The urban and environmental analysis of The Mokotowski Ventilation Corridor

Anna Malgorzata Jachimowicz, Warsaw University of Technology, Faculty of Geodesy and Cartography, Warsaw, Poland, a.m.jachimowicz@gmail.com

Martyna Wlodarczyk, Warsaw University of Technology, Faculty of Geodesy and Cartography, Warsaw, Poland, martyna.wlod@gmail.com

Keywords: Sustainability, Ventilation corridor,

Abstract

The Scientific Project made by the Student Scientific Association of Spatial Planning placed on Faculty of Geodesy and Cartography Warsaw University of Technology titled: The urban an environmental analysis of The Mokotowski Ventilation Corridor . *The project focused on c many sided researchs and analysis indispensable to assess the actual impact of buildings in the corridor on air exchange system in its proximity.*

Undertaken actions indicated the complexity of a problem with location buildings in open urban areas, which are at the same time significant elements of the ventilation system of Warsaw. All implemented analysis led to conclusion, that the buildings recently introduced into aforementioned ventilation corridor affect adversely air exchange, not only on the premises, but also in the areas adjacent. Students performed air flow simulations and shading analysis of the corridor region. Additionally, they conducted researchs to urban barriers. Moreover, students took into consederation Polish law regulations concerning buildings these sites impact of local statutory plans, zoning, buildings permits, agreement with developers for suitable improvements of analyzed area.

The final work is the concept of area development plan sitated in a fragment of the corridor. Plan is a proposition of proper land development, which does not interfere with the ventilation system and includes needs of local population.

The impact of variuos types of land use on city ventilation process, based on example of Mokotowski ventilation corridor

1. The reasons of current condition

Ventilation corridors are important elements of urban greenery system. They deliver clear air from suburbs to centre. Similar function is provided by wide streets and open airport areas, due to their lack of urban development. Ventilation corridors are characterized by fast and undisturbed airflow during windy weather.

In the last twenty years, which were the period of Polish political transformation, urban landscape has changed significantly. Process of transformation is thus far unaccomplished and it still provokes plenty of modifications. It is not only related to the urban planning. The concept of transformation

contains multiplicity of changes that took place in Poland since introduction a new, democratic political system in1989. These changes refer to economy, industry, society, democracy, and many other related domains. Urbanization is also included.

Urbanization is interpreted as a process of population concentration in certain points of geographical space, mostly in the cities. Along with liberalization of market, economy and industry from central planning, it became finally possible to start a private businesses and investments. As a result process of urbanization accelerated and changed its nature ultimately free from central planning. Open market attracted many developers who wanted to build new facilities, like multi-family houses, office buildings and shopping centres.

Lack of supervision over the use of land for construction purposes, caused by confusion in state and local government legislation, has led to chaotic and mostly thoughtless development of open areas in cities and in suburbs. Constant changes in legislation of construction, urban planning and environment impeded a proper supervision. It prevented uniform spatial planning, which is the responsibility of local government units. All mentioned factors led to urban disorder in Warsaw and reduction of green areas, whih ceased to be protected due to constant amendments and revisions of law.

2. The influence of green areas for city climate

The green areas in Warsaw are arranged in irregular system, which is characteristic of the remains of former palace garden units, protected areas or large forests. It is impossible to determined compact green areas system in spatial structure of the city. It is random and gradually decreases.

The Mokotowski ventilation corridor, which is the important part of Warsaw green areas system, has been protected for many years by the planning documents reffering to whole city area. This documents prevented the creation of new buildings on ventilation corridor area. In this way, city government tried to keep the free corridor to air exchange in the city. The main assemtion defined these places as areas of low buildings, green areas and sport areas. The main assumption was sustenance monocentral linear layout development.

In 1916 Prof. To wi ski prepared The sketch of the Regulatory Plan of Plan was placed the first conception about compact green area system. The main ventilation corridor supposed to be the Vistula River. Additional parts of this system are formed from green areas corridors or unbuilt areas e.g. railway areas. This planned green system survived communism period of time. In the 1995 year passed The Act on Protection of Agricultural and forest land. This kind of land use stopped be protected in this Act.

Figure 1: Extent of Mokotowski Ventilation Corridor.

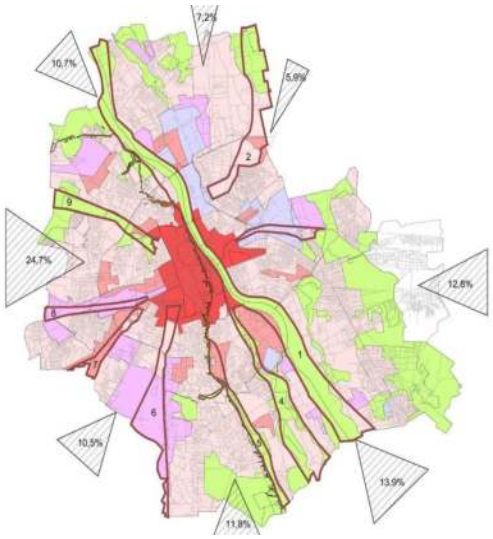

Figure 2: Urban ventilation corridor system in Warsaw

The attractiveness of undevelopment land become more important than city ventilation system in the period of capitalism. That procedure result of systematic reduction of ventilation corridors areas, which had an impact on the deteroration of health air condition. In Mokotowski ventilation corridor, on the biggest green areas was created new housing estates Marina Mokot w, Eko Park and Wi niowy Business Park.

The existance of green areas in the city is very important for air condition and local climate in the city. Green areas in the city are the areas, which are defined as air refinery . Clima the result of natural and anthropogenic factors. The second kind of factors can degrade climate. There are: the size of development area, the structure and building density, type of industry and pollution and the degree of interference in the environment. It is impossible to avoid these factors, because they are inextricably linked with the city. They are also cause the exsistence of phenomena as heat island. It occurs in places where the atmosphere gets a large amount of heat from energy and technological processes and the substrate absorbs the rediation of the sun. However, it should limit the impact of these factors to climate of the city. It can be done by designed of adjacent thermal surfaces and nonthermal green areas. The green areas should have linear shape and be in accordance with the prevailing wind directions, and layout development should include the topography and local angional air circulation.

The green purifies the air in the proces of photosynthesis and reduce the temperature and humidity of air. Planning the location of green areas in the whole city should be taken into account the characteristis of the wind: speed, direction and return. The green areas and development may be the barier for wind, which can loose its speed immediately on it. In that situation can be formed the phenomenon called nozzle and aerodynamic shadow. The aerodynamic shadow is that place, where the wind speed is very low. While in the aerodynamic nozzle, the wind speed increases rapidly. When the air mass enters the tunel, it begins to move with the direction of the tunel. Remember these specific behawior of wind it can be influenced on ventilation of the city and local climate.

3. Built impact on the climate of the city and wind flow

Wind fields modification on city area is determined by air pressure difference between city area and suburban area. The amended thermal conditions inside the city are generated local air circulation e.g. breeze. Higher temperature in city area creates local circulation with winds blowing to inside the city. The main factor causing this type of circulation, is change in the air temperature field inside and over the city.

The wind directions in the city are also generated by street layout. When the air circulation is powerless, which mostly happened in the evenings, the main streets allow air penetration from the outskirtes to city center.

The air flow in urban area depends on surface roughness. This index is calculated as item area projected on a plane to total area, multiplied by the average height of element. The city surface roughness increases thermal and mechanical turbulence, especially in the nights. The city surface reduces the local wind flow, when the winds speeds are high and strengthens the air flow during periods of weak regioanl winds.

Varied heights and building orientation cause certain effects in air flows. The air flow around and between buildings was recognized in researches in aerodynamic tunels.

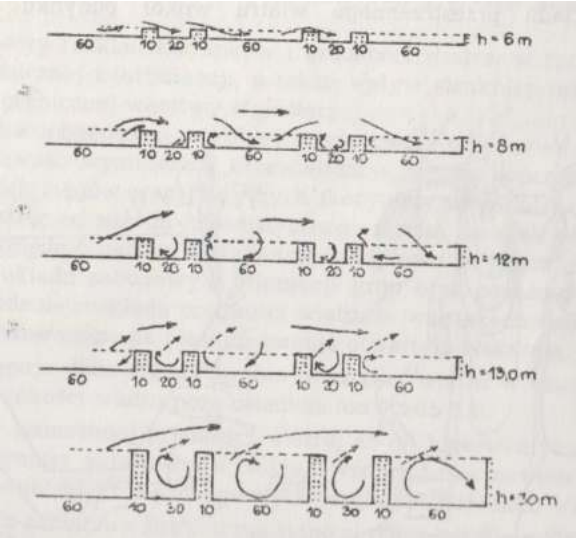

Figure 3: The air flow in urban area

Groups of the high building cause an increase in wind speed on the courtyards and wind flow over the buildings to next street canyon. Smaller courtyards cause wind deceleration on them, while massive blocks cause wind deceleration in adjacent streets. In wide streets canyons, the wind direction is parallel to street axis.

4. Land use structure of Mokotowski Urban Ventilation Corridor -the types and characteristics of individual areas

Mokotowski Urban Ventilation Corridor is located in four districts of Warsaw: Mokot w, Ursyn w, Italy, Ochota. Each of these districts has a different structure and form of land use. There are public facilities, numerous green spaces, allotments and all types of buildings: residential, office and brownfields. What is more, we are able to distinguish the production and service areas (5,3%) the areas with predominantly single-family housing (20.3 %), the areas with predominantly multi-family residential buildings (13.9 %), the areas of health services, science and administration (9.6 %), the areas of sport and recreation services (11.4%) and the areas of services (39.5 %).

Therefore, it is hard to define the name of building system for the entire area of the urban ventilation corridor. There are built-up areas with modern office buildings, luxury apartments and little aesthetic industrial buildings or neglected multi-family residential buildings. Residential buildings are inscribed in a rectangular street layout. On this area dominated development of low buildings - 3-4 floors. There are also the 7- and 8 - storey blocks where at the lowest levels established services. A large group of buildings are a modern apartment and office buildings belonging to the settlements Marina Mokot w and Eco- Park. The area of Mokotowski ventilation corridor have got very well developed public transport network and the satisfactory condition of the roads and pavements. These housing estates are characterized by a clear urban layout.

The first settlement - Marina Mokot w is located entirely inside the air corridor. In the southern and central part of the settlement are located the highest 8- storey buildings. In the eastern part of the settlement the buildings are lower 2-3 storey. The average number of floors is 4.26 , and the rate of development intensity is 1.31. These parameters are accepted in local zoning plans.

The second of settlement EkoPark is characterized by higher rates than residential Marina Mokot w. The average number of storeys is 5.87 and the whole area of the project took the 18000 sqm. The rate of development intensity is 1.46. The whole project represents 10 residential quarters. The quarters are rectangular and adjacent to each other by longer sides . The quarters making the significant barrier aerodynamic, because they are a long string of buildings.

Green areas can be divided into: appointed green areas (27 % of all green areas) , greenery under a system of fortification nineteenth - century fortress Warsaw (2%), green forest (6%) and allotments (65 %). Among the appointed green areas we can distinguish The Pole Mokotowskie Park. This place is frequented by residents of Warsaw. It is a place of rest , relaxation, sport.

5. Frontal area index the method to show the buildings impact for the ventilation city system

The frontal area index is a method that is used to designate architectural barriers blocking the flow of air and determine the most probably ventilation paths between buildings. There are many opportunities to use this method in spatial planing, especially in urban areas. This method was used for the first time at the Technical Unversity in Hong Kong. The frontal index is calculated as the total area of building facets projected to plane normal facing the particular wind direction, diveded by the plane area. This relationship is shown in the following equation and figure:

$$f = Afacets/Aplane$$

gdzie:
f the frontal area index,
Afacets - the total area of building facets facing the wind direction,
Adzia ki the plane area.

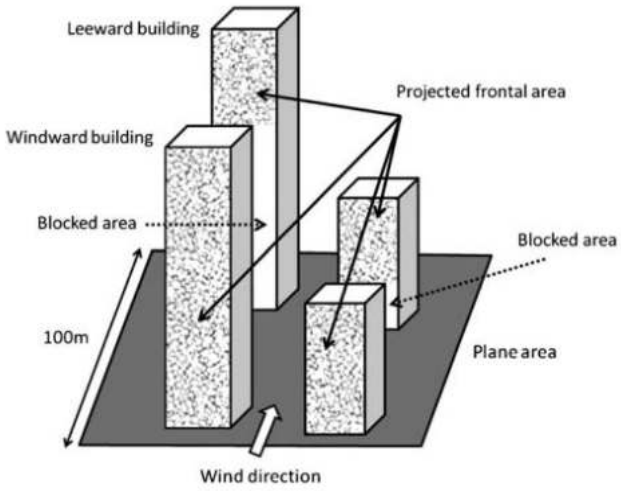

Figure 4: Graphical idea of frontal area index ratio

This method shows the influence of different landuse on city ventilation system. Analyzing the Mokotowski Ventilation Corridor, the frontal area index shows that development effects on the air flow through the Corridor area. Additionally, it was possible to visualize the air circulation through the Corridor before implementation of housing estates.

To show the differences in local air circulation, they were made two analyzes. The end result of this analysis was raster with grid cell of 100 m 100 m. Each pixel con index s value on this sguare plane.

The first analysis was based on Corridor s land use in 2002 year. At that time, th the airport (in the south) and service buildings (in the north of corridor) were the only clusters of the buildings in that area. It can be noticed that the frontal area index for the significant part of the study area was in the 0 0,017 interval, which is the low value. In this areas are also green areas e.g. parks, squares, cemetery.

The second analysis was made for data from the 2012 year. For ten years, investors have built housing development in the corridor area. The new development is low (to 12 m) and medium high (12 25 m). The frontal area index has changed significantly for this areas. The new housing estates have built in the central part of ventilation corridor, which is also the narrowest part. Most of new buildings have got 12-25 metres high, so they are valid architectral barier, which locks air flow through the Corridor.

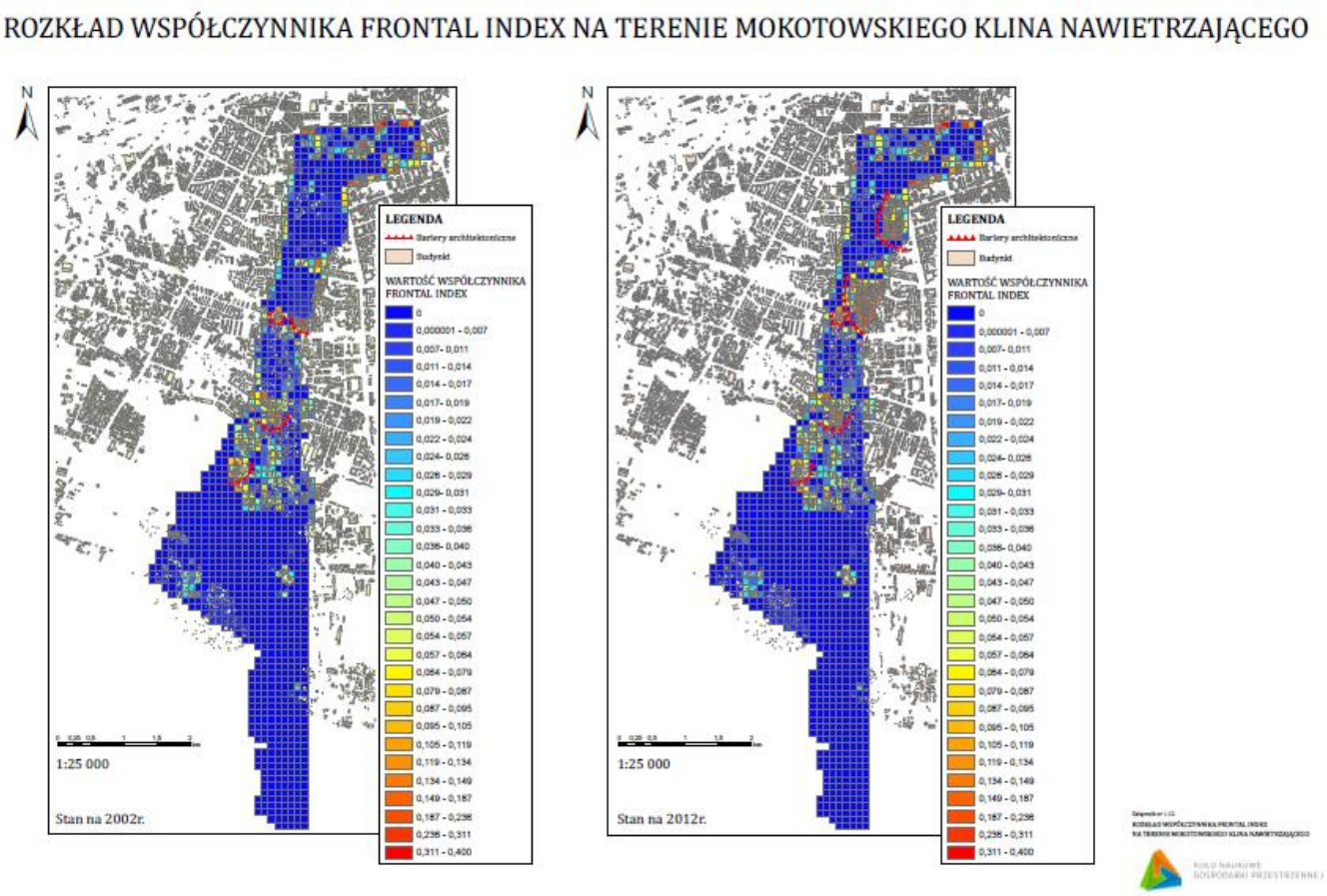

Figure 5 Distribution of frontal area index in Mokotowski Ventilation Corridor

6. The wind flow models for housing estates Marina Mokot w and Eko Park

The frontal index analysis confirmed the hypothesis that new housing estates are significant architectural barrier for air flow. The next analysis was made in the Autodesk In this application were made the wind flow models through the development areas. Using Vasari Application it was possible to mark aerodynamic shadows and nozzle in this areas, because in this programme it is necessary to input typical wind direction and wind speed.

The first model was made for Marina Mokot w estate. It can be noticed that south-western wind has got the same speed before the housing development. When the air flow hits on narrow spaces between buildings, the wind speed increases and formed an effect called aerody is not the predominant trend in this case. The housing estate constitutes the barier for wind flow, which is more observable. Group of buildings locks air flow and formed aerodyna north part of Marina Estate (navy blue in the figure). As a result of the estate construction is reduction in functionality of Mokotowski ventilation corridor.

The second analysis focused on Eko Park Estate model. As in the previous case the urban grid formed some places, in which we can observed aerodynamic nozzles and aerodynamic shadows. The second form is dominant trend, because the longer facades of buildings in this estate areperpendicualr to prevailing winds.

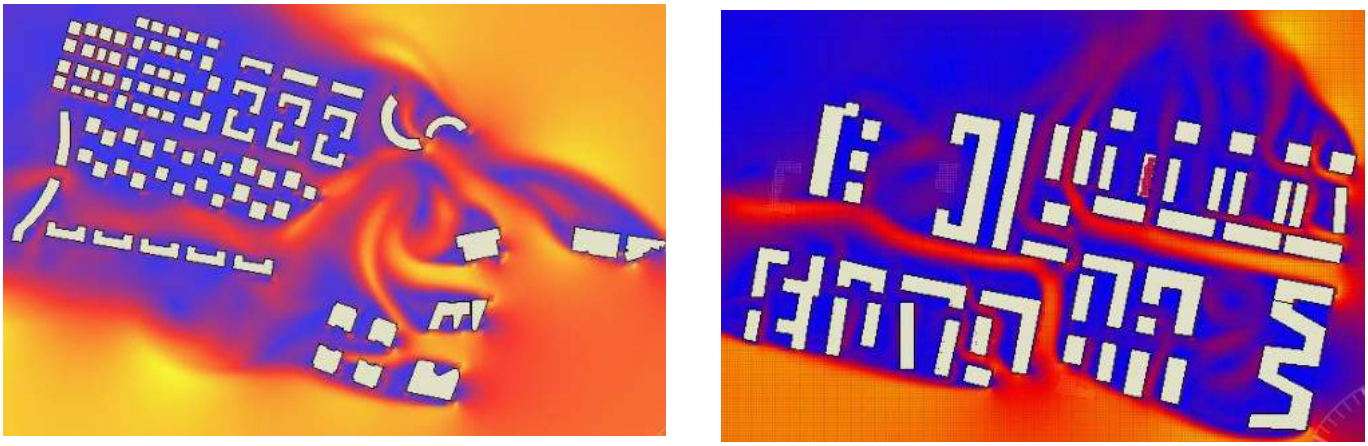

Figure 6: Visualisation of projected frontal area

In both cases, the residential geometrical structure stops vertical air flow, which means that efficiency of Mokotowski ventilation corridor is significantly reduced. But it does not mean that both of this built-up areas completely blocks air flow. In places, where wind has got the lowest speed formed the low-pressure zones. When the wind bypasses the urban areas, it is sucked to windless zones, where the air pressure is very low. Thereby follows air flow through the next part of ventilation corridor, but the wind speed is lower. This situation occurs when the wind do not hit on the next barrier immediately.

Conclusions

Urban areas are addicted to air flow and air pollution. Large complexes of green areas in the city can improve residents health conditions. This areas affect on local climat: wind speed and direction, temperature and air humidity, sunlight. Compact green system provides natural permanence and stimulates local air exchange. The ventilation corridors are important part of cities ventilation system. They are created mostly to the city center and running along prevailing wind.

For recent years, the total green area in cities have decreased. A large part of this areas, which have attractive location are planned for new urban areas. Situations like these, provokes discussions about leave the green areas in central parts of cities.

The analysis, which were made, allowed to extract the conclusions about the relationship between development and air flow through the Mokotowski ventilation corridor.

Analysis of air flow through the urban area shows that high buildings create architectural barier, which changes winds directions and reduce the wind speed on the leeward of buildings. This situation has an impact on air health conditions in built-up areas in city, especially in the lowest level of atmosphere the level, in which live residents.

The green areas next to built-up areas is positive phenomenon, because green areas reduce the heat island areas and cause intensive, local air mass flow. This flow formed when extremely hot urban areas adjacent to the much colder green areas. This atmospheric phenomenon influences to atmosphere regeneration and it is very important in summer time, when occur the atmospheric silence.

To maintain health and normal Warsaw ventilation system it is necessary to protect unbuilt parts of ventilation corridors and restrain city government from allow this areas for new housing estates, services or offices. This is important, because high development is the barier for clean air mass. Ventilation corridors should be continuous, green strips which connected city green areas with green areas abroad the city. Thanks to described land use planning, the supply of clean air to the dense city centre is possible.

The undeveloped part of Mokotowski ventilation corridor forms the air exchange proces in housing estates on its territory, in the neighborhood and in the central part of the city. This proces is very important for inhabitants because it guarantees adequate air quality. Therefore, it is imperative to prohibit construction new development on the discussed area. Local Spatial Management Plan and Study of the Conditions and Directions of the Spatial Management should protect the Mokotowski Ventilation Corridor and promote a larger share of biologically active area. Spatial planners mission is creating urban spaces with respect for the environment.