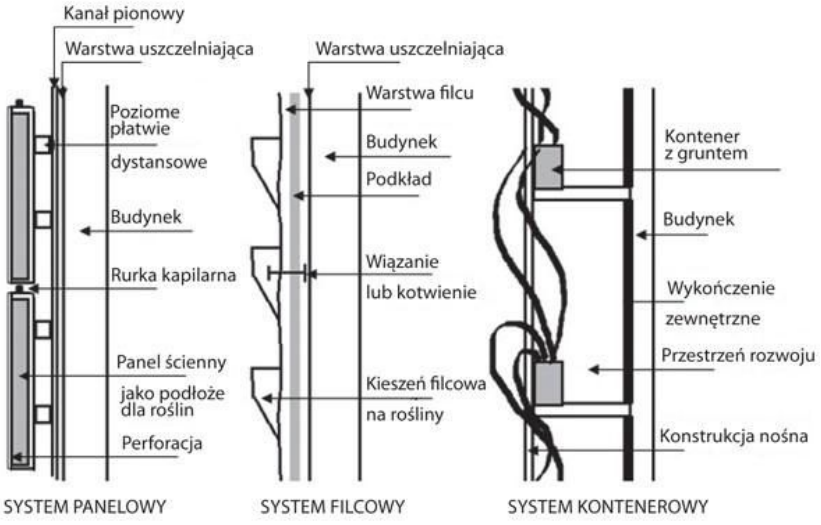

Figure 6: Scheme of three different systems of green walls[15]

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