Assessment of Monsoon Season Air Pollution and its Health Impact of Different Schools in the Adjacent Area of Dhaka City, Bangladesh

A Project submitted to the Department of Environmental Science, Faculty of Science and Technology, Bangladesh University of Professionals for partial Fulfillment of the Requirements for the Degree of B.Sc. in Environmental Science

SUBMITTED BY

Mohosina Rahman Purno

Roll: 2053201054

Under Supervisor of

Professor Dr. Ahmad Kamruzzaman Majumder

Dean, Faculty of science

Chairman, Department of Environmental science

Stamford University Bangladesh

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Dedicated

To

My Lovely Family

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Mohosina Rahman Purno

ID: 2053201054

Email: purnorahman0@gmail.com

DECLARATION BY STUDENT

I, Mohosina Rahman Purno, hereby declared that the project entitled, **“Assessment of Monsoon Seasons Air pollution level and its health impact of different schools in the Adjacent Area of Dhaka City, Bangladesh”** Submitted in partial fulfillment of the requirements for the degree of B.Sc. in Environmental Science. I have composed this thesis based on original research findings from literature review acquired by me along with references from published literature. This has not been submitted in part or full for any other Institution for any other degree. I also certify that there is no plagiarized content in this thesis (maximum 25%).

Mohosina Rahman Purno

ID: 2053201054

DECLARATION BY SUPERVISOR

This is to certify that Mohosina Rahman Purno carried out her project under my guidelines and supervision, and hence prepared the thesis entitled Assessment of Monsoon Seasons Air pollution level and its health impact of different schools in the Adjacent Area of Dhaka City, Bangladesh. So far as I am aware, the researcher duly acknowledged the other researchers' materials and sources used in this work. Further, the thesis was not submitted to any other Universities or institutions for any other degree or diplomas. It is thus recommended that the thesis be submitted to the Department of Environmental Science, Faculty of Science and Technology, Bangladesh University of Professionals, in fulfillment of the requirements for the award of the degree of BSc in Environmental Science. I also certify that there is no plagiarized content in this thesis (Maximum 25%).

Professor Dr. Ahmad Kamruzzaman Majumder
Adjunct Faculty
Department of Environmental Science
Faculty of Science and Technology
Bangladesh University of Professionals
Professor and Chairman, Department of Environmental Science
Dean, Faculty of Science
Stamford University Bangladesh

ABSTRACT

Air pollution poses a significant to the heath of school going students as they are particularly vulnerable to its adverse effects. The objectives of the study to monitor the Particulate Matters ($PM_{2.5}$ and PM_{10}) concentration based on different schools in the adjacent area of Dhaka city. This study also observes health impacts of students by surveying among students. This study was conducted in 5 schools of Dhaka city, by using Aeroqual s500 and also a health impact questionnaire survey among students. This study shows that the schools air quality in the monsoon season is quite good due to the rainfall. In the monsoon season air quality doesn't exceed Bangladeshi standard. This study examines information gathered from a survey given to students in schools to find out about their opinions and experiences regarding air quality. The results show a range of exposure times; 33% of respondents reported 4-6 years of annual exposure, while 67% reported 1-3 years. per participant agrees that they were exposed for five hours per day. A sizable percentage (55%) considers the air at schools to be "unhealthy," and 100% of respondents believe that car emissions are the primary cause of pollution. Remarkably, students between the ages of 15 and 20 occasionally have respiratory problems, which is related to the fact that most of them recognize how air pollution affects the respiratory system. The findings indicate the need for focused interventions to address air quality concerns and support a healthier school environment, even though all participants deny experiencing sleep disturbances.

Keywords: *Air pollution, PM, School, Health Impact, Dispersion, Questionnaire, WHO, Car emission, Monsoon, Respiratory system*

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ABBREVIATIONS

AQI	:	Air Quality Index
AQM	:	Air Quality Monitoring
APTI	:	Air Pollution Tolerance Index
AQS	:	Air Quality Standards
BAEC	:	Bangladesh Atomic Energy Commission
BC	:	Black Carbon
BMD	:	Bangladesh Meteorological Department
CAMS	:	Continuous Air Monitoring Station
CASE	:	Clean Air and Sustainable Environment
CNG	:	Compressed Natural Gas
CO	:	Carbon Monoxide
CO2	:	Carbon Dioxide
DoE	:	Department of Environment
H_2S	:	Hydrogen Sulfide
HEI	:	Health Effects Institute
NAAQS	:	National Ambient Air Quality Standards
NO	:	Nitric Oxide
NO2	:	Nitrogen Dioxide
NOx	:	Nitrogen Oxides
PM	:	Particulate Matter
PM10	:	Particulate Matter with Diameter of 2.5 Microns or Smaller
PM2.5	:	Particulate Matter with Diameter of 10 Microns or Smaller
PPB	:	Parts Per Billion
PPM	:	Parts Per Million
SO2	:	Sulfur Dioxide
SO3	:	Sulfur Trioxide

SOx : Sulphur Oxides

SPM : Suspended Particulate Matter, includes PM10

TSP : Total Suspended Particles

US EPA: United States Environmental Protection Agency

WHO : World Health Organization

µg/m3 : Microgram Per Cubic Meter

% : Percent

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Air is a valuable natural resource that sustains life. However, the contamination of this essential resource can impede human activity. According to WHO, in 2019 over 90% of the world's population were exposed to an annual average $PM_{2.5}$ concentration that exceeded the WHO air quality guideline value of 10 μg/m^3, and air pollution became the fourth risk factor in 2019 for premature death worldwide. Moreover, In Bangladesh, there were 123,000 deaths attributable to air pollution in 2017, increasing to 173,500 in 2019 (SOGA, 2019) (khandaker et al 2023). Furthermore, Environmental air pollution is caused by thousands of pollutants, the most commonly examined of which are particulate matter (PM2.5) with a 50% cut-off aerodynamic diameter of 2.5 µm, PM_{10}, carbon monoxide, ozone, sulfur dioxide, and NOx (Siddiqui et al 2020). These chemicals are derived from a variety of sources, including the automobile, steel, and chemical industries, power plants, manufacturers of rubber and plastic products, and manufacturers of wood products. Moreover, these types of chemicals cause a wide range of health effects, including an increased risk of respiratory, cardiovascular, developmental, and neurological disorders, as well as carcinoma. Lead and manganese, for example, may have direct effects on brain functioning and thus children's ability to perform well in school (Nusrat Jahan, 2020). The most visible effect of various pollutants is human exposure, which comes at a hidden cost to society due to their effects on human health and the environment. The environment, which includes air, has a significant influence on human health and way of life. The monsoon season is praised for its cool breezes and invigorating rains, as well as providing respite from the intense heat. It does, however, also come with certain drawbacks, one of which being the effect on air quality and, by extension, student health. According to the management of air quality (AQM) is essentially depending on various elements, such as kinds of the contaminants, air pollution sources, and requirements for enforcement procedures, general air quality, etc. A human being cannot survive for more than a minute without it because it is so vital. Due to human and environmental pollution, this essential part of the environment is becoming badly contaminated, which has a negative impact on many aspects of life, including agricultural productivity, human health, and mortality and morbidity in Bangladesh's major cities. (Masum et al 2020).

1.2 Problem Statement

Air is very essential elements for our living. Air is polluted for many natural and anthropogenic causes. Air pollution has an adverse impact on physical, social, and phycological wellbeing. Air pollution in different school and college areas are creating health risk for students. It also has an impact on students phycological health. Air pollution in school areas are hampering students learning activities. Particulate matter and gaseous substance concentrations are typically used to assess the amount and quality of air pollution. The air in school and college buildings can include a variety of gaseous pollutants that might harm students' health, including carbon monoxide, ozone, sulfur dioxide, nitrogen oxides, and others. In Dhaka city many schools are located in urban areas or industrial areas so industrial polluted air is entering into the school and college area. Public awareness and other mitigating ways are need to apply to mitigate the air pollution in the school areas. According to WHO estimates, 1.8 billion children, or almost 93% of all children under the age of 15, breathe air so filthy every day that it seriously jeopardizes their health and development, especially in low- and middle-income nations. Sadly, a large number of them pass away, acute lower respiratory illnesses brought on by contaminated air killed 600,000 children in 2016.

1.3 Rationale of the study

Most of the school air is polluted due to their location and anthropogenic causes. Students are the greatest sufferer of air pollution. Because they spend most of the day time in schools. In Dhaka city many students have residence near the school and college area. They are also the greatest sufferer of air pollution. According to the Air Quality Life Index (AQLI) study, it is estimated that the citizens of Dhaka city are losing more than 8 years of life expectancy on average due to air pollution. This study will help to measure the air quality, characterize them and find probable health risk in different school and college. This study will also enlighten school authorities and students about air pollution. If the air pollution level exceeded the permissible limit, the policy makers could take necessary steps to control air pollution in school areas.

1.4 Research Gap

There are different types of previous study considering air pollution and its health impacts. Some previous research study was done for air pollution in different location of Bangladesh and also the health impacts. No previous study was done for Monsoon season air pollution intensity in different schools and students health impacts.

1.5 Research Question

The research question of the project can be

I. What is the status of monsoon seasons air pollution level among different schools?
II. How air pollution effects on student's health?

1.6 Challenges/limitation of the Study

I. Managing permission from school authority for data collection was a big challenge.
II. Survey with students was a challenge for me because of their class schedule.
III. This study was monsoon seasons air quality assessment so sudden rain disrupt the data collection design.
IV. Due to the school program it was a challenge to collect data from the classroom.

1.7 Research Objectives

The main aim of this study is to assessing the air pollution characterization and health impacts in different schools in Dhaka city and also identifying its probable impacts among the students and teachers. The main objectives of this study are:

I. To Measure the Air pollution level in the selected school area.
II. To Compare the air pollution level among different school and college area.
III. To identify probable health risk of air pollution among students.
IV. To assess the relationship among different schools and parameters ($PM_{2.5}$ and PM_{10}).

1.8 Definition of terms used in this project

1**. $\mathbf{PM_{0.1}}$**: The fraction of fine inhalable particles, or PM0.1, that have an aerodynamic diameter smaller than 0.1 micrometers is known as 1 µm, or one millionth of a meter or one thousandth of a millimeter.

2. **$\mathbf{PM_{1}}$:** Fine inhalable particles; the fraction of particles with a micrometer-or less aerodynamic diameter is known as PM1.

3. **$\mathbf{PM_{2.5}}$**: Inhalable fine particles, usually having a diameter of 2.5 micrometers or less. What is the size of 2.5 micrometers? Consider a solitary hair with a diameter of roughly 70 micrometers, human hair is 30 times larger than the smallest tiny particle.

4. **$\mathbf{PM_{10}}$**: Inhalable particles, with diameters that are generally 10 micrometers or Smaller.

1.9 Outline of the project

Outline of the project is given below:

Chapter one provides an introduction on background of the study, problem statement, rationale of the study, Limitation and objectives of the study.

Chapter Two provides Air pollutants, Literature review, Research gap.

Chapter three Discuses about Methodology, Study of the study area, Instrument, and procedure

Chapter four Discuses about the Result and Discussion

Chapter five Summarizes about the Conclusion and Recommendations for future prospects

Lastly References attached at the end.

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Air Pollutants

2.1.1. Particulate Matter (PM_1, $PM_{2.5}$, and PM_{10})

Particulate matter, or PM for short, is the word used to describe a mixture of solid and liquid droplets that are present in the air. It is sometimes referred to as particle pollution. Certain particles can be seen with the unaided eye due to their size or darkness, such as smoke, soot, dust, or dirt. Others are so tiny that an electron microscope is the only tool needed to identify them. Particles fall into a number of categories. First, depending on how they arise, they can be divided into primary and secondary particles. While secondary particles are created via gas-to-particle conversion from precursor gases (such as SO_2, NOx, and VOC) in the atmosphere, primary particles are released straight from their sources, such as smoke stacks and autos (Begum et al., 2009; 2011). Both kinds of particles are susceptible to growth and transformation because the surface of already-existing particles may create secondary material. Second, the physical size of particles can be used to categorize them. Because these qualities control particle creation, physical and chemical features, transformation, transit, deposition, and removal from the atmosphere, it is convenient to categorize particles based on their aerodynamic properties. The aerodynamic diameter, or the diameter of a unit density sphere with the same aerodynamic characteristics, is a useful way to sum up these qualities. Three classes of airborne particulate matter can be distinguished based on their size: (i) Ultra-fine particles are defined as those having an aerodynamic diameter of less than 0.1 pm. According to Begum et al. (2012) and Salam et al. (2013), (ii) particles with an aerodynamic diameter between 0.1 and 2.5 pm are referred to as fine particles, and (iii) particles with an aerodynamic diameter larger than 2.5 pm but less than 200 pm are referred to as coarse particles. Particles less than 2.5 pm, which include ultra-fine particles (less than 0.1 pm), are commonly referred to as fine particles. Fine particles with diameters ranging from 0.1 to 2.5 pm typically make up the majority of the overall mass of airborne particulate matter. Although ultra-fine particles are the most abundant portion of fine particulates, they frequently only make up a small percentage of the total mass due to their rapid disappearance, diffusion to other particles, and aggregation. The bulk of the mass is made up of particles that are between 0.1 and 2.5 pm in size. Although they are far less in number than ultra-fine particles, most of the mass is concentrated on them because of their longer lifespan. As they emerge from the atmosphere, big particles (>2.5 rims) are distinguished by their low quantity, high mass, and brief lifetimes (Nayeem et al., 2020).

2.3. Journal Related with $PM_{2.5}$, and PM_{10}

Mohammad et al (2018) conducted a research on Air pollutants and their possible health effects at different locations in Dhaka city. The research was focused on air pollutants and their possible health effects in the areas of Dhaka city. Different pollutants such as, volatile organic compounds (VOC, s), carbon monoxide (CO), relative humidity (RH), nitrogen oxide (NOx), hydrogen sulfide (H2S), carbon dioxide (CO2), oxygen (O2), sulfur dioxide (SO2), particulate matter (PM10), particulate matter (PM2.5), suspended particulate matter (SPM), and lead (Pb) were found to be at hazardous levels in this study area. Similarly, a positive correlation was found between each of CO2, CO, SO2, NOx, H2S, SPM, PM10, PM2.5, and Pb. Several of the air quality parameters were examined in 7 locations of Dhaka. These locations are Brick Fields in Savar, Dhaka cantonment, West rasulpur, Birulia at Savar, North DEPZ of Savar, South DEPZ of Savar, East DEPZ of Savar and West DEPZ of Savar. The Geographical Positioning System of Dhaka city is altitudes 23°42'37.44"N and longitude 90°24'26.78" E. In this research an inception meeting was arranged at the office of the Bangladesh Council of Scientific and Industrial Research (BCSIR) in Dhaka that lasted for 3 days. a. During this meeting, participants contributed their unique perspectives regarding air quality in Dhaka and their own health effects. Through this meeting, major areas of pollution were identified among the different locations in Dhaka. Based on the inception meeting, they have collected data regarding the effects of pollutants on human health in Dhaka. This information was gathered from different locations in the city of Dhaka. The causes of air pollution found in this research was Population density, Unplanned industrialization and urbanization, Traffic pressure, Brick fields, Climate changes, etc. Lastly the result of the research was People have been facing various diseases due to the increase of toxic air pollutants. Air pollutants such as, volatile organic carbon (VOC), carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), sulfur dioxide (SO_2), nitrogen oxide (NOx), hydrogen sulfide (H_2S), suspended particulate matter (SPM), particulate matter (PM_{10}), and particulate matter ($PM_{2.5}$) have increased significantly in Dhaka. In this way the death rate has been increasing.

Salamat et al (2023) conducted a research on air pollution in Bangladesh and its consequences. The research was about air pollution, both outdoor and household, and its health consequences in Bangladesh. This study shows major sources of outdoor air pollution was both anthropogenic and natural. Anthropogenic sources include burning fossil fuel, including coal, wood, open burning of waste or agricultural residues, emission from motor vehicles, power generation and industries, biomass fuel for cooking, and transboundary air pollution. The Natural sources include windblown dust, sea spray, and forest fires (Natural air pollution sources). This study shows some health impacts such as Both short and long-term exposure to high levels of air pollution increases the risk of respiratory infection, heart diseases, and lung cancer. Children, the elderly, the already ill, and poor people are more susceptible (WHO, 2019). Long time exposure to ambient particulate matter accounts for 62% of all pollution-attributable deaths and 55% Disability Adjusted Life Years. This research also includes role of government in combating air pollution in Bangladesh.

Siddique et al (2020) conducted a research on chronic air pollution and health burden in Dhaka city. The air quality index for Dhaka city from 2013 to 2019 was used for this study. According to this study, air pollution in Bangladesh is responsible for 17.6% of the risk of mortality and disability. Dhaka is home to about 20.6 million people and occupies an area of 306.38 km^. It is one of the world's largest megacities and one of the most polluted (Air Quality Index (AQI) of 215 on December 21, 2019). Dhaka came in right after Damascus and Lagos as the third least habitable city in the world according to a research. 92% of people on the planet are thought to be exposed to PM2.5 levels over recommended limits for air quality. 38.6% for acute lower respiratory tract infections in children (95% CI 30.4-46.3%), 40.5% for ischemic heart disease (95% CI 26.2-60.5%), 35% for COPD (95% CI 22.1-48.1%), and 36% for stroke (95% CI 16.8-46.2%). Given the current infectious epidemics that are already having a significant negative impact on Dhaka's health, significant increases in cardiovascular and respiratory mortality and morbidity will place further strain on Bangladesh's already overburdened and underfunded healthcare system and economy if appropriate steps to effectively reduce the overwhelming ambient pollution are not taken quickly.

Begum et al. (2011) Black carbon (BC) concentrations and airborne particulate matter ($PM_{2.5}$ and PM_{10}) are studied at the Kalabagan and Shishumela locations along the Mirpur corridor in Dhaka. The ambient $PM_{2.5}$ and PM_{10} concentrations were found to be significantly higher than the Bangladesh National Ambient Air Quality Standard for each day. Prior to the implementation of control measures, black carbon was determined to be responsible for almost 50% of the total fine PM mass. Because of this, neither the PM nor the BC have increased in line with the rise in the number of combustion sources, such as cars, diesel generators, or brick kilns. Data on fine particle composition were subjected to Positive Matrix Factorization (PMF) between January 2007 and February 2009. It was discovered that, in relation to the brick kiln business, motor vehicles produce less BC. As a result, the government's policy initiatives have been effective. Previously, autos were BC's main contributors. This long-distance movement of BC also involves mixing with other particles, as a probable source contribution function study shows. Over the past few decades, transboundary air pollution movement has grown in importance in the South Asian region. It is still unknown how much pollution is transferred across large distances compared to locally.

Bilkis et al (2012) Conducted a research on air pollution by fine particulate matter in Bangladesh. In Dhaka, Bangladesh, particular matter (PM) is the air pollutant that is most harmful to public health and the environment when compared to other measured criteria pollutants. This study was based on primary data. The research observed there is also trailing effect of PM movement from northwest towards the southeast that affects Bangladesh. This transport happens mainly during the wintertime when rainfall is minimal and wind speeds are low. However, it is not possible yet to quantify the transboundary transport. As a result, the local air pollution effect is increased.

Peter et al (2015) Conducted a research on Blood Pressure and Same-Day Exposure to Air Pollution at School Associations with Nano-Sized to Coarse PM in Children. The study was about we assessed associations between blood pressure and short-term exposure to air pollution in a population of schoolchildren. In 130 children (6–12 years of age), blood pressure was determined during two periods (spring and fall 2011). They used mixed models to study the association between blood pressure and ambient concentrations of particulate matter and ultrafine particles measured in the schools' playground. The research observed Independent of sex, age, height, and weight of the child, parental education, neighborhood socioeconomic status, fish consumption, heart rate, school, day of the week, season, wind speed, relative humidity, and temperature on the morning of examination, an interquartile range (860 particles/cm3) increase in nano-sized UFP fraction (20–30 nm) was associated with a 6.35 mmHg (95% CI: 1.56, 11.14; $p = 0.01$) increase in systolic blood pressure. For the total UFP (ultrafine particles) fraction, systolic blood pressure was 0.79 mmHg (95% CI: 0.07, 1.51; $p = 0.03$) higher, but no effects on systolic blood pressure were found for the nano-sized fractions with a diameter > 100 nm, nor PM2.5, Coarse, and PM10. Diastolic blood pressure was not associated with any of the studied particulate mass fractions. The study was concluded with Children attending school on days with higher UFP concentrations (diameter < 100 nm) had higher systolic blood pressure. The association was dependent on UFP size, and there was no association with the PM2.5 mass concentration.

Majumder et al (2019) conducted a study in Dhaka, Bangladesh, on ambient particulate matter ($PM_{2.5}$) with various modes of transportation. The study's objective is to determine how the mode of transportation affects the $PM_{2.5}$ concentration in different areas of the city of Dhaka. For this, a traffic volume study was conducted in August 2017 at 12 locations across the city, and an Ecotec Mini 2.5 Sampler was used to assess the ambient $PM_{2.5}$ concentration. The study found that compared to non-motorized and vehicle-free zones, mixed-use and motorized areas frequently had higher $PM_{2.5}$ concentrations. B.C. Das Street had the lowest concentration of $PM_{2.5}$ (40 g/m3), whereas Mirpur-10 had the highest value (172.2 g/m3). The results of the study indicate that an increase in the number of vehicles on the road is one of the major contributors to air pollution in Dhaka. Public transportation systems that are well-developed are therefore chosen over private ones.

Majumder et al (2021) did a study on Evidence from South Asian Megacities on the Effect of COVID-19 Lockdown on Air Quality. Since human activity was severely restricted in many South Asian cities during the COVID-19 (Coronavirus disease-2019) pandemic, there was an opportunity to research source reduction of air pollution. This study looked at changes in columnar nitrogen dioxide (NO2) and particulate matter ($PM_{2.5}$, aerodynamic diameter 2.5 m) in five South Asian megacities: Delhi, Dhaka, Kathmandu, Kolkata, and Lahore from April 1 to May 31 of the previous three years (2018-2020). The Dutch-Finnish Ozone Monitoring Instrument (OMI), which measures tropospheric columnar NO2, was employed in this investigation. The World's Air Pollution: Real-time Air Quality Index Project collected information on hourly $PM_{2.5}$ emissions on the ground. According to the study, in a few locations, tropospheric columnar NO2 declined from April 1 to May 31 in 2020 as opposed to 2018 and 2019. The mean daily $PM_{2.5}$ readings decreased between April 1 and May 31 in Delhi by 36.56%, in Dhaka by 12.67%, in Kathmandu by 28.32%, and in Kolkata by 41.02% and 34.08%, respectively. In Lahore, the $PM_{2.5}$ was 44.26% lower between April 9 and May 31 in 2020 than it was in 2019. The daily mean difference in concentration for both pollutants from April 1 to May 31, 2018-2020 was much smaller at 0.01 level. In South Asian cities, effective mitigation strategies would provide a safer environment and reduce incoming air pollution.

Rahman et al (2022) This study is the first to analyze the relationship between air pollutants (NO2, O3, SO2, and CO) and meteorological parameters over Bangladesh using satellite data from OMI and MOPITT between 2015 and 2020. Geographically weighted regression (GWR) modeling was used to assess the relationship between climatic variables and air contaminants. The spatial representation and average values of the spatially variable coefficients showed that the column densities of air pollutants were influenced by meteorological conditions. The investigation of emission inventories revealed the sources of NO2 and SO2 in Dhaka, and the two most significant influencing factors for NO2 and SO2 were transportation and industrial emissions. Temperature and pressure showed a greater association with all four air parameters than other measurements.

K-E-Khuda (2020) shown how air pollution affects public health in the capital city of Bangladesh. To gather and make use of all the necessary data and information, the primary and secondary causes of air pollution were used. According to WHO standards, 70% of the areas of Dhaka city's roadside environment are extremely polluted, while 30% of those same areas are heavily polluted. Industrial emissions and automotive emissions are the two main causes of air pollution in the city of Dhaka, according to this study. Potential health concerns include heart problems, kidney failure, eye pain, asthma, coughing up mucus, early birth, and failing lungs. Applying the SDGs, regulating air quality, including the public, and creating awareness are some methods to reduce air pollution.

Hasan et al (2019) conducted research on the association between respiratory issues in young urban children and the smoke from biomass fuels. The 2013 Bangladesh Urban Health Survey provided the data. The sample consisted of 10,575 mothers who had at least one living kid. Children under the age of five developing respiratory issues was assumed to be the main consequence. Sequential multiple logistic regression models were used to assess the link between respiratory symptoms and exposure to biomass fuel smoke, while accounting for the influence of living arrangements and mother and child traits. This study found that a significant risk factor for respiratory symptoms in kids under five is the use of biomass fuel at home.

Tarmina et al (2021) In a study conducted in the city of Gazipur, the impacts of seasonal variation were examined with regard to the atmospheric abundance of particulate matter ($PM_{2.5}$ and PM_{10}) and gaseous air pollutants (SO2, NO2, O3, CO). Data on air pollution in the study area were gathered between October 2017 and September 2018 using the Department of Energy's Continuous Air Monitoring Station (CAMS) (CAMS-4, Gazipur). The worst air pollution occurred in the winter. The majority of the air at the sample location during the winter came from the brickfield zones in the northern part of the Gazipur district, according to an analysis of the wind-rose data. On the other hand, rainfall and atmospheric pollution, temperature, and air pollution load revealed a reversal association during the pre-monsoon, monsoon, post-monsoon, and winter seasons. This research showed that the lowest levels of air pollution during the monsoon were caused by the washout effect of precipitation on atmospheric contaminants. The analysis revealed a slight correlation (R2 = 0.58) between CO and O3 pollution, pointing to volatile organic compounds (VOCs) as the likely culprits for their atmospheric origin.

Majumder et al (2023) conducted a research on spatial distribution of air quality in Netrokona district. This study's primary goal was to determine how much particulate matter (PM) was present in Netrokona district town in relation to the various land uses. Throughout the Netrokona district town, a portable air quality monitor was used to help conduct this study at sixty distinct locations. Particulate matter concentrations in the district town of Netrokona were found to be, on average, 60.97, 99.63, and 130.12 $\mu g/m^3$, respectively. Furthermore, the average PM 2.53 exceeded Bangladesh's National Ambient Air Quality Standards (NAAQS) standard by 1.53. The analysis showed that two of the least contaminated locations were in sensitive areas, while three of the most polluted locations were found in commercial districts based on $PM_{2.5}$ concentration. The ratio of $PM_{2.5}/PM_{10}$ was estimated to be 76.76%, whilst the ratio of $PM_1/PM_{2.5}$ was determined to be 61.17%. According to average PM2.5 concentration, the following land uses are ranked by research: mixed area, commercial area, road intersection area, residential area, village area, industrial area, sensitive region.

Majumder et al (2023) conducted a research aims examine Bangladeshi air pollution studies that have been published online between 1995 and 2020. The following search method was used to gather the data of research publications on "air pollution" from the internet database: For the years 1995 to 2020, publications with the phrases "air pollution," "air pollutants," "concentration of particulate matter/aerosol," or "effects on human health," as well as "sources of air pollutants," "gaseous air pollutants," and "heavy metals in the air," were gathered. The majority of author biographies, the contents and quantity of citations, and the features of published papers were compiled in this study. The research on air pollution exposure from pertinent sources, including peer-reviewed papers, conferences, and national and international reports, served as the foundation for this investigation. A total of 143 scholarly papers were located online for this investigation. The first report on air pollution in Bangladesh was released in 1995, and the year 2019 saw the most articles produced. The number of publications published increased quickly in the years 2018, 2019, and 20-15, 19, 16, and 638, respectively. A greater proportion of citations (294) were given to works published in 2004. This study solely looks at online publications; offline publications are not included in the calculations.

Majumder et al (2023) conducted a research on Air quality index (AQI) changes and spatial variation in Bangladesh from 2014 to 2019. The study's goal is to investigate Bangladesh's rising air pollution levels, with a focus on the percentage of the Air Quality Index (AQI) in six districts and four seasons, the monthly mean AQI, and the relationship between PM2.5 and AQI from 2014 to 2019. According to this study, six districts in Bangladesh have worsening air quality between 2014 and 2019, with the winter and monsoon seasons having the worst pollution. The areas with the worst air quality were found to be Dhaka and Narayanganj. Paerticulate Matters (PM2.5) and Air Quality Index (AQI) are strongly correlated, with AQI rising in all cities as PM2.5 concentrations rise. The monthly mean AQI was greater in January, February, March, November, and December, but it was lower in May, June, and July. Depending on the stations and seasons, the F-values were considerable. The study's overall findings emphasize Bangladesh's growing air pollution problem and its negative health implications.

Majumder et al (2023) conducted a research to monitor the concentration of particulate matter (PM_1, $PM_{2.5}$ and PM_{10}) in Lakshmipur district town. It was found that the average concentrations of PM_1, $PM_{2.5}$, and PM_{10} were 91, 149, and 193 µg/m3 in sixty various locations within the town of Lakshmipur district. The average concentration of $PM_{2.5}$ and PM_{10} was found to be 2.29 and 1.29 times higher, respectively, than the Bangladeshi government's National Ambient Air Quality Standards (BNAAQS) limit. The three areas with the highest levels of pollution were Temuhoni CNG station (mixed area), Mia Bari Abasik (road intersection area), and Temuhoni mor (road intersection area). Conversely, the three areas with the lowest levels of pollution were villages: Khoya Sagar Degirpar, Banchanagar Beribad, and Eidgah Dalal Bazar. According to estimations, the $PM_{2.5}/PM_{10}$ ratio was 60.84%, whereas the $PM_{2.5}/PM_{10}$ ratio was 77.11%. The various land uses that were looked into have been sorted in descending order based on the average concentration of particulate matter (PM) based on the study's findings. The following is the order: The order is as follows: village area > sensitive area > mixed area > residential area > road intersection area > industrial area.

Majumder et al (2020) conducted a research on Characterization of Inhalable Ground-Level Ambient Particulate Matter in Dhaka City, Bangladesh. The purpose of this study is to evaluate the trend of particulate matter (PM2.5 and PM10) in connection to climatic parameters between 2013 and 2018. The Continuous Air Monitoring Station (CAMS) at Darus Salam Point in Dhaka City provided the PM data. Using a beta gauge device, which measures the amount of gas extracted from a stack or duct and determines mass concentration, CAMS collects air samples. PM2.5, or tiny particulate pollution, comprised 54% of PM10 in the current study. Because of the highest rate of rainfall in July, PM2.5 and PM10 concentrations were lowest, whereas they were highest in January and December. Furthermore, it has been noted that the yearly average concentration of PM2.5 and PM10 above the Bangladesh National Ambient Air Quality Standard (BNAAQS) by 5–6 times, with wintertime seeing even higher PM concentrations. In Dhaka, this study discovered a markedly inverse relationship between climatic characteristics and ground-level PM. The state of air pollution in Dhaka is fast getting worse, and in order to stop this damage, the Clean Air Act needs to be put into effect immediately.

Majumder et al (2020) conducted a research on Temporal variation of ambient particulate matter in Chattogram City, Bangladesh. The purpose of this study was to evaluate Chattogram City's PM2.5 and PM10 levels in connection to the local weather throughout the 2013–2018 period. Monthly PM2.5 and PM10 data were gathered from the Department of Environment (DoE) of Bangladesh's Continuous Air Monitoring Station (CAMS) in Chattogram City (Agrabad Point), which is run as part of the Clean Air and Sustainable Environment (CASE) initiative. According to this study, the concentrations of PM2.5 and PM10 were highest between December and February, then they decreased between July and September before starting to rise again in October. Seasonally, the PM levels vary, rising in the winter and falling in the rainy season. The mass of PM2.5, which is largely from vehicle activity and biomass burn, was found to be 50% that of PM10. Throughout time, there was a strong inverse relationship between PM2.5 and PM10 and meteorological variables such humidity and rainfall.

Majumder et al (2019) conducted a research on Spatiotemporal Variation of Brick Kilns and its relation to Ground-level PM2.5 through MODIS Image at Dhaka District, Bangladesh. In three

Dhaka subdistricts Dhamrai, Savar, and Keraniganj this study examined the link between the spatiotemporal variation of brick kilns and PM2.5 concentrations. The spatial data used to evaluate the temporal variations of brick kilns was obtained from Google Earth, while the Moderate Resolution Imaging Spectroradiometer (MODIS) data for PM2.5 was sourced from the NASA online database. The ArcGIS 10.2.1 tool and a remote sensing technique were utilized to analyze the spatiotemporal variability of PM2.5 concentrations. The findings indicate that in 2006, 2010, and 2018, there were 307, 497, and 551 brick kilns, respectively. The results show that the PM2.5 concentration was about three to four times higher than both WHO and the Bangladesh National Ambient Air Quality Standard (BNAAQS) guidelines. Furthermore, a growing pattern has been observed in the relationship between brick kilns and concentration. Therefore, encouraging the use of sand bricks and standardizing kiln efficiency through enhanced combustion procedures may be a good way to lower emissions from Bangladeshi brick kilns.

Majumder et al (2019) conducted a research on PM2.5 concentration and meteorological characteristics in Dhaka, Bangladesh. In the heavily polluted metropolis of Dhaka, the objective of this study is to evaluate the concentration of particulate matter (PM) with an aerodynamic diameter ≤2.5 µm (PM2.5) and its interaction with climatic indices. The Bangladesh Meteorological Department (BMD) provided meteorological data, while the Air Now Department of State (Air Now DOS) provided statistics on PM2.5. According to the study, just a small percentage of the hourly Air Quality Index (AQI) category was classified as "Good," with 31.9% of it being unhealthy. In January, the highest average monthly value was recorded at 192.97±89.30 µg/m3, whereas in July, the lowest average concentration was recorded at 29.98±19.37 $\mu g/m^3$. In addition, it was discovered that the winter had the highest concentration of PM2.5 of any season. Furthermore, it was shown that in 2017, the yearly concentration was 79.94±75.55 µg/m3, surpassing both the World Health Organization (WHO) and National Ambient Air Quality Standard (NAAQS) limits. There are several meteorological elements that influence this variation. Furthermore, rainfall and PM2.5 concentrations are found to be strongly and adversely associated. This is likely because ambient dust is settling into the lithosphere. The annual PM2.5 concentration was five times greater than the reference value.

2.4 Research Gap

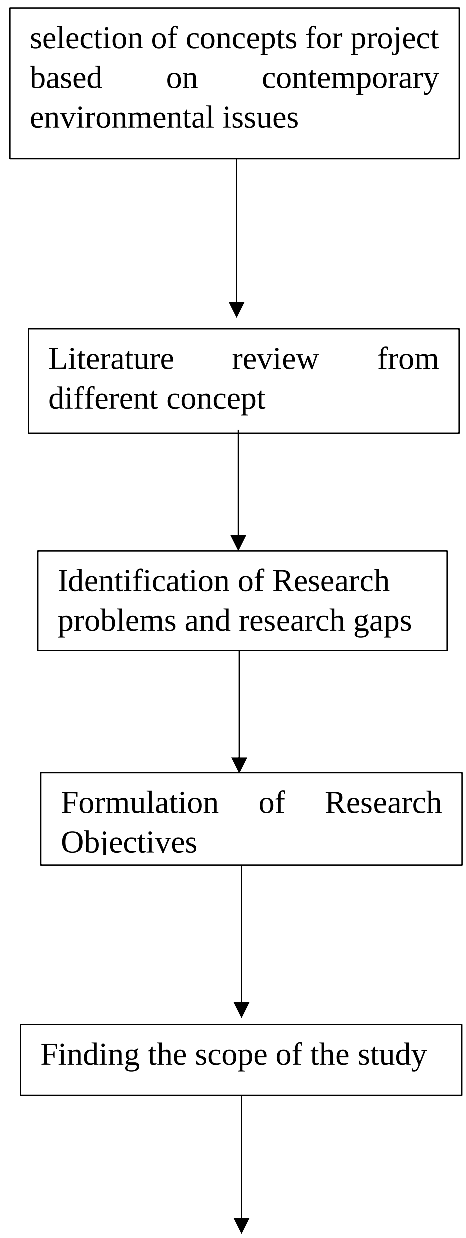
There are different types of previous study considering air pollution and its health impacts. Some previous research study was done for air pollution in different location of Bangladesh and also the health impacts. In my research I will measure air pollution in four different sites (inside classroom, field, gate and adjacent road) of different schools in Dhaka city and also identify its health impacts among teacher and students. No previous study was done for pollution intensity in different schools.

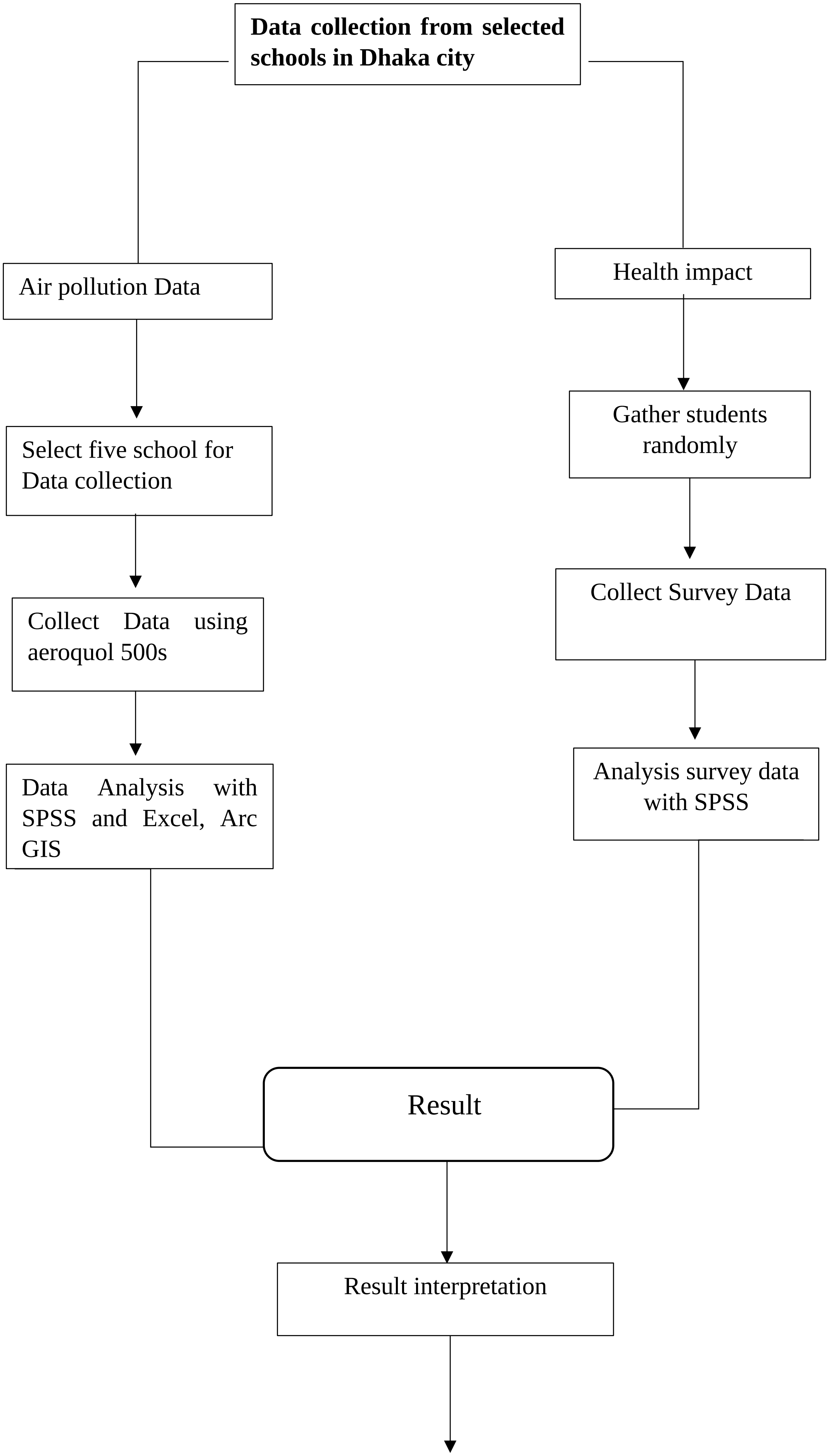
CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Conceptual Framework

This framework is designed to the conduct research activities following steps:




Data collection from selected schools in Dhaka city
Air pollution Data
Health impact
Select five school for Data collection
Gather students randomly
Collect Data using aeroquol 500s
Collect Survey Data
Data Analysis with SPSS and Excel, Arc GIS
Analysis survey data with SPSS
Result
Result interpretation

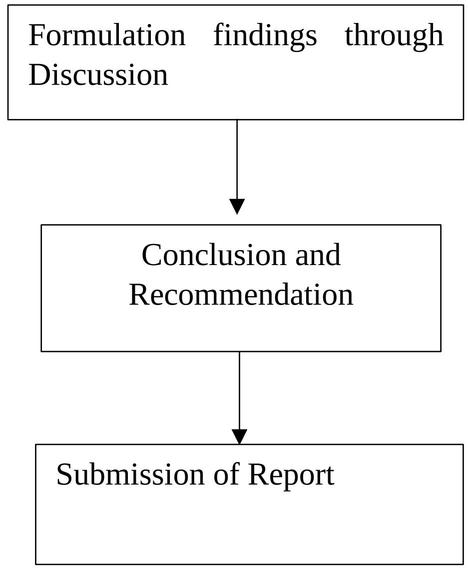


Figure 3.1: Conceptual Framework

3.2 Design

The study will undertake through primary data. This research will be a quantitative research.

3.3 Study Area

The Dhaka Metropolitan area, also known as the Division of Dhaka, Bangladesh, is an upazila within the Dhaka district. The coordinates of Dhaka metropolitan area are 23.8103° N, 90.4125° E. The Buri Ganga River barely passes through this part of Dhaka. Situated in the lower regions of the Ganges Delta, the city spans 306.38 square kilometers, or 118.29 square miles. The area is flat and around sea level, with moist soils and tropical vegetation. Because of this, Dhaka is vulnerable to floods during the monsoon season due to cyclones and high rainfall. To ensure improved public facilities, Dhaka City Corporation was divided into two corporations in 2011: Dhaka North City Corporation and Dhaka South City Corporation. 8,906,039 people were living in the Dhaka metropolitan area as per the 2011 Bangladesh census. The territory inside city corporations was split up into a number of wards, each with an elected commissioner. There are 725 mohallas and 130 wards in the city overall (Wikipedia, 2021). I have selected 5 schools of Dhaka city. I have collected data from different locations of these 5 schools such as field, classroom, gate and adjacent area using aeroquol 500s.

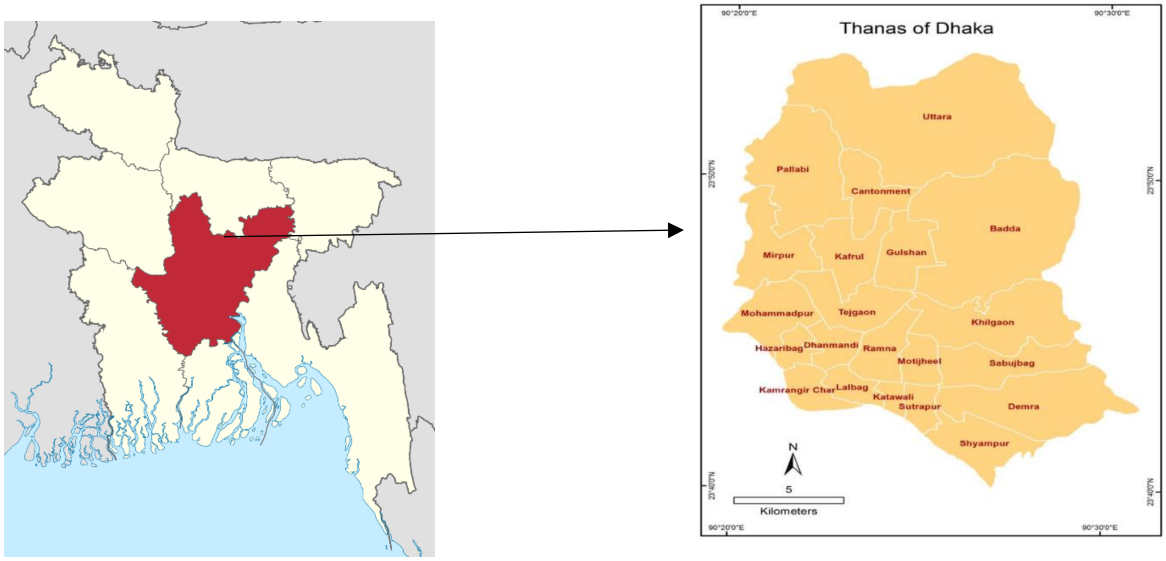


Figure 3.2: study area Map

In this Research selected 5 school located under pallabi thana and Ramna thana. Selected first school is located in Ramna thana 23.7450° N latitude and 90.4110° E longitude. School 1 is located in two roads front and back with many small vehicles such as cars, bikes etc. So, the school areas air is polluted because of fumes of vehicle. Classrooms near the roads are also polluted because of fumes of vehicle. The following figure shows the map of school 1.

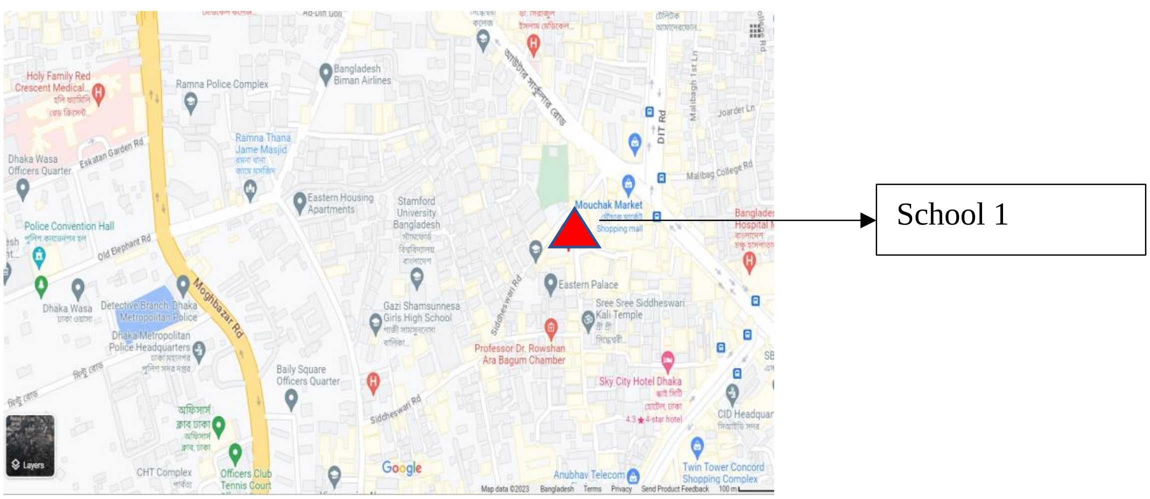


Figure 3.3: Location Map of school 1 (Google Maps, 2023*)*

School 2 is also situated in Ramna thana between 23.7450° N latitude and 90.4110° E longitude. School 2 is Situated in a Commercial area with many shopping malls and residential buildings.

There are two roads front and sides of the school buildings are the air pollution sources. Those roads are very busy with car, bikes and many vehicles. The following figure shows the map of school 2.

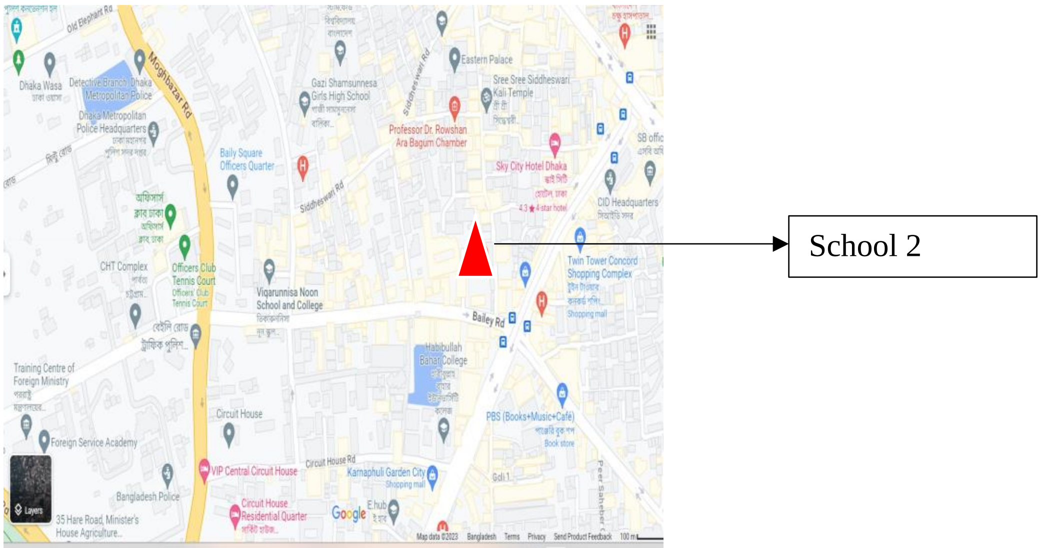


Figure3.4: Location Map of school 2 (Google Maps, 2023)

School 3 is located under pallabi thana between 23.8283° N latitude and 90.3607° E longitude. School 3 is Situated in a very busy area. Wide roads are in front of the school many busy vehicles such as cars, pick up vans, motor bikes, school buses, micro buses and also matro rail. These all are source of air pollution in the school area. The following figure shows the map of school 3.

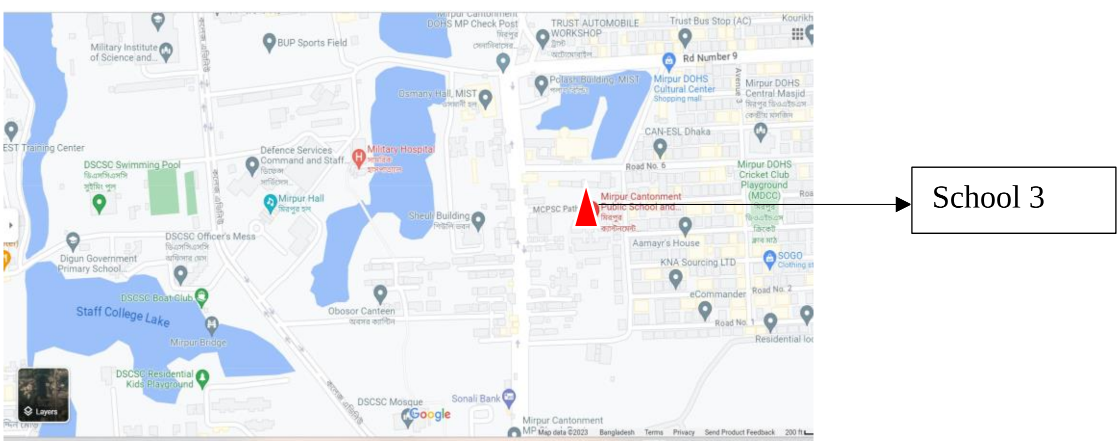


Figure 3.5: Location Map of school 3 (Google Maps, 2023)

School 4 is also located under pallabi thana between 23.8283° N latitude and 90.3607° E longitude. School 4 is situated in a residential area. There is a busy road in front of the school. Many vehicles such as cars, motor bikes, pick up vans are running all days. So, vehicular fumes are the main source of the school areas air pollution. The following figure shows the map of school 4.

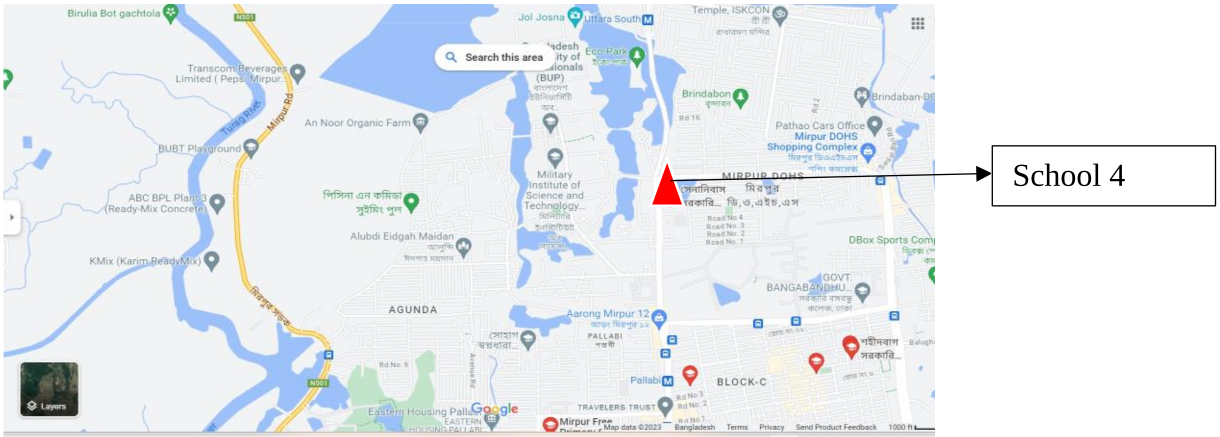


Figure3.6: Location Map of school 4 (Google Maps, 2023)

School 5 is also situated in Ramna thana between 23.7450° N latitude and 90.4110° E longitude. School 5 is also situated in a very busy area. Busy roads are in front and back of the school. Vehicular fumes are the main source of air pollution in the school area. The following figure shows the map of school 5.

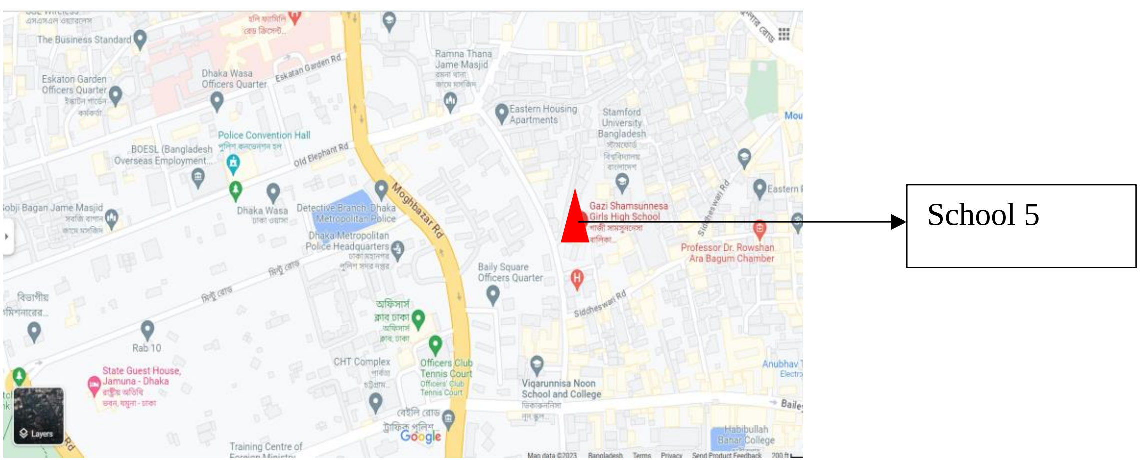


Figure3.7: Location Map of school 5 (Google Maps, 2023)

3.3. Research Methods

I have collected data from selected educational institutions in two categories: by measuring air pollution concentration and by questionnaire. I have collected data from selected schools by measure the physical data by using aeroquol 500s. In this research, I have collected air pollution data from r different sites: a) inside the classroom, b) the field, c) the gate, and d) the adjacent road of a selected school. Then characterize the data in the CAPS lab. Then I will record readings in all points in the selected school's area to identify points where they are highly polluted air. Then I will measure all the data and compare with the standard and guideline that has been used widely. Then Questionnaire forms will give to the selected educational institution's students. In this form, there are questions regarding air pollution problems. By answering this questionnaire, it will help to get some information about the air pollution in a particular area and its probable health impacts among them. Then I will measure all the data and compare it with the standards and guidelines of the DoE.

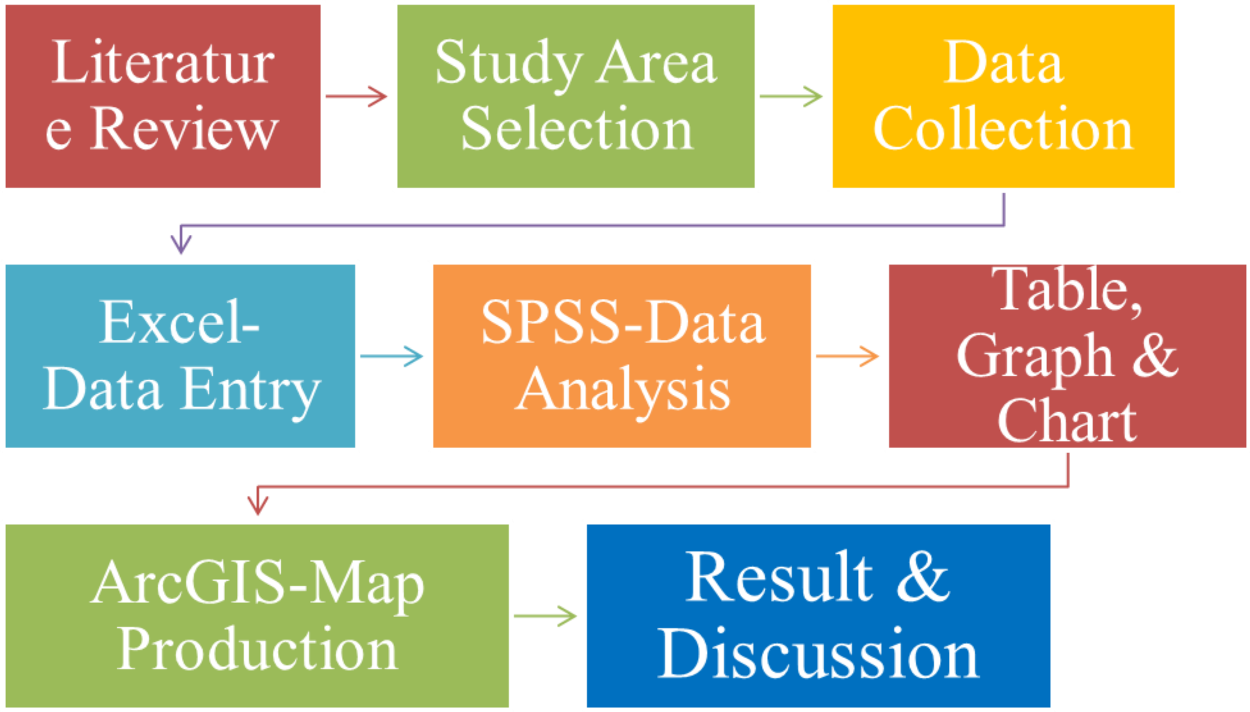
3.3.1. Air Quality Parameter

While there are many other kinds of air quality measures, such as Ozone (O3), Nitrogen dioxide (NO2), Sulfur dioxide (SO2), Particulate Matter ($PM_{1.0}$, $PM_{2.5}$, and PM_{10}), and Carbon Monoxide (CO), we focused on two key metrics in my study. Particulate matter ($PM_{2.5}$, and PM_{10}) parameters. Such particulate matter exposure can have an impact on the heart and lungs of students. Exposure to particle pollution has been linked to a number of health issues, such as increased respiratory symptoms, such as coughing or difficulty breathing, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and premature death in individuals with heart or lung disease. Conversely, particulate matter has the ability to travel great distances on wind before settling on land or in water. These parameters have more adverse effects on health than other parameters. As the presence of parameters in the air increases day by day, we have selected 3 these parameters for our research. These are 2 parameters with their Standards.

Table 3.1: Air Quality Parameter and its Standards for Bangladesh and WHO

Pollutant	**Averaging-Period**	**Bangladesh Standard (μg/m^3)**	**WHO (μg/m^3)**
PM_{10}	Annual	50 μg/m^3	20 μg/m^3
	24-hour	150 μg/m^3	50 μg/m^3
$PM_{2.5}$	Annual	15 μg/m^3	10 μg/m^3
	24-hour	65 μg/m^3	25 μg/m^3

3.3.2. Flow Diagram of Research Methods



3.3.3. Area Selection

For this study Dhaka city corporation has been selected. The study area was 5 differrent schools in the adjacent area of Dhaka city. The schools are Shiddeswari boys' high school & college, Shiddeswari girls' high school & college, Mirpur Cantonment public school & College, Mirpur government primary school, Gazi shamsunnesa girls' high school.

Table 3.2: List of selected schools Latitude & Longitude

S.N.	Institution	Location	Latitude	Longitude
1.	Shiddeswari boys' high school & college	Gate	23.74542	90.411091
		Classroom	23.7448	90.41116
		Field	23.7452	90.41097
2.	Shiddeswari girls' high school & college	Gate	23.7421	90.41148
		Classroom	23.74228	90.41138
		Field	23.74215	90.4112
		Adjacent area	23.7426	90.41137
3.		Gate	23.83728	90.36562

	Mirpur Cantonment public school & College	Field	23.8353	90.36473
		Classroom	23.83728	90.3656
		Adjacent area	23.8363	90.3641
4.	Mirpur government primary school	Classroom	23.83565	90.36475
		Field	23.83571	90.36465
		Adjacent area	23.8359	90.36465
5.	Gazi shamsunnesa girls' high school.	Gate	23.7436	90.40739
		Field	23.74403	90.40794
		Classroom	23.7439	90.40755
		Adjacent area	23.74368	90.40797

3.3.4. Data Collection

Aeroqual monitors were placed tripod at ~1.5 m elevation above the ground. The monitors were positioned horizontally. The monitoring location was nearest to road with no other primary pollutant sources nearby. The Aeroqual monitors were programmed to record 1-min average concentrations of particulate matter continuously. To turn the monitor on: Press and hold the power button until the screen activates. Prior to operation the sensor must be warmed up to burn off any contaminants. When the monitor is first switched on it will warm up for 3 minutes. At the same time surveyor set the location ID for each location. Monitor will collect and store air quality data automatically after warm up. The data downloading is very simple, because the device can be connected to a PC directly with a USB cable: a PC software is available to download/export the data, which can then be exported then to a Excel format. The instrument we used for this study was Aeroqual portable monitors, S500. The Series 500 air quality sensor enables accurate real-time surveying of common outdoor air pollutants, all in an ultra-portable handheld monitor. The Series 500 is usually used by air quality specialists for short-term investigations of air quality and for monitoring "hot spots" of pollution. The Series 500 has a maximum capacity of 8,188 records for data storage. A USB cable to connect to a PC is included in order to download the data. The Series 500 comes with free PC software that collects the data and displays it as a table or chart. Excel can be used to examine and download data. The Series 500 also has location ID and monitor ID as additional features. By using a unique ID, the monitor is identified and all of the data it contains is linked to it. When sampling at a certain location, Location ID can be used to attribute measurements to that exact spot.

Table 3.3: Instrument Description for Air Quality Monitor

Instrument Description	
• Model: S500 • Range: 0.000 to 1.000 mg /m^3 • Measurement Parameters: Particulate matter • Sensor Type: Laser particle counter • Minimum Detection Limit : 0.001 mg/m^3 • Accuracy of Factory Calibration : ± (0.002 mg/m3 + 15 % of reading) • Resolution : 0.001 mg/3 • Response Time : 5 Seconds • Temp: 0 to 40°C • Relative Humidity: 0 to 90% non-condensating	

Software Used in this study:

- Microsoft Excel
- Arc GIS 10.8.1
- SPSS v.26 software package

Figure3.8: Data collection at shiddheswari boys' High school & college

Figure3.9: Data collection at shiddheswari girls' High school & college

Figure3.10: Data collection at Field of shiddheswari girls' High school & college

Figure3.11: Data collection at Mirpur cantonment public school & college

Figure 3.12: Data collection at Mirpur Primary school

Figure 3.13: Data collection at Mirpur cantonment Primary school

Figure3.14: Data collection at Gazi shamsunnesa girls' high school & college

Figure 3.15: Data collection at Gate of Gazi shamsunnesa girls' high school & college

3.2.4. Data Processing

Collected data was input in an IBM SPSS V20 and MS Excel 2020. We used a formula for conversion of concentration of PM2.5 to AQI. Formula for Conversion- To convert from concentration to AQI this equation was used:

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

If multiple pollutants are measured, the calculated AQI is the highest value calculated from the above equation applied for each pollutant.

where:

I = the (Air Quality) index
C = the pollutant concentration

C_{low} = the concentration breakpoint that is ≤ C

C_{high} = the concentration breakpoint that is ≥ C

I_{low} = the index breakpoint corresponding to C_{low}

I_{high} = the index breakpoint corresponding to C_{high}

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Status of Air pollution Studies in Dhaka city

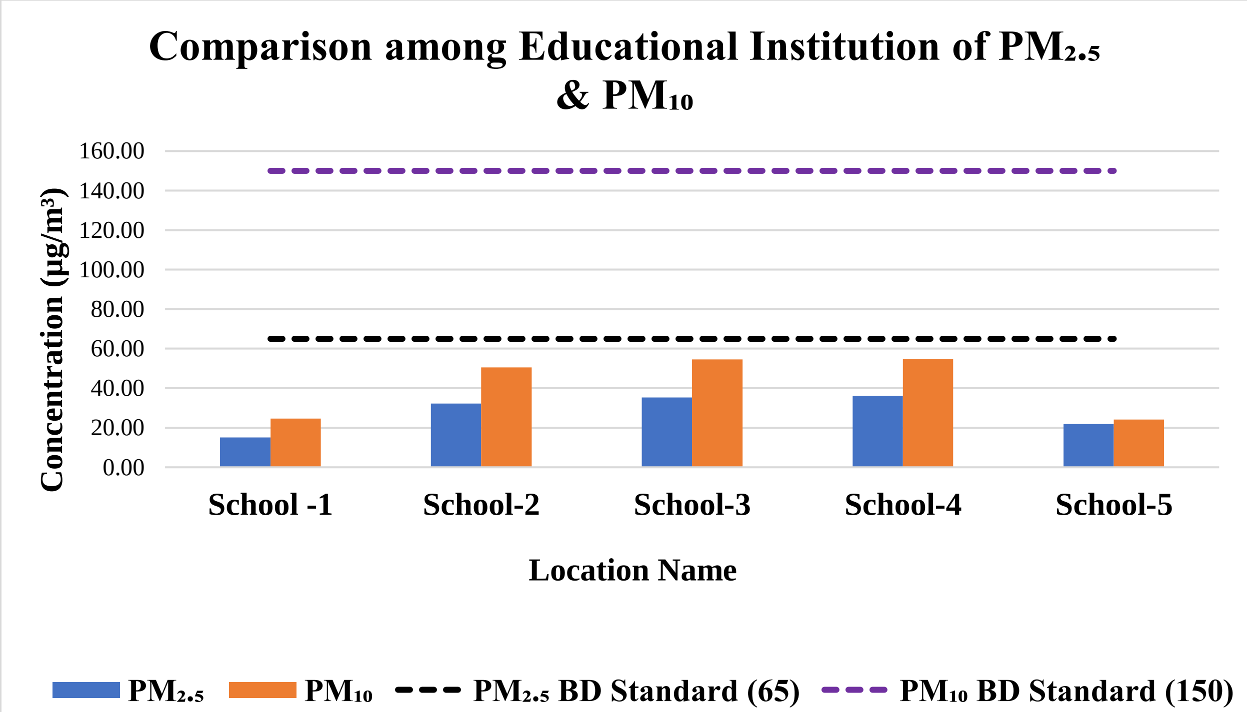


Figure 4.1: Comparison among Selected schools in Dhaka city

The figure 4.1 shows the comparison of the average concentration of $PM_{2.5}$ and PM_{10} of five educational institution in Dhaka city. The Study found that the average concentration of $PM_{2.5}$ was higher in school 4 with the concentration of 36.09µg/m^3 and PM_{10} was also higher in 54.91 µg/m^3. The average concentration of $PM_{2.5}$ and PM_{10} found in the most contaminated area were 11.09 µg/m^3 and 4.01 µg/m^3 higher than WHO standard level which are 25 and 50 µg/m^3 respectively. Moreover, the concentration of $PM_{2.5}$ and PM_{10} were found the least in School 1 with the values 15.07 µg/m3 and 24.69 µg/m^3 respectively. The $PM_{2.5}$ concentration in school 1 was 15.07 µg/m^3, school 2 was 32.30 µg/m^3, school 3 was 35.34 µg/m^3, school 4 36.09 µg/m^3, school 5 was 21.88 µg/m^3. However, the concentration of PM_{10} was found higher in school 4 with the concentration of 54.91 µg/m^3 this school is situated in pallabi area.

4.2. Dispersion of $PM_{2.5}$ and PM_{10}

4.2.1. Dispersion of $PM_{2.5}$

The following table 4.2 shows the descriptive statistics for $PM_{2.5}$ of the studied five different schools. The highest range was found in School_4 with the concentration of 36.09 µg/m^3 which is in Mirpur area and the lowest range of $PM_{2.5}$ was found in School_1 with the concentration of

15.07 µg/m3 which is situated in mailbag area. Among all those land uses the minimum concentration 7 µg/m3 found in the location of gate of School 1 and the maximum concentration 69 µg/m3 found in the adjacent area of school 2. The highest mean value of PM2.5 was found in the adjacent area of school 2 with 43.89 µg/m3 and the lowest mean value 10.6 µg/m3 found in gate and classroom of school 1. The highest standard deviation was seen in school 2 with the value 14.04 µg/m3 and the lowest was seen in school 5. Table also shows that; the highest coefficient of variation was seen in school 1which was 74.06% and lowest was in school 3 which was 2.74%.

Table 4.2: Descriptive Statistics for $PM_{2.5}$

Dispersion $PM_{2.5}$							
S. N.	**Name of School**	**Name of the location**	**Min. (µg/m^3)**	**Max. (µg/m^3)**	**Mean (µg/m^3**	**Std. Deviation (µg/m^3)**	**Coefficient of Variation (%)**
1.	**School 1**	**Gate**	7	12	10.6	0.699	6.59
		Classroom	10	12	10.6	0.69	6.59
		Field	19	35	25.4	6.11	74.06
2.	**School 2**	**Adjacent area 1**	20	25	23.21	1.35	5.84
		Gate	19	21	23	2.70	11.75
		Adjacent area 2	26	69	43.89	14.04	31.99
		Field(raining)	29	50	38.23	7.79	20.37
		Classroom	32	39	35.45	2.06	5.82
3.	**School 3**	**Adjacent area**	34	42	37.80	2.35	6.23
		Gate	36	42	37.65	1.69	4.50
		Field	31	36	33.66	1.28	3.81

		Classroom	32	35	33.14	0.910	2.74
4.	**School 4**	**Classroom**	33	39	35.31	1.325	3.74
		Field	38	41	36.375	1.52	4.19
		Adjacent area	34	40	36.54	1.59	4.36
5.	**School 5**	**Adjacent area**	19	25	21.65	1.46	6.76
		Gate	20	22	21.21	0.59	2.82
		Field	19	24	20.8	1.25	6.04
		Classroom	23	26	24.14	0.91	3.77

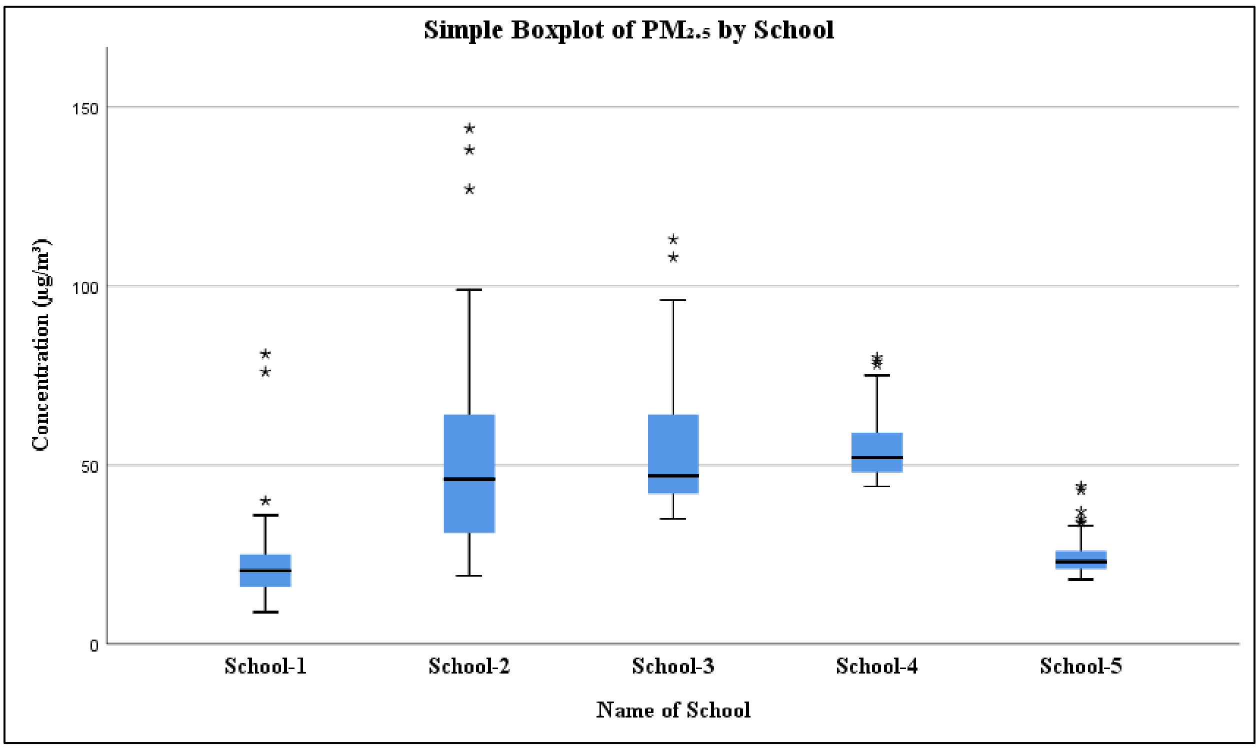


Figure 4.3: Whisker-box plot showing the concentration of PM2.5 in Different schools

The box plot displays the average concentrations of $PM_{2.5}$ in five different schools. Within each box, the horizontal black line represents the median, the lower boundary signifies the 25th percentile, and the upper boundary corresponds to the 75th percentile. The whiskers represent the minimum (lower whisker) and maximum (upper whisker) values for each school's data. Data points located above the upper whisker are considered outliers. The analysis of the PM2.5 concentrations in the schools revealed distinctive patterns. School_2 exhibited the highest dispersion with a normal distribution, including three outliers. School_3 displayed a positively skewed distribution with two outliers. School_4 showed a moderate distribution with one outlier, also following a positive distribution. In the case of School_1, a simple normal distribution was observed with one closer and two distance outliers. Lastly, School_5 displayed a less clustered distribution with three closer outliers.

4.2.2 Dispersion of PM_{10}

Table 4.3 Dispersion Table of PM_{10}

Dispersion PM_{10}							
SN.	**Name of School**	**Name of the location**	**Min. (µg/m³)**	**Max. (µg/m³)**	**Mean (µg/m³**	**Std. Deviation (µg/m³)**	**Coefficient of Variation (%)**
1.	**School 1**	**Gate**	9	39	18.2	7.81	42.93
		Classroom	14	24	18.1	3.07	16.96
		Field	20	81	36.9	22.85	61.93
2.	**School 2**	**Adjacent area 1**	24	32	27.36	2.60	9.52
		Gate	19	58	36.21	10.34	28.55
		Adjacent area 2	32	144	64.25	29.81	46.41
		Field(raining)	33	71	52.46	11.45	21.83
		Classroom	52	92	70.63	10.13	14.34
3.	**School 3**	**Adjacent area**	55	108	77.57	14.52	18.71

		Gate	50	113	62.65	11.94	19.07
		Field	35	51	42	3.66	8.72
		Classroom	38	55	42.577	3.39	7.98
4.	**School 4**	**Classroom**	46	80	57.95	10.50	18.12
		Field	44	78	49.67	6.65	13.39
		Adjacent area	48	75	57.59	6.64	11.53
5.	**School 5**	**Adjacent area**	20	44	27.95	7.05	25.23
		Gate	19	28	22.30	1.91	8.59
		Field	18	25	21.2	1.87	8.82
		Classroom	23	35	25.85	3.26	12.60

The following table 4.2 shows the descriptive statistics for PM_{10} of the studied five different schools. Among all those the minimum concentration 9 µg/m^3 was found in the location of gate of school 1 and the maximum concentration 144 µg/m^3 was found in the adjacent area of school 2. The highest mean value of PM_{10} was found in Adjacent area of school 3 and the lowest mean value was found in school 1 with the value of 18.1. The highest standard deviation was seen in adjacent area of school 2 with the value of 29.81. Table also shows that; the highest coefficient of variation was seen in adjacent area of school 2 with the value of 46.41% and the lowest was seen in classroom of school 3 which was 7.98%.

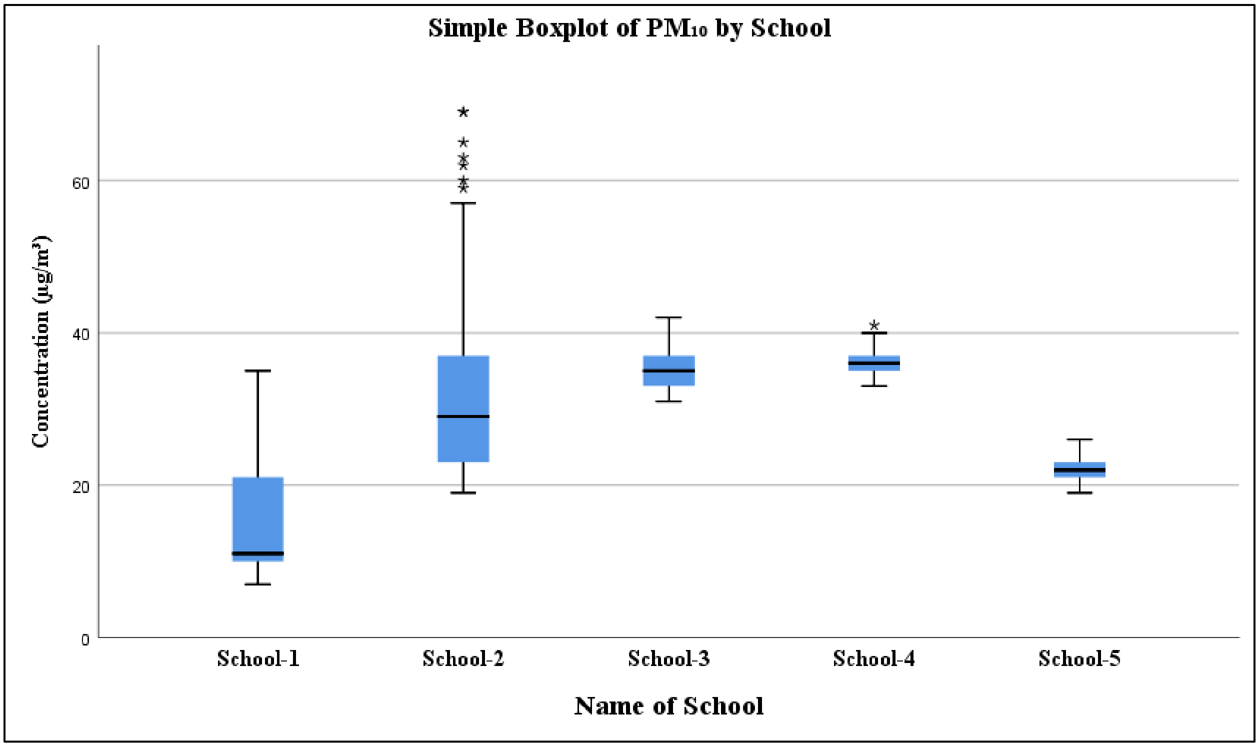


Figure 4.4: Whisker-box plot showing the concentration of PM_{10} in Different schools.

The box plot displays the average concentrations of PM_{10} in five different schools. Within each box, the horizontal black line represents the median, the lower boundary signifies the 25th percentile, and the upper boundary corresponds to the 75th percentile. The whiskers represent the minimum (lower whisker) and maximum (upper whisker) values for each school's data. Data points located above the upper whisker are considered outliers. The analysis of the PM_{10} concentrations in the schools revealed distinctive patterns. School_2 exhibited the highest dispersion with a positively skewed distribution, including six outliers followed by school_1 displayed a normally skewed distribution. Moderate distribution was seen in school_3, school_4 along with one outlier. Less moderate distribution was seen in school_5 with positive skewness.

4.3. Significance Test:

Table 4.3 shows ANOVA for significance test. ANOVA is performed to find whether the changes in the concentration of all the parameters between and within land uses are significant. The F values were calculated to be 64.981for $PM_{2.5}$ and 99.334 for PM_{10}. P value of PM2.5 and PM10 were 0.023 and 0.220. P value of PM2.5 and PM10 were 0.0 and 0.00. The following table shows that the concentrations of $PM_{2.5}$ and PM_{10} change significantly between and within in the land uses as the P values is less than 0.05.

Table 4.4: Significance Test

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
$PM_{2.5}$	Between Groups	71679.438	4	17919.860	64.981	0.00
	Within Groups	110584.059	401	275.771		
	Total	182263.498	405			
PM_{10}	Between Groups	18694.081	4	4673.520	99.334	0.00
	Within Groups	18866.502	401	47.049		
	Total	37560.584	405			

4.4. Land Use Based Cluster Analysis

Figure 4.5 shows the dendrogram plot obtained from cluster analysis in terms of $PM_{2.5}$ with Z-score normalization. For this analysis average linkage between groups has been considered. Three clusters have been found from below graph. First cluster is consisted of school_3, school_4, School_2. The second cluster include school_1, Third cluster include school_5. Moreover, 2^{nd} cluster joined with 3^{rd} cluster at the approximate distance of 10. These broad cluster join with the first cluster at the approximate distance of 25.

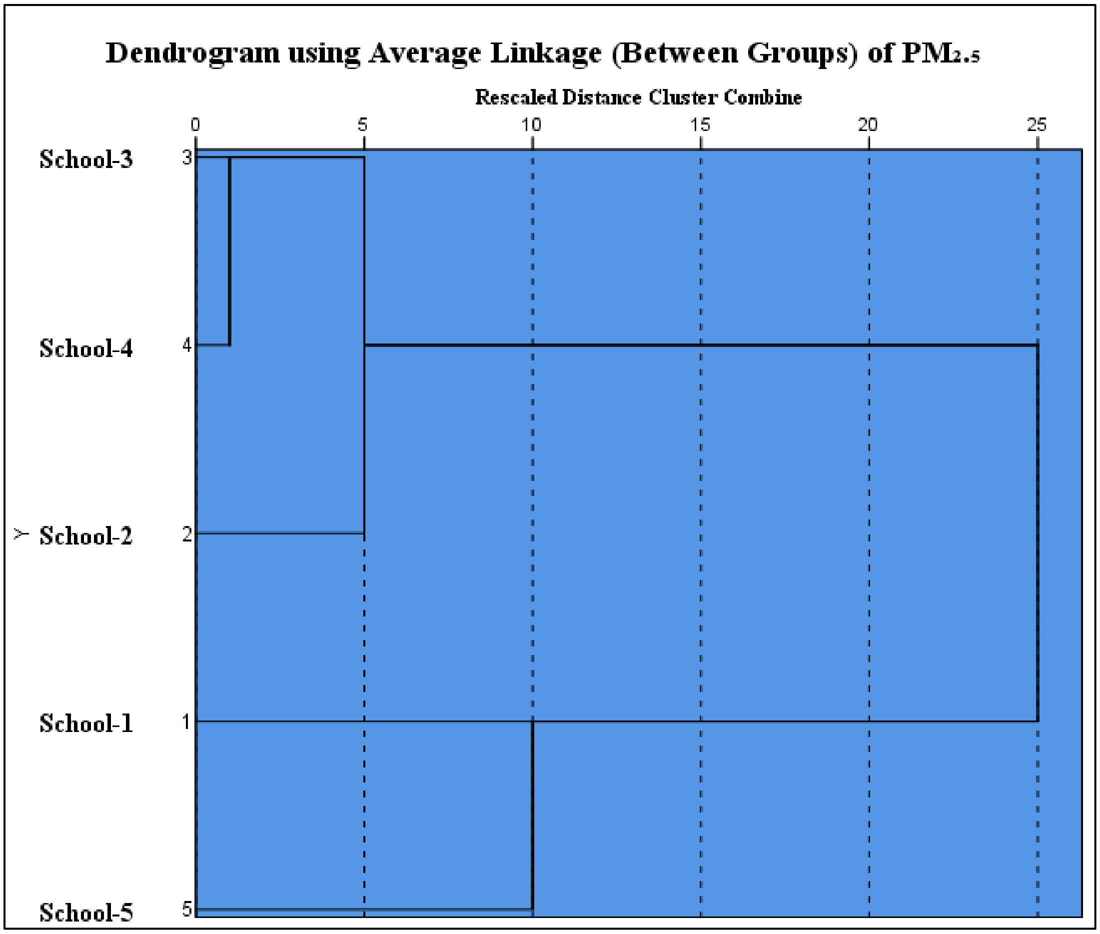


Figure 4.5: Rescaled Distance Cluster Combine for $PM_{2.5}$

Figure 4.6 shows the dendrogram plot obtained from cluster analysis in terms of PM10 with Z-score normalization. For this analysis average linkage between groups has been considered. Four clusters have been found from below graph. First cluster is consisted of school_3, school_4, school_ 2. The second cluster include school_1, school_5 which join with the third cluster involves with school_1 at the approximate distance of 11. These broad cluster join with the first cluster at the approximate distance of 25.

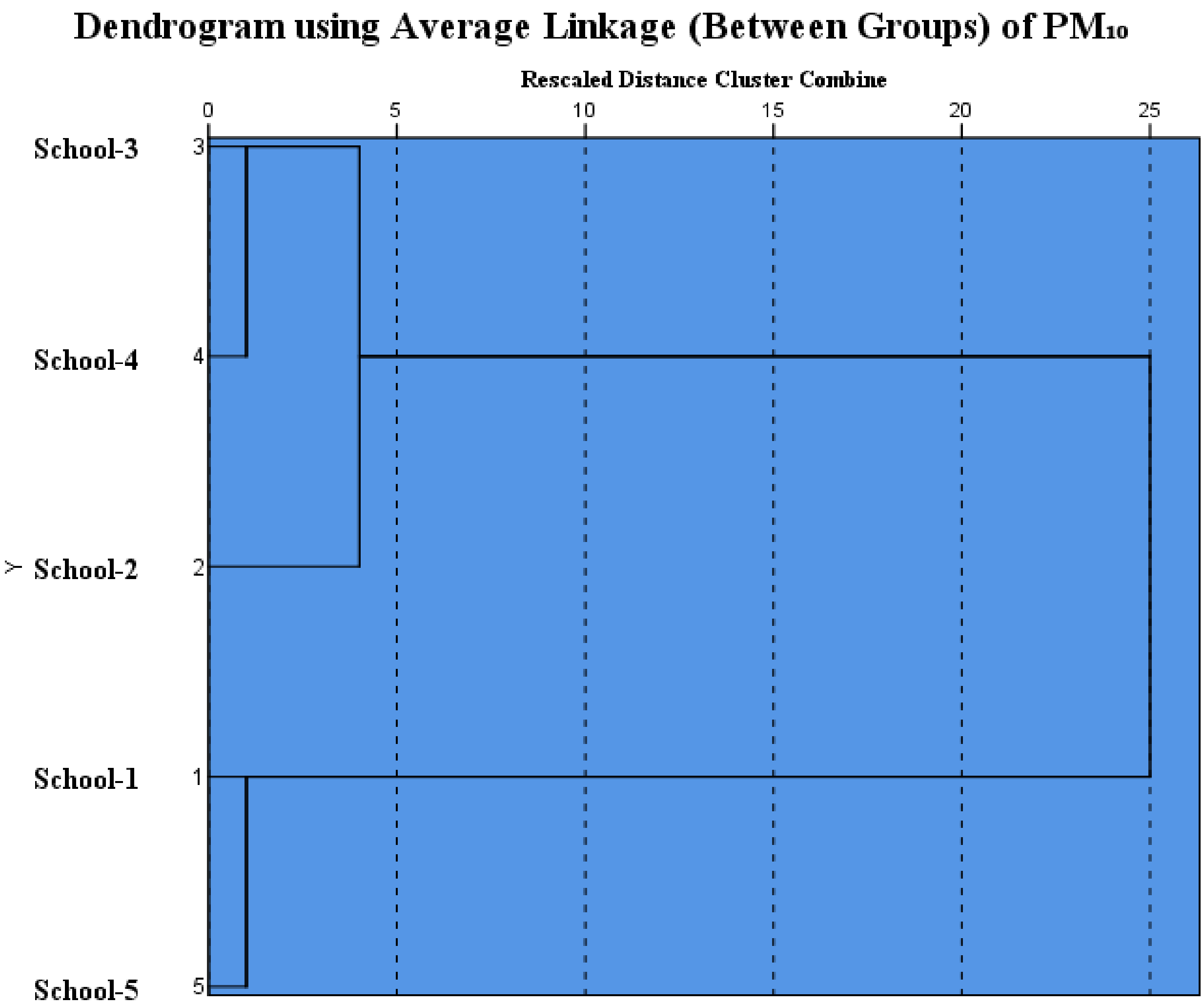


Figure 4.6: Rescaled Distance Cluster Combine for PM_{10}

4.7. Interpolation Map of Different schools in Monsoon on $PM_{2.5}$ and PM_{10}

4.7.1. $PM_{2.5}$ Interpolation Map of selected schools in Monsoon

Figure 4.6 presenting the concentration of Particulate Matter ($PM_{2.5}$) at Different schools of Dhaka City. Concentrations of Particulate Matter ($PM_{2.5}$) are expressed in $\mu g/m^3$. The concentration of $\mu g/m^3$ means one-millionth of a gram of PM per cubic meter of air. Brown and yellow areas have less, while progressively higher concentrations are shown in Blue and light blue. The concentration of $PM_{2.5}$ was found to higher in 32.29-37.22 $\mu g/m^3$ in which is in Mirpur area(school 3) and its color is dark blue. This map is created by using geographic information system (GIS). The Selected schools coordinate latitude and longitude are used to create this Map. Coordinates are added the

Inverse distance weighted (IDW) map created. This map shows the highly and less pollution areas with its color. Though monsoon seasons air quality is quite good less polluted.

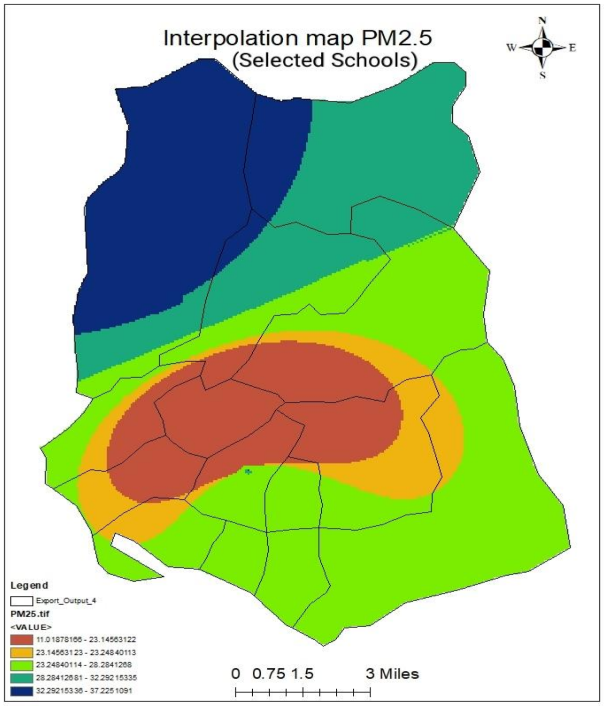


Figure 4.7: Interpolation Map of $PM_{2.5}$ for selected schools

4.7.2. PM_{10} Interpolation Map of selected schools in Monsoon

Figure 4.7 presenting the concentration of Particulate Matter (PM_{10}) at Different schools of Dhaka City. Concentrations of Particulate Matter (PM_{10}) are expressed in µg/m^3. The concentration of µg/m^3 means one-millionth of a gram of PM per cubic meter of air. Light ash and yellow areas have less, while progressively higher concentrations are shown in Red and blue. The concentration of PM_{10} was found to higher in 50.45-70 µg/m^3 which is in school 3(Mirpur area) and its color is Red. This map is created by using geographic information system (GIS). The Selected schools coordinate latitude and longitude are used to create this Map. Coordinates are added the Inverse distance weighted (IDW) map created. This map shows the highly and less pollution areas with its color. Though monsoon seasons air quality is quite good less polluted.

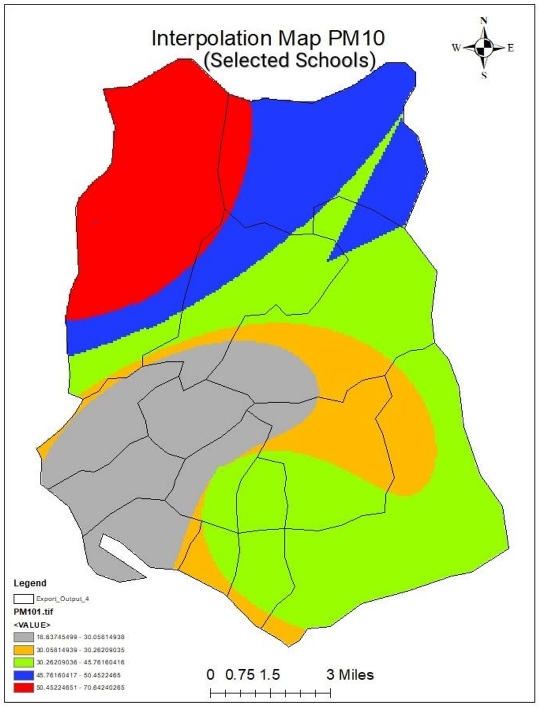


Figure 4.7: Interpolation Map of PM_{10} for selected schools

4.8 Survey on the students about their Health Impacts

I have conducted a questionnaire survey on sixty students of my selected five schools concerning their health impacts and air pollution. The questionnaire survey analysis is given below:

Table 4.5: Duration of Exposure (in a year)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-3 year	40	66.7	66.7	66.7
	4-6 year	20	33.3	33.3	100.0
	Total	60	100.0	100.0	

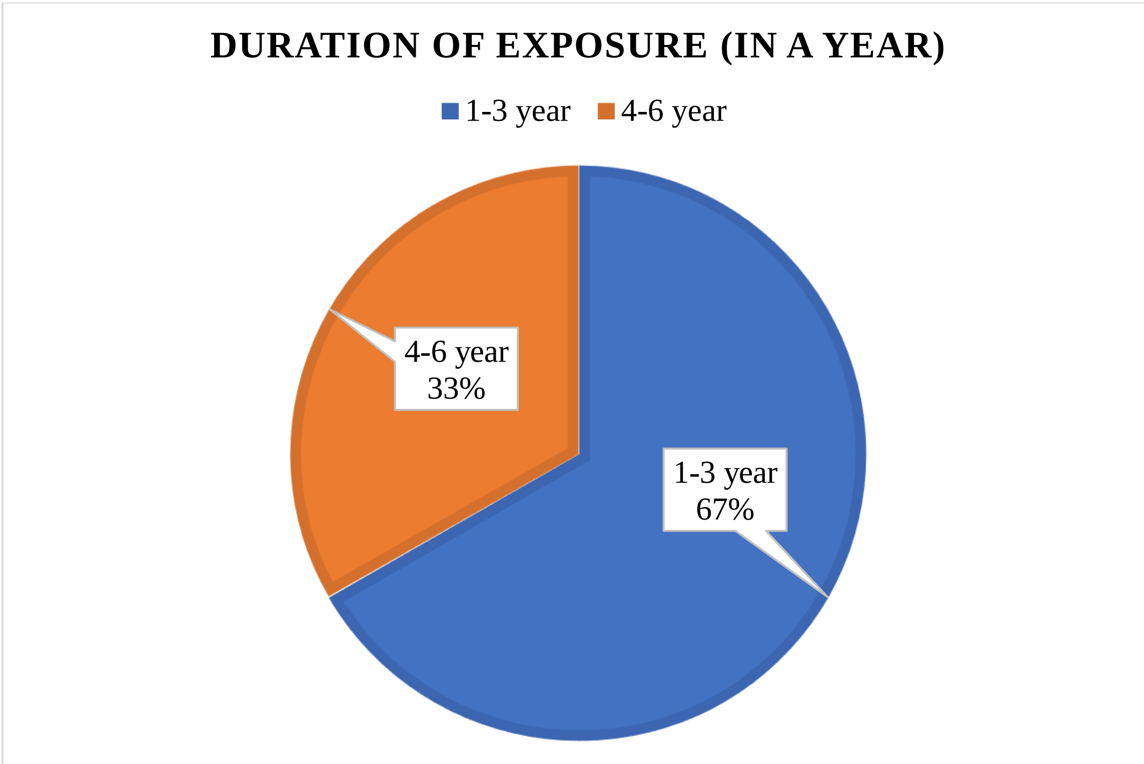


Figure 4.8: Duration of exposure (in a year)

The graph displays the duration of exposure to air pollution (in years). It shows that 66.7% of respondents reported exposure to air pollution for 1-3 years, while 33.3% indicated exposure for 4-6 years. The total sample size included in the analysis is 60 participants. Which means in a year almost 67% students' duration of exposure is 1-3 year and 33% students 4-6 year.

Table 4.6: Duration of Exposure (hours in a Day)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5Hours	60	100.0	100.0	100.0

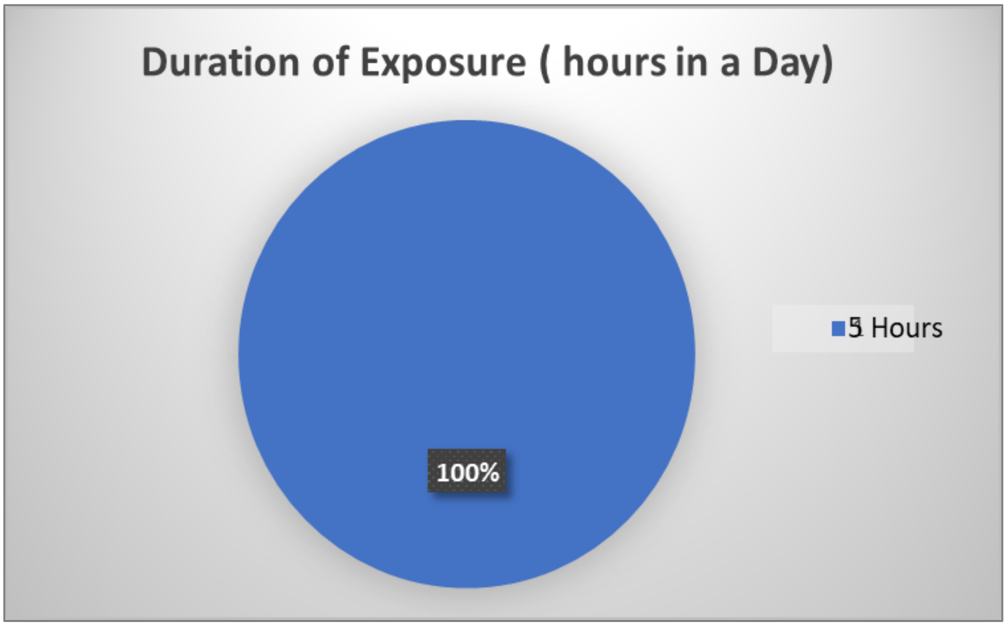


Figure 4.9: Duration of expose (Hours in a day)

This graph suggests that all respondents reported a consistent duration of exposure to air pollution of 5 hours per day. All respondent students agreed that they spend 5 hours in a day in school.

Table 4.7: Evaluation of School's Air Pollution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	27	45.0	45.0	45.0
	Unhealthy	33	55.0	55.0	100.0
	Total	60	100.0	100.0	

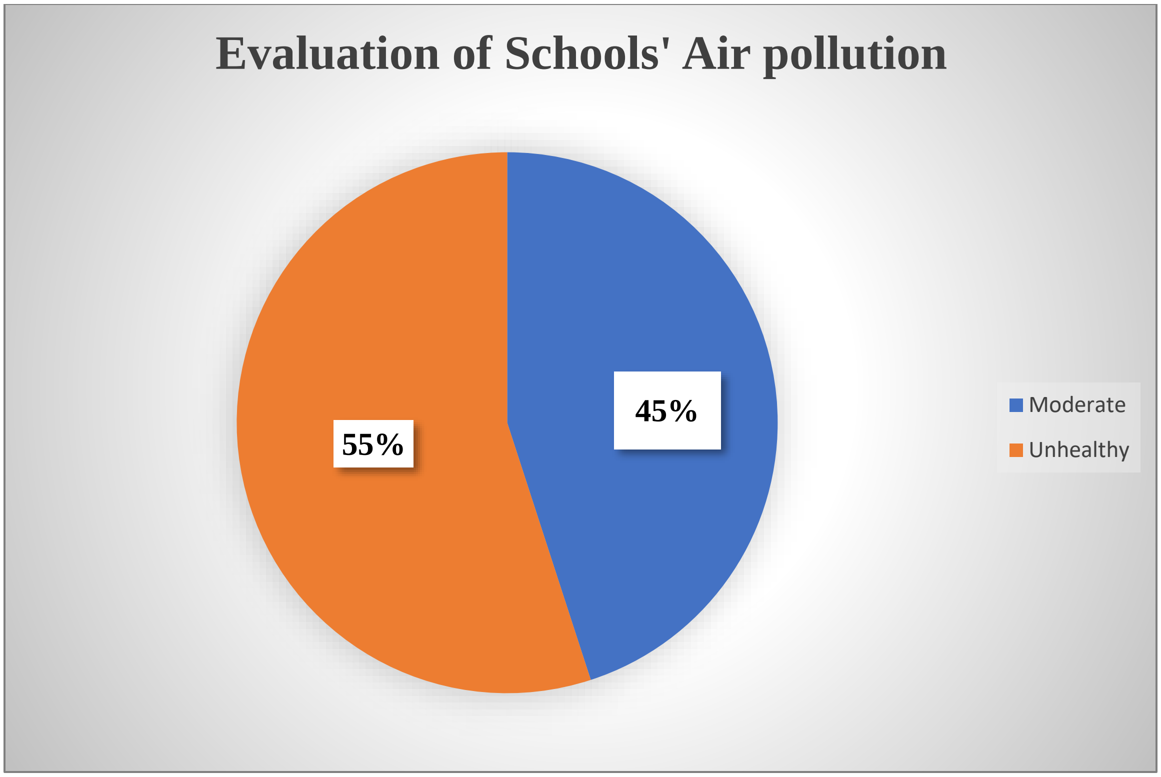


Figure 4.10: Evaluation of school's air pollution

Participants were asked to assess their school in terms of air pollution, and the results indicate that 45% of respondents considered the air quality to be "Moderate," while 55% deemed it "Unhealthy. Total 60 students participated in the survey and most of the students observed their schools air quality as unhealthy and some of the students responded as moderately polluted air.

Table 4.8: Sources of Air Pollution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fumes of vehicle	60	100.0	100.0	100.0

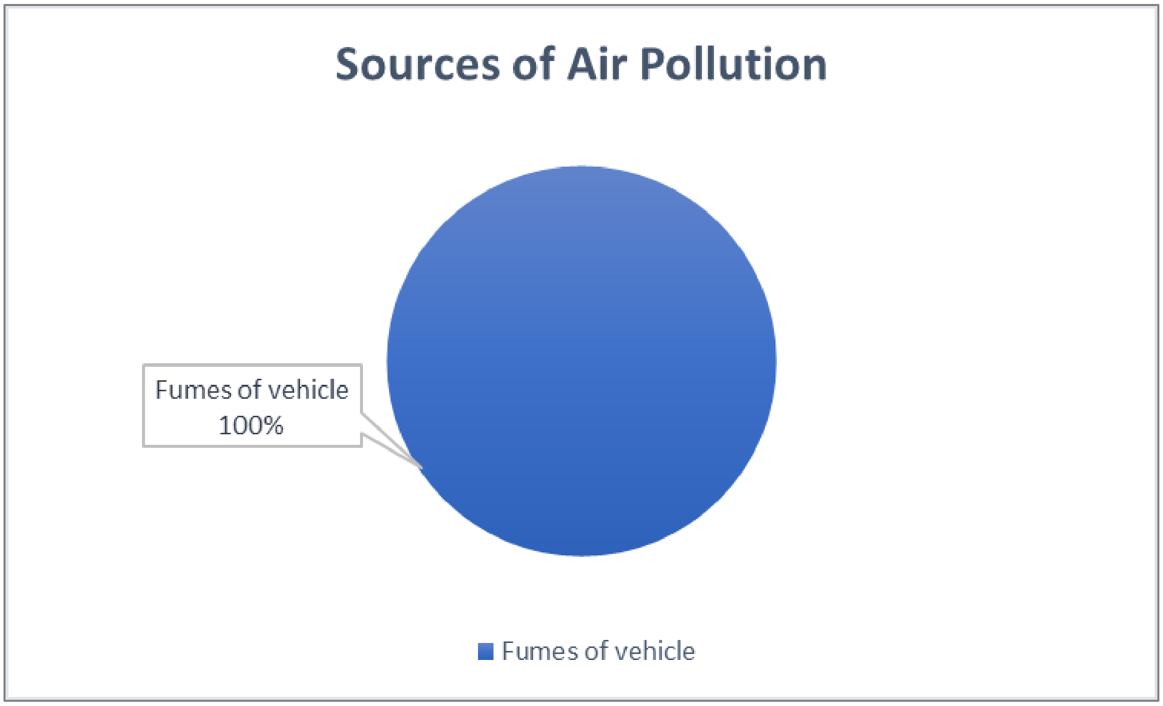


Figure 4.11: Sources of air pollution

Participants' opinions regarding the sources of air pollution in their area were examined, and all respondents attributed it to "Fumes of vehicles," accounting for 100% of the responses. Total 60 students participated in the survey and all of them answered their source of air pollution vehicular fumes. All the selected five schools are roadside so, the main source of air pollution is vehicular fumes.

Table 4.9: Age * Respiratory Problems

Count				
		Respiratory Problems		Total
		Never	Sometimes	
Age	11-15 year	26	0	26
	15-20 year	1	33	34
Total		27	33	60

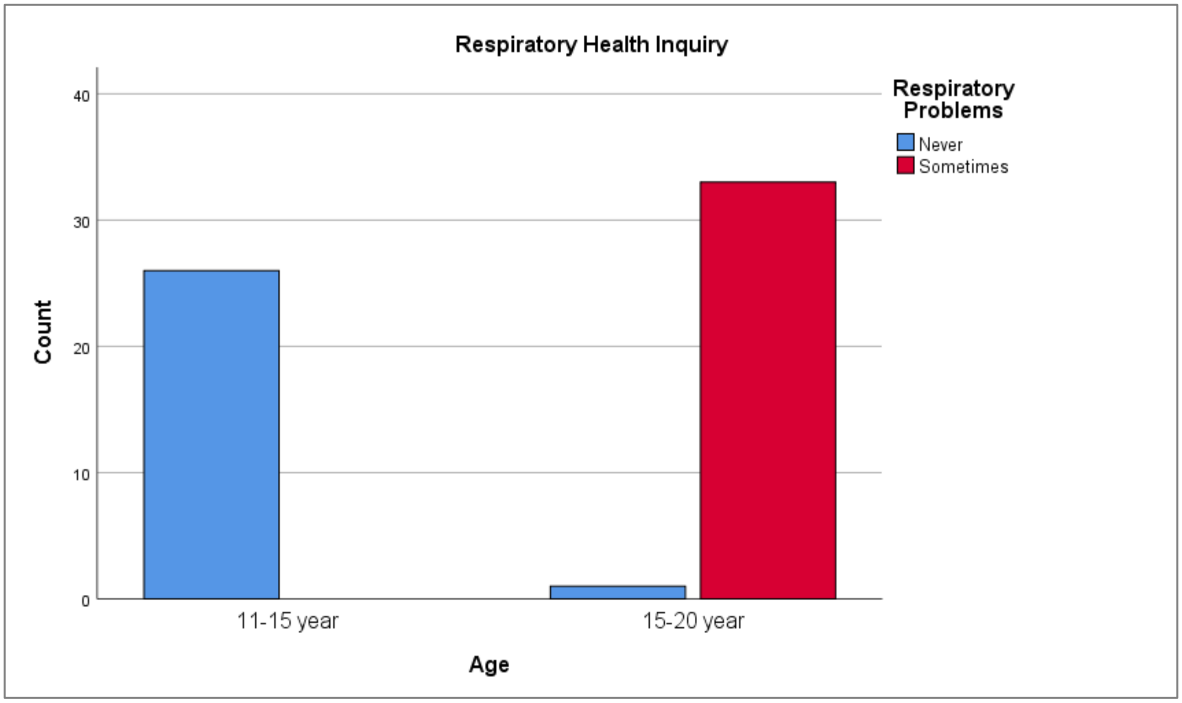


Figure 4.12: Respiratory Health inquiry

The graph depicts the presence of respiratory problems among participants in two age groups. Among those aged 11-15 years, 26 reported never having respiratory problems, while no participants mentioned experiencing them sometimes. For the 15-20-year age group, 1 respondent never had respiratory problems, while 33 participants mentioned experiencing them sometimes.

Table 4.10: Age * Breathing Difficulties

Count				
		Breathing Difficulties		Total
		Never	Sometimes	
Age	11-15 year	26	0	26
	15-20 year	1	33	34
Total		27	33	60

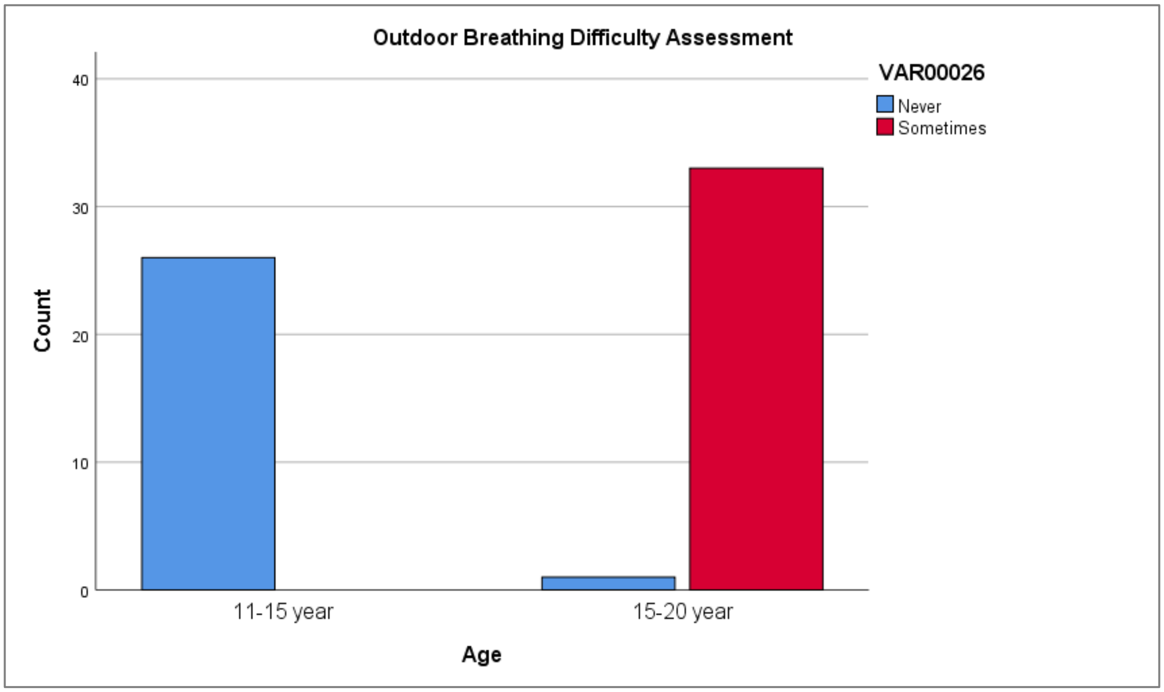


Figure 4.13: Age* outdoor breathing Difficulties

The table presents data on the occurrence of breathing difficulties when going outside, categorized by age groups. Among respondents aged 11-15 years, 26 individuals reported never experiencing breathing difficulties, and none mentioned having them sometimes. For the 15-20-year age group, 1 participant reported never having breathing difficulties, while 33 participants mentioned experiencing them sometimes.

Table 4.11: Age * Suffering Airborne Microbial Infection

Count				
		Suffering Airborne Microbial Infection		Total
		Never	sometimes	
Age	11-15 year	25	1	26
	15-20 year	34	0	34
Total		59	1	60

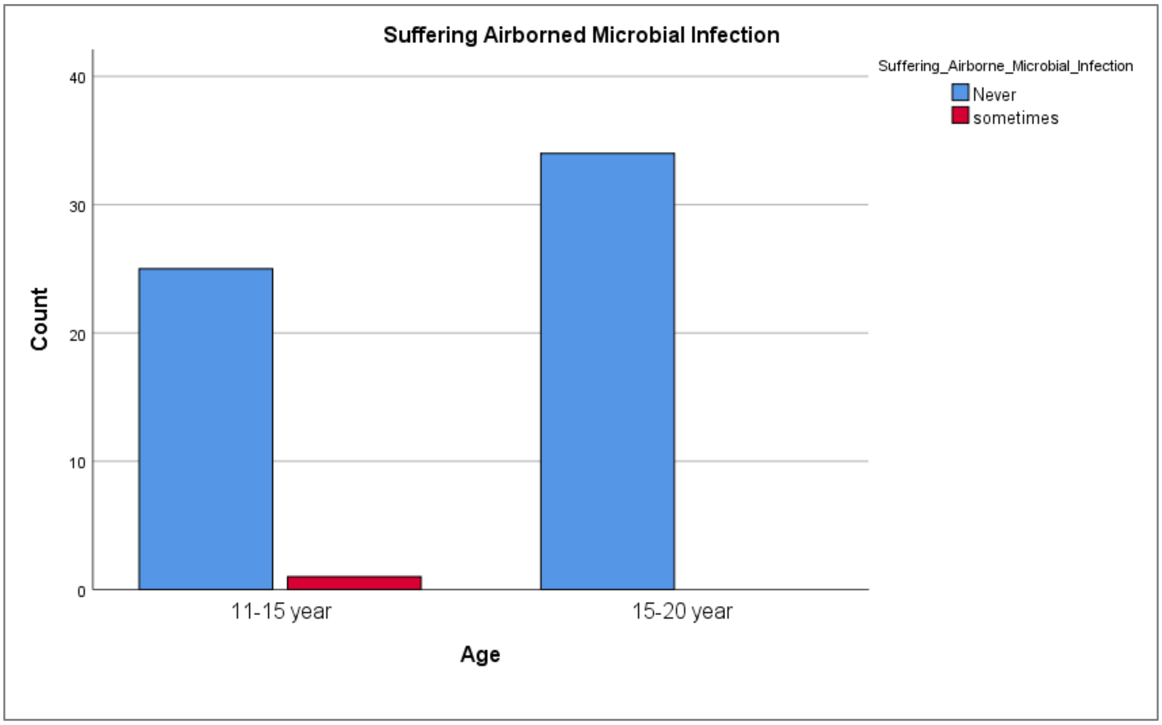


Figure 4.14: Suffering Airborne microbial disease

The table shows how many individuals in two age groups have experienced airborne microbial infections. Among those aged 11-15 years, 25 never experienced such infections, while 1 had them sometimes. In the 15-20-year age group, 34 individuals never had airborne microbial infections, and none of them had them sometimes.

Table 4.12: Age * Regular Inhaler Usage

Count				
		Regular Inhaler Usage		Total
		Never	Sometimes	
Age	11-15 year	26	0	26
	15-20 year	32	2	34
Total		58	2	60

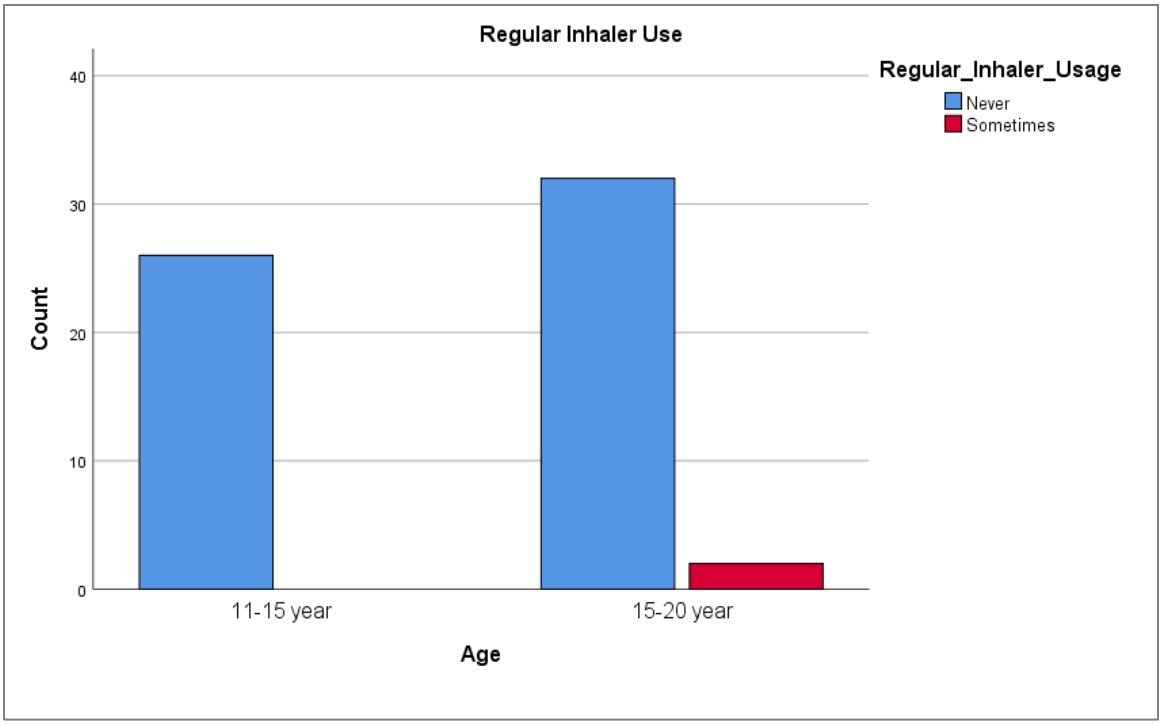


Figure 4.15: Age* Regular inhaler usage

The table indicates the regular use of inhalers by individuals. In the 11-15-year age category, 26 participants never use inhalers, and none use them sometimes. In the 15-20-year age category, 32 individuals never use inhalers, and 2 participants use them sometimes.

Table 4.13 Age* Respiratory medicine Usage

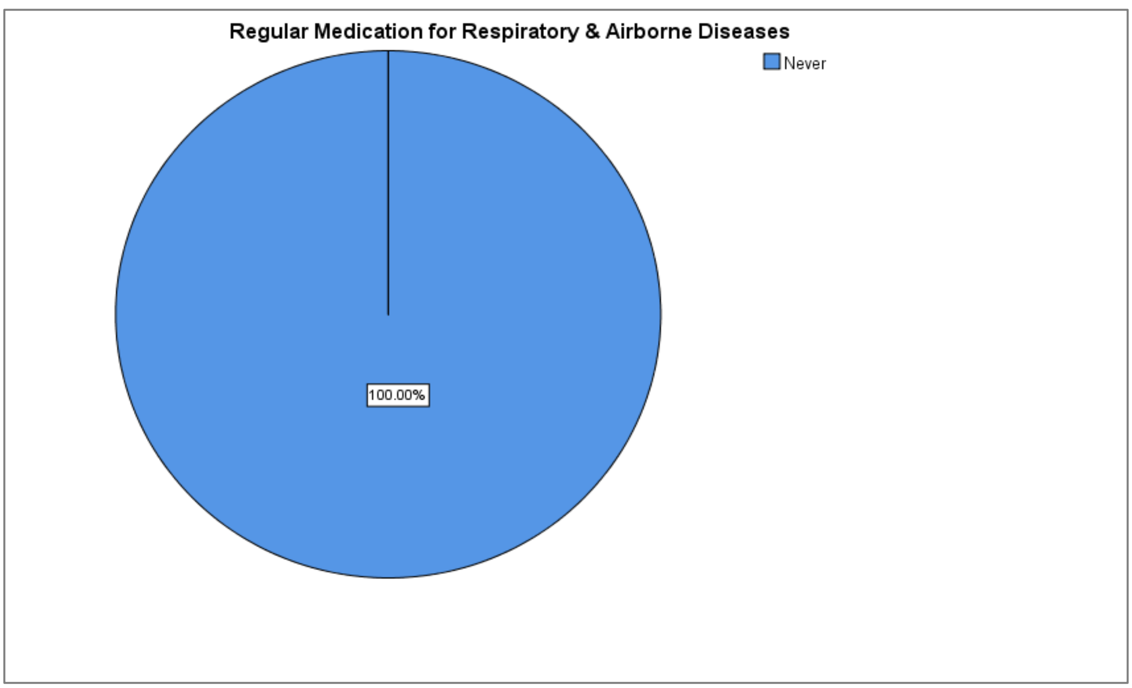


Figure 4.16: Age* Respiratory medicine usage

The graph presents information about regular medication usage for respiratory and airborne diseases among two age groups. In the 11-15-year age group, 26 participants reported never taking such medication, while in the 15-20-year age group, 34 participants also indicated that they never take this type of medication.

Table 4.14: Age * Impact Crosstabulation

Count				
		Impact		
		Always	Sometimes	Total
Age	11-15 year	7	19	26
	15-20 year	11	23	34
Total		18	42	60

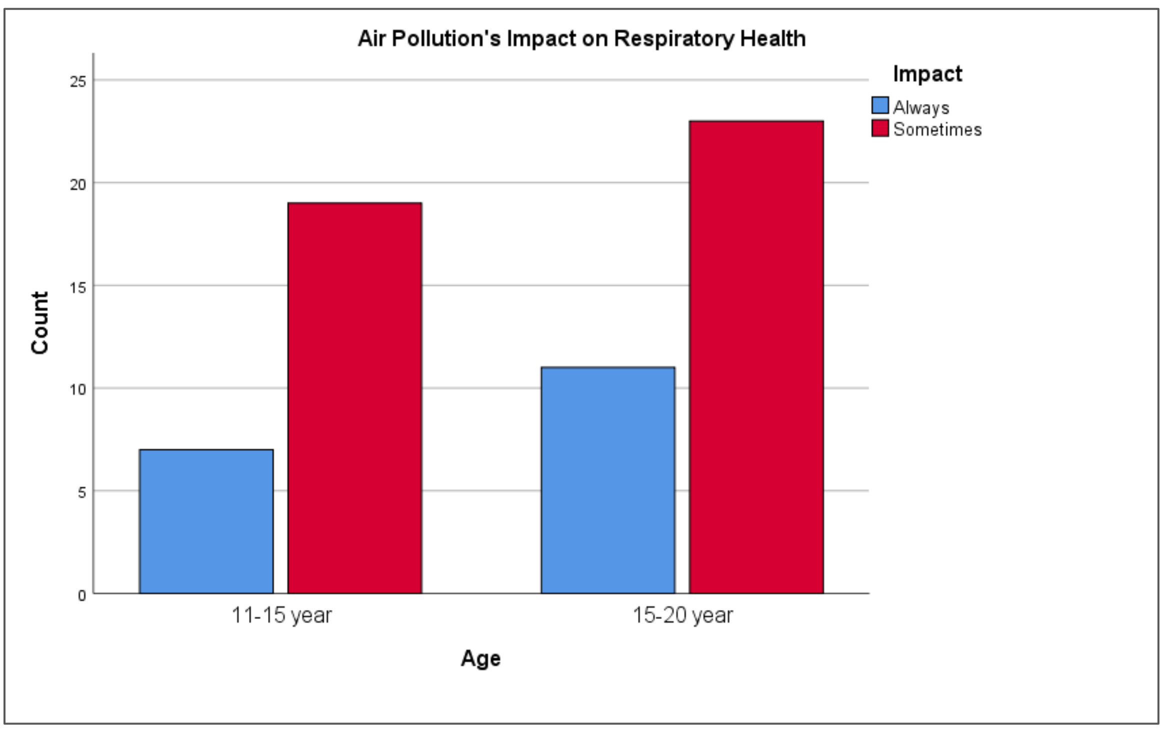


Figure 4.17: Age * Impact Crosstabulation

The crosstabulation table displays responses regarding the belief that air pollution triggers respiratory problems among individuals. For the 11-15-year age group, 7 participants believed it always triggers respiratory problems, while 19 participants thought it sometimes does. In the 15-20-year age group, 11 participants believed it always triggers respiratory problems, and 23 participants thought it sometimes does.

Table 4.15: Age * Doctor Visits

Count				
		Doctor Visits		Total
		1-5 times	Never	
Age	11-15 year	0	26	26
	15-20 year	5	29	34
Total		5	55	60

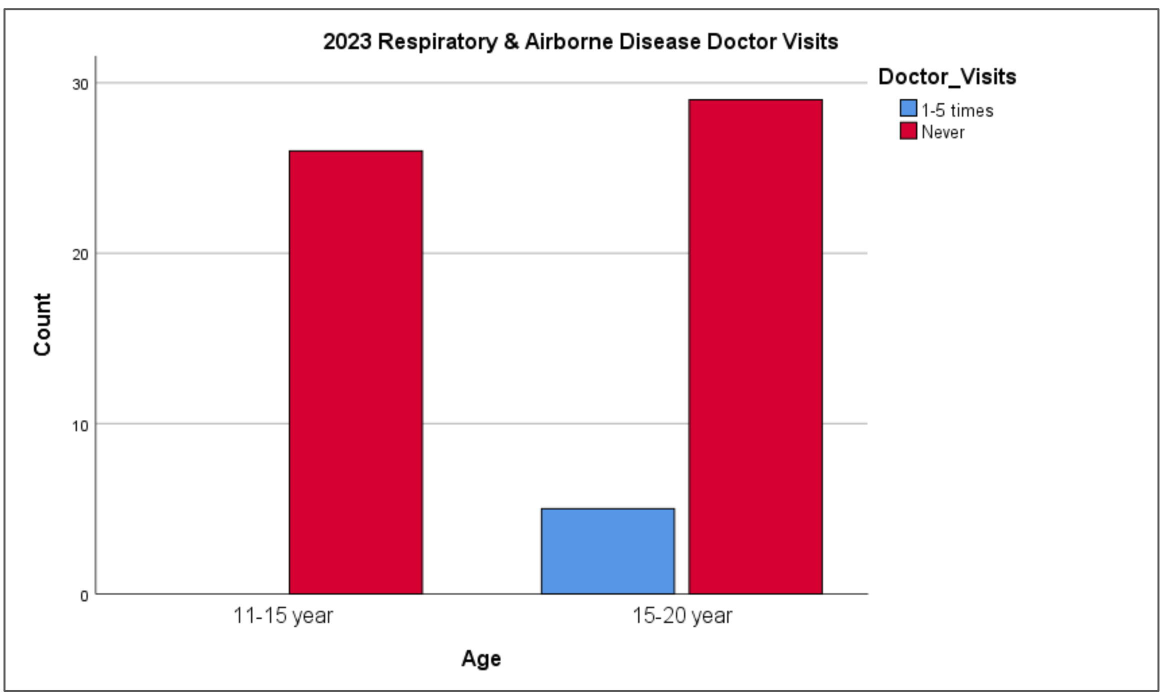


Figure 4.18: Age * Doctor Visits

The graph represents the frequency of visits to doctors in the year 2023 due to respiratory and airborne diseases among individuals. In the 11-15-year age group, none of the participants visited the doctor 1-5 times, while 26 never visited the doctor for such conditions. In the 15-20-year age group, 5 participants visited the doctor 1-5 times, and 29 never visited the doctor for these reasons.

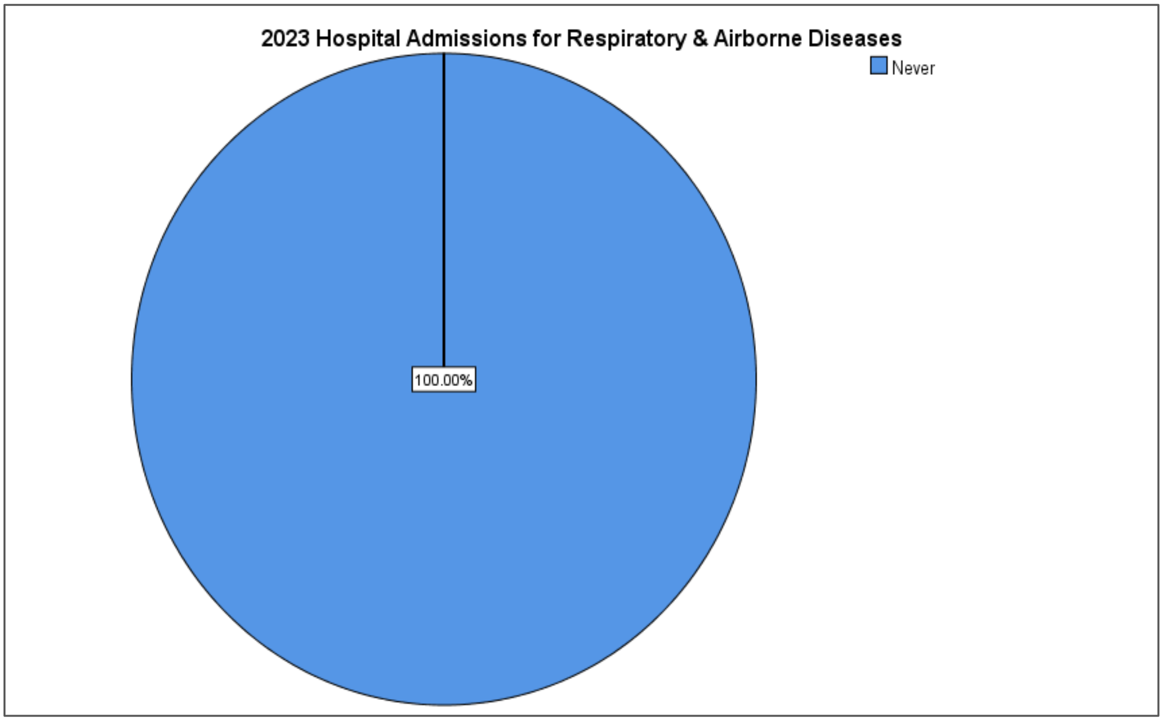


Figure 4.19: respiratory and airborne diseases in the year 2023

In response to the question regarding hospital admissions due to respiratory and airborne diseases in the year 2023, all participants (100%) reported that they had never been admitted to the hospital for these reasons.

Table 4.16: Age * Last Doctor Visit

Count				
		Last Doctor Visits		Total
		Last year	Never	
Age	11-15 year	18	8	26
	15-20 year	2	32	34
Total		20	40	60

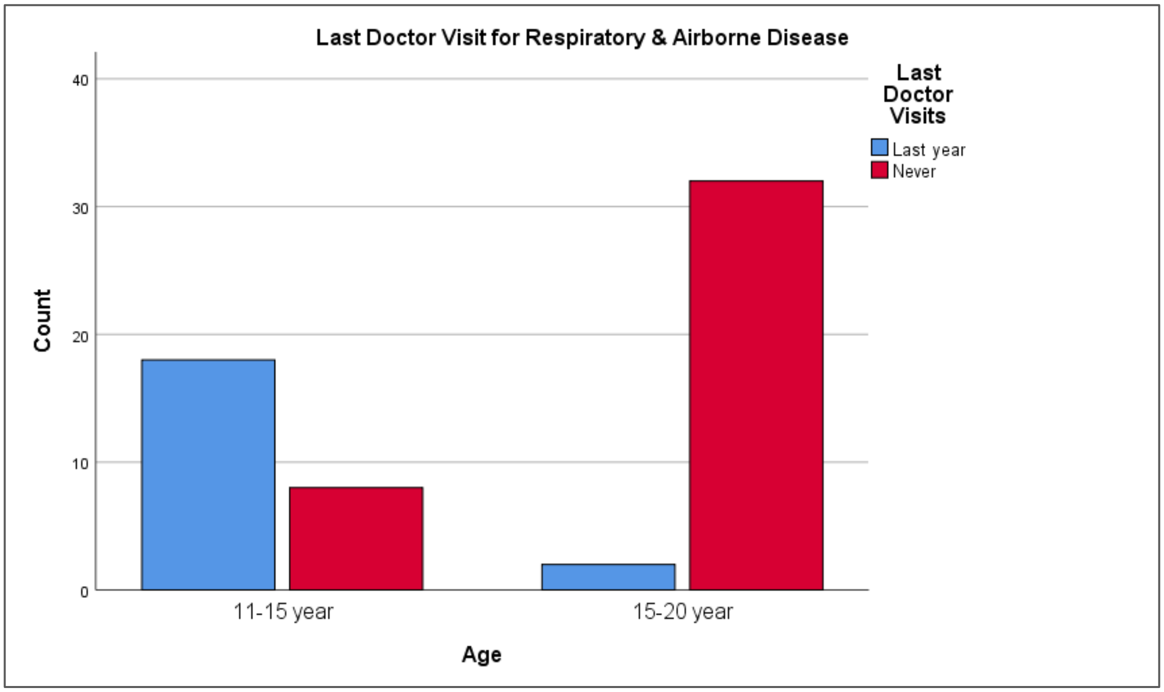


Figure 4.20: Age * Last Doctor Visit

The graph provides information about the timing of the last doctor visit due to respiratory and airborne diseases among individual. In the 11-15-year age group, 18 participants visited a doctor last year, while 8 participants never visited a doctor for these issues. In the 15-20-year age group, 2 participants had their last doctor visit last year, and 32 participants reported never visiting a doctor for these reasons.

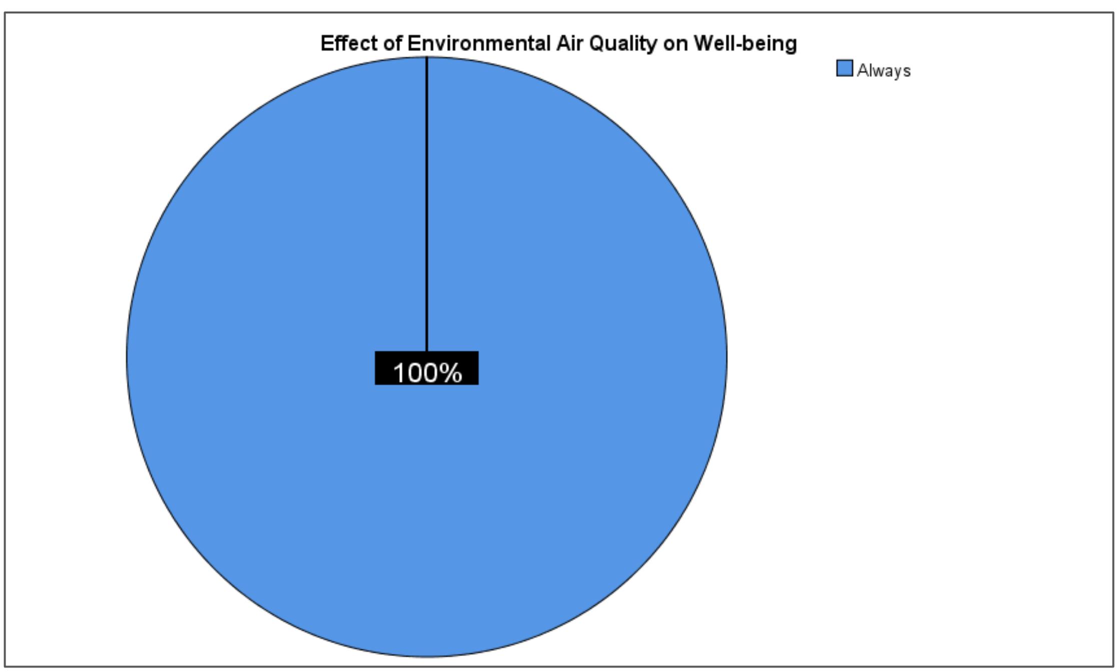


Figure 4.21: Effects of Environmental air quality on well being

In response to the question about feeling better when visiting areas with less air pollution, all participants (100%) reported that they always feel better in such environments. All the participant students answered that they feel better when they visit less polluted areas.

Table 4.17: Age * Respiratory Health & Covid19

Count					
		Respiratory Health & Covid19			
		always	Always	Sometimes	Total
Age	11-15 year	0	16	10	26
	15-20 year	2	13	19	34
Total		2	29	29	60

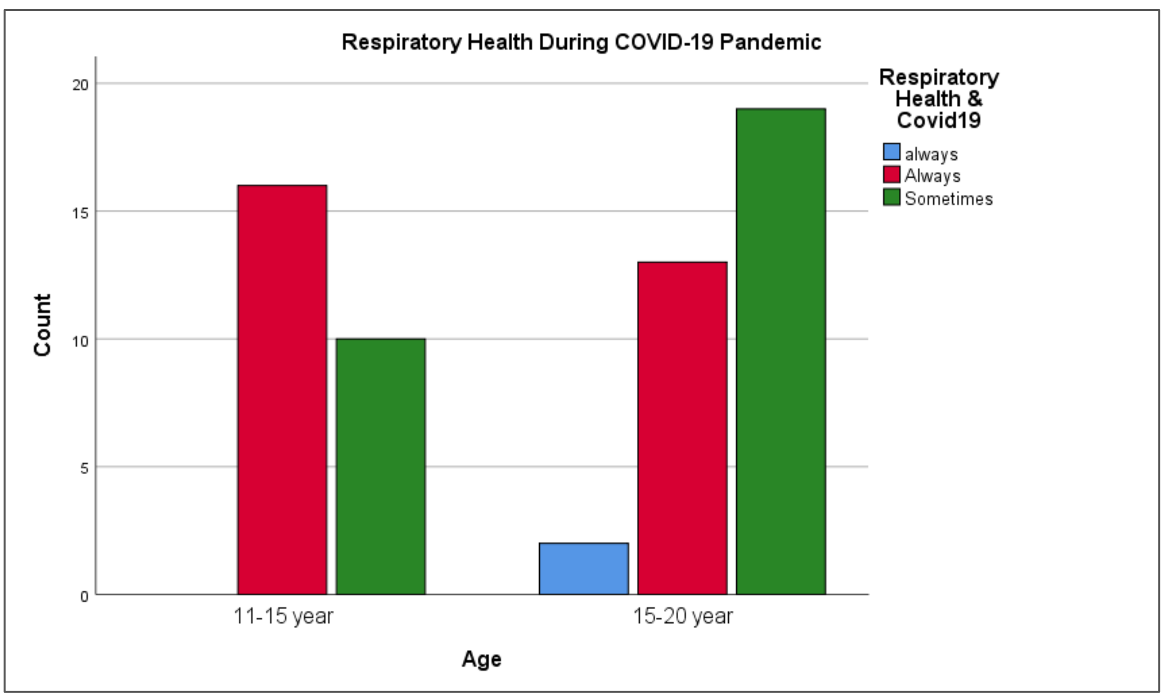


Figure 4.22: Age * Respiratory Health & Covid19

The table provides insights into the impact of the COVID-19 pandemic on respiratory health among individuals. For the 11-15-year age group, none of the participants reported that their respiratory problems always reduced during this period. However, 16 participants mentioned that it sometimes did. In the 15-20-year age group, 2 participants reported that their respiratory problems always reduced, 13 mentioned it sometimes did, and 19 participants indicated that their respiratory problems did not reduce during the COVID-19 period.

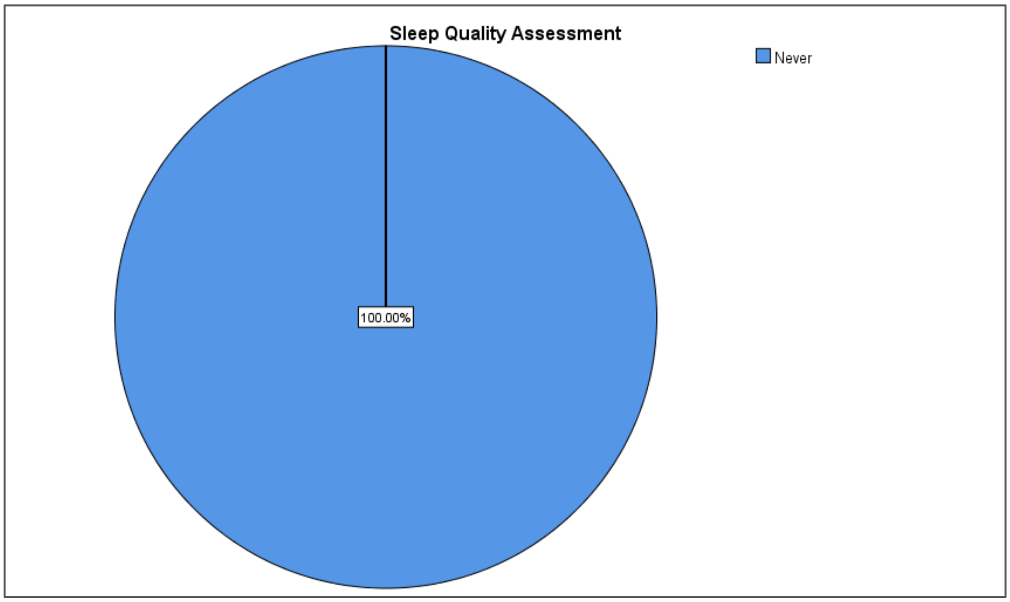


Figure 4.23: Sleep quality Assessment

And lastly, in response to the question about experiencing disturbances during sleeping hours, all participants (100%) reported that they never feel any kind of disturbance during their sleep. All of the participants answered that they don't have any sleeping disturbance.

4.9 Result from Health impact survey summary:

- 33% participants have 4-6-year exposure duration in a year.
- 67% participants have 1-3 year of exposure duration in a year.
- 100% participants say 5 hours duration of exposure in a day.
- 55% of perticipants consider their school air as "unhealthy" and 45% consider as moderate.
- 100% of the students said fumes of vehicle is the main source if air pollution.
- 15-20 years old students said sometimes they have respiratory problem.

- Most of the 15-20 years old students said yes to the question for air pollution has an impact on respiratory system.
- 100% students said they don’t have any sleeping disturbance.

CHAPTER FIVE

CONCLUSION

5.1 conclusion

The study found that the concentration of $PM_{2.5}$ and PM_{10} of five different schools in Dhaka city. The World Health Organization (WHO) and Bangladeshi air quality standards have both been compared to the $PM_{2.5}$ and PM_{10} concentration data related to air quality that was gathered from the five schools. Regarding the amounts of particulate matter pollution in school surroundings, the results show an alarming tendency. The data collected in the monsoon season so air quality was comparatively better. From this study we identify that monsoon air quality is better. Rainfall or precipitation has a great impact on air quality. From the outcome of this research are arranged in descending order based on average concentration $PM_{2.5}$ which follows school 4(36.09 µg/m^3) > school 3(35.34 µg/m^3) > school 2(32.30 µg/m^3) > School 5(21.88 µg/m^3) > school 1(15.07 µg/m^3). Along with that, the concentration of $PM_{2.5}$ and PM_{10} of different land use found one times higher than WHO standard level which are 25 and 50 µg/m^3 respectively but less than Bangladesh standard due to monsoon season and rainfall. Based on $PM_{2.5}$ and PM_{10} dispersion, among all those lands use the maximum range is found in adjacent area of school 2 and the minimum range is found in school 1. Further found that in $PM_{2.5}$ and PM_{10} dispersion coefficient of variation higher in the school 1(74.06%). whisker box graph of $PM_{2.5}$ School 2 exhibited the highest dispersion with a positively skewed distribution, including three outliers. School 3 displayed a normally skewed distribution with two outliers. whisker box graph of PM_{10} School 2 exhibited the highest dispersion with a positively skewed distribution, including six outliers followed by school 1 displayed a normally skewed distribution. Less moderate distribution was seen in school 5 with positive skewness. So, from this research analysis it can be concluded that the air quality in monsoon season quite good. From the questionnaire survey students know about the air pollution some of them are suffering from health and respiratory problems.67% percent of the participants reported an annual exposure duration of 1-3 years, whereas 33% percent reported an annual exposure duration of 4-6 years. This indicates that the participants' exposure times varied significantly. per participant stated that they were exposed for five hours per day. Concerns over the possible long-term cumulative consequences on their health are raised by this regular exposure pattern. Of the participants, 55% said the air quality in their school was "unhealthy," while 45% thought it was "moderate." The variation in perceptions suggests that students have differing levels of awareness and sensitivity to air pollution. All participants agreed in their response that car emissions are the main cause of air pollution. This increased awareness highlights the necessity of focused actions to reduce vehicle emissions near the school. One interesting discovery is that students between the ages of 15 and 20 occasionally have respiratory issues, and most of them think that air pollution affects the respiratory system. This correlation draws attention to the possible health effects of air quality on a particular age group. It's interesting to note that none of the participants said that air pollution caused them to have trouble sleeping. Although this is a good thing, it also begs the question of whether the students are aware of the possible long-term health consequences that may not be evident as sudden sleep disturbances. To sum up, the study findings emphasize how critical it is to address issues with air quality in educational settings. Reducing vehicle emissions and raising students' knowledge of air quality in general could lead to a more sustainable and healthful future.

5.2 Recommendations:

There is no way to completely eradicate air pollution. since it is created naturally and during a period when gasoline and diesel are used in all kinds of automobiles. The need to lessen motor transportation's detrimental effects on the environment is linked to the industry's rapid development. The government ought to have started cleaning up the city sooner. Air pollution is another issue that needs to worry about as it can lessen the number of contaminants we encounter on a daily basis. several recommendations can be made to address the identified concerns and promote a healthier school environment:

- Air Quality Monitoring and Awareness: To measure pollutant levels and educate pupils about the value of preserving excellent air quality, establish a regular program of air quality monitoring within school premises.
- Vehicle Emission Control**:** Work with the local government to put policies in place that will reduce the amount of emissions from vehicles near the school. This can entail encouraging the use of public transit, starting programs to encourage carpooling, or implementing no-idling zones.
- Integrate air quality education into the school curriculum to enhance students' understanding of the sources and impacts of air pollution.
- Involve the Teacher, educators, and parents in conversations and actions about air quality. Encourage a sense of collective accountability for establishing a livable and healthy environment.

- Empower students to take the lead in implementing initiatives that promote a cleaner and healthier environment.

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Appendices

Annex-1: Questionnaire

People's perception regarding Impacts of Air Pollution of school Students; a self-reported study

This is an academic survey. Please spend 10 min to fill up the form & help us to Impacts of Air Pollution of school Students. Thank you in advance.

1. Email address

2. Name

3. Gender

a) Male

b) Female

4. Age

a. Below 10 years

b. 11-15 Years

c. 15-20 Years

5. Duration of Exposure (in a year)

a) less than 1 year

b) 1-3 years

c) 4-6 Years

d) 7-9 Years

e) Over than 10 Years

6. Duration of Exposure (hours in a Day)?

a. ≤4

b. 5 Hours

c. 8-10 hours

d. ≥11

7. Where do you live in (School Name)?

a.

8. How do you evaluate your school in terms of air pollution?

a. Good

b. Moderate

c. Caution

d. Unhealthy

e. Very Unhealthy

f. Extremely Unhealthy

9. What is your opinion about sources of air pollution in your area?

a. Road digging and construction work

b. Brick kilns

c. Fumes of vehicles

d. Waste burning

e. Indoor Air Pollution

10. Do you have any Respiratory Problems?

a. Sometimes

b. Never

c. Always

11. Do you feel breathing difficulties when you go outside?

a. Sometimes

b. Never

c. Always

12. Do you ever suffer airborne microbial infection?

a. Always

b. Never

c. Sometimes

13. Do you take any kind of inhaler regularly?

a. Never

b. Sometimes

c. Always

14. Do you take any kind of Medicine for Respiratory & Airborne diseases regularly?

a. Never

b. Sometimes

c. Always

15. Do you think Air pollution triggers your respiratory problems?

a. Sometimes

b. Never

c. Always

16. How many times did you visit doctors due to Respiratory & Airborne diseases in the year 2023?

a. 1-5 Times

b. 5-10 Times

c. More than 10 Times

d. Never

17. How many times did you get admitted in hospital due to Respiratory & Airborne diseases in year 2023?

a. 1-5 Times

b. 5-10 Times

c. Never

18. When did you last visit doctors due to respiratory & Airborne disease?

a. Last week

b. Last month

c. Last year

19. Do you feel better if you visit some good environmental area where air pollution is less?

a. Sometimes

b. Never

c. Always

20. Did your respiratory problems reduce in COVID-19 Period? (Air quality has improved significantly in this pandemic situation).

a. Sometimes

b. Never

c. Always

21. Do you feel any kind of disturbance during your sleeping hours?

a. Always

b. Sometimes

c. Never

Thank you


Shiddeswari girls adjacent area
24.08.2023 13:23
23.7421, 90.41147


Siddheswari girls classroom
24.08.2023 14:14
23.7421, 90.4106


Gazi field
05.10.2023 12:33
23.74361, 90.40795


Gazi field
05.10.2023 12:33
23.74364, 90.40793


MCPSC adjacent area
27.08.2023 10:42
23.8363, 90.3641