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WEEKDAY/WEEKEND DIFFERENCES IN AIR QUALITY PARAMETERS IN DELHI, INDIA

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ABSTRACT

A comprehensive database for pollution levels from the year 2006 to 2010 was analyzed for a main traffic intersection at ITO, Delhi. The study had come out to assert that pollution levels on weekend i.e. Saturday and Sunday relate to significantly lower concentration of pollutants as compared to that on weekdays i.e. from Monday to Friday by almost 2 to 6 times. On an average increase on only Sundays with respect to weekdays is CO by 3 times, PM2.5 by 1.18 times, NO by 1.62 times, $NO_2$by 5.76 times, $SO_2$by 1.27 times and O_3 by 1.15 times. The pollution levels on Saturdays have been found intermediate. Pollution can hence be related to the weekly cycle of human activities. Emissions from vehicles serve as major sources of pollution. Hence viably possible solutions for pollution control can also be achieved by controlling the magnitude of traffic flow on roads.Similarly holiday effect is observed during public holiday, where the pollution levels reduce by at least 4% for O_3 and PM and up to 11 to 14 % for NO, CO and NO_2 from the pollution levels in the same week.

KEYWORDS: Weekday/Weekend, Holiday Effect, Air Pollution, Delhi

INTRODUCTION

The temporal variation of concentration of pollutant throughout the day varies with the influence of local wind parameters such as direction and speed and other meteorological aspects. On the other hand, changing pattern of vehicular traffic and industrial activities also act as a factor for variation in pollution levels. The weekly cycle of activities of population explain distinct temporal variation in pollution levels from weekdays (Monday to Friday) to weekend (Saturday and Sunday).

Pollutants such as carbon monoxide (CO), particulate matter (10 µ and 2.5 µ size), nitrogen oxide (NO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) surges high on weekdays and are at relatively lower concentrations on weekend (e.g. Charles et. al., Kakoli et. al., Pei-Hua Tan et. al., Rosiberto et. al., S. B. Debaje et. al.). Thorough observation from the data reveal that ozone (O_3), a major photochemical oxidant, increases on weekend especially on Sundays contrary to decreasing concentration of other pollutants like NO_x and some hydrocarbons which acts as its precursors. Such observations are also referred as 'Weekend effect' by many studies (Charles et al., Eric M. Fujita et al., J. G. Murphy et. al., Rosiberto et. al., Pei-Hua Tan et. al, S. Stephens et. al., S.B. Debaje et. al.). Ozone shows a composite pattern as

some instances also show increase concentration of O_3 on weekend irrelevant of the concentrations of its precursors. Such phenomenon is also observed by Pei-Hua Tan et. al. On weekend, the reduced particulate matter and aerosols results in more insolation accompanied with the precursor NO_x accumulated over the week fastens the ozone production. Seasonal variations (summer, winter, North East Monsoon, South West Monsoon) over weekday-weekend differences were also studied. Factors such as diurnal temperature range, daily maximum temperature, daily precipitation, annual precipitation and wind speed, and seasonal maximum and minimum temperature also influence the concentration.

This study attempts to carry out an assessment of six major pollutants for five years (2006 - 2010) exhibiting weekday–weekend differences in pollution levels of daily (24h) mean, weekly cycle and holiday effect was also studied.

POLLUTION EMISSION

Population explosion has led to remarkable increase in vehicular population, which is a significant contributor. The urban population of India has tripled within a period of 1951 to 1991, from 62.5 million to 217.6 million; correspondingly the vehicle population has increased almost 124 times from 0.3 million to 37.2 million (Ministry of State Transport 2000).A major section of population uses private vehicles including petrol and diesel eaters like SUVs, MUVs, trucks and two-wheeled vehicles. However, buses continue to be the most popular means of transportation for intra-city travel; they cater to about 60% of the total commuting requirements.

Private vehicles account for 30% of the total demand for transportation, while the rest of the demand is met largely by auto-rickshaws, taxis, rapid transit system and railways.By and large, the pollutants like CO, NO_x emanates from automobile exhausts, whereas use of coal based fuels causes heavy emissions of SO_2. The levels of NO_x are an issue of concern in the city. The variation strongly relates to the pattern of human activities over environment. The recent change of fuel to unleaded fuels, has omitted a lot of harmful emission but on the contrary it has increased emission of benzene and other organic compounds in urban pollution in Delhi.

Sources of pollution such as consumption of fuels for automobile and industrial purpose, and factors related to individual’s lifestyle, working and non-working environment, religious and cultural practices, festivities, which act as a major factor for variation. This explicitly expresses an idea about the magnitude by which the pollution can be mitigated by altering some of the habits of the population. It can also be resolved that pollution mitigation is a function of public willingness and proper understanding by the masses without with which it is impossible to tackle this threat.

METHODOLOGY

Description of Study Area

National Capital Territory of Delhi (NCT) is the largest metropolis by area and the second-largest metropolis by population in India. It is the eighth largest metropolis in the world by population with more than 12.25 million inhabitants in the territory. There are nearly 22.2 million residents in the greater National Capital Region urban area which also includes Noida, Greater Noida, Ghaziabad, Gurgaon and Faridabad along with other smaller nearby towns. There are 6.5 million registered vehicles in the city, which is the highest in the world among all cities, while the Delhi metropolitan region (NCR Delhi) has 11.2 million vehicles. Public transport in the metropolis includes the Delhi Metro, the Delhi Transport Corporation bus system, auto-rickshaws, cycle-rickshaws and taxis.

The area of study which is around Income-Tax Office (ITO), Bahadur Shah Zafar Marg is one of the prime commercial locations, with numerous corporate offices, govt. offices which makes it a location most affected by vehicular emissions hence turn out to be a principle site for such comparative study.

Ambient air here is greatly influenced by emissions from two coal-fired power generation stations namely, Pragati Thermal Power Plant (Indraprastha) and Badarpur Thermal Power Plants (Badarpur), rendering a lot of particulate pollution as well as CO, NOx and SO_2.

Data

Daily Averages of six pollutants, namely, CO, NO, NO_2, SO_2, O_3, PM (10µ & 2.5µ) were analyzedfor the years 2006 to 2010 from the National Ambient Air Quality Monitoring Station (NAAQMS) of Central Pollution Control Board (CPCB) near Income Tax Office (ITO) at the main traffic intersection on Bahadur Shah Zafar Marg, New Delhi (figure 1).

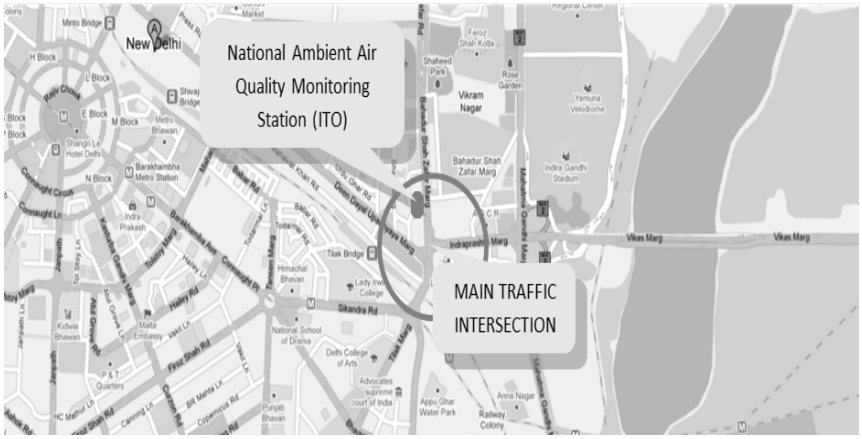


Figure 1: National Ambient Air Quality Monitoring Station (NAAQMS) at BSZ Marg, ITO, New Delhi

RESULTS AND DISCUSSIONS

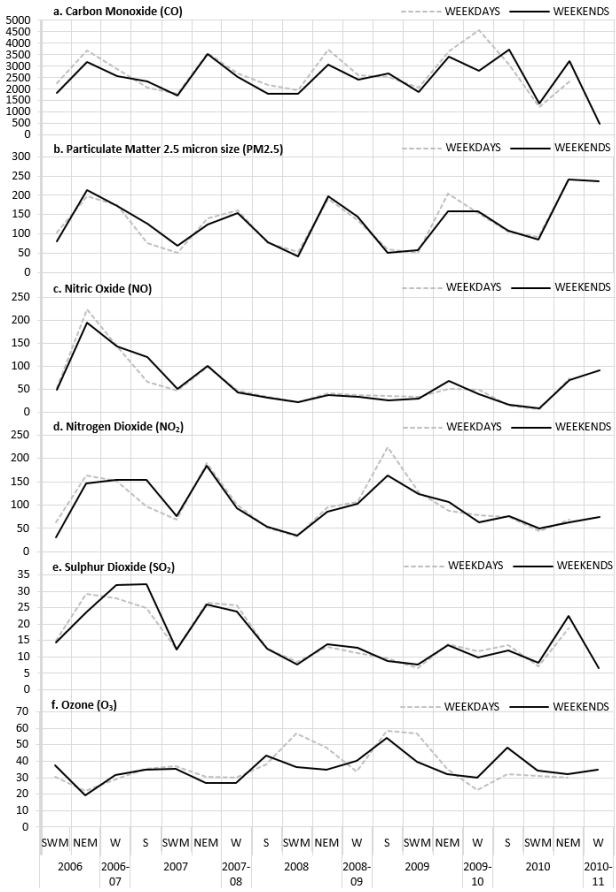
Weekday and Weekend Comparison

The 24-h averages of the parameters have been plotted on a time scale of consecutive seasons from year 2006 to 2010 on x-axis and concentration of respective parameters represented by the graphs of weekdays and weekends. Seasonal grouping of data facilitates analysis with similar meteorological conditions. The observations from figure 2 (a - f) are as follows:-

Carbon Monoxide

It is evident that average weekday concentration of carbon monoxide, as occurrence of co-ordinates of individual temporal ranges show a well defines sequence i.e. pollution levels on Weekdays is more than that on Weekends. Average concentration of CO, from 2006 to 2010, as on weekdays was 1.75 times as that on Saturdays and as much as 2.98 times as that on Sundays.

CO being one of the substances that are agelessly related to vehicular exhausts very well demonstrated the impact of vehicles over the environment. A well-defined pattern exist, with highest concentration during NEM is seen which gradually falls through winter and summer and reaches its lowest in the season of SWM. Year 2010 shows CO with 1.5 times more concentration than that fixed for national ambient air.



SWM – South West Monsoon NEM-North East Monsoon S-Summer W- Winter

Figure 2: Weekday-Weekend Comparison w.r.t. Seasons

Particulate Matter

Particulate Pollution is the category which causes major respiratory track related disorders like asthma, etc. Apart from the natural sources transportation, stationary combustion and industrial and traffic-related fugitive emissions, street dust etc. can be ways of particulate pollution. The concentration of PM2.5 as on Weekdays was 1.12 times as that on Saturdays and 1.18 times as that on Sundays.PM also shows highest concentration during NEM which gradually recedes through winter and summer and reaches its lowest in the season of SWM. Particulates are seen to rise in year 2010. The average concentration of PM2.5 throughout the period (2006-10) studied, had always been above by about 3.34 times the NAAQS permissible limit and hence can be said as an area of greater vitality for the need to mitigate pollution.

Oxides of Nitrogen

Nitrogen oxides are precursors of both acid precipitation and ozone, each of which is blamed for injury to plants. It is nitrogen oxide that absorbs sunlight, initiating the photochemical processes that produce nitric acid, which may precipitate with the rainfall. As substantiated by existing data from 2006 to 2010, on an average, concentration of NO as on Weekdays was 1.56 times as that on Saturdays and 1.62 times as that on Sundays. Also the concentration of NO_2 as on Weekdays was 1.28 times as that on Saturdays and as much as 5.76 times as that on Sundays. NOx higher concentration during NEM is seen which gradually falls through winter and summer and reaches its lowest in the season of SWM. After the high of 2006, level of NO lowered from 2007 to 2009 but soared again in year 2010.

Sulphur Dioxide

Sulphur dioxide, being an integrated component of fossil fuels, leads to emission amount of oxides of sulphur into

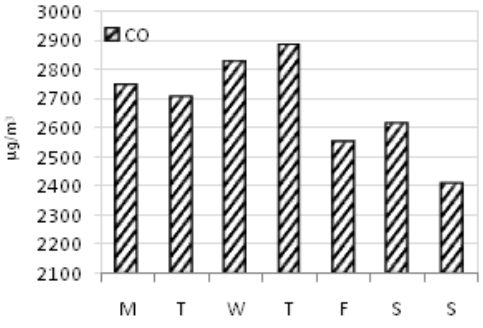
atmosphere. From 2006 to 2010, the average concentration of SO_2 as on Weekdays was 1.31 times as that on Saturdays and 1.27 times as that on Sundays. Similar to CO, PM and NOx, SOx also shows a well-defined pattern with higher concentration during NEM is seen which gradually falls through winter and summer and shows steep fall with the onset of SWM reaches its lowest in this season. The pattern of SOx from 2006 to 2010 is shows a falling trend.

Ozone

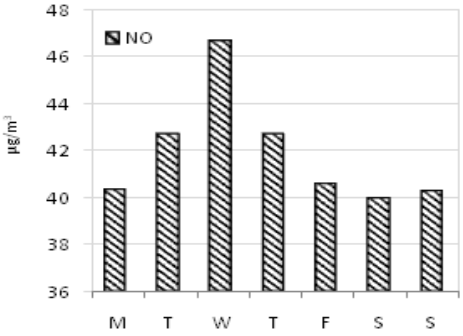
Ozone shows somewhat erratic behavior as per the data from 2006 to 2010, average concentration of O_3 on Weekdays was 1.22 times as that on Saturdays and is as much as 1.15 times as that on Sundays. That is, with respect to other pollutants ozone shows an opposite trend. The graphs shows peaks at Saturdays and Sundays. Contrary to CO, PM and NOx, and SOx, Ozone shows lowest levels in NEM increases through winter and summer and reaches its highest levels in SWM. Ozone shows significant influence of solar radiation and obliquity to sun. The rain-washed air during SWM gives way to increased insolation and causes increased photo-oxidation of NOx and hydrocarbons (HCs). It has been observed that ozone shows higher levels where NOx shows lower levels and vice versa. Years 2008 and 2009 shows higher levels of O_3.

Weekly Variation

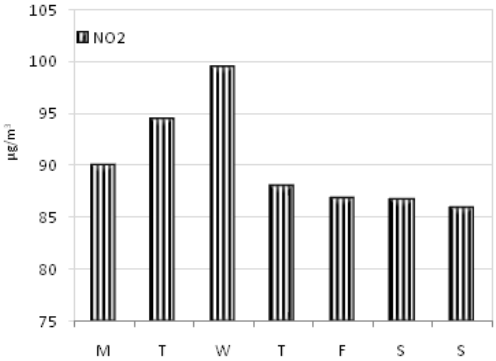
It was observed (figure 3) that the concentration of the pollutants such as CO, NO, NO_2 falls significantly as we approach Sundays i.e. towards the end of the week. It is found so because of the changing pattern of vehicular usage of individuals in urban areas, which shows a cyclic behavior of a periodicity of 1 week. Sunday being a day of official off becomes the day for rest and entertainment for the population; hence it is envisaged with clearer roads, lesser traffic flow, hence less pollution as compared to that on other days. On Sundays, it is evident that the concentration of pollutants even at the normal peak times is far below the average weekday's level of pollutants. Similar trend can be observed as most of the government offices and private offices observe a half-day at work on Saturday; hence rendering a pollution level slightly above than that on Sundays but assertively below the pollution levels on Weekdays.



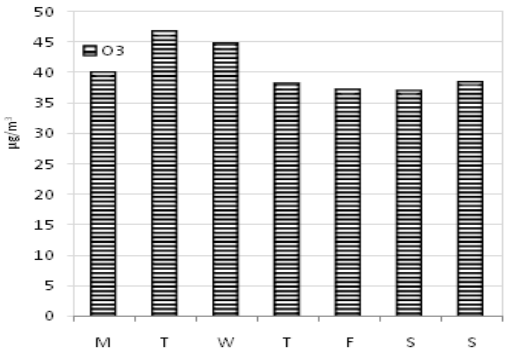
a. Carbon Monoxide



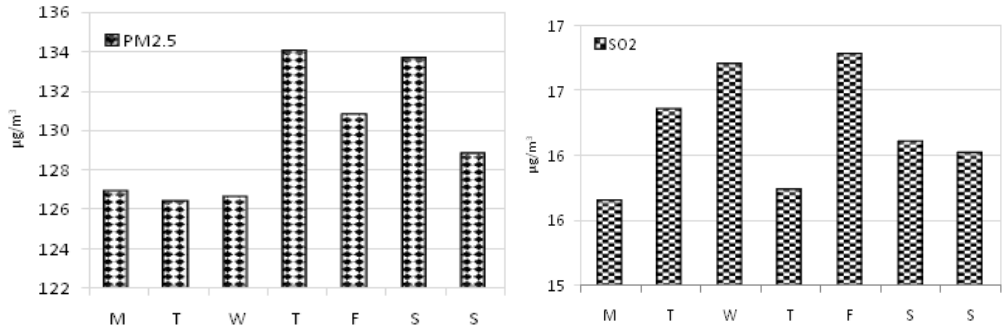
b. Nitrogen Oxide



c. Nitrogen Dioxide



d. Ozone



e. Particulate Matter (2.5µ) **f. Sulphur Dioxide**

Figure 3: Weekly Variations of Various Parameters

Public Holidays

A public holiday or gazetted holiday marks the day-off for all Govt. Offices and many private institutions. The holiday effect on such a leave is exhibited for the period of 2006 to 2010 for approx. 18 public holidays occurring per year. The pollution levels of parameters reduces by 3-4% for O_3 and PM; 11-14 % for NO, CO and NO_2on a holiday w.r.t. the pollution level of the same parameter during working days. The pollution levels falls on the holiday and again starts rising from the next day. By grouping the parameters on the PH according to the day of the week on which it occur, air quality parameters can further be analyzed. It shows that if the PH occurs in the start of the week (i.e. on Monday or Tuesday) the pollution levels were found to be much lower than even those on weekends. Most pollution is observed if PH occurs in mid of the week (i.e. Wednesdays) and at weekends (esp. Saturdays).

CONCLUSIONS

Daily measurements of six air pollutants from CPCB-NAAQMS at ITO station from 2006 to 2010 were used to study the weekday - weekend comparison. The main conclusions from this study are as follows:-

- From 2006 to 2010 a rising levels of carbon-monoxide and particulates, whereas a falling trend of sulphur dioxide, nitrogen dioxide and ozone is observed.
- Concentration of CO as on weekdays is 1.75 times as that on Saturdays and is as much as 2.98 times as that on Sundays. Year 2010 shows CO with 1.5 times more concentration than that fixed for national ambient air.
- Particulates are seen to rise in year 2010 and its average concentration as on Weekdays is 1.12 times as that on Saturdays and is as much as 1.18 times as that on Sundays. The average concentration of PM2.5 throughout the period (2006-10) had been more than 3.34 times the NAAQS.
- Concentration of Oxides of Nitrogen; NO on Weekdays was 1.56 times as that on Saturdays and as much as 1.62 times that on Sundays. Similarly concentration of NO_2 as on Weekdays is 1.28 times as that on Saturdays and is as much as 5.76 times as that on Sundays.
- Average concentration of SO_2 as on Weekdays is 1.31 times as that on Saturdays and is as much as 1.27 times as that on Sundays.
- Concentration of O_3 as on Weekdays is 1.22 times as that on Saturdays and is as much as 1.15 times as that on Sundays. It has been observed that ozone shows higher levels where NOx shows lower levels and vice versa. Years 2008 and 2009 shows higher levels of O_3.

- Public holidays show that the pollution levels reduce by at least 4% for O_3 and PM and up to 11 to 14 % for NO, CO and NO_2 from the pollution levels in the same week. PH if occurs in the start of the week (i.e. on Monday or Tuesday) show lower pollution levels than the weekends. Most pollution is observed if PH occurs on mid-week (Wednesday) or at weekends (Saturdays).

To wrap up, the assessment differentiates air pollutant concentration between weekdays and weekend. The observed phenomena of weekend effect and holiday effect provide evidence of impact of weekly cycle of human activities on ambient air. Pollution variation corresponds to the pattern of working on weekend and weekdays. Vehicular emission largely increases on weekdays and drops down on weekends. Such weekend effect or holiday effect is also seen on public holidays. A general trend of fall in concentration has been found during the season of SWM. The study also shows, in particular, higher levels of Ozone during weekends.

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