CASE STUDY: ENVIRONMENTAL COMFORT IN THE INDOOR SPACE OF AN OFFICE BUILDING, BETWEEN JULY, 14-16, 2010

Adrian-Catalin Mihoc
“Al.I.Cuza” University of Iasi, biagyydog@yahoo.com

Abstract. This study has tried to highlight the way that the values of the main microclimatic parameters affects the employees work inside an office building floor. This way, during a 3 day period from July 2010 I’ve followed and recorded the temperature, humidity and wind speed values, calculating the diurnal regime of these microclimatic parameters and the ambient comfort ones. The recording of this data has been made with the assistance of a microclimatic indoor station, a sound level meter and a light meter. The results help us understand much better how the values of these microclimatic parameters affects the work conditions from office buildings, if the microclimate is one of thermal comfort or discomfort, so if it’s propitious or if it affects the development in good conditions of work activities inside a collectivity.

Keywords: *office bureau, environmental comfort parameters, hourly and daily measurements*

Introduction

The present study aims at describing the working climate inside an office building. Similar studies have been done in various countries (Spain, USA, Sweden etc), but quite few were made in Romania. Hence we’ve decided to perform an experimental study in order to better understand how indoor environments affect the day to day life of the working inhabitants, by means of several high-performance microclimatic equipment which provided the necessary measurement data.

For this project, we’ve made measurements on 3 consecutive days in July 2010, which were considered as tropical days if we take into account the outdoor air-temperatures.

These measurements were made with the following three types of scientific equipments: an indoor air-quality station; a light intensity measuring instrument (luxmeter); a sound level meter.

Location and interval of instrumental observations

The equipment was set in on the 11th floor of a 13-storey-high building NOVO F, located in 5, Fabrica de Glucoza Street, sector 2, Bucharest, hosting, among other companies, HP Geboc as well. There are 265 cubicles (individual posts) on the floor of reference (Fig. 1). They are displayed in rows, and each row has from around 2 to 5 seats inside them.

The place of measurements was specifically chosen on the ground that the latter author actually works in the 18th cubicle (Fig. 2), located in the middle of a 5-seat row.

The measuring period lasted from 14 to 16 July 2010, and all data were collected every 30 minutes (from the 14th of July, 00.00 hrs. to the 16th of July, 23.30 hrs.).

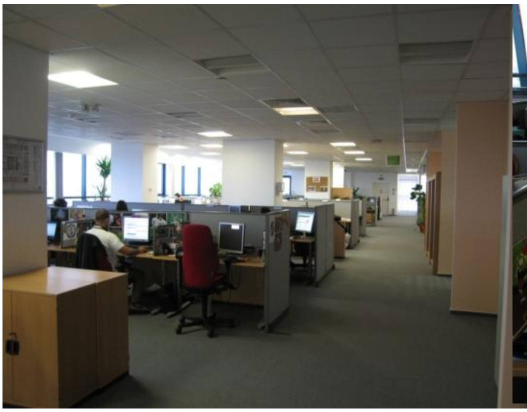

Figure 1 Office posts.

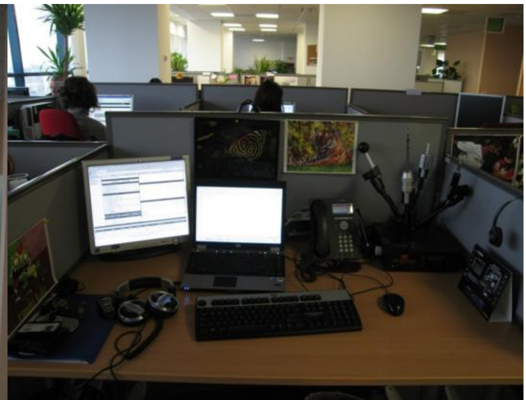

Figure 2 Office bureau number 18

The NOVO complex office building lies in the northern part of the Bucharest town, in the 2nd district, close to a crowded subway station (Fig. 3). The location can be considered as an industrial park, as numerous companies have their head-quarters buildings here and therefore quite a significant number of office buildings have been crowded in the area.

Figure 3 Location of NOVO F office building(aerial view)(Wikimapia, 2011)

The NOVO F building is one of the tallest in the area (13-storey high), having 2 underground parking areas and 3 other ground-floor parking lots (Fig. 4).

Figure 4 NOVO F office building

Instruments and methods used

The most important equipment we have used was the Casella Microtherm indoor air quality system, which is designed to monitor, record, calculate and display valuable data relating to the indoor environment of enclosed or partially enclosed spaces, where human working activity occurs.

The MICROTHERM – INDOOR CLIMATE SYSTEM is one of those advanced equipments for automatic monitoring some important microclimatic parameters (radiant temperature, dew point, vapor pressure, speed air currents) and environmental comfort (PPD, PMV, intensity of turbulent exchange) by means of which we can calculate many environmental stress parameters (human body heat exchange, heat stress index, allowed exposure time, effective heat load, sweat rate, pulse and blood pressure etc).

The MICROTHERM – INDOOR CLIMATE SYSTEM (Fig. 5) is made up of a central unit at which we can connect, through a serial port, a hub with 6 specific locations for different micro-environmental sensors. Each sensor is mounted on a sustaining arm of the hub, being connected to the corresponding jack quite underneath it. The system also has a power cord and an RS 232 serial port which can be connected to any PC. The main unit also has a data-logger which allows a limited storage, in its internal memory, of the data obtained through measurements, until their download in a PC or a laptop.

The main unit of the micro-environmental monitoring system in made up in such a way in which it can allow not only the monitoring and continuous recording of several microclimatic parameters, but also their calculation and digital display.

The base sensors of the MICROTHERM – INDOOR CLIMATE SYSTEM allow the continuous monitoring of some important microclimatic parameters like radiant temperature, air temperature (both dry and wet), air humidity, speed air currents, intensity of turbulent exchange, etc., being represented by a black globe thermometer, a probe for measuring the unidirectional air-flows and a sensor of measuring air temperature and humidity of solid bodies.

The parameter selection is made automatically by the WinIaq software application, based on the sensors connected:

- AT (^{0}C) (*air temperature*) –the air temperature of the indoor space in which the operator is performing his activity.

- RH (%) (*relative humidity*) – the ratio between the real and the saturation tensions of the water vapors from the ambient air.

- NW (^{0}C) (*natural wet*) – the actual temperature of the surrounding air, depending on the dry air temperature, effective air speed of the air currents surrounding the operator, air humidity and medium radiant temperature.
- BG40 (^{0}C) (*blackglobe temperature*) – the hypothetic temperature of an absolute black body having an absorbent coefficient as considered maximum.
- AV (m/s) (*air velocity*) – the instantaneous speed of the air currents which are created in the working space.

Figure 5 Casella MicroTherm (indoor climate system)

- PMV (units) (*predicted mean vote*) – the index which expresses the medium sensation of thermal comfort/ discomfort of a larger group exposed to the same type of environment.
- PPD (units) (*predicted percent dissatisfied*) – the quantifying index of the satisfaction/ dissatisfaction state of a certain number of people towards the thermal comfort of the environment they are located in.
- WBGTin (^{0}C) (*WBGT indoor*) – the effective temperature which a subject perceives during the period of time in which he undertakes an activity inside a building which is not directly exposed to solar radiation.
- WBGTout (^{0}C) (*WBGT outdoor*) – the effective temperature which a subject perceives during the period of time in which he undertakes an activity inside a building which is directly exposed to solar radiation.
- MRT (^{0}C) (*mean radiant temperature*) – the temperature which the operator perceives from the emissive surfaces of radiant energy surrounding him.
- RAV (m/s) (*relative air velocity*) – the semi-sum of the air velocity movement at ground level and the movement speed of the human body (or some of its parts) from ground level.

- TU (%) (*velocity turbulence intensity*) – the speed of the air turbulent mixture expressed through the ratio between the standard speed of air current deviation and its relative speed measurement at a specific moment.
- DR (%) (*draught risk*) – the percent of potential affected people by the draught sensation.

The TESTO 545 LUXMETER (luminous intensity measuring instrument) has a silicon photodiode sensor and a resolution from 0 to 100.000 lux (10 lux) (Fig. 6). The measuring times were daily, at 10, 14, 18 hrs.

Figure 6 Testo 545 Luxmeter

The TESTO 816 SOUND (LEVEL) METER has a sound level measurement ranges of 30-80 dB, 50-100 dB and 80-130 dB, automatic range switchover, two time weightings, two frequency weightings, a maximum/ minimum function, display light and a tripod screw (Fig, 7). The measuring times were daily at 10, 14, 18 hours.

Figure 7 Testo 816 Soundmeter

Results and discussions

Daily variation of the microclimatic parameters

The hourly average of air temperature has reached the lowest values during the first hours of the day (25.2 °C at 8.30) and gradually increased to the highest value of 26.8 °C at 13.00. Values between 26.00 and 26.8 °C have maintained until 22.00 and have later decreased continuously until 8.30.

The ***air-temperature*** variation graph (Fig. 8) shows maximum values in the middle of the day and minimum values in the early morning hours. The maximum value reached over 27.5 °C on the 14th of July and the minimum one decreased to 24.5 °C in the morning of the 15th of July (Fig. 9).

The indoor air temperature has a similar daily pattern variation to the exterior air temperature, to which a significant contribution of the human factor can be added since indoor temperatures immediately increase soon after the arrival of all employees at their working places.

The air-conditioning system has worked all time at around 25 °C, but several differences have been observed between the middle office-seats and the corner ones.

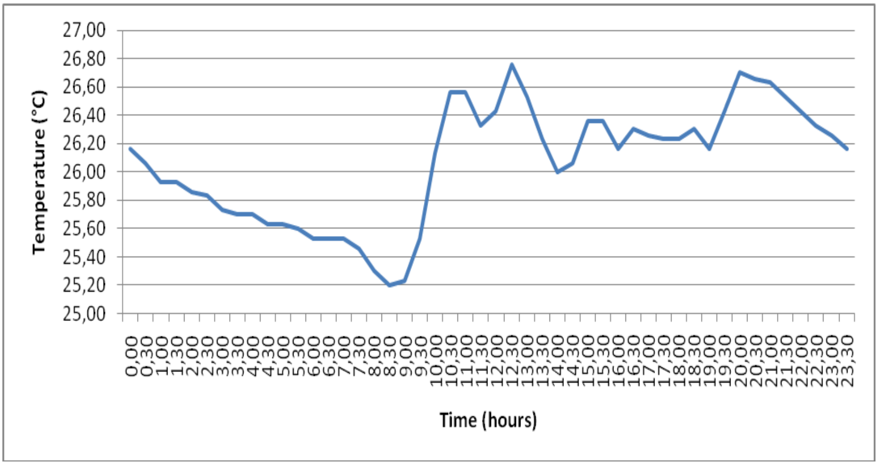

Figure 8 Three-day hourly AT average (°C)

The ***relative humidity*** had a more pronounced variation, but the highs and lows being recorded can directly be linked to the air-temperature ones. The highest values (over 64% on the 16th and 17th of July) were reached at midday, while the lowest ones (below 45%) in the early hours of each morning (Fig. 11).

The RH hourly average shows a maximum corresponding to the time when most employees come to work (around 9 AM), after that it drops continuously until 6 PM (lowest below 49%), then it increases again, to the evening hours (Fig. 10).

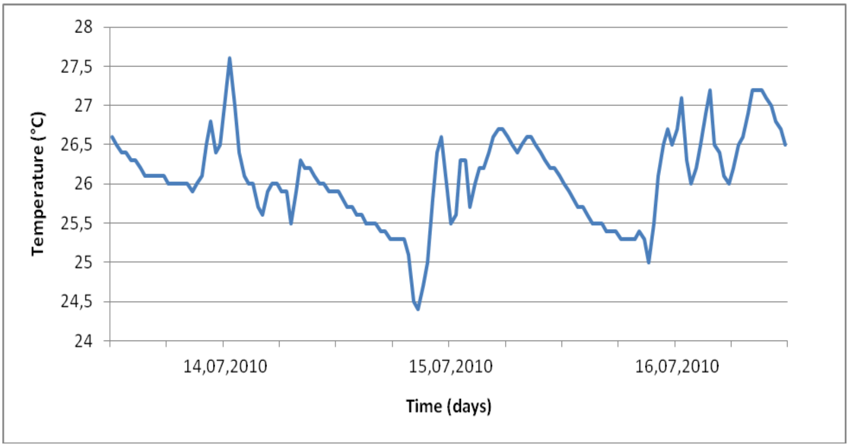

Figure 9 Inter-diurnal AT variation (°C)

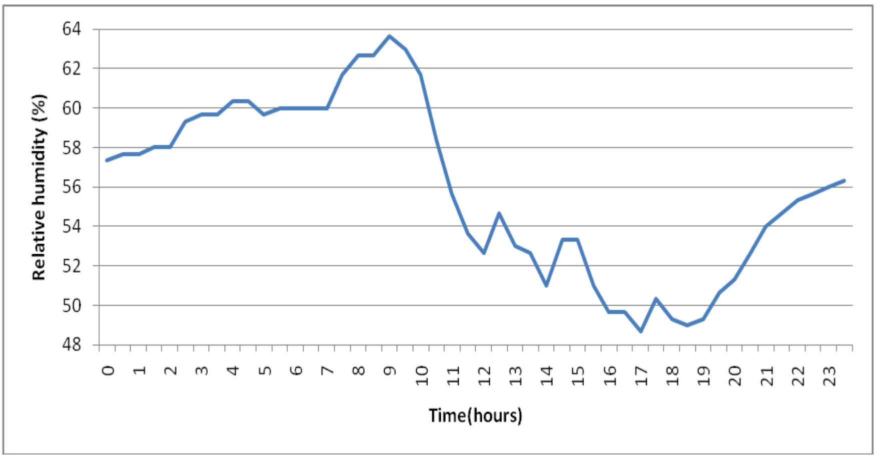

Figure 10 Three-day hourly RH average (%)

The ***NW and BG40 temperature*** had a similar variation scheme, with minimum values down to 24 °C, in the morning of 15th July, and maximum values of almost 27.5 °C in the midday of 14th July (Fig. 13 and Fig, 15). The same connection of these two parameters has also been observed in the three-day hourly average graph (Fig. 12 and Fig. 14).

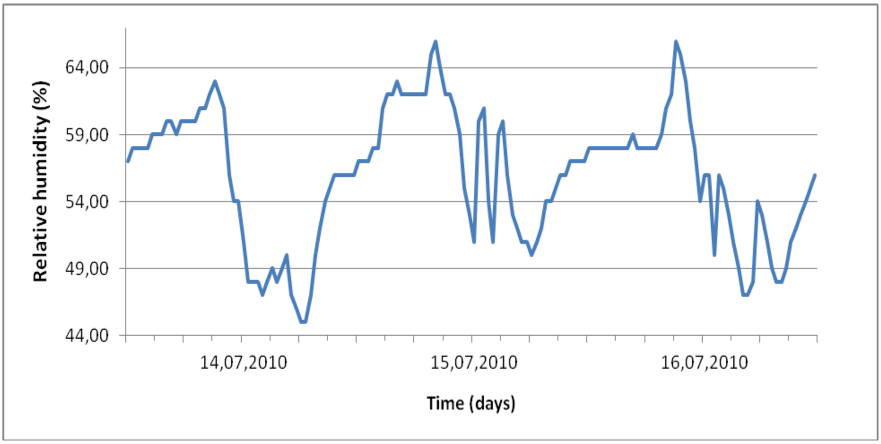

Figure 11 Inter-diurnal RH variation (%)

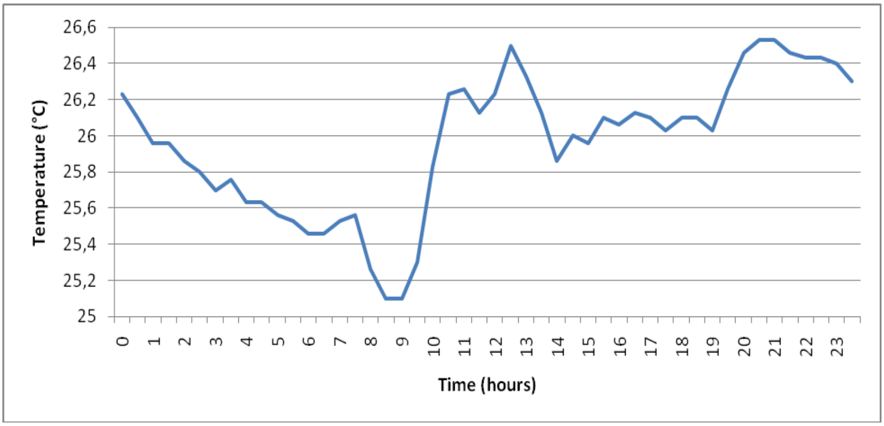

Figure 12 Three-day hourly NW average (°C)

The ***air velocity*** increased constantly from values beneath 0.04 m/s during the night and the early morning hours, to almost 0.26 m/s during the hard-time working hours before noon (10-12 hrs.) (Fig. 17). This pattern has been observed in all the three consecutive days, with high values between 9 to 11 AM, and then gradually decreasing values until 6 PM, soon followed by a slight increase until 7 PM., due to the people's rush on the leaving hrs. and finally, a relative persistence of hardly-perceptible air-flow around 0.03 m/s, which remains constant until 8 AM the next day (Fig. 16). This pattern can easily be correlated with the periods in which employees come to work, go to lunch and again leave the place of work.

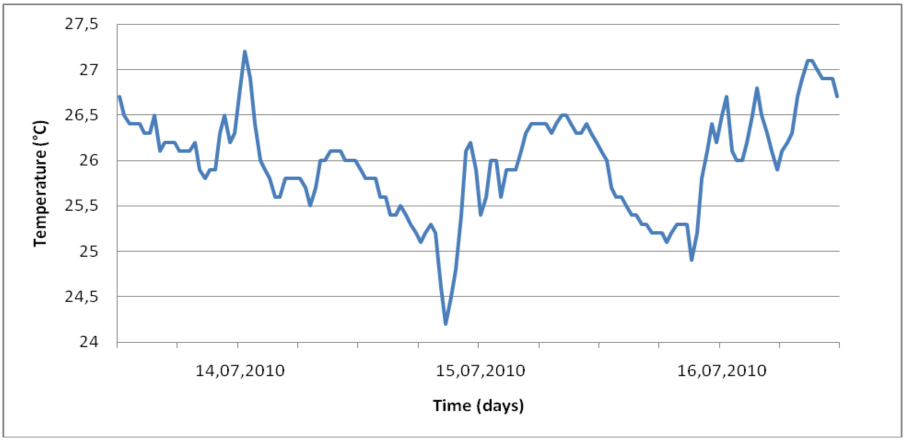

Figure 13 Inter-diurnal NW variation (°C)

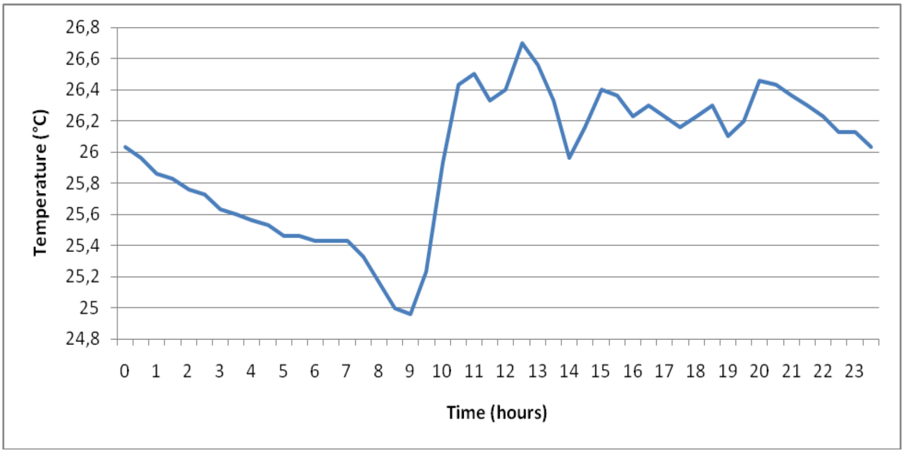

Figure 14 Three-day hourly BG40 average (°C)

Daily variation of the environmental comfort parameters

The variation of the ***indoor environmental parameters*** pointed to pretty good comfort conditions, from 0 to little above 1, where 0 represents the neutral conditions and 1 the optimum ones (Fig. 19). The optimal comfort conditions occur between 7 and 9 AM, just before the employees come to work.

We encountered no major variations of the calculated comfort parameters, and most of them had the same pattern of variation as the microclimatic parameters.

Below you can find an example of PMV (predicted mean vote) variation, which shows that there was no sensation of thermal discomfort, as one should have expected by taking into account the high relative humidity values (Fig. 18).

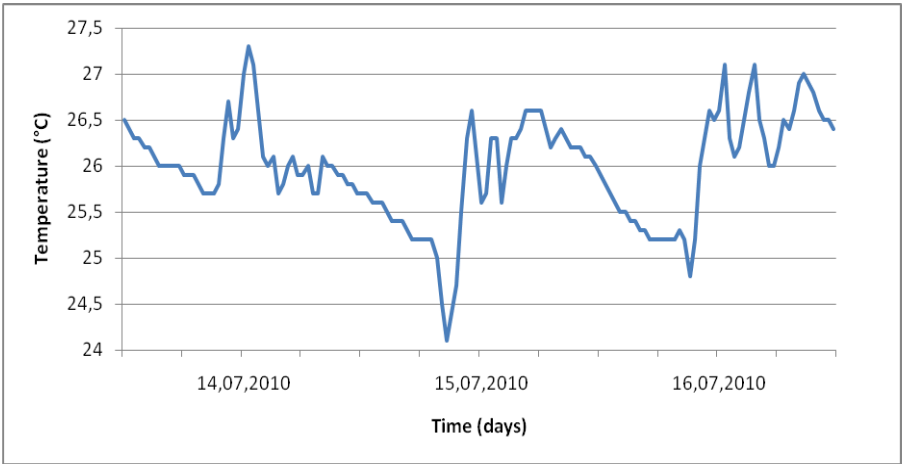

Figure 15 Inter-diurnal BG40 variation (°C)

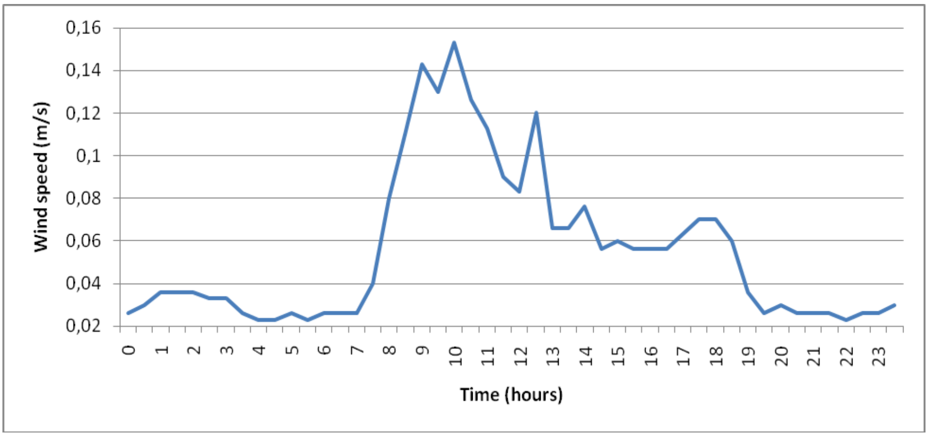

Figure 16 Three-day hourly AV average (m/s)

The ***light intensity*** at the office-seat ranged from lower values in the early hours of each day, to values reaching as high as 300 and even 450 lux, then rapidly dropping to values at around 270 lux at midday, and gradually decreasing to 250 lux at 6 PM. This shows that, during summer, the light intensity values are mostly related to the outside light and not to the indoor artificial light (Fig. 20).

However, these values are considered to be normal, not disturbing the day to day work of the employees. The only cases of disturbance are met towards the seats located by the windows, especially in the evening hours, when sunlight directly falls onto the monitor screen. Of course, vertical blinds are often used to prevent such minor disturbances from occurring.

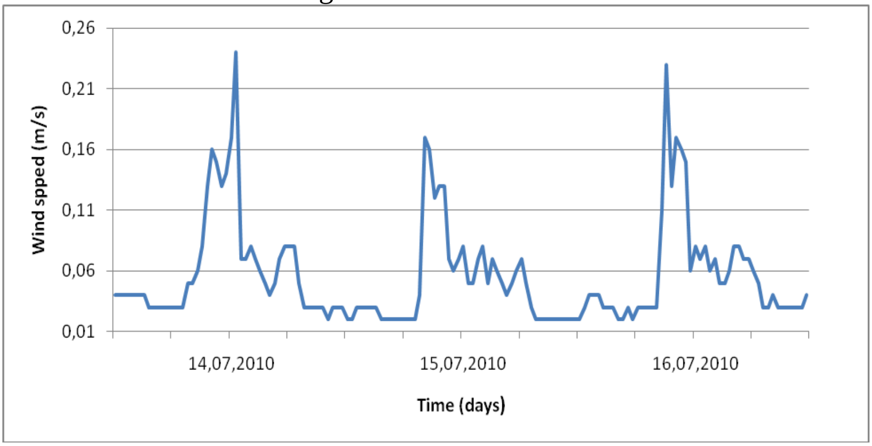

Figure 17 Inter-diurnal AV variation (m/s)

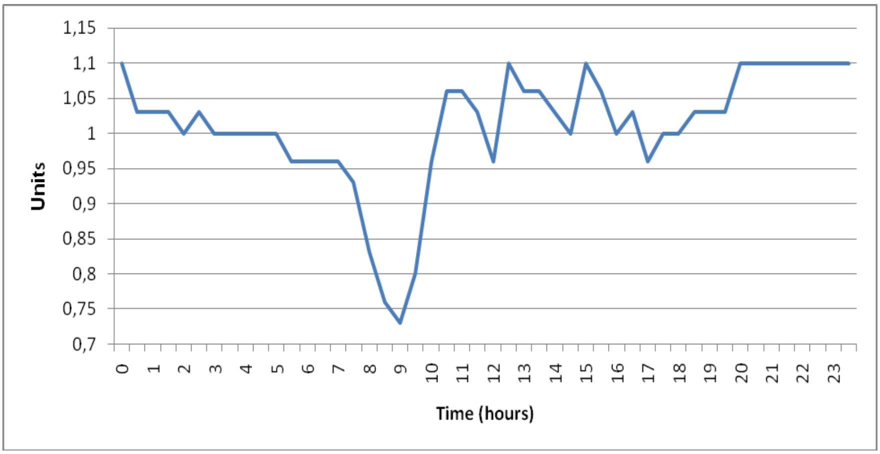

Figure 18 Three-day hourly PMV average (units)

The ***noise intensity*** is the most difficult problem, as values often go above 60 dB and never drop below 46 dB (Fig. 21). The highest values are usually encountered in the morning, when the employees come to work, with values which usually reach as high as 80 dB. These high values of noise level intensity are not artificially generated, as by machines, but are only due to people’s speech, and the conversations which they have with each other simply affects the audibility level for all the others.

Values usually drop in the afternoon and evening, but noise values still remain high.

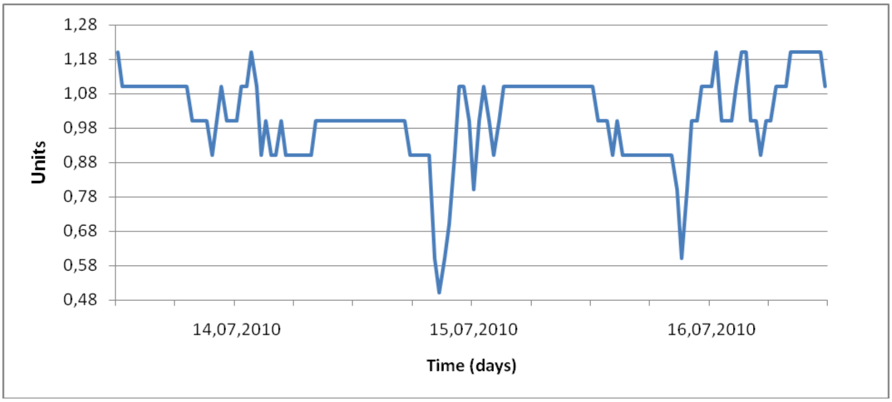

Figure 19 Inter-diurnal PMV variation (units)

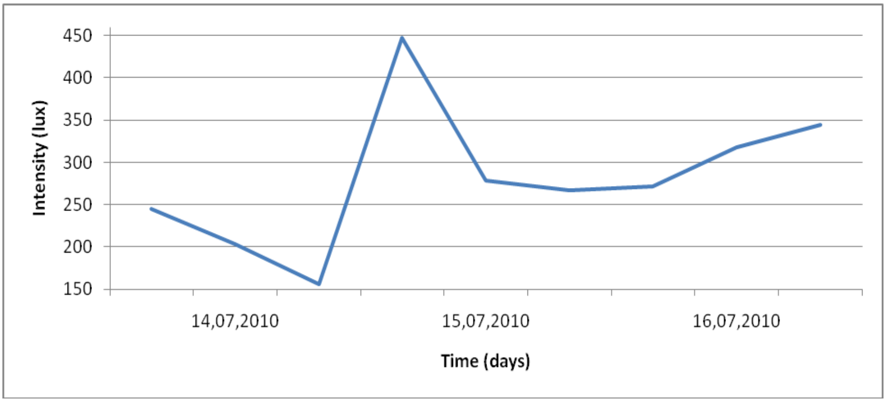

Figure 20 Inter-diurnal light intensity variation (lux)

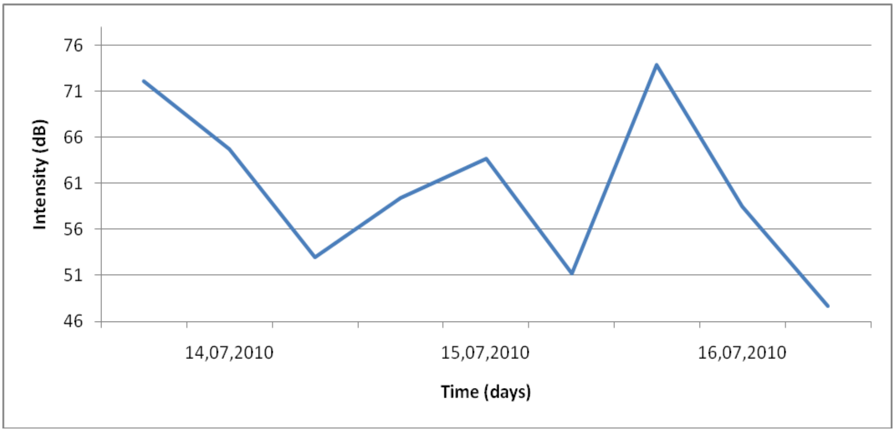

Figure 21 Inter-diurnal light intensity variation (dB)

Conclusions

Air temperatures have reached high values, in direct correlation with the relative humidity ones, mostly because a heat wave just happened to strike Bucharest town-area during the days in which the study was being conducted. Obviously, they have sharply disturbed the normal working activities, especially around noon, generating anxiety states. Such behaviors can be easily demonstrated by the variation graphs of the environmental comfort parameters. The wind speed and light intensity have shown normal to high values, while the noise intensity pointed to very high values, being especially related to the employees' arriving or leaving hours at/from the work place.

References

Dansosh A., 2003. *Elements of Comfort and Satisfaction in the Office Workspace, Journal of Science and Technology Vol. 26 (3): pp. 131-138, Ghana.*

Ionac N., Ciulache S., 2003. *Influența microclimatului spațiilor închise asupra confortului şi sănătății umane, "Comunicări de Geografie" vol. VII, Editura Universității din Bucureşti, p.129-134; ISSN 1453-5483.*

Ciulache S., 2005. *Măsurarea parametrilor microclimatici şi fiziologici cu ajutorul echipamentului Casella Indoor Climate, „Comunicări de Geografie", vol. VIII, Editura Universității din Bucureşti, Bucureşti, p. , ISSN 1453-5483*

*** 2002. *Microtherm Indoor Climate System & WinIaq Application Software – User Manual, Casella Cel Limited, Bedford, UK.*