ACTA UNIVERSITATIS CAROLINAE
2003 GEOGRAPHICA, No. 1, PAG. 31–40

Cities and natural environment

ANDRZEJ BONASEWICZ

Warsaw University, Faculty of Geography and Regional Studies, Poland

Abstract

Location of cities is largely conditioned by the natural environmental factors. They define to an important extent the shape of city, the surface area taken by it, as well as its spatial setting. Natural environment determines the direction of urban development, and forms the development barriers. The role played by the individual elements of the environment has been subject to differing assessments over the course of history. The influence exerted by cities on natural environment is high and is still on the increase, due to the growth of the number of inhabitants and the concentretion of economic activity. High concentration of pollution in the atmosphere of cities brings about bigger cloudiness and higher precipitation than on the adjacent areas. Rapid expansion of urbanisation in the world entails constantly increasing threats and brings about the necessity of pro-ecological actions.

Key words: city, environment, climate, urbanisation

Introduction

The city is a spectacular example of space shaped by both natural and anthropogenic factors. Man creates an environment to live in, changing the natural conditions in the process, and chooses areas that are most favourable for settlement purposes in respect of both the natural conditions and human activity. Spatial concentration of people in a confined space leads to numerous problems in the living conditions. The quality of the natural environment deteriorates owing to the pollution of air, water and soil, produced by the city dwellers. Consumption of water rises sharply; it is becoming deficient in many countries. There is less and less space for depositing city wastes. Frequently, where the existing natural barriers preclude the growth of cities in space, the constantly-increasing population necessitates the construction of high-rise buildings. Currently, over 50 per cent of the world's population live in cities, which occupy as little as 1 per cent of the land surface. Over 70 per cent of the population in the developed countries live in cities, and, according to forecasts, 90 per cent of the global population will inhabit cities by the end of the 21st century. The number of city dwellers rises two times as quickly as that of the population at large, mainly as a result of migration from rural areas. The number of large cities, with a population exceeding one million, is growing extremely fast. In 2000, there were 433 such cities. Some of them merge into agglomerations, with populations in excess of 10 million.

The shape of the city to a large extent depends on the topographic features, the direction of watercourses' flow, climatic conditions and type of land use. In the past, the role of the specific natural environment components has been assessed in a variety of ways, depending on the level of socio-economic development. Initially, the defence capability of the city was an important factor; that is why cities were located in mountainous areas, on the rivers, in the vicinity of fertile soils, which were cultivated in order to satisfy the needs of their residents. Cities were surrounded with walls and, when attacked by an enemy, turned into strongholds. Later the defence function was replaced by the trade function. Cities were located along trade routes and near river fords. In majority events the walls that impeded urban development were brought down. Valley areas were preferred, with small height differences and rivers, since they allowed for the cities' spatial development. Many urban centres were located at the junctions of rivers and in river estuaries. River valleys became an arena for the expansion of settlement.

The examples of cities located on hills are: Rome, Naples, Florence, Assisi, Toledo, Athens, while cities located at the junctions of rivers include: Belgrade, Berlin, Moscow, Paris, Baghdad, Khartoum, and in estuaries – Lisbon, Hamburg, Bremen, Szczecin, London, Dublin, Oslo (lying on the fjord). Many cities have been located in intermontane basins, mainly in subtropical countries (Mexico City – 2500 metres a.s.l., La Paz – 3658 metres, Quito – 2850 metres, Bogota – 2660 metres, Guatemala 1627 metres, Caracas – 970 metres, Teheran – 1200 metres, Ankara – 1000 metres, Kathmandu – 1360 metres, Kabul – 1800 metres). (Janiszewski 1982, 1983, Kurowski 1987)

The factors that most strongly affect the location of cities include topographic features, climate and water conditions. Also, height differences within cities play a substantial part. They can reach high values, e.g. in Budapest from 100 to 529 metres a.s.l., in Vienna – from 145 to 542 metres, in Rio de Janeiro from 0 to 704 metres. Height differences can considerably disrupt the spatial structure of the city, change its microclimate and water conditions. For cities located at the foot of the mountains or in montane basins, the mountains can pose a natural barrier to their further development, as in for example Rio de Janeiro or Lima. In Rio de Janeiro, the mountain ranges are occupied by favels, that is, poverty areas, while the individual districts are connected via tunnels. Residential development on the mountain slopes leads to soil erosion. The inclining mountain slopes in the cities change air movements and reduce the supply of solar energy. Weakened turbulence of the air makes the cooled air move down into the valleys. In the winter, little radiation from the sun reaches narrow valleys. For this reason, in temperate climate zones, location in valleys or hilly areas up to an altitude of 600 metres above sea level is more favourable, while in tropical regions higher situated areas are better positiones, as they alleviate high air temperatures. The climatic conditions affect the type of urban development all over the world. Open green areas play a substantial role since they act as "ventilation corridors", cleansing the air polluted with gases, dusts and ashes. Streets that run along the prevailing wind directions are best ventilated.

The climatic conditions affect urban development in different places of the world. In hot and humid regions, optimal arrangements include dispersed buildings, broad streets, roofed terraces and verandas, light walls with window openings. In tropical forests, near the rivers, pile dwellings are frequently encountered. What is most important in such a climate is the protection against excessive humidity and precipitation owing to free movement of wind. The northern exposure of buildings is the preferable one, as it offers protection from too much heat.

In areas characterised by dry tropical climate, protection against excessive solar radiation and sandstorms matters the most. That is why the buildings ought to have thick walls and small windows, reducing temperature ranges. Narrow, shaded streets and facades of buildings– this is the typical construction pattern in Arab cities in the Near East and North Africa.

In the temperate and cold zones, characterised by substantial precipitation, sleep roofs are preferred, and where there is little precipitation, roofs should be flat, since such roofs isolate the impact of the snow cover. The southern exposure of buildings is better, while windows in the cold climate should be smaller, and in warm climate bigger, owing to the loss of heat.

The water conditions also play an important part. Nearly all cities are located on rivers, channels or water reservoirs (lakes, lagoons or the sea). In cities, water supply has always been important for the lives of their dwellers. Water is used for consumption, hygiene, industry and other purposes. The industry is a particularly heavy consumer of water. For instance, production of one metre of cotton textile requires 220 cubic metres of water, and of woollen material – 580 cubic metres. To manufacture one tonne of steel, 170 cubic metres of water are required, and 1300 cubic metres in the case of aluminium. In general, it can be said that the city uses three times as much water as rural areas, and this value is growing along with the increase in population. Water courses provide a channel for the removal of waste and are also used as transportation routes. The coastal location can be of great significane, too. Half of the world's largest cities are sea harbours. The location on the sea has strongly affected urban development since the most ancient times, to mention only ancient cities-states and cities-republics. Such a location was conducive to the development of the shipping trade, foreign trade and the growth of industry and services owing to international exchange.

The area covered by individual cities, their shape and street pattern largely depends on the natural environment. Cities which occupy the largest area are located in flat regions, e.g. Beijing has 16.8 thousand square kilometres, Los Angeles – 16.6, Sao Paulo – 8, Buenos Aires 7, Shanghai – 6.3, New York – 3.6, Cairo – 3.5, Mexico – 2.5, Tokyo – 2.2, Seoul – 1.7 or Calcutta – 1.3 thousand square kilometres. (Firla 2003). Rio de Janeiro, occupying an area of 6.5 thousand square kilometres and having a topographically varied area within its limits, is the only exception. The shape of cities is determined by the natural conditions. The linear shape is typical of narrow river valleys, along which cities develop, e.g. Kinshasa (15 km), Libreville (8 km), Niamey (7 km) or Bangui (15 km) in Africa. Similarly, an elongated shape prevails in the coastal belts, e.g. Lima, Rio de Janeiro, Oslo, Amsterdam, Stockholm, Helsinki, Bangkok, Buenos Aires. In many cases, mountains or boggy areas represent an unsurpassable barrier to the city's development in space (e.g. Rio de Janeiro, Lima, Oslo, Helsinki, Stockholm

or Buenos Aires, Bangkok). In relatively flat areas, where there are no natural barriers, many cities have a concentric shape. The historic city centre, established in the Middle Ages or in modern times, is surrounded by new districts. The streets have a radial pattern; they start in the city centre and provide direct access to the suburbs. Examples of such cities include Los Angeles, Paris, Moscow, London, Sao Paulo, Bern. The pattern of the city network is frequently preconditioned by the natural conditions and the specific cultural patterns. The chessboard pattern dates back to the ancient Rome and was later adopted, with modifications, in Spain, Latin America and north America. In this pattern, streets cross at a 90-degrees angle, with occasional disruptions caused by hills or ravines. In the cities of the Near East, streets are usually narrow and

Fig. 1 Plan of Bogota

Fig. 2 Plan of Bern

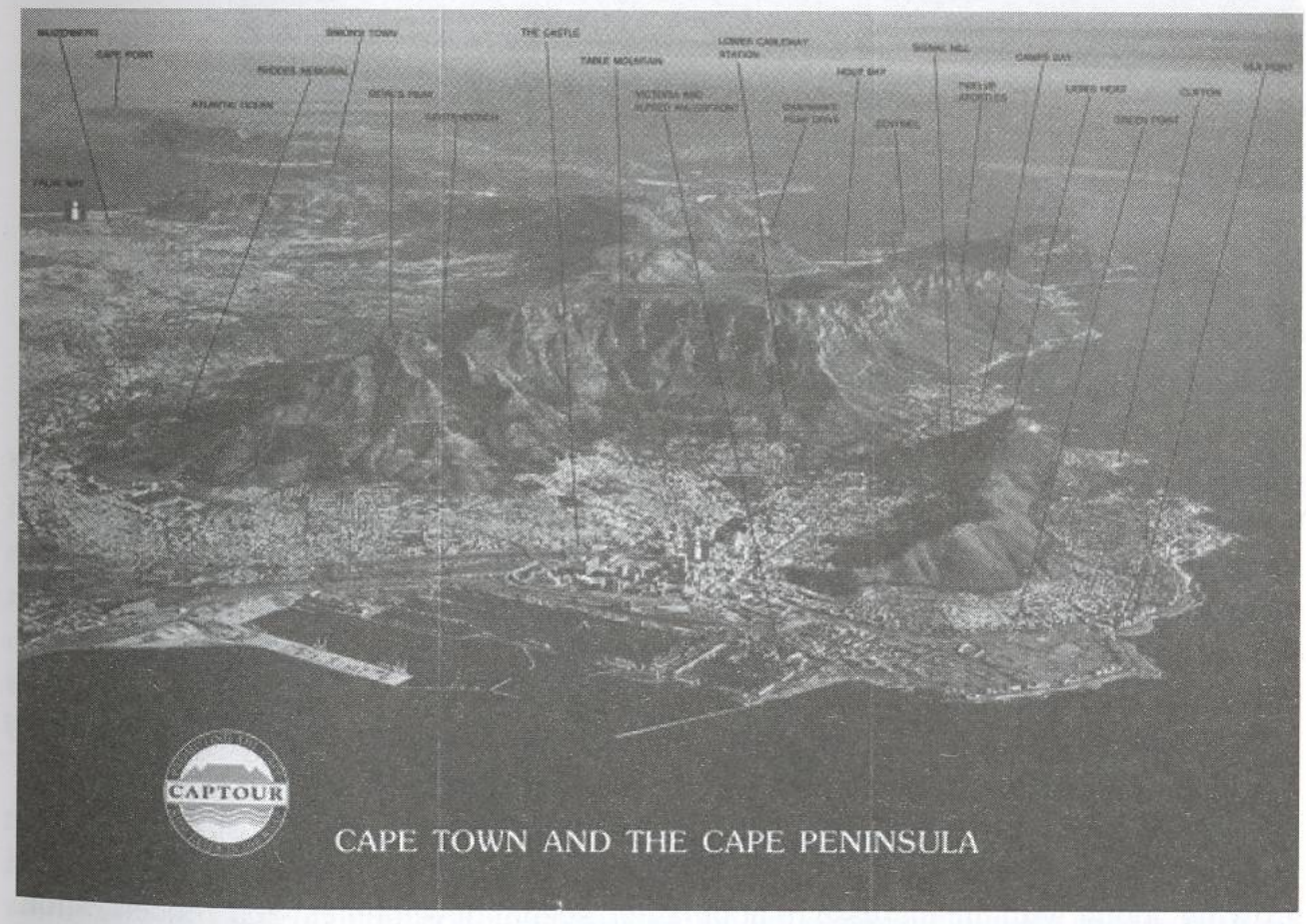

Fig. 3 Plan of Capetown

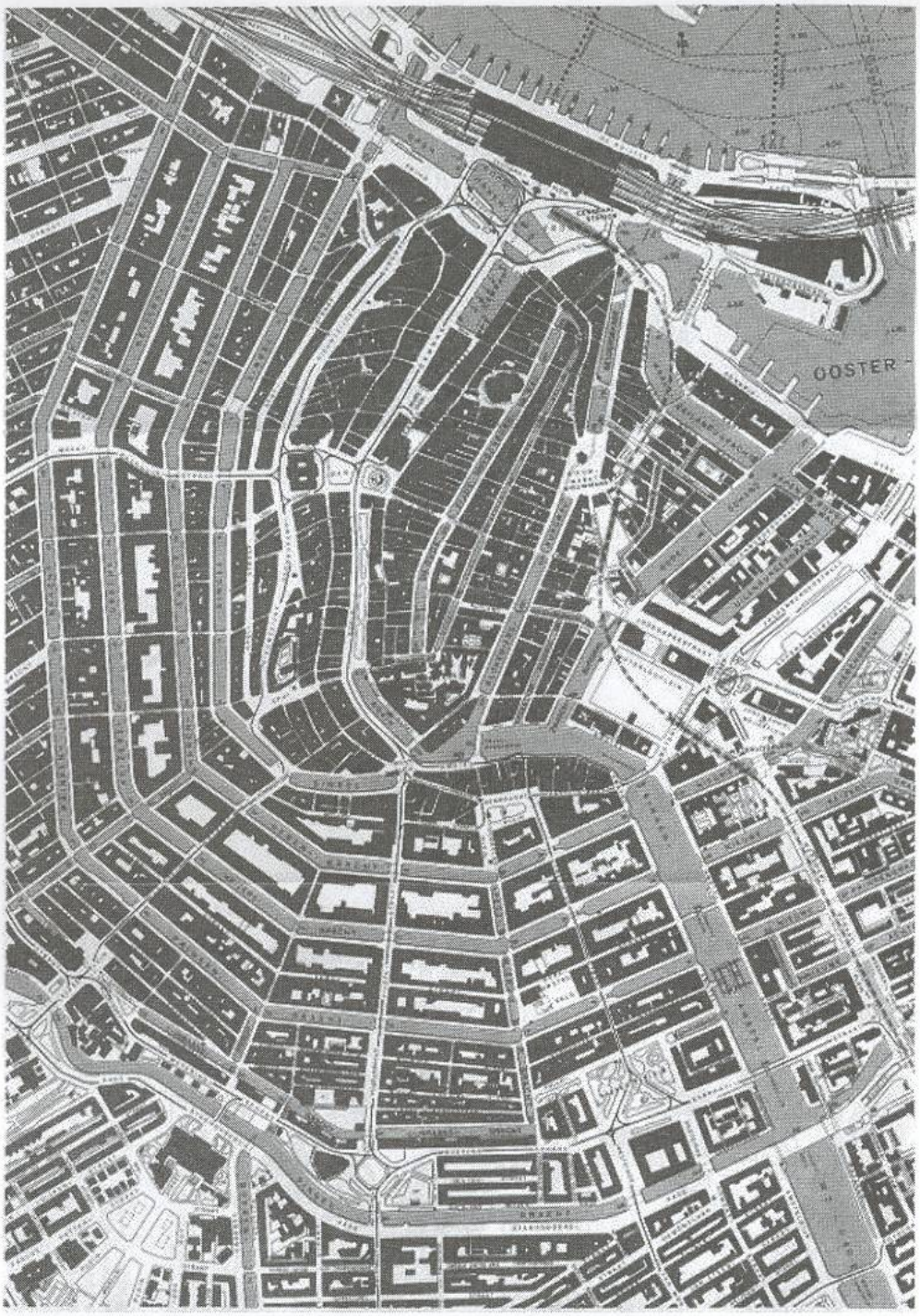

Fig. 4 Plan of Amsterdam

winding, while in African cities, outside European districts, streets are based on an irregular pattern. On the other hand, the urban network in Europe is characterised by many differences between the centre and the peripheral districts. Specific arrangements depend to a significant degree on the functionality of the individual districts and the intention to create optimal transport links.

Consequences of urban growth

The influence of the cities on the natural environment is significant and constantly growing, along with the increase in population, spatial development and concentration of economic activity. The environment has been completely transformed and can truly

Fig. 5 Plan of Caracas

be called an anthropogenic one, since all the components of the natural environment have been modified. The cities change the topographic features of a given area; they eliminate height differences on the one hand, but on the other produce earthworks, mounds or heaps. The level of the city is rising intermittently, as a result of the debris of old buildings, dusts, ashes and wastes accumulating on the ground. For example, the city centre of London rises 30 centimetres every 100 years, and that of Hamburg – between 70 and 80 centimetres; other cities are similarly affected, too. (Barbag 1984).

The construction of the underground causes changes on the surface. The poverty neighbourhoods in the Third World countries frequently occupy montane areas. Following heavy precipitation, soil erosion is accelerated, as a result of which soaked soil may flow down to city, along with wastes that are deposited outside houses in such poor neighbourhoods.

Soils in cities are destroyed owing to liming, fertilising, salting and industrial pollution. On top of that, soils are covered with asphalt or concrete, and even in green area they are transformed by different kinds of industrial pollutants.

It has to be said, however, the cities exert the strongest influence on the climate. All its components are subject to change – intensity, radiation, temperature distribution, wind-rose, air humidity, volume of precipitation, visibility. Solar radiation in cities is 10 to 20 per cent smaller, while ultraviolet radiation in winter is reduced by 30 to 40 per cent. (Flemming 1983). This is due to heavy contamination of air by industry, heat engineering facilities and transport. Over the cities, "umbrellas of pollutants" appear, composed of sulphur oxide, nitrogen oxide, nitrogen dioxide, carbohydrates and sulphur dioxide, which are noxious and can sometimes lead to deaths (Donor, USA, in 1948, London in 1952, the Moselle Valley in 1932). The city has a higher temperature than its surroundings. The so-called "urban heat islands" are created; average annual temperatures are 1 or 2 degrees Celsius higher than in the neighbouring areas, reaching a maximum difference of 3 to 10 degrees Celsius. The winter minimum reaches 1 to 3 degrees. The higher temperature is caused by industry, municipal economy and the reduced nocturnal radiation owing to polluted air and absorption of solar radiation by city buildings, concrete and asphalt. They have a large heat capacity – the low albedo absorbs solar radiation. The majority of energy is absorbed by the surface, walls and roofs. On a sunny day, pavements become hot and cause the distortion and expansion of concrete. The hot air rises upwards and "sucks in" cooler air from the neighbouring area. This leads to higher cloud amount and increased precipitation. Cloudiness in cities is 5 to 10 per cent higher than in the city's vicinity. This is caused by air pollutants, particularly aerosols. The precipitation in the summer is 10 per cent heavier than in the vicinity, and in the winter – 5 per cent. Increased temperature in the cities is largely caused by carbon dioxide, which absorbs infrared radiation and keeps radiation off the earth surface. Through the retention of heat with water vapour, a mantle is created that protects the city from excessive chill. The "heat island" increases on a par with the size of the city, its population, the number of cars. The highest temperature difference between the city and its vicinity is observed three hours after sunset. The walls radiate the heat outwards. As a result, the process of chilling is slow, particularly on cloudless and windless nights. Thus, London is 1.5 °C warmer than its vicinity, Berlin – by 1.7 °C, New York – by 1.1 °C, Moscow – by 1 °C, St. Petersburg – by 0.8 °C, Los Angeles – by 0.7 °C, Toronto – by 1.1 °C and Buenos Aires – by 1 °C. (Flemming 1983, Boryczka 1999). Densely built urban structure generates more heat, while a more loose structure facilitates air change. Unbuilt-up areas are cooler and are characterised by near-ground inversion. Chemical compounds that are present in city fumes affect the precipitation volume due to the condensation nucleus formed in the clouds. Research has shown that there is less precipitation on weekends, which indicates that it is largely caused by atmospheric pollution. It was observed that in Paris the precipitation is 5 per cent smaller on public holidays and other non-working days.

The relative humidity in cities is on average lower by 4–6 per cent, and evapotranspiration is 30–60 per cent lower than in their vicinity.

Winds play a very important part. Where the urban structure is not densely built, winds collect heat and disperse atmospheric pollutants. Frequently they raise clouds

of dust, blow away the snow, causing loss of heat. The velocity of winds blowing at a speed of 3 metres per second is in the cities lower by 40 per cent, at a speed of 3–6 metres per second – by 20 per cent, and at a speed of over 6 metres per second, it is lower by 10 per cent. (Flemming 1993). Near the ground, the wind is distorted and its velocity falters owing to the presence of buildings. In the ravines of the streets, the wind accelerates. In Central Europe, which is characterised by a prevalence of westerly winds, streets having a west-east axis are better ventilated than those situated along the north-south axis. The wind also affects the distribution of precipitation around buildings. On the windward side, heavy rain may soak the walls. In order to secure sufficient supply of solar radiation, an adequate distance between the buildings should be maintained. In a building with a north-south exposure, apartments facing the west and the east should be at such a distance from the neighbouring building that would exceed its height 2 to 6 times. Such a distance could be smaller in the case of buildings having an east-west exposure or ones diagonally situated.

Cities have a huge influence on the water conditions. They change the water network, which they shape in an artificial. Soil over-drying can be distinctly observed, which leads to a substantial lowering of the groundwater level. This is caused by the increasing water intake by industry and municipal economy. The soil covered with asphalt or concrete can retain precipitation water (rain or snow) only to a limited extent. In Los Angeles, the level of groundwater has lowered by 80 m, in Berlin – by 15 m. In some cities, water resources have been depleted, e.g. in Palermo or Baku. (Dobrzyński 1999).

Many water-bearing layers are intersected by underground facilities. In the majority of cities, approximately 50–60 per cent of their surface is impermeable, and for this reason the downflow and runoff or precipitation water is violent. Natural watercourse are usually cased, and frequently there are main drains. Due to artificial river channels, the water level after rainfall rises abruptly in even small rivulets, and the water cannot be discharged onto a larger area since the river channel is narrow. In the Columbia river, a 20 mm rainfall brought about a 30 cm water rise in the river after three hours and a flood. Similar floods took place in Opole and Wrocław in 2000 and in Prague in 2002. In huge metropolises, water shortages are frequent; it is sometimes rationed or closed off in certain hours. Some cities are supplied with water using aqueducts or Artesian wells.

The city also transforms the flora and fauna, as a result of microclimate warming, decreased humidity, pollution of air, water and soil, and reduced greenery areas. In many cities, trees are destroyed, which accelerates immediate runoff, reduces evapotranspiration and transpiration. Owing to the "urban heat island", the blossoming of plants and the ripening of fruit and vegetables is faster. Unfortunately, air and soil pollution makes the crops contaminated. The influence of plants on the cities is significant, since they shape the healthy environment for man, absorbing air and soil pollutants and alleviating city noise. Green areas absorb dust, improve the quality of air and, owing to thermal circulation, lower the temperature in the afternoons and evenings. Trees provide protection against the wind and snowstorms and also assimilate noxious atmospheric pollutants.

Wastes generated by man provide food for city animals, mice, rats and birds. The dwellers of large metropolises produce a lot of waste. For instance, in Mexico City the

daily production of waste is 12 thousand tonnes, which poses a serious hazard for the environment, since only a half is composted. Three million cars pollute the atmosphere, to which 12 thousand tonnes of metals and chemicals is released every year. The death rate is rising – about 100,000 people die every year because of the diseases of respiratory systems. One of the reasons is the devastated natural environment; two thirds of the dwellers do not have running water, while two million live without any sewer facilities or even privies. The level of groundwater is falling by 25 cm per year. Mexico City is located in an intermontane basin; frequently smog appears, combined with industrial dusts. (INEGI, DF 2003)[1]. In London, 144 tonnes of soot fall down per one square metre; this value is three times higher in Chorzów. This leads to decreased solar radiation, e.g. in Sosnowiec – by 30 per cent.

Urban development leads to accelerated degradation of the natural environment. Increased water intake causes its deficit. At the same time, sewage discharged to groundwater and emission of air pollutants lead to increased illness rates. Wastes and garbage contaminate the soil, and indirectly the plants that are cultivated on the soil. A steady rise of urbanisation poses more and more dangers. Having all this in mind, pro-ecological economy in cities is an absolute necessity.

References

BISWAS, R. M., BISWAS, A. K. (1983): Przyroda, żywność, człowiek, Warszawa, PWN, [Nature, Food, Man].

BARBAG, J. (1984): Geografia gospodarcza świata, Warszawa WSiP, [Economic Geography of the World].

BORYCZKA, J. et al. (1999): Ocieplenie i ochłodzenie klimatu miast Europy, Warszawa, WUW, [Climate Warming and Cooling in European Cities].

DOBRZYŃSKI, G. et al. (1997): Ochrona środowiska przyrodniczego, Białystok, Wyd. Ekonomia i Środowisko, [Environmental Protection].

FIRLA, I. (2003) Geografia gospodarcza świata, Warszawa PWE, [Economic Geography of the World].

FLEMMING, G. (1983): Klimat – środowisko – człowiek, PiWRiL, Warszawa, [Climate – Environment – Man].

JANISZEWSKI, M. (1982): Położenie geograficzne, stolic europejskich, "Geografia w Szkole", 1982/2, Warszawa, WSiP, [Geographical Location of European Capital, in Geography at School].

JANISZEWSKI, M. (1983): Położenie geograficzne, stolic pozaeuropejskich, "Geografia w Szkole", 1983/3, Warszawa, WSiP, [Geographical Location of European Capital, in Geography at School].

KUROWSKI, L. (1987): Warszawa na tle stolic Europy, Lublin, KUL, [Warsaw on the background of European Capitals].

RÓŻAŃSKI, S. (1991): Osadnictwo a środowisko przyrodnicze Polski, Warszawa, PWN, [Settlement Activity and Natural Environment in Poland].

[1] INEGI – Instituto Nacional de Estadistica, Geografia e Informatica Distrito Federal, Mexico 2003