



EXPOSURE TO ORGANIC VAPORS IN FOOTWEAR WORKERS

Exposición a vapores orgánicos en trabajadores del calzado

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KEYWORDS

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Volatile Organic Compounds (VOC)
Shoe manufacturing
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ABSTRACT

The footwear manufacturing process often exposes workers to toxic chemicals, such as Volatile Organic Compounds (VOCs), for long periods of time, occupationally and environmentally, which can cause the appearance of malignant neoplasms in a wide variety of organs and tissues, such as lung cancer (asbestos-induced), bladder (by aniline dyes) and benzene leukemia as referred to by Esquiaqui et al. (2012); Zuluaga et al. (2009) y Partanen et al. (2009), becoming the objective of our study in footwear workers in Bucaramanga, Colombia

PALABRAS CLAVE

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RESUMEN

El proceso de fabricación del calzado, suele exponer a los trabajadores a sustancias químicas tóxicas, como Compuestos Orgánicos Volátiles (COV), por largos periodos de tiempo (Rubiano et al 2002), de forma ocupacional y ambiental, lo que puede causar la aparición de neoplasias malignas en una amplia variedad de órganos y tejidos, como por ejemplo el cáncer de pulmón (inducido por el asbesto), de vejiga (por los colorantes de anilina) y la leucemia por el benceno como lo refieren Esquiaqui et al., 2012; Zuluaga et al., 2009 y Partanen, et al., 2009, convirtiéndose en el objetivo de nuestro estudio en trabajadores del calzado en Bucaramanga, Colombia.

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1. Introducción

During the shoe manufacturing process, workers are often exposed to toxic chemicals, such as Volatile Organic Compounds (VOCs), for long periods of time (Rubiano *et al.*, 2012). Occupational and environmental exposure to various chemicals can cause the onset of malignancies in a wide variety of organs and tissues; examples include lung cancer (induced by asbestos), bladder cancer (from aniline dyes), and benzene leukemia (Esquiaqui *et al.*, 2012).

The toxicity of organic solvents and aromatics (toluene, xylene, benzene, etc.) it has been widely recognized in the literature for several decades (Snyder *et al.*, 2012) according to IARC and other studies, chronic exposure to benzene can trigger hematological malignancies such as acute myeloid leukemia and non-acute lymphoid leukemia (Zuluaga *et al.*, 2009).

Substances such as benzene have been classified as carcinogenic in occupational exposure group 1 due to the risk they pose as genotoxic agents with direct carcinogenic potential to the health of workers in the footwear industry (Rubiano *et al.*, 2002).

On the other hand, agents such as toluene are within group 2B considered as a probable carcinogen for humans. Exposure to high levels of these substances can affect the central nervous system, causing concentration difficulties, headache and delayed reflexes, higher levels can cause dizziness, feeling faint and fainting which can compromise the worker's life (New Jersey Department of Health, 2016).

In Colombia, occupational exposure to benzene was evaluated in workers in car paint industries in the city of Bogotá, reporting values higher than those permissible in the air in these industries, although no presence of benzene metabolites was reported (mercapturic phenyl acid), (Palma *et al.*, 2015). Another study conducted in Bogotá on workers in the paint industry investigated exposure to benzene, toluene and xylene and its association with genotoxic risk through cytogenetic testing and evaluation of damage to genetic material (DNA). However, no alterations compatible with genotoxic risk or presence of solvent metabolites in urine samples of the workers were reported.

These results were correlated with the type of glue used in shoe factories (Vermeulen *et al.*, 2004). All these findings allow us to conclude that there is an increased risk of developing hematological tumors in workers exposed to benzene and volatile organic compounds VOCs. In addition, there is a higher concentration of this solvent in workers in the footwear industry due to the use of benzene glues.

Considering the serious effects on the health of workers in the footwear industry, caused by the storage and handling of voC-containing substances we set out to carry out a case study in a worker of the company PIESPORT with the purpose of measuring using an organic vapor monitor (OVMS) and its subsequent analysis through gas chromatography. The above to identify whether there is an occupational risk due to exposure to this type of agents.

This article focuses on industrial field hygiene, which aims to assess the exposure of workers to various risk agents and to obtain information to design or establish the efficiency of control measures (International Labour Organization - ILO-, 2001). The lines of research in occupational cancer and occupational exposure and industrial hygiene are addressed and the lines of research according to what it has been reported are prioritized.

2. Methodological design

A quantitative, descriptive cross-sectional methodology was used, in which a case study was carried out on a worker in the footwear sector who works as a foorer.

2.1. Population and Sample

The worker who participated in this study serves as a foorer in the manufacturing and assembly process, he has been working in the footwear sector for 21 years and he is exposed daily to the use of glues and solvents. The worker voluntarily agreed and signed the informed consent to participate in the research.

2.1.1. Phase 1. Structured survey application for the process of identification, hygienic evaluation and control of chemical risk in the worker.

The process of identification, evaluation, and control of occupational exposure to chemical risks, in different work environments, was based on the implementation of a structured survey whose purpose was to evaluate the risk factors that determine the occupational exposure of the worker in his job. This survey included aspects such as: Economic conditions, health, education and use of free time, factors related to work in the footwear sector, welfare programs received by the company, access to health services.

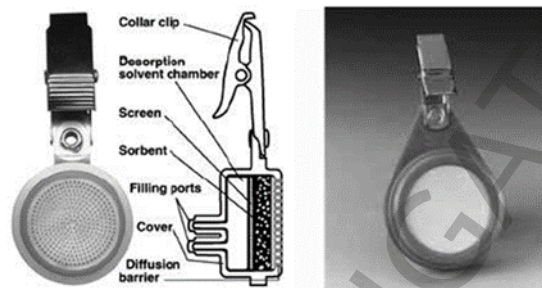
And finally, the survey included the questionnaire of neurological symptoms Q16, whose purpose is to facilitate the early detection of people who suffer effects due to exposure to organic solvents. Thus, this intervention can be done to reduce or eliminate exposure to solvents or receive treatment when other factors are the cause of the problem (Jiménez *et al.*, 2011).

2.1.2. Phase 2. Organic Vapor Monitor (LMOs)

Organic Vapor Monitor (LMOs) is a simple method for measuring concentrations of pollutants in the form of gas or steam (3M Science Applied to Life, 2018). The Method of Analysis used within the study followed the guidelines given within the EPA TO-15 (Supplemented by OSHA and NIOSH methods) for the determination of VOCs present in the work environment. The gas chromatography analysis procedure for the determination of the same was carried out in the USA at the facilities of Advanced Chemical Sensors who have laboratories accredited under ISO/IEC 17025:2005, recognized by the AIHA Laboratory Accreditation Program, LLC (AIHA-LAP, LLC), internationally recognized accreditation body (AIHA®, LLC, 2018). The sampling began at 7:00 am and ended at 5:30 pm covering the entire working day.

A LMO was used (Figure 1), which was installed on the collar of the shirt of the employee's work clothes in order to be as close as possible to your airways. Once the sampling process was completed, the LMO was preserved in its original case and sent to the USA where it was desorption with dichloromethane and analysis by gas chromatography.

Figure 1. Sampling procedure with Organic Vapor Monitor (OVM),



Source(s): AFC International, 2021

3. Results

Regarding their economic conditions, health, education, and use of free time, it was possible to determine that the worker has a primary education level. Their monthly economic income on average is always below the Colombian minimum wage; he has no children or wife.

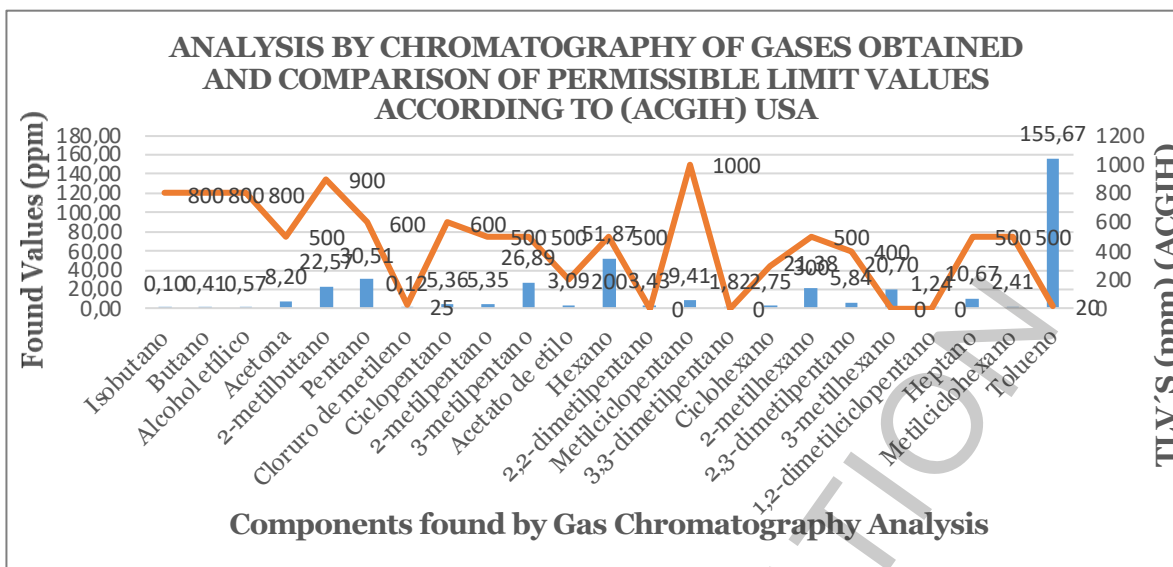
On the other hand, it is a person who claims to practice sports once a week, smokes more than four cigarettes a day and consumes alcohol sporadically (on rest days). Regarding the factors related to work in the footwear sector, it was found that the type of contract is for work or labour, their working day is daytime with one rest day a week, there are no shift rotations, and their working day is from 7 am to 8 pm, working a total of 13 hours a day and 78 hours a week, increasing the risk of VOC exposure.

Active breaks are never taken on the job site within the working day and the company does not provide personal protective items (PPE) required for the development of its activities; the worker changes his work clothes twice a week. It is also continuously exposed to physical contact with glues containing organic solvents, which is an important factor to keep in mind because it increases dermal exposure. The company does not have welfare programs offered to its employees or social security. Finally, regarding the Neurological Symptom Questionnaire Q16, the worker states that he agrees on two of the factors evaluated by the instrument which are: "That his friends and family tell him he's forgetful and claims he often wakes up and then can't go back to sleep."

The values reported in Figures 2 and 3 correspond to the average concentrations for the monitoring period used, which is equivalent to the total working day of the worker. The results obtained through the measurement carried out using LMOs in which a total of 23 analytes were analyzed, they can be observed in two ways.

Figure 2 shows the analysis by chromatography of gases obtained and its comparison of permissible limit values according to (ACGIH) of the USA. The results show that most analytes do not exceed the permissible limit values of exposure, but there is an analyte that is Toluene which exceeds the permissible TLV of exposure which is 20 ppm and the results show that a TLV of 155.67 ppm was obtained, exceeding by 7.78 times the permissible limit value according to the (ACGIH).

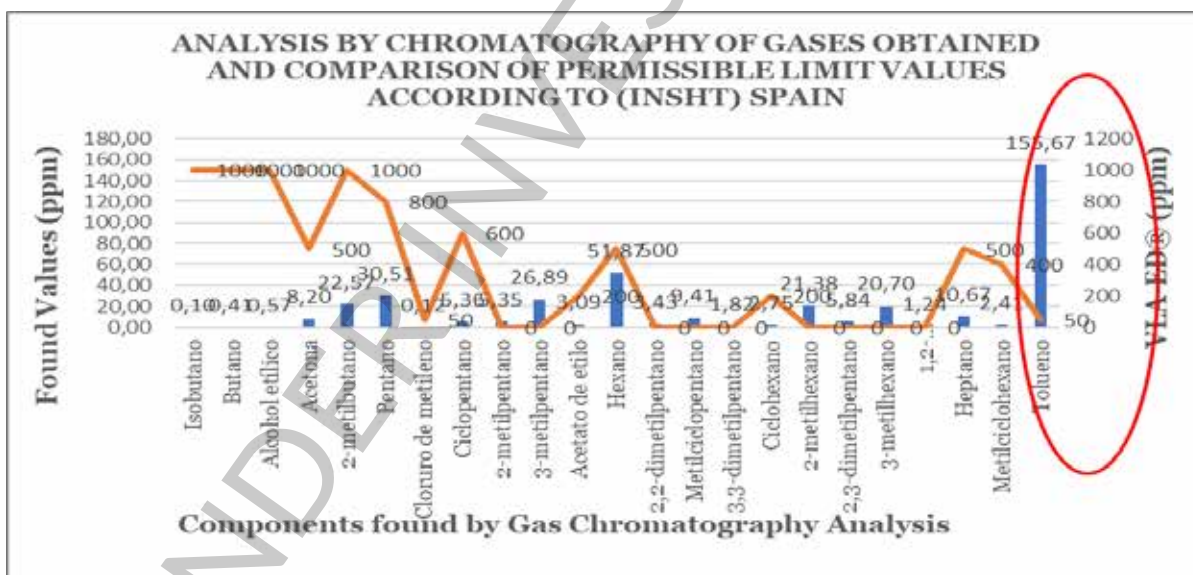
Figure 2. Analysis by chromatography of gases obtained and comparison of permissible limit values according to (ACGIH) USA. US



Source(s): Authors, 2021

In turn, Figure 3 shows the analysis by chromatography of gases obtained and its comparison permissible limit values published by the (INSHT) of Spain, at this point it is observed that the data are consistent with those presented in Graph 1 most analytes do not exceed the permissible limit values for exposure, but there is an analyte that is Toluene which exceeds the permissible VLA of exposure that is 50 ppm and the results show that a VLA of 155.67 ppm was obtained, exceeding by 3.11 times the permissible limit value according to the (INSHT) of Spain.

Figure 3. Analysis by chromatography of gases obtained and comparison of permissible limit values according to (INSHT) Spain



Source(s): Authors, 2021

4. Discussion

Monitoring VOC levels is an optimal technique for monitoring occupational exposure to chemicals and identifying hazards in exposed populations, this makes it possible to establish interventions to reduce or eliminate poisoning in workers who handle industrial solvents. In the case study carried out, the little importance on the prevention of chemical risk was observed, which is reflected in the lack of use of personal protection elements and the null industrial hygiene and safety measures observed in the workplace (absence of safety measures, respiratory protectors and ventilation system). As such there are not many previous studies carried out in the footwear

sector in Colombia which allow a comparison about the results obtained through the measurement of Volatile Organic Compounds (VOCs) using Organic Vapor Monitors (LMOs).

According to the results obtained, it is important to note that although the presence of benzene was not detected, which is the group 1 occupational exposure carcinogenic agent expected to be found in this measurement, the results obtained reflect that some of the concentrations of the VOCs analyzed such as toluene with 155.67 ppm exceed the ALimit Values - Daily Exhibition (VLA-ED®) published by the National Institute of Safety, Health and Welfare at Work (INSSBHT) of Spain which is 50 ppm for this agent, as well as the Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) who has a TLV of 20 ppm for Toluene. Based on these findings, it was found that there is significant occupational risk from VOC exposure, especially to toluene in the position of the worker which is worrying if you take into account that the working days in some cases exceed the eight hours a day of a normal working day, a situation that increases the risk of poisoning.

As such, the most important manufacturing products in terms of occupational hazards of the footwear industry are glues and cleaning solutions based on organic solvents (Mayan *et al.*, 2001). These products have been previously studied. As an example of a work carried out in Uruguay (Cousillas *et al.*, 1998), they found that the glues were composed in greater proportion of: acetone, toluene, benzene, n-hexane and ethyl acetate. Other authors such as (Perbellini *et al.*, 1992), in Italy, the mixture of solvents contained in glues and diluents, finding acetone, ethylacetate and cyclohexane, has been identified as the most frequently used, many of these solvents agree with the data obtained in our case study.

On the other hand, evidence obtained in Italian studies showed a significant increase in the incidence of aplastic anemia and leukemia, in a cohort of 3104 workers from the footwear industry in Florence, followed over a period of 34 years. A total of 14 cases of hematological alterations (12 leukemias and 2 aplastic anemias) were reported during follow-up (Paci *et al.*, 1989). Other research conducted in shoe factories and workshops in the city of Hebron, Cisjordan, was carried out to identify working conditions and estimate the concentrations of organic solvents used, where samples were collected in factories and workshops to be analyzed by gas chromatography. Six main organic solvents were detected in factories which coincide with what was found in the pilot study we conducted in Bucaramanga, acetone was common in gluing tasks, dichloromethane was common in cleaning tasks, heptane, methylethylketone, n-hexane and toluene were common in shoe gluing or gluing tasks (Nijem *et al.*, 2001).

It is important to note that the results found in this study do not allow us to establish a direct relationship between the worker's state of health and exposure to solvents in the workplace, however, it can be assumed that poor working conditions found in the factory increase the risk of suffering health effects derived from the use of VOCs such as toluene.

It is important to note that the results found in the present study do not allow to establish a direct relationship between the health status of the worker, and exposure to solvents in the workplace, however, it can be assumed that poor working conditions found in the factory increase the risk of suffering health effects derived from the use of VOCs such as toluene. We also consider that it is necessary to carry out complementary studies in a larger sample, using biological and environmental biomarkers as a complement. The implementation of prevention and control mechanisms such as the reduction of exposure time is imminently a priority, use of equipment of individual protection elements and compliance with legal regulations (Decree 1072 of 2015).

5. Conclusions and recommendations

It is important to note that, although no benzene was found within the company through measurement and analysis by gas chromatography, the presence of other types of chemical compounds that have interesting hazardous characteristics was obtained. Within this list of compounds to keep in mind in the following phases of research is toluene, analyte of interest for being an agent with carcinogenic potential, in addition to having specific toxicity characteristics in certain target organs due to repeated exposures, generate affectations to the nervous system, reproductive toxicity, aspiration hazards and specific organ toxicity from single exposure.

Bearing in mind the responses given by the worker to the structured survey, it is concluded that there is a need to improve aspects of this survey such as the identification of hazards according to the H-phrases of the MSDS, including aspects related to locative and infrastructure conditions, review of existing controls in the company and intervention measures (elimination, replacement, engineering controls, administrative controls and personal protection elements) and re-validation through a group of experts.

It is necessary to carry out an inventory of the chemical substances used in the manufacture of footwear, in order to determine whether the chemicals used generate combined effects. This is because some chemical agents produce more than a single toxicological effect. On the other hand, the simultaneous presence of more than one toxicant can produce combined effects, that is, to alter the toxicological capacity that each toxicant would have separately, generating additive, synergistic or potentiating, independent, or antagonistic or inhibitory effects.

5. Gratuudes

This text was born within the framework of a project Mincinencias - Call 807 for Science, Technology and Innovation Projects in Health (710-IN-3-19-001) of the Corporación Universitaria Minuto de Dios, "Determination of genetic susceptibility, DNA damage and epigenetic alterations due to occupational exposure to benzene in workers in the footwear industry in the city of Bucaramanga (Santander)".

UNDER INVESTIGATION

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