



ENVIRONMENTAL TRENDS DUE TO ARC WELDING ACTIVITIES: SENSITIVITY OF SOME TYPICAL WORKPLACES

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The associated hazards with welding process are recently looked into because of the emission threat or lack or improper use of safety devices in work places relating to welding that could potentially lead to long- or short-term effect on worker and other staying nearby. This article provides data for various air quality parameters such as Total Volatile Organic Compounds (TVOC), Air Quality Index (AQI), Carbon Monoxide (CO), Carbon Dioxide (CO₂), and Formaldehyde (HCHO) measured at different locations, North (N), West (W), East (E), and South (S) within Lagos Metropolis. The results of CO and HCHO levels are apparently higher than recommended limits in some locations (East and South) which suggest potential harm for workers as CO is mostly dangerous to health. However, other data suggests that air quality is generally good, as all AQI values are significantly below the break point of 50ppm. Further analysis revealed that at 95% confidence, there is no significant difference in the CO emissions patterns from different workshops as well as from different locations (North, West, East, and South) as $P_{value} > 0.05$. However, there is difference in CO₂ as a result of change in locations as $P_{value} (0.014) < 0.05$. About 57.6% of the variability in CO₂ emissions from various locations can be accounted for due to the variation resulting from change in location. The data thus provides useful information that could enable enforcement of personal protective equipment to ameliorate the situation.

1.0 Introduction

Welding is one of the most widely used engineering process in various industries such as construction, manufacturing, and repair. However, the process of welding can produce hazardous fumes and gases, which can be harmful to the welders, coworkers and immediate individuals. The dangers of emissions from welding processes have been studied in some researches (Antonini *et al.*, 2011 and Sjogren *et al.*, 2014), and some of the literatures suggest that these emissions could have serious health consequences. According to studies by Antonini *et al.* (2011) and Sjogren *et al.* (2014), welding fumes could contain a variety of hazardous chemicals, including metals such as nickel, chromium, and manganese, as well as gases such as carbon monoxide (CO), nitrogen oxides (NO), and ozone (O₃). These chemical discharges can cause respiratory and neurological problems in welders, as well as other health issues such as cancer and reproductive problems. Studies by Sjogren *et al.* (2014) also found that welding fumes can also have effects on the cardiovascular system. The study (Sjogren *et al.*, 2014) observed that welders exposed to welding fumes were observed to have higher levels of inflammation and oxidative stress markers, which could eventually contribute to cardiovascular problem.

Welding fumes could also be harmful to the environment over a long and short period of time. Investigation of Ahmed *et al.* (2018) found that welding fumes could increase the level of air

pollution, as they contain particulate matter (PM) in various proportions and other malicious chemicals that can have negative effects on air quality. Some measures are recommended to mitigate the risks associated with welding emissions, such steps as proper ventilation, wearing protective gear, and using safer welding methods are sometimes neglected or partially embraced.

From the investigation by Antonini, (2003) and Maness, (2012), welding process produces harmful emissions, including metal fumes, gases, and ultraviolet (UV) radiation. These fumes could cause serious respiratory problems, such as bronchitis and asthma, and can also lead to more serious health conditions, like lung cancer (Antonini, 2003). Ultraviolet (UV) radiation from welding can as well cause skin burns and eye damage (Maness, 2012). Numerous measures can be taken to mitigate the dangers of emissions emanating from welding processes. Local exhaust ventilation (LEV) methodology could be employed to mitigate the effect of harmful fumes and gases emanating from welding process in workplace (Lippold *et al.*, 2014). Less harmful welding methods, such as gas metal arc welding (GMAW) are reported to produce fewer emissions than other welding methods (Mazumder, 2007).

International Agency for Research on Cancer (IARC, 2017) classified welding as a Group I carcinogen (IARC, 2017). From the report, long-term exposure to welding fumes can cause chronic diseases like lung cancer (IARC, 2017). In a similar vein, other investigators (Meeker and Susi, 2006; Sparer *et al.*, 2010) also discovered that welding emissions can initiate chronic and acute health challenges in welders. Studies have also shown that exposure to welding fumes can have neurological effects as reported by Racette *et al.*, (2017).

Welding fumes are produced from a mixture of gases and small particles generated when the welding electrode or material is melted and deposited on the metal being welded. The resulting composition of welding fumes could vary depending on the type of welding process employed, the welding conditions, and the type of metal being welded. These emissions could have serious health effects on welders and surrounding individuals, as well as contribute to environmental pollution. This has necessitated this research to find out the possible or potential hazard associated with the typical process of welding. One of the recently held United Nations Climate Conference of the Parties (COP 26) in Glasgow was painstaking on how to prevent climate catastrophe. The emissions emanating from small sources here and there need to be checked because of the aggregate contribution to the global climate depletion. It has also been observed that there is obvious proliferation of the welding workplaces as the cities keep on expanding and population is also rapidly growing. We therefore cannot assume all is well as air borne diseases also keep on rising and in some situation some of these diseases are life threatening which is invariable putting undue pressure on the health facilities. The essence of this research is to come up with contemporary situation report and data so that preventive measure could be taken to avert possible catastrophic disaster.

2.0 Materials and Methods

Lagos Nigeria Metropolis (Figure 1) was chosen due to the urban nature of the area. It is located in the western part of Nigeria and is heavily populated with over 20 million inhabitants according to City-Population, (2015). The locations are selected from Lagos metropolis because Lagos is regarded as one of the fastest growing cities in the world. Four typical welding work places; workshop A (WS A), workshop B (WS B), workshop C (WS C) and workshop D (WS D) were selected based on their respective geographical locations (North, South, West and East). For each of the locations, North, South, West and East are also identified and measurement are taken at 3m interval away from the welder to access the severity level on the operator and those in welding environ. Each of these locations were identified based on closeness to residential areas. Ambient data were taken and recorded as baseline data. Gas analyzer 'B09288J77J' manufactured by PalliPartners is used to acquire the various emissions for repository and subsequent data analysis. The data were taken (in a similar version to Shote *et*

al., 2023) when arc welding activities are going on in the various locations. These data are then time-averaged to obtained individual data for location varying at 3m away for the welding activities in all the four directions (North, East, west and North).



Figure 1: Data locations on Lagos metropolis (6.5227°N, 3.6218°E)

3.0 Results and Discussion

3.1 Carbon IV oxide (CO₂) emissions

From Figure 2, it could be observed that the levels of CO₂ vary across different regions. The highest level of CO₂ is recorded in the East and South, with 1371 ppm and 1370 ppm, respectively. The west-region has the next highest level with 903 ppm, trailed by the North with 532 ppm. It is certainly essential to monitor the levels of CO₂ in these places to understand the impact of human activities on the environment and climate change. High levels of CO₂ can have severe consequences as it were, including extreme weather, rising sea levels events, and the loss of biodiversity (Lippold et al., 2014). Analysis of mean variance for CO₂ reveals that there are differences in the emissions pattern due to the various locations ($P_{value} 0.014 < 0.05$). Employing Tukey HSD analysis of significant levels, East and South apparently show remarkable difference from the northern location ($P_{values} 0.032$ and 0.019 are respectively less than 0.05). This is obviously reflecting in Figure 2 as discussed previously.

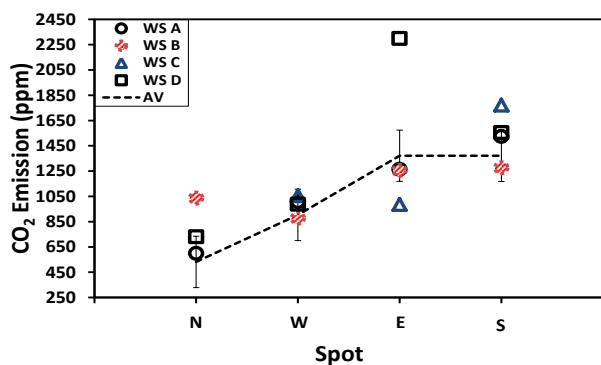


Figure 2: Carbon dioxide emissions (ppm) from four different welding stations (WS)

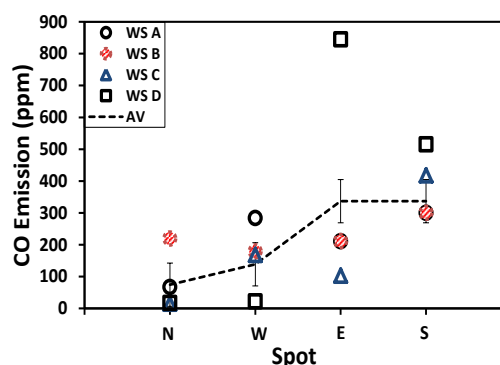


Figure 3: Carbon monoxide emissions (ppm) from four different welding stations (WS)

Apparently from Figure 3, CO appears to be highest in the east and south locations, with both registering a value > 300 ppm. This could be attributed to the diffusion of the CO and partly due to the wind convectional directions during the data acquisition process. However, welding workshop–D (WS D) seems to have an outlier. Further analysis of mean variance of the CO emissions at 95% confidence suggests that there is no significant difference irrespective of the workplace or data location as P_{values} (0.733 and 0.131 respectively) are $\gg 0.05$. This is also corroborated by the error margin (5%) from the average (AV) values in Figure 3.

In Figure 4, the AQI values for the four regions are provided. The lowest AQI value is 3.8 for region N, while the highest AQI value is 5.2 for region S. The average AQI value for all five regions is about 4.6.

Based on the values in Figure 4, the air quality appears to be relatively good in all five regions. All the AQI values are below 50, which is the threshold for good air quality as stated by United Nations Guideline (WHO website). However, it is worth emphasizing that even low levels of air pollution can have negative effects on health over a certain period (Shote *et al.*, 2023), especially for sensitive populations such as the elderly, children, and individuals with respiratory or cardiovascular problems (i.e. asthmatic patient).

In general, an AQI value of 0-50 is considered good air quality (UN Guideline), while an AQI value between 101-150 is considered unhealthy for sensitive groups, and an AQI value of over 300 is considered hazardous. Based on these standards, the AQI values for all five regions in this table are relatively good and do not pose any immediate health risks as it were.

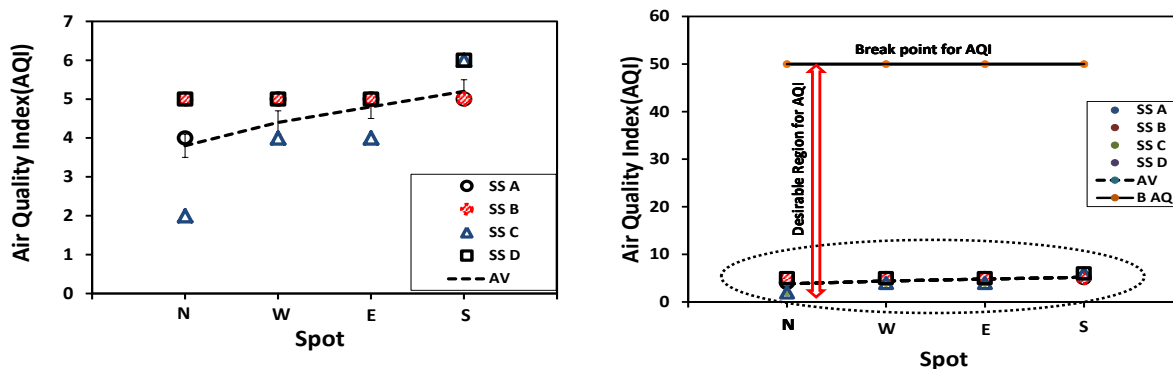


Figure 4: Air quality index for the four different locations

Formaldehyde is a colorless gas that is commonly found in our neighbourhood/indoor environments and can have detrimental health effects if exposure levels are too high. The World Health Organization (WHO) recommends a maximum level of exposure 0.1 mg/m³ over a 30-minute period to avoid adverse health consequences. On average basis, it can be seen from Figure 5 that all regions have HCHO emissions levels above the WHO recommended maximum exposure level of 0.1 mg/m³. The highest emission level is observed in the eastern region with a value of about 0.35 mg/m³. The northern region (N) has the lowest emission level put at 0.13 mg/m³.

There is need for measures to be taken to reduce HCHO emissions in welding environments to ensure that people/operators are not exposed to levels that pose risk to their health. Some of the basic things to do include the use of personal protective equipment. At 95% confidence interval, there is no difference in the HCHO emissions ($P_{value} 0.493 > 0.05$) even as it can be apparently seen that west and East location are recording the highest for welding workshop D (WS D).

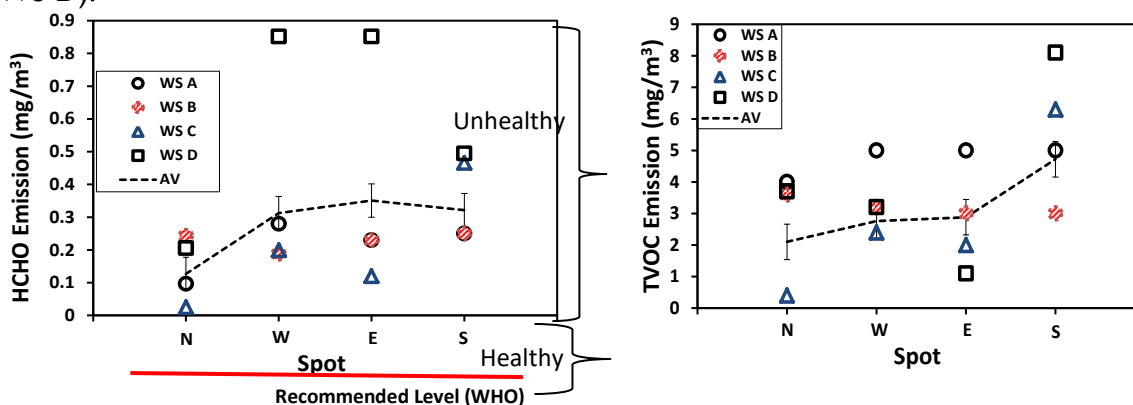


Figure 5: Formaldehyde (HCHO) emissions for the four different locations

Figure 6: Total Volatile Organic Compound (TVOC) emissions for the four different locations

A total volatile organic compound (TVOC) is a measure of the concentration of organic chemicals that are present in the air and can affect neighborhood and indoor air quality. The total volatile organic compounds (TVOC) in different areas are measured in units of milligrams per cubic meter (mg/m^3) and presented in Figure 6. The TVOC concentration in the different locations varies considerably. The lowest concentration is recorded in the north N with a TVOC concentration of about $2.1 \text{ mg}/\text{m}^3$, while the highest concentration is in the south S with a TVOC concentration of $4.7 \text{ mg}/\text{m}^3$. The other locations have TVOC concentrations that fall in between these two extremes. It is important to note that the safe or acceptable TVOC levels in neighbourhood/indoor environments vary depending on the specific compounds present and the duration of the exposure of someone. Besides, as a general guideline for TVOC levels of 0.3 to $0.5 \text{ mg}/\text{m}^3$ are considered low, while levels above $3 \text{ mg}/\text{m}^3$ may cause discomfort and health challenges for some individual people. It is apparent that the TVOC concentration in locations S may be high enough to cause discomfort or health problems for some individuals as stated by Racette et al., (2017).

4.0 Conclusion

Welding is an essential process in many industrial activities. Societal development may be very difficult without welding processes as it were. This shows that welding is very paramount for development to progress rapidly. That is one of the main reasons for embarking on this research.

From the data presented for five different air quality parameters, i.e. - Air Quality Index (AQI), Total Volatile Organic Compounds (TVOC), Carbon Monoxide (CO), Carbon Dioxide (CO_2), and Formaldehyde (HCHO). The emission measurements are taken at four different locations - North (N), West (W), East (E), and South (S) and four different welding work places welding workshop A (WS A), workshop B (WS B), workshop C (WS C) and workshop D (WS D), it is obvious that the levels of each of the parameters differ significantly across the different locations. AQI levels are also highest in the South region, indicating poorer air quality and high pollution in that area.

- From analysis of mean variance, there is no significant difference in the air quality index of the welding workshops as $P_{\text{values}} (0.271) > 0.05$.
- However, it's important to note that AQI values can fluctuate rapidly depending on seasonal changes, weather patterns, and human activity, among other factors. Thus, it's very important to monitor AQI values regularly and possibly take necessary precautions to protect welding operators from potential health hazards caused by air pollution.
- There is a difference in CO_2 emission from different locations (North, West, East, South) as $P_{\text{value}}, 0.014 < 0.05$. North location is substantially different from East and South as $P_{\text{values}} (0.032, 0.019$ respectively) for significant indicators are both less than 0.05. At least 57.6% of the variations in CO_2 emissions can be accounted for as a result of change in different locations.
- There is also no significant difference in formaldehyde emissions from different locations ($P_{\text{value}} 0.493 > 0.05$). Other researches may have to consider the duration of exposure and the impact of cumulative exposure to HCHO on human health.
- Further evaluation and investigation of the specific TVOC compounds present in these locations were done to determine the potential health risks associated with these concentrations. At 95% confidence, there is no difference in TVOC emissions from welding process due to different workshops or different locations as P_{values} of 0.842 and 0.068 respectively are less than 0.05.
- In general, the data provides useful information about air quality measurements and could be used to identify areas of concern and take necessary steps to improve air quality in specific welding areas and regions.

The use of alternative welding methods, such as laser welding and friction stir welding, can reduce the emissions of hazardous chemicals. It is important to take appropriate measures to minimize these risks, such as proper ventilation, the use of safer welding methods and personal protective equipment (PPE).

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