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A COMPARATIVE STUDY FOR ASSESSING THE AIR QUALITY STATUS FOR RESIDENTIAL AREAS

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ABSTRACT

In the present study, a comparative study has been carried out for assessing the status of air quality in two residential areas namely MMMUT Gorakhpur and Ardhali Bazar Varanasi. Air Quality Index was calculated in both the residential areas considering the key pollutants like PM_{10}, SO_2 and NO_x by different methods and results were compared with the standards prescribed by CPCB. It was found that Ardhali Bazar Varanasi was more polluted than MMMUT Gorakhpur during all season. Seasonal AQI calculation indicates that air quality status in the study area was under the various classes from good, moderate, satisfactory, poor, very poor and severe class for different AQI calculation. It was also found that during post monsoon season the condition of the air quality status at the Ardhali Bazar Varanasi was very poor.

***Keywords:** Air Quality Index (AQI), Ambient Air Quality, Air Pollutant, Ardhali Bazar Varanasi, MMMUT Gorakhpur.*

I. INTRODUCTION

Air Pollution is a mixture of gases, particles, aerosols, water vapour which has originated due to human development and other natural/anthropogenic activities. Common people living in urban areas, in urban areas source of air pollution mainly are vehicular pollution, burning of solid waste, use of gensets during power cut, etc. Air pollution is serious worldwide public health problem. A large number of people are suffering from different air pollution induced respiratory and pulmonary decease with higher morbidity and mortality. Today adverse health effect of air pollution is a serious issue in urban areas particularly in developing country including India [1]. Poor air quality has both acute and chronic effects on human health [2, 3]

Among air pollution, particulate matter (PM) is a ubiquitous and it's especially a major problem due to its adverse effect, Visibility reduction and soiling of building. Particulate matter (PM) consists of a heterogeneous mixture of very small particles and liquid droplets suspended in air. These also have identified that PM_{10} as the dominant pollutant in the index value [4]. Sulphur dioxide (SO_2) is a gas formed when fuel containing sulphur, such as coal and oil, is burned and when gasoline is extracted from oil or metal is extracted from ore. Nitrogen oxides (NO_x) are a group of highly reactive gases containing various levels of nitrogen and oxygen.

In this paper, different method of estimating the Air Quality Index (AQI) is evaluated as a tool for assessing the impact of air pollution with a case study. Air Quality Index (AQI) is such an indicator tool which mainly uses in worldwide and in India since last 2-3 decades, includes synergistic effect estimation based on mean of the ratios

of pollutant over guideline level for a certain time period. These can further be classified as AQI using various mean values viz, arithmetic mean, geometric mean and break point concentration. Air Quality Index is the simplest and widely measure of over all air pollution of a region.

II. STUDY AREA DESCRIPTION

The study area is located at MMMUT in Gorakhpur (26°43'46"N, 83°26'0.8"E) and Aradhali Bazar is located in Varanasi (25°20'53''N, 82°58'49"E). Gorakhpur and Varanasi is located along the bank of Rapti and holy Ganga River respectively.

Air quality impact assessment has been concern out at two different locations and their respective names are:

a) Madan Mohan Malaviya University of Technology (MMMUT), Gorakhpur

b) Aradhali Bazar, Varanasi

2.1 Methodology

Present study is comparing the Air Quality Index (AQI) in the MMMUT, Gorakhpur and Ardhali The Bazar, Varanasi during March, 2015 to February, 2016. In order to understand ambient air quality status around that area, three ambient air samples were taken. The parameters were assessed including respairable particulate matter (RSPM or PM_{10}), sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) and results were compared with the standards prescribed by Central Pollution Control Board.

2.2 Air Quality Index (Aqi)

Air Quality Index (AQI) is a tool which is used to report the overall air quality status and trends based on a specific standard. The index of specific pollutant is derived mainly from the physical measurement of pollutant like RSPM or PM_{10}, SO_2 and NO_x etc. PM_{10} as the dominant pollutant in the index value [4]. AQI convert the value of individual air pollutant into single number. As the increasing value of AQI that can directly adverse health effect and environment [5, 6]. In the present study, four different methods were used to calculate ambient air quality index these are given below:

a) Oak Ridge Air Quality Index (ORAQI) Method
b) Arithmetic Mean Method
c) Geometric Mean Method
d) Break Point Concentration

a) Oak Ridge Air Quality Index (ORAQI) Method

In this method Air Quality Index calculated by Oak Ridge National Air Quality Index (ORNAQI) can be considered for the relative ranking of overall air quality status. Over all AQI was estimated by the following mathematical equation developed by Oak Ridge National Laboratory (ORNL), USA as given below:

$$\mathbf{AQI = [39.02 \sum Xi / Xs]^{0.967}}$$

Where,

Xi = value of air quality parameters (PM_{10}, SO_2 and NOx)

Xs = standard and prescribed for air quality parameters [7].

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b) Arithmetic Mean Method

Air Quality Index (AQI) was calculated using the arithmetic mean of the ratio of concentration of pollutant to the standard value of the as PM_{10}, SO_2 and NO_2. The averages multiply by 100 to get the AQI index. AQI was compared with rating scale [8]. For AQI calculate using the following formula:

$$\mathbf{AQI = (V/V_s) \times 100}$$

Where,

AQI = Air Quality Index

V = the observed value of the air quality parameters pollutant (PM_{10}, SO_2 and NO_2)

V_s = the recommended value of National Ambient Air Quality Standards (NAAQS) for residential area [7]

c) Geometric Mean Method

In this method AQI is calculated by taking the geometric mean of the ratio of concentration of pollutants to the standard value of that pollutant such as PM_{10}, SO_2 and NO_x. AQI was compared with rating scale [9].

$$\mathbf{G=Anti\ log}\left(\frac{Log\ a+Log\ b+Log\ c+\cdots+Log\ x}{n}\right)$$

Where G is geometric mean, while a, b, c, and x represent different pollutant values of ratio of concentration value of each pollutant, and n is the number of values of pollutants.

d) Break Point Concentration

In this method Air Quality Index calculated by break point concentration [10, 11]. The individual air quality index for a given pollutant concentration (I_P) as based on following formula,

$$\mathbf{I_P = [\{(I_{HI} - I_{LO})/(B_{HI}-B_{LO})\} \times (C_P-B_{LO})]+ I_{LO}}$$

Where,

I_P = Pollutant concentration

B_{HI} = Breakpoint concentration greater or equal to given concentration

B_{LO} = Breakpoint concentration smaller or equal to given concentration

I_{HI} = AQI value corresponding to B_{HI}

I_{LO} = AQI value corresponding to B_{LO}

C_P = given pollutant concentration

Finally;

$$\mathbf{AQI = Max.\ (I_P)}$$

Where

P = 1, 2, 3.....n, denotes n pollutants

2.3 Result and Discussion

The overall Air Quality Index was found to fall under the category of moderately polluted to very poor area in the Ardhali Bazar, Varanasi and satisfactory to moderately polluted area in the MMMUT, Gorakhpur. The average concentration PM_{10} during this period varies between 146.17µg/m^3 to 407.06µg/m^3, concentration of SO_2 varies between 17.25µg/m^3 to 19.28µg/$m^3$and concentration of NO_x varies between 36.02µg/m^3 to 56.40µg/m^3 in Aradhali Bazar, Varanasi. Average concentration of PM_{10} in MMMUT, Gorakhpur varies

between 88.55µg/m^3 to 112.22µg/m^3, concentration SO_2 varies between 7.17µg/m^3 to 9.97µg/m^3, and concentration of NO_x varies between 17.87µg/m^3 to 21.45µg/m^3 in MMMUT, Gorakhpur.

Comparison of seasonal variation of ambient air quality index with respect to PM_{10}, SO_2, and NO_2 during the period of March 2015 to February 2016 as shown below:

Table 1: AQI of Ardhali Bazar, Varanasi

Location	Ambient Air Quality			AQI			
Ardhali Bazar , Varanasi	**PM 10**	**SO2**	**NOx**	**ORAQI**	**Arithmetic Mean**	**Geometric Mean**	**Break point concentration**
Pre Monsoon (March 15- June-2015)	233.14	19.09	40.55	102.66	103.12	66.18	257.73
Monsoon (July 2015 - Oct 2015)	146.17	17.25	33.06	70.44	69.44	49.44	153.34
Post Monsoon (Nov 2015 - Feb 2016)	407.06	19.28	56.40	164.55	167.20	88.07	385.04

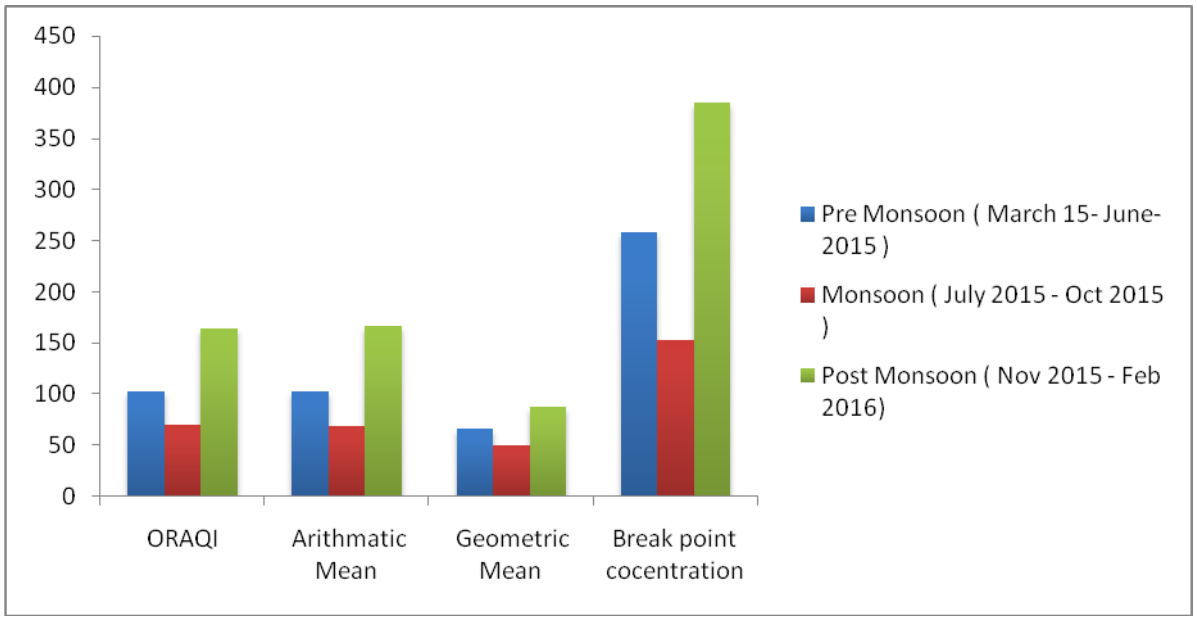

Figure 1: AQI of Ardhali Bazar, Varanasi

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Table 2: AQI of MMMUT, Gorakhpur

Location	Ambient Air Quality			AQI			
MMMUT, Gorakhpur	PM 10	SO2	NOx	ORAQI	Arithmetic Mean	Geometric Mean	Break point concentration
Pre Monsoon (March 15- June-2015)	99.3	9.97	21.45	46.75	46.19	31.90	103.67
Monsoon (July 2015 - Oct 2015)	88.55	7.17	17.87	41.23	39.95	25.91	89.21
Post Monsoon (Nov 2015 - Feb 2016	112.22	7.33	17.91	58.32	47.87	28.43	119.07

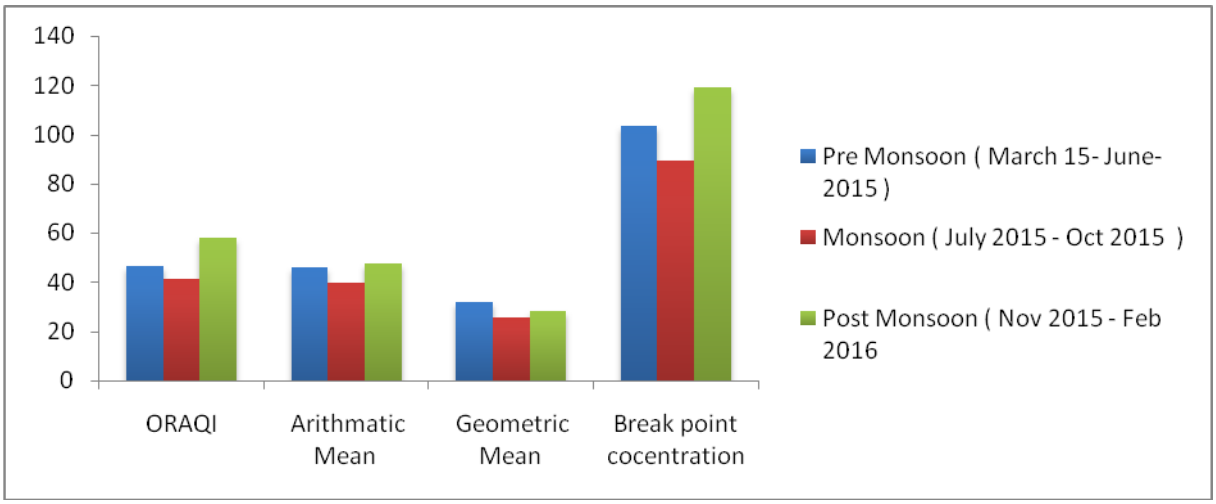

Figure 2: AQI of MMMUT, Gorakhpur

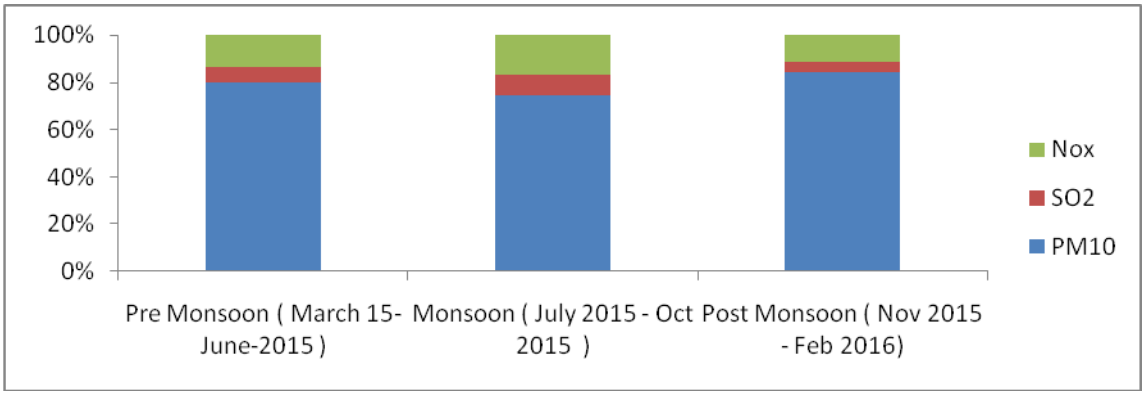

Figure 3: Percentage occurrences of three pollutants in the Ardhali Bazar, Varanasi

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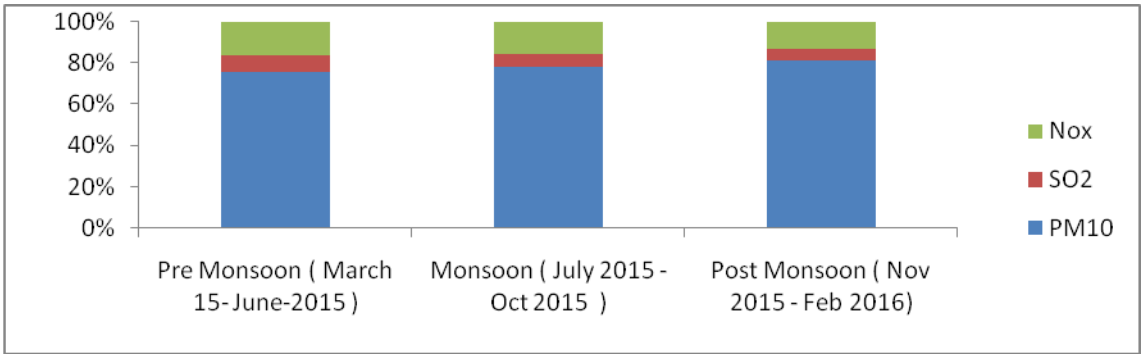

Figure 4: Percentage occurrences of three pollutants in the MMMUT, Gorakhpur

Table 3: Classification of AQI used for Comparative Study

AQI (ORAQI)	AQI (Arithmetic Mean)	AQI (Geometric Mean)	AQI (Break Point Concentration)
(0≥AQI≤25) Clean	(AQI<10) Very Clean	(AQI<10) Very Clean	(0-50) Good
(26≥AQI≤50) Light Air Pollution	(10≥AQI<25) Clean	(10≥AQI<25) Clean	(51-100) Satisfactory
(51≥AQI≤75) Moderately Polluted	(25≥AQI<50) Fairly Clean	(25≥AQI<50) Fairly Clean	(101-200) Moderately polluted
(76≥AQI≤100) Heavy Air Pollution	(50≥AQI<75) Moderately Polluted	(50≥AQI<75) Moderately Polluted	(201-300) Poor
(AQI>100) Severe Air Polluted	(75≥AQI<100) Polluted	(75≥AQI<100) Polluted	(301-400) Very Poor
	(100≥AQI<125) Highly Polluted	(100≥AQI<125) Highly Polluted	(401-500) Severe
	(AQI≥125) severely Polluted	(AQI≥125) severely Polluted	

(Source: CPCB 1994)

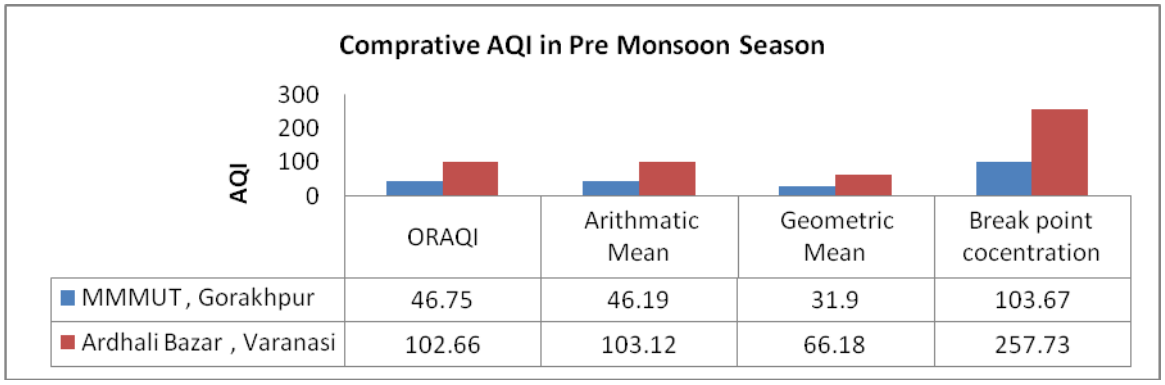

Figure 5: Classification of air quality index during Pre Monsoon Season

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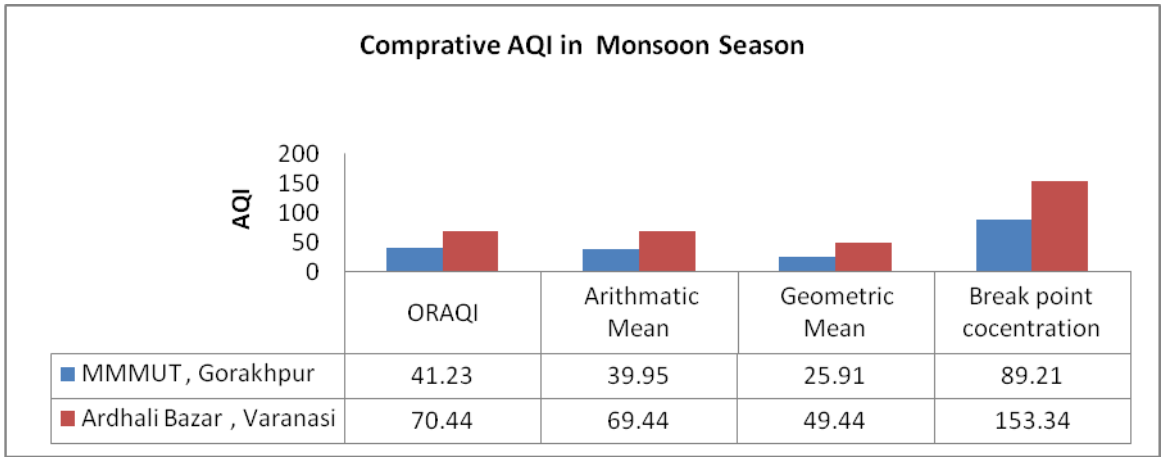
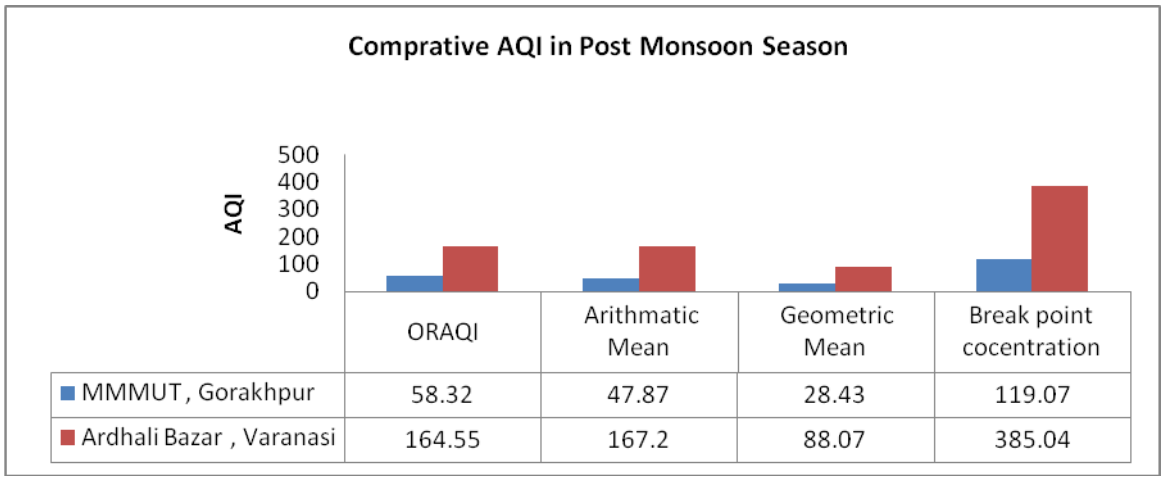


	ORAQI	Arithmatic Mean	Geometric Mean	Break point cocentration
MMMUT, Gorakhpur	41.23	39.95	25.91	89.21
Ardhali Bazar , Varanasi	70.44	69.44	49.44	153.34

Figure 6: Classification of air quality index during Monsoon Season



	ORAQI	Arithmatic Mean	Geometric Mean	Break point cocentration
MMMUT, Gorakhpur	58.32	47.87	28.43	119.07
Ardhali Bazar , Varanasi	164.55	167.2	88.07	385.04

Figure 7: Classification of air quality index during Post Monsoon Season

III. CONCLUSION

The study carried out, regarding the comparative study of two cites with respect to the residential area. The AQI study found that PM_{10} was mainly responsible for the high range of AQI value. Particulate matter is mainly responsible for the serious public health problem in the residential area. The Air Quality Index (AQI) in Ardhali Bazar Varanasi is very high as compare to the MMMUT Gorakhpur. For minimizing the pollution in the surrounding areas, some remedial measure like plantation and green belt can be formed that area for betterment of human life. Air Quality Index can be useful establishing a meaningful assessment of air pollution in the common man perception.

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