# Environmental Quality And It's Impact On Human Health -A Geographical Study Of Siliguri , W.B, India.

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**ABSTRACT**
The surroundings or conditions in which a person, animal, or plant lives or operates. The quality of environment should be maintained as it is very essential for all life forms in the earth. Humans have the responsibility to maintain it and preserve it. Pollution means the major change of the earth's environment with hazardous or from hazardous materials that can contaminate air, water and entire environment and can cause permanent change to the human health, other animals, plants, living and non-living entity, quality of life and to ecosystem. The pollution in Siliguri is creating different health problems. The air and water pollution are said to be responsible mostly in integrating with human health and ecosystem. In Siliguri 60% of air pollution is contribution of automobile sector according to West Bengal Pollution Control Board. The automobiles contributes significantly large amount of particulate matter to the air in Siliguri City. Noise pollution from highway, airports, industries, vehicles can lead to hearing problem. Garbage waste is also one of the major problem in Siliguri city having improper waste disposal management. Heavy deforestation in various areas creating stress on human as well as climatic factors and creating environmental degradation. Proper management is required to opt for sustainable development.

**Key words:** Pollution, Environmental Degradation, Human health, Deforestation, Particulate matter, Waste Disposal.

## 1.0 Introduction:

Due to rapid Urbanization, population increase and other anthropogenic activities, the rate of environmental degradation is increasing in rapid pace in Siliguri city. Siliguri is one of the most important city in West Bengal as it serves as a central city for trade & commerce. But due to heavy demand for those rapid urbanization has been started and thus creating various environmental hazards. The main problem are faulty waste disposal facilities, rapid deforestation, formation of slumps near the river, heavy traffic etc., altogether forming a heavy negative impact on the city.

Siliguri started as a small area in the northern part of city, on the front of Mahananda River, which is now Dagapur. In 1815 it became the Point of transit for the Darjeeling hill and Nepal mainland. In 1865 after the british colonization the entire Deoars used for tea plantation. The 'Siliguri Corridor' was formed during W.Bengal and E.Pakistan divide. So it has a long history so by time the ecosystem gradually decreasing for human demand and population. The main river Mahananda is now degraded though it has its own importance. The length and breadth is gradually dreaming the dissolved oxygen (DO) is increasing and the ecosystem of the river and surrounding is hampered gradually causing health hazards to the people living near to it. The air quality is also degrading due to huge no of vehicles, heat island conditions, and increased number of factories leads to noise pollution and thus affecting the people reside near those industries.

### 1.1 Literature Review:

1. According **to Bijay Halder, Satisankar Bandyopadhyay,** Worldwide Coronavirus created is a major problem for human health, food security, economy and many more. Lockdown is healing the environmental condition because major Indian metropolitan cities are recovered from different pollutants This study is to identify the air quality trend before, during and after lockdown in Siliguri city of West Bengal and the city is also a commercial and transportation hub.
2. According to **Anghadeep Bose, Indrajit Roy Chowdhury**, the reasearch addresses the escalating concern of air pollution, primarily due to fine particulate matter (PM2.5) and coarse particulate matter (PM10), in Siliguri city, West Bengal, India. By using most advantages of the most effective models, namely ARIMA and TBATS, the reasearch make forecasts for PM2.5 and PM10 levels from 2023 to 2025, on a monthly basis. These findings are helpful for air quality management in Siliguri and underscore the importance of using advanced computational models for pollution forecasting, encouraging further research on hybrid models with meteorological Parameters.
3. According to **Anghadeep Bose, Indrajit Roy Chowdhury**, the ambient air quality in a city is heavily influenced by meteorological conditions. The city of Siliguri, known as the 'Gateway of Northeast India', is a major hotspot of air

pollution in the Indian state of West Bengal. According to the trend analysis, the concentration of NH3 in the air of Siliguri is rising, while the concentration of other pollutants is declining.

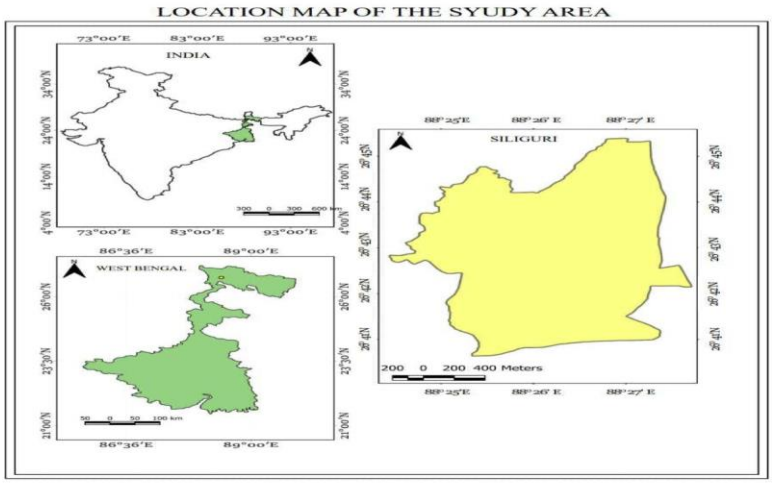
4. According to **Tuhin Dey Roy**, Urbanization refers to the process of becoming urban or in other words urbanization is a cyclical process through which the nation passes as they evolve from agrains to industrial societies. The urbanization is spreading all over the world. The present investigation has been made to analyze the dynamic population growth & the level of urbanization in Siliguri Municipal Corporation and its related growing environmental problem in this area. Especially in developing countries like India, Chronological population increase of SMC and disorganized urbanization created hardship environmental condition particularly for local residents. The present study will help in understanding the causes behind the rapid rate of urban population growth and find out such environmental problems and draw some basic measures to reduce them for planned urbanization in SMC.

5. According to **Chandana Sarkar, Bimal Kumar Kar**, slum is a contiguous settlement characterized by inadequate housing, lack of basic services and unhealthy environment. With the growth of these cities and towns in India, the area under slums has considerable increased. In view of this, the Present study intends to assess the availability of safe drinking water and adequate sanitation and health conditions in the slum areas of Siliguri city. The data for the study have been collected thorough field survey. The study reveals that the incidence of stomach and urinary problems is negatively correlated with piped water supply and availability of toilet system respectively.

6. According to **Sanjoy Shil, Umesh Kumar Singh**, River Water is too much vulnerable to pollution as it exposed to a large no. of pollutants through natural and anthropogenic activities. Mahananda River is an important river in West Bengal and Bangladesh. The study war conducted to identify the dissolvef heavy metals and metalloids in the water quality and pollution status, to evaluate the non-carcinogenic human health hazards by Hazard Index (HI) and to anticipate the incremental lifetime cancer risk (ILCR) by index analysis. As the study area does not Posses any heavy industries, the meta(loid) pollution occurs mainly from heavily populates municipal zones like Siliguri, Barsoi and Malda Town. Moreover, some pollutants are washed out with heavy water during monsoon season. These municipalities need sustainable management planning.

### 1.2 Study Area

The subdivision of Siliguri, the study area, is one of the subdivisions of Darjeeling District of West Bengal. It is the northern most districts West Bengal and also known as the Terai of Darjeeling District. It covers mostly the thick alluvium and partly the piedmont plain of Mechi- Mahananda interfluves which is referred to as Chicken neck. The study area lies between 26° 27' N to 26° 57'N of latitude and 88° 07' E and 88° 31' E of longitude and is represented by parts of the Survey of India (SOI) toposheet no. 78 B/1, 78 B/2, 78 B/3, 78 B/5. 78 B/6 and 78 B/9 on the scale of 1: 50,000. The subdivision contains of Siliguri Municipal Corporation and four community developmental (CD) blocks: Matigara, Naxalbari, Phansidewa and Kharibari. The subdivision is bounded in the eastern side by Jalpaiguri district, in the northern side by Kurseong and Mirik Police stations of Darjeeling district, in the southern side by Chopra block of Uttar Dinajpur district and partly by Bangladesh and western side by Nepal.




**Figure(1): Location of the Study area**

### 1.3 Objectives:

•To know about the impact of environmental pollution on the health of proper living in different parts of Siliguri City.
•Locating areas of Siliguri with high population levels on environmental hazards.
•To understand how environmental quality changes over time.

•To investigate how environmental factors such as air pollution, toxic substances and climate change are affecting human health in Siliguri city.
•Identifying and understanding the health implications of climate change, pollution and other environmental shifts.

**1.4 Materials & Methods/Methodology:**
A number of literature reviews are included in this method to develop this thesis and also some fieldwork in some selected vulnerable areas in Siliguri Sub-division. Both Primary and Secondary data sources were used be explored in this research. A survey method with purposively selected 30 respondents was used to collect statistical data. Simple random sampling method is used for survey purpose for collecting primary data. Secondary data sources such as government publications, international publications as well as other secondary data sources were used.. Therefore the methodology of this work is divided into three consecutive parts. And for making map ArcGIS software has been used.

A. Pre-field work.
B. Field work
C. Post-field works

**A. Pre-Field Work**:
I. Review of available literature from different libraries and offices regarding the pollution and environmental degradation.
II. Collection of different maps of the study area from different sources**.**
III. Collection of different map of the study area.
IV. Collection of data of physical features as well as cultural features.
V. Collection of secondary data from various government and non government organizationetc.

**B. Field Work**:
To gather information on the local physical conditions and impact of both environment and health of the people and its impact onthe next generation, Changing climate patterns, different pollution and impact and others is limited to mainly random sampling.

**C. Post-Field Work:**
I.Whenever necessary data collected from different sources will be analyzed by usingappropriate statistical methods.
II. According to the requirement empirical and quantitative techniques of geography will be applied.

**1.5 Background of the Study Area:**
Siliguri is a city located in the Indian state of West Bengal. Situated in the foothills of the Himalayas, it serves as a gateway to the north-eastern states of India as well as Bhutan and Nepal. Known for its strategic location, Siliguri is a major commercial, trade, and transportation hub in the region. The city has witnessed significant economic growth due to its importance in trade and commerce. Its proximity to international borders has to led to the development of various trade routes and business activities. Siliguri is also a key centre for tea and timber trade. Apart from economic significance, Siliguri is surrounded by scenic landscapes and has become a popular stopover for travellers heading to the hill stations of Darjeeling, Kalimpong . The city has diverse population, reflecting a mix of cultures and communities.

**1.5.1.AREA WITNESSING HIGH POLLUTION RATES**
Pollution is the main cause of degrading the environment influenced by mainly anthropogenic factors, physical factors.

**Areas Affected By Pollution and Deforestation:**
The following are the areas which are more contaminated by pollution so those areas are taken into consideration:

**1.Mahananda Colony:**
This river is a trans -boundary river, mainly fed by rainwater, originated from the Himalayas in the district of Darjeeling of West Bengal State, so the river is degrading mainly due to the presence of waste and sewages. The hotels and buildings dispose their waste in this river. Thus the river is loosing its ecosystem and those from this the areas near it are affecting.

**2. Siliguri Dumping Ground:**
It is located near the Don Bosco colony. The huge dumping ground of Siliguri. Due to this the residents near it is effecting schools and colleges are there and getting. The air is also contaminated by the gases which are emitted from the wastes.

**3. Chadmuni Area:**
It is located near the Siliguri City Centre Mall. The road expansion cause heavy felling of trees and also traffic congestion occurs here causing various disturbance to the residents near it. The wastes of hospitals and the colonies are dumped near the roads and the near the Siliguri Commiserate building.

**4.Champasari Road:**

It is the mid traffic area of Siliguri. Due to urbanization many shops are formed near the road causing heavy traffic congestions and thus contributing to air pollution causing different health problem.

**5. Milan more and Debidanga:**

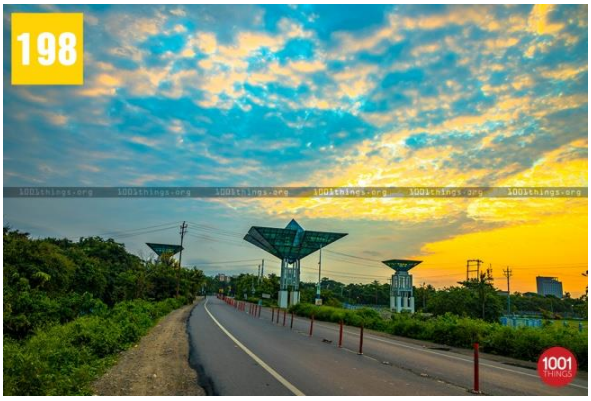
It is located near the Gulma Tea Estate Siliguri. Most of the wastes of meat shops are dumped near the kalkut area creating breathing problem. And the drainage facility is not well developed.

**6.Chamta River :**

The Chamta river is originated Sukna and Sevoke near Mahanda wildlife sanctuary in Jhora .These rivers are flowing from north to south direction maintaining the initial slope of the surface.

**7.Siliguri Industrial Sector:**

It is located in Sevoke road Siliguri 2nd mile as all the small and heavy industries located here including automobile industries, steel industries, tiles making, chemical and fertilizer industries.




**Figure(2): Chadmuni Area (before)**

**Figure(3): Chadmuni Area (after)**

**1.5.2.POLLUTION & ENVIRONMENTAL DEGRADATION**

Pollution refers to the introduction of contaminants into the environments, causing harmful effects. These contaminants can substances like pollutants, chemicals, or waste that disrupt the natural balance of ecosystem, air, water, soil, posing risk to human health and the environment.

**1.Air Pollution:**

Air pollution in urban areas such as Siliguri is the result of a combination of emission from vehicles, manufacturing operations and other anthropogenic sources. The short term standard (24-hour or daily average) is 35 mcg/$m^3$ of air (µg/$m^3$) and the long-term standard (annual average) is 12µg/$m^3$. But the recent $PM_{2.5}$ concentration in Siliguri is currently 48.4µg/$m^3$ (9.7 times higher than usual).


**Figure(4): Traffic congestion in Siliguri**

**Causes:**

- The burning of coal, oil and natural gas in power plant for electricity generation releases pollutants into the air including sulfur dioxide, nitrogen oxides, particulate matter.
- Factories and industrial facilities releases large amount of pollutants into the air.
- Combustion engines in car, trucks, motorcycles, and other vehicles emit pollutants such as carbon monoxide, nitrogen oxide particulate matter and hydrocarbons. The use of fossil fuels particularly gasoline and diesel, contributes significantly to air pollution.

• Open burning waste including plastics and other materials releases harmful pollutants in air.

**Effects:**

• Oxides of nitrogen released from the exhausts of buses, trucks and two wheels causes irritation of eyes and lungs. Inhalation of these oxides in large amount may lead to gum inflammation, internal bleeding, pneumonia and even cancer.
• Air pollution is associated with an increased risk of cardiovascular diseases, including heart attacks and strokes. Fine particulate matter can enter the bloodstream, affecting the cardiovascular system.
• Particulate matter and pollutants can reduce visibility, impacting air travel, road safety and overall outdoor visibility. This poses risks for transportation and can lead to accidents.
• Some air pollutants, such as greenhouse gases like carbon dioxide and methane contribute to alterations in weather patterns, rising global temperature, and associated environmental challenges.

**2 Water Pollution:**

Rivers are the main source of freshwater for any civilisation to flourished. We have seen that most of the settlements are lives were fresh river water is available. For example the alluvial land of Ganga river. In Siliguri the most important river is Mahananda both in rural and urbanized area. But due to rapid urbanisation the river is degrading day by day. The surface temperature is also exceeding and thus living marine creatures decreasing in rate.

**Figure(5): Mahananda River**

**Causes:**

• Factories and industrial facilities often releases pollutants such as heavy metals, chemical and toxins into water bodies through untreated or inadequately treated wastewater.
• The use of fertilizers, pesticides and herbicides in agricultural leads to runoff, carrying excess nutrients and chemicals into rivers and lakes.
• Inadequately treated or untreated sewage from domestic and industrial sources can introduce pathogens, nutrients and pollutants into water bodies posing risks to human health and aquatic ecosystem.

**Effects**

• Polluted water affects fish, amphibians and other aquatic organisms. It can lead to reduced oxygen levels, habitat destruction and the introduction of harmful substances that are toxic aquatic life.
• Contaminated water sources are a breeding ground for pathogens, leading to waterborne diseases such as cholera, dysentery and gastrointestinal problems. Poor water quality poses a significant risk to human health.
• Excessive nutrient runoff, often from agricultural activities can lead to algal blooms. These blooms deplete oxygen level in the water creating 'dead zones' where aquatic life cannot thrive.

**3 Noise Pollution:**

Noise pollution is unwanted sound that cause annoyance. Noise can produce an undesired physiological and psychological effects in an individual, and thus may interfere with activities like communication, work, rest, recreation and sleep. The standard noise level for humans is 70DBA.

**Figure(6): Traffic congestion creating noise pollution**

**Causes:**

- Constant vehicle movement, honking and engine noise contribute significantly to urban noise pollution.
- Factories and industrial processes often generate loud noises, affecting nearby residents and the environments.
- Events with loud music, fireworks or large crowds such as concerts or sports games can contribute to noise pollution.

**Effects:**

- Prolonged exposure to high levels of noise can lead to stress, anxiety, sleep disturbance and even cardiovascular problem.
- Noisy environments can disrupt sleep patterns causing fatigue irritability and decline in overall well-being.
- Constant exposure to loud noises can cause permanent hearing loss and damage to the auditory system.

**The following are the reasons which are degrading the environment with rapid pace in Siliguri:**

- Population
- Urbanization
- Faulty drainage facility
- Faulty waste disposal
- Rapid industrialization
- Waste disposal in river water
- Increasing use of vehicles
- Rising energy use
- Identification of agriculture.

**The above mentioned reasons creating problems such as:**

- Sewage problem which are accommodating in river or drains causing deterioration of river water and also the ecosystem, causing blockage of drains too.
- Population increase is the important cause results in the high demand causing environmental degradation.
- Rapid industrialization allows chemicals to mix with the air creating serious problems to the environment.
- Transportation & trade and commerce is common in Siliguri y creating stress on degradation of air quality.
- The intensification of agriculture causing increased demand of fertilizers, pesticides, urea, etc in those industries causing deterional of those waste causing degrading quality in Mahananda River.
- High population also demands high urbanization causing deforestation by making building, roads, highways in different parts of Siliguri thus degrading the whole environment.
- Faulty disposal of wastes of hospitals, households, industries causing hazards conditions of air as well as water of the Siliguri city.
- The unhygienic condition of drains also leads to the contamination of several bacteria's in air causing several problems.
- Increasing vehicles also leads to emission of different gases which are harmful for the environment.
- So, all these leads to increase in temperature, changing in weather patterns deterioration of air quality , water quality, affecting both human and aquatic life.
- Presence of dumping ground whether small or big like in Don Bosco colony, near Mahananda River, Khaprail area, near Debidanga causing serious degradation of air quality.

**Table(1): Growth Rate of Population in Siliguri**

| Growth Rate of Siliguri | |
|---|---|
| Year | Total Population |
| 1950 | 30000 |
| 1959 | 58000 |
| 1966 | 81000 |
| 1971 | 100000 |
| 1979 | 200000 |

| | |
|---|---|
| 1991 | 367000 |
| 2000 | 464000 |
| 2007 | 609000 |
| 2011 | 715000 |
| 2020 | 1020000 |
| 2023 | 1126000 |
| 2024 | 1159000 |

**Source: World population review**

**Table(2): Growth rate of Urban Population:**

| Growth of Urban Population in Siliguri | |
|---|---|
| Year | Urban Population |
| 1951 | 32480 |
| 1951 | 65471 |
| 1971 | 97484 |
| 1981 | 154378 |
| 1991 | 216950 |
| 2001 | 284602 |
| 2011 | 509709 |

**Source:Annual Rate of Siliguri Municipal Corporation**

From both the table(1) and (2) it is clear that the rate of population is increasing day by day in a rapid way and with that the urban population ids also increasing contributing to environmental degradation in the city. For this reason the Chadmuni area is facing heavy deforestation contributing to several climatic challenges.

**1.5.3.Change Detection:**

To detect the change in air quality "Air Quality Index" is used. It is tool designed for an efficient statement of air quality conditions to the public and is simple to comprehend. It converts difficult air quality records of variety of pollutants into a distinct value classification and colour. At present there are six types of Air Quality index which are simple to understand and every type has a specific colour that is interrelated with human inputs. These types are categorised as Good, Satisfactory, Moderately polluted, Poor, Very Poor and Severe.

**Table (3 ): Air Quality Index**

| Air Quality Index (AQI) | Category |
|---|---|
| 0-50 | Good |
| 51-100 | Satisfactory |
| 101-200 | Moderate |
| 201-300 | Poor |
| 301-400 | Very Poor |
| 401-500 | Severe |

**Source: Central Pollution Control Board**

**Table (4 ): Air quality index category**

| AQI Category | AQI | Concentration Range | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $PM_{10}$ | $PM_{2.5}$ | $NO_2$ | $O_2$ | CO | $SO2_2$ | $NH_2$ | Pb |
| Good | 0-50 | 0-50 | 0-30 | 0-40 | 0-50 | 0-1.0 | 0-40 | 0-200 | 0-0.5 |
| Satisfactory | 51-100 | 51-100 | 31-60 | 41-80 | 51-100 | 1.1-2.0 | 41-80 | 201-400 | 0.5-1.0 |
| Moderate | 101-200 | 101-250 | 61-90 | 81-180 | 101-168 | 2.1-10 | 81-380 | 401-800 | 1.1-2.0 |
| Poor | 201-300 | 251-350 | 91-120 | 181-280 | 169-208 | 10-17 | 381- 800 | 801-1200 | 2.1-2.0 |
| Very Poor | 301-400 | 351-430 | 121-250 | 281-400 | 209-748 | 17-34 | 801-1600 | 1200-1800 | 3.1-3.5 |
| Severe | 401-500 | 430+ | 250+ | 400+ | 748+ | 34+ | 1600+ | 1800+ | 3.5+ |
| CO in $mg/m^3$ and other pollutants in $\mu g/m^3$; 24-hourly average values for $PM_{10}$, $PM_{2.5}$, $NO_2$, $O_2$, CO, $SO_2$, $NH_2$, Pb, and 8-hourly v values for CO and $O_3$ | | | | | | | | | |

**Source: Central Air Pollution Control Board's Air Quality Standards**

**Table (5 ): Air Quality Status of Siliguri, (2014-2018)**

| Air pollution level and Annual concentration of various pollutant | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | $NO_2$ | | $SO_2$ | | $PM_{2.5}$ | | $PM_{10}$ | |
| | Annual average ($\mu g/m^3$) | Air quality | Annual average ($\mu g/m^3$) | Air quality | Annual average ($\mu g/m^3$) | Air quality | Annual average ($\mu g/m^3$) | Air quality |
| 2014 | 24 | M | 6 | L | 0 | NA | 117 | C |
| 2015 | 18 | M | 3 | L | 0 | NA | 91 | H |
| 2016 | 20 | M | 3 | L | 35 | M | 76 | H |
| 2017 | 18 | M | 2 | L | 24 | M | 59 | H |
| 2018 | 17 | L | 2 | L | 34 | M | 72 | H |
| NAAQS (annually): $SO_2$ – 50 $\mu g/m^3$; $NO_2$-40 $\mu g/m^3$; $PM_{10}$-60 $\mu g/m^3$; $PM_{2.5}$-40 $\mu g/m^3$. (All these are values of yearly average, exceeding these standards values consequences in bad air quality) | | | | | | | | |
| Note.* Value of Exceedance factors. ** Air Quality (L = Low pollution, M= Moderate pollution, H= High pollution, c= Critical). NA=Data not available. | | | | | | | | |

**Source: Calculated and tested by the Authors from WBPCB Manual Data, 2014-2018**

**Table (6 ): Air Quality Status of Siliguri, 2020**

| Pollutants | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | $PM_{2.5}$ | $PM_{10}$ | $NO_2$ | $SO_2$ | $NH_3$ | $O_3$ | AQI |
| 2020 | 100 | 163 | 48 | 5 | 32 | 24 | 208 |

**Source: Central Pollution Control Board**

**1.Impact of $NO_2$, $SO_2$, $PM_{2.5}$ & $PM_{10}$:**

$No_2$ or nitrogen dioxide causes respiratory diseases on human. It can decrease the lungs function against bacteria making them more susceptible to infections. It can also aggravate asthama.

$So_2$ or sulphur dioxide can also cause respiratory problems such as bronchitis, and can irritate nose, throat and lung.

$PM_{2.5}$ are fine particles, short term exposure (upto 24-hours) have been associated with premature morality, increased hospital admissions for bronchitis, asthama attacks.

$PM_{10}$ causes coughing and wheezing to asthama attacks and bronchitis to high blood pressure, heart attack, strokes and premature deaths.

**2 Concentration Of $No_2$, $So_2$, $PM_{2.5}$ & $PM_{10}$:**

**Table (7 ):Normal levels of Gases and SPM**

| Gases & Suspended Particulate Matter | Concentration |
|---|---|
| $PM_{2.5}$ | 35 µg/$m^3$ |
| $PM_{10}$ | < 54.0 µg/$m^3$ |
| $NO_2$ | 0.53ppm |
| $SO_2$ | 5ppm |

**Table (8 ): Air Quality Index of Siliguri of 2019-2024**

| SL. NO. | Year | AQ | Index Value | Prominent Pollutants |
|---|---|---|---|---|
| 1 | 2019 | Satisfactory | 74 | $PM_{2.5}$ |
| 2 | 2020 | Satisfactory | 100 | $PM_{10}$ |
| 3 | 2021 | Good | 35 | $PM_{10}$ |
| 4 | 2022 | Moderate | 135 | $PM_{2.5}$ |
| 5 | 2023 | Moderate | 135 | $PM_{10}$ |
| 6 | 2024 | Moderate | 136 | $PM_{2.5}$ |

**Source: West Bengal Pollution Control Board**

So from the above table it is seen that in the year 2018 the air quality was satisfactory and the index value is 74µg/$m^3$ and the prominent pollutant is $PM_{2.5}$ (particulate matter 2.5) which is dangerous for health but it was in control.
In 2019 the index value was 100µg/$m^3$ which was satisfactory and the prominent pollutant was PM10 which is dangerous than $PM_{2.5}$
In 2020, 27 January COVID-19 was first started and on 24 March first lockdown phase occurred. The air quality was good and it was 25µg/$m^3$. All that time the nature by itself as the number of vehicles was less, people was inside their house and pollutants matter was very less.
Again in 2021 it started increasing the air quality was moderate and the index value was 135 and was dominated by $PM_{2.5}$
In 2023 the air quality was moderate and the index value was 136µg/$m^3$ and the prominent pollutant was $PM_{10.}$
Again with the rapid pace of urbanization the value recorded was 136 and the air quality was moderate and prominent pollutant was $PM_{2.5}$
So, from the above table it is seen that the concentration of $PM_{2.5}$ and $PM_{10}$ is most in Siliguri city.
The source of $PM_{10}$ and $PM_{2.5}$ are from combustion of gasoline, oil, disel fuel or wood. Due to increase of population urbanization process is became rapid which leds to the large amount of felling of trees and then causing increase in $Co_2$ and other greenhouse gases and this ultimately leads to health hazards. On the other hand, the heat islands are increasing in the cities where the traffic jams are mostly occur resulting in the increase of temperature and causing tendencies like headache, vomiting, discomfort, etc.

**3 Change in Water Quality:**
The river Mahananda plays an important role in human life of Siliguri Municipal Corporation areas located at the bank of it. Nowadays it has become polluted at some places due to small scale industries activities and conflunce of sewage, domestic waste and industrial effluents of many large medium and small enterprises with various types of organic compounds and heavy metals which are deterionating human health and aquatic organism.
The important parameters of a river includes temperature, turbidity, PH, conductivity, alkalinity, hardness, total suspended solids, total dissolved solids, chloride, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total coliform load and fuel coliform load, etc.

**Table (9 ): Physio-chemical characteristics of water samples collected in Pre-monsoon period from Mahananda River in Siliguri in 2011-2014**

| Water Quality Parameters | Content |
|---|---|
| Temperature °C | 28 |
| pH | 7.8 |
| Chloride in mg/litre | 1.8 |
| Alkalinity in mg/litre | 48.08 |
| Total hardness in mg/litre | 58 |
| Biological oxygen demand (BOD) in mg/litre | 2.7 |
| Dissolved Oxygen (DO)in mg/litre | 7.7 |
| Total coliform (MPN/1000ml) | 4800 |
| Fecal coliform (MPN/100ml) | 7000 |

**Source: West Bengal Pollution Control Board**

**Table (10 ): Statistical summary of Water Quality parameters in the Mahananda River(2022)**

| Water Quality Indicators | Content |
|---|---|
| pH | 7.96 |
| Temperature °C | 28.9 |
| Dissolved Oxygen (DO)in mg/litre | 6.86 |
| Biological oxygen demand (BOD) in mg/litre | 6.28 |
| Chloride in mg/litre | 1.42 |
| Total coliform (MPN/1000ml) | 5800 |
| Fecal coliform (MPN/100ml) | 2240 |

**Source: West Bengal Pollution Control Board**

pH is a measure of how acidic or basic the water is. Heavy metals such as Cadmium, leas and Chromimum dissolved more easily in highly acidic water (lower pH). Heavy metals become more toxic when dissolved in water. pH can change the form of some chemicals in water. Ammonia is relatively harmless to fish in neutral or acidic water. However, as the water become more alkaline (the pH increases), ammonia becomes progressively more poisonous to these same organisms.

Chloride (Cl-) occurs naturally in ground water, streams and lakes but the presence of relatively high chloride concentration in fresh water (about 250 mg/L or more) may indicate waste water pollution.
Calcium (Ca2+) and magnesium (Mg2+) ions cause the greatest portion of hardness in naturally occurring waters. From health viewpoint hardness below 500mg/L is safe.

The Dissolved Oxygen (DO) can be used as a most important parameter in checking water pollution. The lower the concentration the more polluted the water is. Normal concentration ranges between 6.5-8 mg/L.

A very important biological indicator of water pollution is the group of bacteria called coliforms. A particular species of coliform found in domestic sewages is Escherichia coli or E. Coli. Even if the water is only slightly polluted, They are very likely to be form. Coliform bacteria are aggressive organisms and survive in the water longer than most pathogens.
Palatibility, viscosity, solubility, odours and chemical reactions are influenced by temperature. Thereby, the sedimentation and chlorination process and Biological Oxygen Demand are temperature dependent. The normal temperature is considered between 10 °C to 15 °C.

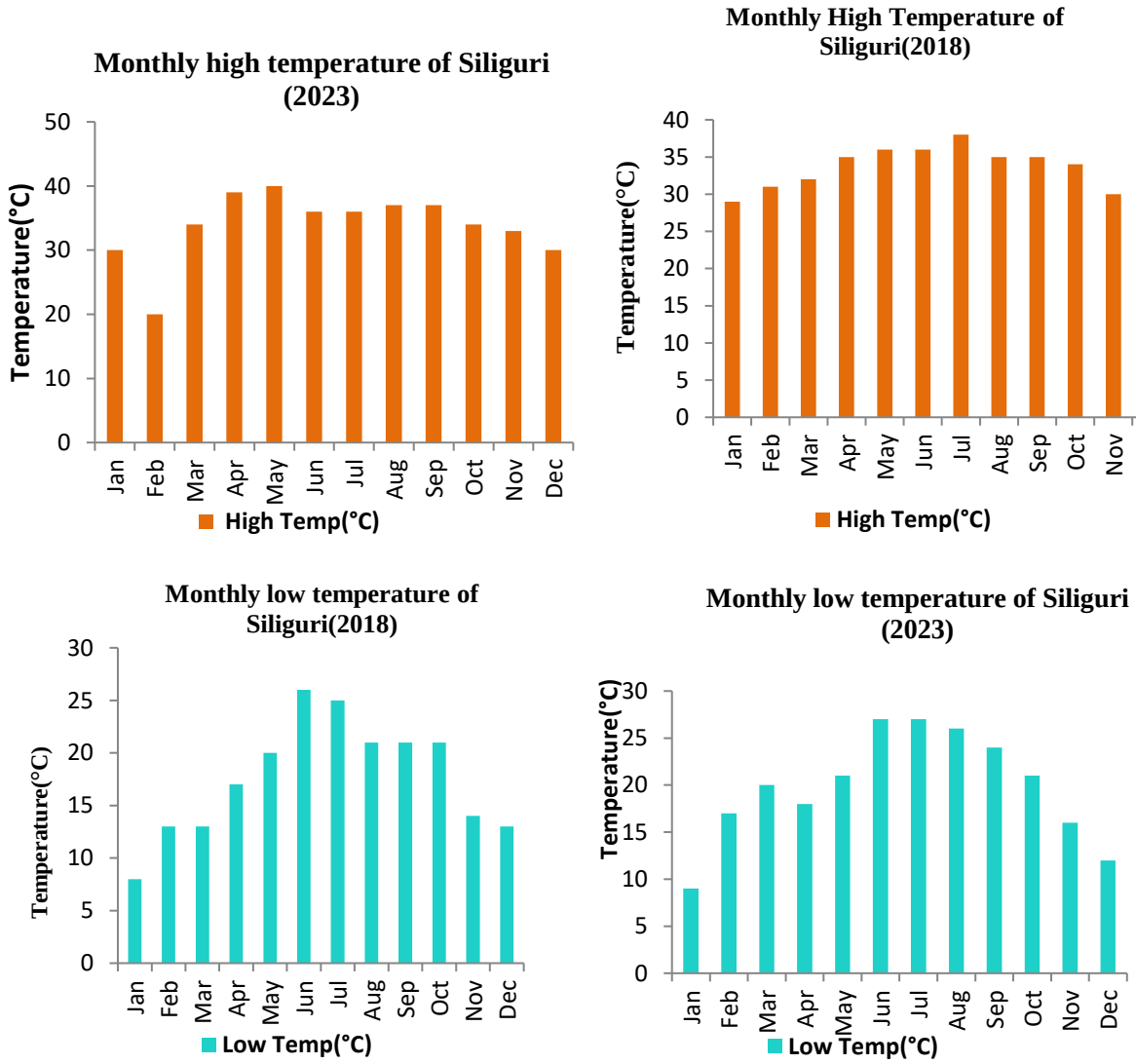
From the table (9) it is clear that the temperature is more or less high, PH level is satisfactory. Chloride content is in trace amount. The DO is considerable. and BOD and total coliform and fecal coliform all very high in concentration.
The reason for high concentration of above mentioned substances is the foresence of small chemical industries, hotels in the Air view release untreated wastes in the river water.

From the table (10), it is seen that the quality is decorating from the past years the water became slightly alkaline. The surface temperature is also increased from the past years so it is also high and the value of BOD is also crossed the limit reflecting the effect in the aquatic life. Phosphate was found exceeding the limit higher phosphate (PO3 4- ) might be due to intense input of fertilizers and pesticides from agricultural lands detergents that are abundant in waste and sewage effluents. The level of coliform and fuel coliform from also exceeded. Slum dwellers with poor sanitation system living in areas adjacent to river might have loaded to higher bacterial load in surface water. The river have high bacterial composition degrading the water quality significantly.

On the other hand the river Chamta is almost deteriorated due to anthropogenic activities i.e, nearness of the Bartaman Newspaper printing company discharge their also chemicals in the river. The temperature ranges between 20°C to 25 °C which is higher than usual. The DO content is low due to presence of algae in the surface water as the oxygen can't penetrate properly if the surface area is not open. The water is acidic in nature and is bacterial dominated as the sewages from that area is drained into that river.

And from the site it is observed that the drainage facility is not well developed, people live in unhygienic condition and there is no proper waste disposal place and the household sewages dispose near the river bank. The bacterial load is gaining due to disposal of sewage in river water and content of DO is becoming lower day by day which is matter of concern.

**4 Change in temperature and rainfall:**




**Figure(7): Temperature Data(2018 &2023)**

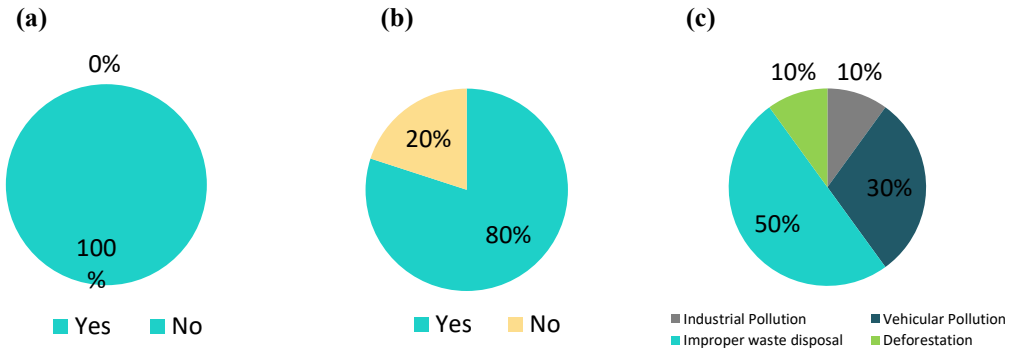
From the figures above it is clear that their is huge variation the temperature in most of the month is gradually increasing from the year 2018 to 2023. The highest temperature was recorded in the year 2018 in the month of july i.e, 38 ℃ in contrast 40 ℃ in the month of May in the year 2023. So it is clear that temperature is rised by 2 ℃ between 2 years and it is a matter of concern.

From this it is very clear that the temperature is gradually increasing this hazards are influenced by number of factors such as deforestation in the Chadmuni area of Siliguri due to expansion of road. The main cause is the increase in the number of population. The population was 464000 lakhs in the year 2000 and it become 701498 lakhs in the year 2011. So, due to rapid increase of population the number of vehicles per person is also increasing thus creating demand for expanded roads. Due to the presence of gases and particulate matters in the air the temperature is gradually increasing contributing to different types of healthy hazards such as sun-stoke, suffocation, headache, discomfort, etc. The rapid felling of tress also contributing to environmental degradation in this city.

It is seen that the most important cause of air pollution is the traffic congestions in Darjeeling more, Air view more, Champasari more, Khaprail more. Most percent of air pollution is served by this area. Due to emission of various harmful gasses like methane, carbon-dioxide, and nitrous oxide, carbon mono-oxide,etc from the vehicles the temperature is gradually increasing which leads to various types of health problems like suffocation, irritation in eyes, lungs problems, headache, etc.

And also the buring of crakers, presense of industries in different areas such as engine industries, fertilizer industries and also automobile, iron and steel industries not only degrade environment in terms of air but also in terms of noise and water.

The rapid pace of urbanization and rapid felling of trees also contributing to the increase of temperature. The increase in temperature may also leads to increased number of mosquitoes and flies make the area more vulnerable to diseases like malaria, dengue, dysentery, vomiting, fever,etc.



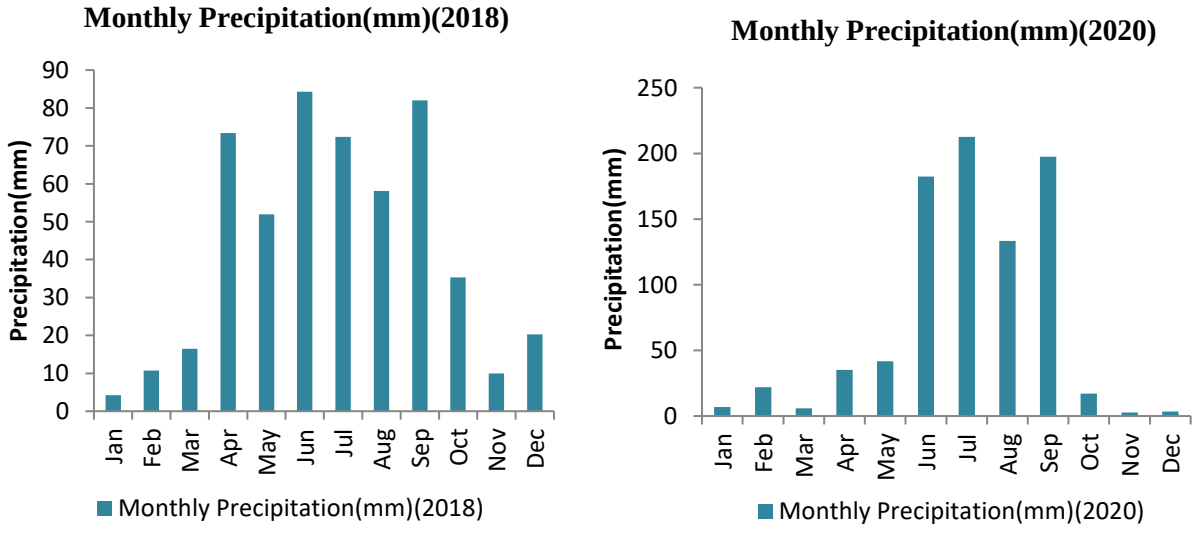

**Figure(8):(a) Feel rise in temperature in heavy traffic,(b) Area affected by heavy traffic,(c) Causes of environmental degradation in your area.**

**Source: Primary Data**

From this data it can be analysed that 100 percent of population can feel heat island in heavy traffic areas this are caused by gases emitted by the vehicles by burning petroleum and diesel causing heavy rise of temperature this areas are mainly the heavy traffic centres such as Chadmuni road, Darjeeling more, Khaprail more, Champasari more i.e, 80% of the area are affected by traffic and the residents near it are also gets affected. Here it is seen that 30 % of the area is affected by vehicular pollution, 50% of them are effected by improper waste disposal,10% by deforestation and 10% by industrial pollution.


**Figure(9): Deforestation in Chadmuni Area**

All of these factors are affecting the climate creating serious problem of temperature variation and climate change and also results into heavy rainfall in shorter period and absence of winter rainfall.




**Figure(10): Monthly Precipitation Data(2018 & 2020)**

So, from the both years it is seen that there is huge difference in the amount of precipitation. The winter rainfall is getting lesser and lesser year by year. The amount of rainfall is increasing it is because of overall climate change in the world. In 2020 the precipitation experienced in the month of July to September in contrast the 2018 experienced a good amount of both summer and winter rainfall. The recent year i.e, 2023 did not get winter rainfall or retreated monsoon. So, due to heavy rainfall in the summer months of June to September the catchment area of river Mahananda gets flooded. The residents in this area are affected by this situations and the wastes which are disposed in the river get into their houses and they get contaminated by different health hazards. The melting of ice and increase in the sea level causing indefinite increase in rainfall causing problems related to agriculture too. The impact of climate change is getting worser day by day.

The disposal of waste in the river causing direct health related problems and also degrading the aquatic ecosystem.

In instance, it may be said that the root cause of environmental degradation the increase in pollution which creating high demand for urbanization creating heavy stress on environment and creating disequilibrium in the ecosystem affecting climate and all the creatures.

**1.5.4.POLLUTION AND IMPACT IN HUMAN HEALTH**

1. **Major Health Related Problems:**

According to the reports of WBPCB and CPCB the average value of AQI of Siliguri was 344 during 8$^{th}$ and 13 February 2018, which was enough to create respiratory illness for lakhs of people residing at Siliguri.

The City of Siliguri like many other big cities in India, is suffering from enormous Air pollution due to excessive high growth of Air pollutant as a result of Vehicular air pollution or fossil fuel burning from rapid growth of motorized transport. As per the Siliguri Municipal Corporation and West Bengal pollution Control Board's report Siliguri's poor Air quality is attributed to:

(1) Much less surface area of the roads comparing to the human and the vehicular population.

(2) The ever growing high density of population uses the same road space as of 1960s.

(3) The ever growing number of vehicular population including the old high pollutant emitting vehicles still in service and it is with the new additions of vehicles that creates problems .

(4) The speed breakers and slow moving vehicles create jams and congestions in the Siliguri city.

(5) Other than the above mentioned problems, the road encroachment by illegal parking, migration of people from adjoining districts & states, by illegal shops or Hawkers makes the slow moving traffic. This essentially raises the Air pollution level. From1990 the number of Vehicles are growing rapidly in Siliguri . From 2004 to 2014 the growth rate of two wheelers was more than 76 % in India, which was highest in the world after defeating China and in case of Siliguri the growth of two wheelers is much higher than any other cities of North Bengal. And the amount of diesel run commercial and personal four wheelers, Good Carriers, three wheelers has grown almost 25% in the mean time.

According the Reports of WHO Cities like Siliguri are much more vulnerable to several respiratory diseases including COPD, Cancer, Ischemic Heart Disease etc as compare to big metros because, of small congested size of the cities , heavy density of growing populations, rapid growth of vehicular traffic and many more.

The degradation of water by the industries, households and hotels making it a way of waste disposal thus effecting the health significantly. The industrial expansion in this city as being the most important city for trade and commerce contributing to the different harmful gases and chemicals to the air deteriorating it significantly and causing various health hazards.

**2. Vehicular pollution effects on health:**

Several effects of vehicular pollution on human heath particularly on respiratory mechanism and nervous system have been observed. Some of them are as follows,

**Allergic Alveolities:** As a result of long term use of adulterated fuel in vehicles and huge emission from large number of petrol driven vehicles , the amount of SO2 and NO2 increases enormously in the Air, which is the cause of Allergic Alveolities. This is a kind of auto immune lung disease.

**Bronchial Asthma:** High amount of NOx, SO2, Particulate Matter and surface ozone in the air are responsible for increase in morbidity and mortality from Bronchial Asthma as a result of air pollution due to automobile emission.

**Chronic Bronchitis:** Due to maximum concentration of dust and SPM in the Air from exhaust emission of automobiles Chronic Inflammatory lung disease or inflammation of bronchus causes breathlessness, chest pain and cough.

**3.Industrial effect on health:**

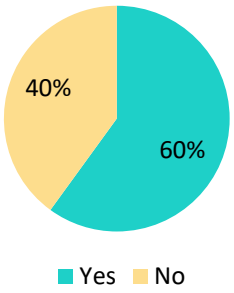
Respiratory diseases
Cancers
Decreased lung function
Asthma

**4.Water pollution effect on health:**
Dengue
Diarrhoea
Dysentery
Hepatitis A
Polio
Fever
Vomitting

**5 Noise pollution effect on health:**
Stress related illness
High Blood Pressure
Hearing loss
Sleep disruption
Headaches

**6 Faulty waste disposal effect on health:**
Asthama
Birth defects
Cancer
Cardiovascular diseases
From above mentioned problems the main diseases that are found common are hearing problem, breathing problem, fever, dysentery, diarrhoea, headache, dengue, vomiting, high blood pressure, etc.

**(a)**

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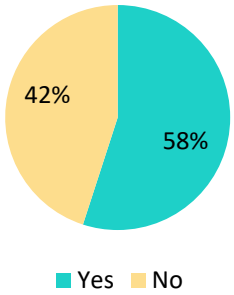


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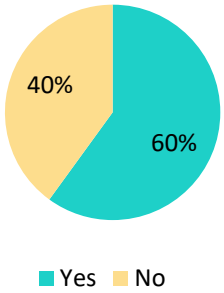


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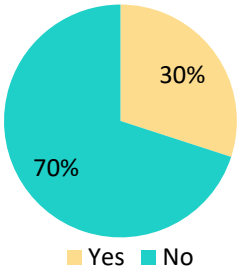


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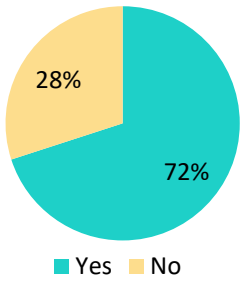


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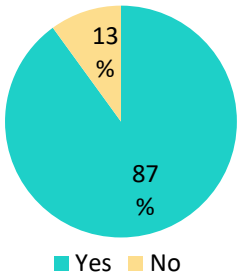


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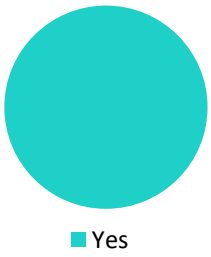


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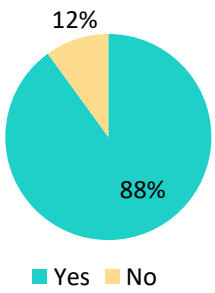
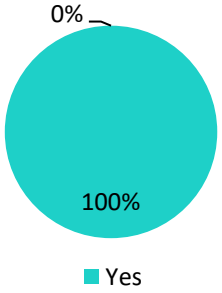
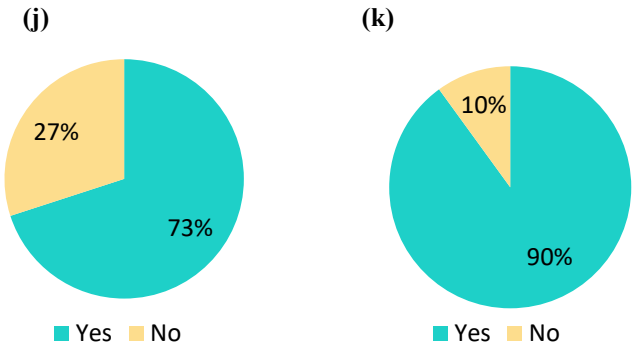



**(i)**






**Figure(11):** (a) Industries creating noise,(b)Industrial noise creating any health problem,(c) Home near dumping ground, (d) Affected by water pollution, (e) Traffic congestion causing any health problem, (f) Drainage facility is developed,(g)Presence of cleaning van,(h) Smoke from industry causing any health problem, (i) Environmental pollution effecting health,(j)Effect of pollution on family or friends,(k) Degraded environment is affecting personally.

**Source: Primary Data**

From the statistical analysis by doing survey it is seen that 60% of the people are facing high noise problems, this are the residents which are situated in front of industries such as iron and steel, motor and automobile industries and engine industries (located at Industrial area of Sevoke road and Mahananda colony of Siliguri respectively). 58% of people from that 60% having health problems like hearing problem, headache, irritability, high blood pressure.
And 60% of the residents live near dumping ground whether small or big. Places like Don Bosco Colony, Chadmuni area, Mahananda colony become a place of dumping wastes materials. The problems regarding health that are caused are breathing problem, dengue, fever, vomiting, dysentery, etc. The presence of engine factory near the Mahananda colony creating hearing problem due to noise from the factory.
70% of the people are affected by river pollution includes rivers such as Mahananda river near air view more and part of Panchai river near Matigara and Chamta river. The rivers already in a deteriorating stage and all the wastes from the newspaper printing company and also the bastis near it are the main source of pollution creating problems like dysentery, fever, diarrhoea, etc. The wastes from all the city area are drained in the river.
72% of the people are affected by problems of traffic congestion daily. People gets affected by various types of gasses emitted by the vehicles and also by the presence of Suspended Particulate Matter(SPM) in the air. Due to these congestions urban heat island is forming creating health related problem. The major problems are allergic alveolities, chronic bronchitis, asthama, headache, etc.
87% of the people resides in the place having poor drainage area and got contaminated by different diseases and during heavy rains the sewages from the drains come out in the street and homes.
100% of the respondents agreed with the presence of cleaning van provided by Municipal Corporation but all the vans collect sewages from homes and dump near the field near the Commissionerate building and also in case of Mahananda colony all the wastes are dumped near the river. It not only creating problems to the humans but also degrading the environment.
88% of the people who live near the industries are got affected. Different chemicals from the factories mixed with the air creates several health hazards.
Either creating small or big issues environmental pollution creates problems to everyone in the city.
73% respondents tell that their friend and family got effected by pollution either creating small or huge problems. People who does job in day to day life have gone through problems of traffic and got effected easily. And also the students who have to travel daily to their respected school or colleges or universities are also got effected.
Finally, the degraded environment is effecting most of the people as it ultimately creating problems like climate change, increase in the temperature, smog's in the air, decrease in rainfall days with high intensity in shorter periods, etc and those problems not only to the humans but also the physical biome and aquatic lives too.

## RECOMMENDATION AND STRATEGIES

**Remedies :**

Urbanisation undoubtedly indicates the major transformation to land use / that profoundly influences the environment. Fast altering urban landscape covered with rapid population growth and immense pressure on land carrying capacity process a great challenge for Siliguri Municipal Corporation (SMC). Sustainable eco friendly approval is required to come back the environment problem at the earliest. The challenge for Siliguri is to create appropriate and effective adaptation strategies to reduce environmental pollution and its impact by building resilience and resistance. Action needs to take place at all levels from the national to local. Community based efforts should also be encouraged.

(I) Proper traffic planning can settle down the problem
(II) Population should be maintained by taking proper population policy.
(III) Time to time cleaning of river water.

(II) CPCB can check the fumes of the vehicles and can make find to filter the society.
(III) The frequency of JNNURM buses should be increased as they are low smoke emission vehicles.
(IV) The garbage is and waste should be properly filtered and dumped.
(V) The health services should monitor about the surplus medical waste.
(VI) Industrial and household troubles should be dumped properly.
(VII) An immediate introduction of CNG and electric vehicles should be necessary, air monitoring stations should be equipped at various locations of the city.
(VIII) The city must incorporate National Action Plan on Climate Change (NAPCC) in its development strategy. (IX) Conservation and protection of resources combined with a planned shift to a low or no- carbon economy, maximize uses of renewables for energy production should be encouraged.

**SCHEMES & PROJECTS ADOPTED IN SILIGURI**

To reduce harmful environmental impact the Siliguri Municipal Corporation (SMC) has adopted the following schemes and projects.

(a) National Urban Health Mission (NUHM)- it reimages to meet health care needs of the city with a focus on the urban poor.
(b) Swiss agency for development and Corporation (SDC)- Siliguri has been selected as a part of the project by SDC that aims in coping with the effects of a changing climate.
(c) Water Audit System- WAS has been Undertaken.
(d) Green City, Clean City- The Green City Mission has been implemented to encourage city governments to come up with schemes to increase green areas, conserve water bodies and prevent harmful environmental impact and beautify public areas.
(e) Siliguri Municipal Corporation- Has also partner with several NGOs to implement community based environmental initiative and projects. One such example in the 'Bengal Clean Air Network (Bengal CAN)' which aims to engage different stakeholders and walk together towards building a sustainable city. These remedial measures aim to mitigate environmental pollution and safeguard the health and well-being of Siliguri's residents.

Though various schemes has been implemented but the process of environmental degradation is still going on creating heavy impact on environment and human health thus more strategic implementation of plan should be taken to make the city less vulnerable to hazards.

**CONCLUSION**

In conclusion, the geographical study of Siliguri city has provided valuable insights into the relationship between environmental quality and its impact on human health. Through comprehensive analysis and examination of various environmental factors, it is evident that Siliguri faces significant challenges in maintaining a healthy environment conducive to human well-being. Siliguri experiences high levels of air pollution, primarily due to vehicular emissions, industrial activities, and biomass burning. The presence of pollutants such as particulate matter (PM), nitrogen dioxide ($NO_2$), sulphur dioxide ($SO_2$), and carbon monoxide (CO) poses serious health risks to the city's residents, leading to respiratory ailments, cardiovascular diseases, and other adverse health outcomes. The quality of water in Siliguri is compromised by pollution from domestic, industrial, and agricultural sources. Contamination of surface water bodies and groundwater with pollutants, including heavy metals, pesticides, and organic compounds, threatens public health by causing waterborne diseases and long-term health hazards. The city experiences significant levels of noise pollution, primarily attributed to traffic congestion, industrial operations, and commercial activities. Prolonged exposure to high levels of noise can lead to hearing impairment, stress, sleep disturbances, and other health issues among residents. Siliguri exhibits characteristics of the urban heat island effect, with higher temperatures recorded in urban areas compared to surrounding rural areas. This phenomenon, exacerbated by urbanization and lack of green spaces, contributes to heat-related illnesses and exacerbates existing health disparities, particularly among vulnerable populations. The adverse effects of environmental degradation disproportionately affect marginalized and economically disadvantaged communities in Siliguri. Poor living conditions, inadequate access to clean water and sanitation, and limited healthcare infrastructure exacerbate the health risks faced by these vulnerable populations. Addressing environmental challenges in Siliguri requires a multifaceted approach encompassing policy interventions, urban planning strategies, public awareness campaigns, and community engagement initiatives. Mitigation measures such as emissions controls, waste management practices, afforestation efforts, and sustainable transportation planning are essential to improve environmental quality and safeguard public health. The continued process of environmental degradation mainly by the anthropogenic factors creating deforestation, change in temperature and weather patterns, etc. In essence, the geographical study of Siliguri city underscores the urgent need for concerted action to mitigate environmental degradation and protect human health. By implementing sustainable practices, promoting environmental stewardship, and fostering community resilience, Siliguri can aspire to become a model city where environmental quality and public health are prioritized for the well-being of present and future generations.

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