IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 29, Issue 4, Series 10 (April, 2024) 18-26
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Evaluation of Air Pollutants Parameters Index Implication and Impacts in Seasonal Indoor Air Pollution on Human Healths In Sukuta Metropolis, Gambia

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Abstract
The purpose of this study was to assessthe spatiotemporal and seasonal concentration of indoor air pollutants in Sukuta. Due to development of road construction, dust particles generated had caused indoor pollution as well as causing soil profile distortion which affects humans environmentally. The purpose of the study also aimed at air quality parameter status health impacts on households in the study location, different air pollutants indicator were collected in the dry and rainy season from the month of March to September 2023, air quality health index standard procedure was used with formaldehyde air quality detector (FAQD), model EGVOC 180. Gaseous and particulate air pollutants areAQI, HCHO, TVCO, $PM_{1.0}$, $Pm_{2.5}$ and $PM_{10.0}$, two meteorological parameters like relative humidity and temperature. The average relative humidity (RH) measured within the dry season was 50.14%, and that of rainy season was 64.29%.Temperature mean value recorded was 29.29^{0}C and 27.99^{0}C in both rainy and dry season. Analysis of data revealed the highest concentration levels was found in PM_{10} with mean value of 25.29±5.97µg/m^3 for dry season, 20.86±2.17µg/m^3, followed by PM2.5 rainy season mean value of 19.00±2.04µg/m^3, PM1.0 dry season had mean value of 16.29±3.86µg/m^3, displaces PM2.5 dry season which recorded 14.86±2.56µg/m^3 and the lowest mean concentration value recorded was found in PM1.0 wet season which had 13.57±1.57µg/m^3 arrange in the sequence as ***PM_{DS}10 > PM_{WS}10 > PM_{WS}2.5 > PM_{DS}1.0 >PM_{DS}2.5 > PM_{DS}1.0 .*** *Kruska Wallis Test (KWT) single utilizing ANOVA, the degree of significance, at the level of P>0.05 AQI, Temp, $PM_{1.0}$, $PM_{2.5}$, PM_{10} and relative humidity were insignificant across the season, only HCHO & TVOC was significant. Sukuta environment is known for high airquality, particulate matter for dry &wet seasonindex (AQPMD&WSI), both dry and rainy season parameter levels of concentrations were above the permissible limits.*

Keywords: *Air Quality Health Index, Indoor Household Pollutants, Pollution Standard, $PM_{1.0,}$ $PM_{2.5}PM_{10.0}$, Dry and rainy season*

Date of Submission: 19-04-2024 Date of Acceptance: 29-04-2024

I. Introduction

As urbanization and global society advances, people spend a lot of time indoor compared to outdoor and in some cases, the air we inhaled indoor is even more contaminated than outdoor air inhaled in an environments, according to [Prasanthrajan and Tamil, N. 2017]. According to work done by [Dimitriou et al., 2011], indoor air quality is becoming one of the primary respiratory issues affecting people's health.Humans may experience long-term effects from indoor air pollution, even at low concentrations, making them even more dangerous than outside air pollutants [WHO, 2014].However, compared to outside surroundings, indoor areas (such school offices and underground subway stations) have higher quantities of main air contaminants. [Oyareme and Osaji, 2023]. Pollution both in-door and out-doors play a significant impacts, chemical substances are diffused, and particulate matters into the environment that is harmful to living things, also causes life disorder or death. A lack of ventilation into the house, results to indoor concentrations of air pollution. Perhaps, people choose to spend more time indoor than outdoor, indoor air quality (IAQ), in many circumstances and situations, resulting to inhalation of indoors air, which is even more polluted and hazardous than outdoorair inhaled. Industries, technological advancement and population increase brings about development and urbanization, results to vehicular pollution for more than 25years accounted for climate change due to excess release of greenhouse gases in the axis of Gambia metropolis, [Oyareme and Osaji, 2022]. Recently, regarding to epidemiological studies, revealed on ultra-fine particles in diameter lesser than 100nm, may be significance in health effects [Bin et al., 2024]. Ultra-fine particles indicated to pass through membranes of the cell [Yanan-feng et al., 2024], which are deposited in the secondary organs, [Younnsuk Son,2023] as well as deposited in the brain tissues [Heliyon et al., 2023] and even nanoparticles usually pass through the to the fetus in the womb [Fang et al., 2023]. Toxic materials had numerously yielded range of burning processes of particles. Polyaromatic hydrocarbons (PAH), are known basically for carcinogenic; carbon and silicon dioxide are not intrinsically toxic still, but show adverse health effects when inhaled as particulate matter. Numerous air filters in this manner, do not efficiently filter particles in the Nano size, a good example is the cars ventilation system, [Rui-Chen et al., 2023]. On the other hand PM_{10} have relatively smaller concentration levels ventilation changes widely in a given location compared to other particulate matters. Their level of concentrations in urban cities has at maximum busy hour pronouncement; their concentration quickly reduces with an increasing distance from a source. This suggests that uncovered evaluations to tiny air pollutant have to be done differently from those coarse particles. With regards to development and urbanization, an air pollutant is a major key problem associate in the environment according to [Cho &Choi, 2014], as noticeable impacts of climate alteration communities due to significant anthropogenic threatening effects which pose a crucial challenge that disturb the stability of the universe thereby leading to climate change globally, by damaging ecosystem and endangering human health. Globally, air pollution in the urban area has received attention by different environmental researcher had focused on causative factor of air pollutants parameters due to their health effects and environmental impacts. Human exposure to these air pollutants globally is constantly accounted for sixteen percent (16%) death rate of the populace, [Power et al., 2018]. Planetary body may be polluted also, as well as the environment of some foreign substances in the form of gaseous or particulate [Omogbai, 1998].

According to [WHO, 2016] reports, emerged as both indoor and outdoor related air pollution caused about 80% premature deaths, as a result of respiratory challenges such as asthma, cough, bronchitis, emphysema, difficulty in breathing, lung cancer with chronic obstructive pulmonary disease [Kjellstrom et al. 2002]. Air pollution has been linked to a number of health effects in humans, including adult cerebrovascular diseases [Chan et al., 2006], adult spirometric lung function [Penttinen et al., 2009], respiratory symptoms in smokers and non-smokers [Ediagbonya and Tobin, 2013], and respiratory diseases in children, the elderly, and people living in urban areas who already had a pre-existing respiratory condition [Sciaraffa et al., 2017].

Sources of indoor air pollution

Inside air pollution includes both externally sourced pollutants and those that are unique to the inside environment.Because indoor and outdoor pollution have different sources, compositions, and concentrations, it is difficult to generalize the consequences of interior air pollution from studies on outdoor air pollution [Wallace et al, 2003].Solid fuel combustion is a major global source of household pollution, and many other household activities that are more prevalent in urban areas have also been linked to the production of pollutants [McCormack et al., 2008, Hansel et al., 2008]. Both contaminants from outside sources and those specific to the inside environment are considered to be part of internal air pollution is still either main and secondary tobacco use or environmental tobacco smoke (ETS). In this analysis, we will however, make activities aimed at lowering smoking rates and smoke pollution in the environment are still vital and should be given top attention.We will concentrate on household habits and behaviors in low- and middle-income nations that are linked to increased pollution output, such as indoor smoking, solid fuel combustion, cooking and heating practices, and cleaning. Certain typical heating and cooking techniques can raise the quantities of household pollutants even in houses without solid fuel usage. Fuels used for heating and cooking have the potential to release particulate matter, CO_2, NO_2, SO_2, VOCs, and CO_2. Exposure concentrations are determined by a number of parameters, such as individual proximity to the source of pollutants, ventilation, and the length of time spent using the cooking or heating equipment. For households where gas stoves are used for cooking, NO_2 is especially important. According to one study, using a gas stove or furnace for one hour increases the concentration levels of indoor air pollutant parameters. One typical household task that can cause allergies and particles to become mobilized is cleaning. One study showed that increased household $PM_{2.5}$ and PM_{10} was linked to indoor sweeping, which re-suspends settled dust. Furthermore, there are direct adverse health impacts from cleaning agents and pesticides, which are covered in more detail in a different article. Ventilation, humidity, dampness, and pest allergens are characteristics of housing.

Some control measures of air pollution

a. **Renewable energy is the answer to climatechange** due to its zero production of greenhouse gases carbon pollutant emission to the environment. Renewable energy is a serious component efforts mitigation and sustainable energy. While may not be the sole answer to climate change, but plays a central role for several important reasons:
b. **Reducing Greenhouse Gas Emissions**: The primary source of greenhouse gas emissions is carbon dioxide (CO2), which is produced when fossil fuels like coal, oil, and natural gas are burned to produce energy that causesclimate change. Hydropower, solar energy, and wind are examples of renewable energy sources that

provide electricity with minimal to no direct greenhouse gas emissions. We can cut emissions considerably by switching to renewable energy sources.

c. **Sustainable Energy Supply:** Renewable energy sources are inherently sustainable and boundless. In contrast to fossil fuels, which have a limited supply, they do not gradually exhaust natural resources. Future generations will have a steady and long-lasting supply of energy thanks to this.
d. . **Improving Air Quality**: Burning fossil fuels for energy havenegative impacts regarding human health, in addition to causing air contamination, which exacerbates climate change.Making the switch to renewable energy can enhance air quality and lessen health-related problems.
e. **Energy Security and Independence:** Relying on by lowering reliance on imported fossil fuels, which are prone to price volatility and geopolitical tensions, renewable energy sources can improve energy security. Countries can become more self-reliant and resilient through the use of indigenous renewable resources.
f. **Technological Advancements:** The renewable energy sector have experienced rapid technological advancements and innovation, leading to cost reductions and increased efficiency. This growth also creates jobs and economic opportunities in manufacturing, installation, maintenance, and research and development.
g. **Diversification of Energy Mix:** A diverse energy mix that includes renewables makes energy systems more robust and less vulnerable to supply disruptions. It also provides flexibility and reliability in meeting energy demands.
h. **Environmental Conservation:** Many renewable energy technologies have lower environmental impacts compared to fossil fuel extraction and use. For example, wind and solar farms have a relatively small physical footprint and can coexist with agriculture or natural landscapes.
i. **Adaptation to Climate Change:** Renewable energy sources can contribute to climate change adaptation by providing resilient and decentralized energy systems. In some cases, renewables combined with energy storage can enhance resilience against extreme weather events and power outages.

Global Cooperation: The transition to renewable energy is a global effort that promotes cooperation among nations to address climate change collectively. International agreements, such as the Paris Agreement, stress the significance of using renewable energy. As for renewable energy is crucial in the future, it is important to recognize that a holistic approach to climate change mitigation involves not only transitioning to renewables but also improving energy efficiency, reducing energy consumption, and addressing other sectors like transportation and industry. Combining multiple strategies and technologies is necessary to achieve the deep emissions reductions needed to mitigate the impacts of climate change effectively.

Health effects

Although there are many negative effects of poor air quality on human health, the most common ones are to the respiratory and cardiovascular systems.Thetype of pollution, the amount of exposure, the individual's genetic composition, and their current health all affect how each person reacts to air pollution.The most common sources of air pollution are particulates, ozone, nitrogen dioxide, and sulfur dioxide.Air pollution has both short-term and long-term effects on human health, impacting numerous organs and systems.It may worsen pre-existing heart and lung conditions, cause lung cancer, cause mild upper respiratory tract irritation, cause acute respiratory infections in children and chronic bronchitis in adults, or cause asthma episodes. Exposures, both short- and long-term, have been linked [Dovjak et al., 2019].

II. Methodical Study Approach:

Quantitative methodical research approach is used in this study, which employs and involves the use of digital formaldehyde air quality detector (FAQD), model EGVOC-180, with an indication and measurement concentration levels of different indoor air pollutant parameters and their respective coloration index categories on the air quality display screen for visible and easy data collection and readings documentation.

Study Description Location

This investigation was conducted inSukuta, and it is one of the towns in Western Division of Gambia (WDG), with global positioning system (GPS), Sukuta has latitude 13^{o}24'37.19"N and longitude 16^{o}42'29.34"W. Recently, the total population of people in this town is 16,153 square meter and the distance covered from Capital city (Banjul) to the town is about 20.90km, which is approximately 41minutes drive with a car, that is equivalent to 2,460 seconds.

Sample Techniques

Different contamination of indoor air sample indicators were gathered during the month of March to September 2023, with an interval of fourteen days that is every two weeks basis for the period of seven (7) months, to enable the researcher determine the seasonal changes and variations that occurred among the detected indoor air pollutant concentrations in dry season and wet season. The location of the study was visited in the morning around 8.00am – 9.00am, to enable the researcher communicates and meet different households in the study vicinity. Eight different indoor air pollutants indicator measurement parameters were detected with the use of formaldehyde air quality detector, and the parameters detected by the air meter are AQI, HCHO, and TVOC, Temperature, Particulate matters ($PM_{1.0}$, $PM_{2.5}$, & $PM_{10.0}$) and Humidity as well as their colours for both dry and wet season. They are compared with Air quality management Index as control, according to Canadian Environment AQHI, (2007).

Study Sample Size

The study sample of air pollutant was collected, in every two weeks for the duration of seven months. Eight different air pollutants were noticed, duplicated and examined; for dry and wet season which accounted for thirty-two parameters for seven months, to give a total sample size of two hundred and twenty-four (224).

Collection of Data

Data collections were done using digital formaldehyde air quality detector, model EGVOV-180. The air quality detector does not used internet, once it is switched on in the study location, all the suspected air pollutant parameters are displayed on the air meter screen, with different values and concentration levels. The colours in which they displayed on the screen, is of scientific significance, because it is a means of differentiation because of different colours they possess. Formaldehyde (HCHO) with its systematic name methanal and total volatile organic compounds (TVOC) have the same colour; AQI & $PM_{2.5}$ have the same colour, $PM_{1.0}$, $PM_{10.0}$, TEMP. & HUM. All of these have the different colours indication on the screen with the air quality detector depending on the category and class they fall in. There are eight different air pollutants detected by the formaldehyde air quality detector meter. Though, their colour fluctuates depending on the levels of their concentration in any location, but the air meter is designated and subjected to, for data capturing and collection of air pollutant parameters.

Determination of Air Quality (Analyses)

Air quality pollution indicators are determined and examined with the aid of air quality meter. Eight different air pollutants were detected by the air quality meter. These detected air indicators include Air Quality Index (AQI), Formaldehyde (HCHO), Total Volatile Organic Compound (TVOC), Temperature (□), Particulate Matter ($PM_{1.0}$, $PM_{2.5}$, and PM10.0) & Humidity. Their level of concentration is also compared to AQI standard as a control, to ascertain the main sources of indoor pollution in the stated study location and measures to be taken to prevent and control it for sustainability. According to AQI indoor air pollution standard, 1-3 indicates blue colouration for (good), 4-6 shows yellow colouration for (moderate), 7-10 signifies brown colouration for (high) and above 10 implies red colouration for very high (hazardous), all these indications with different colours of categorization indication as shown below. Blue green colour depicts good, but people are at low health risk, orange or yellow colouration indicates fair or moderate health risk, deep brown or maroon colouration, indicates high health risk, and red colouration showing very high health risk, and value above this point has a health risk that is hazardous, as detected by digital formaldehyde air quality detector (FAQD), model EGVOC-180.

Examining data statistically (Analyses)

Analyses of data were examined statistically measures, dispersion, and central tendency in determining the seasonal variation that occurred during data collection of air quality indicator measurements level and concentration in terms of dry and wet season stations are all drawn for comparison, using single factor Kruskal Wallis Test (KWT) ANOVA by ranks to test for their level of significance. A graphical representation was also done in a Microsoft word using different colouration representatives of air pollutant parameters the dry and wet seasons, [Ogbeibu, 2014].

Table 1: Spatial variation of dry season indoor air pollutant parameters in different households in Sukuta metropolis in Gambia

No	Parameters of indoor air pollutants	Units	N	Mean $\pi \pm$ SE	CV	Range Min. – Max.
1	Air Quality Index (AQI)	$\mu g/m^3$	6	76.57 ± 12.39	39.64	50.00 – 149.00
2	Formaldehyde /methanol (HCHO)	mg/m^3	6	0.07 ± 0.01	34.99	0.04 - 0.09
3	Total Volatile Organic Compound (TVOC)	mg/m^3	6	0.32 ± 0.03	22.96	0.16 – 0.39
4	Temperature (□)	^0C	6	27.99 ± 0.35	30.63	27.00 -29.00
5	Particulate matter ($PM_{1.0}$)	$\mu g/m^3$	6	16.29 ± 3.86	58.04	8.00 – 40.00
6	Particulate matter ($PM_{2.5}$)	$\mu g/m^3$	6	14.86 ± 2.50	41.21	13.00 – 51.00
7	Particulate matter ($PM_{10.0)}$)	$\mu g/m^3$	6	25.29 ± 5.70	55.21	12.00 – 60.00
8	Relative Humidity (H)	%	6	50.14 ± 3.94	19.25	37.00 – 70.00

All values are expressed as mean ± SE (min. – min), CV, C.I = 95%, error = 5%.

Table 2: Spatial variation of rainy season indoor air pollutant parameters indicator in different households in Sukuta metropolis, in Gambia

No	Parameters of indoor air pollutants	Units	N	Mean $\pi \pm$ SE	CV	Range Min. – Max.
1	Air Quality Index (AQI)	$\mu g/m^3$	6	69.29 ± 6.04	21.35	52.00 – 99.00
2	Formaldehyde /methanol (HCHO)	mg/m^3	6	0.07 ± 0.01	34.99	0.05 – 0.11
3	Total Volatile Organic Compound (TVOC)	mg/m^3	6	0.28 ± 0.01	8.75	0.22 – 0.32
4	Temperature (□)	^0C	6	29.29 ± 0.86	7.19	25.00 – 32.00
5	Particulate matter ($PM_{1.0}$)	$\mu g/m^3$	6	13.57 ± 1.59	28.70	9.00 – 19.00
6	Particulate matter ($PM_{2.5}$)	$\mu g/m^3$	6	19.00 ± 2.04	26.30	13.00 – 27.00
7	Particulate matter ($PM_{10.0)}$	$\mu g/m^3$	6	20.86 ± 2.17	25.48	15.00 – 29.00
8	Relative Humidity (H)	%	6	64.29 ± 3.47	13.22	45.00 – 74.00

All values are expressed as mean ± SE (min. – min), CV, C.I = 95%, error = 5%.

Table 3 Summarized health implications for every Air pollutants in the "at danger population" and general population categories of the Air Quality Health Index in the Study location

Health Risk	Air Quality Health Index	Health Message	
		At Risk Population	General Population
Low	1-3	Enjoy your usual outdoor activities	**Ideal** air quality for outdoor activities
Moderate	4-6	**Consider reducing** or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7-10	**Reduce** or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	**Consider reducing** or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion and should stay indoors.	**Reduce** or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

1	2	3	4	5	6	7	8	9	10	10+ Hazardous

Risk: (1-3) **Moderate: (4-6)** **High (7-10)** **very high (above 10+)**

Air Quality Health Index, (AQHI), [2007]

III. Results And Discussion

Table 1 and 2 above, showed the concentration levels of indoor and outdoor air pollutant indicators spatial variation for dry and wet season in different households in Sukuta, West Coast Region of Gambia. All values of data collected are expressed as mean ± SE (range) in both seasons. Table 3 acts as the control on different health risk and challenges associated among the populace in the study location. Table 3 also, comprises of four different classes/categories, from class 1 to class 4. Class 1 shows blue colour (good) with low health risk assessment and air quality health index ranges from 1-3. Class 2 had orange colour with moderate health risk assessment and air quality health index ranges from 4-6, next is class 3 which had maroon (dark brown) colouration, indication of high, health risk assessment and air quality health index ranging from 7-10. The last class here, according to the table is class 4, which is very high, deep red colouration indication, and air quality index range is above 10^+ according to [AQHI, 2007].This research is carried out in order to investigate air quality changes in Sukuta environment. A thorough analysis of air pollution concentrations during the rainy and dry seasons of the year was provided, viewed from the perspective of non-point sources.This study measures the following air pollutants: $PM_{1.0}$, $PM_{2.5}$, and $PM_{10.0}$, TEMP, HCHO, TVOC. It also analyzes meteorological data including relative humidity and ambient temperature.The aforementioned tables 1 and 2 display all of the outcomes.

Air quality index above for dry and wet season ranged from (50-149 $\mu g/m^3$) in table 1 &2, the air quality index average value noted during the arid season is 76.57±12.39$\mu g/m^3$ and the average value noted during the rainy season was found to be 69.29±6.04 $\mu g/m^3$. Dry season value was higher than that of wet season, this is due to increase in air emission as a result of rush hour traffic or uncontrolled burning that hamper the safety of the environment and causes environmental toxicology. Also values were above the control with an indication of deep red coloration, which as well endangers the live of populace living in the study area with some symptoms of coughing and throat irritation according to my observation during the sampling and data collection of this research. This goes in agreement with previous work done by [Oyareme and Osaji, 2022].

Formaldehyde (HCHO) is a primary ethanol that is usually, utilized as formalin, an aqueous solution containing 37% (w/w) methanol.It has a minor amount of methanol and an inhibitor to stop the aldehyde from building long chain polymers during storage, usually an ethenyl (vinyl) polymer.The substance is a colorless, odorous gas that spontaneously polymerizes into paraformaldehyde.Methenamine, also known as hexamethylenetetramine, is generated from formaldehyde and ammonia and is kept in aqueous solutions. It is utilized as a urinary antiseptic. Formaldehyde for both dry and rainy season ranged (0.04-0.11mg/m^3) as seen in table 1&2. Though, they did not have much environmental effects in the study location because the average mean values recorded in both seasons was 0.07± 0.01 mg/m^3 for dry season, and 0.07±0.06 mg/m^3 for rainy season compared to the control, they are okay because their concentration values were below the control. Formaldehyde is used extensively in the production of urea-formaldehyde resin, phenol-formaldehyde resin, and acetal resin (polyoxymethylene).Formaldehyde is used in the tanning industry and to treat different vegetable proteins to make them fibrous due to its interaction with proteins.Formaldehyde is also used as a soil sterilant, embalming agent, and disinfectiondue to its interaction with proteins.Certain places on Earth release radon (Rn) gas, a carcinogen that gets trapped within homes.Plywood and carpeting are examples of building materials that release formaldehyde (H-CHO) gas.

Total volatile organic compound (TVOC), are indoor pollutants that is generated from paint and other solvents which releases volatile organic compounds (VOCs) during the drying process. Lead (Pb) paint can break down creating dust that can be inhaled [Duflo et al.2008]. Total volatile organic compounds values ranges from (0.16-0.32mg/m^3) for both seasons. Dry season average mean value recorded by TVOC was 0.32±0.03mg/m3. And wet (rainy) season had TVOC mean value of 0.28±0.01mg/m3). Dry season recorded higher mean value than the rainy season but still acceptable because it was below the control of air quality health index. During the production process, specific reactions and VOC reduction were used to account for items that had unique performance repercussions on the paint, such as adhesion-promoting chemicals with reduced VOC content [Pinali et al. 2010].Furthermore, [Zhang et al. (2020)] report on the manufacturing of water-based paints for boats that have antifouling properties, hence reducing boat maintenance and volatile organic compound (VOC) emissions. Enhancing the corrosion protection capabilities of ecologically friendly corrosion protection coatings by the use of polymeric micro- and nano-containers filled with "green" corrosion inhibitors was the subject of another study involving these terms. This study involved interfacial polyaddition to generate polyurea (PUa) micro- and nano-containers filled with corrosion inhibitors, such as 2-methylbenzothiazole (MeBT) and 8-hydroxyquinoline (8-HQ), via emulsion (from oil-in-water emulsions), [Grigoriev et al. 2016]. Paint dealers in the market had turned its focus to integrating performance and sustainability to raise public awareness of environmental issues. Manufacturers are looking for creative green solutions for the paint products on the market as a result of consumers' growing environmental consciousness and increasingly strict restrictions [Dorn, 2009].Using air pollution is intentionally produced by air fresheners, incense, and other scented goods.Both indoors and outdoors, controlled wood burning in cook stoves and fireplaces can emit substantial amounts of harmful smoke particles [Twiller and Nicolas, 2019]. Indoor pollution can cause death when pesticides and other chemical sprays are used indoors without sufficient ventilation.Additionally, contemporary kitchen appliances like toasters are among the greatest contributors of indoor pollutants, producing dangerous particles and gasses.Volatile organic compounds (VOCs) are air contaminants that can be found both indoors and outdoors [USEPA, 2023].Methane (CH4) or non-methane (NMVOCs) are the two groups into which they fall.One very powerful greenhouse gas that exacerbates global warming is methane.Some hydrocarbon volatile organic compounds (VOCs) are also significant greenhouse gases because they prolong the atmospheric half-life of methane and aid in the creation of ozone.The effect change based on the local air quality.Long-term exposure to the aromatic NMVOCs xylene, toluene, and benzene can increase the risk of leukemia and cancer.

Temperature: The temperature, or the degree of heat or cold in any given place, is measured with a thermometer. In terms of correlation, temperature and relative humidity have a straight complimentary relationship. In both the dry and rainy seasons, the temperature values varied from (27–32^{0}C). The temperature during the dry season mean value recorded was 27.99±0.35^{0}C, and that of rainy season temperature mean value recorded was 29.29±0.86^{0}C. The temperature is marginally higher during the dry season and the wet season during the period of the study. High temperature drives relative humidity to be very low, vice versa. It was observed in the study area that dry season temperature was lower than the wet temperature, following the same trends of Relative humidity as shown in table 1&2 above. This disagree with the work done by [Swamgbe et al. 2019] that recorded wet season temperature higher than that of rainy season.

Particulate Matters: The term "particulate matter" (PM) or “pollutant particles" in general describes mixture of liquids and solids floating in the atmosphere. Exposure to chemicals in daily life can be hazardous to people, and additional study suggests that the consequences may be more widespread than previously believed, especially with regard to male fertility.There are several weights within the PM spectrum. For example, PM1.0 and PM2.5 are extremely small particles, measuring 1.0 to 2.5 micrometers or less, while PM10 is categorized as particles with a diameter of 10 microns or fewer.

Particulate matter ($PM_{1.0}$) for dry and wet season ranged from (8.00-19.00μg/m^3). The particulate matter ($PM_{1.0}$) mean value recorded in dry season was 16.29±3.86μg/m^3 and that of rainy season mean value recorded was 13.57±1.59μg/m^3. That makes people to be at very high and hazardous risk since it exceeds the recommended control. Influencing factors responsible for this was as a result of houses he number, age, and activity of the residents as well as the construction, age, and materials of the buildings, ventilation, air purifiers being present, and the indoor and external surroundingselements temperature and humidity, were all influenced by both external and internal variables Proper ventilation, the fundamental elimination of indoor air pollutant sources, and the replacement of structural materials are all actions made to improve indoor air quality.

Particulate matter ($PM_{2.5}$): Tiny, respirable particles of pollutants, often with a diameter of not more than 2.5 micrometers.Despite being smaller than 10 micrometers, particulate matter 2.5 acts as a bridge between $PM1_{.0}$ and PM_{10}. Human hair is 30 times larger than the biggest fine particle, with an average diameter of 70 micrometers. The mean average value of particulate matter (PM2.5) for dry season recorded was 14.86±2.56μg/m^3 lower than that recorded by wet season, which had mean value of 19.00±2.04μg/m3. Both season readings were within the range of (13.00-51.00μg/m^3), but exceeded the recommended control concentration levels as stated in table 3.

Particulate matter (PM_{10}): These are breathable pollutants, typically having sizes of 10 micrometers. High concentration of PM_{10} in the dry season had a mean value of 25.29±5.70μg/m^3 and particulate matter mean value noted during the wet season was 20.86±2.17μg/m^3. Both seasons mean concentrations were above the control, which exceeds the recommendation as stated in table 3. This is as a result of dust particles generated from close roads that are not nylon tiled, markets, desiccated soil and fires in the study location. This is agree with [Akinfolarin et al. 2017; Ujoh et al.2014; Cusworth et al. 2018,] who reported identical high concentrations of particles ($PM_{2.5}$ and PM_{10}) in their work. Traffic congestion pollution often and usually have high concentration levels of PM_{10} alongside greenhouse gases which show significant variations in sperm counts and motility (movement) in comparison to a control group of individuals with low exposure to air pollution [Jurewicz et al. 2018]

Relative Humidity:In contrast to the arid season, the relative humidity distribution is greater during the rainy season at every sampling location**.** They are ranged from (37.00 – 70.00%) for both seasons. In dry season, the average value of relative humidity recorded was 50.14±3.94% and wet season had it relative humidity mean value of 64.29±3.48%. The highest mean value is found in season 2, which is the rainy season. This disagree with the work done by [Bernard et al. 2020] which had a mean value of relative humidity recorded in dry season is higher to those in the rainy season.

All the above explanation regarding to air pollutants of dry and wet season are represented in figure 1&2 below, other than formaldehyde (HCHO) and total volatile organic compounds (TVOCs), which was below recommendation, the remainder were the pollution in the study location that pose health issues and challenges among the populace in the study location.

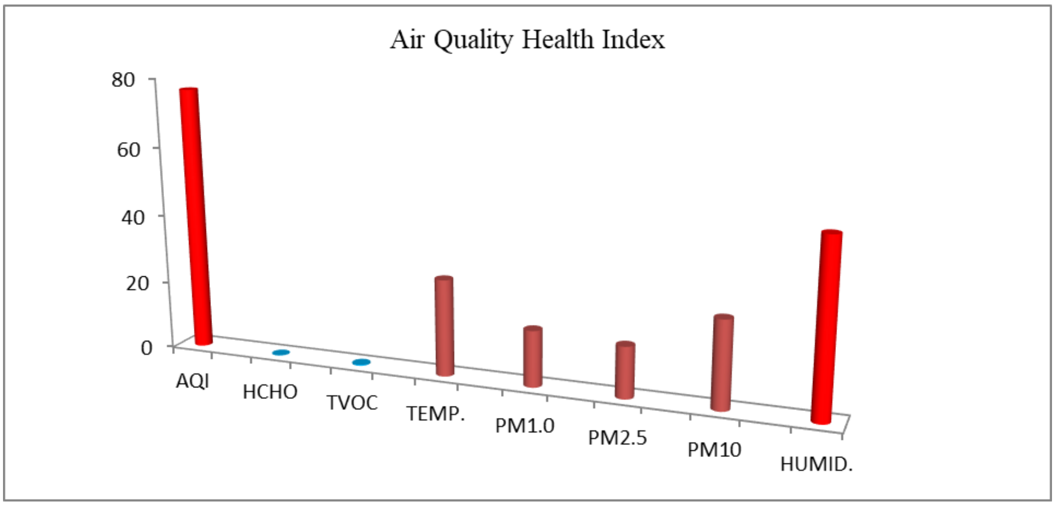

Figure 1 Spatial variation of indoor health index for air quality in dry season

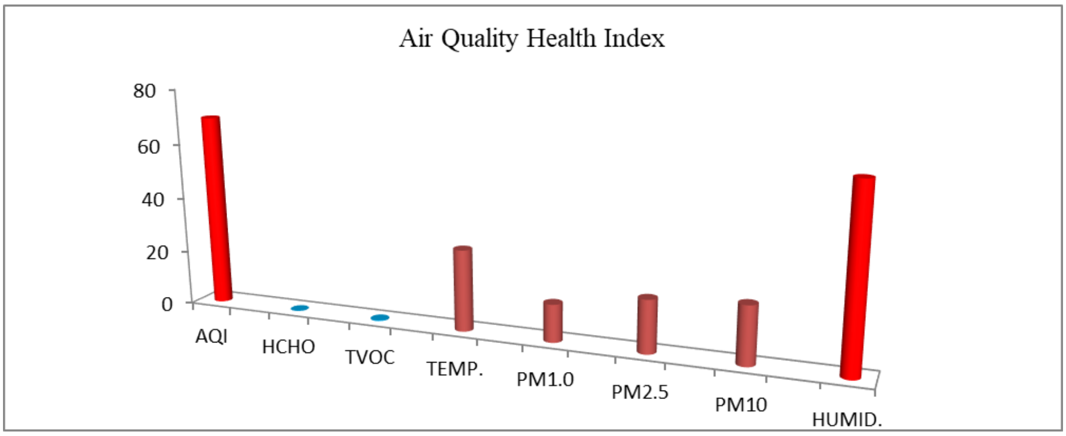

Figure 2 Spatial variation of indoor health index for air quality in rainy season

IV. Conclusions

Studies had showed measured concentration levels of analyzed air pollutant particularly, particulate matters (PM1.0, 2.5 &10.0) concentrations in different households. Furthermore, only few articles compared and contrast comprehensively their results globally to test the significant levels of the indoor environmental factors affecting the sustainability of the environment. However, up until this point, our study has analyzed about 120 peer-reviewed published papers worldwide.The findings of numerous studies conducted by other academics that I have come across indicate that the concentration of particulate matter is higher above the permissible threshold levels.

Author Credit Statement

No funding was given in the form of support in writing the original manuscript draft preparation, Materials and Methods, Writing Reviewing and Editing this paper. Funding is not applicable. In addition, author affirms there is no known conflicting monetary gain connections that might have served as inspiration for the work presented in this article.

Declaration of Conflicts of Interest

The author discloses no conflicts of interest with regards to this work.

Acknowledgement

We acknowledged everyone that contributed in one way or the other to the scientific knowledgeCreativity found in this work. I also thanked staff and colleagues of University of the Gambia, as well as all tutors on environmental contemporary issues in University of Benin, Benin city, Nigeria, for their impactful support and knowledge.

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