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ANALYSIS OF AMBIENT AIR POLLUTION WITHIN KANO METROPOLIS

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ABSTRACT

Models and scant monitoring data point to high concentrations of particulate matter (PM), a significant public health concern in Sub-Saharan African urban regions like Kano.. The analysis was predicated on whether it would be feasible and practicable to use inexpensive air quality sensors (Purple Air-II-SD) to detect ambient air pollutants and other factors influencing them longitudinally throughout the Kano metropolis. During the harmattan period (December 2020), a set of purple air sensors collected data for 31 days within the Kano environment. The purpose of this data collection was to examine the data recovery rate's efficiency and highlight any issues faced by the communities. Additional potential air contaminants and contributors were taken into consideration, including air dust, humidity, anthropogenic ground-level particulate matter, and so on. Through the use of the internet, data created by Purple Air sensors and posted to the Purple Air website was downloaded. The parameters were examined, and recommendations for improving the quality of the air were presented with care for the health of those residing in the research area. Average parameters on record were gathered, and daily recorded data were reviewed, and it was determined that inhabitants are at high risk of being hospitalized as a result of poor air quality caused by particulates. It is a combination of physical and chemical properties that have impacts on short-term exposure, causing lung infections such as chronic bronchitis, heart attacks, irritated eyes, nose, and throat, and long-term exposure, resulting in reduced life expectancy and, eventually, early death.

Keywords: *Particulate matter, ambient air pollution, Kano, Human health, air quality*

I.INTRODUCTION

The health risks associated with ambient air pollution exposure to humans are becoming better acknowledged. However, the amount of risk associated with ambient air pollution in Kano Metropolis is mostly estimated from studies on home air pollution, and its exact scale is uncertain[1]. Numerous illnesses, including hypertension, asthma, lung cancer, heart disease, stroke, arterial thrombosis, and Chronic Obstructive Pulmonary Disease (COPD), are linked to exposure to air pollution. Due to these negative health effects, there is a higher chance of premature death from exposure to ambient air particle pollution, which also increases the number of sick people, emergency room visits, and missed work and school days. The troposphere's low oxygen content is the cause of these consequences [2]. To improve the quality of the air, it is imperative to provide strategies for limiting or mitigating the impact of air contaminants. This can be accomplished by building up the body of knowledge about indoor and outdoor air quality as well as by raising public awareness and advocating for the negative effects of air pollution on health. The total of all solid and liquid particles suspended in the atmosphere, many of which are dangerous to humans, is known as particulate matter. Particles such as dust, pollen, soot, smoke, and liquid droplets are among the inorganic and organic components of this complex mixture[3] . The size, makeup, and source of these particles vary widely. The two main sources of airborne particles are either natural or human-caused phenomena, such as burning fuel or dust being carried by the wind. or indirectly created, when gaseous contaminants that were previously released into the atmosphere recombine their molecules through chemical processes to form particulate matter. Particles' ability to enter and exit the air depends on their aerodynamic characteristics. Additionally, these characteristics control the extent to which particulate matter can enter the respiratory systems of living things through the airways. They also offer details on the origins of the particles and their chemical makeup. The aerodynamic behavior of particles is described in terms of the diameter of an idealized sphere, despite their variable forms. Aerodynamic diameter, sometimes known as "particle size," is the basis for sampling and characterizing airborne particles. Different dimensions and shapes can be found in particles with the same aerodynamic diameter [4]. In terms of aerodynamic diameter, some airborne particles are over ten thousand times larger than others. Particulate matter is primarily separated into two types based on sizes: coarse and fine fractions. The bigger particles, which range in size from 2.5μm to 10μm (PM_{10}–$PM_{2.5}$), are found in the coarse fraction; the smaller particles, which have diameters less than 2.5μm ($PM_{2.5}$), are found in the fine fraction. Ultrafine fractions/particles are those in the fine fraction that are smaller than 0.1μm. Fine particles, which range in size from 0.1μm to 2.5μm, often make up the majority of the overall mass of airborne particulate matter. Even though they make up more than 90% of all particles in the atmosphere, ultrafine particles typically only make up a small percentage of the total mass of particulate matter. Larger solid particles are mechanically broken up to create coarser particles [5].

The coarse fraction can contain non-combustible elements released by the combustion of fossil fuels, dust outbreaks, and dust from roadways, mining activities, agricultural practices, and exposed soil. The coarse fraction may also contain plant and insect fragments, mold spores, and pollen grains [6]. Lastly, the evaporation of sea and ocean salts can result in the production of big particles close to the ocean's coast. These particles are then moved and suspended by wind activity, and when these suspensions react with atmospheric moisture, particulate matter is created. The majority of Earth's atmospheric aerosol load is produced by oceans and arid regions; PM_{10} soil dust and sea salt, respectively, are released into the troposphere. The PM from sea/ocean droplets suspended in the atmosphere, which then evaporates and yields salts like sodium, chloride, magnesium, calcium, potassium, and sulphate, is what makes up sea salt. Because there is no vegetation in the Sahara desert, low soil moisture causes soil particles to be loosely bonded, leading to the formation of soil dust aerosols through wind erosion in arid locations. Ultrafine particles are created via nucleation, which is the first step in the transformation of gas molecules into particles. Fine particles are primarily produced from gases [7]. These particles can expand up to 1µm in size by coagulation, which is the process by which two or more particles join together to produce a larger particle, or condensation, which occurs when more gas condenses on the other particles. Secondary particles are those created when gases in the atmosphere undergo intermediate reactions. It should be noted that burning fossil fuels like coal, oil, and gasoline can release non-combustible materials like fly ash, which can result in coarse particles. Condensation from materials vaporized during combustion produces fine particles, and atmospheric reactions between nitrogen oxides and sulfur oxides that are initially released as gases can produce secondary particles [8] . For both coarse and fine particles in the combined PM_{10} and $PM_{2.5}$ categories, sulfate and organic materials make up the two main components of particulate matter on average. But mineral dust from nearby highways also makes up a significant portion of PM_{10}. PM_{10} surpasses 50µg/m3 when particulate matter concentrations are high. Particulate matter (PM_{10} and $PM_{2.5}$) primarily consists of nitrates, whereas soot—also known as black carbon—contains less coarse particles and between 5 and 10% of tiny particles. According to Basagana et al. [9], the amount of soot along some highways might range from 15% to 20%.

II. PREVIOUS RESEARCH WORK

The primary causes of ambient air pollution in Kano's metropolitan districts include particulate matter, along with emissions from industrial processes, motor vehicle and generator exhaust, and other sources. According to studies, humans can inhale coarse particles (PM_{10}, aerodynamic diameters less than 10µm) and have them lodged in their respiratory tracts. This can have acute health effects like allergies and irritations of the nose, skin, eyes, and throat, as well as serious long-term health effects like cardiovascular disease [10]. Fine particulate matter (PM_1 to $PM_{2.5}$) can, however, enter the pulmonary alveolus deeper and result in asthma attacks and higher death rates. When air quality deteriorates due to the easy accumulation of PM_{10}, $PM_{2.5}$, and PM_1, people often have respiratory system disorders. This is especially true at low wind speeds, which tends to retain the pollutants in the atmosphere for longer. Research has indicated that critical health conditions emerge at low wind speeds [11]. Experiments can offer valuable insights into the dispersion of pollutants and PM transport behavior across all areas for experimental configurations [12] . As a result of CFD models' capacity to replicate the complete flow and concentration fields over a domain rather than just a specific area, it is convenient for CFD to assess airflow patterns and particulate matter concentrations. Particulate matter transport and mechanism are affected by a multitude of factors, including traffic conditions (vehicle movement, vehicle emissions, traffic intensity), building geometry (height, width, and roof type), surrounding building layouts, thermal stratification (solar insulation and orientation, building and street capacitance), and inflow conditions (wind speed, direction, and turbulence) [13] . Micro-scale computational fluid dynamics (CFD) models offer a means of investigating the impacts of several elements that impact the transportation and process of particulate matter. Kumar et al.[14] Large eddy simulations have been used to study the processes of dispersion of contaminants in a solitary region. Aspect ratio has also been utilized to investigate the impact of solar radiation on pollution distribution in a developed region, as well as wind flow and pollutant dispersion in a two-dimensional (2D) pattern [15]. While a study was conducted utilizing wind flow and pollutant dispersion in a two-dimensional (2D) roadway canyon with separate ratios, large eddy simulations were utilized to examine the process of pollutants dispersion within isolated locations [16]. Studies on the canopy airflow patterns and $PM_{10}/PM_{2.5}/PM_1$ transport mechanism in urban areas canopies with different building layouts under low wind speed conditions are still ongoing. Several works have been conducted on the pollutant dispersion and PM transport behaviors around urban street canopies with different building layouts. To help enhance the air quality in our metropolitan regions, more research will be required to examine the fine fraction particulate matter transport mechanism [17].

III. METHODOLGY

The method adopted for this research is qualitative approach, where data is collected and analyzed for better understanding of Kano metropolis environment. Some of the steps taken to issue this is outlined and explained below[18]..

3.1 Data Collection

The Purple Air-II-SD gadget is used to measure the local air quality and provide an environmental reading. When linked to the internet, it utilizes the global positioning system and is powered by a power source. The Purple Air-II-SD gadget employs an integrated sensor to measure the environment in which it is installed when it is powered on and linked to the internet [19]. All of the data acquired by the sensor is stored on a hard drive or micro-SD memory card after the readings are transferred. These data are then saved on the purple Air-II-SD device's web site or storage system. Using the micro-SD card retrievals method, the data/information used in this study was obtained from the Bayero University Purple Air-II-SD device installation center. These information was retrieved, organized, and tallied. Microsoft Excel was used to plot a graph using the tabulated data [20].

3.1.2 Getting Data Using a Wifi Connection

Your sensors must be linked to a Wi-Fi network with an internet connection if you intend to collect data using the PurpleAir Map or the API. This covers configurations made with a mobile hotspot. Your sensors will cease reporting if the linked network loses its internet connection or if it loses its Wi-Fi connection. Sensors that still have electricity will continue to record data to their microSD cards if microSD cards are attached. Nevertheless, the map will not display this data. Issues with mobile hotspots are more common than with standard Wi-Fi networks. Make sure your setup is working properly and pay special attention to the instructions listed below if you intend to use a hotspot [21].

1. Make sure your sensors are still connected to PurpleAir servers by checking them on a regular basis. As long as you want to keep the devices linked constantly, this should be rather simple to accomplish. All you need to do is make sure your devices are still online by visiting map.purpleair.com. Devices that you choose to register as private will remain visible [22].
2. You determine how often to verify the status of the sensor's connection. Please note, though, that you will need to accept a loss of data equivalent to the selected interval. For example, if you choose a two-day interval, there may be up to two days of missing data before the issue is identified.
3. When inspecting your sensors, the PurpleAir map's Uptime data layer might be a useful resource. The duration of a sensor's continuous connection to us is shown in this layer. Additionally, you can check if a sensor has ever suddenly switched off using the map graph and average period option [23].
4. Make sure the map settings are set up correctly so that your sensors can be easily viewed. Most of the settings and your current view location will be preserved to the link when you access the map through it. To check your sensors, we advise you to copy the URL of the map and configure your settings to create a custom link. By doing so, you can make sure you're always using the correct settings and rapidly check your sensors.
5. In the event that your sensor hasn't been reported in a while, the "reporting or modified within" setting can conceal it. To see every sensor that has ever been reported, we advise changing this to "All-time." When the setting is adjusted, your sensors that were hidden in this manner will probably show up as gray on the map[24].
6. Make sure your devices have properly reconnected to the internet in case of an outage. While rare, sensors may stay unplugged once the internet is back up.

3.1.3 Getting Data with a Micro SD Card

Sensors with SD capabilities can store data on a micro SD card. This can be used to get data in places where there isn't Wi-Fi or as a backup source in case your sensors lose internet access. There are a few problems you can encounter if you intend to use SD cards on your devices to collect data. These can include improper SD hardware detection, improper data writing to the micro SD card, or improper appearance of SD data. There are a few things you should think about to address these problems [25].

1. If you need to record data to micro SD cards for any reason, be sure you get Purple Air sensors that support SD cards. The Purple Air Flex, Zen, and Classic-SD are among the suitable models. By default, the Classic lacks a micro SD reader; instead, the SD variant needs to be chosen via the product page's dropdown menu.
2. Check out that article on SD Card Logging and Troubleshooting to make sure you understand appropriate conduct and typical problems that could arise [26].
3. To make sure SD data is being captured correctly, test the sensors before to deployment.
4. Establish a regular check-in time for the SD cards. This procedure would involve taking the cards out and inserting them into a reader to ensure the data is being written as desired. Similar to the last recommendation, you have to accept a loss of data equivalent to the selected interval. If there is a problem, you can lose data for up to two days if your interval is two days.

5. Every piece of data from a device should be written to.csv files on SD cards when using them. Nevertheless, in addition to or instead of the CSV files, data can also be written to.log or.txt files. For files recovered from micro SD cards, we usually advise using Purple Air Utility's SD Data utility utility to identify any recoverable data.
6. Before deploying your sensors, practice using the SD Data Tool so that, in the event that it becomes necessary, the procedure can be expedited in the field [27].

3.2 Data Device Setup

The following structure outlines standard protocols for using, connecting, downloading, and configuring the purple-II-SD device. The following factors were taken into account when choosing the purple Air-II-SD device mounting point for each site. The Purple Air-II-SD device is positioned reasonably far from sources of ground dust, such as rooftop air inlets and unpaved roads, and away from obstacles like trees, tall fences, and buildings. The gadget is set two meters above ground level for uniformity and ease of data comparability, and it should be away from sources of strong traffic on the road, meaning it should be at least 100 meters away from dust or heavily traveled roads. The device is placed away from air conditioning vents, grills, generators, incinerators, and any other source of non-traffic particulate matter. It is connected to the internet for data collection, and an SD card is placed inside the device to save data [28].

3.3 Device Measurement

With the Purple Air-II-SD device, which was linked to the internet and running firmware versions 3.0 and 4.0, measurements of ambient air pollution and concentration were performed. Every two seconds, the device recorded ambient air contaminants for each data record reading. To offer a constant power supply, the device is connected to a solar energy source. The parameters of measured air pollutants are entered into a Microsoft Excel sheet and stored for convenient retrieval [29].

3.4 Data Sampling

A typical pre-coded questionnaire was used to gather data from the sample site (Supplementary file 1). Using a different monitoring form (Supplementary file 2), data was continually gathered throughout daily follow-up addressing the difficulties encountered during installation, use, maintenance, and data download from the Purple Air-II-SD device [30]. Every day, the 24-hour ambient air pollution was computed using the data gathered. When Purple Air devices were not connected to Wi-Fi, researchers would manually download Microsoft Excel files with Separated Value (CSV) files that contained ambient air pollutant data from the device's database. These files would then be sent by email or WhatsApp messaging app to researchers stationed at different locations. When the device was online, data on ambient air pollutants were automatically sent to the Purple Air website, facilitating simple extraction and analysis. An internal Real-Time Clock (RTC) on the Purple Air-II-SD sets itself when it is online. When the device is utilized in SD-logging mode (i.e., not connected to the internet) for prolonged periods, verifications are required to measure the amount of drift [31].

3.5 Data Analysis

Data on ambient air pollutants were obtained from the Kano site for a duration of one month, specifically from December 1st to December 31st, 2020. Every Excel data file with data on ambient air pollutants that was logged every two seconds was noted. To extract daily Particulate Matter with current averages and generate a single CSV file for each study site, each file was first checked and cleaned for mistakes. Afterward, it was run using custom software developed in-house. The data recovery rate was computed by dividing the maximum possible number of hours based on the device sampling rate by the percentage of hours for which PM data was logged in and studied throughout the study period. Using Microsoft Excel, the frequency distribution of measured values by PM threshold categories and the average values of the daily, hourly, and second readings for a period of PM concentrations were calculated based on summary statistics of the data record. Using Microsoft Excel format, the data collected every two seconds was averaged to get readings every day. Another Microsoft Excel sheet was used to tabulate the total averaged values for all ambient air pollutants for December 2020, which was then used to construct the graphs shown in the results.

IV. RESULTS AND DISCUSSION

The following graphs were generated from averaged Data collected from the purple Air sensor of Bayero University, Kano, and these graphs was used for the deliberations appraised below.

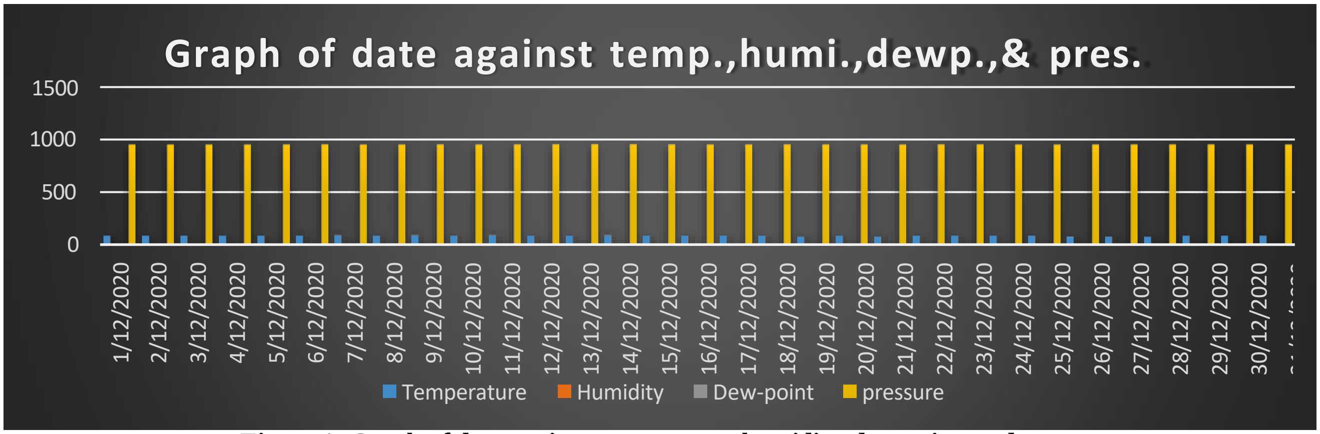
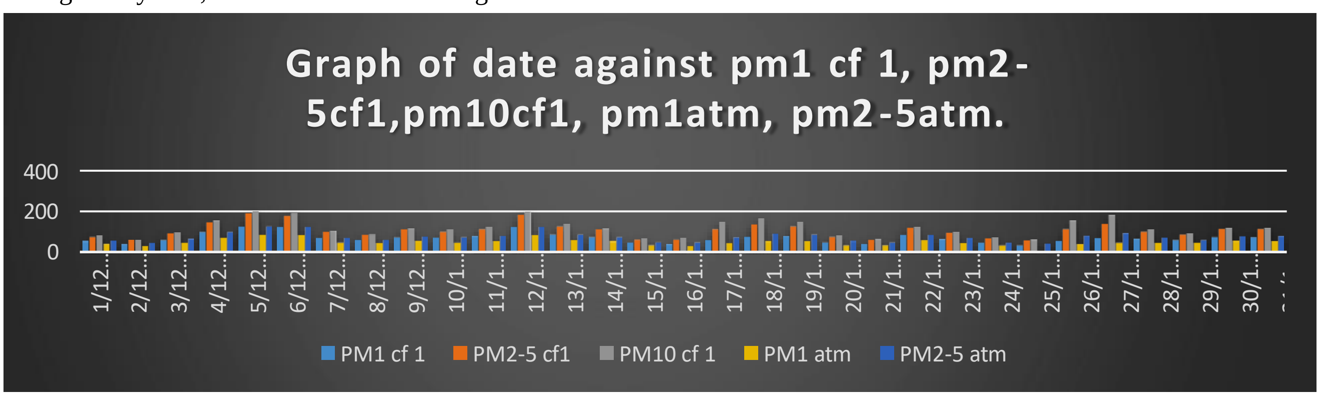


Figure 1: Graph of date against temperature, humidity, dew-point, and pressure.

The preceding figure shows that the pressure during this period is significantly higher than other metrics, and that the temperature, dew point, and humidity all followed suit. According to these data, breathing gets easier at high pressure within sea level, but it gets harder at low pressure because the force that should be pushing good air towards you is lessened because of low gravity. However, at low humidity outside of sea level, there is resistance to the flow of air due to high viscosity on air movement, which makes it difficult to breathe properly and often results in headaches, migraines, and mood swings. Hypothermia is a condition brought on by extremely low body temperature, in which the heart, neurological system, and other essential organs are unable to operate properly as a result of inadequate blood flow. People are unable to move properly or think coherently at low temperatures since the brain is similarly affected. Pressure determines the dew point instead of temperature. Greater pressure causes a lower dew point, which implies that at low dew points, as shown in figure one (1) above, low dew point temperature is related to the impacts of high pressure. The final factor, as shown in Figure one (1) above, is humidity, which indicates that low humidity can cause a variety of health problems ranging from respiratory disorders to skin problems, nosebleeds, dry eyes, sore throats, and an increase in the effectiveness of viruses.



Figue 2: Graph of date against PM_1 cf 1, $PM_{2\text{-}5}$ cf 1, PM_{10} cf 1, PM_1 atm, & $PM_{2\text{-}5}$ atm.

The particulate matter plot from December 1, 2020, to December 31, 2020, as captured by a purple air device, is shown in Figure two (2) above. The crystalline fraction and atmospheric fraction of particulate matter are represented by PM_1 cf 1 and PM_1 atm, respectively; the crystalline fraction and atmospheric fraction of particulate matter are represented by $PM_{2\text{-}5}$ cf 1 and $PM_{2\text{-}5}$ atm, and the crystalline fraction of particulate matter as indicated within the atmosphere is represented by PM_{10} cf 1. Red blood cells measure (7-8) µm in size, while PM_{10} cf 1 is a dust particle measuring (9–10) µm. On the other hand, $PM_{2\text{–}5}$ cf 1 is a dust particle measuring (2–5) µm. Pm1 cf 1 is made up of bacteria measuring (1-2) µm, wildfire smoke measuring (0.4–0.7) µm, and coronavirus measuring (0.1–0.5) µm. The biggest threat to health comes from fine dust particles ($PM_{2\text{-}5}$). These tiny dust particles have the potential to enter the lungs and, in most situations, the bloodstream, blocking arteries and veins and potentially harming the heart or causing strokes. The eyes, nose, throat, and lungs can all be impacted by particulate matter ($PM_{10\text{-}2.5}$), which has a coarse texture. However, these areas receive less attention than the lungs and heart. However, particulate matter (PM_1) has a less direct impact on human health, but it still has a long-term effect. Keep in mind that the volume and density of these particle matter determine the classes of particulate matter based on the readings from both indoor and outdoor sensors.

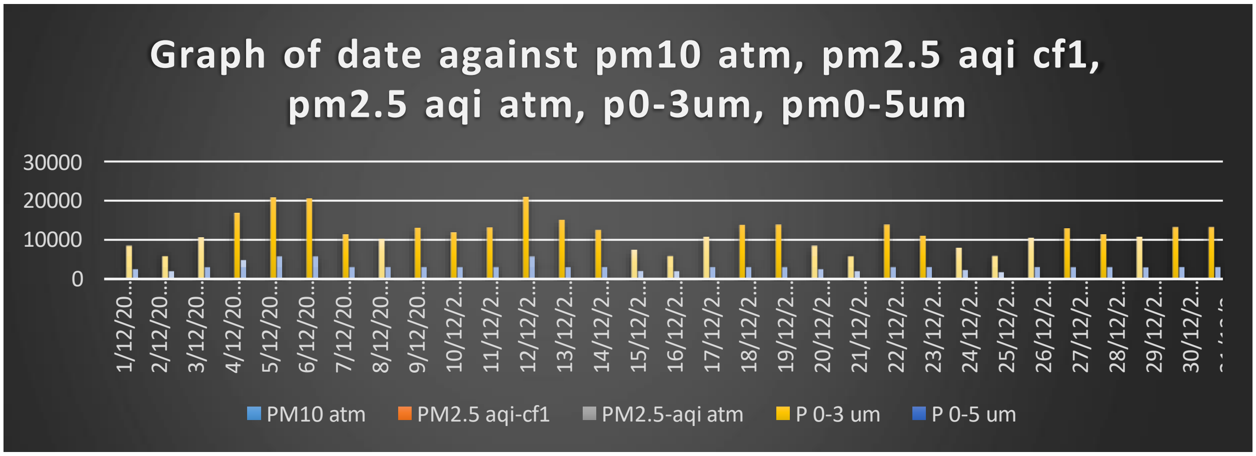


Figure 3: Graph of date against PM_{10} atm, $PM_{2.5}$ aqua cf 1, $PM_{2.5}$ aqua atm, $P_{0\text{-}3}$ µm, & $P_{0\text{-}5}$ µm

The plot of date against PM_{10} atm, $PM_{2.5}$ aqua cf 1, $PM_{2.5}$ aqua atm, $PM_{0\text{-}3}$ µm, and $PM_{0\text{-}5}$ µm is reviewed in Figure three (3). PM2.5 aqua cf 1 is the aqueous crystalline fraction of particulate matter of size 2.5 µm, $PM_{0\text{-}3}$ and $PM_{0\text{-}5}$ are particulate matter of size (0-5) µm, and PM_{10} atm is the atmospheric particulate matter of size less than or equal to 10 µm. The Purple Air gadget detects PM_{10} atm, $PM_{2.5}$ aqua cf 1, $PM_{2.5}$ aqua atm, $PM_{0\text{-}3}$ µm, and $PM_{0\text{-}5}$ µm as particulate matter that appears in different sizes because of the formula utilized in the device's plantower laser counter, which is based on volume and densities. Particulate matter of different sizes can have both short- and long-term negative impacts on health. Long-term impacts can result in early mortality, while short-term repercussions include respiratory conditions including acute and chronic bronchitis, asthma, etc., or even heart disease. It was seen from Figure three (3) above that, by December 2020. Within Kano metropolitan, particulate size $P_{0\text{-}3}$ µm was more prevalent than $P_{0\text{-}5}$ µm.

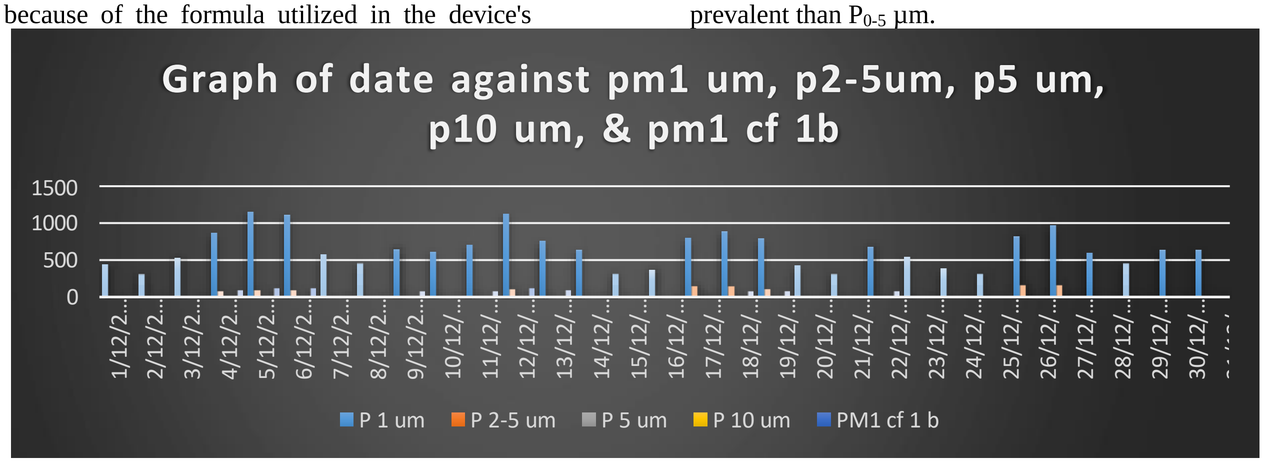
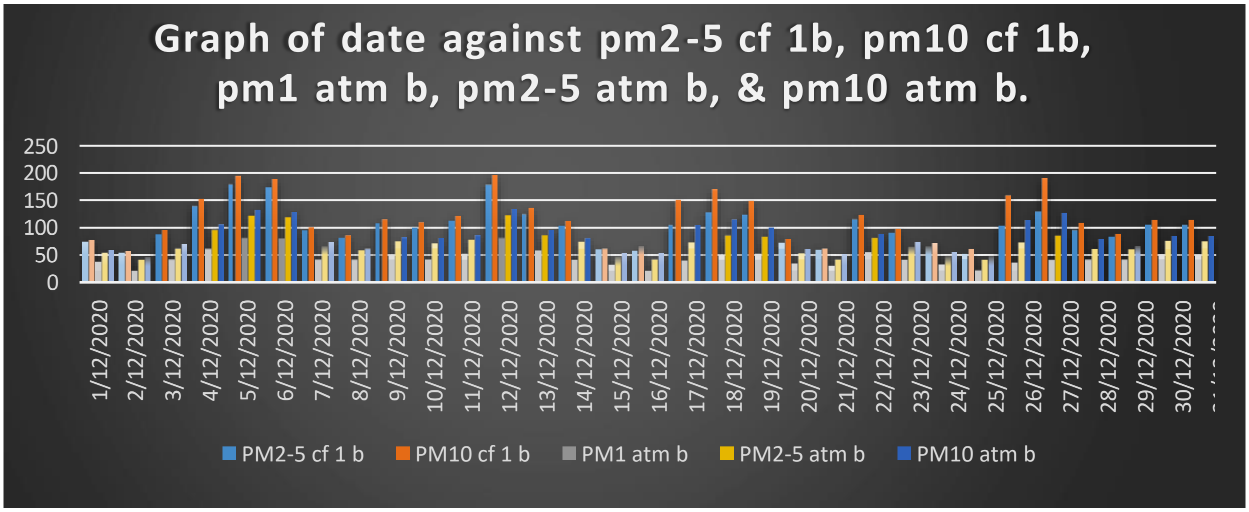


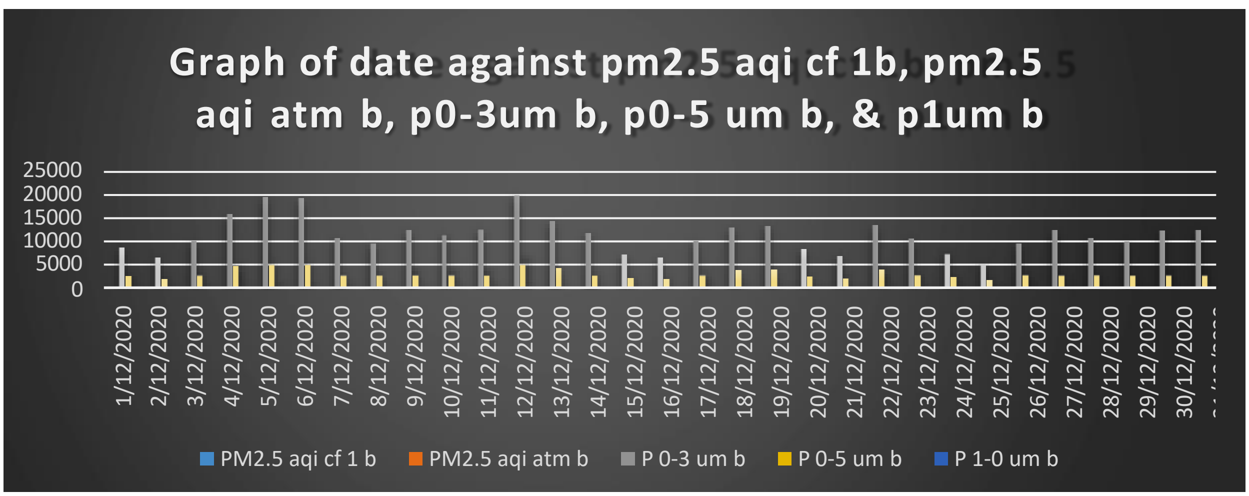
Figure 4: Graph of date against P_1 µm, $P_{2\text{-}5}$ µm, P_5 µm, P_{10} µm, PM_1 cf 1b

Particulate one (1) (P1 µm) was found to be more prevalent in Kano metropolis between December 1, 2020, and December 31, 2020, as shown in Figure four (4) above. In contrast, particulate (2.5) ($P_{2\text{-}5}$ µm), particulate (5) (P_5 µm), particulate (10) (P_{10} µm), and particulate matter (1) cf 1 b (PM_1 cf 1b) were found to be less prevalent in the atmosphere. The fact that this particle appears in the atmosphere in varying amounts on different days is implied by the result shown in Figure four (4) above. The influence on people depends on their availability in the atmosphere, and variations are susceptible to random causes. Humans are affected by these particles and particulate matter both temporarily and over an extended period of time. Physiological research has reviewed how the highly vascularized structure of the human kidney, which receives up to 20% to 25% of the heart's output, makes it a target for exposure to toxic substances, including particulate and particulate matter of sizes less than or equal to 2.5 µm (≤ $P_{2\text{-}5}$ µm).



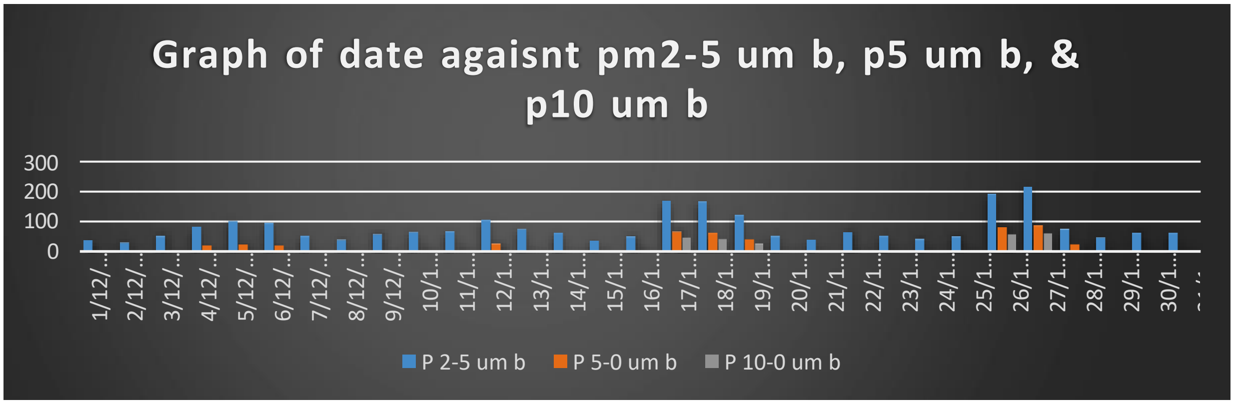
Graph 5: Graph of date against PM_{2-5} cf 1b, PM_{10} cf 1 b, PM_1 atm b, PM_{2-5} atm b, & PM_{10} atm b

As seen in Figure five (5) above. The highest dominated particulate matter in the atmosphere was determined to be particulate matter ten (10) cf 1b (PM_{10} cf 1 b), followed by particulate matter ten (10) atm b (PM_{10} atm b), which was the second highest occurring or dominated particulate matter during that time. However, particulate matter (2.5) (PM_{2-5} cf 1b) was found to be the third dominated particulate matter in December 2020. As of December 1, 2020, to December 31, 2020, particulate matter (2.5) atm b (PM_{2-5} atm b) and particulate matter ten ($PM_{2.5}$) atm b are the fourth and fifth most dominant particulate matter in the atmosphere, respectively. pollutants or contaminants. Instead, it includes liquids that are suspended in the air as well as dust and soil particles. Some, like smoke, smog, and soot, are visible at big enough sizes, but the majority are dangerous. It is possible for this particulate matter to enter both your circulation and lungs. There is less particle matter in the atmosphere the healthier the air. Particulate matter one (1) (PM_1) refers to extremely fine particles with a diameter of less than one micron meter; particulate matter ten (PM_{10}) denotes particulate matter with a diameter of less than 10 microns, or 100 times smaller than a millimeter; and particulate matter two ($PM_{2.5}$),



Graph 6: Graph of date against $PM_{2.5}$ aqi cf 1b, $PM_{2.5}$ aqi atm b, P_{0-3} µm b, P_{0-5} µm b, & P_1 µn b

The graph of date against particle matter is shown in Figure six (6). During this period, particulate matter ranging from zero to three microns (P_{0-3} µm b) was the most prevalent in the atmosphere, while particulate matter ranging from zero to five microns (P_{0-5} µm b) was the second most prevalent particulate in the air. However, because there was little of the other observed particle matter in the air, it was not visible in the displayed graph. While $PM_{2.5}$ particles also come in a variety of sizes, including pollen, spores, and other organic particles, PM_1 particles are the smallest and include dust, combustion particles, bacteria, and viruses



Graph 7: Graph of date against P_{2-5} µm b, P_5 µm b, & P_{10} µm b

Based on the information provided in Figure Seven (7) above, the graph shows the relationship between date and particulate matter for the following sizes: P_{2-5} µm b, P_5 µm b, and P_{10} µm b. The size and degree of dormancy of these particulate matter were found to vary in the atmosphere. From December 1, 2020, to December 31, 2020, particulate matter measuring two to five micrometers (B) is the most prevalent in the atmosphere, according to the graph. Particulate matter measuring five micrometers (B) is seen to appear in the graph in smaller amounts, while particulate matter measuring ten (B) micrometers (P_{10}) is not shown to appear at all. The amount of these particulates at various times during December is shown on the graph.

V. SUMMARY

Pollution increases with the amount of particle matter that accumulates. As can be seen from the above-discussed graph, residents of Kano's metropolitan area will have to deal with a contaminated environment from December 1, 2020, to December 31, 2020. This is because the data analysis revealed that the pollution occurred within this time frame. Different factors affect the body when PM_1, $PM_{2.5}$, and PM_{10} are breathed. These factors include whether or not they can pass through the walls of our airways and enter the body through the nose, as well as how easily they can be stuck in the body and where they will deposit themselves. Particulate matter one (1) (PM_1) can have harmful effects on human lungs when breathed. Particulate matter one (1) particle travels to the lowest point in the lung where a significant portion of it cross the alveolar membranes (the alveoli are the parts of the lung that contain millions of tiny sacs where carbon dioxide (CO_2) and oxygen (O_2) are exchanged). From there, the particle enters the bloodstream and damages the arterial inner walls. It also penetrates tissue in the cardiovascular system and may spread to other organs, including the heart. In the worst cases, particulate matter one (1) can cause fatal illnesses that cause early mortality, such as lung cancer, dementia, emphysema, edema, and heart attacks. Particles of a diameter of 10 micrometers or less are known as particulate matter ten (PM_{10}), and they are small enough to go past the nose and throat and into the lungs. Particulate matter (2.5) (particles having a diameter of 2.5 micrometers or less) are particles so small they can enter deep into the lungs and the circulation; yet, once breathed, these particles can harm the heart and lungs and cause major health repercussions. There is enough data to conclude that prolonged exposure to $PM_{2.5}$ (years) can have a negative impact on health. It is important to remember that PM_{10} comprises $PM_{2.5}$ and PM_1, for additional information. Numerous studies have indicated that there may be health risks linked to particulate matter exposure, including an increase in hospital admissions and deaths from heart and lung conditions. There is currently no proof of a threshold below which exposure to particulate matter does not result in any health impacts, despite substantial epidemiological studies. Both brief and prolonged exposure to particulate matter can have an impact on one's health.

It is believed that the mechanisms of action for short- and long-term exposure vary. Long-term exposure most certainly causes disease and speeds up its progression, but short-term exposure seems to aggravate pre-existing conditions. Hours to days of short-term exposure can result in:

- Ear, nose, and throat irritation.
- Exacerbation of lung conditions such chronic bronchitis, commonly known as chronic obstructive pulmonary disease, or COPD.
- Heart disease patients may experience arrhythmias, or abnormal heartbeats, as well as heart attacks.
- An increase in respiratory and cardiovascular diseases-related hospital admissions and early mortality.

Long-term exposure, however, requires years and can result in:

- Decreased lung function.
- Increased rate of disease progression; emergence of respiratory and cardiovascular disorders.
- Shortened life expectancy.

These findings indicate that particulate matter comes in various sizes and affects people's bodies in numerous ways, most of which result in early mortality.

VI. CONCLUSION

A mixture having distinct physical and chemical properties that change depending on the location is called particulate matter. Particulate matter originates from both natural and man-made sources. Because of this, air pollution varies from location to location, resulting in varying degrees of air quality, depending on the level of pollution present at any one time. Three main categories can be used to classify particulate matter: PM_{10}, $PM_{2.5}$, and PM_1. Particulate matter falls into each category, impacting human health and having the potential to be fatal. The amount of particle matter in the atmosphere and each person's sensitivity in such an environment determine how polluted the air is. Short-term exposure to particulate matter results in lung illnesses such as chronic bronchitis, heart attacks, and irritation of the eyes, nose, and throat; long-term exposure reduces life expectancy and ultimately leads to premature mortality.

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