International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 6 Issue 5, May 2019

ISSN: 2394-4404

Evaluation Of Benzene And Toluene Levels Released Into The Breathing Zone Of Spray Painters Working In Small Scale Informal Auto-Garage, In Embakasi, Nairobi, Kenya

Agnes K. Mwatu

Peterson Warutere

Department of Environmental and Occupational Health,
Kenyatta University, Kenya

Margaret N. Keraka

School of Public Health and Applied Human Sciences,
Kenyatta University, Kenya

Ngethe Muhoho

Department of Pathology, Kenyatta University, Kenya

Abstract: ***Volatile Organic Compounds (VOCs) are both naturally occurring as well as man-made chemicals. They range from harmless, to highly mutagenic and carcinogenic types. Benzene and toluene are among the widely used VOCs as solvents and diluents in products such as paints and aerosols. Lack of exposure control to benzene and toluene in the informal auto garages may lead to spray painters' risk of acquiring ill-health symptoms associated with benzene and toluene exposure. Depending on method of application and control measures applied during auto spray painting in small scale informal auto garages, uncontrolled and a high amount of benzene and toluene may be released into the ambient air and into the breathing zone of the spray painters. The aim of this study was therefore, to evaluate the levels of benzene and toluene compounds in the ambient air and especially the levels emitted in the breathing zone of the spray painters in small scale informal auto garages, through a cross-sectional method of study. The study population was composed of twenty nine (29) spray painters randomly selected from one hundred and ten (110) spray painters in the study area. The benzene and toluene compounds were collected by use of Gastec passive colour dosimeter tubes placed near the breathing zone of spray painters during spraying process. The average amounts of benzene and toluene were 73.46ppm and 61.22ppm respectively, against WHO's recommended maximum of 0.5ppm for benzene and 50ppm for toluene. The amounts of benzene and toluene were significantly high, (P = 0.0001) and (P = 0.001) respectively. T-test was used to compare the means of various variables in the study. The study concluded that there was a high concentration of benzene and toluene released in the breathing zone of spray painters during spray painting exercise and, recommended the results to guide policy on benzene and toluene exposure control and awareness creation among the auto spray painters.***

Keywords: Benzene, toluene, levels, spray painters, small scale auto-garages

I. BACKGROUND

Volatile organic compounds (VOCs) are organic chemicals with a high vapor pressure at ordinary room temperature which make them evaporate easily and spread to the ambient air. They are emitted as gases from various solids or liquids that include variety of chemical compounds such as benzene and toluene. Volatile organic compounds may have short- and long-term adverse health effects (EPA, 2016).

Many industries emit VOCs compounds in their daily processes, which if not controlled may be dangerous to human life and environment as well. Such industries include motor

ISSN: 2394-4404

vehicle repair and spray painting works which have become essential part of today's life (Ahmad *et al.,* 2016). Many solvents used in paint manufacturing or thinning process of spray paints, usually contain Benzene, toluene, ethylbenzene, and xylenes in varying amounts and ratios. These groups of chemicals which make the bulky of spray paints' solvents are collectively referred to as BTEX. The four chemicals, which often occur together, are volatile in nature and have good solvent properties (Farshad *et al.,* 2013). The characteristic of high volatility exhibited in these VOCs makes them ideal for use in auto spray painting processes, where once they rapidly evaporate leave a smooth finish.

In developing countries small scale enterprises such as auto spray painting, are often categorised as informal sector and are classified as small and medium size enterprises. In these enterprises the risk of exposure from organic compounds such as benzene and toluene, is compounded by the fact that various work processes are performed within the same space, and often with limited "roofed" and/or segregated space. Due to lack of emission control measures in small scale auto workshops, high air pollutant concentrations may occur, that emit VOCs in the ambient air (Voliotis *et al*., 2014). Some studies have found that inhalation accounts for more than 95-99% of benzene exposure of the general population (Mackleod and Mackay 1999, IEP 1999). Therefore this calls for need to evaluate benzene and other VOCs' levels in occupational set up, and especially in informal small scale industries.

Some studies have shown that spray painters are at a high risk of diseases due to exposure from chemicals in their workplaces (Tse *et al.*, 2011 and Keski-Santti *et al*, 2010), such as benzene and toluene rich solvents emitted from activities of spray painting. Exposure to different organic solvents have been reported to cause adverse health effects on the functional integrity of different tissues in the biological systems (Uboh *et al.,* 2013).

In addition to environmental pollution, exposure prevention to benzene and toluene is critical for workers, including road side workshop workers such as small scale auto spray painters in high trafficked areas. This group of people are at higher risk of illnesses and diseases associated with exposure to VOCs such as benzene and toluene (Balashanmugam *et al.,* 2012). Study has shown that repeated exposure to solvents such as benzene can progressively lead to illnesses such as aplastic anemia, leukemia and multiple myeloma, in addition to adverse respiratory health symptoms (Roos, *et al* 2018), and more in developing and under-developed countries. Due to limitations in exposure controls, therefore there is need for data in levels of benzene and toluene compounds released from these industries in order to safeguard and protect human and environment from these chemicals.

The World Health Organization (WHO) estimate that 4 in 1 million people are at risk of developing leukemia in their lifetime when exposed to 1 mg/m3 of benzene (WHO, 2014), and thus increasing the risks of acquiring the illnesses associated with exposure to such substances among the workers in allied industries such as auto spray painting occupation in small scale informal auto garages. In these small scale industries workers are exposed to myriad of other chemicals with little or no proper protection which make them vulnerable to illnesses associated with the exposures

Occupational exposure to benzene and toluene in spray painting activities in small scale auto garages, results predominantly from the inhalation of gases and vapours from solvents and additives in paints. Exposures, both by inhalation and skin contact, occur specifically in operations that involve manual handling procedures such as weighing ingredients and loading them into mixing equipment, adding solvents to mills, and cleaning equipment in addition to exposure during spray painting activities.

On the other hand, toluene compounds have a wide range of industrial applications as an aromatic solvent in many industrial processes such as auto paint. Although it is useful as a good auto paint solvent, it can cause ill-health problems as well to spray painters' such as impairment of electrolyte and pH balance, gastrointestinal and neuropsychological disorders, and acute respiratory and reproductive defects (Moro *et al* 2012, Peralta. *et al*., 2012). This makes it more important to evaluate the levels of toluene released during spray painting activities in order to protect the workers in small scale industries, where toluene is involved.

Asthma reactions from various exposure sources such as toluene solvents in auto spray painting can be acutely life threatening in many instances or may lead to chronic occupational asthma (Lauenstein, *et al.,* 2014). These symptoms were also observed in the current study among the spray painters who spend many hours doing spray painting without personal protective equipment.

Many studies have proved that small scale industrial workers are more prone to work place hazards, risks and ill health effects (Adei *et al*., 2011). These hazards can be somehow attributed to limited number of resources, low technical capacity among workers, lack of knowledge and awareness regarding the existing occupational health safety guidelines among others (Ahmad *et al.,* 2016). The hazards associated with exposure to VOCs like benzene and toluene may also cause adverse health effects such as respiratory ailments, acute body injuries, eyes injuries and hearing loss among others (Brosseau *et al.,* 2014)

Exposure to chemicals such as benzene and toluene in the workplace is not only affected by the mechanical controls, but also by other measures such as administrative and behavioral measures like systems of work, supervision and training (Farshad, 2013), and therefore determination of their levels in a workplace set up goes along in designing the protective measures of these chemicals. This includes capacity and awareness creation among the workers in the relevant industry. Also exposure to toxic chemicals is one of the main environmental factors contributing to the global burden of diseases (Farshad, *et al*, 2013), hence volatile organic compounds are indeed associated with air pollution and risk of diseases, and therefore there is a potential for public health risks related to exposure to hazardous chemicals in developing countries. The exposure risk may be magnified by fewer resources set aside for chemical risk control and management, the projected growth in the production and increased use of chemicals (Work Safe, 2010). These chemicals include benzene and toluene

Elevated levels of VOCs such as benzene and toluene emitted into ambient air from industrial processes and other sources are likely to have an adverse health effects to exposed individuals if they are not adequately protected. Subjective symptoms such as sore throat, headache and dizziness that are usually associated with benzene and toluene groups have been reported at elevated levels among many study populations (WHO, 2014). The above scenario is compounded by the fact that there is limited screening data on exposure to benzene and toluene in small scale auto garages in developing countries.

Although many volatile organic compounds are toxic in nature, they are unavoidable in production processes as they play a major role in manufacturing processes as raw materials for many products including paints and allied products in various industries. Lack of regulations and weak monitoring mechanism often presents data and knowledge gap. The World Health Organization (WHO, 2014) has estimated that in developing countries, increasing Urban Air Pollution (UAP) has resulted in more than 2 million deaths per annum along with various cases of respiratory illnesses (WHO, 2014).

The above situation shows that, there is a gap in knowledge, data and information on VOCs, and in particular benzene and toluene exposure levels and emission control, and therefore the data and information will assist in formulating appropriate control mechanism aimed at protecting the spray painters from adverse effects associated with exposure

II. STUDY OBJECTIVE

The objective of this study was to evaluate the amount of benzene and toluene released into the breathing zone of the spray painters in small scale informal auto garages during auto spray painting process.

III. METHODOLOGY AND MATERIALS

This study employed cross-sectional and analytical survey, where benzene and toluene compounds were collected from the breathing zone of selected spray painters. Benzene and toluene compounds were collected from the ambient air in the breathing zone of twenty nine (29) spray painters, randomly selected from a sample population of a hundred and ten (110) spray painters in the study area.

The sample size determination of participants was done by use of Canadian Sampling Guide for Air Contaminants in a workplace, where the exposure source is perceived to be uniform (Daniel and Guylaine, 2013). The twenty nine (29) spray painters were selected at 95% confidence level according to the table below.

Size of the group or number of employees in a work place	12	13-14	15-16	17-19	19-21	22-24	25-27	28-31	32-35	36-41	42-50	51 - ∞
Employees to be sampled for VOCs determination	11	12	13	14	15	16	17	18	19	20	21	29

Table 1: Sample selection criteria for biological monitoring at 95% confidence level

The sampling and collection of benzene from the breathing zone of selected spray painters was done by use of Gastec Passive Dosi-Tube dosimeter colour tubes. The tubes were held near the mouth of the spray painters by clipping them on the shirt collars or clothing of selected spray painters in the study area for a specified time using special tube holders. The duration of gas collection was mainly dictated by the time taken to spray paint a whole or part of part a vehicle, depending on the type of panel beating or piece work required.

The measuring range of the tubes was 2-500 parts per million (ppm), with a detecting limit of 1ppm. A tube, of approximate 10 cm long and approximate 1 cm in diameter was secured into a tube holder and clipped in the shirt collar or coat collar and other clothing (for those who had no shirts, but coats or other types of clothing) of a spray painter. The Gastec tubes used in this study were specific for toluene gas collection, with a correction factor to accommodate benzene compound. The two VOCs were collected from breathing zones of all selected spray painters in the study using this method. Benzene and toluene laden air was drawn into the tubes by diffusion process. The gas sampling using dosimeter colour tubes method, in the current study was a passive air sampling method, where the tubes were exposed to an environment laden or assumed to be laden with specific volatile organic compounds. In the current study benzene and toluene compounds present in the breathing zone of the target individuals were drawn in by diffusion method. After these VOCs were collected, the amount of benzene and toluene were read off, at a scale on the side of the tubes as an extended brown colouration in the tubes. In addition to benzene and toluene compounds collection, a pre-tested questionnaire was used to capture details of symptoms associated with exposure to high levels of benzene and toluene in small scale informal auto garages

IV. RESULTS

The selected garages in the study area had high concentrations of toluene and benzene in the ambient air and, within the breathing zones of selected spray painters. The collected gases had a high concentration of benzene, with an average of 73.46 parts per million (ppm) and a high concentration of toluene with an average of 61.22 ppm in the breathing zones of the active spray painters. The average benzene and toluene compounds collected were, compared to WHO recommended minimum value of 0.5 ppm of benzene for Short Term Exposure Limit (STEL) and 50 ppm minimum value of toluene for Threshold Limit Value (TLV).

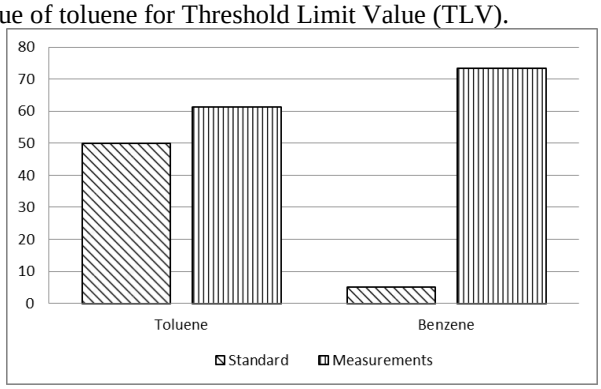

Figure 1: Comparison of Toluene and Benzene levels against WHO values

Volatile organic compound	Levels (ppm) Mean ± SD
Toluene	61.22 ± 15.84
Benzene	73.46 ± 19.01
P-value	0.0001

Table 1: Levels of volatile organic compounds emitted during spray painting

The amounts of the two compounds emitted during spray painting in this study, therefore where subjected to one sample t-test in comparison to the WHO recommendations. The results showed that the levels of toluene in the breathing zone of active spray painters (mean 61.22ppm) was significantly higher than the WHO recommended threshold limit value (t = 3.814, P = 0.001). Likewise the average levels of benzene found in the breathing zone of the active spray painters also (mean 73.46ppm) was significantly higher than the recommended WHO levels (t = 19.394, P = 0.0001). The spray painters also reported ill-health symptoms such as dizziness, nausea, and respiratory related symptoms.

V. DISCUSSION

The study found very high concentrations of benzene and toluene in the breathing zone of spray painters. The concentration of benzene and toluene in the current study was higher than that in a study carried out in Firozabad, India by Chaudhary and Kumar (2012), which monitored benzene, toluene, ethyl benzene and toluene (BTEX) concentrations in ambient air and found a mean concentration of benzene that ranged from 0.197 ppm to 0.207 ppm, toluene (0.198 ppm to 0.209 ppm), ethyl benzene (0.195 ppm to 0.285 ppm). The results of the current study had higher concentration of benzene than that found in a study reported in Iran by Farshad *et al* (2013) for concentrations of ambient air benzene of 19.9 ppm and 5.4 ppm, but had lower toluene concentration compared to the same study in Iran by Farshad *et al* (2013) for concentrations of ambient air toluene of 216.7 ppm and 101.9 ppm in two paint industries, respectively.

The high levels of benzene and toluene in the breathing zone of spray painters was associated with ill-health symptoms that the spray painters experienced as reported in the pre-tested questionnaire administered to workers in small scale informal auto garages in the study area. Exposure to Volatile Organic Compounds (VOCs) including benzene and toluene has been associated with a wide range of acute and chronic health effects such as asthma and respiratory diseases among other illnesses as reported by Stuart *et al* (2015).

VI. CONCLUSION AND RECOMMENDATIONS

The study concluded that there was a high concentration of benzene and toluene in the breathing zone of spray painters compared to WHO minimum recommended values for the two VOCs in the ambient air. The study recommended benzene and toluene exposure control measures in the small scale informal garages and awareness creation on protection and ill-health symptoms associated with exposure to benzene and toluene. The study also recommended consisted use of appropriate personal protective equipment (PPE) among the spray painters and further study on effects of exposure to benzene and toluene in small scale informal garages.

REFERENCES

[1] Adei, E., Adei D., & Osei-Bonsu, S. (2011). Assessment of perception and knowledge of
[2] Agency for Toxic Substances and Disease Registry (2004). Interaction Profile for Benzene.
[3] Ahmad, I., M. Rehan, M. A. Balkhyour, M. Abbas, J. M. Basahi, T. Almeelbi et al (2016). Review of environmental pollution and health risks at motor vehicle repair workshops: Challenges and perspectives for Saudi Arabia. International Journal of Agriculture and Environmental Research. 2(1): 1-20.
[4] Balashanmugam, P., Ramanathan, A. R., & Kumar, V. N. (2012). Assessment of ambient air quality in Chidambaram a south Indian town. Journal of Engineering Science and technology: 7(3):292 – 302
[5] Brosseau, L.M., Bejan, A., Parker, D.L., Skan, M., & Xi. M. (2014). Workplace Safety and Health Programs, Practices, and Conditions in Auto Collision Repair Businesses. Journal of Occupational and Environmental Hygiene, 11: 354–365.
[6] Chaudhary, S. & Kumar, A. (2012). Monitoring of Benzene, Toluene, Ethylbenzene and Xylene (BTEX) Concentrations in Ambient Air in Firozabad, India. International Archive of Applied Sciences and Technology: 3 (2) 92 - 96
[7] David, G. N. & David, L. (2010). Use of passive diffusion tubes to monitor air pollutants. Journal of Air Waste Management Association; 60(2): 204–209.
[8] Environmental Protection Agency (2016). Volatile Organic Compounds' Impact on Indoor Air Quality. Indoor Air Quality (IAQ)
[9] Farshad, A., Oliaei, H.K., Mirkazemi, R. & Bakand, B. (2013). Risk assessment of Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX) in paint plants of two automotive industries in Iran by using the COSHH guideline: European Scientific Journal /SPECIAL/ edition vol.3 ISSN: 1857 – 7881 (Print) e - ISSN 1857-7431
[10] Keski-Säntti, P.; Kaukiainen, A., Hyvärinen, H.K.; & Sainio, M. (2010). Occupational chronic solvent encephalopathy in Finland 1995–2007: Incidence and exposure. International Archives of Occupational and Environmental Health: 83, 703–712.
[11] Lauenstein, L., Switalla, S., Prenzler, F., Seehase S., Pfennig, O., Förster, C., et al (2014). Assessment of immunotoxicity induced by chemicals in human precision-cut lung slices (PCLS). Toxicology In Vitro: 28; 588–599
[12] MacLeod, M. & Mackay, D. (1999). An assessment of the environmental fate and exposure of benzene and the chlorobenzenes in Canada; Chemosphere. 1999;38:1777–1796.

[13] Medical Research Council (Great Britain) Institute for Environment and Health (1999). A report on benzene in the environment : an evaluation of exposure of the UK general population and possible adverse health effects. Leicester: Report R12 / Medical Research Council, Institute for Environment and Health.
[14] Moro, A.M.., Brucker, N., Charao, M., Bulcao, R., Freitas, F., Baierle M., et al (2012). Evaluation of genotoxicity and oxidative damage in painters exposed to low levels of toluene. Mutation Research. 2012; 746(1):42–8.
[15] Peralta, D.P. & Chang, A.Y. (2012). Toluene inducing acute respiratory failure in a spray paint sniffer. American Journal of Case Reports. 2012;13:92–5
[16] Roos, A. J., Spineli, J. J., Atanackovic, D., Cocco, P., & Brown, B. E. (2018). Pooled study of occupational exposure to aromatic hydrocarbon solvents and risk of multiple myeloma; Occupational and Environmental Medicine, 75(11): oemed-2018-105154 •
[17] Stuart B., Feng-Chiao, S., Shi, L., Bhramar, M. & Chunrong, J. (2015): Personal Exposure to Mixtures of Volatile Organic Compounds; Modeling and Further Analysis of the RIOPA Data. Research Report Health Effects Institute. 2014 Jun; (181): 3–63.
[18] Tse, L.A., Yu, I.T.S., Au, J.S.K., Qiu, H., & Wang, X.R. (2011). Silica dust, diesel exhaust, and painting work are the significant occupational risk factors for lung cancer in nonsmoking Chinese men, British Journal of Cancer: 104, 208–213.
[19] Uboh, F.E. & Ufot, S. (2013). Withdrawal from exposure reverses haematotoxicity and hepatotoxicity caused by oral exposure to nitrocellulose thinner in male rats. Journal of Clinical Toxicology: 2013, 3:5
[20] Voliotis, A., Bezantakos, S., Giamarelou, M., Valenti, M., Kumar, P. & Biskos, G. (2014) Nanoparticle emissions from traditional pottery manufacturing, Environmental Science Processes and Impacts: 16, 1489–1494.
[21] Work Safe Alberta (2010). Spray Application of Paint and Coatings. Workplace Health and Safety Bulletin: safety Bulletin CH004
[22] World health organization (2014). Public health, Environmental and Social determinants of health (PHE). Published by the WHO department of public health, environmental and social determinants of health (PHE). Issue 63 / March 2014.