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Environmental Air Quality Parameters Monitory Information Assessments and Its Health Implications on Biotic Factors in Banjul Metropolis, The Gambia

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Abstract

Air quality is one of the major health issues faced in urban areas in recent years. Pollutants are released into the atmosphere through human activities that have an impact on the living factor (biotic factor), which results in anthropogenic ecosystem degradation. The objective of this research aimed at contributing to a better impact evaluation of the air quality in Banjul on environmental resources assessment. The determinant of pollutants parameter was done with the help of an electronic air meter. Air quality and pollution standard indexes are one of the determinant parameter tools for the measurement, management and control of pollution in any given environment globally. Usually, air quality is used to determine the physical and chemical parameters of the air when compared to the World Health Organization (WHO) of AQI and PSI standards. Parameters used in determining and assessing the rate of pollution in this Banjul region are AQI, CO, NO, NO_2, O_3, SO_2, NH_3, PM_{10} & $PM_{2.5}$. Data collection was done between the month of August and October 2021, Particulate Matter (PM) and gaseous matter samples were taken in Banjul capital of Gambia, Western Coast Region of Gambia, in West Africa. The aim of the research was to assess the occurrence and levels of the chemical composition of gaseous and particulate matter established possible emission sources during morning and evening data collection in the rainy season. Some of the pollutants identified by air meter Ei-360 are analyzed and compositional levels obtained were Carbon Monoxide (CO) which recorded the highest level of as 248.54 ± 17.68 in the evening, 240 ± 0.19.78 in the morning. Ozone (O_3) records were next to the highest air pollutants as 64.40 ± 7.06 in the evening, 57.39 ± 12.29 in the morning, fol-

lowed by Particulate Matter (PM_{10}) as 51.20 ± 13.60 in the evening, 50.55 ± 14.22 in the morning. The lowest pollutant recorded was Nitrogen (II) Oxide (NO), which recorded 0.03 ± 0.006 in the evening and 0.05 ± 0.03 in the morning. The report gotten from this research indicates that gaseous and particulate matter pollutants increases due to the constant usage of vehicles and factory machinery that are not smoke efficiently. Their exhaust (smoke) is released into the atmosphere due to the incomplete burning of octane hydrocarbon. Accumulation of smoke and its condensation released in the atmosphere causes air pollution and an increase in temperature as well as global warming and climate change. Results from t-test analysis showed a significant difference, the null hypothesis was rejected at ($P<0.05$). It implies that gaseous and particulate matter of air quality data collection resulted in significant daily change.

Subject Areas

Environmental Sciences

Keywords

Air Quality Index (AQI), Impacts on Human Health, Environmental Degradation and Management, New Age Technology and Efficient Machinery in Road Construction Development

1. Introduction

In recent years, regarding respiratory problems, numerous amounts of polluted air parameters are continuously spreading and frequently in generating environmental pollution menace, has affected human beings and public health globally, leading to a reduction in average human life expectancy in population. However, educational awareness demands for a healthy and protected safety environment exposure had also been increased exponentially. It was reported about ten years ago, by health scientists that over 7 million deaths were caused by air pollution in the whole world according to a study done by World Health Organization [1]. Studies have shown findings, particularly on gaseous substances and particulate matter effects on pollution. Particulate Matter ($PM_{2.5}$ and PM_{10}) were highly related to the population of mortality and morbidity according to [2]. Recently, with the growth of population and the development of modern technology, pollution in the cities has formed and increased rapidly. The rapid growth of population in the urban cities has resulted in several significant factors such as land degradation, air quality deteriorating, water inequality, challenges on infrastructure due to high level of constructions, fast industrialization and factory growths, living standard globally have increased air pollution thereby degrading the quality of air in the metropolitan environment in the country. Gambia capital, precisely Banjul, is one of the targeted areas in the country in which these levels of air physical and chemical parameters have significantly changed their lev-

els of occurrences. Pollutants in the form of gaseous and particulate substances are air quality pollutant parameters which are released in excess into the atmospheres that cause air pollution as well as degrading the quality of the air when subjected to the index and standard according to the Environmental Protection Agency [3] air permissible standard. The imbalance of the atmosphere is a result of the gaseous and particulate matter released into the atmosphere in the form of pollutants. Environmentally, pollution means the release of pollutants in the form of gaseous chemical substances into the ecosystem of the living entity. When these pollutants are released into the globe (atmosphere, lithosphere, and hydrosphere) through anthropogenic activities due to the high increase in pollution uncontrolled and technological advancement, it results in three different kinds of environmental pollution formed, due to the fact that the air quality has been altered, degraded and tempered with air quality parameters, that leads to air pollution. When this happens, the air quality is degraded, as a result of other noxious substances are released into the atmosphere, air pollution, which means the act of introducing chemical substances in the form of particulate matter and gaseous substances in excess concentration levels or foreign materials into the atmosphere that alter the health of individuals which causes harm to human beings and damages to the environment. Air pollution sources result from different gaseous emissions or the release mainly from the industries, thermal power stations, automobiles, household's fuel, etc. are accumulated gaseous chemical substances in the atmosphere condenses due to a mixture of rainfall with other parameters released in the form of Sulphur (iv) oxide, Carbon dioxide, and other greenhouse gases (SO_2, CO_2, Cl_2, etc.) into the atmosphere from different industries which results in acid rain, and falls back to the land/soil as well as water bodies, hence land and water pollution is formed. All these air quality parameters generated in the environment are through technological advancement and petrochemical industries which bring about deteriorated air quality because of biotic factors that affect the food chain and food web relationship in the environment. Selected qualities of air measurement parameters in this area of study are air quality index which is written as AQI. It is measured in microgram per meter cube. Carbon monoxide in limited supply and carbon dioxide excess supply during the chemical reaction of hydrocarbons in the industries, which are written as CO, NO_2, O_3, SO_2, Ammonia Gas (NH_3), and particulate matter (PM_{10} & $PM_{2.5}$), Nitrogen Mono Oxide (NO), are not detected throughout the sampling period. The quality of air pollution can easily be determined in a workplace according to [4]. This research aimed at using the meteorological instrument, an air meter, of a model Ei-360. The air meter is used to detect the levels of air quality parameters present in the study area, with help of different colour detection. Sometimes when green is detected, it showed that the quality of air is good, excellent indicating that such ecosystem is green vegetation, meaning air quality pollutants free, regarding the parameter indicated, yellow colour shows fair or moderate air quality as shown in **Table 1**.

Table 1. Description of air color and air quality [3].

Air color	Concern levels	Classes	Index values	Air quality description
Green	Good	1	0 - 50	Satisfactory air quality. Air pollution here, pose little or no risk.
Yellow color	Fair/Moderate	2	51 - 100	Acceptable air quality. This category may pose risk for some people, especially those who are usually prone to air pollution.
Orange color	This group is concerned with unhealthy health issues for some sensitive people.	3	101 - 150	Pollutant levels here, members of people in this category are affected due to the sensitive health effects experience by the general public health.
Red color	Concern levels for people is not healthy.	4	151 - 200	Some members of people in this group where the pollutants indicate red color, the general public may experience health effect that some sensitive member may experience very serious health effects.
Purple color	People in this category are very unhealthy.	5	201 - 300	Here, everyone experience the risk of health effects alert.
Maroon color	Hazardous	6	301 an above	Everyone here, are likely to be affected due to health emergency warning condition alert.

The major source of pollution in the atmosphere that causes air pollutions are human activities such as congestion of roads traffic by vehicles, smoke from plants in different industries, wastes with gaseous and particulate matter generated from landfills, roads construction in Banjul metropolis, most of these air pollutant are captured and biologically remediated by plant species. As observed in this research, high concentrations of these gas and particulate matter are at the high level of stations, especially in the closing hour of most likely from 4.00 to 5.00 pm for the five working days. The main components of air quality monitory information according to this study in Banjul were NO_2, PM_{10}, $PM_{2.5}$, O_3, CO and SO_2. These were generally mentioned and detected by the air meter in terms of either colour or readings, on 50% or more of the study area. Oxides of carbon and other air pollutant were found although. Particulate matter (PM_{10} & $PM_{2.5}$), were found only once or twice. The morning and evening visit in Banjul for air

quality data collection for daily variation of gaseous and particulate substances of PM_{10}, SO_2 O_3 and N O_2. Due to the exponential increase in numbers of the vehicle and rapid growth in the number of factories, uncontrolled burning of wildfire individually as well as burning in the industrial areas, there is a numerous amount of gaseous substances that cause wastes, climate change, and pollution into the atmosphere thereby damaging the ozone layer due to excess hazardous substances of Greenhouse Gasses (GHGs). The gaseous wastes contain many gases like Carbon (iv) Oxide (CO_2), carbon monoxide (CO), Sulphur (iv) Oxide, Nitrogen (II) Oxide (NO), Methane (CH_4) and greenhouse gases like Chloro Fluro Carbon (CFC) ammonia gas (NH_3), excess of three oxygen molecules occurrence in the form of Ozone gas, etc. and particles of matter in the form of PM_{10} and $PM_{2.5}$, according to [5]. The temperature of the study area was also investigated during sample collection in the field. Air quality in the Gambia, precisely Banjul, is generally acceptable to some extent, for some individuals. Moreover, sensitive groups of people may experience minor or moderate health challenges, unhealthy to very unhealthy symptoms from long term exposure in the public based on the current air pollutant investigated, Particulate matter (PM_{10}) of air pollutant particles are inhalable by human beings, because of its tiny particles that are lesser in diameter than 10 micrometers. These particles are larger in diameter difference of 7.5 micrometers, due to this difference in diameter; it can be deposited in airways, which results in different health issues. Human beings exposed to the exposure of these pollutants can result to the itching of eyes, as well as making reddish in color throat itching, coughing or difficulty in breathing and aggravated asthma. Moreover, continuous release of this air pollutant into the atmosphere can result in serious health issues and challenges faced by human in such an environment, as seen in the research work done by [6].

Particulate Matter ($PM_{2.5}$) is also another inhalable particulate matter of air pollution quality pollutant with a particle matter less than 2.5 micrometers in diameter, it is been differentiated from the previous, in their diameter sizes which can enter into the lungs through the bloodstream, resulting to serious health issues as well. The most serious and negative impacts these pollutants have contributed in terms of health impact assessments in the environment are basically on the human respiratory organs such as the lungs, heart, alveoli, diaphragm, nostril, etc. of human beings. Uncontrolled exposure to these pollutants in the atmosphere can result in coughing, sneezing, headache in humans, also difficulty in breathing resulting to increase asthmatic symptoms and the development of chronic respiratory diseases. Regarding health, even people can experience public health impacts from polluted air which causes respiratory irritation or breathing difficulties during the exercise of outside activities. The occurrence risks that are unfavorable to humans depend on the current health condition, the pollutant type, the concentration levels, and the location of one's exposure to the polluted air. High air pollution levels can cause instant or no delay health challenging problems such as: frustrated heart issues and breathing illness, additional stress to the heart and lungs circulatory system, which must work harder to supply the body with

oxygen in the blood, destroyed cells in the respiratory system all these are short-term exposure to air pollution. On the other side long-term exposure to polluting with air pollution can have permanent health challenges and effects resulting in the lungs speedy aging, Loss of lung capacity and reduced lung performance, diseases developments such as asthma, bronchitis, and emphysema, possibly cancer, Life span expectancy of affected people is shortened according to [7].

Nitric Oxide (NO), is one of the oxides of nitrogen due to its oxidation number one, hence nitrogen monoxide. It is a colorless gas with a pungent odor, a serious air pollutant generated by automotive engines and thermal power-generating plants. When it mixes with air and hydrocarbon, it burned in an internal-combustion engine or a power plant. Ordinarily, nitrogen in the air combines with oxygen at a very high temperature to form nitric oxide. Sunlight plays a role by causing nitric oxide to react with ozone (O_3) chemically, thereby changing the ozone into molecular oxygen (O_2) [8].

Ozone (O_3) formation occur when the reaction between volatile organic compounds (VOCs) and oxides of nitrogen (NO_x) in the presence of the sun's ultraviolet rays, as the primary source of air pollutants. Mobile sources of these pollutants NO_x and VOCs, include cars, trucks, buses, construction equipment and agricultural equipment. The peak attained by ground-level ozone is during the evening hours of the day. High concentration levels occurred mostly and often during the summer periods. It leads to very limited airways, forcing the respiratory system of human to work harder in order to provide oxygen. Moreover, there is also a death risk associated with patients that contract air pollution diseases with effects on a respiratory organ such as the heart and lung that have the greater effect in the body, according to [9]. Recently, numerous diseases caused by air pollution have been on the increase, as estimated earlier that millions of deaths are caused by both indoor and outdoor air pollution respectively every year [10].

CO is a colorless, odorless, and tasteless gas, when breathing in at high concentration levels it causes headache, nausea, dizziness and vomiting. Long-term human exposure repeatedly can cause cardiovascular complications of the heart stunning, left ventricular dysfunction, pulmonary edema, and arrhythmias. Short-term myocardial ischemia has been reported also, from thrombogenicity increment due to CO poisoning. It is produced when carbon fuels are combusted under the ideal condition that is less. Uncompleted combustion of carbon with air, gives CO instead of CO_2, which should have been used by plants for their food manufacturing in the presence of light through a process known as photosynthesis. Most CO emissions are generated from the transportation sector. Atmospheric exhaust pollution rate concentrations of CO often reflect in the city driving patterns every hour. Highest CO levels occurrence in daily activities during the morning and late afternoon rush hours after closing from work.

SO_2 also affects human functions of respiratory organs, and also stimulates the respiratory tract, thereby increasing asthma and chronic bronchitis in humans, thereby making people more vulnerable to diseases such as respiratory infections.

Different groups of people are most susceptible with regards to severe health problems from air pollution are individuals having heart disease, coronary artery disease or congestive heart disappointment (failure), are the individuals that have diseases of the lungs such as asthma, emphysema or chronic obstructive pulmonary disease (COPD), pregnant women, outside staff activities, elderly and old people, children of age below 14 year old and athlete who exercise Athletes who exercise with powerfully in outdoors activities. On the other hand, group of people who may experience lower health impact of air pollution on exposure levels for a long period of time, their health challenges may be of higher intensities.

1.1. Effects of Air Pollutants in the Study Area Banjul

Air pollution is one of the leading causes of death from non-communicable diseases, after Cigarettes-smoking. The Federal Ministry of health in Gambia has warned that both active and passive smokers are liable to die young, that youths should desist from it. In 2018, a high-level conference held by United Nations on non-communicable diseases (NCDs) reviewed indoor household air pollution as one of the risk factors for NCDs, Coupled with unhealthy diets, smoking and sniffing of tobacco, excessive alcohol consumption that is harmful to human health resulting to heart and kidney problems. Five hundred deaths were recorded about six years ago by World Health Organization European Region that attributed to ambient air pollution of household joint effects on humans. The main associated non-communicable diseases (NCDs) of air pollution are; ischemic heart disease, Paralysis (stroke), chronic obstructive pulmonary disease and lung cancer. Epidemiologically evidence, showed a substantial disease-associated link with air pollution diverse health outcomes, extensively, the study had shown on the mechanistic pathways of advanced understanding of conducted research on these air parameters pollutants. Among the complex combination of air pollutants, particulate matter is a major public health concern. In order to reduce exposure to air pollution and improve air quality, the use of a respiratory dust particle-faced mask may be a new age technology used in reducing and controlling the levels of particulate matter that enters our body through the nostril. It also has a huge potential in protecting health and contributing to reducing the burdens of NCDs, making healthier environments for reducing NCDs can result in multiple benefits for health, global warming/climate change and the atmosphere [11].

1.2. Main Health Effect of Air Pollutant to Humans

Below are the challenges (effects) of air pollutants to humans and other biotic factors, such as:

1) Unfavorable quality of air can kill many biotic factors;

2) Pollutants of atmospheric ozone layer can cause respiratory disease development on human exposure for a longer period of time;

3) In 2010, a study showed the analysis in air pollution in China, Asia conti-

nent and Egypt in Africa continents which estimated a million deaths, according to [12];

4) The excessive mixture of smoke and fog (smog) either in the form of photochemical smog or sulfurous smog levels is what China is been encountering for a longer period of time, due to damages and health challenges human-faced. It had also showed about 50,000 people are eliminated yearly in the United State of America due to these air pollutant issues.

1.3. Air Pollution Control

These are methods used to control air pollution; they are divided into two different types. They are:

1) Particulate Matter Emission Control (PMEC) examples are Stack air pollution depression, filter, wet scrubber, respiratory faced mask, etc. are used to control smoke, soot, and dust particles that are released into the atmosphere and in the environment during industrial operations and Agricultural activities;

2) Gaseous Emission Control (GEC). On the other hand, are gaseous substances that are generated and released from factories and industries as polluted gaseous products that pollute the stratosphere of the environment; they include oxides of sulfur (SO_x), oxides of carbon (CO & CO_2) and oxides of nitrogen (NO_x) released during various processing and manufacturing operation, which can be controlled by the use of electrostatic precipitator, airbag oxidizer, cyclone separator, etc.

1.4. Air Pollution Mechanism

The complex toxins of air pollution, with regards to ecotoxicology in the environment, are causing the central nervous system through various correlated mechanisms that may lead to Central Nervous System (CNS) disease. These effects of air pollution mechanisms can be subdivided into four distinct groups as systematic inflammation, particulate matter, absorbed compounds and ozone.

1.5. Bioremediation

This is the biological method of solving environmental problems through planting trees or culturing microorganisms in order to get rid of those environmental pollutants. Planting trees in our surrounding we are saving the earth more from global warming and climate change. Adapting to trees planting and growing of plants brings about "the New Age Cleaning Technology" in the environment. Awareness of tree planting in regards to doing the right thing at the right time, we choose to adopt this part of environmental solution significantly. The 21st new age technologies of air pollution reminder are as follows:

1) Smoking should be stopped; at least no smoking indication should be followed;

2) The use of unleaded gasoline in your cars instead of leaded gas;

3) The use of fuel and smoke efficient burning cars should be adopted in the road;

4) Instead of driving a car always, share a bicycle ride as well as engaged in car-

pooling;

5) Sometimes one should choose to walk and jog whenever possible, which makes you keep fit;

6) Do not incinerate in the open in order not to cause air pollution.

1.6. Ozone Destruct Devices Technology for Oxidation of Air Pollutant

Under ozone destruct devices, we have Catalyst Destruct Unit (CDU) for ozone destruction safely revert ozone to oxygen using this catalyst ozone destruct devices. These devices are suitable for wet or dry ozone gas streams. Ozone off-gas or wet ozone gas can be destroyed safely, with the Catalyst Destruct Unit (CDU), devices with an optional heater band available with each unit. The optional water trap is also available to remote bulk moisture from the gas stream. When used for the dry gas stream, the capacity of each catalyst destruct unit device destruct essentially doubles as a result of the lower contact time required for adequate and appropriate ozone destruction. Specification for detail larger units and customized units are available upon request.

1.7. Gas Destruct Unit

At rated flow rate, these destruct units perform 99.96% ozone destruction, designed for high ozone concentration. Rated flow rate based on 10% ozone concentration. Dry ratings assume a gas stream with a dew point of zero or no degree Fahrenheit typically the output of an ozone generator is considered dry. Wet ratings for streams are the one with humidity in the gas stream.

1.8. Ambient Air Destruct Units

With regards to rated flow rates, these destruct units perform 90% destruction of Ozone, designed for operation in a room, chamber, or area where Ozone concentration levels are in a space need to be lowered. It suggests that this can be used in the area where Ozone levels are 200 ppm or lower. A good example of such device is the CDA-75 Ozone Scrubber (75CFM & 550) and CDA-250 Ozone Scrubber (250CFM & 950).

1.9. Ultraviolet Water Purification System

The Ultraviolet purification systems are capable of destroying Ozone efficiently from water. This system uses ultraviolet radiation from germicidal ultraviolet lamps to purify water in the environment that must have caused air pollution.

1.10. Destruct Unit Replacement Parts

Replacement of destroyed pieces of parts is to repair your destruct units. These parts are compatible with either the Catalyst Destruct Unit (CDU) or Catalyst Destruct Ambient (CDA) destruct units. Example: Ambient Destruct media, CDA destruct units, and Care lite CDU destruct units.

2. Methods of Study

The study method employed in this research is that of quantitative method, which involves the use of Air Quality meter with model Ei-360, to measure the concentration levels of different air quality parameters as well as their different color index categories.

2.1. Description of Study Area

These studies were carried out in Banjul, capital city of Gambia, West Africa. The Gambia city, Banjul, officially was known as Bathurst. Banjul is the capital city of Gambia; it has a total pollution of about 34,828 meter Squared people. In addition to the Greater Banjul Area, which comprises of Banjul City (BC) and Kanifing Municipal Council (KMC) has a total population 357,238 meter Squared according to 2003 Census. Banjul has Latitude of 13˚27'0.9" N and Longitude of 16˚34' 40" W. Banjul is bounded on the Western Coast Region of the Banjul Island towards the River Gambia, which enter into the Atlantic Ocean. The Island converge, covers the mainland to the west, the rest parts of Greater Banjul Areas through the construction of the bridges.

2.2. Sampling Technique

The samples were collected from August 2021 to October 2021 on daily basis. The sampling station was visited twice daily for the study period, in the morning time and evening. Air quality parameter indicator samples such as Air Quality Index (AQI), Carbon Monoxide (CO), Nitrogen Monoxide (NO), Nitrogen Dioxide (NO_2), Ozone (O_3), Sulphur Dioxide (SO_2), Ammonia (NH_3), particulate matter (PM_{10} & $PM_{2.5}$) were collected in the early hours of the morning between 8.30 am to 9.00 am and 4.00 to 4.30 pm for the evening sampling of Air Quality parameters in each sampling day, in order to ascertain the daily variation of some of the detected air pollutant level of concentration, as well as their rates of polluting the stratospheric environment.

2.3. Sample Collection

A total of 324 samples of air atmospheric pollutants indicator as stated above in the sample techniques consists of nine different gaseous air quality pollutant indicators, including both gaseous substances and particulate matter were collected for duration of three months. In each month, one hundred and eight (108) samples of air quality assessment monitory parameters were collected for three months, both in the morning and evening hours with different occurrences level including colour indication for good, moderate, poor, unhealthy, very unhealthy and hazardous for human health in the capital city of the Gambia, Banjul according to Environmental Protection Agency [3].

2.4. Sample Preparation

Samples of air quality monitory information assessment pollutants were subjected

and prepared for this study in order to obtained accurate readings with the use of electrical gadget known as electronic air meter, model Ei-360. This air meter model uses internet facility in them in order to get accurate air pollutant parameters. The screen of the air meter is cleaned properly with white handkerchief or tissue paper properly, before the start of operation and readings collection indicated with this meter. As soon as the stations were visited in each collection day, air meter is connected to the internet and subjected it to the atmospheric pollutant for it to function well; the necessary atmospheric air pollutants indicators are indicated immediately, the levels and concentration of each parameter and readings were taken. Air meter is immediately used when it is switched on, in the study locations as soon as the researcher gets to the study station, to take the necessary available parameter daily readings including the temperature of the area as indicated in the air quality meter screen, and make sure the meter battery is fully charged to avoid pollutants parameters reading disruption. The temperature at which the readings were taken is between 26˚C - 32˚C for in the morning and in the evening. Although, in the evening, readings were more difficult compare to that of morning readings, the reason is due sun rays reflection on the screen of the meter, if not handled properly may lead to the total damage of the air meter screen to be opaque that will make readings not to be transparent and visible.

2.5. Air Quality Determination/Analysis

Air Quality measurements of some different pollutant parameter indicators such as Temperature, AQI, CO, NO, O_3, SO_2, NH_3, PM_{10} and $PM_{2.5}$ were determined with the use air meter, to ascertain the levels of damaging effects done to the atmosphere and warming of the globe in Banjul metropolis and its implication on human health's and the environment. Some of these indicators detected by the air meter as a result of their of their levels of concentration as well as different coloration categories index describes the level of concern such as green coloration, good or excellent, ranges from 0 - 50 values of index, yellow coloration, moderate, ranging from 51 - 100 values of index, orange coloration, for unhealthy for sensitive groups of people, ranges from 101 - 150 values of index, red coloration, unhealthy, ranges from 151 - 200 values of index, purple coloration, very unhealthy ranging from 201 - 250 index value and maroon coloration, hazardous ranges from 251 an above values of index.

2.6. The Statistical Analysis

Simple statistical measurement of central tendency and dispersion was used to determine station mode of sampling collection in terms of morning and evening Air Quality indicators assessment concentration. Inter-station (morning and evening) comparison were carried out for test of significant levels of differences in Air Quality Index concentration using one way nonparametric analysis of variance (ANOVA) or the paired t-test for testing significant difference, this is said

to occur in pairs simply means each observation in the morning (Station 1) is correlated with the observation in the evening (Station 2), for each air meter parameters, samples were performed separately using variables such as morning visit (Station 1) and evening visit (Station 2), according to [13]. The significant differences among the stations mean values were determined using a single factor (one way ANOVA) to test for the hypothesis. Graphical representations were done in Microsoft Word (Tables 2-4).

Table 2. Air quality morning data collection of gaseous and particulate parameters in Banjul Metropolis, Gambia.

Parameters	Units	N	Mean ± SE	SD	%	Range in parentheses
Temperature (T)	˚C	21.00	25.57 ± 1.23	5.64	7.90	24 - 30
Air quality index (AQI)	$\mu g/m^3$	21.00	2.67 ± 0.36	1.65	0.82	1 - 5
Carbon monoxide (CO)	$\mu g/m^3$	21.00	240 ± 19.78	90.66	74.10	87 - 378
Nitrogen (II) oxide (NO)	$\mu g/m^3$	21.00	0.05 ± 0.03	0.12	0.02	0.01 - 0.51
Ozone (O_3)	$\mu g/m^3$	21.00	0.73 ± 0.16	0.73	0.23	0.17 - 3.38
Nitrogen (IV) oxide (NO_2)	$\mu g/m^3$	21.00	57.39 ± 12.29	56.31	17.71	19.13 - 279
Sulphur (IV) oxide (SO_2)	$\mu g/m^3$	21.00	0.94 ± 0.27	1.26	0.29	0.12 - 4.47
Ammonia (NH_3)	$\mu g/m^3$	21.00	0.14 ± 0.06	0.25	0.04	0.01 - 0.79
Particulate matter (PM_{10})	$\mu g/m^3$	21.00	50.55 ± 14.22	65.14	15.60	1.15 - 253
Particulate matter ($PM_{2.5}$)	$\mu g/m^3$	21.00	22.73 ± 8.47	38.81	7.02	0.76 - 70

All values expressed as mean ± S.E (Range), CI = 95%, Error = 5%, n = 21.

Table 3. Air quality evening data collection of gaseous and particulate parameters in Banjul Metropolis, Gambia.

Parameters	Units	N	Mean ± SE	SD	%	Range in parentheses
Temperature (T)	˚C	21	28.76 ± 0.28	1.30	8.87	26.00 - 31.00
Air quality index (AQI)	$\mu g/m^3$	21	2.76 ± 0.37	1.70	0.85	1.00 - 5.00
Carbon monoxide (CO)	$\mu g/m^3$	21	248.54 ± 17.68	81.02	76.76	29.00 - 358.00
Nitrogen (II) oxide (NO)	$\mu g/m^3$	21	0.03 ± 0.006	0.03	0.01	0.01 - 0.08
Ozone (O_3)	$\mu g/m^3$	21	0.59 ± 0.16	0.73	0.18	0.04 - 40.00
Nitrogen (IV) oxide(NO_2)	$\mu g/m^3$	21	64.40 ± 7.06	32.33	19.88	0.09 - 129.00
Sulphur (IV) oxide (SO_2)	$\mu g/m^3$	21	1.12 ± 0.42	1.94	0.35	0.09 - 7.00
Ammonia (NH_3)	$\mu g/m^3$	21	0.19 ± 0.08	0.31	0.06	0.01 - 1.30
Particulate matter (PM_{10})	$\mu g/m^3$	21	51.20 ± 13.64	62.34	15.80	3.21 - 178.00
Particulate matter ($PM_{2.5}$)	$\mu g/m^3$	21	15.22 ± 3.21	14.73	4.70	0.97 - 37.00

All values expressed as mean ± S.E (Range), CI = 95%, Error = 5%, n = 21.

Table 4. The t-test, mean values of data collection variation of evening and morning Air Quality gaseous and particulate matter pollutant and in Banjul capital city of Gambia.

	Parameters	Units	Evening (E)	Morning (M)	Variation (E − M)
1	Temperature (T)	˚C	28.76	25.57	3.13
2	Air quality index (AQI)	μg/m^3	2.76	2.67	0.09
3	Carbon monoxide (CO)	μg/m^3	248.54	240.00	8.54
4	Nitrogen (II) oxide (NO)	μg/m^3	0.03	0.05	−0.02
5	Nitrogen (IV) oxide (NO_2)	μg/m^3	0.59	0.73	−0.14
6	Ozone (O_3)	μg/m^3	64.40	57.39	7.01
7	Sulphur (IV) oxide (SO_2)	μg/m^3	1.12	0.94	0.18
8	Ammonia (NH_3)	μg/m^3	0.19	0.14	0.05
9	Particulate matter (PM_{10})	μg/m^3	51.20	50.55	0.65
10	Particulate matter ($PM_{2.5}$)	μg/m^3	15.22	22.73	−7.51

N = 10, **10** **n = 11.98**

SD = 24.17, **23.23** **Mean (π) = 1.198**

$$\text{Standard Error}(s\pi) = \text{Standard Deviation divided by the Square root of } N$$
$$= (24.17 - 23.23) \div \text{square root of } 10$$
$$= 0.94 \div 3.1623$$
$$= 0.297$$

Apply the t-test formula:

$$t = (\pi - \mu) \div \text{S.E}(s\pi) = (1.198 - 0) \div 0.297 = 4.034$$

$$t_{cal} = 4.034$$

$$t_{0.05}(2)9 = 2.26$$

2.7. Test for Hypotheses

There are two types of hypothesis test as stated below as null hypothesis and alternate hypothesis.

Null Hypothesis (H_O): ***This state that there are no significant differences between air pollutant parameters of gaseous and particulate air quality data collection in Banjul.***

Alternate Hypothesis (H_A): ***There are significant differences between parameters of gaseous and particulate air quality data collection in Banjul.***

Since the calculated ***t*** value (**t_{cal} = 4.034**) is greater than the critical value or tabulated value, **$t_{0.05}$ (2) 9 = 2.264**. The Null hypothesis is rejected (P < 0.05). This means parameters of gaseous and particulate air quality data collection resulted to significant daily change.

3. Results and Discussion

Using the data collected for the morning and evening air quality parameter pollutants detected by the air meter model Ei-360, the mean concentration of each pollutant, were determined using hour's daily variation.

3.1. Temperature Concentration

The temperature of any given area is the degree of its hotness and coldness of that area. It is measured an instrument called thermometer. The temperature of the study area, Banjul metropolis ranged from 24˚C - 31˚C (**Table 2** and **Table 3**). All values were within the maximum permissible limits of 25 - 31 for air quality weather condition in any given environment or ecosystem according to work done by [14]. The temperature recorded in this research were in agreement with the previous studies reported Lome, Togo according to [6] [15] [16]. The temperature mean value recorded in the morning is 25.57˚C ± 1.23˚C and evening temperature recorded was 28.76˚C ± 0.28˚C, the highest temperature was found in the evening hour compared to the morning readings. This is because temperature increase results from the hotness of the day due deforestation and insufficient planting of trees that supposed to reduces the hotness of the sun as it rises which will bring the hotness and variation of the weather condition. This is one major contributing factor in capital city of the Gambia, Banjul metropolis, due to the fact new age technology that involves the planting of trees that supposed to reduce the hotness of the weather in that particular environment are not adopted and practiced because of city development, the capital city, Banjul will continue to be very hot until the new age technology of planting ornamental trees is adopted.

3.2. AQI Concentration

The standard is use to determine the air quality. The air for morning, evening readings ranged from 1 - 5 μg/m^3. The mean value of air quality index in the morning recorded 2.67 ± 0.36 μg/m^3 which accounts for 0.82% as the lowest compared to the mean value of AQI recorded in the evening as 2.76 ± 0.37 μg/m^3 with 0.85% as the highest due to the release of exhaust from vehicles and other air quality pollutants parameters that degrades the quality of the air. Although, the proportion of the air quality here remain good which falls in the class 1 proportion with green colour air quality satisfactory, this pose little or no risk to occupants staying in this study area. Air quality pollution cannot be only altered or tempered with fumes and exhaust coming out from our vehicles, rather air pollution can also be caused by fire set in a pit according to [17].

3.3. Carbon Monoxide Concentration

Carbon Monoxide (CO), in some text books, is called carbon (II) oxide as the case may be. The minimum and maximum values of morning and evening readings from Banjul metropolis ranged from 29 - 378 μg/m^3. The average mean value

of carbon monoxide recorded in the morning was found to be 240 ± 19.78 μg/m^3, which still give about 74.10% of exhaust pollution in the environment and 248.54 ± 17.68 μg/m^3, recorded in evening with 76.70%. Comparing both of them, the evening reading, recorded the highest while morning readings recorded the lowest, but both of the falls in the class 5 proportion, according to EPA, 2010. It is one of the major air pollutant observed in the study area (Banjul) due to its metropolitan environmental nature. The excess of its exposure results to the production of carbon dioxide which brings about global warming and climate change according to the work done by [18]. In this class 5, of gaseous air pollutant parameter, their values fall in purple coloration which depicts very unhealthy to the public. The health alert here, showed increased risk of health effect to everyone, except government embark on vehicles and other industrial machinery that are efficient to smoke burning, stop incineration of waste in the capital city, and stop importing goods and services that does more negative impacts to the environment than the positive impacts. We should adopt the use of positive five "P" **(5P)**. The positive five p strategy approaches stands for Proper Planning Provide Prevalent Performance of the air quality pollutant as a waste in Banjul, according to work done on waste in Serrekunda, in Gambia by [19]. In environmental Chemistry, study had shown that during combustion reaction of alkane's family, (burning of fuel) for instance, methane react with oxygen (air), in limited supply, gives carbon monoxide, which causes air pollution in the environment, in excess supply of air with methane, it gives carbon dioxide which is one of the major cause of climate change and atmospheric global warming. Both carbon monoxide released from exhaust of vehicle during burning of hydrocarbons affects the environment, on the other hand, the excess supply of it in the air gives carbon dioxide respectively, these are the major air quality parameter in the capital city of Gambia, precisely Banjul metropolis.

3.4. Nitrogen Monoxide Concentration

Nitrogen Monoxide (NO) concentration for both morning and evening readings is summarized in (Table 2 and Table 3). It ranged from 0.01 - 0.51 μg/m^3. The mean value recorded in the morning (station 1), was 0.05 ± 0.03 μg/m^3 which accounted for 0.02% and mean value nitrogen monoxide recorded in the evening was lower, which had 0.03 ± 0.006 μg/m^3 with 0.01%. This shows green coloration indicating excellent indication. The mean values of nitrogen monoxide recorded in the morning were higher compared to the mean value recorded in the evening. It was still within the pollution standard index rate as stated by the international body of Environmental Protection Agency.

3.5. Ozone Concentration

Ozone (O_3) is a gaseous air parameter, which is composed of three atoms of oxygen. It occurs due to air pollutants given off by our vehicles in the form of exhaust, smoke from power plants, industrial boilers, refineries gas flare, and chem-

ical plants, etc. It can also be spread in a distance by wind; especially most people in rural areas can experience high levels of ozone concentration than those urban area dwellers. Its concentration in both Table 2 and Table 3 ranged 0.04 - 40 μg/m^3. The highest mean value was recorded as 0.73 ± 0.16 μg/m^3 in the morning time, with a percent of 0.23% compared to evening mean value, which had 0.59 ± 0.16 μg/m^3 which accounted for a percentage rate of 0.18%. Their concentration are usually low in the cities because they are secondary pollutants of the air pollution, this means they are not generated by themselves rather from another source like vehicles that makes them secondary pollutant, according to [20].

3.6. Nitrogen Dioxide Concentration

Nitrogen dioxide in both morning and evening concentration in Banjul ranged 0.09 - 279 μg/m^3.

In Table 2, the average mean concentration recorded value of nitrogen dioxide is 57.39 ± 12.29 μg/m^3 recorded lower concentration value, with a percentage rate of 17.71% compared to the evening mean value, which records 64.40 ± 7.06 μg/m^3, higher than the morning average mean value. The percentage rate of evening nitrogen dioxide records was 19.88%, slightly greater than the percentage rate in the morning. This is due to weather alteration and changes as well devices resulted in generating this air pollutant. They belong to the class 2 air quality index, their level of concentration is fair and moderate due to the yellowish coloration they possess. The quality of air here is acceptable, but they may be risk especially some of them that are aware and able to understand other people and their feeling to air pollution. Nitrogen Dioxide (NO_2) is a gas of indoor and outdoor air pollutant. It mixed with water to produce a strong acid (HNO_3) and nitrogen monoxide, in oxidation and reduction reaction, sometimes, its chemical equation can also be written as the reaction between two molecules of nitrogen dioxide reacting with water to give two different acids trioxonitrate (v) acid and trioxonitrate (iv) acid (strong and weak acid) are formed respectively as products. Health associated diseases on exposure to this nitrogen dioxide gas to the public, generate health issues, in which individual will be at risk in excess supply of this gas and difficulty in respiration which result to asthma, coughing and severe sneezing continuously.

3.7. Sulphur Dioxide (SO_2)

Sulphur Dioxide or Sulphur (IV) Oxide air pollutant parameter n Banjul metropolis, for daily records in the morning and evening in (Table 2 and Table 3), ranged 0.09 - 7.00 μg/m^3. The mean value concentration recorded in the morning is 0.94 ± 0.27 μg/m^3, while the evening daily concentration values records 1.12 ± 0.42 μg/m^3. Both readings had a percentage rate of 0.29% and 0.35% respectively, but their readings were within the maximum pollution standard. They are in class 1 of the air quality values of index, with green coloration for good. Here, the air pol-

lutant pose little or no risk, it is satisfactory, because majority of occupants or individuals that work here don't experienced skin irritation because their pollution rate is minimal, still a minor air pollutant parameter detected in a study area, study had shown according to the work done by [21], that the air pollutant of two different places can never be the same due to the fact that appliances of different technologies used in terms of vehicles, electronics, etc. does not have the same level of pollutant concentration according to [22].

3.8. Ammonia (NH_3) Concentration

The concentration of ammonia gas as air pollutant parameter in the morning and evening reading in the study area in the capital city of Gambia, Banjul metropolis ranged from 0.01 - 178 μg/m^3. The average mean value of ammonia concentration recorded in the morning was 0.14 ± 0.06 μg/m^3, with a percentage rate of 0.04%, compared to the evening mean value of ammonia gas which had 0.19 ± 0.08 μg/m^3 with a percentage rate of 0.06%. The evening daily average mean value recorded highest in comparison to the daily morning average value of ammonia gas concentration. Although, the ammonia gas pollutant is within the threshold limits of pollution standard index value, their greenish coloration of both morning and evening records shows green color indication which does not pose risk to the people despite the fact that many.

Refrigerator uses ammonia gas as a refrigerants as well as the oldest gas that can be compressed easily.

3.9. Particulate Matter (PM_{10})

The Particulate Matter (PM_{10}) is inhalable air pollutants with a diameter less than micrometers. Particulate Matter (PM_{10}) in both morning and evening readings ranged 0.01 - 179 μg/m^3. The mean value recorded in the morning was lowest, which had 50.55 ± 14.22 μg/m^3, with a percentage rate of 15.60% and the average mean value of particulate matter (PM_{10}) recorded in the evening reading was highest, which had 51.20 ± 13.64 μg/m^3 and percentage rate of 15.80%. Both morning and evening readings indicated red coloration, which shows that the air quality is very poor. The increase in particulate matter in the evening was as a result of dust particles in the study area, road traffic congestion coupled with particles that are removed from vehicle exhaust pipe which is the major cause of pollution in this study area. Epidemiologically, disease associated with this kind of air pollution asthma, coughing, difficulty in breathing, severe chest pain, chronic headache, etc. Some of the members in this level of health category are unhealthy, and general public may experience serious health challenges, this agreed with [23].

3.10. Fine Particulate Matter ($PM_{2.5}$)

Atmospheric air pollution of fine Particulate Matter ($PM_{2.5}$) is also inhalable air quality pollutants with particles less than 2.5 micrometer in diameter, which en-

ters the lungs and blood stream, results in a serious health challenges of human beings. Fine Particulate Matter ($PM_{2.5}$), of both readings ranged from 0.76 - 70 μg/m^3. The mean value recorded in the morning of fine particulate matter ($PM_{2.5}$) concentration was 22.73 ± 8.47 μg/m^3, and percentage rate of 7.02%, as the highest in comparison with the mean value recorded in the evening which had 15.22 ± 3.21 μg/m^3 with a percentage rate of 4.70%. Here, the reading in the morning recorded highest due to atmospheric fluctuation of vehicle movement and weather condition, this is in accordance with [24].

4. Summary

This research had stressed its significance on one to be aware of related contemporary environmental issues faced by people in the study area and other department with regards to theoretical emphasis and focus on environmental sustainability for future generation of everyone in the Gambia to benefit from it. Rather than focusing on unsustainable plan that will not bring sustainable development to the country, all the products that are imported into the country should be subjected into the country pollution standard, any of the goods that did not meet up to standard should be return back to where they been sent from. Government of Gambia should all introduce pollution pay cost (ppc) strategy that will bring about profit maximization positive externality of Internal Generating Revenue (IGR) of pollution to the country. As well as pollution proper planning provides prevalent performance (6P) health risk adoption.

4.1. Recommendations

Based on the findings of this research, the following recommendations were made in the study area and other parts of the country as:

1) Government should draft a master plan called Government Implementing Plan (GIP) that helps to monitor pollutants concentration levels in the country and improve the area;

2) They must be Government Description Plan (GDP), which must be given as a measure and standard for polluter, in order not to pollute the environment rather improve the quality of air in the country;

3) Government air quality pollutant standards for designated area in terms ma "maintenance area" of less air pollutant;

4) More roads network should be constructed to avoid road traffic congestion that increases the risk of air pollution;

5) Vehicles coming from abroad as import goods should be of fuel efficient, good octane number as well as zero smoking;

6) Sophisticated and electronic tools for smoke detection should be deploying in the port authority in order to check mate these pollutants in the environment;

7) Biological remediation such as phytoremediation should be encouraged in the country which is one of the new age technology to reduce and control pollution in any given environment.

4.2. Conclusion

The results in this research showed that vehicles' manufacture due to technological advancement at the manufacturing level should be given conditions on the efficient concentration level of CO_2 in both excess supply of fuel-burning and CO concentration in the limit of fuel burning via the exhaust (smoke) that comes from their smoke exit pipe while in motion respectively. As these vehicles accelerate in motion on the road dust particles of particulate matter (PM_{10} & $PM_{2.5}$) are generated which is also another major type of air pollutant parameter that pollutes the air. On the other hand, the quantity of air is altered due to these pollutants generated from our vehicles which are not friendly to the environment in terms of the negative environmental impacts assessment to the health of people as a result of Social Impacts Assessment (SIA) and Health Impact Assessments (HIA) carried out respectively. This tends to threaten the life of people and other biotic species because of the risk and diseases related to air pollution.

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Authors' Contributions

All authors made an important contribution to this research, collection of data in the field, and the analysis interpretation of each air pollutant concentration parameter's, were part of drafting this article for reviewing it critically for significant and intellectual benefits; collective efforts agreed to submit to this journal currently, gives the trust for the final approval of this paper version of the article to be published; and concord to be accounted for all other aspects of this work.

Conflicts of Interest

The authors declare no conflicts of interest.

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