

Short Research Article

Comparative Assessment of Formaldehyde Concentrations in Public and Private Mortuaries in Rivers State, Nigeria

Abstract

Introduction: Formaldehyde is an industrial chemical that is classified as a volatile organic compound (VOC). It is commonly used in mortuaries for the preservation (embalming) of the dead in Rivers State. Mortuary workers are occupationally exposed to formaldehyde by inhalation and skin contact. This study was to measure and compare the concentration of formaldehyde in public and private mortuaries of Rivers State, Nigeria.

Methodology: This cross-sectional (field) survey was carried out in 9 public and 6 private mortuaries in Rivers State. The Time-Weighted Average (TWA) and short-Term Exposure Limit (STEL) of formaldehyde concentration in the embalming section of both mortuaries was measured using a suitable instrument after ethical clearance. Mortuaries were selected by a multistage sampling technique. Data were collected, entered and analyzed using XL STATA and SPSS and presented in tables and graphs.

Results: The mean TWA concentration of formaldehyde in public and private mortuaries was 2.42±1.77 and 2.52±0.99ppm respectively. Also, the STEL concentration measured in public and private mortuaries were 0.91±0.99 and 1.93±1.22ppm. The 8hour TWA values exceeded OSHA (0.75) and NIOSH (0.016ppm) standards.

Conclusion: There was a high concentration of formaldehyde in both public and private mortuaries which may pose high risk to the health of the mortuary workers of Rivers State. The study recommended health education and surveillance among mortuary workers and good engineering design in the mortuary.

Keywords: Formaldehyde, public mortuaries, private mortuaries, mortuary workers, exceedance factors, coefficient of variation, health effects.

Introduction

Formaldehyde (FA) is one of the industrial chemicals that is produced and widely used in many factories/ industries due to its adhesive, preservative and antiseptic properties (Ki-Hyun, 2011). FA, though a natural product in most living systems is formed endogenously in mammals including humans, as a consequence of oxidative metabolism. In addition to its wider use in industries, sciences and household the potential for its occupational and environmental exposure is increasing (Tang, Bai, Duong, Smith and Zhang, 2009; Ki-Hyun, 2011). Currently, China remains the highest producers and consumers of formaldehyde worldwide (Ki-Hyun, 2011).

The international Agency for Research on Cancer (IARC) monograph volume 88 (IARC, 2006), classified Formaldehyde as a carcinogen based on its association with nasopharyngeal cancer.

Several cohort studies in the United States among industrial workers exposed to FA has showed statistically significant excess of deaths from nasopharyngeal cancer in comparison with the US national population (Roush, Walrath, Stayner, Kaplan, Flannery and Blair, 1987). Hauptmann, Lubrin, Stewart, Hayes and Blair (2013) found that an excess of deaths from nasopharyngeal cancer occurred in a proportional mortality analysis of the largest US cohort of embalmers. The result of this study further corroborated the Danish study (Hanson and Olsen, 1995). Though, the general population is exposed to FA, because of its presence in the environment, it's usually at low levels (less than 0.03 parts per million (ppm) parts of air). However, industrial workers who produce FA or FA containing products (Ki-Hyun, 2011), human anatomists, laboratory technicians and morticians in most developing countries (Including Nigeria), where over 95% of human (body parts) embalment/preservation is done with aqueous solution of formaldehyde (Formalin), are occupationally exposed to higher levels of FA than the general Nigeria populations.

Exposure occurs primarily by inhaling the FA gas or vapours from the enclosed air or by absorbing liquids containing FA through the skin (Ki-Hyun, 2011). Study has shown that mortuary workers are exposed to high concentrations of formaldehyde (Ki-Hyun, 2011)

Some empirical evidence from studies in China and United States had shown an association between FA occupation exposure and multiple adverse health effects such as asthma, nasopharyngeal cancers and myeloid leukemia (IARC, 2010; Ki-Hyun, 2011). Some other studies indicated that evaluated environmental exposure to FA have impeded sperm morphology in men and increased the rate of miscarriages, endometrioses and prolonged pregnancies in women and further increase the risk of having a child with mental retardation, learning disabilities or behavior problems (NICNAS, 2006).

Formaldehyde (FA) is a widely used chemical in Nigerian mortuaries, as a preservative (Tissue Fixative), adhesive and anti-septic. In fact, FA- based aqueous solution (Formalin) is the main stay of corpse preservation (Embalment) in Nigeria and most developing African countries. Morticians remain the highest category of workers that use FA for preservation of the dead. These categories of workers in Nigeria are poorly recruited. In most cases, the mortuary proprietors neither offered pre-employment medical examination nor training nor carry out periodic medical examinations on them. Studies have revealed that most mortuaries do not have standard operating procedure (SOP) nor occupation regulatory framework/body that enforces any existing laws (Ki-Hyun, 2011). Permissible exposure level (PEL) of FA and other chemicals in Nigeria are not well documented and defined. The Federal Ministry of Labour and Productivity, saddled with that responsibility has not taken the issue of occupational health seriously despite the strong agitation by Nigeria labour Congress (NLC).

In Nigeria, there is paucity of scientific information relating to the occupational exposure/effects of formaldehyde on morticians and this necessitated the conduct of this study. Oloto 2010 carried out a study on the "assessment of the effect of formaldehyde exposure on the liver in mortuary workers in south western Nigeria". The study analyzes the blood samples of some mortuary workers and found that formaldehyde impairs the synthetic function of the liver mortuary workers. However, he did not measure the concentrations of formaldehyde in the mortuaries to which to workers are exposed that resulted in liver impairment. Therefore this study is designed to measure and compare the concentrations of formaldehyde in public and private mortuaries in Rivers State.

Methodology:

Study Area/ Population: The study was carried out in fifteen mortuaries spread in 15 Local Government Areas (LGAs) of Rivers State, located in the Niger-Delta (South-South) region of Nigeria. The mortuaries selected are clustered in three senatorial zones, namely General Hospital Omoku mortuary, General Hospital, Buguma mortuary, General Hospital, Abua mortuary and General Hospital, Bonny mortuary and General hospital mortuary, Joinkrama (Rivers West cluster); Ashes to Ashes, Port Harcourt mortuary, Matona mortuary, Obio/Akpor, Okrika General Hospital mortuary Atata mortuary, Emohua and Madonna mortuary, Ikwerre (Rivers South East cluster) and Final Home call, Oyigbo mortuary, General Hospital, Bori mortuary, General Hospital, Bodo mortuary, Otaigbe Mortuary, Andoni and General Hospital Nchia, Eleme mortuary (Rivers East cluster).

Inclusion Criteria: All formaldehyde using mortuaries that accept research protocol and agree to participate in the study.

Study Design/Sample Size: This was a cross-sectional comparative field study and applying sample size for mean (including allowance for non-response), a total of 15 mortuaries were used.

Sampling Method: Multistage sampling method was used for this study- the study population (mortuaries) 42 was staged. In the first step, the mortuaries were distributed into 3 clusters based on the senatorial zones. In the second step, the mortuaries were stratified into private and public mortuaries. From the records, private mortuaries were 20 and public mortuaries were 22. Therefore the sample size was proportionately allocated to each of the strata. In the third step, the selection of mortuaries from each of the cluster is done by simple random sampling method of balloting using the list of mortuaries as a sample frame.

Study Instrument: Formaldehyde gas detector was used to measure the concentration of formaldehyde gas in the embalment section of the mortuary. In order to meet international standards, and for results from this study to be accepted for publication, a specific and sensitive FA gas detector was ordered from China to measure the FA gas in the embalment section of the mortuaries studied (Figure 1). A GLOBE Instrument, model PGas-20 CH₂O gas detector (Figure 1) was used to measure the concentrations of formaldehyde in the mortuaries. The instrument was manufactured in November 2017 by Globe instrument and marketed by Henan Zhiyi System Engineering Co., Ltd. China. The instrument has a built-in pump and a 20cm long probe as shown in Figure 1. It was calibrated in the factory and also has built-in calibration coefficients with auto zeroing mechanism. The measurement range of the instrument is 0 – 10ppm, resolution/detection limit is 0.01ppm and the response time is ≤20s. The measurement principle is photo ionization detection (PID).

The study used both the time weighted average concentration of formaldehyde in the air environment of the mortuaries. The instrument displayed the time weighted average (TWA) and short time exposure limit (STEL) concentrations of formaldehyde as well as the maximum values of each. The instrument was placed 1.2meters above ground level in each of the mortuaries. The TWA readings were taken every 1 hour interval for of 8 hours, while the STEL readings were taken after every 15 minutes in compliance with Occupational Safety and Health

Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) standards.

Regulatory bodies like the National Institute of occupation, safety and environment (NIOSH) and Occupational Safety and Health Administration (OSHA) have set standards and permissible exposure limits in work places. While in China, United States, Canada and other countries had set occupational exposure limits (OEL) for FA; Nigeria, where FA usage is the mainstay in corpse preservation and anatomy laboratories, standard/occupational exposure limit is yet to be set by any of the Federal agencies responsible for monitoring and supervising the usage of chemicals



Figure 1: PGas-20 CH₂O gas detector

Methods of Data Analysis

The data obtained from the 7 public mortuaries and 8 private mortuaries were averaged, aggregated and categorized as public mortuary and private mortuary data respectively. Statistical analyses were accomplished using XLSTAT-2018 Premium version software developed by Addinsoft (2018) and Statistical Package for the Social Science (SPSS) software version 22, originally developed by International Business Machines (IBM). Descriptive statistics were used to determine the measures of central tendency (mean, median, and mode) and coefficients of variation of the concentrations of formaldehyde measured in the mortuaries. The exceedance factor (a factor by which the mean value exceeds the limit) was computed using Equation (1). The coefficient of variation of the measured data was computed as the percentage ratio of the standard deviation to the mean value.

The Exceedance Factor (EF) was calculated as follow:

$$\text{Excedence Factor (EF)} = \frac{\text{Observed mean concentration of formaldehyde}}{\text{Mean standard}}$$

The computed exceedance factors were expressed in terms of low, moderate, high and critical (CPCB, 2006). Where: <0.5 is low; 0.5-1.0 is moderate; 1.0-1.5 is high; >1.5 is very high.

The concentration ranges for different levels have been selected based on the OSHA Occupational Exposure standards for formaldehyde by calculating the exceedance factor. Measured concentrations of formaldehyde were compared with Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) standards

Coefficient of variation of measured formaldehyde concentrations was calculated using Equation (2)

$$\%CV = \frac{s}{\bar{X}} = \frac{\sqrt{\frac{\sum (X_i - \bar{X})^2}{N-1}}}{\frac{\sum_{i=1}^N X_i}{N}}$$

Where X_i is the i^{th} data sample, \bar{X} is the mean, s is the standard deviation and N is the total number of data samples.

The minimum and maximum concentrations for both the public and private mortuaries are presented; the mean, standard deviation, and coefficient of variation were statistically computed as presented; the coefficient of variations (CV) in the formaldehyde concentrations in the public and private mortuaries were computed as the ratio between the standard deviation to the mean and determines the relative percentage of deviation from the mean values.

Data Management: Data were collected with 4 trained research assistants, 3 persons were involved in the administration of the questionnaire to mortuary workers and proprietors within a week (before the actual formaldehyde measurement) and 1 person that measured the formaldehyde gas in the mortuaries after 15minutes, Short Term Exposure Limit (STEL) and after 1hour, Time Weighted Average (TWA). Data were entered into Statistical Package for Social Sciences (SPSS) and descriptive statistics (mean, median and standard deviation) while chi-square was used to inferential statistics at a confidence interval of 95% and p-value set at <_0.05. Data were presented in tables and graphs.

Ethical Consideration: Approval was obtained from the ethics committee of the University of Teaching Hospital. A signed informed consent was obtained from each of the proprietors and workers. All mortuary proprietors were assured of maximum confidentiality and that information derived will be used mainly for research purposes.

Study Limitation: Mortuary proprietors were adamant in accepting the study, having a feeling that results will discourage workers from continuing to work in the mortuary in view of perceived health implications.

Results: The aggregated averaged values of the time weighted average concentrations of formaldehyde in both the public and private mortuaries are shown in Table 1; while the aggregated averaged values of the short-term exposure limit concentrations of formaldehyde in both the public and private mortuaries are shown in Table 2. Descriptive statistics of the TWA data set are presented in Table 3. Plots of daily TWA and STEL formaldehyde concentrations are shown in Figures 2 and 3. The mean TWA values in comparison with OSHA and NIOSH standards are shown in Figure 4; while the STEL mean values in comparison with OSHA and NIOSH standards are shown in Figure 5. Computed coefficient of variations and exceedance factors for both TWA and STEL in the mortuaries are presented in Tables 4 and 5 respectively. The box plots of TWA and STEL values are shown in Figures 6 and 7 respectively; while the scatter plots showing the variations of formaldehyde concentrations with time is shown in Figure 8.

Table 1: Time Weighted Average (TWA) concentrations of Formaldehyde (ppm)

Time (hour)	Public Mortuaries	Private Mortuaries
1	8.25	4.58
2	4.75	3.55
3	3.33	3.35
4	2.75	2.92
5	2.12	2.85
6	1.53	2.76
7	1.03	2.35
8	0.45	1.45
9	4.52	3.09
10	3.15	2.0
11	2.45	1.66
12	2.12	1.62
13	1.0	1.35
14	0.91	1.27
15	0.12	1.18
16	0.0	1.18
17	3.44	4.21
18	3.46	1.6
19	2.96	3.01
20	2.65	3.65
21	2.24	2.93
22	1.83	2.67
23	1.75	1.98
24	1.38	3.21
Range	0.0-8.25	1.18-4.58
Mean	2.42	2.52
Stdv	1.77	0.99
OSHA limit	0.75	0.75
NIOSH limit	0.016	0.016

Table 2: Short-Term Exposure Limit (STEL) concentrations of Formaldehyde (ppm)

Time (minute)	Public Mortuaries	Private Mortuaries
15	0.51	4.32
30	0.47	3.44
45	0.33	3.3
60	0.23	2.68
75	0.11	1.45
90	0.09	1.83
105	0.0	3.46
120	0.0	2.24
135	0.54	4.32
150	0.52	3.14
165	0.42	2.47
180	0.42	1.12
195	0.4	1.11
210	0.39	1.05
225	0.36	0.86
240	0.34	0.68
255	3.53	1.78
270	2.76	2.1
285	2.62	0.9
300	2.14	1.2
315	2.03	1.6
330	1.65	0.8
345	1.05	0.4
360	0.98	0.0
Range	0.0-3.53	0.0-4.32
Mean	0.91	1.93
Stdv	0.99	1.22
OSHA limit	2.0	2.0
NIOSH limit	0.1	0.1

Table 3: Descriptive Statistics of the Data set

Statistic	Public Mortuaries	Private Mortuaries
Nbr. of observations	24	24
Minimum	0.000	1.180
Maximum	8.250	4.580
1st Quartile	1.293	1.615
Median	2.180	2.715
3rd Quartile	3.195	3.120
Mean	2.425	2.518
Variance	3.126	0.971
Standard deviation	1.768	0.986

Variation coefficient	0.714	0.383
Mean absolute deviation	1.253	0.838



Figure 2: Daily TWA Concentrations of Formaldehyde Measured in Public and Private Mortuaries

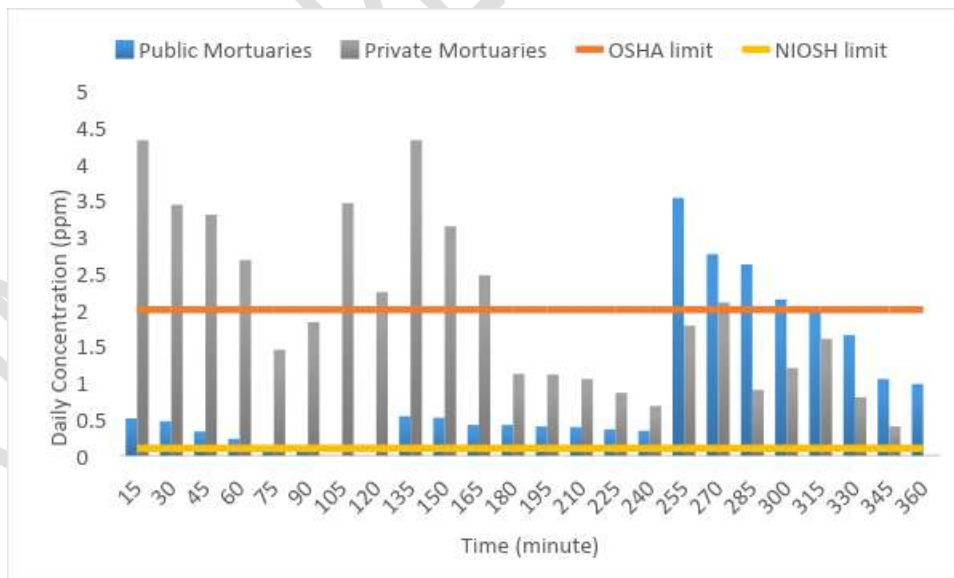


Figure 3: Daily STEL Concentrations of Formaldehyde Measured in Public and Private Mortuaries

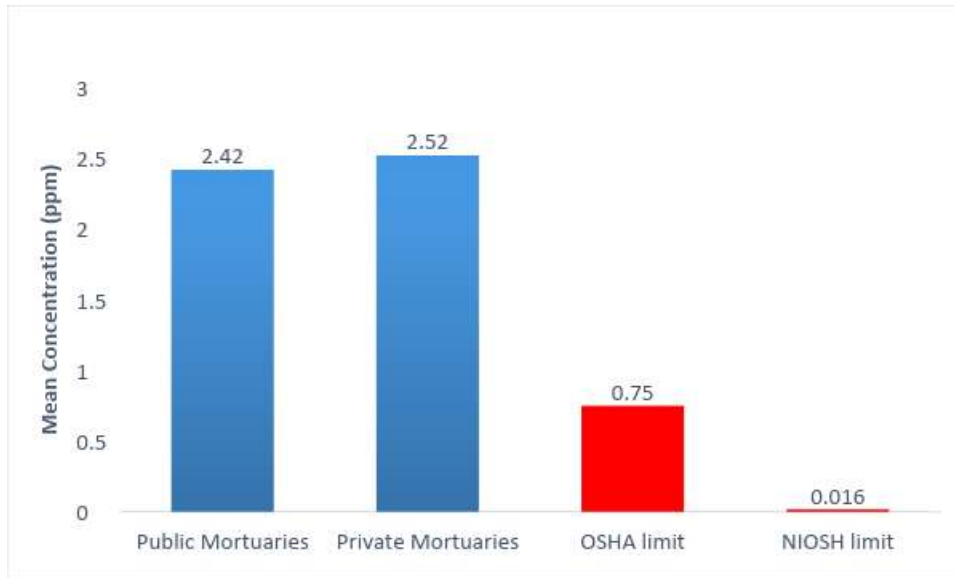


Figure 4: TWA Mean Concentrations in both Public and Private Mortuaries in Comparison with OSHA and NIOSH Standards

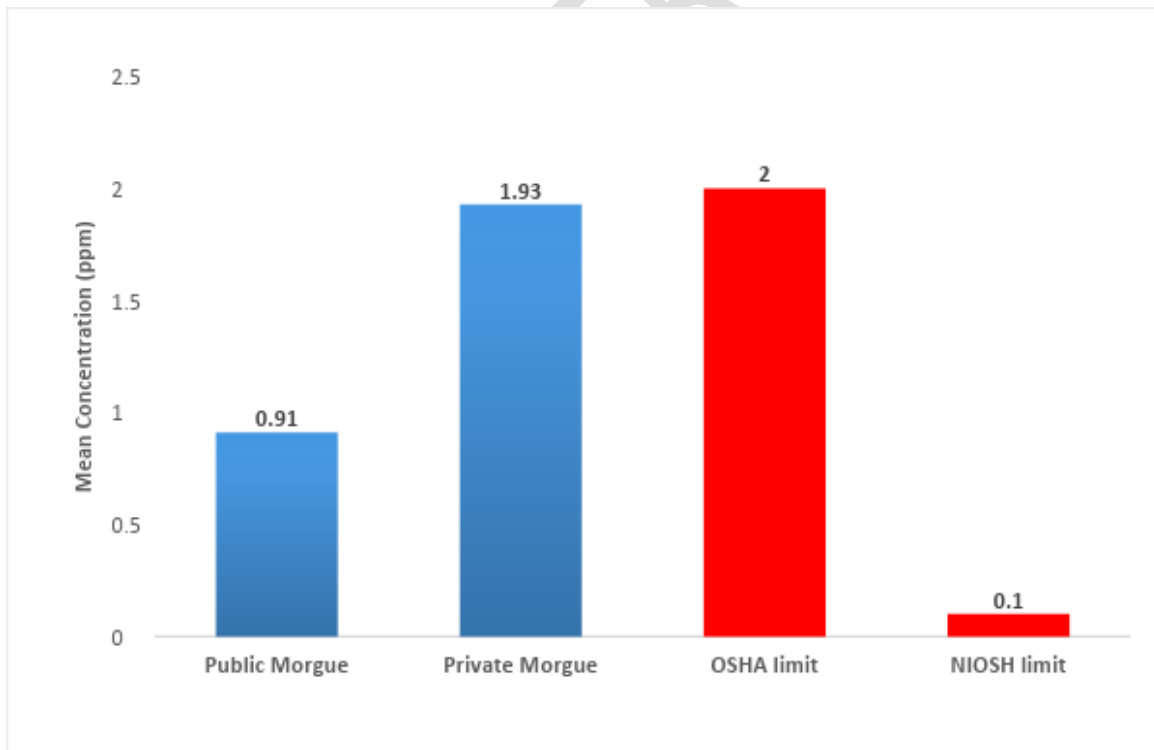


Figure 5: STEL Mean Concentrations in both Public and Private Mortuaries in Comparison with OSHA and NIOSH Standards

Table 4: Statistics of Formaldehyde Time Weighted Average in the Mortuaries

Mortuary	Min (ppm)	Max (ppm)	Mean (ppm)	Stdv. (ppm)	OSHA Limit	CV (%)	EF	Rating
Public Mortuary	0.0	8.25	2.42	1.77	0.75	73.14	3.23	Very high
Private Mortuary	1.18	4.58	2.52	0.99	0.75	39.29	3.36	Very high

Stdv. = standard deviation, CV = coefficient of variation, EF = exceedance factor

Table 5: Statistics of Formaldehyde Short-Term Exposure Limit in the Mortuaries

Mortuary	Min (ppm)	Max (ppm)	Mean (ppm)	Stdv. (ppm)	OSHA Limit	CV (%)	EF	Rating
Public Morgue	0.0	3.53	0.91	0.99	2.0	108.79	0.455	Very low
Private Morgue	0.0	4.32	1.93	1.22	2.0	63.21	0.965	Low

Stdv. = standard deviation, CV = coefficient of variation, EF = exceedance factor

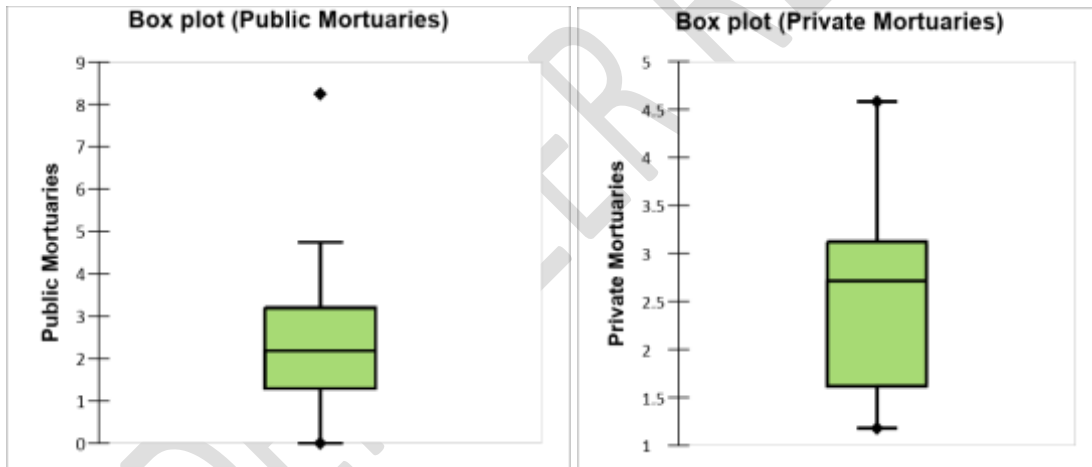


Figure 6: Univariate Box Plots of Time Weighted Average values

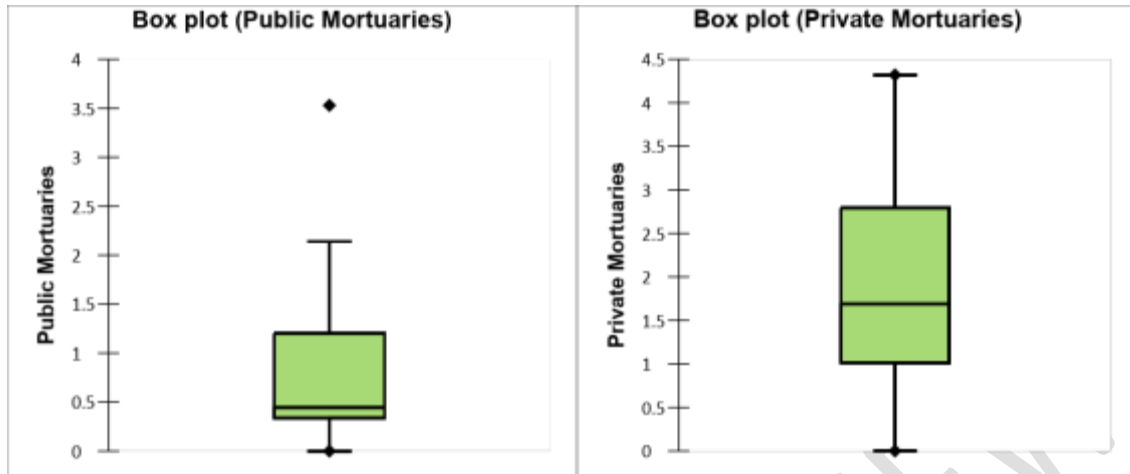


Figure 7: Univariate Box Plots of Short Time Exposure Limit values

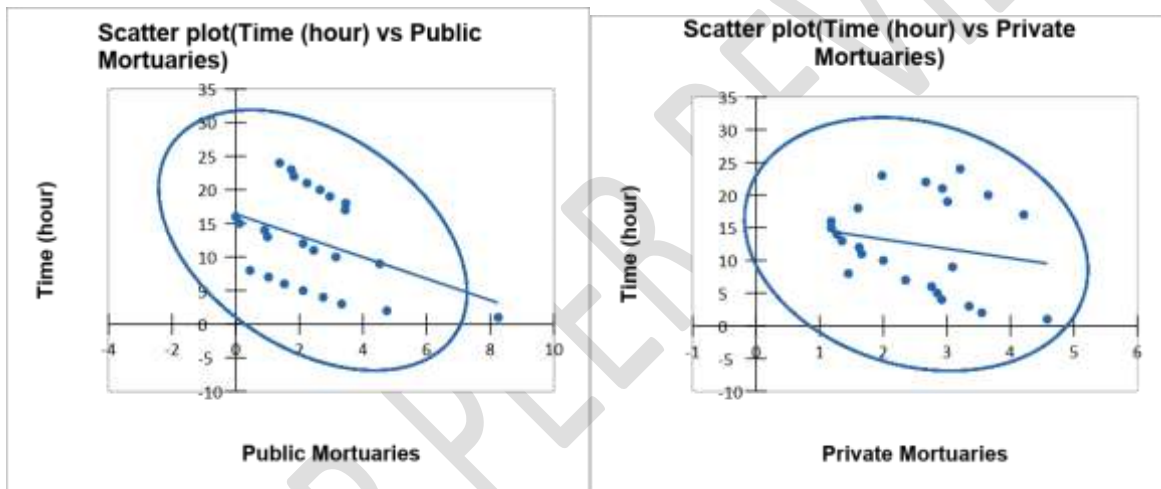


Figure 8: Scatter plots of Formaldehyde concentrations in the Mortuaries

Discussion:

The time weighted average (TWA) concentrations of formaldehyde measured in public mortuaries (Table 1 and Figure 2) ranged from 0.0ppm to 8.25ppm with a mean deviation of 2.42 ± 1.77 ppm; while TWA concentrations measured in private mortuaries (Table 1 and Figure 2) ranged from 1.18ppm to 4.58ppm with a mean deviation of 2.52 ± 0.99 ppm. The short-term exposure limit (STEL) concentrations measured in public mortuaries (Table 2 and Figure 3) ranged from 0.0ppm to 3.53ppm with a mean deviation of 0.91 ± 0.99 ppm; while the STEL measured in private mortuaries (Table 2 and Figure 3) ranged from 0.0ppm to 4.32ppm with a mean deviation of 1.93 ± 1.22 ppm. Winkler, 2011 in his study obtained a mean 8-hour TWA 0.33 ppm and a mean STEL concentration of 6.6ppm among mortuary student during embalmmnt. Also Chia et al. (1992) obtained a mean formaldehyde concentration of 0.74 ppm in the breathing zone samples and 0.50 ppm for area samples. These values are lower than the mean 8-hour TWA obtained in this study (Figures 4 and 5). Some factors that are responsible for the high

levels of formaldehyde can be attributed to poor engineering and administrative control measures, poor mixing procedures, poor ventilations, different embalming fluids used and different embalming tables.

The mean TWA value of formaldehyde in the public mortuaries exceeded OSHA TWA limit by 222.7%; while the TWA mean value in the private mortuaries exceeded the limit by 236%. A t-test statistical analysis showed that the difference between the TWA mean concentrations of formaldehyde in the public and private mortuaries is significant at 95% confidence interval (p-value = 0.04846). The mean STEL values of formaldehyde in both the public and private mortuaries are below the OSHA STEL limit, however, the mean STEL value in the private mortuaries was closed the limit by 4%. A t-test statistical analysis showed that the difference between the STEL mean concentrations of formaldehyde in the public and private mortuaries is highly significant at 95% confidence interval (p-value = 0.0000104) and also highly significance 99% confidence interval (p-value = 0.000020). These results imply that the formaldehyde concentration levels in private mortuaries are high compared to public mortuaries. However, the concentration levels of formaldehyde in both private and public mortuaries exceeded stipulated limits and may pose long time adversely affects to the health mortuary workers.

Computed coefficients of variations for both the public and private mortuaries indicate high percentage in public mortuaries compared to private. This implies that public mortuaries good dispersion compared to private Mortuaries. The high levels of FA observed in the embalmmnt section of the mortuaries may be partly due to poor ventilation and lack of safety rules especially in the private mortuaries. Formaldehyde concentration was observed to reach maximum during embalmmnt and then decreases gradually at the end of the embalmmnt. Formaldehyde concentrations decrease faster with time in public mortuaries compared to private mortuaries as shown in Figure 8. The formaldehyde exceedance factors (EF) for both the public and private mortuaries were calculated using the mean values of the measured concentrations and the OSHA permissible exposure limit (PEL). Exceedance factor less than 1 ($EF < 1$) is below prescribed limit, while exceedance factor greater than 1 ($EF > 1$) exceeds prescribed limit. Computed exceedance factors for both the public and private mortuaries based on long time TWA are 3.23 and 3.36 respectively rated as very high. This indicates that the level of formaldehyde in the mortuaries may pose long-term hazards to the health of the morticians. Similarly, computed exceedance factors based on STEL for both the public and private mortuaries show low acute health effects in the public and mortuaries and moderation acute effects in private mortuaries. Formaldehyde effect is dose-dependent and continuous inhalation might have prolong health effects thus chronic health effects are envisaged among workers in both the public and private mortuaries in the State.

The high concentration levels of formaldehyde observed in both the public and private mortuaries may cause severe irritation of the eyes, and affect the mucous membrane of the upper respiratory system. Formaldehyde concentrations between 0.1ppm and 0.5ppm have been found to cause nasal and eye irritation, neurological effects, increased risk of asthma and/or allergies (ATSDR, 2010), concentrations between 0.6ppm and 1.9ppm may cause nasal and eye irritation, eczema, change in pulmonary function. Other health effects reported by ATSDR (2010) include

dry and sore throat, eyes irritation, increased thirst and sleep disturbance among mortuary workers (ATSDR, 2010). Study by Lang et al., (2008) indicated that concentrations ranging from 0.4ppm to 3.0ppm cause irritation of the nose, throat and eyes. Studies conducted in funeral homes showed that concentration levels ranging from 0.25ppm to 1.39ppm result in respiratory tract problems, irritation of the eyes and headache among mortuary workers (WHO, 2001, Winkler, 2011). Tang et al (2009) in their study reported headache, sore throat, coughing, and shortness of breath, as well as blurred vision and vomiting as some of the health effects of formaldehyde among mortuary workers. Kryzanowski et al (1990) have associated formaldehyde exposure with diseases such as pulmonary function, asthma, chronic bronchitis and other chronic respiratory symptoms.

Mortuary workers can be protected through engineering and administrative controls, best work practices and procedures, used of personnel protective equipment, regular air monitoring of morgues, training of workers and worker medical surveillance. Mortuary workers should be educated on the hazards associated with poor handling and inhaling high concentrations of formaldehyde.

Regulatory bodies like the National Institute of occupation, safety and environment (NIOSH) and Occupational Safety and Health Administration (OSHA) have set standards and permissible exposure limits in work places. While in China, United States, Canada and other countries had set occupational exposure limits (OEL) for FA; Nigeria, where FA usage is the mainstay in corpse preservation and anatomy laboratories, standard/occupational exposure limit is yet to be set by any of the Federal agencies responsible for monitoring and supervising the usage of chemicals.

Conclusion

Formaldehyde concentration levels in private mortuaries are high compared to public mortuaries. The difference between formaldehyde concentration levels in the public and private mortuaries is highly significant. The concentration levels of formaldehyde observed in both the private and public mortuaries exceeded stipulated limits, thus there is high concentrations of formaldehyde in the air environment of mortuaries in Rivers State during embalmment, which may significantly affect the exposed mortuary workers. Therefore, both short-term and long-term health effects are envisaged among the mortuary workers. The management and mortuary workers should be informed of the high levels of formaldehyde so they can take precautionary measures and reduce exposure times. There is epidemiologic evidences that exposure to formaldehyde is positively correlated with adverse health effects, therefore formaldehyde pollution should of greater health concern to both the government and operators of mortuaries in Rivers state. The government of Rivers State should act quickly by setting up an assessment team to investigate formaldehyde pollution in all the mortuaries in the State as a way of intervention.

RECOMMENDATION

All mortuary workers should be well protected against exposure to high levels of formaldehyde. Awareness and training programs for mortuary workers on safety of use of formaldehyde should be carried out regularly. A regular Medical Assessment/Test or health surveillance should be conducted on mortuary workers in the State for early symptoms of formaldehyde related

diseases. Regular auditing of the mortuaries in the State should be conducted by relevant government agency. Mortuaries in Nigeria should be designed in compliance with relevant international standards. Government should enact and enforce laws or guidelines on the use of formaldehyde in mortuaries in the State. Mortuary proprietors should be advised to have a formaldehyde measuring device.

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