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Monitoring Studies of Pre, During and Post Lockdown Period on Air Quality Parameters in Sarora, Raipur (C.G.)

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ABSTRACT: Covid-19 lockdown plays a major role in reducing air pollutants all over the country. The present work aims to analyses the air pollutants such as particulate matter (PM_{10}), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) in Chhattisgarh i.e., Raipur in 3 phases of Pre-lockdown, During lockdown, and Post lockdown in the same time frame (1st March- 31st May).All the data are taken from Chhattisgarh Environment ConservationBoard (CECB) (https://www.enviscecb.org/). We compared the Pre, During, and Post lockdown data to check the increments and decrements of Air Quality. For these, we used Different Types of Air Quality Index (AQI) to conclude the air quality such as Indian AQI, Oakridge AQI, and Average AQI. The results show some mixed variation such that in Pre lockdown (1st March-31st May 2019) the Air Quality Index of Sarora, Raipur was 81 but During lockdown (1st March-31st May 2020) reduced to 47 a fall of 40% and in Post lockdown (1st March-31st May 2021) it increases approx. 45% i.e., 69. The overall study gives a hint that During the lockdown phase (1st March-31st May 2020) shows a declination but when the unlock process starts the main pollutant show increments gradually. The current review gives proof that the boundless execution of air contamination measures can bring about prompt air quality advantages.

KEYWORDS: Covid-19 Lockdown, $PM_{10,}$ SO_2, NO_2, Air Quality:IND AQI, AVG AQI, and ORAQI.

I. INTRODUCTION

Air is one of the most important constituents of our environment an average human being requires about 12 kg of air each day, which is nearly 12 to 15 times greater than the amount of food consumed. Eventually, even a small concentration of pollutants present in the air becomes more harmful to human health, in comparison to similar concentrations of pollutants present in food. Any change in the natural and normal composition of the air (either qualitative or quantitative), that may adversely affect the living system, particularly the human life, invariably causes air pollution. When the quantum of air pollutants exceeds the self-cleansing properties of the ambient air and starts causing harmful effects on human health and the surrounding abiotic world, then the air is said to be polluted.

Study Area

Raipuristhecapitalcity of theIndianstateof Chhattisgarh.Raipurisalsotheadministrative headquarters of the Raipur District and Raipur division, and the largestcity of the state. It is located at21.25°N 81.63°E. WoolWorth(I)Ltd,Sarora,Raipur(IndustrialArea)whichislocatedat21.35678^{0}N81.6565^{0}E.

1.1 Various Pollutants Causing Air Pollution:

The atmospheric air may contain hundreds of air pollutants from natural or anthropogenic (manmade) sources. The following five primary pollutants contribute to about 90% of the global air pollution The Important Primary air pollutants are:

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S. No.	Pollutant	Characteristics	Source	Health Effects
1.	Suspended particulate matter	Solid particles like dust, smoke and	Dust storm; cigarette	Effects on breathing and
2.	Sulphur dioxide (SO_2)	Colourless gas; taste threshold at	Combustion of oil and coal in	Effects on breathing,
3.	Nitrogen dioxide (NO_2)	NO is a reddish brown highly	High temperature	NO plays a major role in

1.2 Covid Situation:

A Coronavirus pandemic makes a misfortune our country. It is started in the Wuhan lab in China. Because of these SARS-CoV-2, the human is influenced without any problem. Toward the beginning of March 2020, because of its quick spread, the WHO proclaimed COVID-19 as a pandemic. Along these lines, on 22nd March 2020, the Government of India declared a Janta time limit all around the country, however one day isn't sufficient to control this hazardous infection so again on March 24, 2020, the lockdown is reported. The significant areas adding to air contamination are transport, ventures, power plants, development exercises, biomass and decline to consume, street dust resuspension, and private exercises. Because of severe travel limitations and the closing down of superfluous exercises including those of air contaminating areas, air quality improvement has been noted in numerous towns and urban communities the country over. Lockdown because of the COVID-19 pandemic has added to further developing the general air quality. Over 40% abatement in $PM_{2.5}$ and 47% diminishing in PM10 in north Indian urban communities. Over a 40% abatement in CO in north Indian urban communities aside from Delhi and Patna.

1.3 Air Quality Index (AQI)

An air quality index is defined as an overall scheme that transforms the weighed values of individual air pollution-related parameters (for example, pollutant concentrations) into a single number or set of numbers (Ott, 1978). The result is a set of rules (i.e., a set of equations) that translate parameter values into a simpler form by 3 means of numerical manipulation. If actual concentrations are reported in µg/m3 or ppm (parts per million) along with standards, then it cannot be considered as an index. At the very last step, an index in any system is to group-specific concentration ranges into air quality descriptor categories.

Oakridge Air Quality Index (ORAQI)

Oak Ridge National Laboratory published the ORAQI in 1971. It was based on the 24-hour average concentrations of the following five pollutants:

1. SO_2
2. NO_2
3. PM
4. CO
5. Photochemical Oxidants

The sub-index is calculated as the ratio of the observed pollutant concentration to its respective standard. As reported by Babcock and Nagda (1972), the ORAQI aggregation function was a nonlinear function:

$$\mathbf{ORAQI = \{5.7\ \Sigma\ Ii\}^{1.37}}$$

Where Ii = (X/Xs)i
X = Observed pollutant concentration
Xs = Pollutant Standard
I = Pollutant
The standards for the pollutants used in developing ORAQI are given in Table

BreakPoint Concentrations of ORAQI

Pollutant	Standard Value
Photochemical oxidants	0.03 ppm
Sulphur oxides	0.10 ppm
Nitrogen dioxide	0.20 ppm
Carbon monoxide	7.0 ppm
Particulate matter	150 ug/m^3

The constants (e.g., 5.7 and 1.37 in the equation) are so selected that the ORAQI = 10 when all concentrations are at their naturally occurring or backgrounds levels and ORAQI = 100 when all concentrations are at their standards. Although well-defined descriptors are given, its developers imply no correlation with health effects. It is subjected to eclipsing and ambiguity. It is also difficult to explain to the public and involves complex calculations.

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Indian Air Quality Index (IND-AQI)

Air quality standards are the basic foundation that provides a legal framework for air pollution control. An air quality standard is a description of a level of air quality that is adopted by a regulatory authority as enforceable. The basis of the development of standards is to provide a rationale for protecting public health from adverse effects of air pollutants, to eliminate or reduce exposure to hazardous air pollutants, and to guide national/local authorities for pollution control decisions. With these objectives, CPCB notified (http://www.cpcb.nic.in) a new set of Indian National Air Quality Standards (INAQS) for 12 parameters [carbon monoxide (CO) nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), particulate matter (PM) of less than 2.5 microns size ($PM_{2.5}$), PM of less than 10microns size (PM_{10}), Ozone (O_3), Lead (Pb), Ammonia (NH), Benzo(a)Pyrene (BaP), Benzene(C_6H_6), Arsenic (As), and Nickel (Ni)]. The first eight parameters have short-term (1/8/24hrs) and annual standards (except for CO and O_3) and the rest four parameters have only annual standards.

Indian National Air Quality Standards (units: µg/m^3 unless mentioned otherwise)

Pollutant	SO_2	NO2	$PM_{2.5}$	PM_{10}	O_3		CO		Pb	NH3
Averaging time	24	24	24	24	1	8	1	8	24	24
Standard	80	80	60	100	180	100	4	2	1	400

B(a)P, C6H6, As, and Ni have annual standards

IND-AQI Category and Range

AQI category	AQI Range
Good	0-50
Satisfactory	51-100
Moderate	101-200
Poor	201-300
Very poor	301-400
Severe	401-500

Breakpoints for AQI Scale 0-500 (units: µg/m3 unless mentioned otherwise)

AQI	PM10	PM2.5	NO2	O3	CO	SO2	NH3	Pb 24-
Good	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory	51-100	31-60	41-80	51-	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate	101-	61-90	81-	101-	2.1- 10	81-380	401-800	1.1-2.0
Poor	251-	91-	181-	169-	10.1-17	381-	801-	2.1-3.0
Very poor	351-	121-	281-	209-	17.1-34	481-	1201-	3.1-3.5
Severe	430+	250+	400+	748+	34+	1600+	1800+	3.5+

Health Statements for AQI Categories

AQI	Associated Health Impacts
Good	Minimal Impact
Satisfactory	May cause minor breathing discomfort to sensitive people
Moderate	May cause breathing discomfort to the people with lung disease
Poor	May cause breathing discomfort to people on prolonged exposure
Very Poor	May cause respiratory illness to the people on prolonged exposure
Severe	May cause respiratory effects even on healthy people and serious

Interpretation of Air quality using IND-AQI

The sub-index (Ip) for a given pollutant concentration (Cp), as based on 'linear segmented principle' is calculated as:

Ip= [{(IHI - ILO)/ (BHI -BLO)} * (Cp-BLO)] +ILO

BHI= Breakpoint concentration greater or equal to given concentration BLO= Breakpoint concentration smaller or equal to given concentration IHI = AQI value corresponding to BHI

ILO = AQI value corresponding to BLO; subtract one from ILO, if ILO is greater than 50 Finally; AQI = Max (Ip) (where; p= 1,2,...,n; denotes n pollutants).

Average Air Quality Index

Another method to determine the air quality index by (Joshi et al., (2010)) The air quality

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index (AQI) is a measure of the ratio of the pollutant's concentration to the status of ambient air in places. Indices of air pollutants or air quality have been used for about 25 years.
The following computation was used to drive the air quality index of the sites under consideration:

Avg AQI = ¼(RSPM/sRSPM + SPM/sSPM+ SO2/sSO2+ NO2/sNO2) * 100

Where sRSPM, sSPM, sSO_2, and sNO_2 represent the ambient air quality standards as prescribed by the Central Pollution Control Board of India (CPCB), and RSPM, SPM, SO_2, and NO_2 represent the actual values of pollutants obtained on sampling. After compiling the results, the concentration of each pollutant was converted into an AQI. The pollutant with the highest AQI number became the overall AQI for a particular location. The higher the AQI value, the greater is the level of air pollution and the greater the damage to health. The AQI scale was divided into five categories describes the range of air quality and its associated potential health effect. The indices use health• based descriptions to provide meaningful information to the public. The five levels of AQI are depicted in Table

Index values of air quality index calculation

Index value	Remark
0-25	Clean air
26-50	Light air pollution
51-75	Moderate air pollution
76-100	Heavy air pollution
Above 100	Severe air pollution

II. LITERATURE REVIEW

This review addresses pollutants, an instrument used to determine pollutants, different types of AQI, their calculation, The AQI is obtained from CPCB was assess for three lockdown phases researcher compared the air quality data for the unlocking phase with a coinciding period in 2019 to determine the change in pollutant concentration during lockdown analyzing the daily AQI data for six pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, and O_3) meta-analyses also performed to determine the standard deviation and mean of each lockdown phase and their difference was computed in percentage in comparison to 2019 along with Linear Correlation and Linear Regression to determine the relationship among the air pollutants and their trend for the lockdown the result shows some variation gradually to rapid reduction in the main pollutant such as PM_{10}, $PM_{2.5}$, SO_2, and CO but the increment in Ozone due to drastic increase in NO_2 by 80% later when the to unlock process starts the main pollutant show increment gradually. During total lockdown air quality significantly improved which gives information of cities administration to develop rules and regulations on how they improve can the air quality.Studied Impact of Lockdown during COVID- 19 Pandemic on the Air Quality of North Indian Cities. The main aim was to determinethe change in air pollutants including Particulate Matter $PM_{2.5}$ and PM_{10} and gaseous pollutant SO_2, NO_2, and O_3.in all-region all the pollutants showed a declining trend but O_3 shows mixed variation.

III. MATERIAL AND METHODOLOGY

1. Particulate Matter (PM_{10})

Particulate matter is also known as atmospheric aerosol particles, atmospheric particulate matter, particulate matter (PM) or suspended particulate matter (SPM) are microscopic particles of solid or liquid matter suspended in the air. The term aerosol commonly refers to the particulate/air mixture, as opposed to the particulate matter alone. They have impacts on climate and precipitation that adversely affect human health, in ways additional to direct inhalation.

Instrument used / Equipment:

PM 2.5/10 Sampler i.e., Ambient Fine Dust Sampler, Model no. IPM-FDS-2.5/10µ INSTRUMEX is an advanced sampler that conforms to the USEPA and CPCB norms.This sampler uses a set of Impactors standardized by USEPA to separate coarse particulates from the air stream. For a sampling of PM 2.5, particles with an aerodynamic diameter larger than 10 microns are trapped by using the opposed jet impaction over a filter paper of specified Whatman number 7582-004 37mm diameter supported on surface by silicon oil and those having a diameter between 2.5 and 10 Microns are trapped over PTFE filters using the WINS Impactor. But for the sampling of PM 10, the WINS Impactor unit is replaced by PM 10 impactor assembly. Finally, the air stream leaving the WINS Impactor consists of only fine particulates with an aerodynamic diameter smaller than 2.5 microns. The flow is controlled by a

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microprocessor-based flow controller for maintaining the flow rate constant at 16.67 LPM.

Calculation of the volume of air sampled
$V = (F1 + F_2) T/2$
Were,
V = volume of air sampled in m^3
F1 = measured flow rate before sampling

F2 = measured flow rate after sampling
T = time of sampling
PM 10 concentration is calculated by:

PM 10 = (Wf-Wi) 1000/Va
Were,
PM10 = Mass concentration of PM 10 collected during the sampling period, µg/m^3
Wf, Wi = final and Initial mass of glass fibre filter paper, mg
Va = Total air volume sampled, m^3

2. Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2), a Colourless, bad-smelling, toxic gas, is part of a larger group of chemicals referred to as Sulphur oxides (Sox). These gases, especially SO_2, are emitted by the burning of fossil fuels — coal, oil, and diesel — or other materials that contain Sulphur. Diesel vehicles and equipment have long been a major source of Sulphur dioxide, but recent federal regulations to reduce the Sulphur content of diesel fuels have made a significant improvement in emissions from this sector. Sulphur dioxide is also a natural by-product of volcanic activity.SO_2 is the component of greatest concern and is used as the indicator for the larger group of gaseous Sulphur oxides (Sox). Control measures that reduce SO_2 can generally be expected to reduce people's exposures to all gaseous Sox. This May have the important co-benefit of reducing the formation of particulate Sulphur pollutants, such as fine sulphate particles. Emissions that lead to high concentrations of SO_2 generally also lead to the formation of another Sox.

Instrument used / Equipment:

High Volume Samplers are the basic instruments used to monitor ambient air quality. Envirotech APM 415 with its attachment for gaseous pollutant monitoring APM 411 was used. In these samplers, air-borne suspended particulates (SPM) are measured by passing air at a high flow rate of 1.1 to 1.7 cubic meters per minute through a high-efficiency filter paper (Whatman GF/A Glass Microfiber Filters) which retains the particles. The instrument measures the volume of air sampled, while the number of particulates collected is determined by measuring the change in weight of the filter paper as a consequence of the sampling. In High Volume, Sampler provisions have been made for simultaneous sampling of gaseous pollutants. The gaseous attachment contains three impinger bottles of 35 ml capacity for simultaneous absorption of different gaseous pollutants. Here the air is passed through suitable reagents that would absorb specific gases where gaseous pollutants like SO_2 , NOx, etc. The gaseous sampling requires only a few LPM (1-3 LPM) of airflow.
With the help of stoichiometric calculations, calculate the concentration of SO2, in the ambient atmosphere.

SO_2 concentration can be calculated by
SO_2 = (Mol. wt. of SO_2 W*10^6)/ (Mol. wt. of $BaSO_4$Va)
Were,
SO_2 = Concentration of SO_2 , µg/m^2
V = Total air volume sampled, m^3
W = weight of $BaSO_4$ formed i.e., the difference between filter paper before and after filtration, g
SO_2 ,
Calculation Formula: SO_2

SO_2 (µgm/m^3) = ((As-Ao) x Kc x Vs x 1000)/ (Va (Litres) x Vt)
Here:
Vs - Taken Volume of Absorbing Solution for sampling Vt-Taken Volume of Absorbing Solution for Analysis
Va - Volume of Air Avg. Flow rate (LPM) x Time (min) As per ml absorbance of the sample by Spectrophotometer Ao - per ml absorbance of Blank by Spectrophotometer Ko-Calibration Factor.

3. Nitrogen dioxide

Nitrogen dioxide, or NO_2, is a gaseous air pollutant composed of nitrogen and oxygen and is one of a group of related gases called nitrogen oxides, or NOX.NO2 forms when fossil fuels such as coal, oil, gas, or diesel are burned at high temperatures.NO2 and other nitrogen oxides in the outdoor air contribute to particle pollution and to the chemical reactions that make ozone. It is one of six widespread air pollutants that have national air quality standards to limit them in the outdoor air. NO2 can also form indoors when fossil fuels like wood or natural gas are burned.

Instrument used / Equipment:
NO_2 is a gaseous pollutant and for that high-volume sampler also used the same as SO_2.

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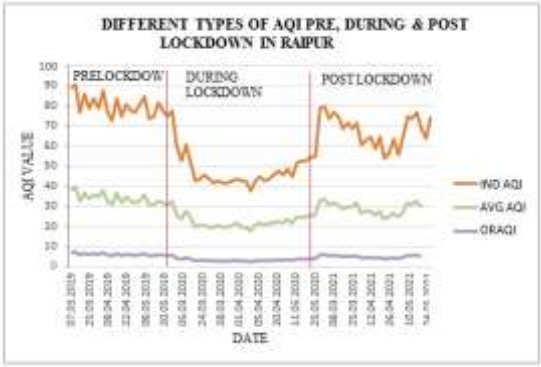
IV. RESULT AND DISCUSSION

Comparison of Different types of AQI Pre, During & Post Lockdown in Sarora



In pre-lockdown, all the AQI were plotted and compared in one graph. IND AQI and AVG AQI show some increments and decrements. IND AQI, AVG AQI, and ORAQI in overall pre lockdown were 80, 34, and 6.34 respectively. During lockdown, all the AQI were plotted and compared in one graph. IND AQI and AVG AQI show some increments and decrements. IND AQI, AVG AQI, and ORAQI overall during lockdown were 47, 22, and 3.33 respectively. In post lockdown, all the AQI were plotted and compared in one graph. IND AQI and AVG AQI show some increments and decrements. IND AQI, AVG AQI, and ORAQI in overall post lockdown were 68, 29, and 5.09 respectively. So, we conclude that in pre lockdown the IND AQI was 80 during lockdown 47, and in post lockdown 68 so during lockdown decrement was observed, and in post lockdown increment was observed.

V. CONCLUSION

IND AQI in Pre lockdown For Sarora, Raipur in Pre lockdown IND AQI was 81 i.e., it comes in the category of satisfactory, during lockdown it shows decrement i.e., 47 which means it comes in the category of good, and in post lockdown shows increments i.e., 69 that means it comes in the category of satisfactory.

AVG AQI in Pre lockdown for Sarora Raipur was 34, during lockdown it shows decrement i.e., 22, and in post lockdown, it shows increments i.e., 29.

Oakridge Air Quality Index or ORAQI was also calculated in Pre lockdown Sarora, Raipur ORAQI was 6.39 in during lockdown phase it shows decrement i.e., 3.36 and in post lockdown, ORAQI shows increments i.e.,5.29.

While Comparing IND AQI, AVG AQI, and ORAQI we have drawn some conclusions from their result that when we use three pollutants i.e., particulate matter, Sulphur Dioxide, Nitrogen Dioxide, and using the formulae of IND AQI, AVG AQI, and ORAQI for them we get that AVG AQI is thrice of IND AQI approximately and ORAQI is five times of AVG AQI approximately when we use formula and putting their concentration and their standard values then this conclusion evaluated.

Since ORAQI is US-based formula and also the formulae are nonlinear, after calculating it gives data under 10 and cannot be used for Indian standard but when we individual see the graph of IND AQI, AVG AQI, and ORAQI concerning dates the pattern is similar in all. But when we combine IND AQI, AVG AQI, and ORAQI we cannot jump to the conclusion since ORAQI gives a straight line whereas IND AQI and AVG AQI give similar variation from graph comparison.

Based on the observation obtained from the statutory bodies such as (CECB) during this field study and the corresponding data there should be some restrictions periodically followed:

- An odd-even policy should be implemented by the state government.
- Avoid excessive idling of automobiles.
- Refuel your car in the evening when it's cooler.
- Look for the ENERGY STAR label when buying a home or office equipment.
- Use filters for chimneys

FUTURE SCOPE

Further study can be done using annual data of Particulate Matter, Sulphur dioxide & Nitrogen dioxide for Pre, During, and Post lockdown.

More stations should be installed as per the National Ambient Monitoring Program site selection Norms.
Manually calculated data and Continuous Ambient Air Quality Monitoring Systems can be compared for various locations.
Using ArcGIS software different types of interpolation methods i.e., inverse distance weighting, kriging & spline can be compared for better understanding.
Further study can be carried out by using air quality data of different districts i.e., Durg, Raigarh, and Korba to evaluate the Air Quality Index.
Different types of pollutants rather than Particulate Matter, Sulphur dioxide, and Nitrogen dioxide such as Carbon monoxide, Lead, Ozone and can also be determined for calculating IND AQI.
In future scope, New AQI can also be made or altered using ORAQI because it is US based and it cannot compete with Indian Standard so we can alter the formulae.
By using Linear Regression and correlation we can predict the forecast of air quality approximately.We can also use machine learning for better and accurate predictions of air quality.

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