Depósito Legal ppi 201502ZU4668

Vol. 25, Nº 2

Abril - Junio 2017

CIENCIA

Esta publicación científica en formato digital es continuidad de la revista impresa

Depósito Legal: pp 199302ZU47

ISSN: 1315-2076

An International Refereed Scientific Journal of the Facultad Experimental de Ciencias at the Universidad del Zulia

Vol. 25, Nº 2, Abril - Junio, 2017
ISSN: 1315-2076
Depósito legal pp 199302ZU47

CIENCIA

An International Refereed Scientific Journal of the Facultad Experimental de Ciencias at the Universidad del Zulia devoted to publish original research in Biology, Chemistry, Computer Sciences, Mathematics and Physics
Maracaibo, Venezuela

This Journal is covered in:

Analytical Abstracts (RSC), Aquatic Sciences and Fisheries Abstracts (ASFA) Bibliography and índex of Geology, Biosis, Chemical Abstracts, Latindex, Physics Abstracts, Revencyt, Zoological Record, Zentralblatt für Mathematik / Mathematics Abstracts

This Journal is supported by Consejo de Desarrollo Científico y Humanistico (CONDES) de la Universidad del Zulia

Aim and Scope

CIENCIA publishes original papers, preliminary Communications, technical notes, and reviews dealing with modern scientiflc aspects of Biology, Computer Sciences, Mathematics, Physics and Chemistry. Relevant papers in Environmental Chemistry and Food Chemistry are also invited to be submitted. Manuscripts should be addressed to: Dra. Marynes Montiel (Executive Editor) or Dr. Regina Vallejo (Associate Editor). Editorial Office of CIENCIA, Facultad Experimental de Ciencias, Universidad del Zulla, Maracaibo 4001-A, Venezuela. Telephone/Fax: +58 261 4127719. Maracaibo, Venezuela. E-mail: revistaciencia@fec.luz.edu.ve. Web Page: http://produccion cientificaluz.org/index.php/ciencia.

Description

Manuscripts submlssion is understood to imply that the article is original and unpublished and is not being considered for publication elsewhere. CIENCIA accepts papers in Spanish and English only. There are no pages charge. Manuscripts should conform in layout and style to the papers published in this issue. See the "Instruction for Authors" that appear in every issue of CIENCIA.

Publication

CIENCIA (ISSN 1315-2076/Legal Deposit pp 199302ZU47) is a publication of the Experimental Faculty of Sciences at the Universidad del Zulla. Vol. 1 (1993) and Vol. 2 (1994) appeared wlth two issues each year. From Vol. 3 (1995) until Vol. 8 (2000), three issues per year. From Vol. 9 (2001) in anead, this publication appeared with four issues each year. Vol. 24 appears in 2016. The articles published in this Journal are protected by Copyright.

CIENCIA

Alcance

CIENCIA publica artículos originales, comunicaciones preliminares, notas técnicas, comunicaciones cortas y revisiones relacionadas con todos los aspectos científicos modernos de la Biología, Ciencias de la Computación, Matemáticas, Física y Química. Artículos significativos en el área de Química Ambiental y Química de los Alimentos también pueden ser publicados en CIENCIA. Los manuscritos deben ser dirigidos a Dra. Regina Vallejo (Editora Ejecutiva). Oficina Editorial de CIENCIA, Facultad Experimental de Ciencias, Universidad del Zulla, Maracaibo 4001-A, Venezuela. Teléfono/Fax: +58 261 4127719. E-mail: revistaciencia@fec.luz.edu.ve. Página Web: http://produccioncientificaluz.org/mdex.php/ciencia.

Descripción

El envío de un manuscrito a CIENCIA supone que éste es original y no ha sido publicado ni está siendo considerada su publicación en otra revista. CIENCIA acepta manuscritos en español y en inglés. No hay cobro por página. Los manuscritos deben adaptarse al estilo de los artículos publicados en este número. Los autores deben guiarse por las condiciones expuestas en la sección de "Instrucciones para Autores", que aparecen en cada número de CIENCIA.

Publicación

CIENCIA (ISSN 1315-2076/Depósito legal pp 199302ZU47) es una publicación de la Facultad Experimental de Ciencias de la Universidad del Zulla. El Vol. 1 (1993) y el Vol. 2 (1994) aparecieron con dos números al año. Desde el Vol. 3 (1995) hasta el Vol. 8 (2000) la revista tuvo tres números al año. Desde el Vol. 9 (2001) en adelante, sale con cuatro números al año. El Vol. 25 corresponde al año 2017. Los artículos publicados en esta revista están protegidos por Copyright.

CIENCIA
Revista Científica de la Facultad Experimental de Ciencias de la Universidad del Zulia
Vol. 25 Nº2, Abril - Junio 2017

CIENCIA 25(2),75-, 2017
Maracaibo, Venezuela

Evaluation of air quality inside a painting factory through the use of gas sensors

Mehdi Dhia[1,2], Khalil Zaghdoudi[2], Angel Morales Rubio[*,1] and Miguel de la Guardia[1]

[1]Department of analytical chemistry, University of Valencia, Jeronimo Muñoz Building, 50th Dr.Moliner St., 46100 Burjassot (Valencia), Spain

[2]Department of chemistry, Tunisian private university, 32 Avenue Kheireddine Pacha 1002 Tunis, Tunisia

Recibido: 24-01-17 Aceptado: 28-01-17

Abstract

The quality of air inside a painting factory was evaluated from the determination of carbon monoxide (CO), carbon dioxide (CO_2), particulated materials (PM) with sizes 0.5, 2.5 and 5 µm, volatile organic compounds (VOCs), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) concentrations. Measurements were made by using gas sensors in six hot points of a factory in the area of Valencia (Spain): Air evacuation system (Aes), Storage warehouse (Swh), Research and Development laboratory (R&D), Quality control zone (Qzn), Ground (Gpd) and Upper (Upd) floor of the production area were considerated as sampling points. Maximum concentration levels of CO_2 were found in Gpd and it was around 1100 ppm and the maximum of CO concentration was 0.5 ppm near the Aes. The most contaminated area was the R&D; VOCs achieved high value of 184 mg/m3 and concentration of SO_2 was 2.65 mg/m3. PM was higher in Qzn and also in R&D. It varied around 30 thousand for the smallest size and 3 thousand for the biggest one. 0.128 mg/m3 was the highest concentration of the nitrogen dioxide and it was detected in the Qzn. Additionally the breath of the experimenter was used as a test of the passive exposure of the people working in the factory. The relationship between the studied parameter in breath, after/before making measurements inside the factory were 3252/436 (ppm), 1 million / 0.6 million (Particles), 100 thousand / 10 thousand (particles) , 5 thousand / 2 thousand (particles), 2.67/1.72 (mg/m3) , 0.04/0.1 (mg/m3) for CO_2 , PM 0.5 , PM 2.5, PM 5 , VOC and NO_2 respectively.

Keywords: Painting factory, Indoor air, Sensors, Working space, Breath analysis.

Evaluación de la calidad del aire interior de una fábrica de pinturas por medio del empleo de sensores de gases

Abstract

Se evaluó la calidad del aire en el interior de una fábrica de pinturas a partir de la determinación de monóxido de carbono (CO), dióxido de carbono (CO_2), material particulado (PM) de tamaño 0,5, 2,5 y 5 µm, compuestos orgánicos volátiles (VOCs), óxido de nitrógeno (NO_2) y óxido de sufre (SO_2). Las medidas se realizaron con sensores de gases en seis puntos calientes de una empresa en el área de Valencia (España). Los puntos de muestreo fueron: El sistema de evacuación de aire (Aes), el almacén de productos (Swh), el laboratorio de investigación y desarrollo (R&D), la zona de control de calidad (Qzn), el nivel de producción (Gpd) y el nivel superior (Upd) de la zona de fabricación. Los niveles máximos de concentración de CO_2 se obtuvieron en la zona de producción Gpd y fueron de 1100 ppm y el

*Autor para la correspondencia: angel.morales@uv.es

máximo de CO de 0,5 ppm se obturo en la zona Aes. El punto de mayor contaminación fue el R&D en el que los VOCs se detectaron hasta 184 mg/m3 y la concentración de SO2 fue de 2,65 mg/m3. Las PM fueron altos en las zonas R&D y Qzn. Varían alrededor de 30000 para las partículas de menor tamaño y 3000 para las mayores. Se detectó un nivel de 0,128 mg/m3 de NO2 en el Qzn. Además, se midieron los parámetros estudiados en el aliento del operador como indicador pasivo de la exposición de los trabajadores de la factoría. La relación entre los parámetros estudiados en el aliento después/antes de medidos en la fábrica fueron de 3252/436 (ppm), 1 millón / 0,6 millones (Partículas), 100000/10000 (partículas), 5000/2000 (partículas), 2,67/1,72 (mg/m3), 0,04/0,1 (mg/m3) para CO2 , PM 0,5, PM 2,5, PM 5, VOC and NO2 respectivamente.

Palabras clave: Fábrica de pinturas, aire de interior, sensores, espacio laboral, análisis del aliento.

Introduction

The evolution of life and human needs has provoked an apogee in the industrial production. Nowadays all fields are industrialized and in less than two weeks, factory produces the equivalent of the material production of all the year 1900. This allowed facilitating the daily however, the industrialization affect the atmosphere and was one of the causes of the global warming. 52% of pollution in the world is caused by the excessive activities of the industries (1). The pollution of air is the contamination of the indoor or outdoor environment with chemical, biological or physical hazard. Related to OMS (2) 7 millions of death are related to air pollution in 2012. Biodiversity and ecosystem services are currently at risk because of human footprint such as climate change, soil degradation and air pollution (3).

Indoor Environmental Quality is essentially the conditions inside buildings, which typically concern air quality, views, pleasant acoustic conditions, and occupant control over lighting and thermal comfort. And it is not surprising to learn that poor indoor environmental quality has become one of the major concerns we face today not only in the home, but also in education facilities and the workplace. Indoor air quality can lead to poor health, learning difficulties, and productivity problems.

Between the most harmful pollutants in the air; particulates materials (PM), carbon oxides (CO and CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and volatile organic compounds (VOC). Their concentration varied form activity sector to another and the sources also. Unfortunately, until recently, there has been insignificant federal legislation controlling indoor air quality. In factories the degradation of the indoor air quality is usually the result of sources that release gases or particles into the air. Inadequate ventilation or insufficient filtration is generally the most common cause of pollution because it can increase indoor contamination levels by not creating an airflow with adequate velocity to evacuate the poor air from inside and replace it by the cleanest one (4). High temperature and humidity levels can also increase concentrations of some pollutants like NO_2 and O_3.

In the active sampling way, samples were collected in polymeric filter and were took to laboratory to quantify the concentration of the analytes by using usual methods mention may be made ion chromatography for PM (5) The determination of organic compounds in air is a complex question of the wide range of organic elements. Gas chromatography (GC), liquid chromatography (HPLC), mass spectroscopy (MS) has been use in this case and the methodology was adapted for each type of organic molecules (6).

The aforementioned methods assure the precision and high quality of data. However samples cannot be treated in the same place of tests and they must be collected in filters and took time to be analyzed. Because of that, in this study the measurements were done directly in the sampling places by using a several handheld sensors to have a real idea of the presence of hazardous compounds. Measurements were done inside a painting factory in the eastern side of Spain (Valencia) in normal condition of temperature and humidity.

Materials and methods

Apparatus

The determination of the quality of air inside the factory was done by using several handheld air monitoring devices: i) an airflow multi-function anemometer TA465-P from TSI (Shoreview, MN, USA). This device was equipped with infrared spectroscopy technology to do the measurements of CO and CO_2; and a telescoping thermo anemometer probe to measure temperature and relative humidity, ii) a CEL-712 Microdust Pro from Casella Cel (Kempston, UK) with a photoelectric sensor to determine the concentration of suspend particulate matter (PM), iii) an Airy Technology P311 (Stoughton, USA) equipped with laser particle counter to determine PM in terms of amount of particles of different size (0.5 µm, 2.5 µm and 5 µm), iv) PhoCheck Tiger from IonScience (Laubach, Germany) to determine VOCs based on the use of photo-ionization detector and v) a Series 500 Portable Indoor Air Quality Monitor from Aeroqual (Auckland, New Zealand) for the determination of the NO_2 and SO2 concentration it uses an electrochemical detector. This device is equipped by interchangeable head sensors to allow the determination of the different target molecules. All devices were programmed beforehand and employed after stabilization. Table 1 provides details about the concentration's range and the resolution of the handheld devices.

Table 1. Specifications of air monitoring devices employed through this study

Device	Ranges of concentration	Resolution
Airflow multi-function anemometer TA465-P	0 to 5000 ppm (CO_2)	1 ppm
Airflow multi-function anemometer TA465-P	0 to 500 ppm (CO)	0.1 ppm
CEL-712 Microdust Pro	0.01 to 250 mg/m³ (PM)	0.001 mg/m³
Air technology P311	0.25 to 5 µm (PM)	1 particle
PhoCheck Tiger	1 to 10000 ppm (VOCs)	1 ppb
Airoqual S500 EWN	0.02 to 10 ppm (NO_2)	0.001 ppm
Airoqual S500 ESO	0.05 to 10 ppm (SO_2)	0.01 ppm

Samples

The study was carried out in the paint factory and focused on six different areas, chosen as hotspots, to take measurements. 1) The first measurement place was near the production plant air evacuation system situated outside the factory. It is important to mention that this place is an external place, then the results of measurement parameters can be influenced by the wind speed and the evacuation system because of the high sensitivity of the sensors employed. 2) The second "hot point" was the storage warehouse. In this place, reagents and solvent are stocked in special containers. 3) Research and development laboratory was the third place where measurement was taken. This little space (± 20 m^2) was dedicated for developing new type of paint products. In fact, many type of organic solvents were used. In this closed area there was a lack of air evacuation system. 4) The fourth place was the quality control zone where the paint products were sprinkle to test their quality. 5) The fifth area was the production plant where the whole of work was achieved. 6) The last measurements were done in the first floor of the production area on there was a lot of deposited powder. Figure 1 represents the plan of the factory in which it has been identified the sampling points. However, all details were deleted to preserve the trade name of the factory.

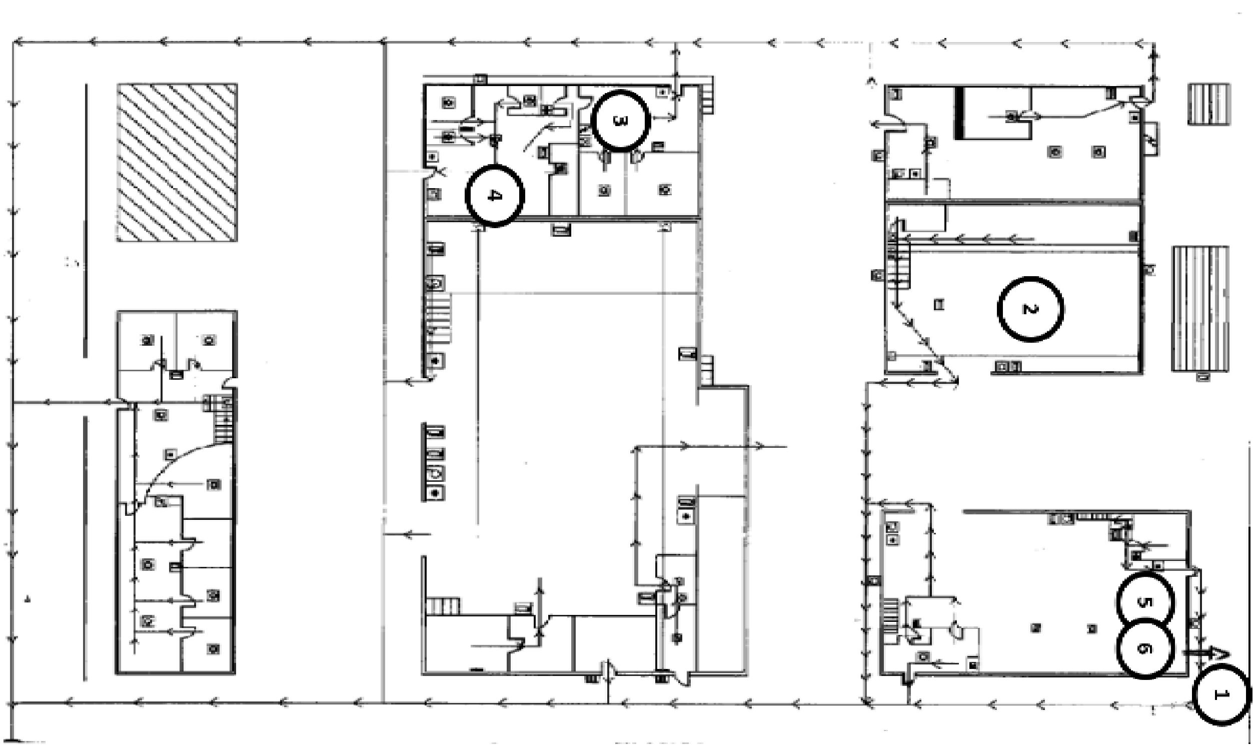

Figure 1. Plan of factory indicating the different sampling places

Analytical procedures

Sensors were programmed beforehand to establish measurement and measurement parameters were fixed like time intervals or reading unities.

After stabilization, measurements were taken under normal conditions at a height of 150 cm from the ground and 20 cm of the experimenter in each sampling point. Devices memorized automatically the concentration of each parameter and values were uploaded in the computer to be converted to tables and figures and interpreted in accordance with activity in each area.

In this study, the experimenter breath (normal respiration rhythm) values of the target analytes were taken before going inside the factory. After finishing the experiments inside the factory, the experimenter breath was measured again, by using the same method and in the same place (outside the industry). These results will be used as a passive pollution indicator and will give the degree of short term contamination of the indoor atmosphere on the lungs of people working in the factory, this providing an indicator on the direct impact in the human health.

Results and discussion

Ambient measurement values

Figure 2 shows the average measurement of temperature (in centigrade degree) and related humidity in different points of the factory as it can be seen the temperature was quite stable, between 21.1 and 23°C and the humidity evaluated from 32.8 % outside the plant till 46.9 % in the quality control area. All the aforementioned data are representation of the weather in the Valencian (Spain) spring day.

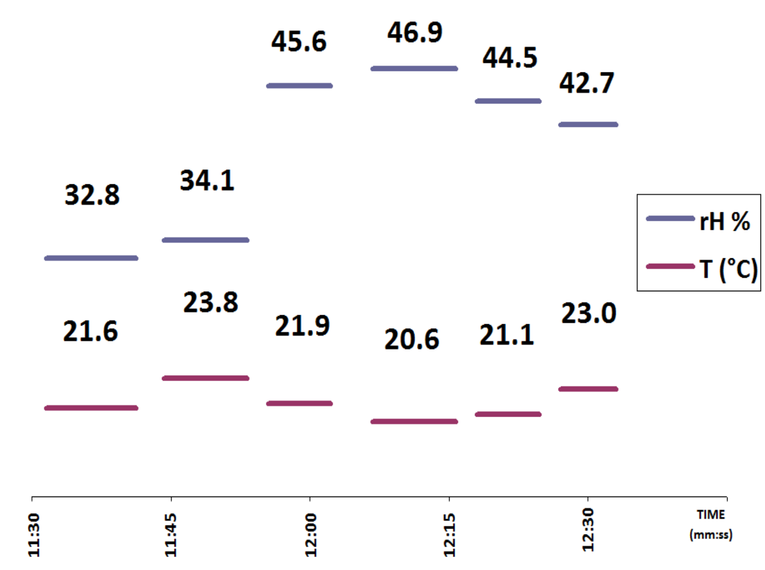

Figure 2. Variation of temperature and humidity in areas

Carbon oxides

The Airflow multi-function anemometer TA465P was programmed to memorize one value each 10 seconds. In the outdoor evacuation point CO_2 concentration was, more or less, constant around 434 ppm. This value is almost the normal concentration in air according to ANSES (7). However the concentration of CO reached 0.5 ppm after 40 seconds of measurement and stabilized in this value for 2 minutes. In the warehouse of solvent and finished products, the CO_2 varied between 400 ppm and 590 ppm and the maximum CO concentration reached was 0.2 ppm. Being this area near 90 m^2 place with a big open door obtained values of CO_2 must be due to loses of stored products. In the R&D lab the concentration of CO_2 varied between 700 and 461. This variation was caused by the air flow created by the movement of the employees in this small place. In the quality control zone the CO_2 concentration was around 600 ppm. However, in the sampling site number 5 the variation range was even high, reaching a concentration of 1150 ppm because the measurement was taken in the corner of the site between factory machines. In the first floor of the production plant the concentration was normal, near 400 ppm, and did not changed from the beginning to the end of measurement time. It is not worthy that no measurable concentrations of CO were found in the fourth latest areas.

Figure 3 summarizes the variation of the CO_2 concentration in all the factory point chosen.

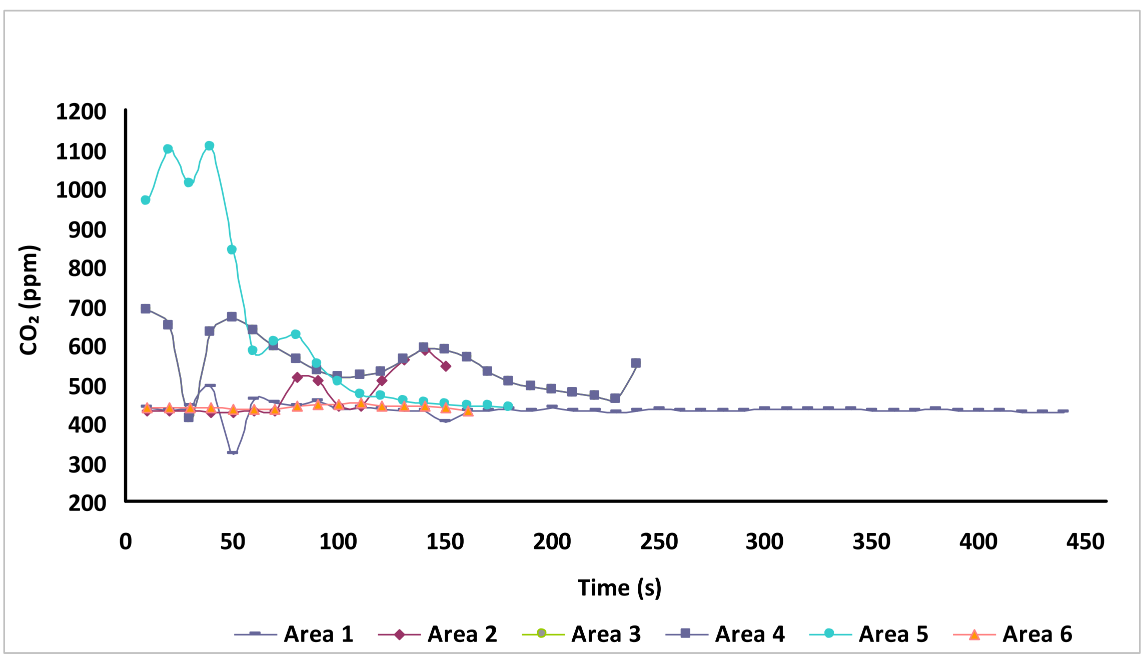

Figure 3. Overview of carbon dioxide emission in different sites of the paint factory

Particulate matter PM

Air technology P311 was programmed to calculate the number of PM each 10 seconds for sizes of 0.5 µm, 2.5 µm and 5 µm. For the determination of PM concentration, CEL-712 MICRODUST Pro was programmed to take measurement every 5 seconds. Results of the outside of the factory measurements were normal related to Su et al. (8) and did not exceed 5 million of aerosols in an open space after 110 seconds of measurement. In the second area the smallest particles presence was higher than 2.5 µm and 5 µm; the presence of 25 million of finest particle increased the concentration from 0.0035 mg/m³ to 0.0351 mg/m³ in more or less 2 minutes of measurement in the warehouse. The highest number of aerosols was detected in the R&D laboratory of the painting factory and exceeds 45 million particles because of extended use of solvent and solid regents. Figure 4 shows, as an example, the variation of number of particles in site 3.

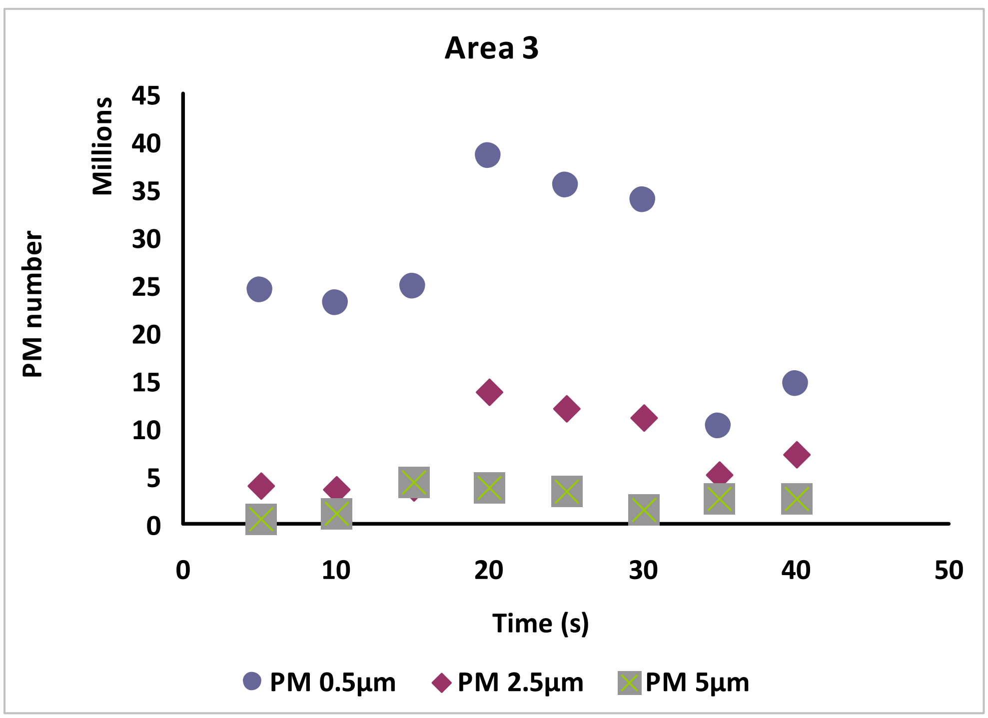

Figure 4. Variation of PM number in the R&D lab

The number of particles decreased all long the measurement (110 s) in site 4 and go, for example, from 40 million particles to 5 million of 0.5 µm, but it is important to mention that in this área it was detected the highest concentration of aerosols around 0.3 mg/m³. This variation can be seen as an example in the Figure 5.

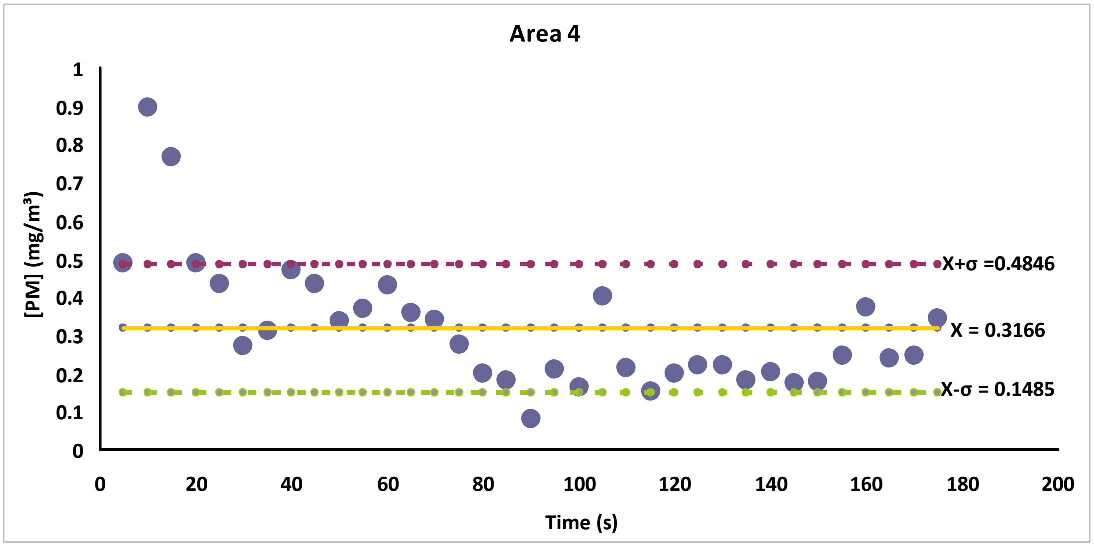

Figure 5. Concentration of particles in the quality control area of paint factory

The variation of PM in the production plant (site 5 and 6) varied between 0.001 and 0.04 mg/m3. These values can be considered like normal values based on norms of EPA (9). The site 6 value passes the normal concentration because of the existence of dust on the floor. The PM 0.5 particles were the most abundant in all areas and in all cases as a consequence of their lowest weight and highest volatility

Volatile organic compounds

The VOC sensor was programmed to make a measurement each 5 seconds which means around 22 minutes of measurement in the six areas. The variation of VOCs in areas 1 and 2 was around 7 mg/m3 and indicated that the air evacuated was charged by the organic solvents from the paint and in the warehouse the high value of VOC was caused by the volatility of organics in the raw container.

An astonishing concentration was seen in the laboratory of the factory. A value of 185 mg/m3 (Figure 6) was even reached and the average in this case was 180 mg/m3: extremely high VOCs concentration in a small closed area of 20 m2, probably due to the non-existence of air evacuation system. It can be harmful for the staff of the factory because data found were higher than that of Official Journal of the European Union concern 100 mg/m3 in 28 days (10). For site 4 and site 5 emission of VOC were around 45 mg/m3. Even if this values was constant and lower than the concentration of VOC in site 3 it must be indicated that VOCs can affect the human health for a long time exposition. For a painting industry the average of concentration (24.6 mg/m3 of VOC) obtained in upper floor of the production plan was normal.

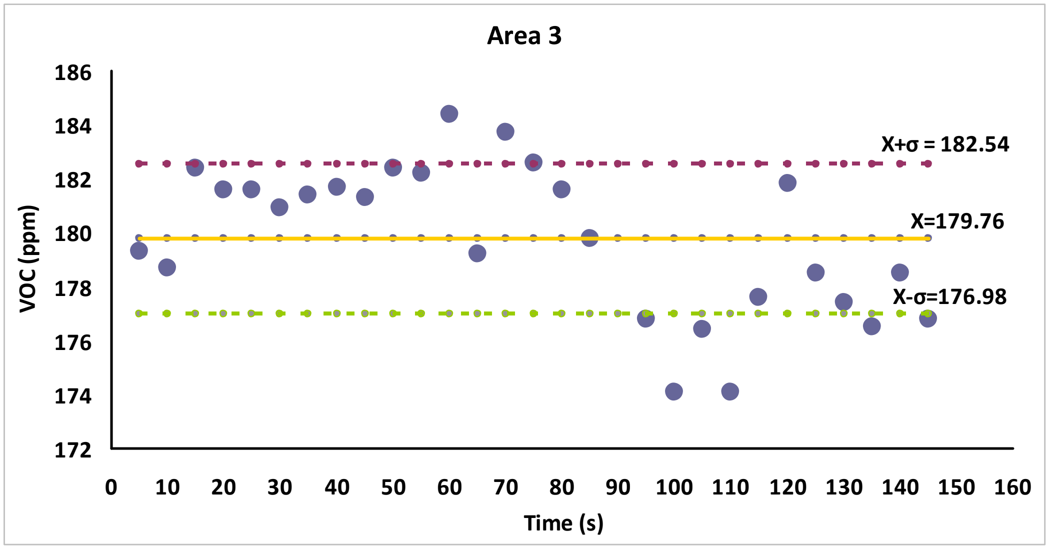

Figure 6. Evolution of concentration of VOC in site 3

Nitrogen dioxide (NO_2)

Airoqual S500 EWN was equipped with NO_2 sensor and measured the concentration each 5 seconds. The measurements outside give a variation between 0.02 and 0.06 mg/m^3 and it is like a normal value of ambient air related to OMS (2). No nitrogen dioxide was detected in the warehouse of reagents. The highest concentration of NO_2 was found in laboratory which was 0.1 mg/m^3. The absence of evacuation system in this little space could be the reason of the increase of nitrogen oxide. The quality control zone variation of nitrogen oxide concentration (site 4) was between 0.02 and 0.12 mg per m^3. A value of 0.1 was also detected in the production plant but decreased till 0.045 mg/m^3 on area 6. Figure 6 summarizes the variation of the nitrogen dioxide in the different areas of the paint factory.

Sulfur dioxide (SO_2)

The sulfur dioxide was detected in all places in which it was present in raw materials (sites 3, 4 and 5) because of the use of solvents derived from petrol in produced paints. It is necessary to mention that in outdoor site the concentration of SO_2 (2.3 mg/m^3) was more or less similar to the concentration in the sites previously mentioned. In the warehouse and the upper floor of the production plant sensor did not detected sulfur dioxide. Table 2 shows the concentration of SO_2 in the points of painting factory.

Table 2. Concentration of sulfur dioxide in the paint factory sampling points

Area	1	2	3	4	5	6
[SO_2] mg/m^3	2.3	0	2.65	2.91	2.56	0

Air pollution impact on the operator breath

Human breath measurements, made before to pass inside of the Factory and at the end of the study, were used as an estimation of the passive effect of pollution on the human lungs. After spent more or less 3 hours inside a painting factory, it can be mentioned that some compounds can affect the respiratory system. Related to results of this study, the smallest particles passed from 1 million to double and reached in the breath of operator 7 million (Figure 8B and C). The concentration of CO_2 exceeds 3000 ppm after stage inside the factory. Tests made after going out the factory are summarized in Table 3 and in Figure 8 it can be seen that VOC concentration are higher than in tests made before. The concentration in the two cases decreased but before entrance it achieved 1.5 mg/m3 however in the second case at least the concentration was 2.2 mg/m3.

Table 3. Measurement of the operator breath before (Bef) and after (Aft) his stage in the painting factory

	NO_2 mg/m³	CO ppm	CO_2 ppm	SO_2 mg/m³	VOC mg/m³
Bef	0.101	0	436	0	1.725
Aft	0.048	0	3252	0.47	2.673

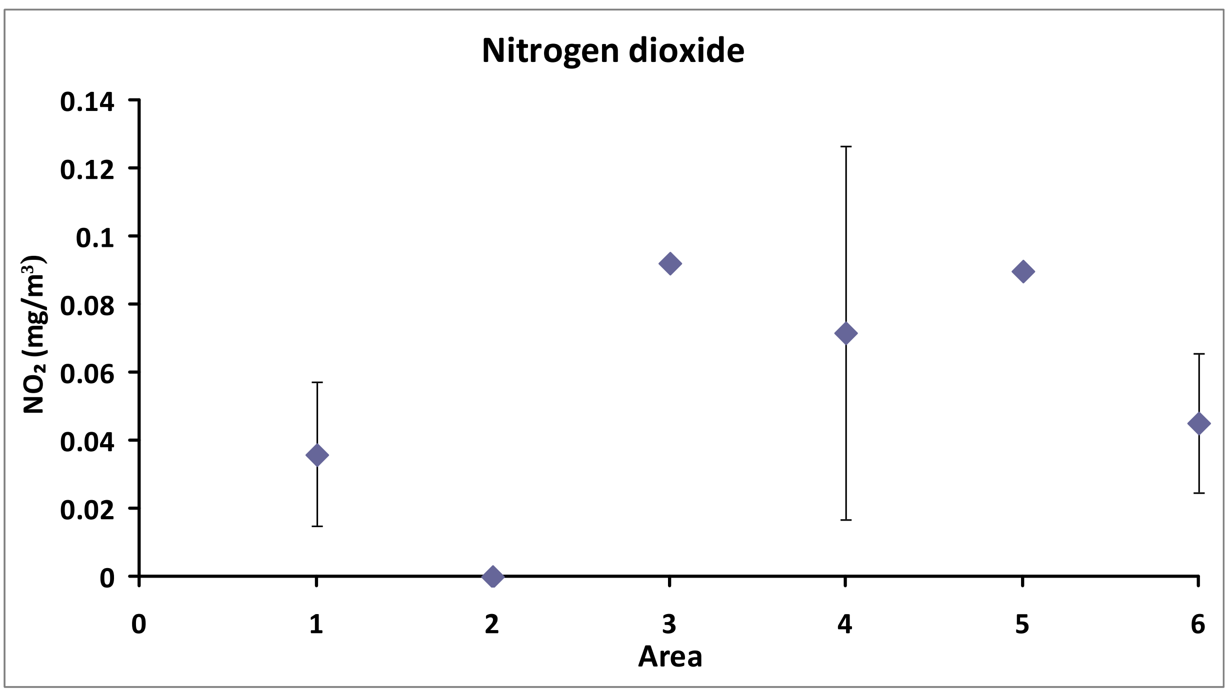

Figure 7. Variability of nitrogen dioxide in different sites of the paint factory

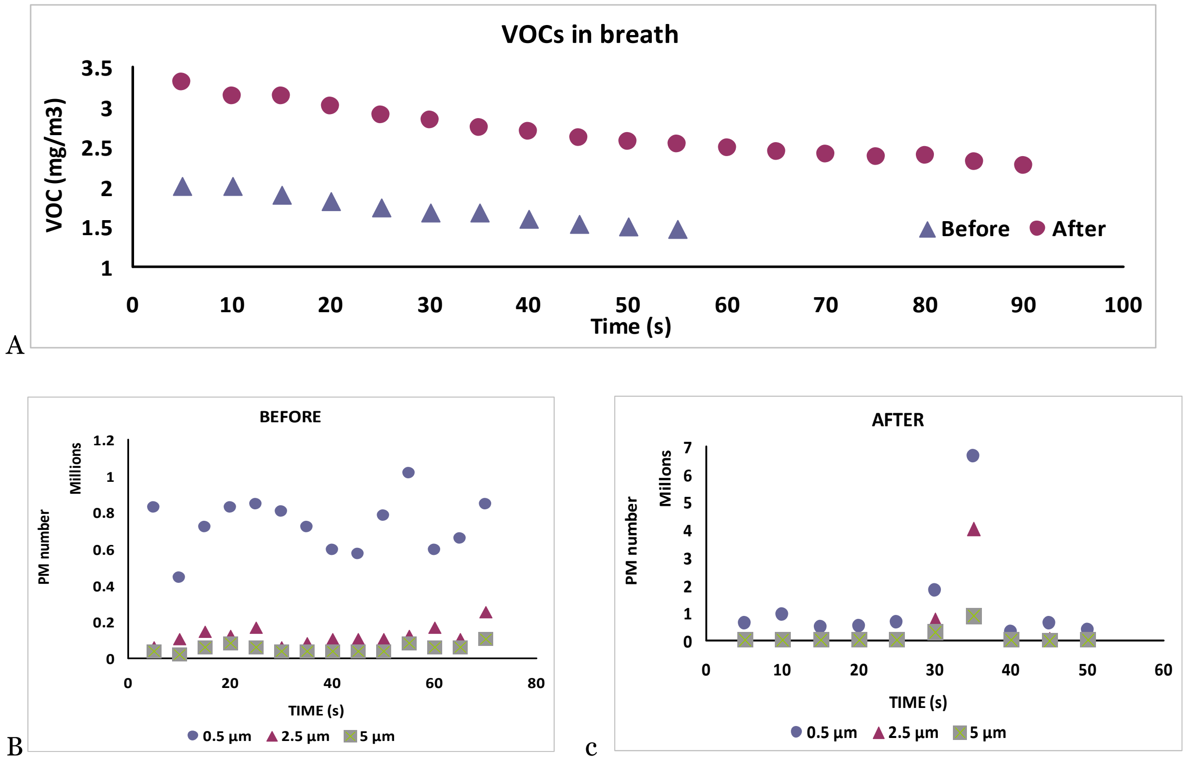

Figure 8. Effect of the air pollution inside the paint factory on the breath parameters of the operator: A) VOCs before sampling and after sampling, B) PM before sampling and C) PM after sampling

Conclusion

Related to the activity inside the factory it is not worthy to find some oncentration of analytes higher tan the normal values but it would be necessary to install ventilation systems in the research & development laboratory to provide a stable quality of air for the employer and staff.

The use of the sensors has provided data, in a fast way, about the quality of air inside the working space in order to be able to make the appropriated decisions on time.

On the other hand, the use of gas composition of the operator breath provided an idea about the degree of contamination inside the industry and its impact on human lungs.

Acknowledgement

Authors gratefully acknowledge the financial support of Generalitat Valenciana (project PROMETEO-II 2014-077), the University of Valencia and the Tunisian private university (ULT).

References

1. Environment and Climate Change Canada http://www.ec.gc.ca/Air/default.asp?lang=En&n=F963E49C-1. Fecha de consulta: 12/06/2017

2. OMS http://www.who.int/topics/air_pollution/en/. Fecha de consulta: 12/06/2017

3. OCHOA-HUESO R., MUNZI S., ALONSO R., ARRONIZ-CRESPO M., AVILA A., et al., ***Environ. Pollut.*** 227: 196-198, 2017.

4. WEI W., RAMALHO O., MANDIN C. ***Building Environment*** 92: 10-19, 2015.
5. MIHUCZ V.G., SZIGETI T., DUNSTER C., GIANNONI M., DE KLUIZENAAR Y., CATTANEO A., MANDIN C., BARTZIS J.G., LUCARELLI F., KELLY F.J., ZARAY G. ***Microchem. J.*** 119: 22-29, 2015.
6. ROSSIGNOL S., RIO C., USTACHE A., FABLE S., NICOLLE J., MEME A., D'ANNA B., NICOLAS M., LEOZ E., CHIAPPINI L. ***Atmos. Environ.*** 75: 196-205, 2013.
7. ANSES French Agency for Food, Environmental and Occupational Health & Safety https://www.anses.fr/en/thematique/environmental-health. Fecha de consulta: 12/06/2017
8. SU X., GOUGH W., SHEN Q. ***WIT Transactions on Ecology and the Environment,*** 207:215-226. 2016**.**
9. EPA. United States Environmental Protection Agency https://www.epa.gov/indoor-air-quality-iaq. Fecha de consulta: 12/06/2017
10. DIRECTIVE 2004/42/CE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 April. L143/87-L143/96. 2004

UNIVERSIDAD
DEL ZULIA

CIENCIA

Vol. 25, Nº 2 (2017)

Esta revista fue producida y editada en formato digital en el mes de julio de 2017
por el personal de la **Revista** CIENCIA **,** Oficina de Publicaciones Científicas de la Facultad Experimental de Ciencias, Universidad del Zulia.
Maracaibo - Venezuela

www.luz.edu.ve
www.serbi.luz.edu.ve
produccioncientifica.luz.edu.ve