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INDOOR AIR QUALITY IN BUCHAREST HOUSINGS IN THE FRAMEWORK OF PRESENT ENVIRONMENTAL CHANGES

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Abstract

The indoor air quality represents one of the factors conditioning housing quality in urban residential spaces. The paper analyses the spatial and temporal distribution of parameters defining the indoor air quality from representative housings in Bucharest, correlated with their influence factors. The characterisation of *permanent*, *seasonal* and *circumstantial* influence factors was realised using the US EPA (1991) and WHO (2006) methodologies. Between November 2008 and February 2010 there were applied questionnaires for appreciating the dimension of influence factors inside and outside the housings. In the same time, for determining the values of representative indicators analysing the indoor air quality, measurements were realised in selected housings. From analysing the obtained results, it can be stated that in the indoor habitat of most residential spaces from Bucharest, the quality of air is unsatisfactory, values of human comfort recommended by international legislation being exceeded at indicators such as: volatile organic compounds, carbon dioxide or particulate matter. The building's ventilation systems are mostly dismantled or not functioning, and as a result the thermal isolation of buildings only aggravates these problems as it isn't compensated with an improvement of the ventilation systems. The significant expansion of areas affected by Sick Building Syndrome, which are economically, ecologically and/or sanitary inefficient, in the framework of recent environmental changes, it requires an integrated approach of problems concerning the air quality management in Bucharest residential spaces.

Keywords: *housings, air quality indicators, indoor air quality, environmental changes, heat island, Sick Buildings Syndrome, Bucharest, Romania*

Rezumat

Calitatea aerului interior din locuinţele bucureştene în contextul schimbărilor climatice prezente. Calitatea aerului interior reprezintă unul dintre factorii ce condiţionează calitatea locuirii din spaţiile rezidenţiale urbane. Lucrarea îşi propune să analizeze distribuţia spaţială şi temporală a parametrilor ce definesc calitatea aerului interior din spaţii de locuit reprezentative ale municipiului Bucureşti în relaţie cu factorii de influenţă. Caracterizarea factorilor de influenţă *permanenţi*, *sezonieri* şi *conjuncturali* s-a realizat utilizând metodologiile US EPA (1991) si OMS (2006). În perioada noiembrie 2008 – februarie 2010, s-au aplicat chestionare pentru aprecierea dimensiunii factorilor de influenţă din interiorul şi exteriorul spaţiilor de locuit. Concomitent, pentru determinarea valorilor indicatorilor reprezentativi de calitate a aerului interior au fost efectuate măsurători în spaţiile de locuit selectate. Din analiza rezultatelor obţinute se poate afirma că în habitatul intern al majorităţii spaţiilor rezidenţiale din municipiul Bucureşti calitatea aerului este nesatisfăcătoare, fiind depăşite valorile de confort uman recomandate prin legislaţia internaţională, la indicatori precum: compuşi organici volatili, dioxid de carbon ori pulberi în suspensie. Sistemele de ventilare ale clădirilor sunt în cea mai mare parte dezafectate ori nu funcţionează, astfel că izolarea termică a imobilelor vine să agraveze aceste probleme în cazul în care nu este combinată cu îmbunătăţirea sistemelor de aerisire. Extinderea semnificativă a spaţiilor rezidenţiale "bolnave", ineficiente economic, ecologic şi/sau sanitar, în contextul schimbărilor actuale de mediu, impune o abordare integrată a problemelor ce ţin de managementul calităţii aerului în spaţiile rezidenţiale din municipiul Bucureşti.

Cuvinte-cheie: *spaţii de locuit, locuire, indicatori de calitate a aerului, calitatea aerului interior, schimbări actuale de mediu, insulă de căldură, Sindromul Clădirilor Bolnave, Bucureşti, România*

INTRODUCTION

The interest for assessing the indoor air quality increased significantly at scientific, political and administrative levels, as modern population spends more and more time in the indoor environment (Koren and Bisesi, 2002; WHO, 2006).

Therefore, the indoor air quality becomes very important, especially as the pollutants exposure of population is larger in the indoors than the outdoors (US EPA, 1991).

Problems concerning the indoor air quality are found among the preoccupations of decision factors at international level, interested in the sustainable development of human settlements. The United Nations Convention for Human Settlements (Habitat II) recognises that adequate housing condition represents a human right and promotes the assurance of corresponding housings and human settlements which are safe, healthy, inhabitable, equitable, sustainable and productive (Bălteanu and Şerban, 2005). *The Declaration of Cities and Other Human Settlements in the New Millennium* draws attention upon the fact that globally there is present a tendency of accentuated degradation of habitation conditions (UN, 2001). For resolving these problems, at the Global Summit on Sustainable Development, held in Johannesburg in 2002 was launched ***The Partnership for Clean Indoor Air*** which recognises that the improvement of indoor air quality is not possible without changing the societies' consume patterns, and especially those related with the energy use (Iojă, 2008).

The preoccupations of the World Health Organization (WHO, 2006), of the European Commission and national governments in developing guides and regulations for assessing, monitoring and enacting aspects related with the indoor air quality, sustain the importance of this critical problem in human settlements, accentuated as the number of housings with thermal isolation increases (Iojă, 2008). Furthermore, the thermal isolation and the development of air-conditioning systems are closely related with the appearance of the *sick buildings syndrome (SBS)*[1], concept used in describing situations in which the buildings inhabitants present discomfort and unfavourable health state due to the fact that they spend a long time inside a building, and no specific disease or cause can be identified (US EPA, 1991; Lindvall, 1992; Bărbulescu, 2007). The causes of SBS appearance are mainly determined by the inadequate ventilation and the presence in high concentrations of chemical and biological contaminants from the indoor or outdoor environment (Marinescu, 2006; Oahn and Heng, 2005).

Furthermore, in the international scientific literature, the main problems approached in evaluating indoor air quality concern the description of the sick buildings syndrome (Lindvall, 1992; Kostiainen, 1995; Koren and Bisesi, 2002), the determination of pollutants sources and the factors influencing the quality of indoor air (Owen et al., 1992; Wolkoff and Kjaergaard, 2007), the assessment of the dynamics of specific pollutants (Kostiainen, 1995, Zhao and Wu, 2007; Gardner, 2009), the influence of indoor air quality on the population health (Kjaergaard, 1991) and establishing measures for improving the indoor air quality (Franz and Johnson, 2007).

These active preoccupations are sustained by the fact that a poor indoor air quality determines higher costs in improving the population's health state, in housing sanitation, interior endowments, and clothing items or even in the maintenance of the housing's functions.

Study area

Among the natural characteristics which influence the air quality from housings, in Bucharest the presence in the substratum of loess deposits is of significant importance (source of suspended particulate matter, especially through the numerous cracks present on the construction sites), the temperate transition climate with excessive nuances, strongly influenced by the urban environment (average multi-annual temperature of 11,2^{0}C, annual rainfall of 615 mm, absolute maximum amplitude of 71^{0}C, determining the need of a higher quality thermal isolation of buildings), an artificial catchement (the canalisation of Dâmbovita, the lakes on Colentina, the dissolution of wetlands which influenced the balance of air humidity) and the predominant presence of anthropic soils with a high concentration of contaminants (CCMESI, 1992; Lăcătuşu et al., 2007). Bucharest has a surface of 228 km^2 (of which 9 % green spaces and 4 % aquatic surfaces), a stable population of 1.9 million inhabitants, plus approximately 500,000 commuters (Rey et al., 2007). The youth (0-14 years old, 11.35 % of total population) and elder population (over 65 years, 14.45 %) present the highest exposure at factors with negative impacts in the indoor environments, as they are characterised by a reduced mobility. The high percent of built surfaces and the expansion of green fields contributes, due to the anhydrous character of different surfaces, to the generation of suspended particulate matter in the urban atmosphere (Pătroescu et al., 2003-2004).

Besides the problems of poor air quality, others have entered already in the population's collective mental, in a such called *normality*, such as the accentuation of the effects of the *urban heat island* due to the increasing number of built surfaces especially in the northern, eastern and south-western periphery (areas which bring fresh air to Bucharest), the wrong waste management, an increasing of functional incompatibilities diversity (especially the development of residential surfaces correlated with

[1] SBS is conceptually diferent from Buildings Relationed Diseases (BRD), in which the symptoms of a diagnosed disease are identified and can be linked directly with pollutants from the indoor environment.

other incompatible functions), the inefficient system of road traffic management, the uncontrolled use of dangerous chemical substance or the ageing of urban infrastructure, all of these influencing the indoor air quality (Pătroescu et al., 2003-2004).

In 2007, in Bucharest there were 785,696 housings grouped in 112,907 buildings, with a total surface of **30.4** km^2 (Iojă, 2008). According to housing typology, in Bucharest there were identified three main categories of residential spaces: *individual* (77.6% from the total buildings, 11.2% from the total housings, integrating 13.7% from the total Bucharest inhabitants), *coupled and stringed – wagon type* (10.6% from total buildings, most in an advanced state of degradation) and *collective* (11.8% of total buildings, 84.4% of total housings and 81.1% of inhabitants) (Fig.1) (Suditu, 2005).

The study has as objectives: a) identifying the characteristics of factors influencing the indoor air quality dynamics in Bucharest, b) assessing the indoor air quality in selected housings and c) estimating a development tendency of the indoor air quality indicators.

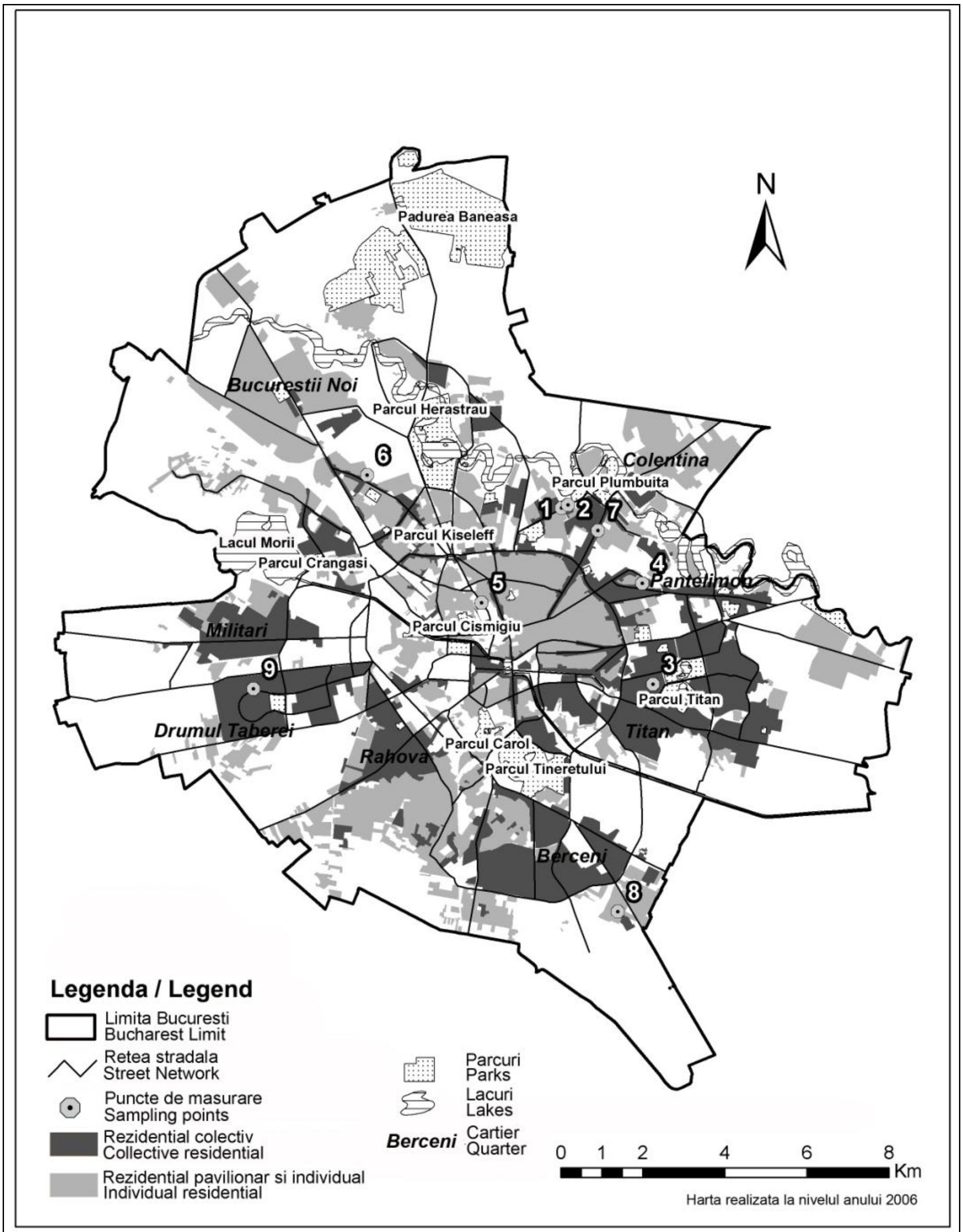

Fig. 1 The distribution of residential spaces categories in Bucharest (2006)

METHODOLOGY

The evaluation of the indoor air quality in Bucharest housings was realised based on the methodologies recommended by US EPA (1991) and the World Health Organization (WHO, 2000, 2006), the monitored indicators being adapted to the characteristics of the Romanian indoor environments and the available technologies. Between 2008 and 2010, by applying two categories of questionnaires there were assessed the *permanent factors influencing the indoor air quality* (technical characteristics, functioning of the maintenance systems, finishing works, internal endowments), the *seasonal factors* (characteristics of the outdoor environment) and *circumstantial factors* (the functioning of the existing appliances and equipments, consume patterns and adopted behaviours, the use of chemical and biological agents, specific activities). The questionnaires for evaluating the elements specific to the indoor habitat (**60** questionnaires, applied in the whole Bucharest) emphasise the features related with the residents' structure, endowments, and specific behaviours, consume and perceived problems related with the housing. The second categoryies of questionnaires (**610,** of which **528** statistically validated, applied in the Berceni, Tei, Colentina and Drumul Taberei quarters) evidenced commune characteristics of the housings (number of inhabitants, consume, endowments and external utilities, waste management). For the factors of seasonal climatic influence there were realised temperature and humidity measurements in the indoor and outdoor environment of the housings, using the DS 1923 Hygrochron sensors, with an hourly frequency of data recording and errors of $\pm 0.0625^0$C and 0.06 % (Dallas semiconductor TX).

The determination of different pollutants concentrations in the indoor air (particulate matter, CO_2, CO, O_3, NH_3, SO_2, H_2S, NO_2) was realised in the *November 2008 – February 2010* period, in **9** housings from Bucharest, where there were previously applied questionnaires. For evaluating the suspended particulate matter concentration, there were done measurements using the Casella CEL dust analyser. For the gases it was used the multi-gas analyser Gray Wolf Direct Sense Indoor Air Quality Kit, the average duration of a measurement being of 30 minutes. The measurements were realised in all the rooms of each housing, at the height of 1.2 meters from the floor, in conditions of lack of activities and also in conditions of normal activities.

The information was processed by using the software IBM SPSS Statistics 18, allowing the correlation of indoor air quality indicators with their influence factors.

RESULTS

Characteristics of permanent and seasonal influence factors

In Bucharest, the most important *permanent and seasonal influence factors* of the indoor air quality are the technical characteristics of the building (construction materials, size and housing spaces subdivision, the relation with the outdoor environment, finishing works), the building's maintenance systems, the number of inhabitants and the characteristics of the outdoor environment.

a. *Technical characteristics of the construction*. The used construction materials are important in terms of their content of toxic chemical substances or with irradiation potential, but also from the point of view of their capacity of realising a healthy relationship with the outdoor environment (Spaul, 1994). In Bucharest, the buildings are built especially from concrete prefabricates (**47 %**), brick (**31 %**) and BCA (**20 %**) (Suditu, 2005), but in urban peripheries, clearly differenced structurally and functionally, the cheaper construction materials are dominant (recycled bricks, construction materials based on sand, gravel, clay and wood). In all the situations, the indoor air quality is affected especially by particles of persistent substances (heavy metals, other persistent compounds) or with radiant character (radon) (Lăcătuşu et al., 2008).

The materials used for isolation, interior joinery, finishing works or decoration are also important for the quality of indoor environments (Spaul, 1994). In Bucharest, the percent of housings which have their walls covered with washable paints is approximately of **49 %,** with a percent of **98.3 %** for housings in which capital repairs were realised in the past 10 years. In the case of the rehabilitated housings with more than 10 years ago (16.3 % of the analysed housings) is observed that the percent of finishing works with calcium, mica or clay is larger.

The housing size is an important indicator for appreciating the air quality (WHO, 2006). Thus, the air quality is better as the space is larger (as the contaminants have more dispersal space), but only if the number and activity of degradation sources are not very high. In the case of Bucharest, the average housing size is of **34.54** m^2 (**63.82** m^2 in the analyzed spaces), as the average height of the rooms is of **2.6** m. The corresponding subdivision of space is essential for avoiding the functional incompatibilities between different rooms from the housing. In Bucharest, the problems are related with the un-corresponding emplacement of catch-all (**65 %** of cases), of the sleeping space for pets (**36 %**), ateliers (**8 %**) in relation with bedrooms or other sensible spaces.

b. *The functionality of the building's maintenance systems* (ventilation systems, sanitation services, air conditioning, sewerage). The maintenance systems of buildings are those which bring inside or lead outside the chemical and biological agents (Franz and Johnson, 2007). In Bucharest they are those which significantly increase the air quality problems inside housings, especially in conditions of their imperfect functioning or their absence.

In the case of Bucharest, in **84 %** of cases, ventilation is made exclusively through the windows, with an average frequency of **2.34** openings per day per housing. Although in most situations, the ventilation through windows brings from the exterior new contaminants (especially those specific to traffic or fossil fuel burning at the P, P+1 housings), it is still preferred by most of the residents as it is the simplest and less expensive than the mechanical ventilation. Over **50 %** of those questioned sustain that the ventilation systems of the building were either destroyed, either they are recessed or closed, and **35 %** don't know about their existence, facts explaining the problems which appear in the indoor environment regarding air quality (humidity excess in air, elimination of bathroom smells, etc.).

The sewerage and spaces for the primary and secondary domestic wastes collection bring a supplementary addition of compounds from anaerobic decomposition (volatile organic compounds, hydrogen sulphide, ammonia, etc.), especially in housings situated at the inferior levels of blocks-of-flats and old buildings. Significant is the role of insalubrious and un-isolated garbage cans from the ground floor of the blocks, provisioning the air of the housings in the proximity with compounds specific to waste decomposition.

c. *The number of persons in the housings.* The intensity of problems generated by metabolic processes in the air quality is appreciated according to the number of persons in a housing (an average of **2.45** in Bucharest) and in a room (**0.98**), the volume of apartments (average of **75.9** m^3) and the average time spent in the housing. The average time spent in the housing by its residents in Bucharest is of approximately **13.6 hours** (**17.4 hours** in the weekend), with significant variations among different professional categories and age groups.

Thus, children under 7 years old and elders above 65 years spendt **20 hours** on average inside the housing, whereas the adults spend **9-10 hours** on average**.**

d. *The characteristics of the outdoor environment.* Among the influence factors representative for the analysed area, the meteorological conditions (air pressure, wind speed, temperature and air humidity) and the outdoor air quality are detached. The relation between the dynamics of exterior and interior climatic parameters depends of the housing isolation efficiency, and of the modalities in which it is ventilated (Wolkoff and Kjærgaard, 2007). Following the measurements realised with the DS 1923 sensors in the analysed housings, it was observed that the average temperature of the indoor air was **21.5^{0}C**, with a thermic amplitude varying between **4-8^{0}C**, much lower than the outdoor environment. The air humidity recorded larger fluctuations (between **32.1** and **76.2** %), with an average of **63 %**.

These high values of, humidity and air temperature, influence significantly the reactivity of contaminants from the indoor air, increasing their aggressiveness (Koren and Bisesi, 2002).

Bucharest represents one of the cities with problems determined by the high frequency in exceeding the maximum admitted limits at the outdoor air quality indicators (ARPMB, 2009). The suspended particulate matter, the carbon monoxide, the nitric oxides and the volatile organic compounds record exceedings of the annual maximum limits at most of the air quality monitoring stations (Iojă, 2008), situation generated mainly due to human activities (the expansion of built surfaces, intensification of traffic, degradation of green spaces, development of construction works, degradation of the buildings) (Pătroescu et al., 2003-2004). The concentrations of these contaminants present a seasonal dynamics, influenced by the activity of generating sources, but also by the dispersal conditions (Iojă, 2008).

Characteristics of circumstantial influence factors

The functioning of interior installations, housing sanitation, activities taking place in the indoor environment (the use of domestic appliances, smoking, professional activities), and materials deposited inside (chemical substances, food, medicines, etc.), interior decorations (carpets, lightning installations, curtains, ornamental plants) or external risks (such as technological accidents) are a few examples of *circumstantial influence factors* (US EPA, 1991).

The domestic appliances are responsible with the charging of the indoor air with nitric oxides, particulate matter, carbon monoxide, cooling agents (ammonia, CFCs) and carbon dioxide (Gardner, 2009). They have a high diversity inside housings, being present in most of the rooms, but with a variable functioning time.

The analysed housing are endowed in a degree of **1.07** refrigerators/household, **1** cooker/household, **0.94** washing machines/household, **1.75** television sets/household, **1.6** computers/household, **0.62** microwave ovens/household and **1.03** dusters/household. In Bucharest, the highest concentration of domestic appliances is in the *kitchens* (refrigerators, cookers, microwave ovens, other appliances used for preparing food), *living-rooms* (television sets, DVD players, tape recorders, other agreement installations) and *bathrooms* (washing machines, other appliances for personal hygiene).

Among the activities with the highest influence upon the indoor air quality, we enumerate smoking (**40 %** of the analysed housings), food preparation (**93 %**), sanitation and cleaning activities (frequency of **0.7fold** per week) and pest control (**1.95fold** per year). The materials found inside the housing are also an important circumstantial influence factor in determining the indoor air quality (Spaul, 1994). They permanently supply in the air contaminants which can be removed only by periodical ventilation or trough their elimination outdoor. In Bucharest, problems regarding the indoor air quality appear also due to the inadequate *books storage* (**62 %** of situations), *medicines* (**42 %**) or *paints and solvents* (**36 %**).

Dynamic of air quality indicators

In Bucharest, the indoor air quality is, at most parameters, poorer than that of the outdoor environment (Table 1). This phenomenon is not due entirely to the existence of a large number of contaminant sources in the indoor habitat, but also to a deficient ventilation of the rooms.

Volatile organic compounds are present in housings from metabolic activities, and from a series of internal sources (such as finishing works with washable paint, other paints and varnishes, plastic materials, rubber, some decorative plant species, fuel burning, food preparation, the use of cosmetic products, etc.) or external sources (cars) (Wallace et al., 1987). The momentary concentrations of volatile organic compounds inside the analysed residential spaces (Table 1, Fig. 2) varied between **78** ppb[2] and **2 289** ppb (an average of **388** ppb, ±359), characterising, according to Kostiainen (1995), the *sick buildings)*. The highest values were recorded in storage spaces with deficient ventilation, in rooms with smoking habits or where paints, adhesives, rubber articles, plastic are deposited and in housings with problems at the domestic sewerage system (values over **500** ppb).

The smallest values, similar to those from the outdoor environment (under **150** ppb) were recorded in large rooms, with frequent ventilation, without intense activity and in which the washable paints were not used. During a day, the highest values are recorded in the morning, when the effect of pollutants accumulation is obvious. Annually, the highest values are recorded during winter (1.2-1.5 times higher than in summer) due to insufficient ventilation. The importance of ventilation in the case of volatile organic compounds is evidenced by decreases in concentrations of over 50% in most of the situations. The exceptions were present in the warm season in apartments situated at the lower floors, where the ventilation is done towards the parking space, and thus bringing important volumes of volatile organic compounds.

In the case of ***carbon dioxide***, recorded values varied between **422** and **5495** ppm[3], with an average value of **1,676** ppm (compared with 3,000 ppm, the maximum value recommended by the World Health Organization) (Table 1, Fig. 3).

Higher values are recorded during winter, when the frequency of ventilation is smaller and the heating systems are functioning. Problems are higher in housings with thermal isolation (especially with PVC), in which the source of producing thermic energy (heating stations, stove based on liquid or solid fuel, etc.) is inside the building (Gardner, 2009).

The carbon monoxide is a gas which doesn't generate problems in Bucharest, with an average concentration of **2.21** mg/m^3 (**±0.8**), with higher values (of about **5** mg/m^3) in housings with own heating systems (**11** mg/m^3 maximum value recommended by the World Health Organization).

For ***ozone***, the average recorded concentration is **29** μg/m^3, far less than the value recommended by the World Health Organization (**120** μg/m^3). The average value of this indicator contributes at increasing the aggressiveness of pollutants from the indoor air, already found in high concentrations (especially the volatile organic compounds). In the case of ***suspended particulate***

[2] ppb – parts per billion
[3] ppm – parts per million

matter, the situation is extremely variable, depending both from the outdoor environment and from a series of elements in the indoor environment (type of finishing works and decorations, surface covered by different textile products, the dynamic of housing activities, food preparation, smoking, etc.) (Koren and şi Bisesi, 2002). The average concentration in the analysed housings is **70** μg/m^3 (**50** μg/m^3 maximum recommended value), the interval of variation being extremely large (**2-675** μg/m^3). An important role in the indicators' dynamic is played by the dimension of surfaces that can receive suspended particulate matter, as well as their emplacement and characteristics (Owen et al., 1992).

Thus, parts of the surfaces retain suspended particulate matter until their removal, but most of them only retain them on limited terms until they are activated by different forces (air currents in the housing, dynamic activities, etc.). From this point of view, in Bucharest housings, the surfaces that can retain suspended particulate matter on a limited period are extremely large and varying in composition.

Table 1
Indoor air quality indicators dynamics in Bucharest housings, November 2008–February 2010

Indoor air quality indicators	Average and standard deviation	Medium	Minimum	Maximum	Recommended limit*
Volatile organic compounds– ppb	388 (±360)	286	78	2289	300
Carbon dioxide – ppm	1676 (±959)	1471	422	5495	3000
Carbon monoxide – mg/m^3	2,21(±1,11)	2,08	1,13	5	11
Ozone – μg/m^3	29,75 (±19,15)	21,9	0	63,4	120
Suspended particulate matter- μg/m^3	70 (±138)	33	2	675	50
Ammonia - μg/m^3	142 (±105)	131	0	330	100
Hydrogen sulphide - μg/m^3	6,3 (±13,6)	0	0	60	8
Nitric oxide- μg/m^3	127 (±142)	69	0	508	200
Sulphur dioxide - μg/m^3	56 (±243)	0	0	1239	250

* *maximum value recommended by the World Health Organization*

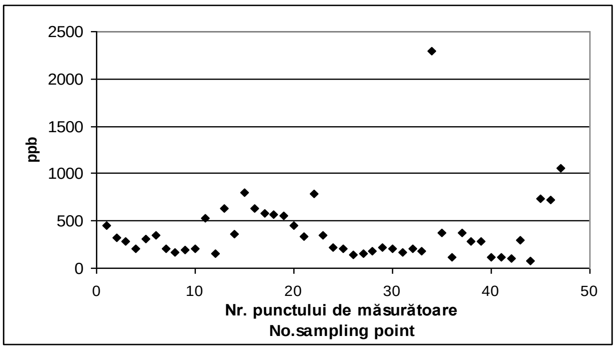

Fig. 2 Variations in the concentration of volatile organic compounds in the analysed housings in Bucharest

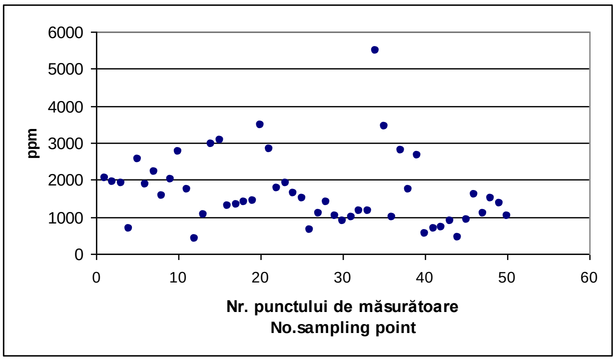

Fig. 3 Variations in the concentration of carbon dioxide in the analysed housings in Bucharest

The ammonia represents an insult related with metabolic processes which take place in the housing, but also with the presence of substances emanating ammonia (organic wastes, cosmetics, cleaning products, paints, medicines, etc.).

The values of this indicator are higher in small rooms, with poor ventilation and in bathrooms which present problems with the domestic sewerage system, recording here values over **300** μg/m^3. In the other rooms, the recorded values have rarely exceeded **150** μg/m^3. A similar situation is recorded for at the ***hydrogen sulphide***, where the average recorded values are **21** μg/m^3 in rooms with such sources (bathrooms, kitchens, and storage spaces) and **0–5** μg/m^3 in the rest.

The Nitric dioxide rises problems especially during the use of electric appliances (such as washing machines, irons, toasters, cookers, computers, etc.), the average concentration being of **127** μg/m^3 (**200** μg/m^3 the maximum value recommended by the World Health Organization). These values draws attention upon problems appearing in rooms in which electric appliances function, where values are frequently higher than those recommended, situation extremely delicate as this insult is a very stabile one (Gardner, 2009).

The Sulphuric dioxide does not represent an insult characteristic to Bucharest housings, the concentrations being generally under **20** μg/m^3. The Higher values appear especially in houses which use coal or wood for heating, where the recommended value is frequently exceeded.

DISCUSSIONS

The indoor air quality is extremely variable in time and space. Modifications in the activity of a single influence factor can generate significant transformations in the indoor air quality (Oahn and Heng, 2005). The perception manner of authorities and resident population influences decisively their reaction towards quality situations and states encountered in different housings. A certain state can be considered acceptable by some and unacceptable by others, according to their consume patterns, housing standards, education and financial levels, or circumstantial situations (Marinescu, 2006).

The factors influencing the indoor air quality are very complex (WHO, 2006). Some of these are controllable or determinable, while others are extremely variable and depend on of different circumstances. The percentage of their influence on the indoor air quality is not fixed, as in different moments but in relatively similar situations, their action can be different (US EPA, 1991). On the long term, the importance of *permanent and seasonal influence factors* determines the appearance of a certain air quality, the percent in which substances generated by them influence the air quality being estimated at **73 %** (US EPA, 1991). In Bucharest there is an equilibrated ratio between permanent and circumstantial factors, due to the high diversity of activities from housings, the strong relation between different housings from the same building (accentuated by modifications realised in the technical structure of the building) and the variability of functions outside the housings. It is estimated that permanent factors determine the quality of indoor air in Bucharest in a percent of **50-75 %**, with smaller values in the case of individual housings.

This atypical situation is determined by the current environmental changes, the ageing of urban infrastructure, the insertions realised in housing and by the un-corresponding models of behaviour.

The degradation tendency of air quality in Bucharest is a reality of the past years, determined by an increase of aggressiveness of environmental degradation sources and the significant decrease of the oxygenized surfaces (Pătroescu, 2003-2004). The projection in the indoor air quality is accentuated by the fact that degradation sources are approaching housings, examples in this direction being the gas stations, large commercial and storage spaces, the number of parking lots, etc. (Ioja, 2008).

The ageing of urban infrastructure determines a less efficient functioning of technical and urban technical networks (Lindavall, 1992). At most individual housings built before 1966, transformed trough lease in collective housings (Suditu, 2005) pollutants are brought in the indoor air also by the sewerage system which is not functioning properly. Also, in individual housings with their own system of producing heat, the ageing of building usually signifies a reduced efficiency in eliminating the contaminants resulted from the burning of fuels, generating significant increases of the burning gases concentration (ONU, 2001).

A current issue in the collective residential spaces is related with the tendency of dismantling the centralised ventilation systems through interior works. For this reason, the ventilation systems do not have the role of removing contaminants from inside to the outside, but they are relocating them from one housing to another. Therefore, the classic ventilation system using windows remains the only operational one, although it does not have a high efficiency as the quality of the indoor air is unsatisfactory (ARPMB, 2009).

A fact that is observed is that secondary toilets transformed in storage spaces (for different textile and leather products, footwear, detergents, sanitation products or electric appliance) as well as other spaces inside the housings depositing different chemical substances are confronted with an ***excessive charge*** with *volatile organic compounds, suspended particulate matter, ammonia, nitric oxides and hydrogen sulphide*. These contaminants are transferred in other rooms, but also to other housings situated at higher levels.

The thermal isolation of buildings (**72 %** of the analysed housings have thermopane window, and **21 %** have the walls out covered) improves the interior thermal regime, but in the same time accentuates the problems related with the indoor air quality, as the ventilation systems or air filtration systems have not been developed for mitigating the changes in the air circulation between the interior and exterior of the housing.

The generated problems concern pollutants accumulation, but also the improvement of conditions for them to generate synergic effects (increases of air temperature and humidity, reduction of air circulation). Besides, the obtained results emphasises that pollutants concentrations in the indoor air of thermal isolated housings are higher with **0.5 – 3** times thant the others.

The behaviour models are those contributing to a significant increase of the circumstantial factors percent in influencing the indoor air quality. Smoking, using street footwear inside the housing, the use of electric appliances during the rest periods, the frequent use of chemical substances for cleaning, the odorization of the indoor air trough aerosols or the high number of pets, represent significant circumstantial factors in the balance of indoor air quality in Bucharest housings.

Therefore, the pollutants concentrations in the indoor air of Bucharest's housings exceed frequently the recommended maximum limits for volatile organic compounds, carbon dioxide and suspended particulate matter. The obtained values place **7** of the **9** housings in the ***sick buildings*** category, in which the quality of indoor air is un-corresponding and can generate health problems to residents (Lindavall, 1992; Kostiainen, 1995; WHO, 2000).

CONCLUSION

The significant expansion of residential areas suffering from the "Sick Building Syndrome", which are economically, ecologically and/or sanitary inefficient, in the framework of current environmental changes, requires an integrated approach of problems concerning the air quality management in Bucharest residential spaces.

This is necessary as the residents' health is aggravating (the incidence of diseases characteristic to sick buildings, especially respiratory, heart and nervous diseases increases), the living costs increase (for cleaning the housing and clothing, eliminating uncomfortable odours, introducing equipments with the role of improving the conditions in the indoor environment, pests control, general repairs, for maintaining a favourable indoor microclimate, etc.) and the work productivity decreases significantly (US EPA, 1991; WHO, 2006).

The problems related with the indoor air quality are difficult to manage, as the people spending the most time in housings come from sensitive categories, represented by children, elders and ill people. Also, as most of the housings are situated in collective buildings, resolving the problems of indoor air quality requires an integrated approach. First of all, there must be increased the awareness level of the population towards behaviour which can determine increases of contaminants concentrations inside the housings, and afterwards there have to be developed technical measures for increase the efficiency of pollutants removal or fixation.

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