

Toluene Exposure in a Chemical Industry Plant

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ABSTRACT

Introduction: The occupational use of chemical substances is a worldwide reality, being a growing public health problem. Several work activities are related with handling of chemicals contributing to the exposure of workers to these substances. Toluene is a non-polar organic solvent, easily absorbed by lipid-rich tissues, and is suspected of damaging fertility, or the unborn child, and may be fatal if swallowed and enters airways. **Objectives:** The aim of the study was to assess the occupational exposure to toluene, in a chemical industry, through environmental monitoring. Additionally, the study also aimed identifying the main factors that influence the exposure. **Methodology:** Active sampling was performed on 11 exposed workers, during 3 specific operations of the production process. Samples were analysed by gas chromatography with flame ionization detector. With the results of the toluene concentration, the time-weighted average exposure was calculated for 8 hours of activity and compared with the toluene indicative occupational exposure limit value for the same period. **Results and Discussion:** All results were below the reference value, ranging from 0.07 to 2.24 ppm for a time-weighted average exposure of 8 hours a day. The operation with the highest exposure level was the filling operation, with a value of 11.51 ppm, whose value approaches the exposure limit established by the Portuguese Standard NP 1796:2014 and by the American Conference of Governmental Industrial Hygienists (20 ppm). This exposure is due to the absence of a closed system and a local exhaust ventilation near the emitting source, that allows the removal of toluene vapours after emission. **Conclusions:** The results support the need to implement a closed system and, if not possible, apply engineering measures at the handling sites.

KEYWORDS: Toluene, occupational exposure, local exhaust ventilation

1. INTRODUCTION

The occupational use of chemicals is a worldwide reality and is a growing public health problem. The adverse effects that may arise from the handling of these substances promote the in-depth investigation of the interactions between substances, the human organism and the exposure scenario. Most liquid chemicals volatilize easily (Yasar et al., 2016), contributing to a deterioration of the workplace air quality and, consequently, to the exposure of workers to these substances. These enter the body through inhalation (Forster et al., 1994), being incorporated in the organic tissues where they trigger their harmful effects, being later metabolized through detoxification processes. Toluene is a non-polar organic solvent (HSE, 2004) and is used in industrial paints (HSE, 2004; Fiequimetal, 2010), adhesives, coatings, dyes (HSE, 2004), cleaning products (HSE, 2004; Prista & Uva, 2002), glues (Prista & Uva, 2002; Fiequimetal, 2010), printings, automotive and shoemaking industry (Moro et al., 2012; Akgür et al., 2001). It is a lipophilic hydrocarbon (Prista & Uva, 2002; Forster et al., 1994), and is easily absorbed by lipid-rich tissues such as the brain, myelin, bone marrow, liver, kidneys, nervous and adipose tissues (Prista & Uva, 2002; Forster et al., 1994), and is suspected of damaging fertility, or the unborn child, and may be fatal if swallowed and enters airways.

Decreto-Lei n.º 24/2012, of February 6th, which transposes European Directive 98/24/EC of April 7th, stipulates the employer should assess the risks and verify the existence of hazardous chemical agents in the workplace (Moro et al., 2012) and establishes the

indicative occupational exposure limit value for a time-weighted average (TWA) exposure for 8 hours of activity of 50 ppm for toluene. However, Portuguese Standard NP 1796:2014, Occupational Health and Safety, Occupational exposure limits and biological indices to chemical agents, and the American Conference of Governmental Industrial Hygienists (ACGIH) establish the reference value of 20 ppm for the same type of exposure.

Exposure assessment allow to assess the risk of exposed workers, set priorities for intervention, and identify the most appropriate exposure control measures (Siqueira & Paiva, 2002). The aim of the present study was to evaluate the occupational exposure to toluene in workers of a chemical industry plant, through environmental monitoring, identifying the main factors that influence exposure.

2. MATERIALS AND METHODS

The study was developed in a Portuguese chemical industry that has its own health and safety service. There are 124 workers, of whom 76 are plant workers that perform their activities in one of the 2 plants belonging to the industrial complex. The 76 workers are allocated to 8-hour shifts (from 00:00 to 08:00, from 08:00 to 16:00, from 16:00 to 00:00), working 7 days a week. Breaks are also rotatable. The plant workers are distributed in several jobs titles namely: Shift Responsible, Technician of Production and Analysis, Reactor Operator, Weighing Operator and Filling Operator. The activities studied are developed in specific areas of the resin plant, in certain

stages of the production process, which involve direct contact with toluene. Previously, the company has performed some air monitoring campaigns on this

shifts, in a total of 4 shifts, corresponding to a complete work cycle with toluene.

When calculating the exposure in each workplace, it

Table 1 – Concentration Results and Weighted Average Exposure Calculation

Function	Operation	Operation Duration (hours)	Sampling Time (hours)	Concentration (ppm)	TWA (ppm)
Reactor Operator	Preparation of Primer Solution	00:10	00:05	75	0.78
Filling Operator		01:30	01:00	6	0.75
Filling Operator		01:30	00:57	7	0.83
Reactor Operator	Adjustment and Filtration	01:30	00:59	7	1.64
Production and Analysis Technician		01:30	01:08	8	1.51
Shift Responsible		01:30	00:54	18	2.24
Production and Analysis Technician		02:00	02:00	0.8	0.2
Reactor Operator	Filling	02:00	01:05	0.5	0.07
Filling Operator		02:00	01:03	14	1.84
Shift Responsible		02:00	01:24	0.6	0.11
Filling Operator		02:00	01:05	85	11.51

substance, however without the degree of detail of the present study.

To access the concentration of toluene, active samplings were carried out through personal samplers during operations performance (Forster et al., 1994). Samples were collected on all workers of 2 different shifts (morning and evening), in a group of 11 workers, from a total of 20 exposed workers, in 3 specific operations of the production process: Preparation of Primer Solution, Adjustment and Filtration by Recirculation and Filling. Workers were distributed in the aforementioned operations, where the handling of toluene occurs.

The procedures adopted for the collection and analysis of the air samples were those recommended in the NIOSH 1501 method – Hydrocarbons, Aromatic, 2003. Subsequently, the results of toluene concentration in the ambient air were used to calculate the TWA for 8 hours of activity. This result was later compared to the reference values of toluene in the Portuguese Standard and ACGIH.

For the statistical analysis, Microsoft Excel™ software, belonging to Microsoft Windows™ 10, was used.

Workers, and their respective sector managers, were informed through acknowledgement sessions on the objectives of the study and necessary materials. The study protocol was analysed by the Legal and Insurance Department of the company where the study was carried out and approved for its development. Individuals who declared that were not interested in participating were excluded from the study population.

3. RESULTS

Concerning the operations performed, about 60% of workers should use personal protective equipment during their working hours. Air monitoring was carried out in 2

was considered the individual exposure of each worker in every operation they perform throughout the workday. The concentration of toluene in the air in each operation and the respective exposure durations were added, and divided by 8 hours of workday to calculate the TWA. During the rest of the workday it was considered, based on previous operations observations, that workers were not exposed to toluene.

The results of the samplings were extrapolated to the remaining shifts since operations are performed by workers in a similar way and risk management measures are the same, confirmed through direct observation of the production activities.

The results are shown in Table 1. All results were below the reference value, ranging from 0.07 ppm to 2.24 ppm for a TWA of 8 hours. The workplace with the highest exposure level was the filling operator, during filling operation, with a time-weighted average value of 11.51 ppm.

4. DISCUSSION

The results show that, under the conditions studied, the TWA values are below the reference values (20 and 50 ppm). The workplace with the highest exposure level was the filling operator, during the filling operation, with 11.51 ppm, whose value approaches the exposure limit established by the Portuguese Standard NP 1796:2014 and by the ACGIH (20 ppm). However, we should also consider that a concentration of 85 ppm was obtained during 2 hours and, in some cases, this might surpass the 60 ppm reference value (3 times TLV-TWA) during more than 30 minutes per shift. If this situation occurs, we are facing an inconformity that needs immediate action.

Specifically, in the filling operator job title, during the filling operation, there is a significant difference between workers. Despite being the same job title, workers

performed the operations in a different manner, since one of the workers carried out the filling and the gradual replacement of empty containers for this operation, moving away from the exposure zone, while the other filling operator carried out only the filling of containers, resulting in an exposure of 1.84 ppm and 11.51 ppm, respectively. This supports the fact that exposure can be very variable, and the way operations are developed directly influence the exposure. Only with detailed observation of operations before and during sampling it was possible to recognize which variables affect exposure and to understand the different exposure values obtained during the performance of the same operations (Viegas, Almeida-Silva, Faria, Dos Santos, & Viegas, 2016; Viegas, Faria, Dos Santos, & Carolino, 2016).

Although most of the production process operations took place in a closed circuit, the filling of packages is carried out in an open system, allowing the release of vapours. The resulting exposure is due to this open system and the absence of engineering controls, namely local exhaustion ventilation (LEV) near the emitting source, allowing the removal of toluene vapours after emission, avoiding workers exposure. Like in other studies (American Conference of Governmental Industrial Hygienists [ACGIH], 1998; Jafari et al., 2009; Mohammadyan & Baharfar, 2015) and, if well installed and maintained, LEV should contribute to reduce/eliminate workers exposure.

The results of "Shift Responsible" job title, during the adjustment and filtration operation, also had shown exposure values higher than most workplaces. Since this worker often plays the role of other operators, there is a cumulative exposure related with the entire shift. An additional aspect that should be considered is the fact that workers are exposed, during their daily operations, to other substances. Therefore, it might be important to consider potential interaction, in particular additive or synergetic effects that can result in harmful health effects being observed below the reference values of each substance.

The company managers considered the study very important and considering the implementation of suggested risk management measures.

5. CONCLUSIONS

The results obtained support the need to redefine the workplace. It is suggested the implementation of a closed system and, if not possible, the application of engineering measures, specifically dedicated to the filling operation, promoting the extraction of toluene vapours from the working atmosphere.

6. REFERENCES

Akgür, S. A., Öztürk, P., Kurtulmus, Y., Karali, H., & Ertürk, S. (2001). Medicolegal Aspects of Blood-Urine Toluene and Urinary Ortho-Cresol Concentrations in Toluene Exposure. *Turkish Journal of Medical Sciences*, 31, pp. 415-419.

American Conference of Governmental Industrial Hygienists. (1998). *Industrial Ventilation - A Manual of Recommended Practice* (23rd Edition ed.). Cincinnati, Ohio, United States

of America: American Conference of Governmental Industrial Hygienists, Inc.

Fiequimetal. (2010). *Riscos Químicos*. Lisboa: Fiequimetal.

Forster, L. M., Tannhauser, M., & Tannhauser, S. I. (1994). Toxicologia do tolueno: aspectos relacionados ao abuso. *Revista de Saúde Pública*, 2, pp. 167-172.

Fundacentro - Ministério do Trabalho e Emprego. (2007). *Princípios Básicos para o Controle das Substâncias Nocivas à Saúde em Fundições*. São Paulo: Fundacentro.

Fundacentro - Ministério do Trabalho e Emprego. (2014). *Manual de Orientação sobre Controle Médico Ocupacional da Exposição a Substâncias Químicas*. São Paulo: Fundacentro.

HSE. (2004). *A step by step guide to COSHH assessment*. Surrey: HSE Books.

Jafari, M. J., Azari, M., & Karimi, A. (2009). The Challenges of Controlling Organic Solvents in a Paint Factory due to Solvent Impurity. *Industrial Health*, 47, pp. 326-332. doi:10.2486/indhealth.47.326

Mohammadyan, M., & Baharfar, Y. (2015). Control of workers' exposure to xylene in a pesticide production factory. *International Journal of Occupational and Environmental Health*, 21(2), pp. 121-126. doi:10.1179/2049396714Y.0000000098

Moro, A. M., Brucker, N., Charão, M., Bulcão, R., Freitas, F., Baierle, M., . . . Garcia, S. C. (2012). Evaluation of genotoxicity and oxidative damage in painters exposed to low levels of toluene. *Mutation Research*, 746, pp. 42-48.

Prista, J., & de Sousa Uva, A. (2002). *Aspectos Gerais de Toxicologia para Médicos do Trabalho* (1ª Edição ed., Vol. 6). Lisboa: Obras Avulsas.

Siqueira, M. P., & Paiva, M. N. (2002). Hippuric acid in urine: reference values. *Revista de Saúde Pública*, 6, pp. 723-727.

Viegas, S., Almeida-Silva, M., Faria, T., Dos Santos, M., & Viegas, C. (2016). Occupational exposure assessment to particles with task-based approach. (Arezes et al, editors.) *Occupational Safety and Hygiene IV*, pp. 1-6.

Viegas, S., Faria, T., Dos Santos, M., & Carolino, E. (2016). Task-based approach importance for the occupational risk assessment: the case of particles exposure in feed industry. (Arezes et al, editors.) *International Symposium on Occupational Safety and Hygiene - SHO2016*, pp. 380-382.

Yasar, S., Yildirim, E., Koklu, M., Gursoy, E., Cclik, M., & Yuksel, U. C. (2016). A case of reversible cardiomyopathy associated with acute toluene exposure. *Turkish Journal of Emergency Medicine*, 16, pp. 123-125.