

## Determination of Air Quality Life Index (Aqli) in Medinipur City of West Bengal(India) During 2019 To 2020 : A contextual Study

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### Abstract

The Air Quality Index (AQI) utilized in various nations doesn't plainly show how much air pollution influences the average life expectancy (LE). This study explicitly shows how much air pollutants (especially atmospheric particulate matter) reduce the average LE of an individual in a given year in a specific city. This study has determined the Air Quality Life Index (AQLI) and has shown a reduction in the average LE of each resident of Medinipur city in 2019 and 2020. The reduction in human LE due to particulate matter pollution is actually based on a pair of semi-experimental variation studies, especially in the Chinese setting, derived from the impact of coarse particles ( $PM_{10}$ : particle size ranges between 2.5 micro meter sand 10 micrometers) on the northern and southern border populace of the China Huai River. The results showed that "an additional 10 micrograms per cubic meter of  $PM_{10}$  exposure reduces LE by 0.64 yrs".<sup>1</sup> The methodology used in this study is based on the University of Chicago Energy Policy Institute's (EPIC) epidemiological estimates that provide the most acceptable and modified equation for determining global AQLI, which uses  $PM_{2.5}$  to  $PM_{10}$  ratios due to global  $PM_{10}$  data unavailability and recommends that 'additional sustainable exposure to fine particles or  $PM_{2.5}$  (particle size less than or equal to 2.5 micrometers) reduces LE by 0.98 years per 10 micrograms per cubic meter' which was followed by a pair of experimental results by Chen *et al.* (2013) and Ebenstein *et al.* (2017) on the impacts of long-term PM pollution on permanent residents of both the north and south sides of the China Huai River.<sup>2</sup> Regional or global previous fine particle ( $PM_{2.5}$ ) densities are measured at a specific resolution using an integrated geophysical-statistical method that provides the global fine particulate or



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
### Keywords

Aqli; Average Life Expectancy (Le) Loss; Medinipur City;  $PM_{2.5}$ ;  $PM_{10}$ ; Who Guideline.

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PM<sub>2.5</sub> data<sup>3</sup> used to determine the AQLI of a country or city, although PM<sub>2.5</sub> concentrations are considered for world atmospheric pollution because atmospheric particulate matter (PM<sub>2.5</sub>) invades the deeper structures of the respiratory tract and has a more harmful or toxic impact on humans than coarse particles (PM<sub>10</sub>).<sup>4,5</sup> Therefore, the current annual PM<sub>2.5</sub> data is used by the ground-based monitor of PM<sub>2.5</sub> concentration to determine the AQLI of the respective city in this study. The results of the study have shown that the current annual concentration of PM<sub>2.5</sub> obtained from Breezo Meter and PMS3003 at four selected stations (S1 to S4) in Medinipur city ranged from 23 to 29 µg/m<sup>3</sup> per year and the average LE loss in Medinipur varied from 1.3 years to 1.87 years per person, which may be caused by cardiopulmonary disease and lung cancer.

### Introduction

The Air Quality Index (AQI) doesn't precisely decide the unsafe impacts of air pollutants on human health. Although most developing countries utilize their own air quality indicators, they are unable to give the public a positive idea of how harmful air pollutants are. Particulate matter (solid and fluid particles such as ash, smoke, residue, and others that are suspended and noticeable all around) is a vital and significant pollutant in the ambient air that can shorten human LE and is estimated by an exceptionally evolved technique called the Air Quality Life Index (AQLI). Different research has shown that there is a link between human life expectancy and atmospheric particle (PM<sub>2.5</sub>) exposure. For instance, in the United States during the 1980s and 1990s, an immediate appraisal of the differential fluctuation of PM<sub>2.5</sub> air pollution utilizing regression models, assembling data on LE, financial status, and populace attributes, showed that the decrease in ambient PM<sub>2.5</sub> concentration per 10 µg/m<sup>3</sup> expanded average human LE by 0.61 (SE ± 0.20) years.<sup>6</sup> Using the same method, combining a dataset for 545 U.S. counties from 2000 to 2007, the county-specific (annual) average PM<sub>2.5</sub>, the county-specific (annual) LE, and socio economic status, smoking trend changes assess a reduction in fine particle concentration of 10 µg/m<sup>3</sup> associated with an increase in human LE of 0.35 years (standard deviation of 0.16 years).<sup>7</sup> To determine the relationship between PM<sub>2.5</sub> density and LE in adults, county-level yearly average PM<sub>2.5</sub> density data for the period 2010 to 2017 was collected concurrently with potentially confusing variables (including population data, financial conditions, and smoking trends) in a Taiwan-wide

(China) study. Accordingly, using linear regression models, evidence was found that for every 10 micrograms per cubic meter of PM<sub>2.5</sub> increment, the average LE of adults was diminished by 0.3 years.<sup>8</sup> Using a generalized additive model and meta-analysis, the daily PM<sub>2.5</sub> values achieved in 72 cities in China between 2013 and 2016 indicate that significantly longer LE can be achieved by reducing the atmospheric PM<sub>2.5</sub> concentration.<sup>9</sup> It is astonishing that even if particulate matter values (PM<sub>2.5</sub>) are taken as per WHO guidelines, the average LE loss of all people in the world is reduced by about 2.3 years when the average person is exposed to particulate matter concentrations of 33 µg/m<sup>3</sup>. And if the value of particulate matter is considered by different countries according to their own national standards, then, at that point, the average LE loss of some countries like Bangladesh, India, Pakistan, and even Singapore is more than 2.8 years in 2018.<sup>4</sup>

It is also possible to determine the AQLI from the annual fine particle or PM<sub>2.5</sub> concentration. The historical studies by Aaron van Donkelaar *et al.* (2016) were used to measure prehistoric, long-term man-made atmospheric fine particle concentrations worldwide using aerosol optical depth (AOD) derived from satellite products,<sup>3</sup> which is extremely helpful for determining AQLI. Various studies have also observed a positive trend in atmospheric fine particle concentration (PM<sub>2.5</sub>) world wide (especially in India), indicating an increase in the detrimental impacts on the cardio pulmonary system of the human body in the future, which increases the risk of lung cancer and mortality.<sup>10</sup> Such as, the long-term trends in PM<sub>2.5</sub> density have been observed

from 1998 to 2018 using satellite product AOD, simulation, and surface-based monitors, where the worldwide  $PM_{2.5}$  density is  $0.04 (\pm 0.02) \mu\text{g}/\text{m}^3/\text{yr}$ , and India has a positive trend of  $1.13 (\pm 0.15) \mu\text{g}/\text{m}^3/\text{yr}$  has been registered. Again, between 2005 and 2013, a significant positive trend was observed in India, which was around  $2.44 (\pm 0.44) \mu\text{g}/\text{m}^3/\text{yr}$ .<sup>11</sup> Furthermore, measuring the world's population-weighted  $PM_{2.5}$  density using satellite-derived data (AOD) using a combined geophysical-statistical method at a resolution of  $0.1^\circ \times 0.1^\circ$  from 2004 to 2008 shows that particulate organic mass, secondary inorganic aerosol, and mineral dust are  $11.9 (\pm 7.3) \mu\text{g}/\text{m}^3$ ,  $11.1 (\pm 5.0) \mu\text{g}/\text{m}^3$ , and  $11.1 (\pm 7.9) \mu\text{g}/\text{m}^3$  respectively.<sup>12</sup> The current research shows how particulate matter (PM) pollution shortens human LE. The appropriate response is that the destructive impact of atmospheric particulate matter adversely affects the entire human body system. Various experimental studies have clearly shown that fine particles can easily reach the lungs through the nasal section, even the circulatory system,<sup>13</sup> and harm the lung walls, including the lung tissue. The known methods of destroying lung tissue are to reduce cell antioxidant levels by increasing reactive oxygen species (ROS) production, increase the production of inflammatory chemicals, and inhibit the calcium balance in the cell.<sup>5</sup> Subsequently, chronic inflammatory lung disease, is chemically cardiac disease, cancer in the pulmonary system, stroke, and pneumonia are more likely to develop, which further increases the morbidity and mortality rate.<sup>14</sup> Like molecular vector, particulate matter (PM) even enters the central nervous system (brain) through the first cranial nerve (olfactory nerve) which later passes and obliterates gradually the blood-brain barrier (BBB). It can also cause inflammation, DNA damage symptoms, and Alzheimer's disease,<sup>15</sup> even in children's brains.<sup>16</sup> The constant release of particulate matter from industries, coal combustion, vehicles, and so on makes these complex diseases more uncomfortable, which results in a reduced average LE of human beings.<sup>17</sup>

Using the most acceptable and modified formulations of the Energy Policy Institute University of Chicago (EPIC) developed by Michael Greenstone and Claire Qing Fan (2018),<sup>4</sup> the average human LE loss for atmospheric particulate matter pollution in 2019 and 2020 is determined separately in the respective cities, where the required  $PM_{2.5}$  concentration is

measured by Plan tower Particulate Matter Sensor (PMS3003) and Breezo Meter (BM) air quality app ground-based monitors.

## Study Area, Materials, and Methods

### Study Area

Notable town Medinipur is the base camp of the Paschim Medinipur district of West Bengal, situated 23 meters above sea level, with warm heat and humidity, covering an area of 18.36 square kilometers. According to 2011 statistics, the population of Medinipur Municipality, which consists of 25 wards, is 169,127 people. 10% of the population is under six years of age. As per the report of Medinipur Municipality, Aadhaar estimates that by mid-2020, the total population of Medinipur is about 107661 males and 104065 females, where the population density is 11531.9 (per sq km). Extensive transportation and quick urbanization are significant sources of air pollutants (especially  $PM_{10}$  and  $PM_{2.5}$ ) in integrated Medinipur city; where vehicle emissions, household incineration, and street dust are the primary sources of pollution.

### Materials, and Methods

To measure the concentration of  $PM_{2.5}$  ( $\mu\text{g}/\text{m}^3$ ), four significant densely populated areas (S1 to S4) with heavy traffic were selected in Medinipur city (residential urban area) as shown in table 1 with specific coordinates and used sensor or app. The current concentration of  $PM_{2.5}$  from 7 March 2019 to 31 December 2020 was estimated by using the Plan tower Particulate Matter Sensor and the Breezo Meter (BM) Air Quality app that provides ground-based  $PM_{2.5}$  data. As there is no conclusive  $PM_{2.5}$  data for 2019, the leftover days of  $PM_{2.5}$  data have been retrieved from the Pollution Control Board (WBPCB). For 2019, the deficit has been filled by adding 65 days of retrieved  $PM_{2.5}$  data to all stations to accurately determine the annual  $PM_{2.5}$  value in the respective city. From these four geological areas displayed in Figure 1, the concentration of  $PM_{2.5}$ , excluding S1 (estimating the daily average), was estimated to have different movements every morning, afternoon, evening, and late evening over a 1-hour integration period. Thus, the value of  $PM_{2.5}$  is obtained by determining the average  $PM_{2.5}$  per day for four periods from S2 to S4. In the case of missing date data, the values of the previous and next date have been replaced by an average.

**Table 1: Location, coordinates, used air quality sensor/detector of air monitoring station in Medinipur city**

Air monitoring station no.	Air monitoring station locations (zone)	Coordinates	Used air quality sensor /detector
S1	Rabindra Nagar, Medinipur, West Bengal 721101, India (central)	N 22° 25'28.4196"E 87°19'09.894"	BreezoMeter (BM) Air Quality app
S2	Abasgarh, Medinipur, West Bengal 721102, India (North- Eastern)	N 22°26'25.296" E 87°19'37.65"	Plantower particulate matter sensor (PMS3003)
S3	Tantigeria, Medinipur, West Bengal 721102, India (North-western)	N 22°25'59.8332" E 87°18'27.324"	Plantower particulate matter sensor (PMS3003)
S4	Mahatabpur, Medinipur, West Bengal 721101, India (Southern)	N 22°24'22.896" E 87°19'00.444"	Plantower particulate matter sensor (PMS3003)

The BM air quality app has been used to measure the PM<sub>2.5</sub> concentration at Medinipur station 1 (S1). The hyperlocal, real-time, highly accurate BM app provides data from the nearest available monitoring station.<sup>18</sup> The Breezo Meter (BM) Ltd. company has made an application that shows a worldwide

guide of air pollution. As well as showing air quality indicators, the application additionally incorporates the quality of every impurity, a conjecture and history of air quality indicators, allergen concentration, and proposals for individuals with pulmonary disorders, children, and sports.



**Fig. 1: Geographic location of air monitoring station of Medinipur**

The application can be introduced on an Android phone, where it screens the client's developments by means of GPS and cautions them, assuming that they are in a low air quality region. The principal contrast between the current technique for estimation and the Breezo Meter idea is that the current strategy utilizes the public pollution checking organization, which shows information only about nearby static estimation communities. Furthermore, Breezo Meter gathers worldwide information from

an assortment of sources, like climate information, traffic streams, GPS, and information assortments from estimation focuses. This ostensibly massive amount of data is gathered and verified on the server before being used to display a total air quality indicator. The diffused interpolation algorithms utilized for displaying depend on machine learning or AI methods. The organization (BreezoMeter) offers the application's inter connection with smart cities, smart homes, automotive circles, and more.

Since the precision of the algorithm is routinely checked by different statistical techniques and since the algorithm consolidates AI and can adjust dependent on previous experience, the application works in real-time regardless of whether the source information isn't accessible in real-time. Breezo Meter's algorithm is currently fit for examining pollution dissipating in real-time, implying that air pollution shifts several times each day dependent on the dynamics, relevance, and area of the individual utilizing the application and is constrained by complex flow dynamics.<sup>19,20,21</sup>

The Plan tower Particulate Matter Sensor (Model No- PMS3003) instrument has been used to determine the PM<sub>2.5</sub> concentration of the remaining three stations (S2, S3, and S4) in the city of Medinipur. The PMS3003 Sensor (size: 50mm long × 43mm wide × 21mm high; weight: ≈ 40g; validity from manufacturer's report: ± 10% in the 100 to 500 µg/m<sup>3</sup> range). The digital, real-time, low-cost PMS3003 laser light dispersion PM2.5 sensor, which measures PM<sub>2.5</sub> concentration at regular intervals throughout the year, is used multiple times per day (morning, afternoon, evening, and late evening) as an everyday average during the 1-hour integration time.<sup>22</sup> An exceptional element of the Plantower sensor (PMS) is that atmospheric particle size (in the range of 0.3 to 10 microns) can be measured at specific integration times in the air around coastal and urban areas using laser light scattering principles.

The suboptimal reference analyzer is used to choose the fitting meantime, regularly generating a surging sound mark over a long time (for example, 24 hours) and therefore displaying similar errors.<sup>23,24</sup> The inclusion of commercially accessible Plantower PM sensors has been chosen because of the promising results, rationality of use, general functionality, and minimal cost of lab approval studies.<sup>25,26,27</sup>

The reduction in human LE due to particulate matter pollution is based on a pair of semi-experimental variation studies, especially in the Chinese setting, derived from the impact of coarse particles on the northern and southern border populace of the China Huai River. The results showed that 'an additional 10 micrograms per cubic meter of PM<sub>10</sub> exposure

reduces LE by 0.64 yrs' with a 95% confidence interval (95% CI) value of 0.21 years to 1.07 years.<sup>1</sup> The methodology used in this study is based on the University of Chicago Energy Policy Institute's (EPIC) epidemiological estimates and provides the most acceptable and modified equation for determining global AQLI using a standard 0.65 PM<sub>2.5</sub> to PM<sub>10</sub> baseline ratio,<sup>28</sup> which is based on 589 pairs of data across more than fifty cities and regions.

The result is finally converted to:

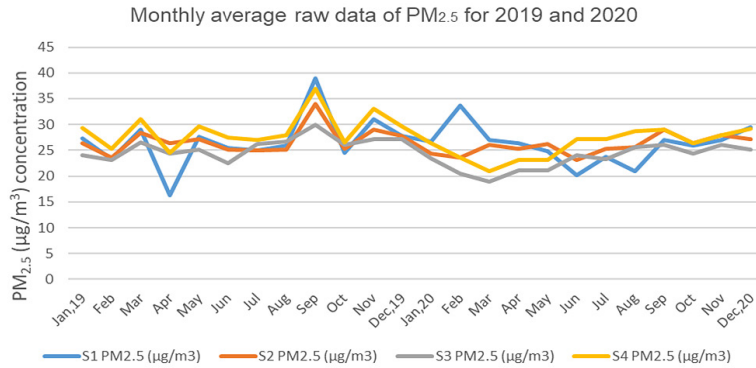
$$[(0.64 \text{ years} \div 10 \text{ } \mu\text{g}/\text{m}^3 \text{ of PM}_{10}) \times (1 \mu\text{g}/\text{m}^3 \text{ of PM}_{10} \div 0.65 \text{ } \mu\text{g}/\text{m}^3 \text{ PM}_{2.5})] = 0.98 \text{ years per } 10 \text{ } \mu\text{g}/\text{m}^3 \text{ PM}_{2.5}$$

Due to global PM<sub>10</sub> data unavailability, EPIC recommends that "additional sustainable exposure to fine particles or PM<sub>2.5</sub> reduces LE by 0.98 years per 10 micrograms per cubic meter," which was followed by a pair of experimental results by Chen *et al.* (2013) and Ebenstein *et al.* (2017) on the impacts of long-term PM pollution on permanent residents of both the north and south sides of the China Huai River. It also evaluates the current advanced polluted area setting by incorporating the key link between long-term PM exposure and human LE.<sup>1,2,29</sup> Historical research shows that previous man-made long-term global PM<sub>2.5</sub> values were estimated using an integrated geophysical-statistical method including AOD data from satellite products (such as MODIS and MISR), models (GEOS-Chem Chemical transport), and ground-based monitors that provide PM<sub>2.5</sub> data worldwide, which is highly effective in determining AQLI.<sup>3</sup> Since only atmospheric fine particle (PM<sub>2.5</sub>) data is used for air pollution worldwide, its standard values are used. Thus, the current ground-based annual concentration of PM<sub>2.5</sub> has been used to determine AQLI in this study.

## Results

Details of required PM<sub>2.5</sub> values obtained by Breezo Meter and PMS3003 readings at four stations for AQLI determination in Medinipur city in 2019 and 2020 are given in table 2. The monthly change in the concentration of PM<sub>2.5</sub> from 2019 to 2020 at different air observation centers in Medinipur city is shown in figure 2. The 24-hour average PM<sub>2.5</sub> values obtained by BreezoMeter from Medinipur S1 station had almost the same minimum and maximum values in both years. In S1, the lowest and highest

values were 7.5  $\mu\text{g}/\text{m}^3$  and 172  $\mu\text{g}/\text{m}^3$ , respectively. The annual average values of  $\text{PM}_{2.5}$  at S1 stations in 2019 and 2020 were 26.98 ( $\pm 5.73$ )  $\mu\text{g}/\text{m}^3$  and 26.20 ( $\pm 4.04$ )  $\mu\text{g}/\text{m}^3$ , respectively.



**Fig. 2: From 2019 to 2020, the monthly change in  $\text{PM}_{2.5}$  concentrations at used air monitoring stations in Medinipur city**

The lowest, highest, and annual mean ranges of  $\text{PM}_{2.5}$  concentration as an average of four times daily obtained from the Plantower Particulate Matter Sensor (PMS3003) device in 2019 and 2020 for stations other than S1 were 2.22 to 4.23  $\mu\text{g}/\text{m}^3$ , 145 to 181  $\mu\text{g}/\text{m}^3$ , and 23.2 ( $\pm 2.86$ ) to 29 ( $\pm 3.83$ )  $\mu\text{g}/\text{m}^3$ , respectively, as shown in table 2.

**Table 2: Number of observed data, minimum, maximum, and annual mean value of  $\text{PM}_{2.5}$  ( $\mu\text{g}/\text{m}^3$ ) in different air monitoring stations of Medinipur city for the years 2019 and 2020**

Station Name	Year	Min.	Max.	Annual Mean $\pm$ SD
S1	2019	7.5	172	26.98 $\pm$ 5.73
	2020	7.5	172	26.20 $\pm$ 4.04
S2	2019	2.22	180.33	26.93 $\pm$ 2.93
	2020	4.23	173.34	25.90 $\pm$ 2.69
S3	2019	3.34	170.36	25.79 $\pm$ 2.44
	2020	2.80	145	23.20 $\pm$ 2.86
S4	2019	2.56	181	29.00 $\pm$ 3.83
	2020	3.14	167.12	26.63 $\pm$ 2.83

Comparing the mean value of  $\text{PM}_{2.5}$  for each station obtained from PMS3003, the lowest average value of  $\text{PM}_{2.5}$  at the S3 station in 2020 and the highest mean value of  $\text{PM}_{2.5}$  at the S4 station in 2019 were 23.20 ( $\pm 2.86$ )  $\mu\text{g}/\text{m}^3$  and 29 ( $\pm 3.83$ )  $\mu\text{g}/\text{m}^3$ , respectively. Table 3 shows the AQLI results that meet the WHO guidelines for 2019 and 2020, obtained by determining the yearly mean concentration of  $\text{PM}_{2.5}$ . Since the current yearly mean concentration of  $\text{PM}_{2.5}$  in Medinipur city is well below the national standard in India (40  $\mu\text{g}/\text{m}^3$ )<sup>30</sup> for each station; the

average LE loss per person cannot be measured according to the national standard. But according to WHO guidelines (the yearly mean concentration of  $\text{PM}_{2.5}$  is 10  $\mu\text{g}/\text{m}^3$ ,<sup>31</sup>), the yearly mean concentration of  $\text{PM}_{2.5}$  in those years is much higher in Medinipur city.

Based on the ground-based current annual  $\text{PM}_{2.5}$  values of each station, the average LE loss per person at the S1 station was 1.67 years (95% CI: 0.54-2.78 years) and 1.59 years (95% CI:

0.51-2.65 years) in 2019 and 2020, respectively. The same goes for the rest of the stations, where the average LE loss per person was 1.66 years (95% CI: 0.54–2.77 years) and 1.56 years (95% CI: 0.5–2.6 years); 1.55 years (95% CI:

0.5–2.58 years) and 1.3 years (95% CI: 0.4–2.16 years); 1.87 years (95% CI: 0.6–3.11 years) and 1.63 years (95% CI: 0.53–2.72 years) in 2019 and 2020 for S2, S3 and S4 respectively.

**Table 3: Air Quality Life Index: Best Estimate and 95% CI of average life years lost in 2019 and 2020 by fulfilling WHO guidelines at S1 to S4 monitoring station of Medinipur city**

Station name	Year	Cuts average LE/person; if Medinipur city met the WHO guidelines*.	
		Best estimate (years)	95% CI: (0.32-1.64)
S1	2019	1.67	0.54 – 2.78
	2020	1.59	0.51 – 2.65
S2	2019	1.66	0.54 – 2.77
	2020	1.56	0.5 – 2.6
S3	2019	1.55	0.5 – 2.58
	2020	1.3	0.4 – 2.16
S4	2019	1.87	0.6 – 3.11
	2020	1.63	0.53 – 2.72

\*The annual average concentration of PM<sub>2.5</sub> is 10 µg/m<sup>3</sup>

**Discussion**

The results of this study show that the annual standard of PM<sub>2.5</sub> concentration in each monitoring station in Medinipur city in 2019 and 2020 is much higher than the WHO annual standard (10 µg/m<sup>3</sup>) and the U.S. Environmental Protection Agency (EPA) annual standard (12µg/m<sup>3</sup>) announced in 2012 but much lower than the Indian NAAQS annual standard (40µg/m<sup>3</sup>). Since the average human LE loss is largely proportional to the concentration of PM<sub>2.5</sub> levels, a slight change in the value of annual PM<sub>2.5</sub> affects AQLI. In this contextual study, it is not known whether there is any statistically significant difference in the concentration of fine particles (PM<sub>2.5</sub>) obtained from the four monitoring stations in the city of Medinipur as a slight change in the yearly mean concentration of PM2.5 for AQLI measurement. The results of Table 3 show that the AQLI value of each station in 2019 is slightly higher than that in 2020, which indicates that the people of Medinipur city have a higher risk of cardiopulmonary illness and pulmonary cancer associated with PM<sub>2.5</sub> in 2019.

**Conclusion**

From this contextual study, it can be concluded that the annual concentration of PM<sub>2.5</sub> obtained from BreezoMeter and PMS3003 at four selected stations (S1 to S4) in Medinipur city ranged from 26.93 to 29.00 µg/m<sup>3</sup> in 2019 and 23.20 to 26.63 µg/m<sup>3</sup> in 2020. The average LE loss in Medinipur city varied from 1.3 years to 1.87 years per person. However, since the expected LE reduction is directly related to the mortality rate, the AQLI results suggest that the mortality rate in 2019 is higher than in 2020. With every 10 micrograms of long-term PM<sub>2.5</sub> exposure, there is a risk of cardiopulmonary mortality and lung cancer mortality increasing by 6% and 8%, respectively,<sup>10</sup> so it may be said that cardiopulmonary disease and lung cancer are responsible for the average LE loss of Medinipur residents in 2019 and 2020. Authorities at the metropolitan level in Medinipur need to take preventive steps to decrease the destructive effects of particulate matter by reducing the origin of required PM emissions and providing a healthier climate in the future.

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**Conflict of Interest**

The author has no conflict of interest with any monetary, individual, or other relationship with other individuals or organizations that might influence the work.

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