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Assessment of Temporal Variations in Air Quality of Bankura and Barjora Towns, Bankura District, West Bengal

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Abstract

Urban and industrial pollution has been a major environmental concern around the world. Rapid rate of industrialization with consequent rise in urban population, unprecedented growth of transportation sector and lack of adherence to the pollution control measures may be attributed to the major factors of such point pollution sources. Recent trends of urbanization in Bankura and growth of industrial cluster in Barjora, adjoining to the so-called Asansol-Durgapur industrial conglomerate of West Bengal are of no exception in this regard. In spite of being the pollution hotspots of the district, these areas lack environmental concern and awareness among general people and academic fraternity. The present study attempts to assess the temporal variations of different air pollutants in these areas during last four years. The study is mainly based on the archived data from the WBPCB pollution monitoring stations located in the study areas. The Air Quality Index (AQI) calculated from the air pollution parameters (PM_{10}, SO_2, NO_2 etc.) revealed that the air pollution in the district is mainly responsible for industrial activities. The AQI values are much lower than the National Ambient Air Quality Standard (NAAQS) in Bankura town whereas it is relatively higher in Barjora. The study also shows the seasonal variations of air pollutants particularly the concentration of PM_{10}. It has been found that the winter months are more susceptible to heavier concentration of PM_{10} nearer to the surface due to the rising air density during winter, causing occurrence of frequent smogs in and around Barjora. The paper is expected to create awareness among the general public with a view to more and more administrative intervention in addressing this rising environmental issue.

Keywords: Air Quality Index, Industrial Pollution, National Ambient Air Quality Standard, Pollution Hotspot, Smog, Urban Pollution

1.1 Introduction

The majority of Indian cities suffer from extremely high levels of urban air pollution, particularly in the form of suspended particulate matter (SPM), SO_2 and NO_2 (Mannucci & Franchini, 2017; Huang, 2014). Levels of all pollutants are increasing due to industrial processes, agricultural activities, building construction, and road traffic, as well as reductions in natural habitat and other natural sources. Pollution sources can be divided into two types: mobile sources such as various vehicles and stationary sources such as municipal power plants, solid and liquid wastes, and residential combustion. Several industrial processes, such as iron and steel production, combustion of fossil fuels, biomass-burning power plants are major polluters in the cities (Laschober, 2004; Azam et al., 2016). The rapid growth in urban population, increasing industrialization, poor environmental regulation, less efficient technology of production, congested roads and rising demands for energy and motor vehicles are the worsening air pollution levels (Mishra, 2003). The majority of SPM emissions to the atmosphere are attributable to natural and anthropogenic sources, such as suspended terrestrial dust, oceans, forest fires, and natural gaseous emissions (Morawska & Zhang, 2002; Karar et al., 2006). There are many other sources of particulate emissions, including large industrial plants, medium- and small-scale industries, refuse burning, household burning of biomass for cooking and heating, vehicular exhausts, resuspended road dust, construction, particles migrating from other regions, and naturally occurring dust.

In 2014, 92% of the world's population was living in places where the WHO air quality guideline levels were not met (WHO, 2016). Furthermore, Ambient (outdoor air pollution) is a major cause of death and disease globally. An estimated 3 million premature deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children (WHO, 2016). The high concentration of air pollutants has worsened the human health (Tandon et al., 2008) and quality of life. The impact of gaseous and particulate pollutants on health varies with season, hence; seasonality has always been a factor for determining the concentration of pollution in the lower atmosphere (Balogun & Orimoogunje, 2015). Sustainable development Goals (2015) includes three indicators related to air pollution. First Indicator (3.9.1) states that by 2030 mortality rate due to household and ambient air pollution should be reduced. Second indicator (11.6) explains that by 2030 the adverse per capita impact on air quality and other waste management should be reduced and third indicator (8.4) implies that by 2020, the impact of chemicals on air, water, and soil should be minimized.

India is currently exposed to high levels of ambient and household air pollution. Global burden of disease data analysis reveals that more than one million premature deaths are attributable to ambient air pollution in 2015 in India (Khilnani & Tiwari, 2018). A report by the Ministry of Health and Family Welfare, India in 2015 "Air pollution and Health-Related Issues" explains that residents of urban settlements are exposed to increasingly higher levels of Particulate Matter (PM_{10} and $PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxides (NO_2), Carbon Monoxide (CO) and Ozone (O_3). While SO_2 levels have declined in recent years, levels of all other pollutants routinely exceeded the National Ambient Air Quality Standards (NAAQS). India's pollution is growing at an alarming rate due to the severe unsafe web of particulate matter (PM) and harmful gases present in the air that living organism's breath. Levels of particulate matter are extremely higher in all cities of India. Considering global levels of Ambient Particulate Matter (PM), India ranks tenth and thus is among the most polluted countries with an annual average PM_{10} level of 134 $\mu g/m^3$. Indian cities are listed among the 100 most polluted cities worldwide (Tobollik et al., 2015). Increase in an immense number of vehicles, industries and manufacturing units has resulted in the excess assembly of pollutants in the air, making air pollution as a state of national emergency across various cities around the country (Nasir et al., 2016).

The purpose of this study is to bring objective information to the air quality in two major towns (Bankura and Barjora) in the district of Bankura in West Bengal by examining long-term monitoring data (2017-2020). The study also shows the monthly and seasonal variations of air pollutants of these two monitoring stations. These towns are selected for data availability which is provided by West Bengal Pollution Control Board (WBPCB), and compared between census town and statutory town. It was focused on three major air pollutants – particulate matter (PM_{10}), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2).

1.2 Methodology

The daily concentration of Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2) and Particulate Matter (PM_{10}) were obtained from WPCB for two monitoring stations, Bankura and Barjora from January, 2017 to December, 2020. In this study, only two towns were considered because WBPCB provides relevant standards data only for these two towns, and they are critically polluted areas of this district. These two towns have different characters of Bankura district – rapid urbanization in sadar and residential town of Bankura, and growth of industrial cluster in Barjora town (adjoining of Durgapur-Asansol industrial zone). Most of this pollution is attributed to uncontrolled growth of vehicle population, and poor inspection and maintenance systems in the study areas.

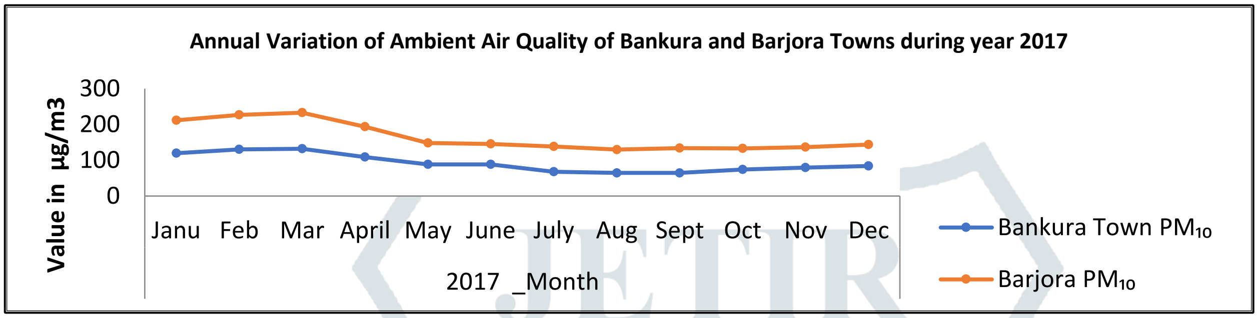
The air quality index (AQI) is a measure of the ratio of the pollutant concentration to the status of ambient air in different places. The AQI is one of the important tools available for analyzing and representing air quality status uniformly (Dadhich et al., 2017). The cumulative effect of concentration of individual pollutants in the ambient air is often expressed through a single value in the form of AQI. Three pollutants namely, PM_{10}, SO_2 and NO_2 were considered for calculation of AQI, which was already provided by WBPCB.

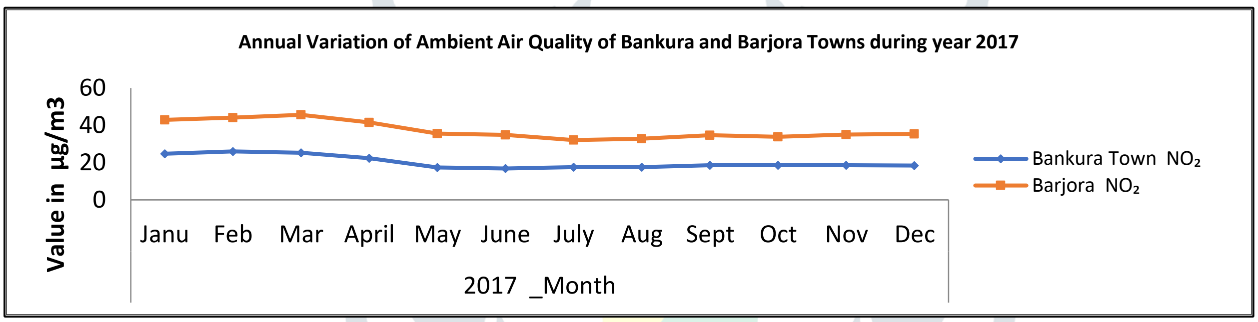
1.3 Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year from 2017 to 2020

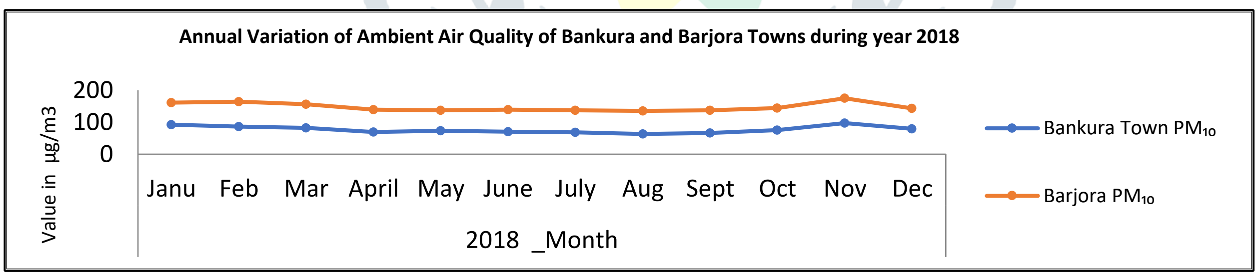
The West Bengal Pollution Control Board monitored ambient air quality of Bankura during 2017-20 through a network of manual station using Respirable Dust Samplers for monitoring criteria air pollutants like Respirable Particulate matter (RPM), Sulphur Dioxide (SO2) and Nitrogen Dioxide (NO2). At station RPM, SO2 and NO2 levels are monitored on each monitoring day following the national ambient air quality monitoring protocol.

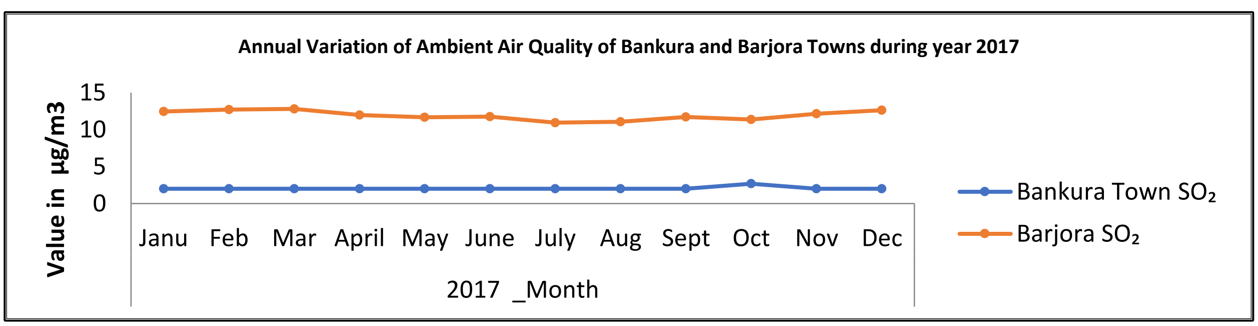
There are mainly three air quality parameters such as RSPM: Respirable Suspended Particulate Matter. These particles cause the worst damage as they can penetrate deep into the lungs and cause asthma. NO2: Nitrogen Dioxide cause reduced immune system, irritation and burns skin and also effects vegetation. Longer exposure can cause asthma. SO2: Sulphur Dioxide is a harmful gas which has a sharp smell and makes harmful substances when combined with other chemicals causing coughing, shortness of breath and also causes acid rain. Investigation for four years to show annual variation between Bankura Town and Barjora. The concentrations of air pollutants viz. PM10, SO2 and NO2 were analyzed for the period of 2017-2020 in Bankura Town and Barjora. The air quality parameters pollutant (like PM_{10}, NO_2 & SO_2) of Bankura Town and Barjora in 2017 is shown through simple line diagram. Level of PM_{10} in Bankura Town was 119.97 and 67.72 µg/m3 in January and July month respectively other hand Level of PM_{10} in Barjora was 211.88 and 138.11 µg/m3 in January and July month respectively. PM_{10} of Barjora is much more than that of Bankura Town. Similarly Level of NO_2 in Bankura Town was 24.7 and 17.5 µg/m3 in January and July month respectively other hand Level of NO_2 in Barjora was 42.88 and 32.06 µg/m3 in January and July month respectively. NO_2 of Barjora is much more than that of Bankura Town. Level of SO_2 of Bankura Town is 2.00 µg/m3 and Level of SO_2 in Barjora was 11.77 and 12.61 µg/m3 in July and December month respectively.

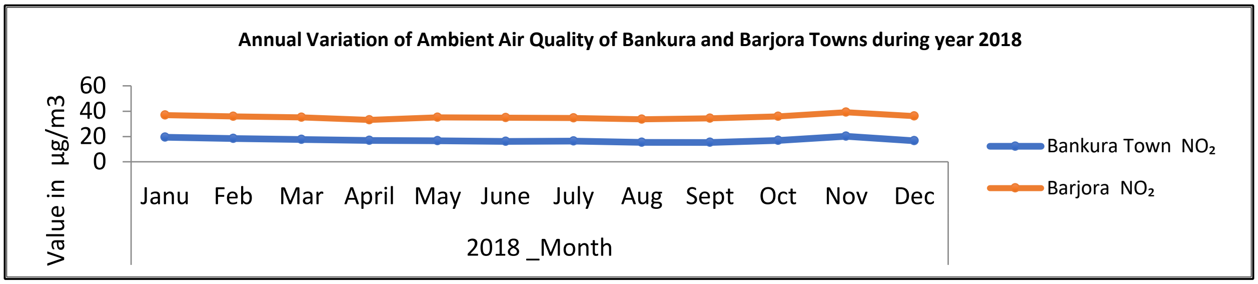
In 2018 and 2019, air quality parameters pollutant of Barjora are higher than that of Bankura Town. Finally in 2020 Level of PM_{10} in Bankura Town was 88.88 and 66.98 µg/m3 in January and July month respectively other hand Level of PM_{10} in Barjora was 183.79 and 87.86 µg/m3 in January and July month respectively. Similarly Level of NO_2 in Bankura Town was 20.88 and 13.97 µg/m3 in January and July month respectively other hand Level of NO_2 in Barjora was 44.73 and 26.98 µg/m3 in January and July month respectively. Level of SO_2 of Bankura Town is 2.00 µg/m3 and Level of SO_2 in Barjora was 15.73 and 14.23 µg/m3 in January and July month respectively. The air quality parameters pollutant in 2017 are higher than in 2020. However, in 2020 Level of PM_{10} has decreased compared to others pollutant.

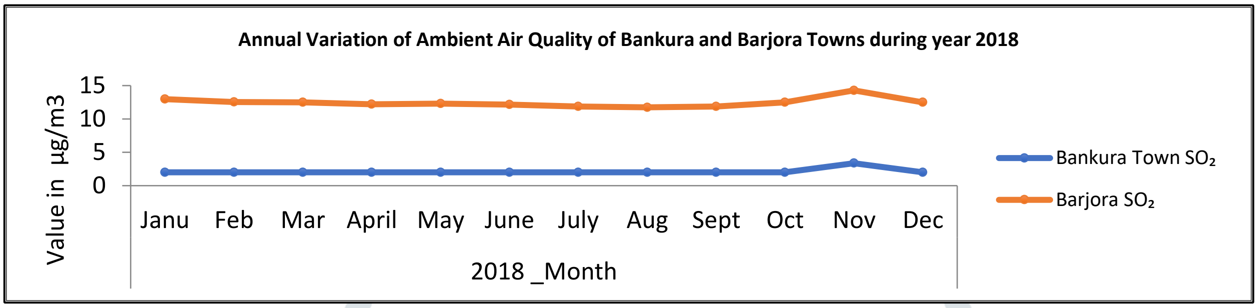


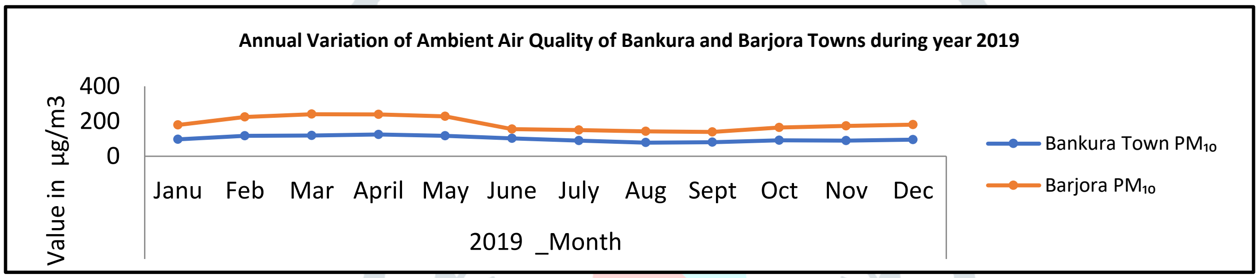


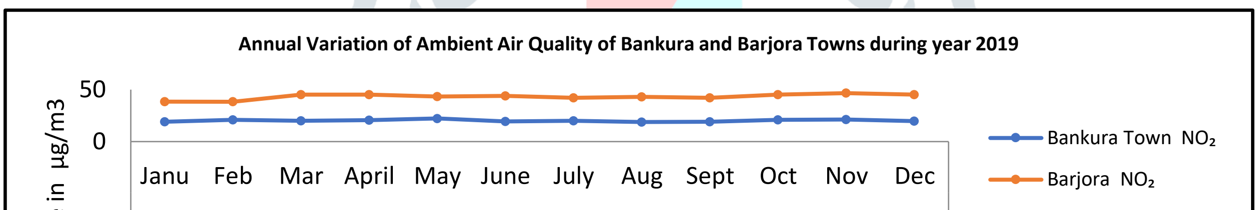


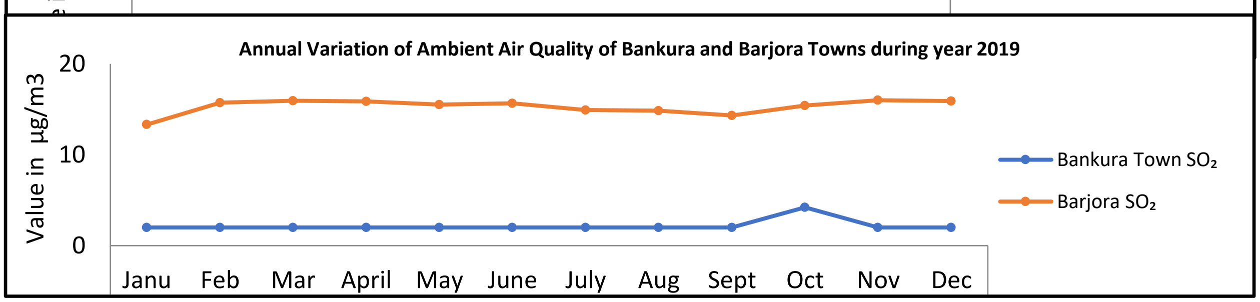


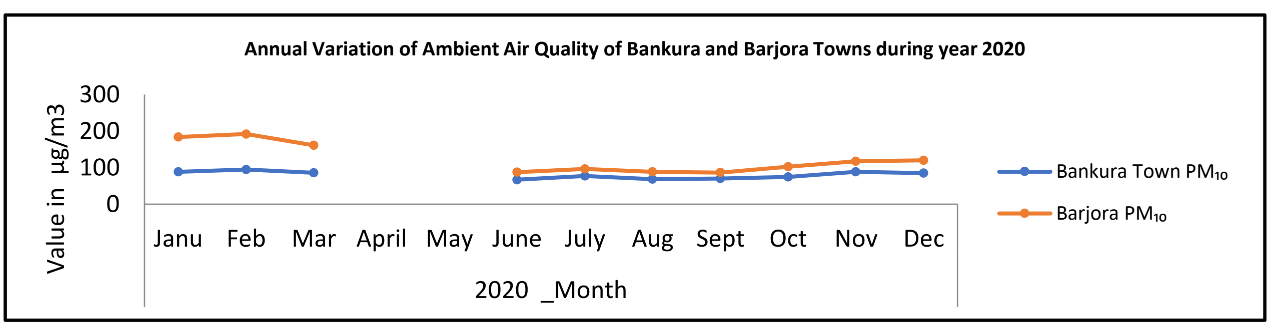

Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2018
Value in µg/m3
60
40
20
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
2018 _Month
Bankura Town NO₂
Barjora NO₂

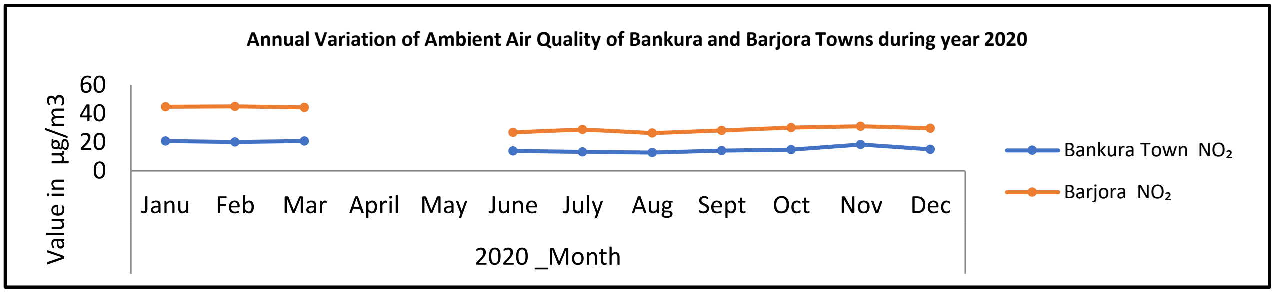

Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2018
Value in µg/m3
15
10
5
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
2018 _Month
Bankura Town SO₂
Barjora SO₂

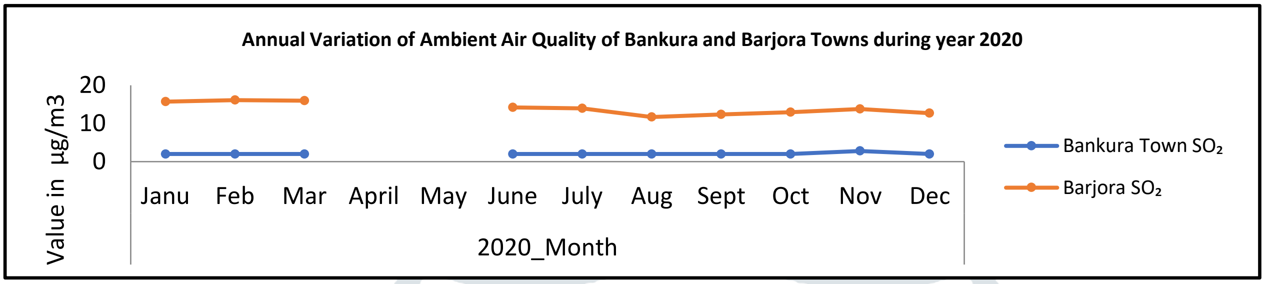

Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2019
Value in µg/m3
400
200
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
2019 _Month
Bankura Town PM₁₀
Barjora PM₁₀


Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2019
µg/m3
50
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
Bankura Town NO₂
Barjora NO₂


Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2019
Value in µg/m3
20
10
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
Bankura Town SO₂
Barjora SO₂

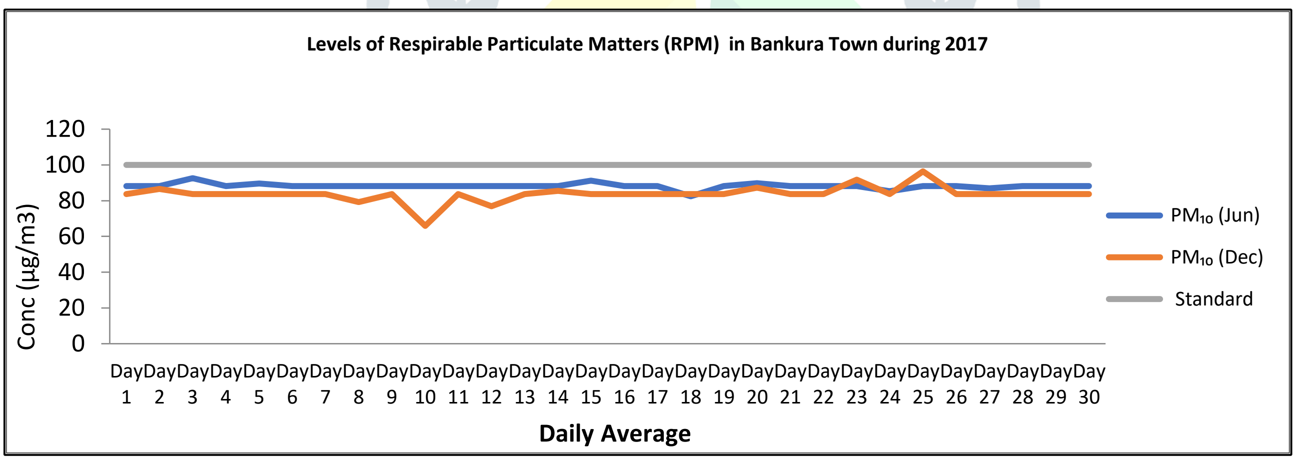

Annual Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2020
Value in µg/m3
300
200
100
0
Janu Feb Mar April May June July Aug Sept Oct Nov Dec
2020 _Month
Bankura Town PM₁₀
Barjora PM₁₀

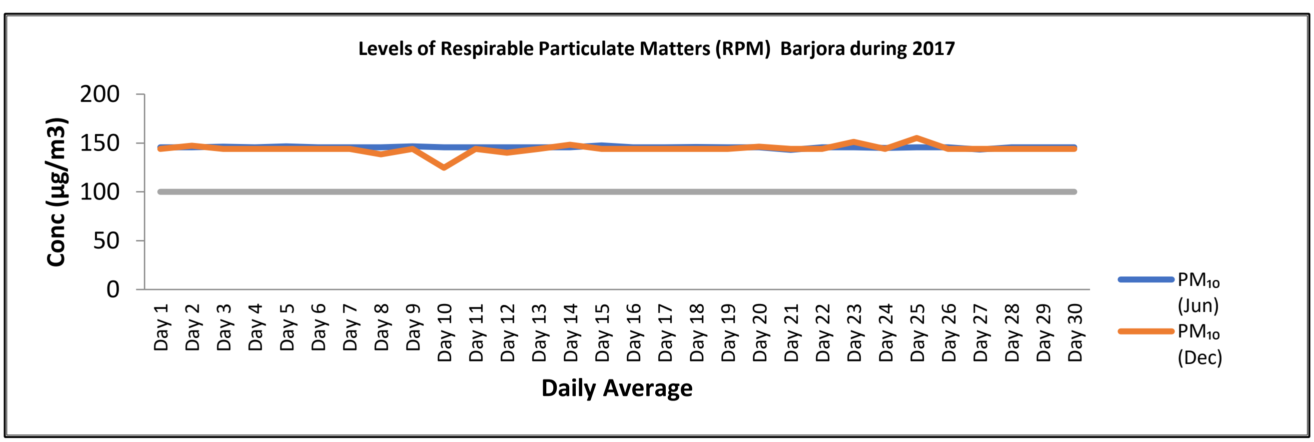


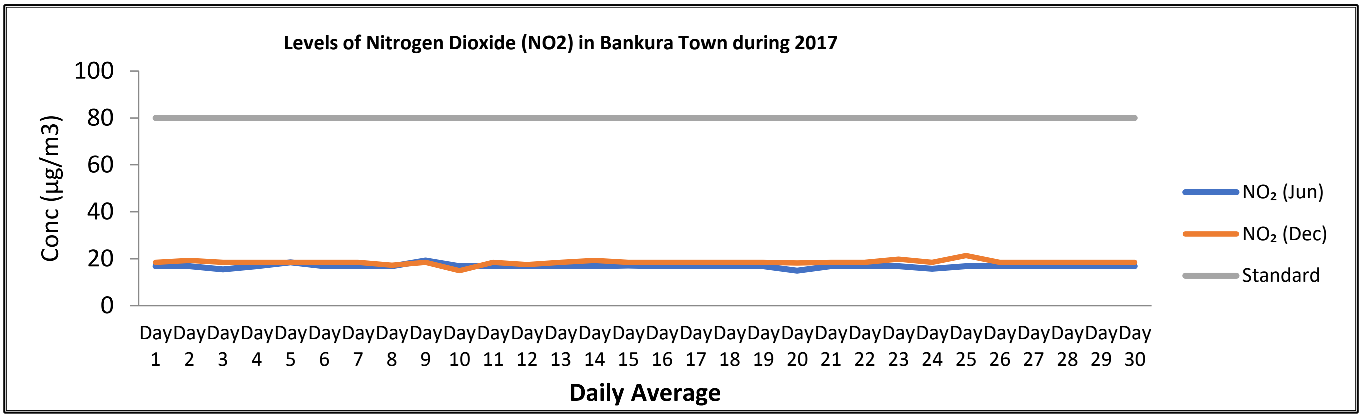


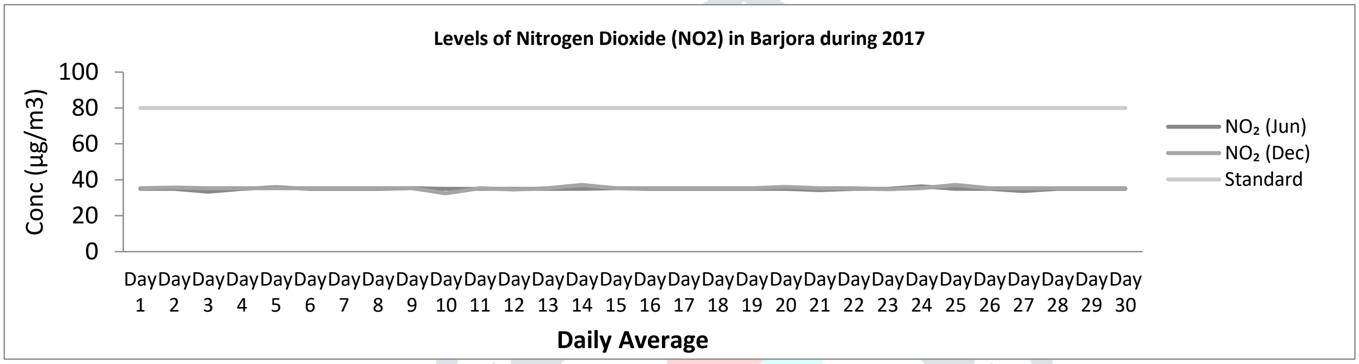
1.4 Seasonal Variation of Ambient Air Quality of Bankura and Barjora Towns during year 2017 & 2020

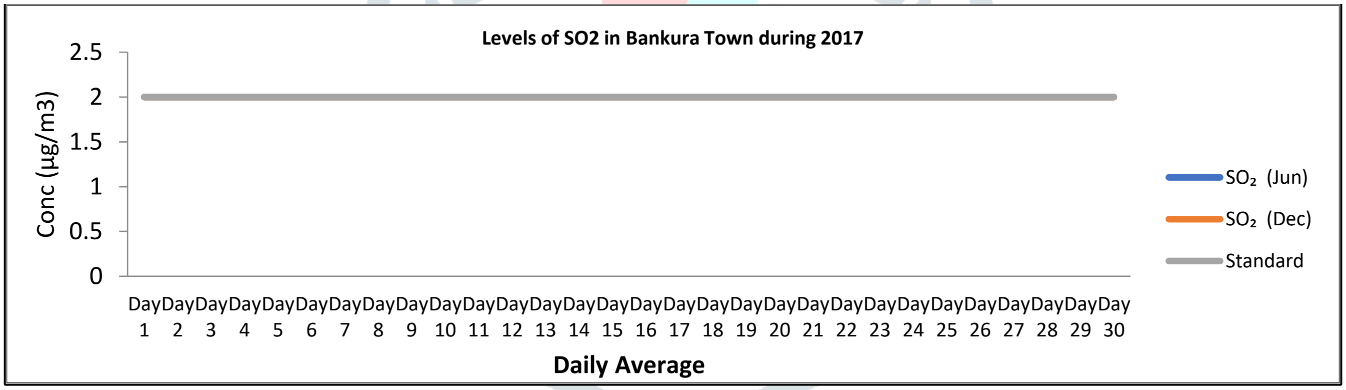
Studies have been done on June and December of 2017 and 2020 to show the seasonal variation of ambient air quality of Bankura and Barjora Towns. It has been observed that the air pollutants viz. PM_{10}, SO_2 and NO_2 of 2020 has decreased significantly from the air pollutants of 2017. However, air pollutants of Barjora are always more than air pollutants from Bankura Town.It has been observed that the concentration of PM_{10} (µg/m3) is more from Bankura Town to Barjora. Among all the air pollutants in ambient air, PM affects more people than any other pollutant (see the review by Pope and Dockery, 2006). Results show that the concentrations of the air pollutants are high in winter (Dec. month) and summer (June. Month)in comparison to the monsoon.

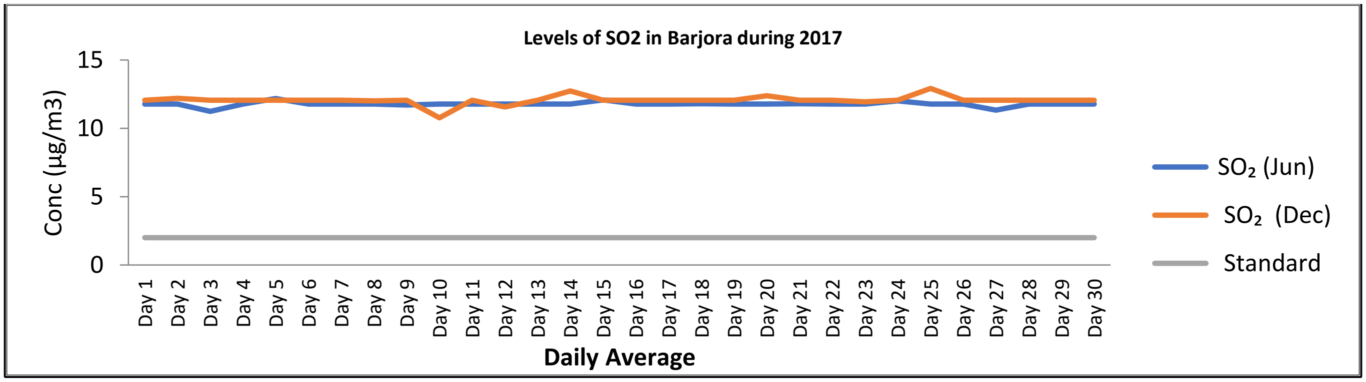


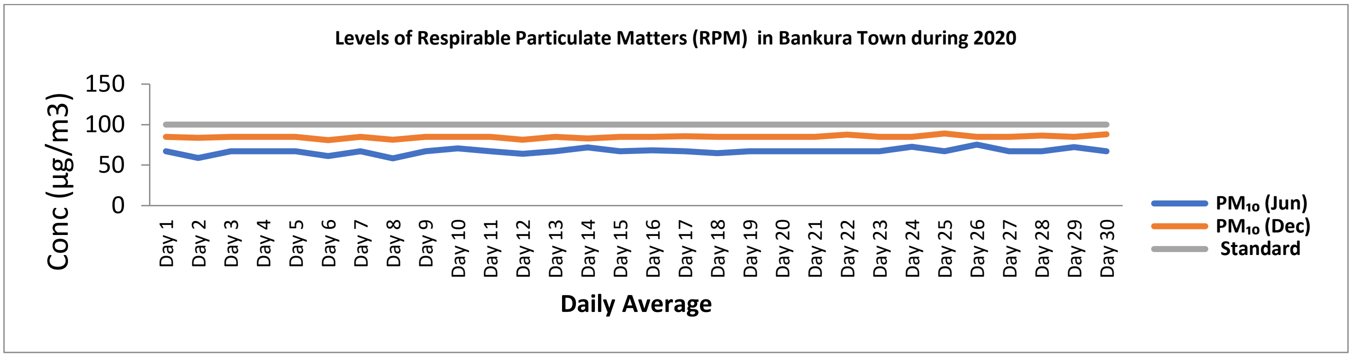


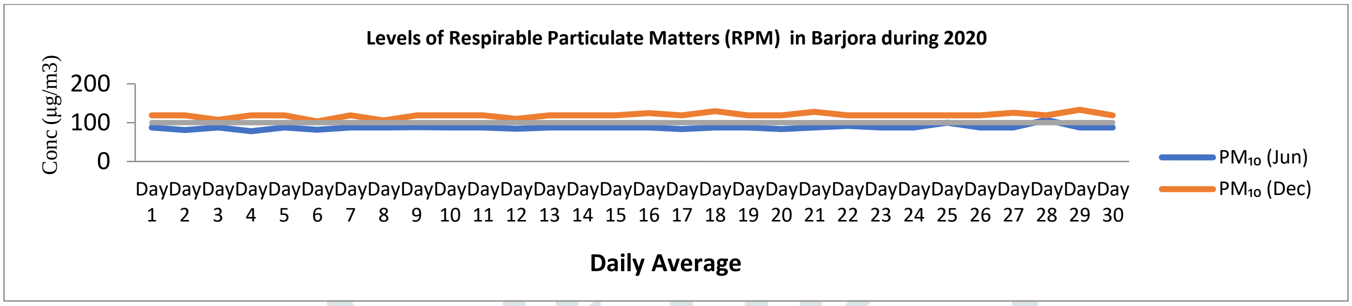

Levels of Nitrogen Dioxide (NO2) in Bankura Town during 2017
Conc (µg/m3)
NO₂ (Jun)
NO₂ (Dec)
Standard
Daily Average

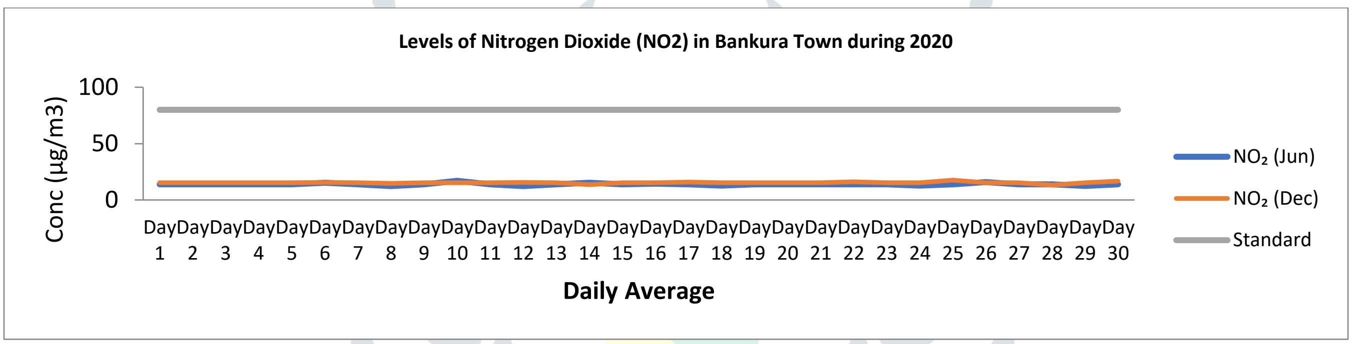

Levels of Nitrogen Dioxide (NO2) in Barjora during 2017
Conc (µg/m3)
NO₂ (Jun)
NO₂ (Dec)
Standard
Daily Average

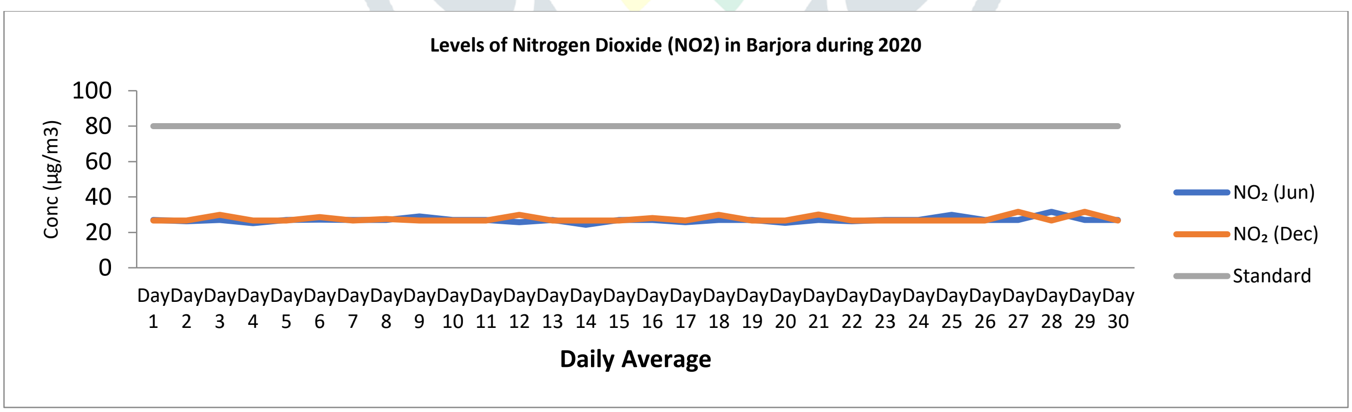

Levels of SO2 in Bankura Town during 2017
Conc (µg/m3)
SO₂ (Jun)
SO₂ (Dec)
Standard
Daily Average

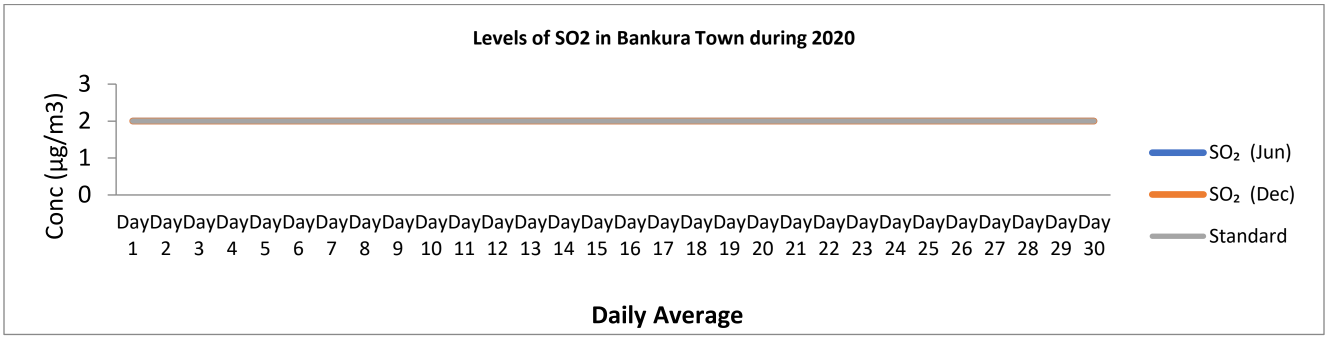

Levels of SO2 in Barjora during 2017
Conc (µg/m3)
SO₂ (Jun)
SO₂ (Dec)
Standard
Daily Average

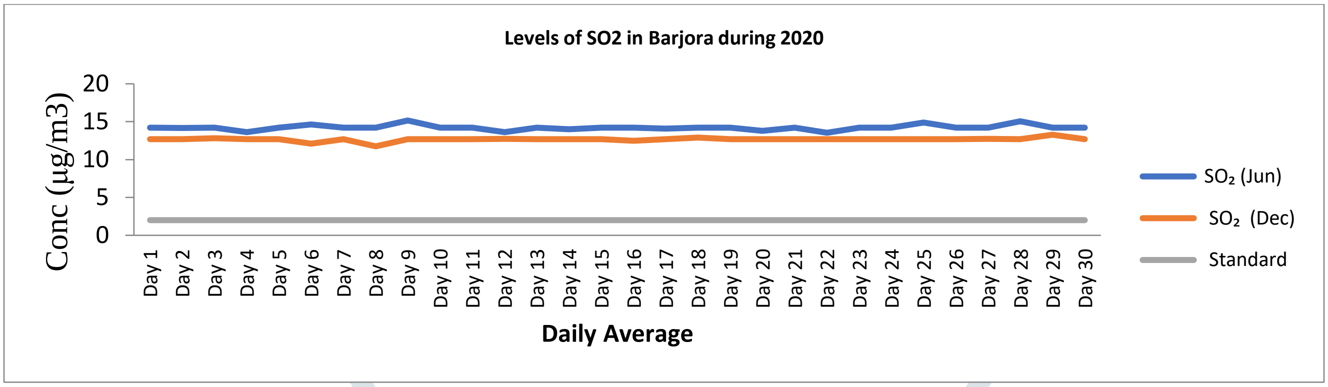

Levels of Respirable Particulate Matters (RPM) in Bankura Town during 2020
Conc (µg/m3)
150
100
50
0
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15 Day 16 Day 17 Day 18 Day 19 Day 20 Day 21 Day 22 Day 23 Day 24 Day 25 Day 26 Day 27 Day 28 Day 29 Day 30
Daily Average
PM10 (Jun)
PM10 (Dec)
Standard


Levels of Respirable Particulate Matters (RPM) in Barjora during 2020
Conc (µg/m3)
200
100
0
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15 Day 16 Day 17 Day 18 Day 19 Day 20 Day 21 Day 22 Day 23 Day 24 Day 25 Day 26 Day 27 Day 28 Day 29 Day 30
Daily Average
PM10 (Jun)
PM10 (Dec)


Levels of Nitrogen Dioxide (NO2) in Bankura Town during 2020
Conc (µg/m3)
100
50
0
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15 Day 16 Day 17 Day 18 Day 19 Day 20 Day 21 Day 22 Day 23 Day 24 Day 25 Day 26 Day 27 Day 28 Day 29 Day 30
Daily Average
NO2 (Jun)
NO2 (Dec)
Standard


Levels of Nitrogen Dioxide (NO2) in Barjora during 2020
Conc (µg/m3)
100
80
60
40
20
0
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15 Day 16 Day 17 Day 18 Day 19 Day 20 Day 21 Day 22 Day 23 Day 24 Day 25 Day 26 Day 27 Day 28 Day 29 Day 30
Daily Average
NO2 (Jun)
NO2 (Dec)
Standard





1.5 Discussion

Presence of any solid, liquid or gaseous substance in the atmosphere at such concentration causing impact on human health, animals, plants and / or property is considered as air pollution. Depending on the process of formation, the air pollutants are generally classified as primary and secondary pollutants. The primary air pollutants are generated directly from the sources whereas the secondary air pollutants are produced from the primary pollutants by complex chemical reactions in presence of ultra - violet radiation involving free radical formation.

Three main pollutants parameter have been discussed to compare the air quality of Bankura Town and Barjora such as PM_{10}, SO_2 and NO_2. According to the Air quality pollutants concentration of the last four years, in the case of Bankura Town, the air quality pollutants concentration were mostly close to the National Ambient Air Quality Standards (NAAQS). On the other hand, the value of Barjora is always higher than the National Ambient Air Quality Standards (NAAQS). The reason is that the amount of industry in Barjora. The air pollution caused by transportation and industries is a serious environmental issue in urban settlements, and 50% of the PM in the urban air comes from traffic emissions (Li et al. 2017). The largest difference in PM_{10} concentration between 2017 and 2020 is noticed, that is, 2020 the PM_{10} concentration is low than NAASQ. This reason is that all work was closed (lockdown) for the novel coronavirus, SARS-CoV-2. India recorded 34,867 COVID-19 cases (as of 30-04-2020) and a nationwide lockdown was imposed in India on March 25, 2020 for 21 days (MoHFW 2020). This study is aimed at quantifying and analysing the reduction in air pollution due to the lockdown and to determine the effect of lockdown on the air quality in an urban environment. The increase in the AQI levels was due to low precipitation recorded in average rainfall of Bankura district is 387.27 mm on july-september, 2017 and other hand average rainfall of Bankura district is 394.53 mm on july-september,2020 (source: worldweatherOnline.com).PM on human health occur at levels of exposure currently being experienced by most urban and rural inhabitants in both developed and developing countries. An improved understanding of the association of the particulates with mortality suggests the importance of sub-micron particles (PM10) to which motor vehicles are major contributors (Anon, 1995). Automobile exhausts and certain industrial pollutants contain NO2,which by photochemical reaction produces O3and effects allergic asthmatics by augmenting allergic responses (Steinberg et al., 1991). Similarly SO2, NO, particulate matter and acid aerosols effect pulmonary function and cause inflammation of bronchial mucous (Karen and Michak, 1991; Giuseppe and Francesco, 1993). The major constituents of PM are sulphates, nitrates, ammonia, sodium chloride, carbon, mineral dust, and water. PM consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in air. The major sources of anthropogenic emissions of NO2 are combustion processes (heating, power generation, and engines in vehicles and ships). Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO2. SO2 is produced from the burning of fossil fuels (coal and oil) and the smelting of mineral ores that contain sulphur. The main anthropogenic source of SO2 is the burning of sulphur containing fossil fuels (e.g., coal) for domestic heating, power generation, and motor vehicles. SO2 can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma, and chronic bronchitis, and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO2 levels. When SO2 combines with water, it forms sulphuric acid; this is the main component of acid rain that affects sensitive ecosystems.

1.6 Conclusion

Adverse effect of air pollution on human health is an established fact. Air pollution not only affects the human health but it has definite impact on the plant, animals and materials. Exposure to high concentration of Particulate Matters has definite impact on human health. Particulate Matters of different sizes affect the human health differently however; the defence mechanism in the respiratory system can restrict the entry of the particulate matters inside the lungs. The effects of Nitrogen Dioxide include serious pulmonary disorder, destruction of bronchiolar and alveolar epithelium, oedema, emphysema, destruction of defence mechanism of living organism. It has been observed from several studies that air pollution plays an important role in the genesis and augmentation of allergic disorder and it is described as a disease of civilized society (Dennis, 1996; Bonai et al., 1994).The high concentration of PM10 in all commercial sites was due to plying of diesel vehicles which generate a range of particulate matter through the dust produced from brakes, clutch plates, tires and indirectly through the re-suspension of particulates on road surfaces through vehicles– generate turbulence (Watkins, 1991; Sandhu et al., 2004). Exposure to high concentration of Sulphur Dioxide (SO2) affects the pulmonary function. Even short term exposure to high level of SO2 may result in morbidity and or mortality.

The WBPCB is engaged in promoting environmental awareness and education for ac a long time. Every year on the World Environment Day, the WBPCB organizes various workshops and discussion programs, releases posters, and conducts sit and draw competitions in collaboration with different NGOS. During the celebration of the Silver Jubilee Year of the Board, various workshops, seminars and round table conferences were organized by the Board on various environmental issues. The WBPCB formulated community based environmental awareness development project like the preparation of environmental workshop-cum-training programs. Besides, the board regularly conducts training programs for the district authorities, police authorities and school and college students on air pollution, automobile pollution etc.

Further Suggested Actions for Air Quality Improvement like 1. Expansion of the air quality monitoring network in the other areas of the District. 2. Introduction to cleaner fuels in public transport system. 3. Improvement in the quality of conventional liquid fuels. 4. Improvement of road conditions in the urban and semi-urban areas of the District. 4. Ensuring installation of adequate emission control systems in industries. 5. Development of dedicated Environmental Management Division in industries. 6. Spreading environmental awareness at all levels of the society.

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