THE INFLUENCE OF WIND ON BIOCLIMATIC TOWN PLANNING

Mila PUCAR, Milan PAJEVIĆ

Institute of Architecture and Town Planning of Serbia, 11 000 Beograd, Bul. revolucije 73/II fax: 381-11-3226-369
Institute of Technical Sciences of the Serbian Academy of Sciences and arts 11 000 Beograd, Knez Mihailova 35/IV, fax: 381-11-185-263
Yugoslavia

ABSTRACT The influence of wind is an important part of the bioclimatic town planning criteria. Ventilating and mechanical action of the wind towards reduction of air pollution in urban areas is becoming increasingly important and must be analyzed along with other factors such as thermal losses, comfort etc. Numerous errors committed in overlooking the ecological factor and the role of the wind in the siting of residential districts and industrial plants in Belgrade point to the need for a better organized, multidisciplinary research in this area, including the production of basic topoclimatological maps and the establishment of an adequate network of stations recording air pollutants and wind characteristics.

1. INTRODUCTION

The use of wind is an important criterion for energy efficient planning and design of buildings. It allows for better ventilation and an agreeable microclimate during the summer period, provision of shelter from the effect of cold winter winds, as well as reduction of thermal losses during the heating season and a discomfort and danger around buildings.

Another, increasingly important town planning parameter, is the role of ventilating and mechanical action of the wind on the reduction of air pollution in cities. Wind is involved as an important variable in many phenomena of pollution transport and diffusion within the atmosphere. The ground level concentration of air polluters decreases according to the transport velocity, while transport itself is regulated by the mean wind speed in the boundary layer.

Guidelines on energy-efficient urban planning include as an important parameter the relation between urban wind climate and the geometry of urban space. The application of this knowledge to urban design lags behind, mainly due to lack of organized transfer of information from the meteorological community to the town planning practice. Integration of the design of urban environment as one of the many requirements to be met by the urban planner should also include wind as an important factor.

2. THE BELGRADE AREA

The city of Belgrade is the largest urbanized area in Yugoslavia (ab. two million inhabitants and an area of 330.000 ha). Uncontrolled rate of urbanization during the period after the WW II had many negative effects including air pollution. Thermal conditions in the moderately continental Belgrade climate vary from those in the Mediterranean region and the Adriatic sea, to the conditions prevailing in the area of the Carpathians [1]. The area is exposed throughout the year to numerous penetrations of polar and subtropical air masses. The city has a large variation of microclimates because of changes in elevation, topography, distance from rivers etc (Fig.1).

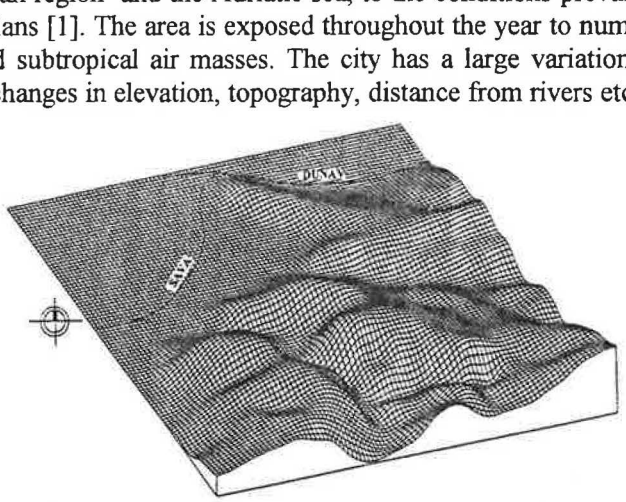

Figure 1. Complex topography of Belgrade and its surroundings

The characteristics of this climate include forming of heat islands with temperature differences up to 3^0C during the morning hours and stable weather conditions, as well as a forming of pools of cold air in the low lying areas of the Belgrade territory. Temperature difference between the flat and the hilly parts of Belgrade amounted in certain measuring periods up to 10^0 C. The highest point in the center of the urban district is 248 m and the lowest 75 m.

The wind is a significant climatic factor in Belgrade. Prevailing winds in autumn and winter come from ESE, while the dominant winds in spring and particularly in summer are western and northwestern winds. There is a pronounced difference between the summer and the autumn wind rose. Physical planning on the general scale was until now mainly based on a well known fact that "Koshava", the South-easterly wind clears the air.

The horizontal thermic gradient of the air in the city creates breezes. Air-flow towards city squares provokes a draft, i.e. increased wind speed. Channeling effect occurring with increasing wind speed while streaming through narrower streets, is also present. The fog occurrence is most frequent during the stable weather conditions, with weak winds, and within temperature intervals between -5 to $+5^0$C. Air pollution with a high sulphur dioxide content and smoke concentrations is for the territory of Belgrade directly linked with the duration of calm period and fog.

3. WIND AND POLLU

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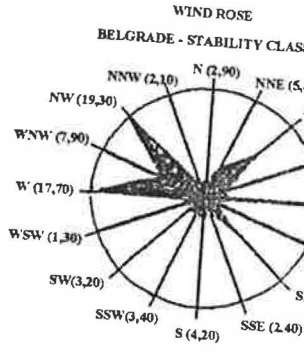

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3. WIND AND POLLUTION IN BELGRADE

The general scale

Air quality in Belgrade, as in other metropolitan areas, represents the ratio between the degree of polluting emissions and the speed of dispersion [2]. Dispersion coefficients of turbulent dispersion can characterize weather changes and spatial distributions of weather conditions. Dispersion coefficients are evaluated for classes of atmospheric stability determined through (a) data about wind speeds, cloudiness and radiation, (b) vertical temperature gradient, and (c) data on wind orientation fluctuations [3]. Stability classes for Belgrade, ranging from extremely unstable (class A) to stable (class G) are shown in Figure 2.

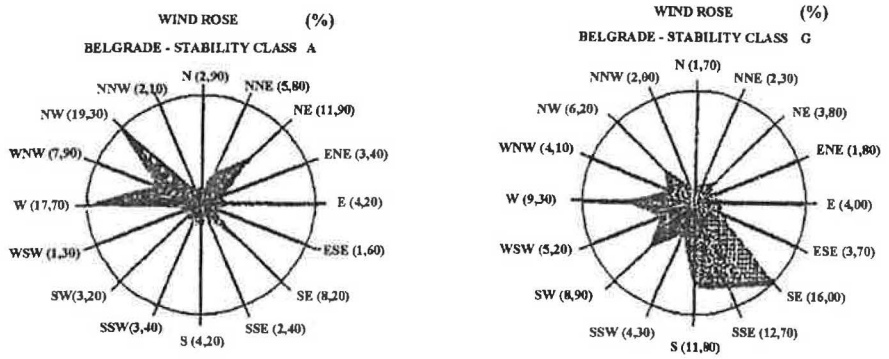

Figure. 2. Wind stability classes for Belgrade A - extremely unstable, G - stable

Conclusions regarding the quality of air are mainly based on sulphur dioxide and dust particles measurements which gave reliable results on concentration levels during the heating season. The summer period, characterized by an increase of emissions from industrial sources, traffic as well as the dispersed-diffuse emissions of evaporable organic compounds, is not covered by an adequate monitoring of air quality.

The meso scale

Simplified approach based on the assumption that ESE wind clears the air basin, encouraged the construction of big sources of industrial air pollution within the radius of 40 km. from Belgrade, in particular within the stretch from Obrenovac to Pančevo due to convenient river transport. The situation is further aggravated by the erection of a coal-fired steam power station complex in the vicinity of Obrenovac and the chemical industry zone Barič, 36 km. away from Belgrade, emitting nitrous oxides and sulphur dioxide in quantities which sometimes exceed the maximum allowed concentration as shown in Figure 3.

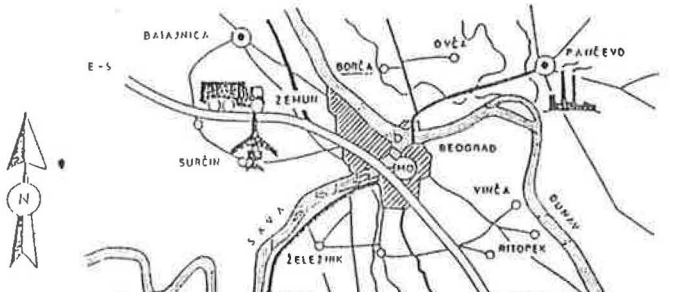

Figure 3. Location of important air pollution sources in Belgrade area

Available scientific potential and data banks, as well as the conclusions of T.Tirabassi [5] and numerous other authors on the correlation between wind speed and pollutant concentrations, did not prevent the mistakes made in the physical planning of this basin from the air pollution aspect. The analysis of meteorological conditions centered on negative thermal effects of cold winds while seriously misjudging the unfavorable situations with low wind speeds, anticyclones, creation of ground level and raised temperature inversions, which favour dangerous levels of air pollution during warmer periods.

As a result of their synergetic action due to transformation of pollutants in the atmosphere these sources seriously endanger, during the warmer part of the year, the quality of air in the most attractive part of the city located at the confluence of the Sava and the Danube rivers.

The local scale

The air in Belgrade is one of the most polluted on the territory of Yugoslavia, comparable with the air in industrial towns with the highest content of sulphur dioxide.

Air pollution is mainly due to the use of oil in district heating systems, use of coal for heating in individual boilers and boiler houses in the city center, absence of air cleaning devices, irregular inspection and maintenance of boilers and their emissions, etc. This situation is expected to improve with the successive attachment of individual users to the new gas-heated district heating grid and the completion of the circular road for transit traffic.

Dangerous levels of air pollution in the town center are also caused by the heavy car traffic, lack of parking places and garages and heavy transit traffic through the center. Public transport is mainly relying on diesel buses and the stations are frequently placed on the steepest parts of the longitudinal street profile.

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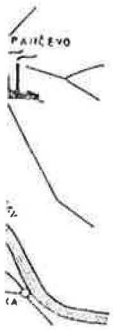

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4. PLANNING LEGISLATION

Environmental protection criteria including air protection must be a part of planning and design of human settlements. They must be based on the full knowledge of polluting agents, and the identification of their sources and venues of spreading.

The first attempt to treat the natural environment as a system was made within the 1952 Belgrade Master Plan pointing to (a) complex topographic influences (differences in elevations cause downward air movement during certain parts of the day), and (b) that highest points lie in the suburbs on the directions of dominating winds in the Belgrade wind rose.

The Master Plan specified that all the high elevations around the city should be afforested creating a thick tree belt linked to green areas in the background. The 1972 Master Plan represented in this respect a step backward since directions of urban expansion interrupted the green belt in two of the most sensitive spots. The declared system of "settlements archipelagoes in the sea of greenery" resulted in moving the green areas greenery to positions which were irrelevant from the ecological point of view.

Environmental protection was included for the first time in the Planning and Physical Planning Act of the Republic of Serbia issued in 1974. The 1989 Physical Planning Act further stipulated rational use and protection of the built space, protection and advancement of the living environment as a responsibility of local authorities.

The above mentioned did not prevent a series of planning mistakes since environmental problems remained for many years marginal in spite of their declarative presence in physical plans of the Republic.

CONCLUSIONS

1. Wind environment must have a high priority in the early stages of planning and design of urban areas.
2. A large body of experience on wind in the built environment should be nationally summarized in guidance for planning and design.
3. A model describing the spreading of polluted air and its relation to relevant meteorological and topographic characteristics should be made for each new residential district as shown in Figure 4.
4. A research project should be initiated in order to :
   - develop uniform methods and procedures for the production of topoclimatic maps, and
   - construct two basic topoclimatological maps presenting physical properties of the earth-atmosphere interface, including aerodynamic properties such as roughness parameter and zero-plane displacement, for the areas of Belgrade and the industrial zone Obrenovac - Pančevo - Barič.

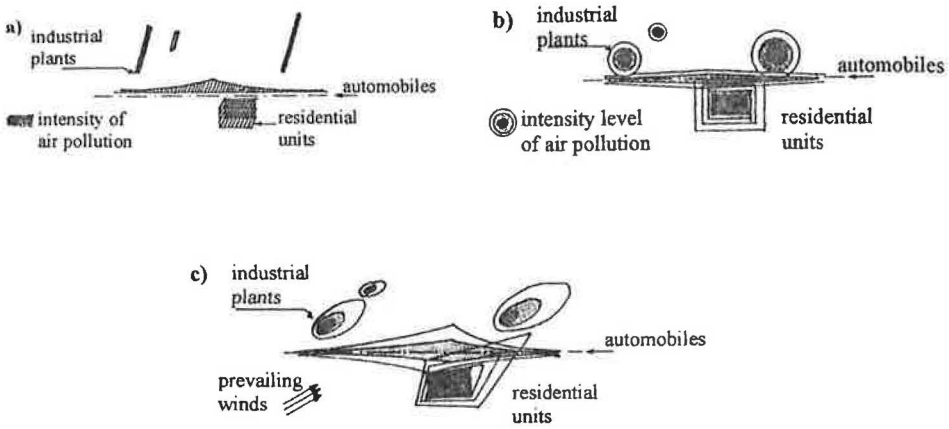

Figure 4. A model describing the spreading of polluted air [4]
a) Assumed locations and intensity of pollution sources
b) Spreading of pollution during periods of still
c) Spreading of pollution under the influence of winds

5. A successful solution of complex air pollution problems and energy aspects of planning require a well co-ordinated, cross-disciplinary effort based on a greater two-way flow of knowledge between different planning specialists and administrations.
6. Identification of the sources, levels and directions of air polluters requires the establishment of a network of recording stations along the main directions of wind roses as well as at all the main points of urban and industrial air pollution. The criteria for wind- observation sites as well as physical and statistical analyses of the recordings should be in compliance with the methodology established by relevant commissions of the European Community.

REFERENCES

[1] Popović, Z. (1990) Characteristics of Belgrade Climate, Conference: Ecological problems of Belgrade, Vol.2, pp.307-316
[2] Matić, S. (1990) Protection of Air Pollution and Influence on Health, Ibid. Vol.2, pp.245-260.
[3] Vuković, T. Meteorological aspects of air pollution, Ibid, Vol.2, pp.283-291.
[4] Galić R. (1980) Urban Zoning, "Makedonska knjiga" Skoplje, 1980.
[5] Tirabasi T. et al, (1991) Wind Circulation and Air Concentration in the Coastal City of Ravenna, Energy and Buildings, 14

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