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COMPARATIVE ANALYSIS OF AMBIENT AND HOUSEHOLD AIR QUALITY AND ITS ASSOCIATED PUBLIC HEALTH IMPACT IN BAUCHI STATE, NIGERIA

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Abstract **:** Air pollution is the release of chemicals and harmful substances into the atmosphere due to human activities. Short-term and long-term exposure to air pollution can create health issues in both animals and plants. It was observed in Bauchi State that there are increased cases of environmental pollution related diseases; therefore, this study investigated the house and ambient air quality and its associated public health impact. The instrument used for data collection was a hand held device (Air Quality Detector). The Local Government Areas (LGA) in the three senatorial zones of the State were clustered into three clusters where one LGA was selected from each cluster, headquarters of the each LGA were selected for data collection, three sites were randomly identified from each LGA head quarter. Data were collected from the three sites in each of the selected LGA; the data were collected in three different periods (June, August and October 2023). The study revealed that CO_2, and $PM_{2.5}$ in both ambient and household were above the acceptable level in most of the study centres, however, CO and TOVC were not significant. It was concluded that high concentration of some air pollutants were observed in all the study areas. Carbon dioxide concentration was observed to be high in all the study centres in the State, in both ambient and household. Similarly, high concentration of $PM_{2.5}$ was also

observed to the level that can pose serious public health impact. However, carbon monoxide and TVOC were observed to pose non-significant health challenge in the State. Therefore, enlightenment campaign should be intensified on the proper waste management, and heavy machines, small-scale industries operators and motor parks should be sited outside town to prevent pollution of the environment due to their activities.

Keywords: Comparative, Ambient, Household, Air Quality

Introduction

Any substance that alters the natural properties of the atmosphere, whether it is chemical, physical, or biological, is considered an air pollutant. Air pollution can occur in household (Indoor) or Ambient (outdoors). Common causes of air pollution include motor vehicles, industrial operations, household combustion appliances, and forest fires. Particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulphur dioxide are pollutants of great public health concern. According to the World Health Organization (WHO), both outdoor and interior air pollution are significant contributors to morbidity and death through causing respiratory and other illnesses. The presence of one or more pollutants in the air that can be harmful to human health, such as dust, fumes, gas, mist, odour, smoke, or vapour, has also been classified as air pollution (WHO, 2022).

According to WHO data, 99 per cent of the world's population breathes air that includes high levels of pollutants and exceeds WHO guideline limits, with low- and middle-income nations seeing the worst exposures. The burning of fossil fuels is one of the main causes of air pollution and also contributes to greenhouse gas emissions which are the main source of energy (WHO, 2023). The respiratory system is the primary route by which people are exposed to air pollution. Breathing in these pollutants causes cells all over our body to become inflamed, under oxidative stress, immunosuppressed, and mutagenic, which affects the lungs, heart, and brain among other organs and eventually results in illness (WHO, 2021).

Although numerous toxins have harmful effects on health, Particulate Matter (PM), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2) are the pollutants with the best evidence for public health concern this is due to their ability to travel to organs, enter the circulation, and cause systemic harm to tissues and cells, fine particulate matter is a particularly significant source of health concerns (WHO, 2021). In the same vein, the impact of industrialisation such as road travel, air travel, and urban expansion has resulted to increased air pollution in our environment (Power, et al., 2018). Annually, approximately 7million people die worldwide due to effects of air pollution, out of that, 4.9million million deaths were as a result of urban ambient air (WHO, 2018). The study revealed that the pollutants were CO, $PM_{2.5}$, Volatile Organic Compound as a result of heavy road traffic, domestic heating and local industries (Puler & Strumbelj, 2018).

A study revealed that the concentration of NO_2 was highest at location A of the study in 2017, whereas lowest was detected in 2010 and 2021. So also the concentration of $PM_{2.5}$ was highest in location A of the study area in 2017 while lowest in location C of the study area. The study further revealed that the metrological parameters of temperature and relative humidity were responsible the intense concentration of pollutants. No significant difference was observed within the studied areas as to relative humidity and temperature (Ivanoski et al., 2023).

Nearly all of the world's population (99%) is exposed to air pollution levels that are higher than the $PM_{2.5}$ $\mu g/m^3$ safe WHO guideline limit, with low- and middle-income nations seeing the greatest exposure levels (PAHO, 2018). Carbon dioxide is a colourless, odourless, and inflammable gas that is found in the atmosphere naturally. It is created by human metabolism, the combustion of fossil fuels, and other natural processes like volcanic eruptions. Although, it can reach 600-900 ppm in urban areas, outdoor carbon dioxide levels typically range between 300-400 ppm (0.03%) to 0.04% (OSHA, 2023). Carbon dioxide is mainly toxic, the health effect include reduce or displace of oxygen in the breathing air, it symptoms include headache, drowsiness due to mild exposure, while at higher level may include rapid breathing elevated

breathing, confusion, increased cardiac output, however serious exposure to high concentration of carbon dioxide can cause death by suffocation. The permissible tolerable level of carbon dioxide as reported by OSHA is 5,000 parts per million (ppm) CO .5% in air (OSHA, 2023).

WHO reported that the safe levels of carbon monoxide were 9–10 ppm for no more than 8 hours, 25–35 ppm for no more than 1 hour, and 90–100 ppm for no more than 15 minutes. Death by poisoning is one of the health impacts of carbon monoxide exposure. It competes with oxygen to connect with red blood cells in the blood, reducing the amount of oxygen delivered to the brain, and if exposed for a longer length of time, it can affect blood chemistry (CO2metre.com, 2023).

The term "airborne particulate matter" (PM) refers to a variety of chemical species that include coatings, small liquid droplets, dry solids, and solids in the form of aerosols. The particles also vary greatly in size, shape, and chemical makeup; the particles can be inorganic ions, metallic compounds, organic compounds, elements of carbon, and other materials from the earth's crust (California Air Resources Board, 2023). Many negative health effects have been associated with $PM_{2.5}$, including premature mortality, an increased rate of hospitalization for heart problems, acute and chronic bronchitis, asthma attacks, and respiratory system problems. $PM_{2.5}$ is an airborne particle that is produced when fuels like gasoline, oil, diesel, or wood are burned. But the long-term exposure effects can also lead to early death, especially in those who already have heart, lung, and chronic lung illness, as well as those with impaired lung function (California Air Resources Board, 2023).

Stroke, ischemic heart disease, chronic obstructive pulmonary disease, lung cancer, pneumonia, and cataract (only from household air pollution) are the particular illness outcomes most closely associated with exposure to air pollution. Exposure to air pollution increases the chance of developing neurological and other disorders, including malignancies, diabetes, and bad pregnancy outcomes include low birth weight and small-for-gestational-age babies (WHO, 2021). Short-term and long-term exposure to air pollution can create health issues in both children and adults. Each pollutant has different acceptable exposure levels and durations, as well as different illness effects. There are no thresholds below which detrimental effects do not happen for some pollutants (WHO, 2021). For instance, short-term exposure to high amounts of particulate matter can cause decreased lung function, respiratory infections, and exacerbated asthma. A person's risk for illnesses having a longer incubation period, such as various non-communicable diseases including cancer, chronic obstructive pulmonary disease, stroke, and heart disease, is increased by long-term or chronic exposure to fine particulate matter (WHO, 2021).

For instance, short-term exposure to high amounts of particulate matter can cause decreased lung function, respiratory infections, and exacerbated asthma. A person's risk for illnesses having a longer incubation period, such as various non-communicable diseases including cancer, chronic obstructive pulmonary disease, stroke, and heart disease, rises with prolonged or chronic exposure to fine particulate matter (WHO, 2022). The phrase "ambient air pollution" is used more broadly to refer to air pollution in outdoor settings. When contaminants are present in high enough amounts to harm the environment or human health, the ambient air quality deteriorates. Urban outdoor air pollution is a more specific term referring to the ambient air pollution experienced by populations living in urban areas, typically in or around cities (PAHO, 2018). The health impacts from exposure to ambient air pollution or household air pollution are dependent on the types and concentrations of the pollutants in the air pollution mixture to which an individual is exposed. However, the health risks and disease pathways between ambient and household air pollution exposure are often similar, due to their similar composition. Fine particulate matter for example is a common and critical pollutant of both ambient and household air pollution leading to negative health impacts.

It is important to note that the death and disability estimates attributed to air pollution do not account for all health outcomes associated with air pollution. WHO estimates are likely conservative as only health outcomes for which there is strong certainty in the epidemiological evidence are included (i.e. stroke, ischemic heart disease, chronic obstructive pulmonary disease, pneumonia, and lung cancer) (WHO, 2021). An estimated 4.2 million deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer and acute respiratory

infections. Estimates of the disease burden of household air pollution at the global, regional and national level can be found here. The combined or joint effects of ambient (outdoor) and household air pollution exposure cause about 7million premature deaths every year from increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. PAHO (2018) reported that worldwide 4.2 million premature deaths are attributable to ambient air pollution in 2016. About 88% of these deaths occur in low and middle-income countries. It was reported that in Africa, 425000 deaths were associated with ambient air quality.

Methods

The sampling equipment used for the study was a portable digital hand held air quality monitor censor to measure the level and concentration of pollutants in the study area, the instrument measures Total Volatile Organic Compound (TVOC), Carbon Monoxide (CO), Carbon Dioxide (CO2), PM2.5, Formaldehyde (HCHO), and metrological parameters of Temperature and Relative Humidity (RH).

Materials

Bauchi State LGAs were clustered (as in the Senatorial zones) into three (3) clusters, Cluster A Bauchi South, Cluster B Bauchi central and Cluster C Bauchi North. One Local Government Area headquarter was randomly selected from each cluster, three different site were also randomly identified for data collection. The Data were collected at different occasions, the first was conducted in June 2023 representing the beginning of rainy season, second in August 2023 representing the middle of the rainy season while the last was done in October 2023, representing dry season with the interval of 2months each. Four parameters of air pollution were measured (CO, CO_2, TOVC, and PM2.5,) in both ambient and household to assess the level and concentration of pollution in the area of the study.

Results

The results of the study from both household and ambient environment are presented as follows:

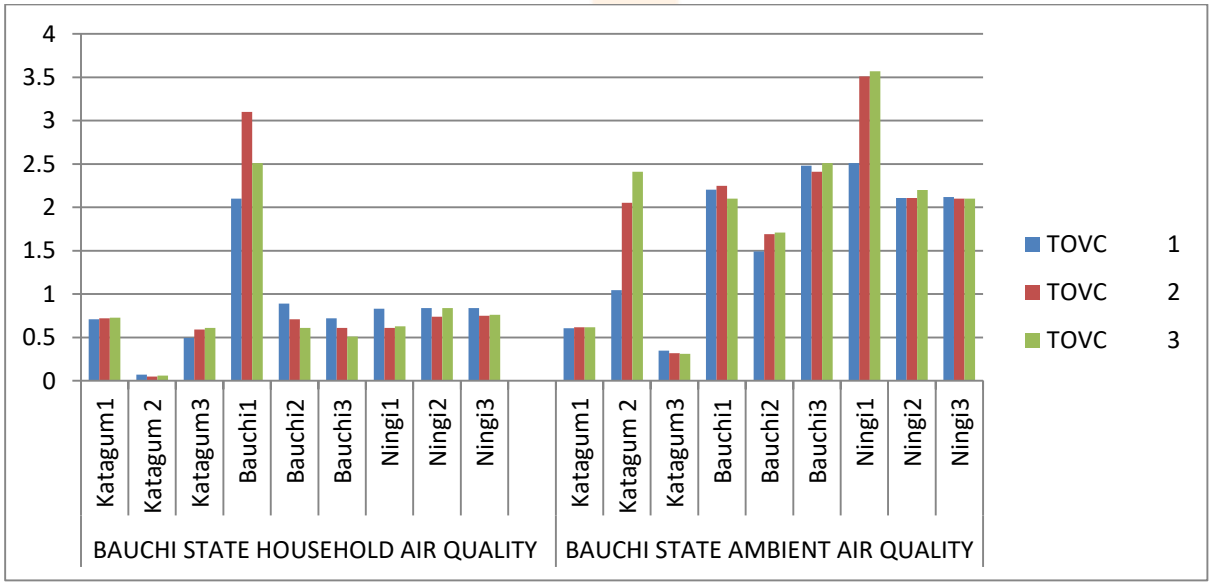

Figure 1: Total Volatile Organic Compound in both Household and the Ambient

Figure 1 presents the TOVC in both ambient and household in Bauchi State, the figure shows that the house concentration of VOTC was in Bauchi Metropolis site A with 3.2, 2.5 and 2.1 in the first, second and third collection respective, the figure further revealed that the least TVOC for household was from Katagum town site A with less than 1 TVOC. The figure shows that the ambient air highest measurement was 3.6.

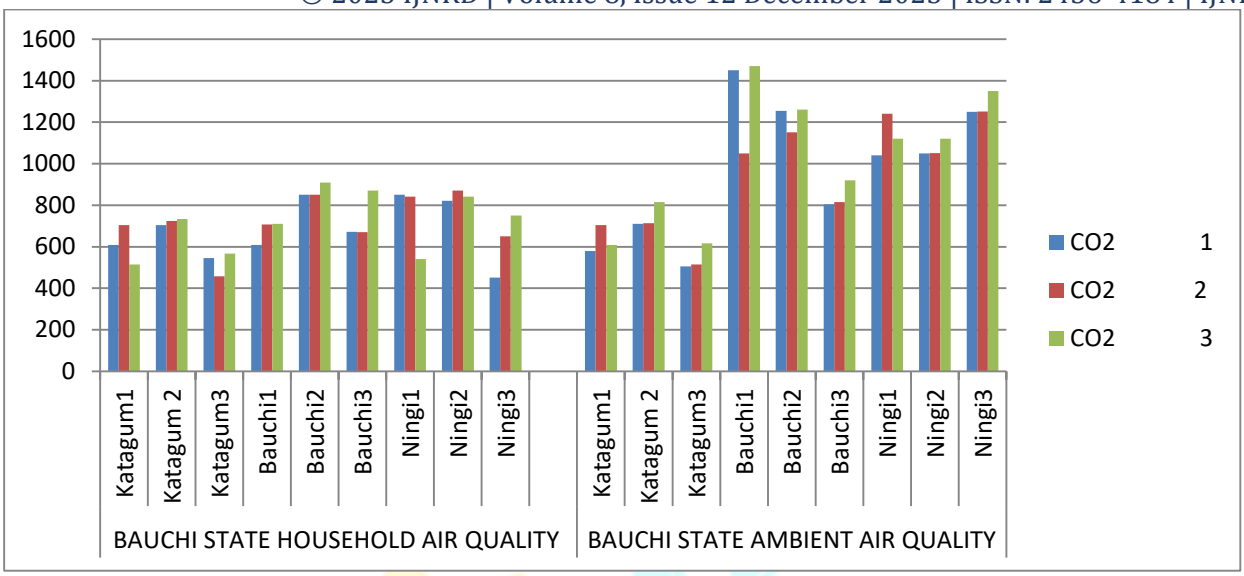

Figure 2: Showing the level and concentration of Carbon dioxide in Bauchi State

Figure 2 revealed the concentration of Carbon dioxide in Bauchi State, the figure shows that the concentration of Carbon dioxide in household is higher in Bauchi Metropolis than any other part of the state, the figure also shows that the highest concentration was observed in the site B, 3rd collection, followed by Ningi site C 2nd collection. However, the highest concentration of Carbon dioxide was observed the ambient air with the highest in Bauchi site A in 3rd collection followed by 1st collection, then Ningi site C 3rd collection. The overall assessment of the concentration of Carbon Dioxide the table shows the household air quality was higher than the ambient air quality.

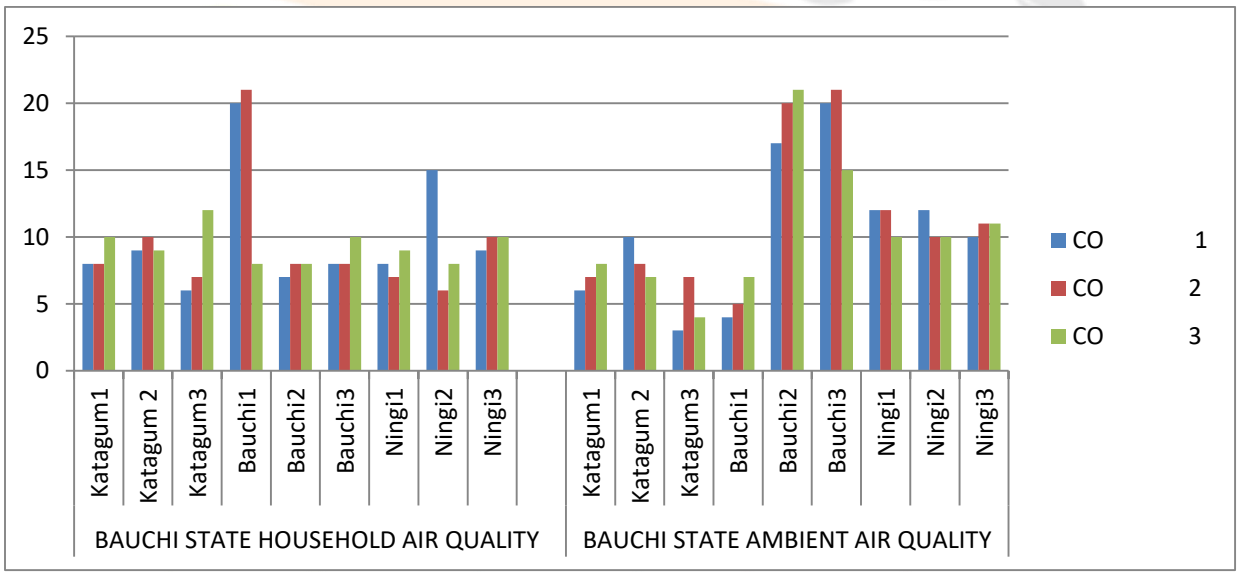

Figure 3 Carbon Monoxide Concentration in Bauchi State

Figure 3 revealed the concentration of Carbon Monoxide concentration in Bauchi State, the figure shows that the highest concentration of household carbon monoxide in Bauchi State was from Bauchi site A, 2nd collection followed 1st collection, followed by Ningi site B, 1st collection. However the least concentration was from Katagum site C, 1st collection. The figure also shows that the highest ambient concentration of carbon monoxide was from Bauchi site B and C 3rd and 2nd collection respectively, followed by Bauchi site B and C 2nd and 1st collection respectively. The figure further revealed that the least concentration was Katagum site C, 1st collection. In general, the overall carbon monoxide concentration in ambient environment is greater than that of household.

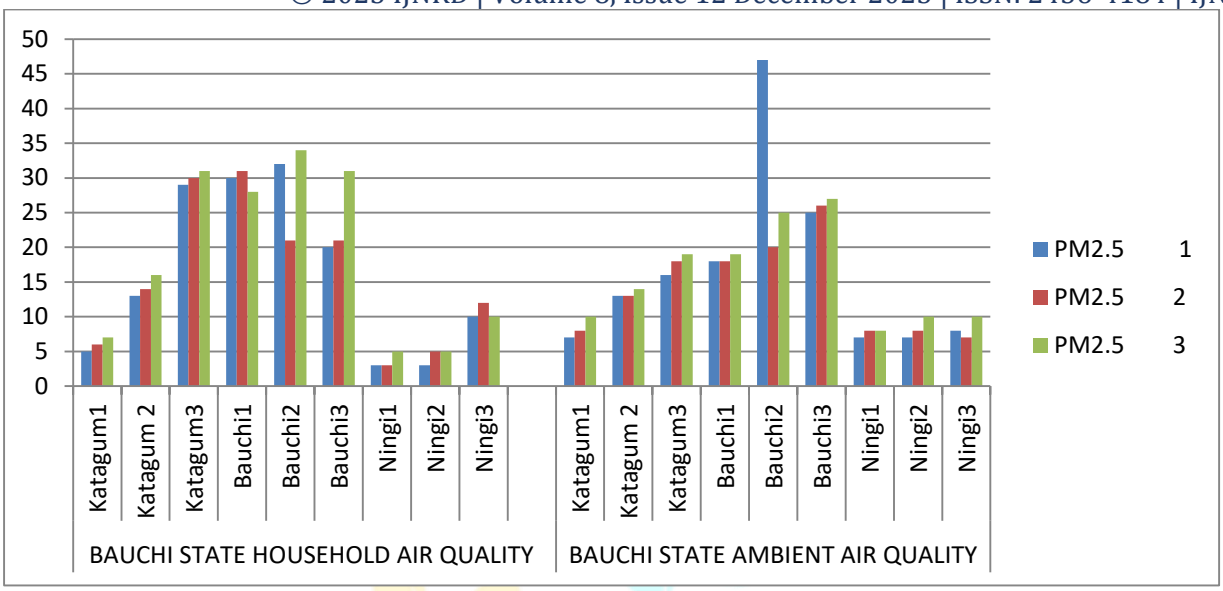

Figure 4: Level of PM2.5 in Bauchi State

Figure 4 revealed the concentration of household and ambient $PM_{2.5}$ concentration, the figure shows that the household concentration of particulate matter was more in Katagum site C in 3rd collection with 30, followed by Bauchi metropolis in site 3 with 32, however, in the Ambient air Bauchi metropolis site recorded the highest amount of $PM_{2.5}$ of 45.4 followed by site C 3rd, 2nd and 1st collection.

Discussion of Findings and Public Health Impact of Air Pollution

Carbon Dioxide: Result of the study shows that the highest level of COII recorded was 1420ppm in the ambient air while for the household was 800ppm. The level for the household was within the acceptable limit of 1000-2,000ppm, however, that of the ambient is above the acceptable limit of 400ppm which may be accompanied health risk. The acceptable limit for outdoor levels of carbon dioxide as reported by OSHA (2023) range from 300-400 ppm (0.03%) to 0.04%) but can be as higher as 600-900 ppm in metropolitans areas. COII level above 1,000-2,000ppm is normally indicates poor air quality which is accompanied with health problems such as drowsiness, headache, fatigue, poor concentration and loss of focus and death due to deprivation of oxygen.

Particulate Matter $PM_{2.5}$: The result revealed that most of the sites and the three collections made in Bauchi State shows the level of Particulate Matter is above 5µg/m^3 which is the minimum acceptable level, six sites in both ambient and household indicates a level above the acceptable one which indicate poor and very poor air quality. The high level of $PM_{2.5}$ shows a public health concern (European Public Health Alliance, 2022). When air is polluted with high level of $PM_{2.5}$ it poses risk to public health. The particles vary widely in size and shape and chemical composition and may contain inorganic ions, metallic compound, elemental carbon, organic compound and other components from earth crust (California Air Resources Board, 2023). Emissions from combustion of gasoline, oil, diesel fuel, or wood produce much $PM_{2.5.}$ Varieties of adverse health impact have been linked with adverse effect of $PM_{2.5.}$ The short term effects can lead to premature mortality, increased rate of hospitalisation due to heart problems, acute and chronic bronchitis, Asthma attack and system of respiratory problem. However, the long term exposure effect to include premature death, particularly in people with chronic and heart and lung disease and reduced lungs function (California Air Resources Board, 2023).

Carbon Monoxide CO: The result shows that in both ambient and household environment a high level of carbon monoxide which is harmful to human, the result also shows that level is not up to 30mg/m^3 that when one stays for than an hour can create serious health risk, however, the result revealed that the level is above 4 and10mg/$m^{3,}$, that can constitute risk when stayed for more than 8hours and for 24hours respectively. This shows that the level of CO in Bauchi State constitute health hazard as it is polluted with CO. The acceptable permissible limit for carbon monoxide as reported by WHO was 9-10ppm for not more than 8hours, 25-

35ppm for not more than 1hour and 90-100ppm for not more than 15minutes. The health effects of exposure to carbon monoxide include death by poisoning; it competes with oxygen to bind with red blood cells in the blood leading to reduce supply of oxygen to the brain, and if exposed for a longer period of time can impact on blood chemistry (CO_2metre.com, 2023).

Total Volatile Organic Compound (TVOC): The result revealed that the highest concentration of TVOC was 3.6 which very negligible levels that pose no significant health risk. Research reveals that when the level and concentration of TVOC is above the permissible level can cause health consequences such as eyes, nose and throat irritation, headaches and loss of coordination, nausea and damage to the liver, kidney or central nervous system (Minnesota Pollution Control Agency 2023).

Conclusion

High concentration of some air pollutants were observed in all the study areas. Carbon dioxide concentration was observed to be high in all the study centres in the State, in both ambient and household. Similarly, high concentration of $PM_{2.5}$ was also observed to the level that can pose serious public health impact. However, carbon monoxide and TVOC were observed to be non-significant health challenge in the State.

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