TEST Engineering & Management

January - February 2020
ISSN: 0193-4120 Page No. 16448 - 16454

Relationship between Location-Wise Air Quality and Public Perceptions in Dhaka City

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Article Info
Volume 82
Page Number: 16448 - 16454
Publication Issue:
January-February 2020

Article History
Article Received*: 18 May 2019*
Revised*: 14 July 2019*
Accepted*: 22 December 2019*
Publication*: 28 February 2020*

Abstract

Air pollution due to particulate matter (PM) is perhaps the most significant environmental risk factor for human health. It is inevitable to incorporate public opinion in setting up air quality standards and policy formulations. There had been very few instances where public opinion is taken into considerations, especially in the least developed and developing countries to estimate the level of exposure. The present paper introduces an approach to determine the health impact of air pollution, assessing the relationship between the variation of location, exposure duration, and public opinion. A cross-sectional study following the psychometric paradigm method by a convenient sampling technique was carried out at four sites of Dhaka city in Bangladesh. A total of 200 people (50 people from each location) of different age groups and gender were interviewed in the survey. Air quality data was obtained from fixed-site monitoring stations and low-cost air quality monitoring sensors after necessary validation with equivalent standard equipment. An extensive statistical analysis was carried out using MS Excel and IBM SPSS software. In the end, A chi-square test was performed to check the relationship between location-wise air quality and seven probable health risks related to PM concentration. Results show that 80.5 percent of the respondents opined that they are very much affected by air pollution. It is found that 94.5 percent of the total respondents considered emissions from motor vehicles as the most common cause of pollution. A strong association was found between skin disease and location-wise level of exposure (Cramer's V=.43). However, four risks were moderately dependant, and two were weakly dependant on location. Cross-examining the air quality data and public perception, it was evident that health risk is highest at the location of maximum pollution. This paper highlights only seven indicators of health risks. A further epidemiological and clinical study is needed to conform to the results of this study.

Keywords:*air quality, field survey, health risk, particulate matter (PM), public perception*

I. INTRODUCTION

Air pollution is viewed as one of the major global problems and environmental concerns in the modern world. Growth in population, rapid expansion in industries, unrestrained urban development, and excessive vehicular emissions has represented air pollution as a social and environmental problem [1]. World Health Organization (WHO) has declared it as one of the significant root causes of cancer [2]. Dhaka city is facing similar difficulties because of its rapid growth in urbanization, industries, and public transport. Association between short-term exposure to PM2.5, PM10, and increased death rate, increased numbers of hospital admissions, and increased risks of cardiovascular diseases (CVD) have already been proved [3].

Exposure to polluted air can result in intranational wellbeing loss by increasing the lethality of CVD and respiratory problems, affecting cognitive impairment as well as psychological health [4]. This circumstance has forced WHO to include air pollution and its health effects on its agenda [5]. The

Published by: The Mattingley Publishing Co., Inc.

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absence of air quality data is perhaps the significant challenge for encounter PM associated air pollution for the developing and low-income countries [6], and Bangladesh faces the same impediments.

As per the European Environment Agency (EEA), an eight-stage methodology is developed to assess health impact due to air pollution. The third stage of this method is to determine the population's exposure to air Pollution [7]. In its general principle of air pollution health risk assessment (AP-HRA), WHO includes air quality data as an input tool to determine the adverse health effect of air pollution [8]. In both cases, air quality data and exposure levels are considered as essential tools to decide on important health risk factors and policy formulation. In developing countries like Bangladesh, the absence of air quality data makes the HRA very troublesome.

Reports refer that for a sustainable world, the participation of people in access to information, decisions, and changing manner of life is intensely required [1]. PM is considered as an indicator of air quality very often. Presently in some countries, results of epidemiological studies and concentration-response models combining with air quality data from monitoring stations have facilitated the HIA of PM. There are set criteria for analysis of air quality data and epidemiological information for health impact assessment (HIA) [5].

There is a number of researches studying the low-cost approach of air quality monitoring, and there are researches using public perception as a tool for HIA. But there is none who did both. This study is unique as it has applied low-cost monitoring sensors to assess the ambient air pollution due to PM2.5 and PM10 to determine the exposure in various locations and relate it with the public perception of air pollution. Air visual Pro (AVPro) was used in four sites of Dhaka city to find out the air pollution exposure. Public opinion was carried out by a psychometric paradigm method for a more straightforward approach to HIA. After the analysis, the exposure map was produced by Arc GIS. Another map was created based on public perception. A comparison between the maps shows that the exposure level remains the same in both cases.

The aim of the paper is to receive the public perception of air pollution by field survey. It also aims to use a low-cost monitoring sensor to find out the exposure and variation of air pollution due to PM2.5 and PM10. The ultimate objective of the paper will be to match the results of exposure and public perception to provide guidelines for HIA and policy formulation on environmental issues.

Table 1.

Various attributes of the study area

Location	Status of the Site
Mirpur Cantonment	Educational and Residential Sites with limited traffic and construction work
Mirpur – 12	Commercial area with heavy traffic and construction work
US Embassy	Commercial area with heavy traffic
Darus-Salam	Commercial area with medium traffic and construction work

II. THE METHODOLOGY OF THE STUDY

This study was based on quantitative and qualitative primary data. A systematic approach was followed to collect data from the field study and interviews of participants.

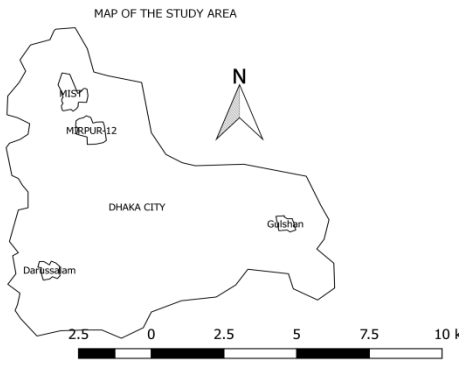

Fig 1. Study area within the Dhaka city of heterogeneous

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January - February 2020
ISSN: 0193-4120 Page No. 16448 - 16454

A. Study area

Four locations of the heterogeneous environment were selected to carry out the study. Fig 1.showsthe location of the study area. Table 1.displays the attributes of four study locations.

Table 2. A brief overview of the survey

Variable	Gender		Age (years)					Work Place		Duration of Exposure (hours)					Affected by Air Pollution			Air Quality of the Area				
Groups	Male	Female	<20	20~30	30~40	40~50	>50	Indoor	Outdoor	0~2	2~4	4~6	6~8	>8	Very Much	A Little	Not at All	Very Good	Good	Average	Poor	Very Poor
Percentage (%)	63.5	36.5	9.5	42.5	29.5	12.5	6	28	72	3	11	34.5	34.5	17.5	48	46	6	3	16	24	36	21

B. Design of the cross-sectional study

A simple set of questionnaires was adopted with the help of the air pollution perception survey of clean air initiative for Asian cities [9]. The questionnaires were designed to obtain information regarding the source of air pollution, level of affection, and public views on air quality. A three-point Likert scale was introduced as 1 (very much), 2 (A little), 3 (Not affected at all) to determine the level of affection. Another five-point Likert scale was introduced as 1 (very good), 2 (good), 3 (average), 4 (poor), and 5 (very poor) for measuring the air quality. Respondents were requested to express their self-evaluation. It should be mentioned that factual degree was not considered while collecting public response. The response from the respondents was processed and projected on a map by using Arc GIS software.

A parallel study of air quality was carried out by using low-cost portable equipment in similar study areas. The collected data was processed to generate an air quality map using Arc GIS software. At last, both the results from two different studies were compared to confirm the level of pollution.

C. Data Collection Procedure

The survey was conducted targeting the people who usually pass a considerable amount of time in the study area of four locations randomly. A field survey was carried out to assess public perception. Since most of the people do not have internet access; therefore, this study was designed to collect the data physically. The survey was conducted over 200 people from different locations of Dhaka city (50 respondents each). There was not any specific proportion of sex,age, and occupation. Table 2 shows a brief overview of the survey.

III. RESULTS

A comprehensive statistical analysis of the study is discussed in this section. MS Excel and IBM SPSS V. 23 was used to analyze the data. The data were collected, evaluated, and processed to generate the air quality map by Arc GIS software.

A. Causes of air pollution

Source apportionment is a complex issue as the nature of air pollution is heterogeneous in space. Using the positive matrix factorization (PMF), a study found a motor vehicle as to the most contributing source of pollution in the Dhaka city. The contribution of the motor vehicle is about 38.2% [10]. the respondents of this study were asked to put their opinion on the source of pollution. 94.5% of respondents think the motor vehicle is the most responsible source of air pollution in Dhaka city. Table 3 shows the various sources of air pollution according to public perception.

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January - February 2020
ISSN: 0193-4120 Page No. 16448 - 16454

Table 3.

Public Perception about Causes of Pollution

Causes	Mirpur - 12	MIST	US Ambassy	Darus Salam	Total (%)
Motor Vehicles	96	88	98	96	94.5
Industrial Source	56	30	38	62	46.5
Const-ruction	96	90	74	98	89.5
Household Cooking & Heating	16	12	16	10	13.5
Waste Disposal & Burning	62	48	50	48	52
Use of Mosquito Repellant	4	16	4	12	9

B. Exposure duration to the ambient air

There is a complicated relationship between humans and the environment [11]. The exposure assessment is critical to conduct the HIA. Respondents were asked to specify their duration of presence in the ambient environment. Fig 2 shows the period of exposure location-wise of the respondents.

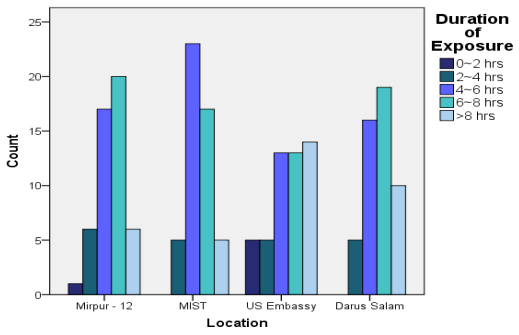

Fig 2. Duration of exposure of the respondants

C.Affect of air pollution

The respondents of the study were asked to put forward the opinion on the general perception of air quality to get an idea of the status of air readily. Fig 3 shows the responses in brief.

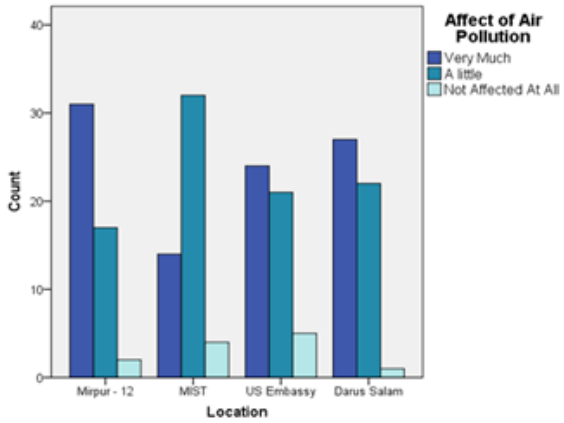

Fig 3. Level of affection due to air pollution

D. Definition of air pollution by the Respondents

Respondents rated the overall air quality of the individual locations. A significant variation is observed in the rating location-wise. Fig 4 shows the definition of air quality location wise.

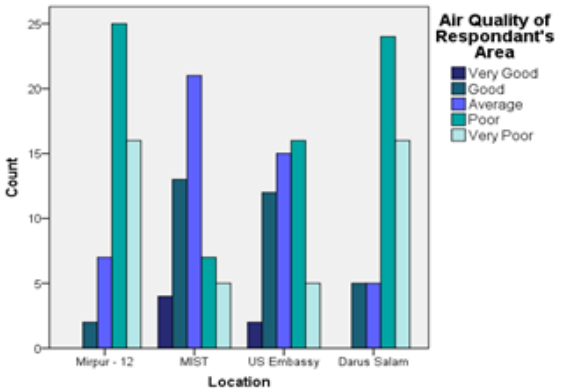

Fig 4.Respondants evaluation of air quality of their area

E. Air quality assessment by the low-cost sensor

A parallel study was conducted by using low-cost portable equipment after necessary validation with equivalent standard equipment. A summary of 91 days of data is shown in Table 4. The data were processed to generate an air quality map of the study area to see the spatial variation of the study area.

Sites	Days	$PM_{2.5}$		PM_{10}	
		Mean	Sd	Mean	Sd

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January - February 2020
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US Embassy	90	100.88	33.01	-	-
Darus Salam	91	98.44	38.91	216.44	22.04
Mirpur 12	91	122.63	19.50	186.24	24.87
MIST	91	47.89	20.70	104.46	35.44

F. Health endpoints due to air pollution

Apart from the epidemiological and clinical study, few common health impact indicators help to assess the air quality rapidly. The responses from the survey are concise in Table 5. The chi-square test was carried out to see the association between location-wise air quality and health risk indicators.

The summary of the test is shown in Table 6.

Table 5.Response on health indicators

Diseases	Mirpur - 12	MIST	US Ambassy	Darus Salam	Total
Irritation to eyes, nose and throat	39	26	34	35	67
Breathing Problem	31	14	26	27	49
Asthma	14	3	9	4	15
Sleepeless -ness	24	17	17	18	38
Anxiety	21	11	14	19	32.5
Poor Visibility	33	17	30	32	56
Skin Diseases	29	9	5	9	26

Table 6.Location-wise dependency of diseases

Disease	Cramer's V value	Level of Association
Skin Disease	.43	Strong
Irritation to eyes, nose, and throat	.20	Moderate
Breathing problem	.25	Moderate
Asthma	.24	Moderate
Anxiety	.17	Weak
Sleeplessness	.12	Weak
Poor Visibility	.26	Moderate

G. Comparison between Health risk map and Level of air pollution map

A similar study was carried out to see the risk perception of the public spatially by a survey [4]. This study tried to compare the health risk perception map generated from the study with the air pollution map generated directly from air quality data. See Fig 5 and Fig 6 compare both the study.

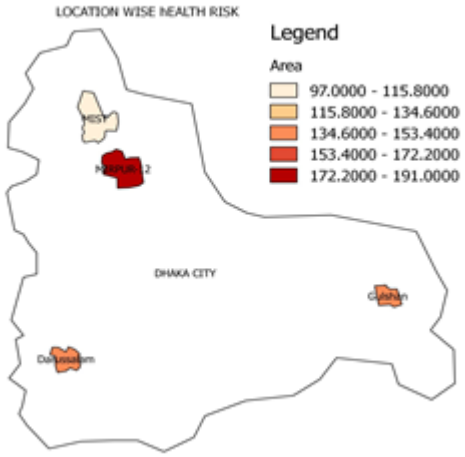

Fig 5. Health risk is projected in the map location-wise

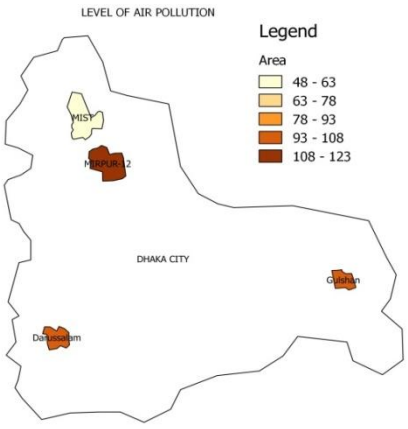

Fig 6. Map showing level of air pollution location-wise

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January - February 2020
ISSN: 0193-4120 Page No. 16448 - 16454

IV. DISCUSSIONS

The summarized opinion of the study recognized the motor vehicle to be the primary source of air pollution in Dhaka city. It also showed that according to 89.6% of respondents, ongoing construction work has a significant contribution to the burden of air pollution. This study gives a quick tool to find out the major sources of air pollution for a particular area.

The findings showed that exposure duration only affects people when the level of air pollution is high. From Fig 2, we see that in the study area of MIST, public exposure duration is comparatively high. Since the level of pollution is less in that location; therefore, the health risk is less. From Fig 3, it is observed that a significant amount of respondents (80.5%) are very much affected by the air quality of Dhaka city. This study found a strong relationship between the air quality from the public perception and the air quality measured physically by instruments. From Fig 4 and Fig 5, we can see the same color graduation of various locations. So this study confirms public perception as a reliable indicator of air pollution. From Table 6 it is found that skin disease has a strong level of dependency location-wise. Other diseases relationships are also mentioned in Table 6.

CONCLUSION

This is the first unique endeavor to our knowledge, which combined and compared the result from the psychometric paradigm method and accurate physical air quality monitoring results. Similar outcomes from both the studies strengthened its potentiality. We introduced a cheap, easy, and quick process to asses the health impact. We tried to show spatial variation of air quality, and we found that the status of health also changes spatially. However, one of the limitations of the study is a limited member of respondents, and restricted study areas were evaluated. Another drawback is the absence of epidemiological and clinical studies. However, this study can compensate for the limitations of narrow fieldwork carried out in this field. Low-income countries can adopt this method in HIA and policy formulation.

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