

ENVIRONMENTAL POLLUTION IN FUNCTIONALLY RESTRUCTURED URBAN AREAS: CASE STUDY – THE CITY OF BUCHAREST

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ABSTRACT

This study aims at analyzing the changes that the functional restructuring of economic activities developed in the communist period brought upon the quality of the natural environment. It has been done an individualization of the main areas affected by the marked dynamics of economic activities in Bucharest due to numberless sources of emission distributed all over the city. The striking lack of balance in the condition of the environment is determined by the profound alterations inside the urban structure. Once the location of performing economic activities has been shifted towards the outskirts of the city, other economic activities have been developed inside the urban structure causing tides to compress, thus exceeding the capacity for support of the road structure. As a consequence the polluting emissions are greater than the admitted maximum limits in many areas of Bucharest. Besides road traffic, numerous construction sites inside the city which are not suitably organized, add to the increase of polluting emissions. The local authorities have initiated great projects which aim at easing the traffic flow inside the city and developing systems of redirecting the road traffic at city entrances.

Key words: Functional restructuring, Territorial management, Urban pollution

INTRODUCTION

The study tries to pinpoint the changes that occurred in the quality of the urban environment following the functional restructuring of big cities, in countries which have joined the European Union. The analyses have been carried out in Bucharest, a city which has felt the effects of an impressive economic dynamics, spatially expressed by shifting between the locations where economic activities had been traditionally performed and spectacular growths in urban traffic. This is not to mention the pressure that the environment has to face by the condensing of living, economical, cultural-administrative and strategic functions in limited areas.

The urban structures in countries which have

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joined the European Union are faced today with a heavy pressure that the differentiated evolution of the components of town systems put on the natural environment. This pressure increases as the gap in the evolution of the components widens. For example, the development of great business centers or the functional restructuring of former industrial platforms led to an intensification of traffic while driving lanes remained the same as they were 30 years ago. Under these circumstances, important lack of balance appear, polluting emissions exceeding the admitted maximum concentrations. Former industrial platforms are being replaced with shopping and business centers, many of which are oversized compared to the capacity of the existent infrastructure of coping with the traffic

they generate. A series of lacks in legislation made possible the construction of office buildings without parking spaces, or with an insufficient number of parking lots.

John Glasson (2001) in *Methods of Environmental Impact Assessment* underlined the fact that in analyzing the quality of the environment one should pay a significant amount of attention to the socio-economical impact, insisting on the type, the duration and the spatial distribution of the impact. For an encompassing and edifying approach on the impact one should answer a few questions: what should one include? what period of time? what area does it cover? who will be affected?

When analyzing pollution in a functionally restructured urban environment, a major problem is the noise level. In time, this form of pollution proved to be extremely harmful for human health. Riki Therivel and Mike Breslin (2001) have identified certain health problems which may arise due to exposure to phonic pollution. They enumerate: high blood pressure and partial or total lose of hearing, stress and anxiety, sleep disorder, lack of concentration, nervousness and low levels of efficiency. It has been scientifically proven that the sounds the human ear perceives are situated between 18 Hz and 18 000 Hz. The World Health Organization suggests that during the day, the level of outside noise should be under 50dB, LA_{eq} (WHO, 1988).

Noise represents a major source of pollution in all urban areas, the decision factors sometimes ask for some prediction models in order to contribute at the optimum projection of the accessibility corridors (Ogwueleka, 2009).

Jeremy Richardson and Greg Callaghan (2001) claimed that, in an evaluation of the impact of transportation on an area, one has to take into account the number of cars, buses, bikes, trains, the frequency and safety of the services, as well as the starting point and destination of the travelers. They also emphasized that there are certain means of transportation, including road vehicles, railway transportation, bicycles or walks, which should not be neglected in a new stage of development. Hughes (1994), quoted by Richardson and, Callaghan in 2001 in *“Transport, Methods of Environmental Impact Assessment”*, 2nd edition,

Spon Press, p. 84, describes the components that determine a certain impact on the quality of the environment: the possibility that a highway be connected, the possibility of junction, slow driving/time spent on a queue, speed, the number of accidents or their ratio, the number of heavy trucks, the number of bus drives, how often one can cross the street, how often one can have access, movements for turning, location and the type of street parking, how the land in the front is used. Speaking about transportation on the railways, the same author identifies some other valid factors, among which we may note: the capacity of the railway line (simple or double), the capacity of the station (the height of the stairs, the width of the platform), the length of the platform, the traffic of passengers, the frequency and the time spent waiting in the station, the capacity for junction and signaling, the time spent waiting near the line, the rate of the goods trains and the speed.

MATERIALS AND METHODS

Environment pollution in Bucharest evinces a high degree of specificity because of the various sources of emission distributed all over the city. The lack of balance in the condition of the environment is heightened by the deep transformations inside the urban structure. Once the performing of economic activities was moved towards the outskirts of the city (industry, warehouses), inside the town structure other economic activities developed (business centers, shopping centers). This led to an increasing of the traffic, while the infrastructure remained unchanged since 1990.

Analyses completed for Bucharest were based on the records of the Bucharest Agency for Environment Protection and on the field notes which contained traffic polls. The values were compared to the list of the lowest value of a polluting agent, which can cause health problems, drawn up by the World Health Organization (the values are presented in Table 1).

Starting with 1980, the European Union put up their own quality standards regarding the admitted concentration of air polluting agents. The limits for the original EU values were first set up in 1980 (revised in 1989) for sulphur

dioxide and suspended particles, for lead (Pb) in 1982, for nitrogen dioxide (NO₂) in 1985 and for ozone (O₃) in 1992. In September 1996 the European Union decided to review this list and to amend it with a number of new polluting agents. The revised and amended new list, can be found in Table 2.

For each polluting agent, the generating source has been identified:

Table 1. World Health Organisation air quality guideline values (Morris and Therivel, 2001)

Pollutant	Value	Averaging time
Carbon monoxide	100 mg/m ³	15 min
	60 mg/m ³	30 min
	30 mg/m ³	1 h
	10 mg/m ³	8 h
Ozone	120 µg/m ³	8 h
Nitrogen dioxide	200 µg/m ³	1h
	40 µg/m ³	annual
Sulphur dioxide	500 µg/m ³	10 min
	125 µg/m ³	24 h
	50 µg/m ³	annual
Benzene	6x10 ⁻⁶ (µg/m ³) ⁻¹	UR/lifetime *
Dichloromethane	3 mg/m ³	24 h
Formaldehyde	0.1 mg/m ³	30 min
PAHs ¹	8.7x10 ⁻⁵ (ng/m ³) ⁻¹	UR/lifetime *
Styrene	0.26 mg/m ³	1wk
Tetrachloroethylene	0.25 mg/m ³	24 h
Toluene	0.26 mg/m ³	1wk
Trichloroethylene	4.3x10 ⁻⁷ (µg/m ³) ⁻¹	UR/lifetime *
Arsenic	1.5x10 ⁻³ (µg/m ³) ⁻¹	UR/lifetime *
Cadmium	5 ng/m ³	annual
Chromium	0.04 (µg/m ³) ⁻¹	UR/lifetime *
Lead	0.5 µg/m ³	annual
Manganese	0.15 µg/m ³	annual
Mercury	1.0 µg/m ³	annual
Nickel	3.8x10 ⁻⁴ (µg/m ³) ⁻¹	UR/lifetime *

*UR=excess risk of dying from cancer following lifetime exposure

**Specially benzo(a)pyrene

Sulphur dioxide

The most important sources are thermo-electric power stations that use solid or liquid fuels, industrial boilers, waste cremators, house heating and vehicles using diesel engines.

Particles (dust, smoke PM₁₀ and PM_{2.5})

The main sources that have been identified are: thermo-electric power stations that use solid or liquid fuels, house heating, vehicles using diesel engines, construction sites and road traffic in the areas surrounding the city.

Nitrogen oxide and its chemical compounds

The main sources have been identified to be:

Table 2: E.U. air quality limit values (Morris and Therivel, 2001)

Pollutant	Target date	Measuring period	Limit value
Lead	2005	annual	0.5 µg/m ³
Nitrogen dioxide	2010	hourly	105 ppb (200 µg/m ³), no more than 18 exceedance per year
		annual	21 ppb (40 µg/m ³)
PM ₁₀	Stage 1(2005)	daily	50 µg/m ³ , no more than 18 exceedance per year
		annual	40 µg/m ³
	Stage 2(2005)	daily	50 µg/m ³ , no more than 7 exceedance per year
		annual	20 µg/m ³
PM _{2.5}	Action level 2005	daily	40 µg/m ³ , no more than 14 exceedance per year
		hourly	132 ppb (350 µg/m ³), no more than 24 exceedance per year
Sulphur dioxide	2005	daily	47 ppb (125 µg/m ³), no more than 3 exceedance per year
		hourly	132 ppb (350 µg/m ³), no more than 24 exceedance per year

Source: Morris P., Therivel R. (2001) Methods of Environmental Impact Assessment, p. 149.

thermo-electric power stations that use solid or liquid fuels, industrial boilers, waste cremators, house heating and vehicles using diesel engines.

Carbon monoxide

The main sources are: vehicles engines and all vehicles that use fuel.

Volatile organic compounds (VOCs)

Like benzene, the main sources are exhaust emissions, leaks from petrol stations and the dyes industry.

Greenhouse gases (CO₂, CH₄)

For carbon dioxide the main source is fuel burning, and for methane the main sources are gas leaks.

Ozone (O₃)

Its main source is second-hand polluting agents which are a result of volatile organic compounds and nitrogen oxide.

Ionic radiation

The sources of which are nuclear reactors and waste tanks, as well as some medical facilities like medical imagnostic.

Bad smells

Most of them come from waste waters and sewers, oil distilleries, food processing, paintings and plastic constructions.

The studies are based on recordings of the Bucharest Agency for Environment Protection related to common polluting agents (SO₂, NO₂, NH₃, suspended particles) and specific polluting agents (HCl, phenols, aldehyds, Cl, H₂S, CS₂, F, H₂SO₄, Pb, Cd). Detailed analyses were focused on two agents that frequently exceed the admitted maximum concentrations: suspended particles and nitrogen dioxide.

Although it can not be observed some overtaking of the maximum admitted concentration concerning the heavy metals, there were periodically realized measurements, due to the significant contributions of these pollutants at the degradation of the environment, by their cumulative effect at the ecosystem components level (Khellaf and Zerdaoui, 2009).

Starting from the analyses completed in Bucharest, studies have been concluded in the functionally restructured areas, between 1990-2009, and the particularities regarding the quality of the environment of these areas have been identified. A special focus was placed on the areas that function as entrances in Bucharest, improperly organized for taking over, inside the urban structure, the flow of vehicles, and where the admitted maximum limits for polluting emissions are often topped.

The study targeted the new business and residential centers where, it has been noticed, the number of parking spaces is too small. This leads to traffic jams and, thus, an increase in polluting emissions.

Detailed analyses have been conducted on the Bucharest ring-road, a location towards which a lot of economic activities, especially industrial and storage, are shifted today. Concentrating these activities along a one-lane road for each direction causes frequent traffic blockings and excessive pollution.

RESULTS

Passing from a mainly industrial function to a services-providing one inside Bucharest, has fundamental effects on the spatial organization of the city. The functional dynamics of Bucharest after 1990 meant first of all a decline of former industrial platforms which have been transformed into big shopping centers or headquarters for

services providers.

The rapid growth causes a series of lacks in balance with respect to the number of the population, the number of dwellings, daily traffic or parking spaces, the providing of basic or entertainment services for the population. In the quest for new sites for building residential edifices, shopping centers, or office structures the former industrial areas are overwhelmed with bold projects. After 1990, paralleling the process for deindustrialization, a great bid for the available lands, once huge industrial platforms, starts. Hence, a chaotic character in planning and rehabilitating the town in the last 10-15 years.

Liviu Chelcea (2008) identifies 9 industrial areas spread all over the capital city. Inside these platforms we can notice three different processes: pulling down the factories and building modern structures with different functions, erecting new buildings on disaffected areas or on the empty areas of the industrial platforms, or partially keeping the factory, often part of the national patrimony.

Each industrial platform was faced with massive transformations, as follows:

1. Militari Area has been, after 1990, the place of massive restructuring of economic, mainly industrial, activities. The functional restructuring determined an increase in road traffic for over five times, on which the new spaces for activities situated along A1 motorway had its influence. Road traffic and construction sites which were opened here determine a constant exceeding of admitted maximum limits for suspended particles. The main transformations in the area are:

- Cora Lujerului Shopping Center in the area formerly occupied by milk factory Miorita, a project which made traffic in the junction more intense;
- a couple of meters south there lies Plaza Romania and Anchor Plaza office building, causing traffic blockings at rush hour;
- at the crossroads between Timisoara Blvd. and Vasile Milea Street one could find, not long ago, Uzina de Masini Electrice Bucuresti (Bucharest Electric Cars Factory) which has been pulled down to make room for a new shopping mall – Cotroceni Park;

2. Grozavesti-Semanatoarea Area marks remarkable alterations after 1990, practically all of the industrial activities have been replaced with shopping centers and office buildings which brought their share to the escalation of road traffic. In order to eliminate problems in the area an over ground 2 Km-long passage way will be built, ensuring the traffic flow over the railway lines. Here are the main changes in the region:

- between bread factory Plevna, which functions in a building that is part of the national patrimony, and Spicul factory, Carrefour supermarket was built. This has utterly blocked the traffic in the junction formed by Splaiul Independentei with Orhideeleor Road;

- in the region formerly occupied by Semanatoarea Plant a large-scale project, which will fulfill a mixed function and will comprise residential and shopping structures, entertainment or office buildings, is planned.

- Titan Area registered a spectacular rise in road traffic from the building of big shopping centers which replaced former industrial activities. At the crossroads between Pantelimon Road and Vergului a shopping center that consists of Cora, Bricostore and Mobexpert stores was erected. On those grounds one could find, before the fall of the socialist regime, Granitul factory and the military Mill.

3. On Pipera industrial platform, besides the already existing units, one can find new, modernized ones which form the so-called entrepreneur industry. Many buildings that host Romanian and foreign firms that are specialized in providing services add to the intensification of the work-force traffic in that area and in the region surrounding Bucharest;

4. Progresu-Aparatorii Patriei Area marks nowadays a stressed dynamics, the major economic activities being the competing shopping centers Metro, Selgros, Real and Carrefour. The supermarkets attend not only the inhabitants of the Bucharest southern neighborhoods, but also a great number of people from outside the capital city. As a consequence the traffic in this area and especially that in the junctions is heavy, and traffic jams are often formed.

Apart from the new buildings erected on the grounds of familiar industrial platforms, Bucharest is invaded, particularly in its northern part, on the wide boulevards or at the crossroads of important lines of communication, by sky-scrappers or the well-known megalomaniac projects, that were designed without taking into consideration their capacity of being integrated in the urban system. Most of these projects do not make available enough parking spaces, and the access roads are undersized, thus traffic jams occur at rush hour. Analyzing these items according to their degree of functionality, one can separate the following projects that have multiple effects over space:

Buildings with a residential purpose

These buildings are located all over the capital city (Fig. 1) and are to be found more often in the northern part: Monaco Towers, Jupiter, Asmita Gardens, In City Residence, Neopeninsula, AFI Towers, Europa Group Residence, Alia Apartments, West Park, Metropole Residence, Residenz, Ansamblul Belvedere and others.

These residential buildings do not lie exclusively between the administrative borders of Bucharest, but they play an important part in the pressure that it is put on the environment. Asmita Gardens buildings will generate a higher pressure on the only access road along Dambovită river, which is already overwhelmed even before the opening of the residential complex.

Buildings for offices and for rendering services

These buildings are located mostly in the northern part of the city, on which the major real estate investments are focused. The most remarkable projects of this sort contain: Kiseleff Business Plaza, BRD-Tower, Piraeus Bank all of them in Victoriei Square, Charles de Gaulle Center Tower, Floreasca Tower, Cefin Tower, Global Park, Cascade Europe Tower, The Citygate Office Complex in the north part, Romfeti Plaza and Anchor Plaza Downtown.

Buildings erected for commercial activities

This category includes the numberless malls and shopping centers like Mall Vitan, Plaza Romania, City Mall, Cotroceni Mall, Sun Plaza, Băneasa Fair and Shopping Center Militari.

Buildings fulfilling mixt functions

They maybe the most controversial part of the project considering their size and complexity. Most of them are not finalized (Sema Park or Dambovita Center); others are still at project level, (e.g. Esplanada). On an area covering 659000 m² in Sema Park Project, planned for Semanatoarea area, there will be built 1200 dwellings, office buildings, a hotel, green areas and areas for relaxation, commercial spaces. Dambovita Center, in Eroilor region, will be made up of commercial centers, a hotel, office buildings and 300 apartments, while Esplanada, near Piata Unirii, includes, besides commercial, office and residential buildings, many areas for

of Bucharest and it is determined by the spatial distribution of the major industrial polluting agents which evince the tendency of shifting their location towards the ring road and along the two motorways. Although the location shifting process is advanced, there are still industrial platforms which alternate with living areas and add to their pollution (Militari industrial platform).

On Bucharest's ring road and on the two motorways (up to 35 km) one can find companies which pollute the air, like the ones in the construction business (stations which produce concrete, pitch mixtures, kerb stones) or warehouses that contribute to the emission of varied substances: organic and inorganic particles that contain metals (Pb, Zn, Al, Fe, Cu, Cr, Ni, Cd), gas and vapors (SO₂, NO_x, NH₃, HCl, CO, CO₂, H₂S), organic solvents and soot (*The annual report regarding the status of the environment for Bucharest-Ilfov region, 2009, p. 39*).

The thermo-electric plants situated on the outskirts of the city add to the increase of polluting emissions through the many toxic particles they release: SO₂, NO_x, CO, CO₂, smoke, ash. Investing in the modernisation and heightening of the evacuation chimneys led to a decrease of the toxic concentrations around these plants, but an increase of pollution in the remote areas.

Air pollution in Bucharest (Figs. 2-5 and Table 3) caused by traffic jams is determined by hundreds of chemical compounds in the atmosphere, out of which the ones that are harmful to the health of the population are being monitored.

High levels of concentration are registered on the major city roads that are bordered by tall compact buildings where pollution dispersion is difficult to achieve.

The high levels of pollution from the access roads to Bucharest is determined on the one hand by the lack of an efficient system of redirecting the traffic and on the other hand by the tendency to shift the location where people live and work and where activities are being performed towards the outskirts.

The high degree to which the population moved towards the suburbs is demonstrated by the number of buildings that have been completed in 2007 in the areas surrounding Bucharest, (4155), compared to those concluded inside the city,



Fig.1. Functional restructuring of Bucharest

taking exercise, relaxing, or being entertained. Air pollution is different for the various areas

(2573). The daily traffic of the population inside the city leads to blockings on the main access roads where polluting emissions exceed, at rush hour, the admitted maximum concentrations (Figs. 4 and 5). It can be noticed a remarkable rise in the level of suspended particles, which evince an augmentation after 2006, once big building sites have been opened inside and along the ring road (Fig. 2).

The need for coherent policies regarding the setting up of access roads in the new inhabited areas is another factor that adds to the rise of the concentration of suspended particles. In many of the new neighborhoods, the roads are not built and this causes an exceeding of the admitted maximum concentrations.

The analyses that have been conducted on the basis of the records from the points for monitoring the quality of the environment indicate that the limit values are surpassed at all stations, at a higher frequency in the central areas that concentrate, in some parts of the day, elevated levels of traffic. High values are being registered in the west part as well, where many factors act together: the

existence of thermo-electric plants, building sites and a heavy traffic.

From all the polluting emissions, the nitrogen dioxide is the one that frequently surpasses the admitted maximum concentrations. This led to organizing the actual system for monitoring the air quality (Programul Integrat de Gestionare a Calitatii Aerului – The Integrated Program for Monitoring the Air Quality) that covers the entire area of the city.

The high levels are specific for the areas in which the road traffic is heavy and the traffic blockings are frequent (see map ref: traffic jams).

The evolution of the polluting emissions of nitrogen dioxide between 2004 and 2008 shows, in general, a decrease, but surpassing the admitted maximum concentrations is registered in the majority of measuring points. More precisely the records show significant exceeding of the alert threshold like the one in 11.03.2008 when for three consecutive hours the level went beyond $400 \mu\text{g}/\text{m}^3$ (*The annual report regarding the status of the environment for Bucharest-Ilfov region, 2009, p. 57*).

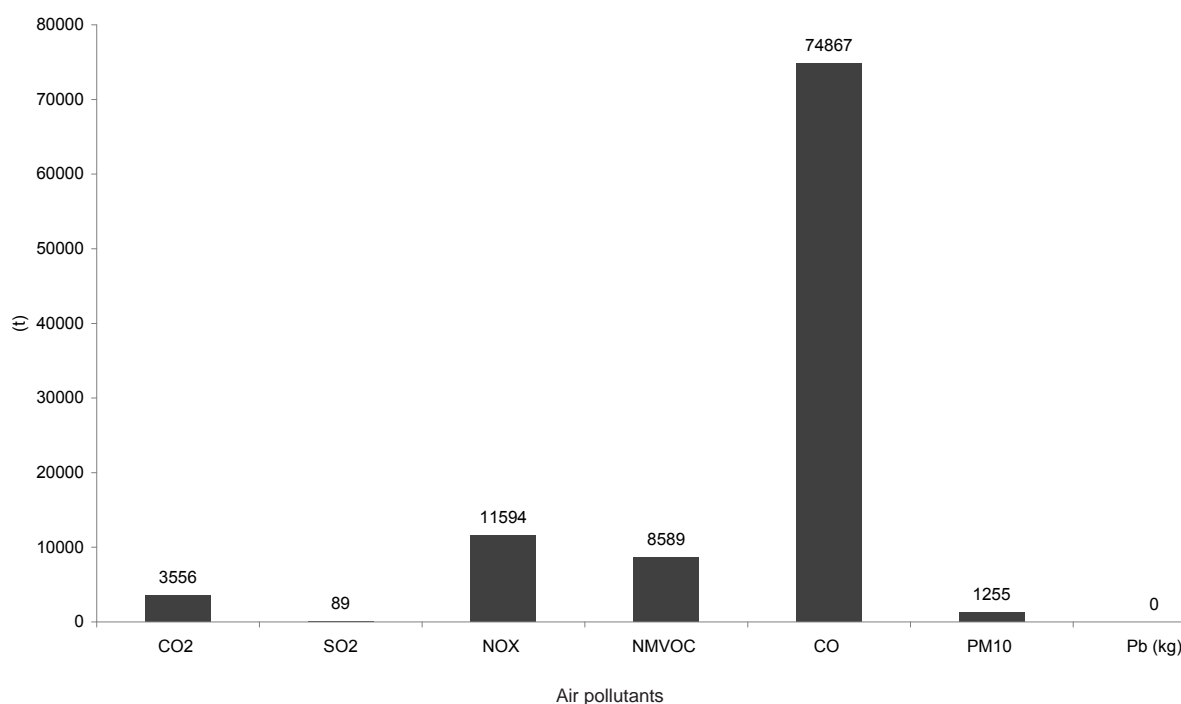


Fig.2: The pollutants of the road transportation in Bucharest (2008)

(Data source: Annual report on Bucharest-Ilfov environment)

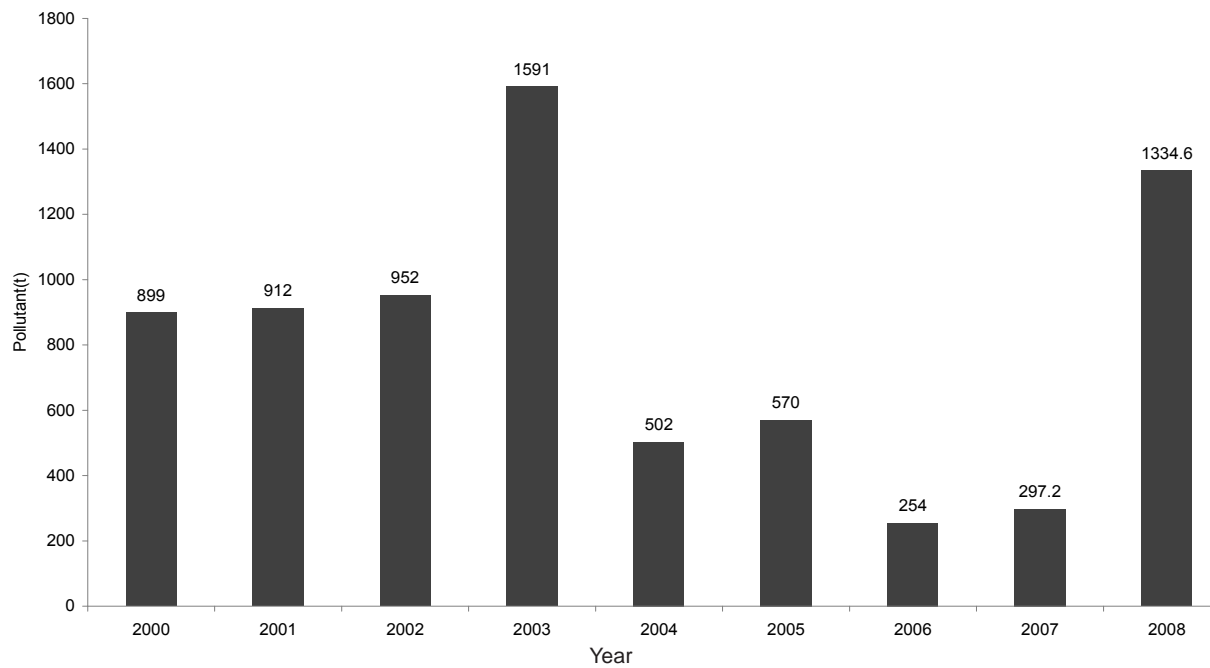


Fig.3: Annual pollutants evolutions of powders in suspension
(Data source: Annual report on Bucharest-Ilfov environment)

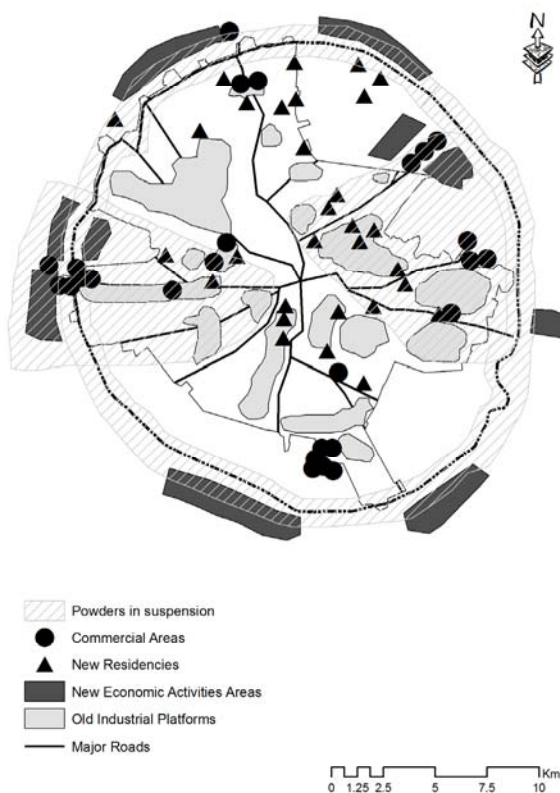


Fig.4: Annual concentration of powders in suspension

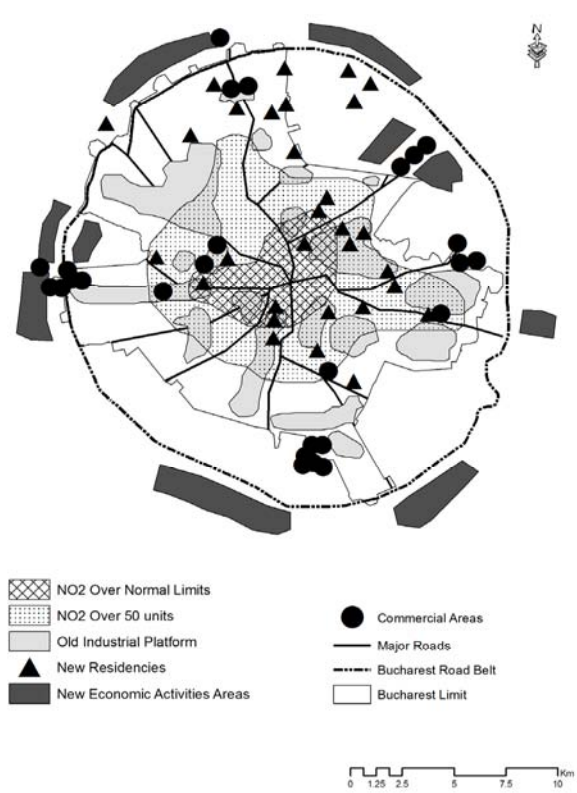


Fig.5: Annual concentration of NO₂ (µg/m³)

The water quality has been analyzed along the two rivers that cross the city, Dambovita and Colentina, and in the accumulations that they form. It has been observed an important degradation of the streams caused by the residual, unpurified waters that are poured into the two rivers. The elevated level of pollution is determined by the polluting economic activities which are situated near them. According to AEM (the Administration for Environment Protection), Bucharest (2009) the water from the two rivers is highly degraded, being registered a low value of oxygen (an average of 2, 97 mg/L) and at the same time a high level of organic substances in the water (expressed by CBO₅, CCO-Cr, CCO-Mn), which corresponds to the 5th class of quality.

Furthermore, nutrients have been registered as having values which correspond to the 5th class of quality, elevated scores have been marked on NH₄, total N and total P. These high values stay up for several years now because of the lack of an efficient system for purifying wastewaters.

The analyses conducted by specialized institutions in the accumulations formed by the rivers that cross Bucharest have shown an exceeding of the admitted maximum values for dissolved Cu and Ni, these being marked as part of the 5th quality class, since there are no systems for cleaning the wastewaters.

DISCUSSION

Territorial development strategies need nowadays complex approaches, so that they could respect the environment (Fekete, 2006; Ianos *et al.*, 2009).

Table 3.: The situation of suspension powders at the observation stations from Bucharest (2008)

Station	No of determinations	Annual concentration ($\mu\text{g}/\text{m}^3$)	Over limits values VL
Cercul Militar	250	53	117
Mihai Bravu	318	55	167
Titan	274	43	79
Drumul Taberei	279	53	121
Balotești	172	29	18
Măgurele	282	44	85
Lacul Morii	303	45	92
Berceni	297	49	118

Data source: APM, 2009

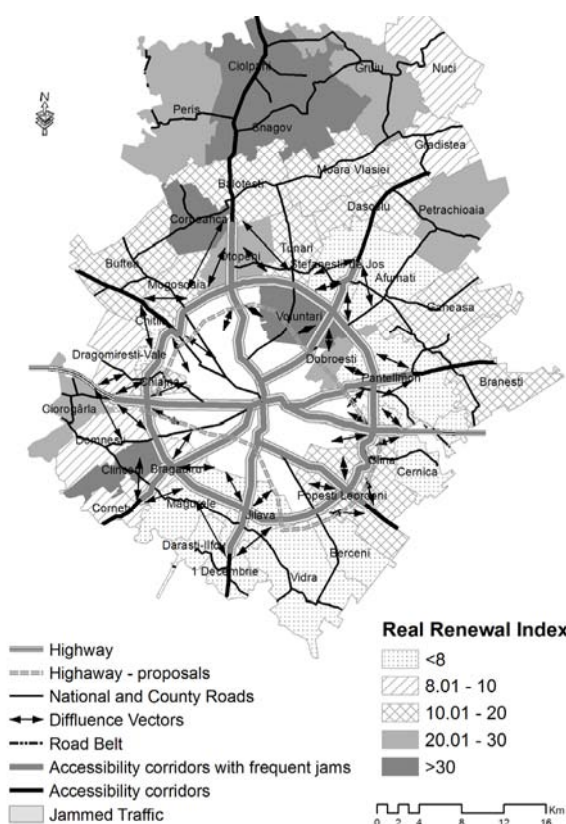


Fig.6: The direction of persons motions from the peri urban areas and the main diffidence directions necessities

(Data source for the Real Renewal Index: CURS SA, 2007 cited by Chelcea, L., 2008, pp. 304)

The positive impact of the strategy concerning the urban space restructuring is influenced by a better consultancy of local communities (Szigethy, 2007). Urban space restructuring, in many cases is accompanied by the administration of the green spaces, the decision factors ignoring their recovery necessity (Makhelouf, 2009). The alteration of the natural environment, along with the stressed economic dynamics, convinced people with decision power to elaborate strategies for development that will lead to the reduction of polluting emissions in accordance with European standards. The main measures aim at modernizing the access roads from around the city and building systems of redirecting the traffic where the A1 and A2 motorways enter the city, as well as constructing a connecting road between the two motorways, which will take over the transit traffic that crosses the city nowadays (Fig. 6).

Organizing a system of redirecting the traffic is, today, one of the major concerns of persons in

charge, the access roads to Bucharest being in need of reorganization which would eliminate the frequent blockings. The studies conducted in the area surrounding the city show a spectacular increase of the population that moved out of Bucharest. An analysis concluded on the index for real estate renewal showed higher values in the northern part of the city where there are concrete plans for developing access roads to the city.

Systematizing access towards the new shopping and residential centers is another concern of the authorities, since these new structures are very crowded, with only one possibility of reaching them.

Modernizing the ring road is an on-going project of the local authorities in cooperation with those from the surrounding areas, this route being overwhelmed by the recent flow of traffic. Developing this road has become a priority when taking into account the intensification of traffic flow as a result of shifting the location of economic activities towards this region. The project presupposes the widening of the road such as it will comprise two lanes for each direction, having many exits towards the new platforms.

Exceeding the admitted maximum limits for suspended particles is caused by the heavy traffic from peripheral areas of the city, areas inhabited by highly-paid people who travel to town for work every day. The development of these new residential centers in the area surrounding the city was not backed by a development of the road infrastructure, so that the traffic in these regions is carried on rudimentary roads determining, in the dry periods of the year, a rise in the level of particles in the atmosphere. Solving this malfunction can be achieved by developing and sustaining partnership programs between authorities from Bucharest and the neighboring areas.

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