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Research Article

Air Quality Changes during Weekend Lockdown amid Coronavirus (COVID-19) Pandemic: Case Study of Jammu District (J&K), India

Vishaw Vikas[1]*, Jag Paul Sharma[2], Mahender Singh[1], Manish Kr. Sharma[3], Rohit Sharma[4], Vinod Gupta[5], Balbir Dhotra[2], Amitesh Sharma[2], Satish Kumar[2] and Aarushi Singh[6]

[1]Agrometeorology Section, Division of Agronomy, SKUAST Jammu
[2]Directorate of Research, SKUAST Jammu
[3]Division of Statistics and Computer Sciences, SKUAST Jammu
[4]AMFU, Regional Agricultural Research Station, Rajouri, SKUAST Jammu
[5]Krishi Vigyan Kendra, Samba, SKUAST Jammu
[6]Division of Plant Pathology, SKUAST Jammu

Abstract

An analysis was performed to evaluate the impact of weekend lockdown on air quality parameters of Jammu district, Jammu Kashmir Union Territory, India. The data was analyzed through Descriptive Statistics, Pearson Correlation, ANOVA and Regression using SPSS 16.0. The results stated that $PM_{2.5}$ and PM_{10} consistently dropped by -11.71% and -12.18% during weekend restrictions as compared to weekdays. NO_2 and O_3 also projected significant deviations in atmosphere by -8.37% and -17.01% ultimately imparting change in air quality index by -15.09%. Also, the ANOVA and regression models projected that the air quality parameters significantly contributed to Air Quality Index (AQI) which means that the reduction in emissions due to weekend lockdown restrictions must have contributed to better air quality index. Therefore, with the variable significant patterns observed in almost all air quality parameters, it can be concluded that weekend lockdown might be an effective tool in mitigating the air quality and might act as basis in framing emission control policies for future.

Keywords: $PM_{2.5}$, PM_{10}, NO_2 (Nitrogen Dioxide), O_3 (Ozone), Air Quality Index (AQI)

***Correspondence**
Author: Vishaw Vikas
Email: vishaw.vikas@gmail.com

Introduction

Despite the large-scale implementation of programmes and plans like National Clean Air Programme (NCAP) to curb the menace of emissions [1], India hasn't achieved a great success in maintaining healthy air quality index. Every year, the parts of North India are being exposed to pollutants due to emissions from stubble or crop residue burning, vehicular movement and industries [2-4] raising concerns about healthy air quality. Also, increasing population and overexploitation of natural resources can be considered as a major reason for deterioration of air quality [5-8]. It has been noticed that since 2008, there has been increase in sales of vehicles with a rate of 15% per annum [9] and the same demand is expected to rise by 200% in between 2015 to 2030 [6] which will also cause a huge surge in heart and lung diseases in humans. According to World Health Organization and Central Pollution Control Board, Indian cities have been reflected every year in top 20 most polluted cities in world in which particulate matter (PM) is considered as dominant air pollutant in major parts of North India [10, 11] and accumulation of which has resulted in poor air quality leading to death of approximately 10 lakh people in 2015 and 12.4 lakh in 2017 in India [10, 12]. Shockingly, in 2019 Jammu city also faced highly deteriorated air quality and since then there is a sharp rise in infections related to respiratory system [13].

Coronavirus disease 2019 was first traced in Wuhan, China in December 2019 [14]. The World Health Organization declared COVID-19 as pandemic [15] because of its rapid spread in several countries outside China and as a result of which India imposed restrictions in the form of total lockdown for 21 days (in 1st phase) and subsequent lockdown and unlock down phases to avoid the spread of coronavirus. As a result, almost every industrial operation was halted and public transportation movement was prohibited ultimately having a dramatic impact on weather and pollution parameters of Shivaliks, PirPanjal and mid hill region of J&K [16, 17]. After the complete unlock down in Jammu during March to June 2020, the district again witnessed a surge in coronavirus cases [18, 19], in response to which the Jammu Kashmir Union Territory administration implemented weekend lockdown strategy i.e. Friday 6:00 PM to Monday 6:00 AM (72 hours) from July 24, 2020 [20] onwards to minimize the human-human interaction and disease spread. The weekend lockdown restrictions not only proved to be an effective strategy to curb the infection rate but indirectly also worked as a medium to improve the air quality.

So, the weekend lockdown enforces restrictions and self-quarantine measures in Jammu district, which helps in reducing emissions from transportation and industries. The changes in air pollution during the weekend in area can provide an insight into the achievability of air quality improvement when there are significant restrictions in emissions. Consequently, quantitative appraisal of changing air quality parameters desired to be carried out so as to understand the upshot of weekend lockdown measures on air quality index particularly when there is a need to implement such alternative control actions in the area. The present study is an effort in this direction to assess the usefulness of the weekend lockdown as an alternative strategy for diminution of changing air quality pattern in Jammu district of Jammu Kashmir. The objectives of the study:

- To quantify the change in concentration of pollutants due to the implementation of lockdown regulation
- To study the correlation among the pollutants
- To analyze the efficacy of lockdown in improvement of Air Quality Index (AQI) of the district

Focusing on the Jammu district, the study is thought to be a conceivable addition to the scientific community and policy makers not only to assess the impacts of lockdown restrictions on improving the air quality, but also its efficacy as an easy alternative action plans for upgrading healthy air quality levels within the region with public involvement in upcoming years.

Material and Method

Jammu occupies an area of about 3097 sq. kms and lies in between 32°39'35.5''N latitude and 74°47'35.0''E longitude at an elevation of 332 meters above the mean sea level in site the Shivalik foothill plains of North-Western Himalayas and is the winter capital of Jammu Kashmir. It is largest populated District of the Union Territory and second largest in terms of population density. In order to analyze the changes in air quality, AQI (Air Quality Index), $PM_{2.5}$, PM_{10}, NO_2 (Nitrogen Dioxide) and O_3(Ozone) were the air quality parameters selected to quantify the change during weekend lockdown restrictions i.e. From 31st July to 24th August 2020. The real time data pertaining air quality parameters of the mentioned timeline was collected from air.plumelabs.com. The daily data pertaining Temperature and Rainfall of the area was collected from accuweather.com. The data was analyzed through Descriptive Statistics, Pearson Correlation, ANOVA and Regression using SPSS 16.0.

Results and Discussion

Correlation

The Pearson correlation analysis (**Table 1**) clearly describes a positive relation of Air Quality Index (AQI) with $PM_{2.5}$ and Ozone (O_3) stating the significant impact of both these pollutants. The PM_{10} was found in significant positive correlation with $PM_{2.5}$ and not with any other parameter. Nitrogen dioxide (NO_2) was found negatively significant with ozone (O_3). Similar pattern of correlations were also during analysis of air quality variation by [21].

Table 1 Correlation of coefficients among air pollutants and AQI (Air Quality Index)

↓Air Quality Parameters→		AQI	$PM_{2.5}$	PM_{10}	NO_2
$PM_{2.5}$	Pearson Correlation	.545*			
	Sig. (2-tailed)	0.036			
	N	15			
PM_{10}	Pearson Correlation	0.348	.553*		
	Sig. (2-tailed)	0.204	0.032		
	N	15	15		
NO_2	Pearson Correlation	-0.304	0.498	0.041	
	Sig. (2-tailed)	0.271	0.059	0.886	
	N	15	15	15	
O_3	Pearson Correlation	.664**	-0.11	0.253	-.812**
	Sig. (2-tailed)	0.007	0.695	0.363	0
	N	15	15	15	15

**Correlation is significant at 1% level of significance;
*Correlation is significant at 5% level of significance

Descriptive Statistics

The descriptive coefficients were highlighted in **Table 2**. The magnitude of change was highlighted by a significant deviation of -15.09% in Air Quality Index (AQI) during implementation of weekend lockdown restrictions compared to weekdays normal activities. Also, $PM_{2.5}$ consistently dropped by -11.71% during weekend as compared to weekdays. PM_{10} also decreased in atmosphere by -12.18% during weekend lockdown restrictions. NO_2 and O_3 also projected significant deviations in air by -8.37% and -17.01% during weekend lockdown.

Regression Models

Regression models were generated keeping Air Quality Index as dependent variable (**Table 3**). In model 1, it was noticed that ozone (O_3) alone was contributing 44% variation to air quality index. However in model 2, ozone (O_3) along with $PM_{2.5}$ tend to contribute 38% more variation in air quality index compared to model 1; however in last model, the ozone (O_3) along with $PM_{2.5}$ and PM_{10} reflected 6% and 44% more variation than model 1 and 2 towards air quality index. This reflects that lowering of emissions of all pollutants during lockdown could have significantly contributed to healthy air quality during weekends, according to model 3.

Table 2 Descriptive Coefficients of Air Quality Parameters of Jammu district during weekend lockdown restrictions

Descriptive Coefficients	Mean	Std. Deviation (SD)	C.V (%)
AQI (Air Quality Index)	54.59	6.76	12.4
$PM_{2.5}$ (µg m^{-3})	22.05	3.33	15.1
PM_{10} (µg m^{-3})	39.32	6.40	16.3
NO_2 (µg m^{-3})	19.58	5.40	27.6
O_3 (µg m^{-3})	84.49	17.76	21.0

Table 3 Regression Models of Air Quality Parameters of Jammu District during weekend lockdown restrictions

Model Summary					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.664[a]	0.44	0.39	5.24	
2	.910[b]	0.82	0.79	3.02	
3	.941[c]	0.88	0.85	2.58	1.47

a. Predictors: (Constant), O_3 (µg/m³)
b. Predictors: (Constant), O_3 (µg/m³), $PM_{2.5}$ (µg/m³)
c. Predictors: (Constant), O_3 (µg/m³), $PM_{2.5}$ (µg/m³), PM_{10} (µg/m³)
d. Dependent Variable: AQI

Table 4 ANOVA (Analysis of Variance) of air quality parameters during weekend lockdown restrictions

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	281.84	1	281.84	10.25	.007[a]
	Residual	357.20	13	27.47		
	Total	639.04	14			
2	Regression	528.95	2	264.47	28.82	.000[b]
	Residual	110.09	12	9.17		
	Total	639.04	14			
3	Regression	565.35	3	188.45	28.12	.000[c]
	Residual	73.69	11	6.70		
	Total	639.04	14			

a. Predictors: (Constant), O3 (µg/m³)
b. Predictors: (Constant), O3 (µg/m³), PM 2.5 (µg/m³)
c. Predictors: (Constant), O3 (µg/m³), PM 2.5 (µg/m³), PM 10 (µg/m³)
d. Dependent Variable: AQI

ANOVA

To observe the aggregate data variability, ANOVA test was applied which led to the generation of three models (**Table 4**), Model 1 (O_3), Model 2 (O_3 + $PM_{2.5}$) and Model 3 (O_3 + $PM_{2.5}$+ PM_{10}) which projected that the air quality parameters were significantly contributing to Air Quality Index (AQI) and deviation in any parameter will lead to a significant change in Air Quality Index (AQI).

Graphical Analysis

The graphical observation (**Figure 1**) clearly depicts the pollutant level in air significantly reduced with time during weekend lockdown. Ozone is usually found in stratosphere protecting us from harmful ultraviolet rays and during the interaction with organic compounds emitted by vehicles and industrial smoke; it then reacts in presence of sunlight and even gets transported to rural areas as a pollutant [22]. During the analysis, it was found that ozone levels consistently dropped during weekend starting from Friday to Sunday and can be attributed to reduced vehicular movement and industrial operations; however a steep increase in ozone concentration can be noticed during weekdays. Nitrogen dioxide (NO_2) is emitted from the combustion of fossil fuels and is a highly reactive pollutant [22]. The main source of NO_2 is traffic pollution and because of restrictions on vehicular movement during lockdown, a decreasing pattern was observed in NO_2 levels on Saturday and more effective on Sunday; although an increasing pattern observed during weekdays. Particulate matter (PM) is a pollutant consisting a mixture of solid and liquid particles suspended in air and the main sources of PM are combustion engines, industrial fuels, and other industrial activities like mining, manufacture of cement, building, etc.; also, PM is formed in the air through chemical reactions of gaseous pollutants and are the products of atmospheric transformation of nitrogen oxides and sulfur dioxide [22]. However, both $PM_{2.5}$ and PM_{10}, consistently dropped with time during weekends especially on Saturday and Sunday with steep increase during weekdays. Overall, AQI (Air Quality Index) along with air quality parameters (**Figure 2**) improved during the weekend lockdown thereby making air healthier to breathe. The same impact of lockdown on air quality improvement was noticed in several parts of the India and world during lockdown restrictions [16, 23-30].

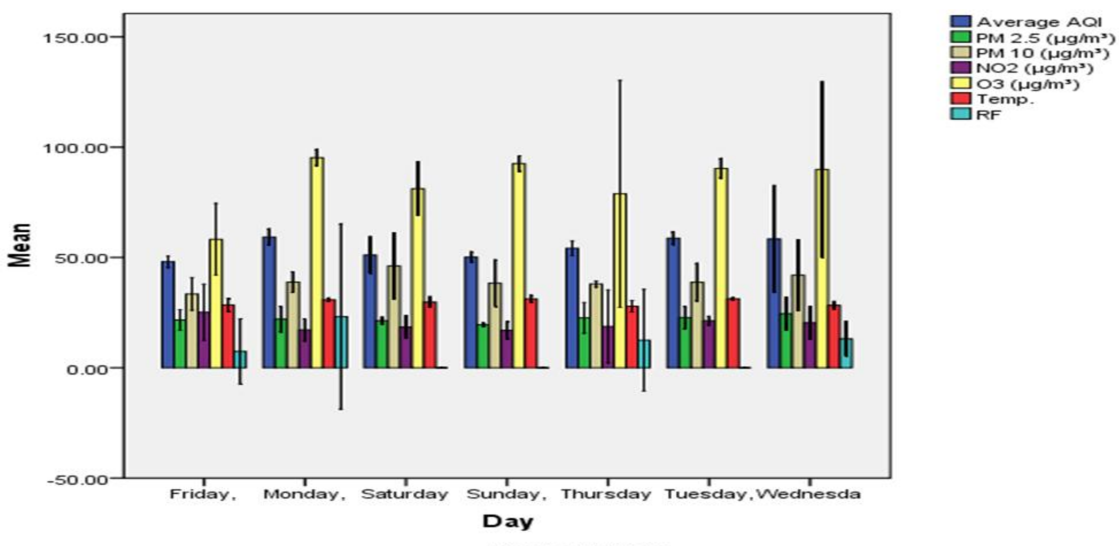

Figure 1 Graphical description of pollutants level during weekend lockdown timeline in Jammu

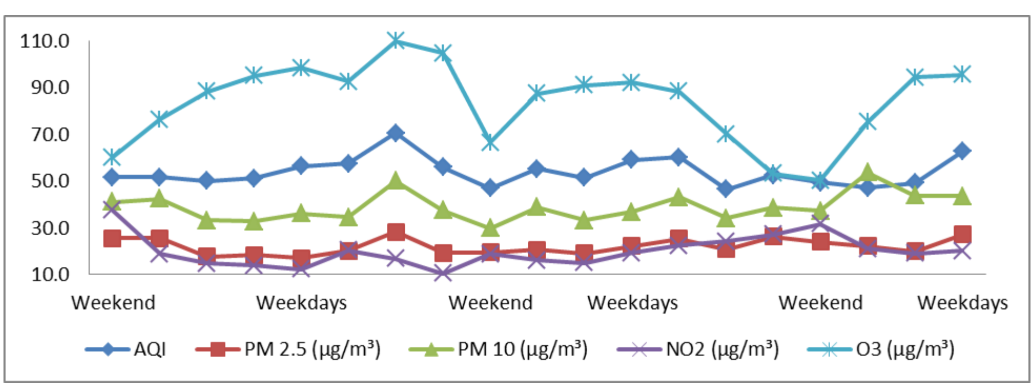

Figure 2 Air Quality Parameters during weekdays and weekend

Conclusion

Among all pollutants, $PM_{2.5}$ and PM_{10} had a maximum reduction in the area, so, the preliminary analysis of air quality data shows that the COVID-19 pandemic may be considered as a 'blessing in disguise,' where air quality is improving and earth is reviving itself [25]. This reduction in the air pollution due to the implementation of weekend lockdown can significantly minimize several health issues such as respiratory problems, cardiovascular illness, asthma, premature deaths, etc. The results of the study will also attract the attention of the Jammu Kashmir Union Territory administration to ponder on how to improvise the air quality which will help to sustain better public health in the area. This study is therefore, beneficial to the policymakers and environmentalists to analyze and assess the effect of weekend lockdown restrictions on reduction of pollutants and improvement of air quality so that future infrastructure and policy can the planned accordingly for better human, plant and animal health.

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