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Air Pollution and Human Health in Kolkata, India: A Case Study

Md. Senaul Haque * and R.B. Singh

Department of Geography, Delhi School of Economics, University of Delhi, Delhi 110007, India; rbsgeo@hotmail.com

* Correspondence: senaulhaque68@gmail.com

Received: 29 June 2017; Accepted: 22 September 2017; Published: 12 October 2017

Abstract: Urban air quality in most megacities has been found to be critical and Kolkata Metropolitan City is no exception to this. An analysis of ambient air quality in Kolkata was done by applying the Exceedance Factor (EF) method, where the presence of listed pollutants' (RPM, SPM, NO_2, and SO_2) annual average concentration are classified into four different categories; namely critical, high, moderate, and low pollution. Out of a total of 17 ambient air quality monitoring stations operating in Kolkata, five fall under the critical category, and the remaining 12 locations fall under the high category of NO_2 concentration, while for RPM, four record critical, and 13 come under the high pollution category. The causes towards the high concentration of pollutants in the form of NO_2 and RPM have been identified in earlier studies as vehicular emission (51.4%), followed by industrial sources (24.5%) and dust particles (21.1%). Later, a health assessment was undertaken with a structured questionnaire at some nearby dispensaries which fall under areas with different ambient air pollution levels. Three dispensaries have been surveyed with 100 participants. It shows that respondents with respiratory diseases (85.1%) have outnumbered waterborne diseases (14.9%) and include acute respiratory infections (ARI) (60%), chronic obstructive pulmonary diseases (COPD) (7.8%), upper track respiratory infection (UTRI) (1.2%), Influenza (12.7%), and acid fast bacillus (AFB) (3.4%). Although the pollution level has been recorded as critical, only 39.3% of the respondents have felt that outdoor (air) pollution has affected their health.

Keywords: air quality; respiratory health; sustainable city; Kolkata; ARI

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1. Introduction

Urban areas, broadly understood as cities and towns, occupy less than 5% of the Earth's land area and are estimated to produce as much as 80% of the CO_2 pollution [1]. The ever-increasing size of the population in urban centers, and associated anthropogenic activities with changing land use patterns, have resulted in changes of cities' local environmental conditions which further aggravate the exiting micro-climate and, thus, create great complexities for the city dwellers [2,3]. These complexities that have emerged have been exhibited in the form of housing and infrastructure shortages, traffic and transportation problems, proliferation of slums and squatter settlements, paucity of water supply, inadequate latrines and drainage facilities, poor sewage and the absence of cleanliness, lack of open spaces, carbon emission, and the accumulation of waste and air pollution [3–8].

Air pollution is a major threat to human health. The United Nations Environment Programme has estimated that, globally, 1.1 billion people breathe in unhealthy air [9]. Epidemiological studies have shown that concentrations of ambient air particles are associated with a wide range of effects on human health, especially on the cardio-respiratory system [10,11]. The World Health Organization (WHO) has estimated that urban air pollution is responsible for approximately 800,000 deaths and 4.6 million people lose their lives every year around the globe [12]. Air pollution is associated with increased risk of acute respiratory infections (ARI), the principal cause of infant and child mortality in developing countries [13].

Changes in the air quality are predicted to be leading to increasing rates of respiratory and allergenic diseases in many regions. Ground-level ozone and particulate matters are of particular concern [14]. Studies demonstrate that the presence of ultrafine particles due to automobile traffic and exposure to it in the urban atmosphere can have negative health implications which can further be taken as the basis for epidemiologic study [15]. Gurjar et al. have pointed out that urban air pollution poses a significant threat to human health in both developed and developing parts of the world [16]. Epidemiological studies have shown that air pollution in developing countries annually accounts for tens of thousands of excess deaths and billions of dollars in medical costs and lost productivity [17]. Brashier et al., has hypothesised that non-communicable respiratory morbidities such as asthma and chronic obstructive pulmonary diseases (COPD) are rapidly rising and can emerge as leading causes of mortality worldwide [18]. It is also being predicted that the four leading causes of death in the world in 2030 will be ischaemic heart disease, cerebrovascular disease (stroke), COPD, and lower respiratory infections (mainly pneumonia) [19].

Epidemiological research on air pollution over the past 20 years has demonstrated cardio-respiratory health effects ranging from minor respiratory symptoms to increased hospital admission and mortality [20]. Amongst the air pollutants, nitrogen dioxide (NO_2) is highly reactive and has been responsible for bronchitis and pneumonia, and also increasing susceptibility to respiratory infections. A review of epidemiological studies suggests that children exposed to NO_2 are at increased risk of respiratory illness [21]. NO_2 has also been associated with daily mortality in children less than five years old [22]. Chronic bronchitis and individuals with emphysema (respiratory disorder) or other chronic respiratory diseases may also be sensitive to NO_2 exposure [23]. Smith demonstrates that around 40–60% of ARI are due to environmental causes [24]. There is growing evidence that the poor are affected relatively more by ambient air pollution due to greater exposure, weaker biological defence mechanisms against air pollution, inadequate nutrition, and limited access to medical care [25–27].

Looking at the growing urban spaces associated with increasing number of city inhabitants, demand for higher consumption and the plan to build 100 new smart cities in India; it is needed to take initiative with a vision and commitment to the *Sustainable Cities and Human Settlements* goal (SHS) with targets that cover urban planning, resilience preparedness, urban sustainability, health and wellbeing, and the integration of housing, transportation, and open spaces [28–30]. Future development of low-carbon cities based on alternative non-polluting energy resources should be a priority concern [31]. With this little background, the subject matter of the current paper has been framed under three broader headings; namely, status of the urban environment in terms of air quality, health outcomes of air pollution, and addressing some suitable measures with a view to mitigate the menace of air pollution to pave the way for bringing sustainable urban development to Kolkata.

2. Study Area

The study has been conducted in Kolkata, the capital city of West Bengal state in India (Figure 1). According to the Census of India (2011), Kolkata had 4.5 million population, with the urban agglomeration, which comprises the city and its suburbs, home to approximately 14.1 million people, which makes it the third most densely populated metropolitan area in the country [32]. The first count is for Kolkata City (4.5 million), which is under the Kolkata Municipal Corporation (KMC), while the second count (14.1 million) is for the Kolkata Metropolitan Authority (KMA), which comprises the city (KMC) and its suburbs. The city of Kolkata has been dubbed as one of the most unplanned and polluted cities in the world [33]. A study in comparison of air quality data among four metropolitan areas in India indicates a higher pollution level in Kolkata in comparison to Mumbai and Chennai, and is close to Delhi [34]. It has also been termed as the dusty city [2]. Air pollution in Kolkata becomes acute during winter, when pollution ranges higher than at other times [35]. On the other hand, the worst-polluted traffic intersections double the city's average pollutants during busy hours [36].

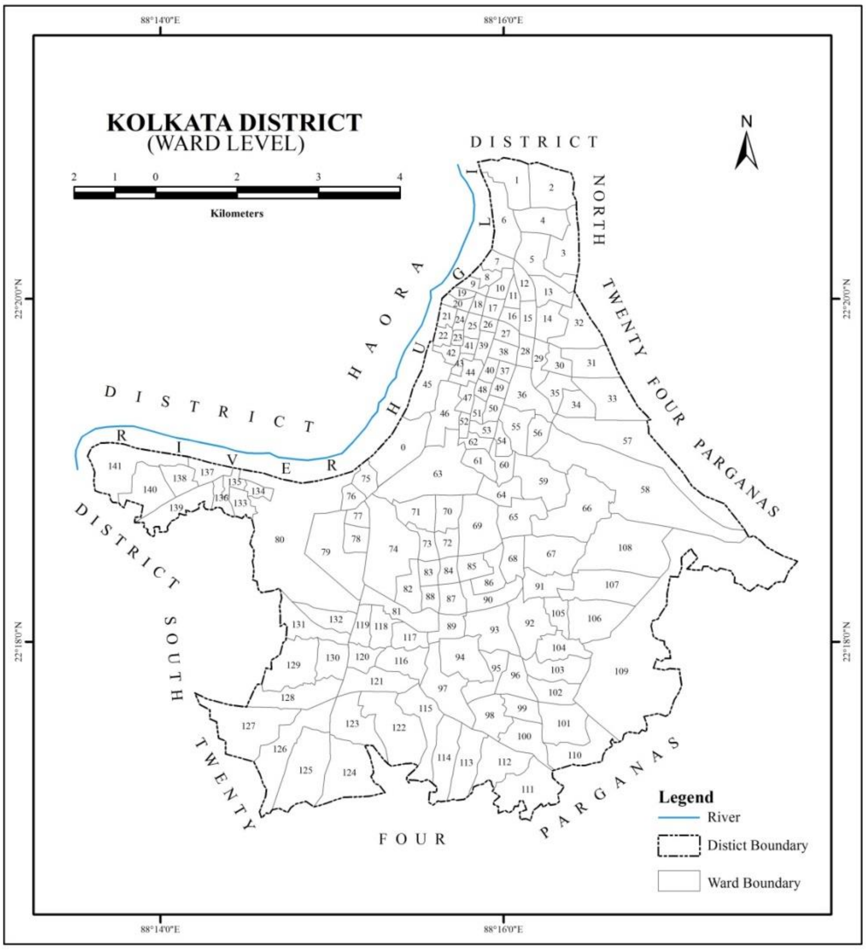

Figure 1. Location of the study area.

A joint study by Chittaranjan National Cancer Institute (CNCI), West Bengal Department of Environment and the Central Pollution Control Board (CPCB) has found that around 70% of people in the city of Kolkata suffer from respiratory disorders caused by air pollution [37]. In 1995, an estimated 10,647 premature deaths were attributed to air pollution in Kolkata [38,39]. Studies have demonstrated that children inhaling polluted air in Kolkata suffer from adverse lung reactions and genetic abnormalities in exposed lung tissues [40]. Approximately 47% of Kolkata's population suffers from lower respiratory tract symptoms with the lungs of city residents being approximately seven times more burdened compared to their rural counterparts due to air pollution [39,41,42]. Other air pollution-related health problems, including haematological abnormalities, impaired liver function, genetic changes, and neurobehavioral problems, are found to be more prevalent amongst those categories of workers exposed to high levels of vehicular emission. They include roadside hawkers, traffic policemen, and taxi and auto drivers [37].

2.1. Sources of Air Pollution in Kolkata

Several factors cause air pollution in Kolkata and among them the main factor is transportation [43,44], where the abundance of poorly-maintained vehicles, use of petrol fuel, and poor controlling are making transportation the major air polluting sector [45,46]. Additionally, there are three thermal power plants operating in and around Kolkata, and some small-scale industries which also affects the air quality [47]. An analysis of different sources of air pollution in Kolkata has revealed that motor vehicles are the leading contributor to air pollution (51.4%) which is followed by industry (24.5%) and dust particles (21.1%), respectively (Table 1) [48].

Table 1. Sources of air pollution emissions in Kolkata.

Source Types	Emissions (Tonnes/Year)			Totals	% RPM	% NOx	% SO_2	% Total
	RPM	NOx	SO_2					
Motor Vehicles	16,115	95,452	0	**111,567**	7.4	44.0	0	**51.4**
Industry	6571	34,208	12,378	**53,157**	3.0	15.8	5.7	**24.5**
Road Dust	45,881	0	0	**45,881**	21.1	0	0	**21.1**
Area Sources	6573	0	0	**6573**	3.0	0	0	**3.0**
Grand Totals	**75,140**	**129,660**	**12,378**	**217,178**	**34.5**	**59.8**	**5.7**	**100.0**

Source: Compiled by Researcher from WBPCB, 2005.

The vehicular pollution in Kolkata is attributed to a large number of automobiles plying daily over only 6% available road space, causing congestion which reduces the average vehicular speed and also results in heavy vehicular emission [49]. The number of vehicles has a growth of about 2.00 times, numbering to 1.20 million in 2011 from 0.73 million in 1996 [50]. The vehicular population in Kolkata has increased at an annual growth rate of 4%. Private cars have increased from 0.26 million in 2000 to 0.65 million in 2011, which indicates a 2.5 times increase [51]. The heavy concentration of private motor vehicles has been one of the key reasons for congestion, increased travel times, pollution, and accidents. In terms of available surface road length, Kolkata has the least coverage, with about 1416 km, whereas the vehicular density is one of the highest, nearing 823/km [52].

3. Database and Methodology

3.1. Monitoring Stations and Criteria Pollutants

The ambient air quality monitoring network involves measurement of a number of air pollutants at different strategic locations in the country. The task of any monitoring network thus involves the selection of pollutants, the selection of locations, frequency, duration of sampling, sampling techniques, infrastructural facilities, manpower, operation, and maintenance [53]. The Central Pollution Control Board (CPCB), back in 1984, initiated National Ambient Air Quality Monitoring (NAAQM) at the national level to regularly monitor ambient air quality of selected major urban cities and industrial towns of the country. This was later renamed as the National Air Monitoring Programme (NAMP). In West Bengal, the regular ambient air quality monitoring under NAMP was started at Kolkata, Howrah while Haldia and Durgapur were subsequently added to the network. The West Bengal Pollution Control Board (WBPCB), under the guidance of NAMP, regularly monitors ambient air quality of major urban towns and industrial areas of the state. During the year 2010–2011, the board monitored air quality in the district of Kolkata at 17 stations (Figure 2) [54]. The monitoring of pollutants in these stations was carried out for 24 h (four-hourly sampling for gaseous pollutants and eight-hourly sampling for particulate matter) with a frequency of twice a week to have 104 observations in a year [53]. The sampling for 24 h for a day had been collected in three shifts and from there the average was calculated to obtain representative values for the entire day. Since the target sampling of 24 h in a day could not be fulfilled at all locations due to power failures etc., the values monitored for 16 h and more are considered as representative values for assessing the ambient air quality for a day. The target frequency of monitoring twice a week, 104 days in a year could not be met in some of the locations; in such cases 40 or more days of monitoring in a year was considered adequate for the purpose of data analysis [53]. The two days of monitoring in a week has not been assigned to any two specific days; rather, it could be of any two days in a week. Air quality data used in this study were monitored during April 2010–March 2011 for four criteria pollutants, namely, suspended particulate matter (SPM), respirable particulate matter (RPM), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2). The measurement of SO_2 and NO_2 was conducted by applying the wet chemical method while a high volume sampler was used for particulate matter measurement (SPM an RPM). Counting the "two days" for the dataset ranging from April 2010–March 2011, it totalled 104 days of monitoring where, in the year 2010 (April to December), it was 78 days, and for 2011 (January to

March), it was 26 days. The National Ambient Air Quality Standard (NAAQS), as prescribed by the Government of India has discontinued the monitoring of suspended particulate matter (SPM) effective from January 2011 [54].

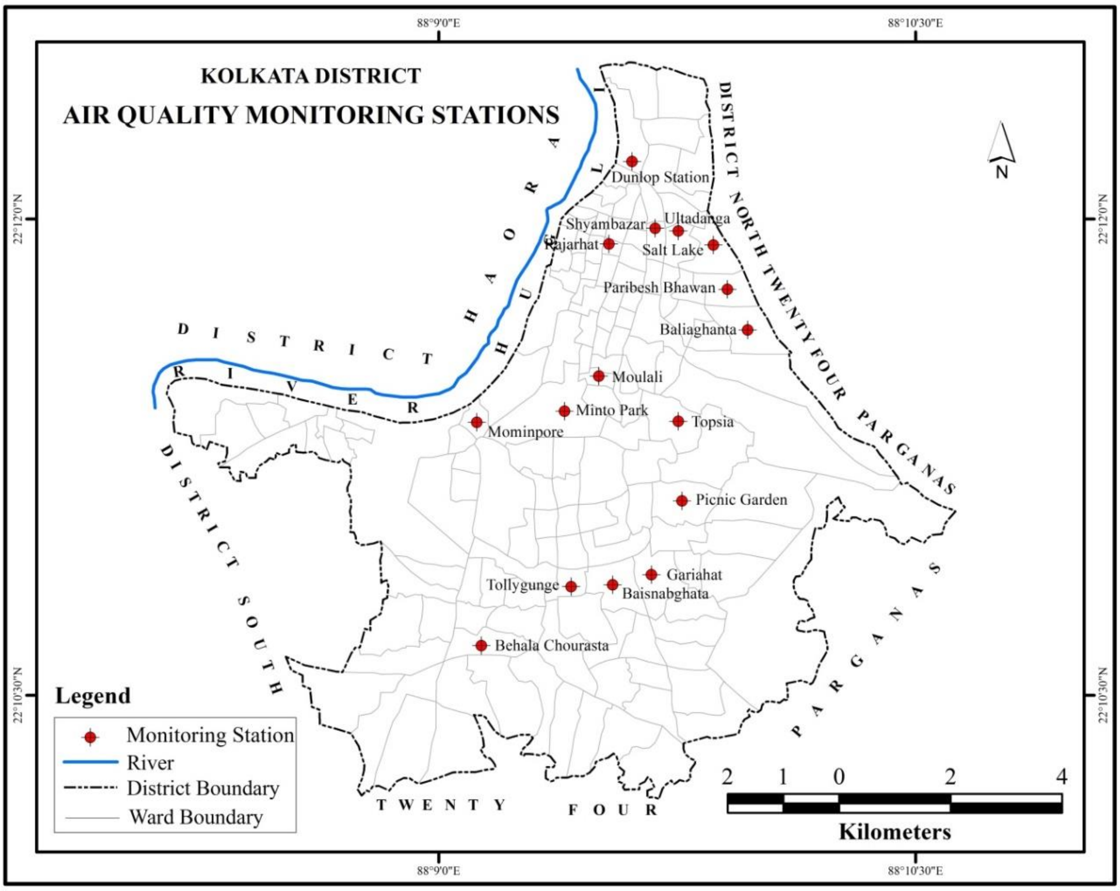

Figure 2. Air quality monitoring stations in Kolkata.

3.2. Air Quality Assessment

Data for the assessment of ambient air quality in Kolkata has been obtained from the West Bengal Pollution Control Board (WBPCB), the Central Pollution Control Board (CPCB), and the Centre for Science and Environment (CSE). The assessment of the monthly average concentration of ambient air pollution in Kolkata has been conducted with the recorded data (from Annual Report WBPCB, 2010–2011) against all 17 monitoring stations for each month and comparing the average value with the given NAAQS. The assessment of air pollution level has been conducted by applying the Exceedence Factor (EF) method introduced by CPCB, which is broadly understood as "the ratio of annual mean concentration of a pollutant with that of a respective standard". The air quality has been classified into four broader categories by applying the EF equation; namely, low, moderate, high, and critical. The trend analysis of air quality (from 2003 to 2011) has been conducted by comparing the recorded data which has been obtained from WBPCB with the NAAQS and the representation has been conducted through depicting the data by drawing line graphs. The dataset for trend analysis has been arranged as 2003–2004 and 2004–2005 until 2011, which may seem overlapping with one year to another. However, the rationale is that the data collected for the year 2010–2011 is done in between April 2010 to March 2011, which is mentioned in WBPCB Annual Report 2010–2011, and the arrangement thus follows the given pattern as shown in Section 4.1. Therefore, the readers can read the data following the year as it is counted from the month of April and ended with March, thus following one complete year.

The Exceedence Factor (EF) is calculated as follows:

$$\text{Exceedence Factor} = \frac{\text{Observed annual mean concentration of criteria pollutant}}{\text{Annual standard for the respective polluant and area class}}$$

The four air quality categories are:

- Critical pollution (C): when EF is more than 1.5;
- High pollution (H): when the EF is between 1.0–1.5;
- Moderate pollution (M): when the EF between 0.5–1.0; and
- Low pollution (L): when the EF is less than 0.5.

3.3. Health Assessment

A study (health survey) has been conducted at dispensaries (a health unit) run by the Kolkata Municipal Corporation (KMC) in Kolkata. The rationale behind the selection of dispensaries for conducting the survey was the easy accessibility and availability of target cases. The main purpose of this health survey was to investigate whether air pollution conceived by the target respondents is a major challenge for healthy living and not to be misinterpreted as a correlation between air pollution and health. There are more than 25 major dispensaries, and many more minor dispensaries, operating throughout Kolkata. Two dispensaries have been identified for the primary survey based on pollution level data, i.e., Behala Dispensary, where air pollution has been recorded as critical, and Ultadanga Dispensary, where it is higher as per RPM concentration. As the concentration of SO_2 remained low across the monitoring stations and no single station was under moderate and low pollution categories in terms of RPM and NO_2 concentration, the identification of dispensaries under the low pollution category remained unexplored. Although the study design is aimed to cover three dispensaries from varied pollution levels, the selection remains restricted to critical and high pollution categories only. One more dispensary was chosen for the health survey, i.e., Tangra Dispensary, which was not assigned to any monitoring station (Figure 3). The selection of Tangra Dispensary must not be misunderstood as being from the low pollution category; rather, it is based on easy accessibility and availability of target cases the study is looking for. A total of 100 respondents were interviewed from Ultadanga Dispensary (28 respondents), Tangra Dispensary (43 respondents), and Behala Dispensary (29 respondents), respectively. Only those patients were interviewed who were suffering either respiratory or waterborne diseases. Here, the patients with respiratory diseases has outnumbered waterborne diseases and constitutes more than 85% of the total respondents.

The identifications of respondents (patients with respiratory diseases and waterborne diseases) were done with the help of medical officers and health practitioners from each of the three surveyed dispensaries. The survey was conducted in July and August 2014 with a structured questionnaire comprising questions on people's reactions to ambient air pollution, major symptoms involving the patients (respondents) with respiratory diseases, and outdoor pollution-averting activities practiced by the respondents in their day to day life. The survey technique was purposive where the priority was given to those dispensaries which fall under varied pollution categories with their easy accessibility and availability of target cases, and only those patients were interviewed who were had the diseases under study.

3.4. Data Analysis

The primary data obtained through questionnaire survey was entered into SPSS software and the analysis was carried out by calculating the simple percentage, tabulation, cross-tabulation, and average mean. The graphical representations of primary data, as well as secondary data, were done by drawing bar graphs and pie diagrams using MS Excel. Furthermore, a considerable change might have taken place in terms of air pollution data, but as the study was completed in 2014–2015 (primary survey), and by that time the latest available data on air quality was from 2010–2011 (Annual Report, WBPCB), the study bears some implication.

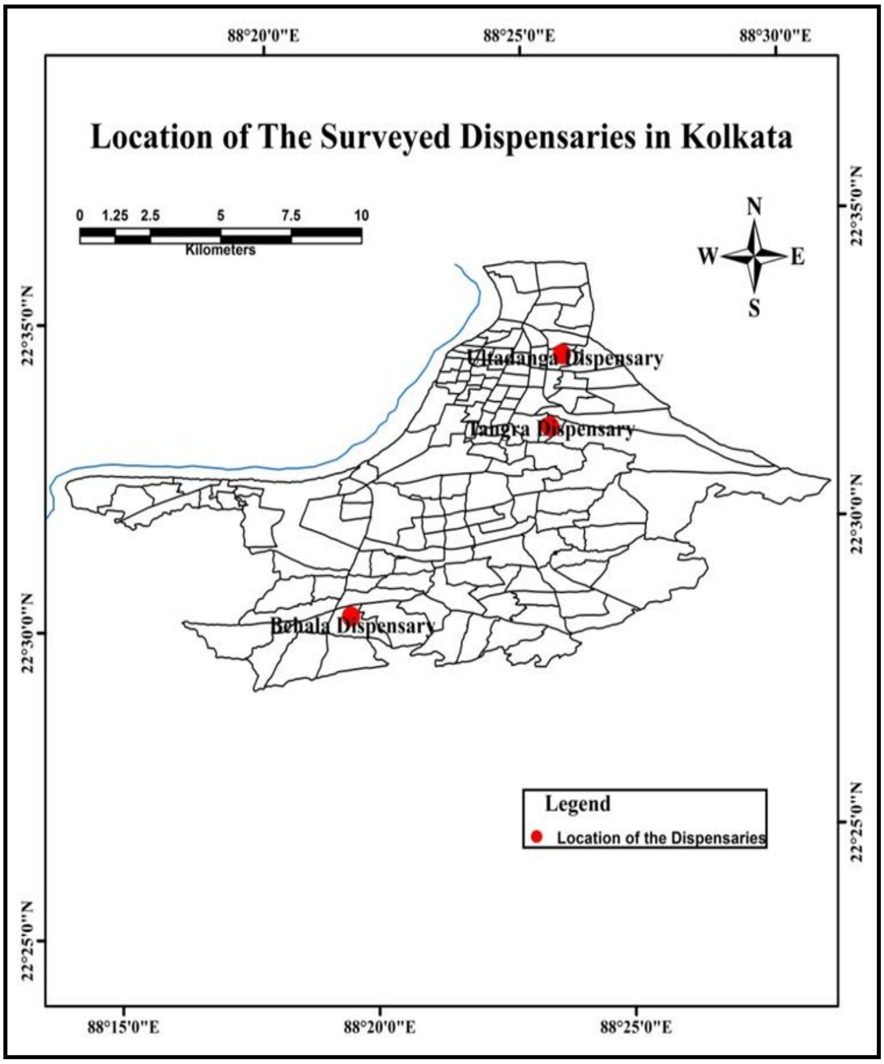

Figure 3. Locations of the surveyed dispensaries.

4. Results and Discussion

4.1. Concentration and Trends of Ambient Air Quality

The monthly average concentration of pollutants represents the pollution variation for the entire year that the city may have in terms of the pollutants presence for different months in the ambient air. The concentration of pollutants recorded through the monitoring stations (17 monitoring stations for Kolkata City) gives the representative figure of the city as a whole. The analysis has revealed that the monthly average concentrations of pollutants in terms of NO_2 and RPM were recorded higher during the months of November and December in 2010 and January and February in 2011 with values 65.8 $\mu g/m^3$, 78.9 $\mu g/m^3$ and 94 $\mu g/m^3$, 79.7 $\mu g/m^3$ for NO_2 and 127 $\mu g/m^3$, 129 $\mu g/m^3$ and 211 $\mu g/m^3$, 172 $\mu g/m^3$ for RPM, respectively (Table 2). The value in the month of January was recorded to be the highest and found to be more than two times the national average as in the case of RPM concentration. The reason behind the high concentration of pollution during these months may be due to seasonal effects. The months from November to February are the winter season in Northern India. During winter the vertical movement of winds get stopped due to the pressure variation (most probably high pressure on the ground) and the pollutants remain concentrated at ground level for a longer period, thus, recording the high concentration. The lowest values were recorded in the months of August and September in 2010 with values of 38.3 μg/m^3 and 37.1 μg/m^3 for NO_2, and for RPM in the months of July and August with values of 28 μg/m^3, respectively. The lowest values in these months may be the outcome of monsoonal effects (the months comprising June to September are the monsoon season in Northern India). The SO_2 level remained within the national standards for the entire monitoring year. Furthermore, to clarify, the monthly average concentration as discussed here in this analysis has not been included for neither identification of dispensaries nor the months to conduct the health survey. Rather it gives an overall picture in terms of air quality for the city with monthly variation of different pollutant concentrations.

Table 2. Monthly average concentrations of ambient air quality in Kolkata (2010–2011).

Sl. No.	Months	Monthly Average Concentration (μg/m^3)			
		SO_2	NO_2	RPM	SPM
1	10 April	7.6	50.2	45	117
2	10 May	5.4	42.3	35	96
3	10 June	5.0	43.8	34	90
4	10 July	4.4	39	28	77
5	10 August	4.2	38.3	28	75
6	10 September	4.4	37.1	34	88
7	10 October	6.1	49.3	63	155
8	10 November	7.9	65.8	127	265
9	10 December	9.9	78.9	179	342
10	11 January	9.2	94	211	-
11	11 February	8.2	79.7	172	-
12	11 March	5.5	59.7	96	-

Note: (NAAQS: SO_2–80 μg/m^3; NO_2–80 μg/m^3; RPM–100 μg/m^3; SPM–No Standard). Source: WBPCB, Annual Report 2010–2011.

The analysis of the criteria pollutants by applying the Exceedence Factor (EF) equation has revealed that out of a total of 17 monitoring stations, SO_2 shows low levels in all the locations. Twelve locations came under the high category and the rest of the five locations were in the critical category of pollution level in terms of NO_2 concentration. Similarly for RPM (PM_{10}), 10 locations came under the high category and the remaining seven locations came under the critical level of air pollution (Table 3). It may be inferred that the concentration of RPM and NO_2, as assessed in this study, are found to be restricted under critical and high pollution categories across the 17 monitoring stations. This may also have a connotation that ambient air pollution in Kolkata has fallen under a precarious stage which must not be treated safe for healthy city living. The identification of varied sources responsible for making the city air unsafe for breathing is of utmost importance. In this study, an attempt has been made to assess a report on source apportionment of air pollution in Kolkata by varied sectors with their percentage share and has been discussed in Section 2.1.

Table 3. Urban ambient air quality in Kolkata during 2010–2011.

Sl. No.	Monitoring Stations	Air Pollutants, Annual Concentration and Pollution Level								
		SO_2			NO_2			RPM		
		Annual Average (μg/m^3)	Value of E.F *	Air Quality **	Annual Average (μg/m^3)	Value of E.F *	Air Quality **	Annual Average (μg/m^3)	Value of E.F *	Air Quality **
1	Dunlop Station	7.9	0.1	L	67.2	1.6	C	108	1.8	C
2	Picnic Garden	5.6	0.1	L	48.9	1.2	H	73	1.2	H
3	Tollygunge	6.7	0.1	L	57.2	1.4	H	81	1.3	H
4	Hyde Road	6.5	0.1	L	58.1	1.4	H	92	1.5	H
5	Behala Chowrasta	7.8	0.1	L	68.0	1.7	C	97	1.6	C
6	Beliaghata	5.8	0.1	L	54.0	1.3	H	80	1.3	H
7	Salt Lake	6.5	0.1	L	57.8	1.4	H	87	1.4	H
8	Topsia	5.6	0.1	L	51.4	1.2	H	74	1.2	H
9	Baishanabghata	5.6	0.1	L	51.0	1.2	H	86	1.4	H
10	Ultadanga	7.1	0.1	L	62.1	1.6	C	92	1.5	H
11	Mominpore	6.0	0.1	L	53.8	1.3	H	85	1.4	H
12	Moulali	8.2	0.1	L	70.7	1.7	C	107	1.7	C
13	Shyambazar	7.4	0.1	L	60.8	1.5	C	90	1.5	H
14	Gariahat	5.9	0.1	L	51.0	1.2	H	78	1.3	H
15	Minto Park	6.8	0.1	L	58.0	1.4	H	70	1.2	H
16	Rajarhat	5.5	0.1	L	47.5	1.1	H	79	1.3	H
17	Paribesh Bhawan	5.4	0.1	L	43.1	1.0	H	113	1.9	C

Note: (NAAQS: SO_2–50 μg/m^3; NO_2–40 μg/m^3; RPM–60 μg/m^3; SPM–no Standard.). * Value of Exceedence Factor. ** L = low, M = moderate, H = high, C = critical. Source: Calculated by Researcher from WBPCB, Annual Report 2010–2011.

To know the concentration of pollutants in the ambient air and its varying nature, a trend analysis has been conducted for the years ranging from 2003 to 2011 with the criteria pollutants; namely, SO_2, NO_2, RPM, and SPM, in Kolkata. The trends in annual average concentration of SO_2 have been found lower than the NAAQS during all the monitoring years. For the year 2010–2011, the recorded value of SO_2 was 6.5 μg/m^3, which was much below the NAAQS, and even lower than the previous two years. This indicated that a decreasing trend was prevailing in Kolkata for SO_2 concentration in the ambient air. The annual average concentration of NO_2 for all the monitoring years has been recorded to be higher than the NAAQS. For the year 2010–2011, it was recorded at 56.5 μg/m^3, which was above the NAAQS and much more than the previous year, which was 45 μg/m^3 in 2009–2010. This means that there was an increasing trend prevailing in the region. The concentration of RPM has also been showing an increasing trend, as it was 88 μg/m^3 for the year 2010–2011, which was higher than the previous three years, with concentrations of 60 μg/m^3 in 2009–2010, 67 μg/m^3 in 2008–2009, and 84 in 2007–2008 respectively. The SPM is also showing an increasing trend, but NAAQS has discontinued recording the value from January 2011 onwards (Figure 4).

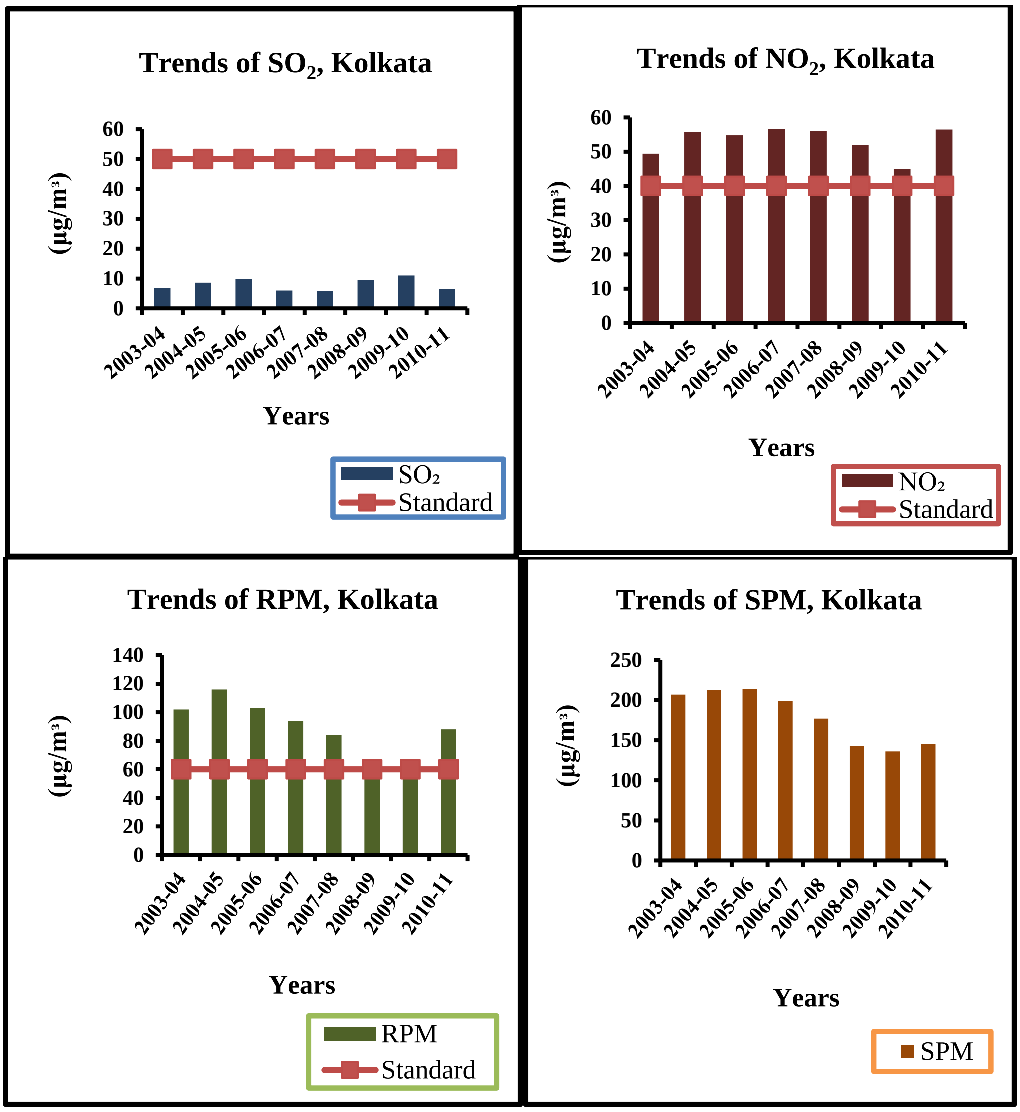

Figure 4. Air quality trends in Kolkata (2003–2011).

4.2. Interpreting Health Outcomes of Surveyed Dispensaries in Kolkata

The health survey that has been conducted at dispensaries was framed to gather information on people's reactions to air pollution and the associated health issues. Nowhere does the interpretation represent a correlational analysis, e.g., high levels of air pollution being synonymous with a high number of cases with pollution-induced diseases. Rather, it is the people's understanding of air pollution around them while living in a megacity and their practices, if any, towards avoiding being exposed to the polluted environment. The information thus gathered has revealed that more than 80% of the respondents were from slums (Table 4). Cooking inside the living room has been found to be very obvious and, when asked, a majority of them (71%) replied that their living room doubles as a kitchen room (Table 5). Those who cooked inside their living room have been found to use kerosene as the major source of fuel (37.3%), followed by LPG (30.3%). This can now be interpreted that susceptibility to indoor air pollution of those of the slum-dwellers has been noticed in this study, but as it has not checked the level of indoor pollution the establishment of any fact would not be possible here. People who reside in slums in megacities are thought to be devoid of the basic amenities for their day to day life and it is no exception in this case study. Here, it has been found that the majority of the respondents use their living room for cooking purposes. The issue thus emerged must be placed under grave concern from the healthy city living point of view. For this, improvement to the living conditions by providing affordable housing could be an alternative in bringing the slum-dwellers up to the level of mainstream city habitants.

Table 4. Total number of respondents and their slum and non-slum status.

Name of the Dispensaries	Ward Number	Respondents	% Slum and Non-Slum	
			Slum	Non-Slum
Ultadanga Dispensary	14	28	82.1	17.9
Tangra Dispensary	57	43	86.2	13.8
Behala Dispensary	121	29	79.1	20.9
Average			82.5	17.5
Total		100	100	

Source: Primary Survey, 2014.

Table 5. Fuels used for cooking by the respondents.

Name of the Dispensary	% Cooking Inside the Living Room				% Cooking Outside the Living Room				Total
	Firewood	Coal	Kerosene	LPG	Firewood	Coal	Kerosene	LPG	
Ultadanga Dispensary	-	-	28.0	40.0	15.7	3.1	6.3	6.3	100
Behala Dispensary	-	2.6	46.1	20.5	25.6	-	-	5.1	100
Tangra Dispensary	2.0	4.1	38.8	30.6	14.3	-	4.1	6.1	100
Average	0.6	2.2	37.6	30.3	18.5	1	3.5	5.8	100
Total	71				29				100

Source: Primary Survey, 2014.

4.3. Outdoor Pollution-Averting Activities

In a comparative risk assessment of global health risk, the WHO ranked urban outdoor air pollution as the tenth leading cause of premature death, and indoor air pollution as the fourth leading cause [12]. The WHO has estimated that 75% of the world statistics in death and lost life are due to urban outdoor air pollution occurring in Asia [12]. To live a healthy life and have better well-being, practicing pollution-averting activities in one's day to day activities is needed. The outdoor pollution-averting activities, as asked to the respondents at Ultadanga Dipensary, revealed that 96.4% of them do not prefer to remain inside to avoid the outdoor pollution, 75% do not prefer to avoid busy roads and busy times for local travelling, 89.3% do not prefer to use a mask while traveling on the road, and 71.4% do not avoid garbage and landfill disposal sites. Although the level of pollution has been found to be very high to critical in Kolkata, only 39.3% of the respondents have felt that the outdoor pollution has affected their health. In Tangra Dispensary and Behala Dispensary the same responses were also found from the respondents (Table 6). Negligence towards the pollution-averting practices can further be interpreted as negligence with respect to the air pollution. These pollution-averting practices can only be possible when awareness among the masses is generated that the air they breathe outdoors is not found to be safe and can be fatal if precautionary measures are not adopted in time. Awareness campaigns involving college students and NGOs, pictorial exhibitions of health impacts of air pollution on human beings in public places, mandatory course curriculum on the environment and health at nursery, primary, as well as secondary levels, and putting forward the idea of summer school to be organised in slums involving local people with its focus on environmental education could be some of the possibilities in making people aware of air pollution and the associated health outcomes.

Table 6. Responses on outdoor pollution averting activities.

Outdoor Pollution Averting Activities	**% Share of the Respondents at Dispensaries**					
	Ultadanga Dispensary		**Tangra Dispensary**		**Behala Dispensary**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Prefer to Stay Indoor	3.60	96.4	2.00	98.0	00.0	100
Using Mask While Walking on the Road	10.7	89.3	28.0	72.0	28.0	72.0
Avoiding Busy Road and Busy Timing	25.0	75.0	28.0	72.0	48.0	52.0
Avoiding Landfill/Garbage Disposal Site	71.4	28.6	67.0	33.0	90.0	10.0
Outdoor Pollution has Affected Health	39.3	60.7	44.0	56.0	38.0	62.0

Source: Primary Survey, 2014.

4.4. Diseases Analysis

Out of the three surveyed dispensaries, Behala and Tangra Dispensaries have recorded more than 90% of the respondents under respiratory diseases, while Ultadanga Dispensary has recorded 71.4%. In Ultadanga Dispensary, among the respiratory diseases, the patients with (ARI) constitute 21.4%, COPD constitute 10.7%, influenza constitute 35.7%, and UTRI constitute 3.6%, respectively. In Behala Dispensary respondents with ARI comprise 72.4%, COPD comprise 10.3%, and acid fast bacillus (AFB) comprise 10.3%. The AFB patients are those who have symptoms that suggest pulmonary TB or other mycobacterial lung infection, such as chronic cough, whereas the disease frequencies in Tangra Dispensary havebeen found concentrated very much to ARI, with an 86.1% share of the total respiratory patients (90.9%) (Table 7). The interpretation may be carried out that the disease categories covered in this study are more or less similar across the surveyed dispensaries. No established pattern has emerged that can assert that a greater concetration of pollution will represent a greater number of disesaes of respiratory origin. It could be quite difficult to link the pollution level to a particular kind of disease. Disesaes are the outcome of a number of factors and one of the major factors could be of long-term exposure to the airborne pollutants. In this study it could be an incorrect interpretation if established that due to air pollution only, the respondents with respiratory diseases are found to be greater in number. For such inferences to be drawn, there is a need to have an exposure assessment by bringing the occupational pattern of respondents under study. However, the paper is not extended to that kind of interpretation. Here, the percentage share of respiratory diseases may be of concern for such further studies with a defined approach towards establishing a relation between exposure to pollutants and diseases outcome.

Table 7. Disease pattern at dispensaries (Kolkata).

Name of the Dispensary	% Respiratory Diseases					Total	% Waterborne Diseases		Total
	ARI [1]	COPD [2]	Influenza	UTRI [3]	AFB [4]		Diarrhoea	Ringworm	
Ultadanga Dispensary	21.4	10.7	35.7	3.6	-	71.4	25.0	3.6	28.6
Behala Dispensary	72.4	10.3	-	-	10.3	93.1	6.9	-	6.9
Tangra Dispensary	86.1	2.3	2.3	-	-	90.9	9.3	-	9.1
Average	60.0	7.8	12.7	1.2	3.4	85.1	13.7	1.2	14.9
			85.1					14.9	
Total					100				

Note: [1] Acute respiratory infection; [2] Chronic obstructive pulmonary diseases; [3] Upper tract respiratory infection; [4] Acid fast bacilli. Source: Primary Survey, 2014.

5. Conclusions

The concentration of RPM and NO_2 in the ambient air has been found to have violated the national standards and exceeded the NAAQS. While interpreting the pollution concentration, most of the monitoring stations have been found to fall under the critical and high pollution categories. The pollution categories, thus, emerged have been used for the selection of dispensaries to conduct the health survey. While evaluating the responses (mainly patients with respiratory diseases which share 85%) from the three surveyed dispensaries, it emerges that people who reside in slums are found to be have a significant share among the total participants. It may not be a sound interpretation to say that those who are residing in slums are exposed more to the pollution, which is why they experience a greater number of diseases of respiratory origin. There may be some other causes towards their susceptibility to the kind of diseases the study is evaluating, and for that further exploration could be required. Along with exposure; poor living conditions, less awareness towards avoiding pollution sources, lack of knowledge about pollution, indoor cooking, and poor resistance to air pollution could be some of the reasons that make slum-dwellers susceptible to the pollution-induced diseases. Cooking inside the living room has emerged as the major issue practiced by those living in the slums of Kolkata as expressed in this study. Although the study has not been framed to assess the susceptibility of people to the indoor pollution, it could infer the level of vulnerability the slum-dwellers are having while being exposed to the indoor gases released due to domestic fuel exhaust. As the study was made to assess the disease frequencies of respiratory origin at dispensaries, it resulted in the following disease types, i.e., ARI, COPD, Influenza, UTRI, bronchitis, asthma, AFB, etc. The cases with ARI infection have emerged as the leading disease type. The study thus carried out has talked about the cases and not included the control group, which may be taken as a drawback. In the end, it would be worthwhile to suggest introducing a comprehensive framework for slum development with focusses on their health and habitation so that they could be brought under mainstream city living, which may further help in bringing sustainable urban development in Kolkata.

Acknowledgments: The authors are highly thankful to the Chief Medical Health Officer (CMHO) of Kolkata Municipal Corporation (KMC), and to medical officers (MDs) of all the surveyed dispensaries for issuing permission to conduct the survey at dispensaries. Heartfelt thanks goes to the respondents who shared their experiences at the time of survey. Special thanks goes to Saddam Sheikh for his contribution with the English editing.

Author Contributions: Md Senaul Haque collected the data, performed the analysis and drafted the manuscript; Professor R.B. Singh provided supervision of all stages and commented on the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

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