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Health assessment on children exposed to air pollutant PM10 in Bangalore city

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***ABSTRACT**--Air pollutants are present in the atmosphere in the form of any solid or gaseous substance, which are considered injurious to living system of the planet. The objectives of the study were to assess the relationship between air pollution and childhood respiratory morbidity in various identified polluted areas and the relevant morbidity conditions of children in different living conditions were evaluated. To achieve the objective of the study, a retrospective study was done for the period from January 2011 to December 2015. The morbidity conditions of the children below 14 years were collected from the Primary health centres (PHC) located near the study area. From this study it was found out that there was a statistically significant positive correlation($r=0.227$, $p<.01$) between the levels of pollutant PM_{10} and the respiratory illnesses viz., cold, cough,fever, lower respiratory illness and upper respiratory illness of children. Binary logistic regression (BLR) model was employed to explore the various factors for the causes of respiratory illnesses. This model showed that the exposure of pollution level, PM_{10} significantly influence the respiratory illnesses and female children were found to be more sensitive. Overall explanatory variable of age group less than 5 and 6-10 years of age showed highly significant associationwith theillness. Monsoon and winter season were found to possesshighly significantassociation with the disease condition. From this study, it has been concluded that morbidity conditions of respiratory illnesses among children arestrongly associated with the pollution levels of the area.*

***Key words**-- Respiratory illnesses, Particulate matter PM_{10}, Lower respiratory Infection, Upper respiratory illnesses, Binary logistic regression*

I. INTRODUCTION

Air pollution is a major environmental health problem affecting large populations around the world. Exposure to air pollutants causes a number of adverse health outcomes including respiratory infections, cardiovascular diseases, lung cancer, etc. [1,2,3] Worsening outdoor air pollution, as a result of increasing urbanisation, population growth, motor vehicle use, unregulated industrial emissions and unsustainable policies, is causing considerable problems [4]. Air pollution in India is quite a serious issue with the major sources being biomass burning, fuel adulteration, vehicle emission and traffic congestion. Vehicle exhaust fumes are the largest

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source of air pollution in cities. Since India is a developing country, industries and usage of vehicles are rapidly growing. Air pollution causes irritation in the throat, nose, lungs and eyes. It causes breathing problems and aggravates existing health conditions of emphysema and asthma. It is a major environment-related health threat to children and a risk factor for both acute and chronic respiratory disease. The Global Burden of Diseases study estimates that pollution related disease was responsible for 9 million premature deaths in 2015,16% of total global mortality. WHO estimates that, in 2012, unhealthy environments were responsible for 12.6 million deaths worldwide-23% of total global mortality- and for 26% of deaths in children younger than 5 years. [5,6,7,8]. Children are at high risk of pollution related disease and even extremely low-doseexposures to pollutants during windows of vulnerability in utero and in early infancy can result in disease, disability and death in childhood and across their lifespan [9] . A large number of epidemiological studies have reported an association between exposure to air pollutants and several morbidity conditions in children [10,11]. Urban children are more prone to asthma than rural children [12]. A surveyconducted in 2008 of Delhi schoolchildren by Central Pollution Control Boardfound a higher prevalence of upper, lower respiratory disease symptoms, and lung function deficits in Delhi urban children compared to age-and sex-matched rural controls. It showed respiratory problems in 32% of children examined in Delhi, in contrast to 18.2% of the rural children. Reduced lung function was recorded in 43.5% of school children in Delhi, compared to 25.7% in villages [13]. An Indian study showed anincrease in ambient air pollution significantly increases child morbidity.One of the hospital based study showed the prevalence rate of asthma among children under the age of 18 years was kept increasing year wise [14]. In India very few studies, however, have focused on young children and very few have evaluated the impact of air pollution on groups of children that may be more vulnerablebecause of poor living conditions. This is important because there is a need for a fair assessmentof relationship between air pollution and children's health. While recognizing the need for further research, current knowledge on the health effects of air pollution is not sufficient for it to be strongly recommended that children's current exposure to air pollutants be reduced, particularly with regard to traffic-related pollutants. The past few years data indicates that the quantity of Respirable Suspended Particulate Matter (RSPM/PM_{10}) exceeded the limit (60 microgram /cubic meter) in most places of Bangalore City [15] due to uncontrolled growth of vehicular population and industrialization. Karnataka pollution control board has started monitoring of ambient air quality during 1983. At present environmental monitoring is being done under three different zone categories, viz., industrial, mixed urban area and sensitive area). In India there is no substantial literature on the health effects of air pollution on children in general and on children within certain subgroups of susceptibility, particularly those with respiratory illnesses. Therefore, our aim is to understand the relationship between the levels of air pollutants and child morbidity status in selected urban areas in Bangalore city.

II. OBJECTIVES

III. METHODOLOGY AND STUDY AREA

This is a retrospective study based on data collected for the period between January 2011 and December 2015. Levels of air pollutant $PM_{10}$was compared with morbidity conditions of children for the period. In this study we focused our analysis on children's population subgroups which are considered to be more susceptible to the effects of air pollution such as young children (≤14years).The study areas Peenya Industrial area, AMCO

Batteries and SG Halli residential areahas been represented from each zones industrial area, mixed urban area and sensitive area, respectively.

A household questionnaire survey was carried out in Peenya Industrial and AMCO Batteries area to collect the information of socioeconomic status and living style of the population. 127 households were selected for the survey. The selection of the household was made by the systematic sampling procedure.

Total 17178 registered cases were covered from three primary health centres located near Peenya, AMCO Batteries and SG Halli residential area. The monthly average concentrations of PM10 of these areas were taken (Source KSPCB). The data of morbidity conditionof the children aged below 14 years were collected from the out patient division (OPD) register maintained bythe Government hospitals or Primary health centres located near the study areas for the period from January 2011 to December 2015. From Karnataka State Pollution Control Board (KSPCB) the ambient air pollution data (PM_{10})for the same period (2011-2015) has been collected.

Morbidity data were further straitified by specific respiratory illnesses including URI, LRI, asthma and other diseases with the age groups ≤5, 6-10, 11-14 years. Duplicate cases were carefully omitted while collecting the morbidity data. The health data were linked to ambient air pollution. The collected data has been entered in the MS excel, the statistical techniques like descriptive statistics, correlation, time series and logistics regression method were applied for analysis by using SPSS 20.0 version.

IV. RESULTS AND DISCUSSION

The demographic characteristics and living conditions such as monthly income, educational status of parents, and ventilation system in home and water source,of the population living near the indusrial area has beenrepresented in the table 1.

Table 1: Demographic characteristics of the population

Variables		**(No. of Households) n= 127**	**%**
Average no. of children in the household		Mean ±S.D 2.7 ± 1.6 (Min.=1 Max.=7)	
Monthly income (Rs.)	≤5000	16	12.6
	5001-10000	63	49.6
	10001-15000	28	22.0
	≥15001	20	15.7

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Parental education			
Mother	Upto 10th	74	58.3
	Higher secondary	35	27.5
	Graduate	18	14.2
Father	Upto 10th	65	51.2
	Higher secondary	43	33.8
	Graduate	19	15.0
Smoking Habit	Smokers	29	22.8
	Smoking in indoor	16	12.6
Distance between house	1-2	85	66.9
proximity to industry (km)	2-4	37	29.1
Ventilated with windows	Yes	111	87.4
	No	16	12.6
Type of fuel used at home	LPG	92	72.4
	Kerosene	32	25.2
	Biomass	3	2.4
Usage of water	Bore well	20	16.7
	Corporation supply	107	84.3
Food habit	Vegetarian	16	12.6
	Non vegetarian	111	87.4

The qustionnaire survey was carried out in 127 households, it was found that 343 children with average number of 2.7 ± 1.6 (Minimum=1 Maximum=7) were the habitants. The monthly income of the families below Rs.5000 was 12.6% and 50% of the families having monthly income in the range of Rs. 5001-10000. The literacy rate of parent is shown in the table1. The education level of mother's were up to 10th (58.3%), higher secondary (27.5%) followed by graduates (14.2%) whereas father's were up to 10th (51.2%), higher secondary (33.8%) followed by graduates (15%). It is observed that 22.8% were smokers and 12.6% people had the habit of smoking inside their house. This could lead to Environmental Tobacco smoke (ETS) concentration. Windows for the ventilation in the house of 12.6% of the households were not present. The types of fuel used for cooking were LPG (72.4%), kerosene (25.2%) followed by biomass (2.4%). Most of the people (84.3%) were using treated water supplied by Government only. 12.6% of the people had the food habit of vegetarian whereas non vegetarians were 87.4%.

Table 2: Annual average levels of pollutant (pm_{10})$\mu g/m^3$ recorded at various areas for five years (2011-2015)

Year	**Peenya Industrial Area**	**AMCO Batteries**	**SG Halli Residential Area**

	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
2011	99.8	58	180	64.1	25	131	14.5	6.5	30.6
2012	106.6	51	184	137	56	280	55.7	8.9	72
2013	113.8	49	163	159.9	102	233	25.7	17.6	34.3
2014	136.5	105	165	220.9	132	273	34.4	28.2	35
2015	136	87	187	134.7	78	243	57.8	36	75.2

Table 2 shows the annual average concentration of PM_{10} recorded at Peenya, AMCObatteries and SG Halli residential area for the period from 2011 to 2015. The mean PM_{10}levelswere 99.8 (Min. 58 & Max. 180) µg/m^3, 64.1 (Min. 25 & Max. 131) µg/$m^3$and 14.5 (Min. 6.5 & Max. 30.60) µg/m^3, recorded at Peenya, AMCO and SG Halli areafor the year 2011 respectively. It could be noted that the levels were increased continuously in all the three sites till 2015.The annual mean concentration of PM_{10} recorded at industrial areaexceeded the NAAQS of 60 µg/m3 which were under critical classification based on pollution level classification (CPCB, 2012) whereas in the residential area the pollutant levels were below the permissible limit. Based on this recorded level these areas were chosen as study areas.Fig 1 described the study area. Table 2 showed the annual average levels of PM_{10} recorded at the study areas for the period from January 2011 to December 2015).

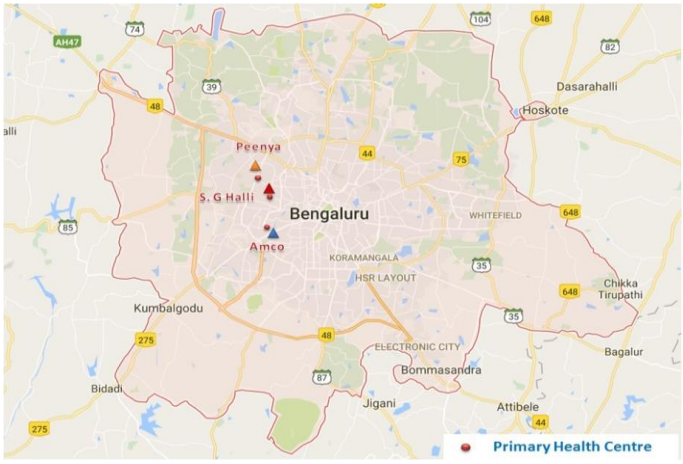

Figure 1: Discription of the study area

V. PEENYA INDUSTRIAL AREA

Table 3 shows the morbidity conditions of the children registered at PHC, which is located near Peenya Industrial area. It was revealed that out of 8074 registered cases, nearly 50% (4821) cases were below 5 years of age. Out of these 50% (4821) cases, 46.7% of children were suffering with respiratory illnesses viz., lower respiratory illness and upper respiratory illness. The study showed that the percentage of diseased female children were slightly higher (53.8%) than the male (46.2%)(Fig 2).It was observed that younger age group children were more affected by respiratory illness compared with other age groups. In this study it was noticed that the children suffered with LRI and URI were highest (39.9%) followed by other diseases (39.1%), andcold

cough &fever (20.9%). Other diseases meant that the children suffered with abdominal pain, allergy, anaemic, ear pain, constipation, back pain, chicken pox, dengue fever, diarrhoea, dog bite, fungal infection, gastritis, pyoderma, rashes & scabies, tooth pain, vomiting, worm infection and wound. Less number of asthma cases were registered.

Table 3: Distribution of morbidity conditions of children visited at PHCcentres located near different locations according to age groupfor the period from 2011-2015

Area	Age Group	Types of diseases				Total
		Cold Cough & Fever	LRI & URI	Asthma	Other Diseases	
Peenya Industrial area	≤5	927 (19.2)	2252 (46.7)	2 (0.04)	1640 (34.0)	4821 (100)
	6-10	451 (24.1)	584 (31.2)	3 (0.2)	834 (44.6)	1872 (100)
	11-14	308 (22.3)	388 (28.1)	1 (0.1)	684 (49.5)	1381 (100)
	TOTAL	1686 (20.9)	3224 (39.9)	6 (0.1)	3158 (39.1)	8074 (100)
HalliAMCO Batteries	≤5	1331 (61.3)	96 (4.4)	1 (0.04)	743 (34.2)	2171(100)
	6-10	542 (53.8)	33 (3.3)	1 (0.1)	432 (42.9)	1008(100)
	11-14	348 (51.1)	20 (2.9)	-	313 (46.0)	681(100)
	TOTAL	2221 (57.5)	149 (3.9)	2 (0.1)	1488 (38.5)	3860 (100)
SG Halli Residential area	≤5	677 (20.8)	486 (14.9)	-	2091 (64.3)	3254 (100)
	6-10	181 (14.9)	158 (13.0)	-	873 (72.0)	1212 (100)
	11-14	15 (13.5)	54 (6.9)	-	619 (79.6)	778 (100)
	TOTAL	963 (18.4)	698 (13.3)	-	3583 (68.3)	5244 (100)

LRI – Lower respiratory illness & URI – Upper respiratory illness

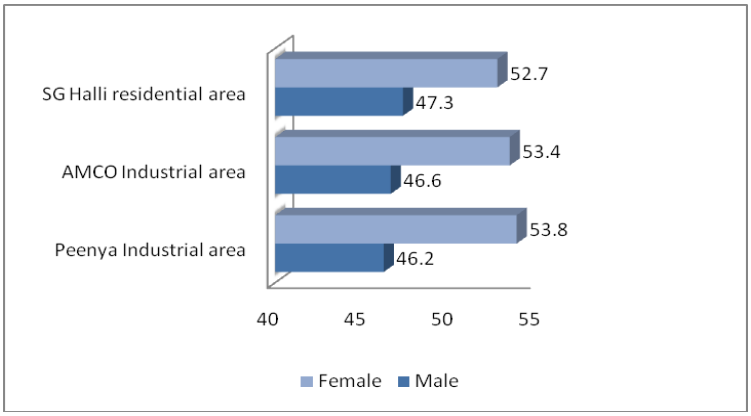

Figure 2: Percentages of children by gender

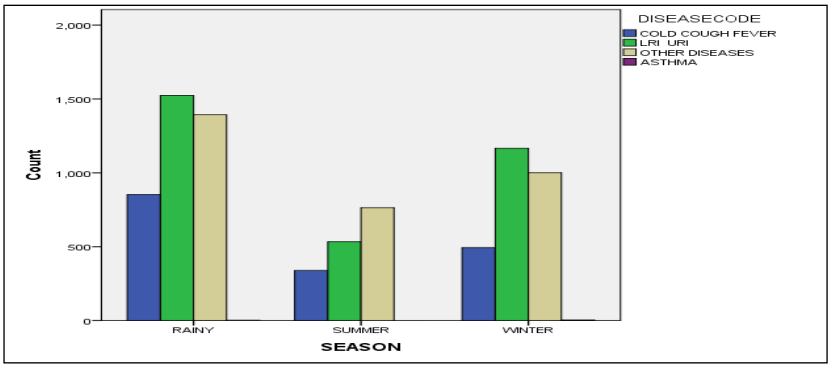

Figure 3: Distribution of types of diseases according to the seasons (2011-2015)

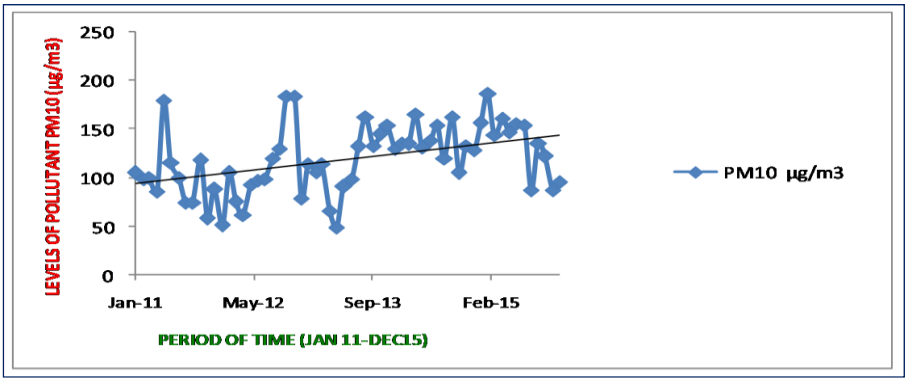

Figure4: Trend analysis of Levels of pollution (PM 10)µg/m3 recorded at Peenya Industrial area for the period from 2011-2015

Children suffered with all types of diseases (mentioned earlier) more in rainy season followed by winter and summer seasons. (Fig 3). Trending analysis for the monthly average levels of pollutant recorded for the period from January 2011 to December 2015 were performed. It was observed that the levels of pollutant for this area showed increasing trend. (Fig 4)

VI. AMCO BATTERIES

Table 3 shows the morbidity conditions of the children registered at PHC located near AMCO Batteries. From this study it has been revealed that out of 3860 registered cases, nearly 56% (2171) of the cases were below 5 years of age. Out of 2171, 61.3% of children were suffered with cold cough and fever. It was observed that younger age group affected more by respiratory illness compared with other age groups.The study showed that the diseased female children were slightly higher in percentage (53.4%) than males (46.6%) (Fig.3).

From this study it has been noticed that the proportion of children suffering with cold cough & fever was highest (57.5%) followed by LRI & URI (3.9%) and other diseases (38.5%). Other diseases meant that abdomen pain, allergy, anaemic, ear pain, constipation, diarrhoea, dog bite, fungal infection, gastritis, pyoderma, rashes & scabies, tooth pain, vomiting, worm infection and wound. There was less number of cases registered of children

suffering from asthma. Children suffered more with respiratory diseases compared with all other types of diseases in monsoon season followed by winter and summer seasons. (Fig 5).

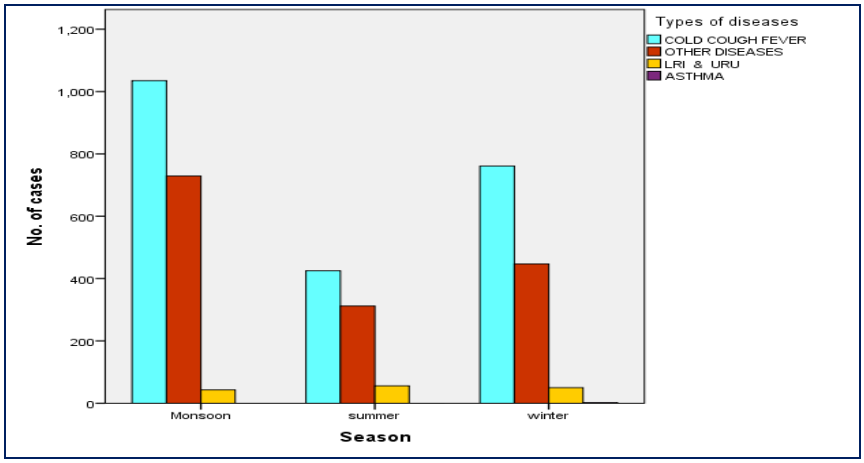

Figure 5: Distribution of types of diseases according to the seasons (2011-2015)

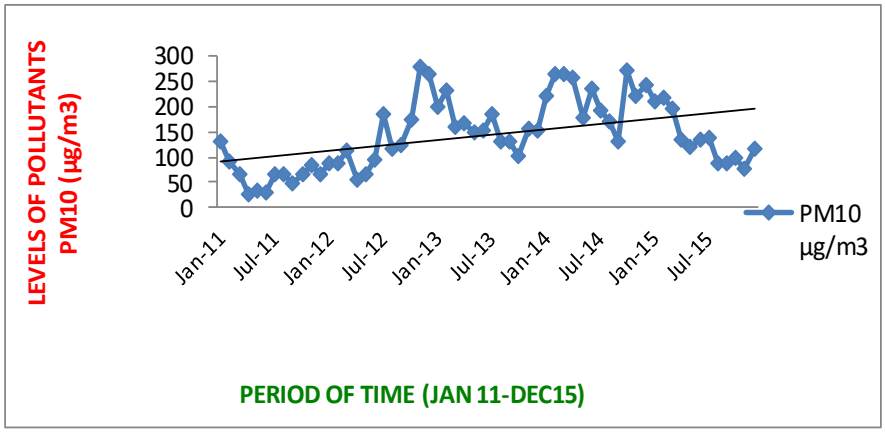

Figure 6: Trend analysis of Levels of pollutant (PM_{10}) µg/m^3 recorded at AMCOBatteries area for the period from 2011-2015

Time series analysis for the monthly average levels of pollutant recorded for the period from January 2011 to December 2015 were performed. (Fig 6)

VII. SG HALLI RESIDENTIAL AREA

Table 3 showed the morbidity conditions of children living near SG Halli residential area for the period 2011-2015. From the OPD data, it was revealed that out of 5244 registered cases nearly 60% (3254) of the cases were below 5 years of age.

Contradiction with the Industrial areas, respiratory illnesses were registered less in this area. 31.77% of children suffered from respiratory illnesses viz., LRI, URI, Cold and fever. 3583 of children (68.3%) out of 5244

were suffered with diseases other than respiratory illnesses. The study showed that the diseased female children were slightly higher (52.7%) than male (47.3%) (Fig 3).

It was observed that the prevalence rate of morbidity conditions of children with all types of diseases were showing increasing trend from 2011 to 2015 onwards. Fig 7 showed that monsoon season affected more than other seasons like rainy and summer at residential area.

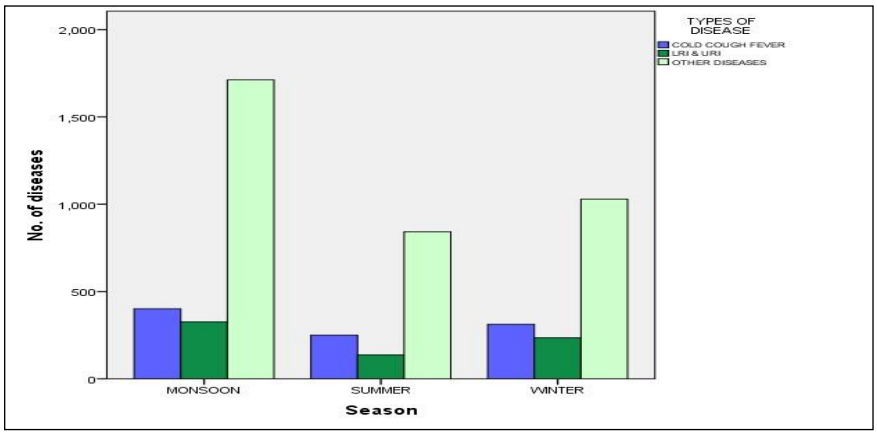

Figure 7: Distribution of types of diseases according to the seasons (2011-2015)

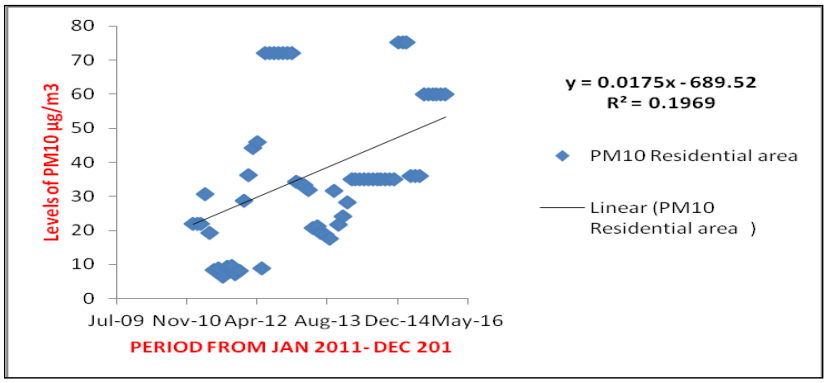

Figure 8: Trend analysis of Levels of pollutant (PM 10)µg/m3 recorded at SG Halliresidential area (2011- 2015)

Trend analysis of pollutant PM_{10} at SG Halli residential area observed for the same period showed increasing trend (Fig 8).

VIII. COMBINED RESULTS OF 3 AREAS

From this study it was found out that there was a statistically significant positive correlation($r=0.227$, $p<.01$) between the levels of pollutants PM_{10} and the respiratory illnesses of children.(Fig 9). Out of registered 17178 cases, 8949 (52.1%) were having respiratory illness.

Binary logistic regression model was employed to explore the various other risk factors for causes of respiratory illnesses, the pearson correlation revealed that it had a significant association with the levels of air pollutant. This model showed the pollution level PM_{10} had significant influenceon the respiratory illnesses ($p<.001$, OR=.993 95% CI (.993, .994)).Female children were highly significant in the respiratory illnesses

(p=.001, OR=.901 95% CI (.847, .959)). It supports with the study high prevalence of bronchial asthma among children living in urban areas with a high prevalence among girls(Nitin Kumar et. al 2017)[16].\

Overall explanatory variable age group less than 5 years (p<.001, OR=.549 95% CI(.504, .598)) and 6-10 years (p<.001, OR=.810 95% CI (.734, .894))showed highly significant with this illness. On the basis of this model monsoon and winter season showed highly significant (p=.002, OR=.881 95% CI (.813, .995)), (p<.001, OR=.831 95% CI (.762, .906)) Table 4

Table 4: Binary Logistic regression model (BLR) explored the respiratory illnesses with levels of pollutant associated with different age groups, sex and seasons

Explanatory variables	(n=17178)	Regression coefficient	OR	95% CI Of OR	P value
PM_{10}	Mean±S.D 102.26± 60.1	-0.007	.993	(.993 .994)	<.001
Gender					
Female	9164	-0.104	.901	(.847, .959)	.001
Male	8014	Reference group			
Age group					.
≤ 5	10245	-0.600	.549	(.504, .598)	<.001
6-10	4093	-0.211	.810	(.734, .894)	<.001
11-14	2840	Reference group			
Season					
Monsoon	8019	-0.127	.881	(.813, .955)	.002
Winter	5500	-.185	.831	(.762, .906)	<.001
Summer	3659	Reference group			

Dependant variable = Respiratory illness (presence or absence)

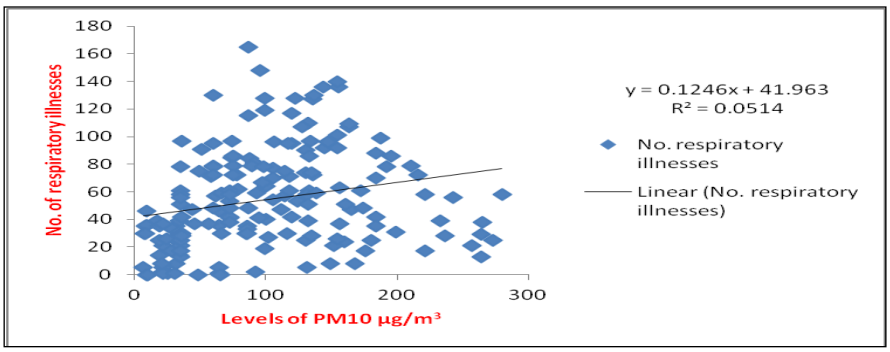

Figure 9: Trend analysis of Levels of pollution (PM_{10})µg/m3 with cases of respiratory illnesses for the period from 2011-2015

A study reported that air pollution, specifically, particulate matter, has a large and negative health effect. Effects of air pollution are three times larger for children living in slums in comparison to children living outside slums. This suggests that improving urban air quality can lead to equity-enhancing health gains in developing countries (Ghosh et. al. 2014)[17]. The high level of outdoor air pollution in north china are positively associated with children's respiratory symptoms, the association with TSP appear to be stronger than SO2 and NO2 (Pan et. al 2010)[18].

Another study showed that air pollution promotes adverse effects on children's respiratory health even when pollutant levels are lower than the air quality standards (Bakonyi et. al.)[19]. There was a significant association between traffic-related pollution and the development of asthma exacerbations and respiratory infections in children born to atopic parents and in those suffering from recurrent wheezing or asthma. These findings suggest that environmental control may be crucial for respiratory health in children with underlying respiratory disease (Esposito et.al 2014)[20]. Some studies have reported an association between ambient air pollution and increased risk of sudden infant death syndrome (Woodruff et. al 2008). Asthma is one of the most common chronic diseases in childhood and its prevalence has been increasing within industrializing nations (Mandeepet.al 2015)[21].

IX. CONCLUSION

From this studywe concluded that there was a statistically significant positive correlation ($r=0.227$, $p<.01$) between the levels of pollutant PM_{10} and the respiratory illnesses of children. The result supported the hypothesis of this project.Binary logistic regression (BLR) model explored the various factors for the causes of respiratory illnesses.This model showed the pollution level PM_{10} significantly influenced the respiratory illnesses ($p<.001$, OR=.993 95% CI (.993, .994)). Respiratory illnesses in female children arehighly significant ($p=.001$, OR=.901 95% CI (.847, .959)). Overall, explanatory variable age group less than 5 years ($p<.001$OR=.549 95% CI(.504, .598)) and 6-10 years ($p<.001$, OR=.810 95% CI (.734, .894))showed highly significant associationwith this illness. On the basis of this model monsoon and winter seasons have been found to be highly significant in association with the disase condition($p=.002$, OR=.881 95% CI (.813, .995)), ($p<.001$, OR=.831 95% CI (.762, .906)). From this study, it has beenconcluded that children morbidity conditions of respiratory illnesses were strongly associated with the pollution levels.

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