

SPREAD PREDICTION OF COVID-19 IN ANDHRA PRADESH BASED ON ENVIRONMENTAL CHEMISTRY

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ABSTRACT

COVID-19 had already spread throughout the world, and the novel coronavirus continues to pose a threat to the majority of countries. The current study uses the Susceptible-Exposed- Infectious-Recovered idea to assess the effects of social and economic factors, particularly the use of a medical mask, on the spread of COVID-19 in Andhra Pradesh. The influence of environmental parameters such as temperature and relative humidity on the number of COVID-19 cases per day is also investigated using numerical methods such as the Response surface methodology model. We provide the results of the curfew lockdown started by the Government of Andhra Pradesh for COVID-19, as compared to a total lockdown scenario. As a result of the irresponsibility and crowded gatherings, the number of cases increases, stretching the mitigation period of the second wave COVID-19 spread, prolonging the curve's straightening. The Susceptible-Exposed- Infectious-Recovered model's predictions have been put to the test in a number of real-world scenarios. The fast spread of second-wave COVID-19 cases in Indian cities is similarly connected to temperature, as indicated by the well function of higher temperatures in breaking the lipid layer of coronavirus, but is severely inhibited by the critical component of social distancing, leading to uncertainty. As a result, it's critical to incorporate environmental factors into epidemiological models like Susceptible-Exposed-Infectious-Recovered, as well as methodically design managed laboratory tests and modeling experiments to catch conclusive findings, assisting decision-makers and investors in developing comprehensive action plans to combat COVID-19's second wave

Keywords: SEIR, Response Surface Methodology, COVID-19, Rate of Transmission, Average Recovery

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INTRODUCTION

Various Indian states are currently dealing with the second wave of the Covid 19 virus, and have confirmed partial to complete lockdowns in their cities as a result of the new cases. Unless there is an emergency, residents are advised to remain indoors. According to the researchers, the virus spreads to more than two people for every infected individual, implying that millions might be afflicted. Environmental surfaces have been identified as potential sources of viral virus transmission. For lockdown to be effective, people must avoid social gatherings and limit population movement

This article uses environmental chemistry to depict the spread prediction of COVID-19 in Andhra Pradesh based on confirmed cases, recoveries, and death toll per day surveys. The impact of environmental factors on the virus's ability to survive has also been identified as a potential element influencing its transmission. Few studies have revealed that the virus behaves similarly to most flu viruses. SARS, and its activity is limited in hot and humid circumstances. However, it is critical to look into the effects of environmental circumstances on virus transmission.

The fast spread of SARS-CoV-2 in the community has a profound impact on public health, the economy, and societal behavior. SARS-CoV-2 infects patients in the same manner as other influenza viruses do, by primarily infecting the respiratory tract and being sensitive to temperature and humidity. Environmental elements such as temperature and relative humidity (RH) clearly affect the virus's ability to survive, as evidenced by recent research.^{1,2} There is a relationship between air pollution and SARS-CoV-2 susceptibility, according to some recent research. SARS-CoV has been shown in the lab to become more

robust in temperatures lower and drier circumstances, strengthening the assistance in transitivity via various properties like longer suspension duration, enhanced attachment situations, and so on.^{3,4} It has been discovered that the temperature effect and human-to-human transmission have a substantial impact on the virus's ability to spread.⁵ The impact of environmental parameters on establishing COVID-19 cases is extremely important since the flu virus multiplies quickly in cold and dry conditions and befits in active over 30 °C.⁶ As a result of previous and contemporary research, the impact of elements like ambient temperature and relative humidity is quite evident and tangible. SEIR models are being considered a good approach for understanding the outbreak condition and measuring the effects of external and societal elements for COVID-19 spread.^{7,8} As a result, the current study uses the SEIR model and statistical techniques to examine the effects of societal behavioral elements and environmental conditions on COVID-19 propagation. The current evaluations were carried out in two stages. The initial stage is to assess the number of actual COVID-19 cases in Andhra Pradesh, and the time it will take for the disease to subside. Second, to see how ecological factors like temperature and relative humidity impact COVID-19 spread.

EXPERIMENTAL

Material and Methods

The SEIR (Susceptible-Exposed- Infectious-Recovered) concept was used to model two genuine implementation scenarios related to human behavioral difficulties, as well as to predict COVID-19 circumstances. The SEIR model for infectious illness transmission is a forgery, comparable to severe acute respiratory syndrome.⁹ The compartments of the model include immunity, infection, exposure probability, and recovery/removal.¹⁰ The primary data sources are reports from the Indian government. The following are the parameters that were taken into account when developing the model.

SEIR model parameters

The SEIR model parameters are listed in Table-1 below. The model is tested in two scenarios: total lockdown for the period (Case B) and gradual breach opening (Case A). The transmission rate is computed on a weekly basis for the available data sets for each instance using approaches adapted from the literature.¹¹⁻¹⁵

Table-1: SEIR Model Parameters

Parameter	Data Description in a Nutshell
Suspected people ($S[t]$)	The number of persons suspected in India is based on WHO summaries, which indicate a proportion of suspicious samples for testing, with some showing positive findings (SARS-CoV-2). When a suspect comes into contact with contaminated agents, they get infected. The total number of persons tested equals the total number of individuals suspected ($S[t]$).
Population (N)	The total population is taken from the census report. Andhra Pradesh has a population of 9.17 million people.
Possibility of transmission (β) ¹⁶	The possibility of transmission changes with the number of illnesses over time and is used to calculate β_1 and β_2 . $[S] \rightarrow [C]$ (β_1) susceptible to contagious $[S] \rightarrow [E]$ (β_2) susceptible to exposed
Rate of transmission (β_1 and β_2)	COVID-19 has a mortality rate of roughly 2.334 percent in AP and roughly 1.2 percent outside AP. The SARS-CoV-2 transmission rate is 1.5 - 4.5, which is faster than the SARS transmission rate. ^{46,66-68} $\beta_1 = k_1 \times \beta$ $\beta_2 = k_2 \times \beta$ Where, k_1 = Probability of symptomatic infection (3 days) k_2 = represents the probability of infectious disease (15 days)
Growth rate (σ) ¹⁷	SARS-CoV-2 has been reported to be contagious for 2 to 14 days.
Average recovery or death rate (γ)	For India, the normal time frame from the affirmation of identification to removal, for example, death or recovery, is 14 days. $\gamma = 1/\text{Average recovery time} = 1/14 = 0.07$
Number of interactions per individual ($r[t]$) ¹⁸	The number of people exposed during population influx and outflow may be defined as the number of contacts per individual. It is calculated using data such as population, age and other variables.
Affected People ($E[t]$) ¹⁹	The group of individuals affected may be calculated by multiplying the

	rate of entry from other states by the rate of exit from the AP state.
Contagious People (C[t])	The overall number of individuals affected in Andhra Pradesh

Statistical Analysis

The Indian state -Andhra Pradesh has been chosen to investigate the effects of environmental factors on the second wave of COVID-19 cases each day. The state was chosen for two reasons: first, its unique climatic parameters in regards to temperature and relative humidity, and second, the accessibility of reliable data on atmospheric circumstances and tracking COVID-19 incidents. The source data on meteorological characteristics for the state is available from the State Pollution Control Board, AP, and is obtained by averaging all of the locations data over a 24-hour period, taking into consideration day and night values. As a result, investigating the effects of climatic conditions at the municipal level is crucial in the attempt to improve assumptions formed during the state-level study.

RH and temperature are used as the foundation factors when exploring the relationship between environmental conditions and second wave COVID-19. To explore the relationship, day-to-day COVID-19 cases in different Andhra Pradesh municipalities are connected with the aforesaid criteria.

RSM (Response Surface Methodology) is used in Andhra Pradesh as a statistical tool for analyzing the linear and quadratic impacts of environmental components, as well as the interaction between these environmental aspects, on daily COVID-19 instances over confirmed/ recorded COVID-19 cases each day. RSM has the benefit of requiring fewer data to map throughout the whole domain of the input variable as compared to standard techniques. The RSM quadratic model also allows us to collect the non-linearity of atmospheric events and hence parameters using a complete quadratic model, as shown in Eqn.-1.

$$R_0 = \beta_0 + \sum_{i=1}^n \beta_i x_i + \sum_{i=1}^n \beta_{ii} x_i^2 + \sum \sum_{i < j} \beta_{ij} x_i x_j \quad (1)$$

Where, R_0 are the time-dependent variables, i.e. COVID-19 incidents each day; β_0 is a constant; β_i is the sequential factor; β_{ii} is a squared factor and β_{ij} is the product component, x_i represents the linear coefficient of the input variable, x_j represents the squared influence of the input variable, $x_i x_j$ represents the input variable's interaction term, and n is the number of components.^{20,21} The model parameters (i.e., β_0 , β_i , β_{ii} and β_{ij}) are calculated by minimizing the total of squared residuals using the least square approach. A P-value of less than 0.05 at a 95% normal distribution is considered adequate to reject the null hypothesis and indicate the parameter's relevance in any studies. A high R^2 (also known as R-Sq.) value, which may be used to measure the model's competency, confirms a strong model fit. The highest and lowest parameter values were set to +1 and -1, respectively, while the other parameters were linearly interpolated between -1 and +1.

We utilize β variables in the equations rather than R_0 , since $R_0 = \beta / \gamma$, so $\beta = R_0 \cdot \gamma$

In fact, R_0 in Eqn.-2 mostly never "jumps" from one integer to the next. Instead, it is always changing more or less rapidly e.g. if social distancing measures are loosened and then tightened again.

$$R_0(t) = \frac{R_{0start} - R_{0end}}{1 + e^{-k(-x+x_0)}} + R_{0end} \quad (2)$$

The function (chosen for our needs) is as follows:

And here's what the parameters do in practice:

- R_{0start} and R_{0end} are the quantities of R_0 on the starting and the last day
- x_0 is the x-value of the accelerating point (i.e. the moment of the sharpest decrease in R_0 , which might be considered the major "lockdown" period).
- k (Logistic function) allows us to control when quickly R_0 is decreasing.

These graphs may assist in understanding the parameters:

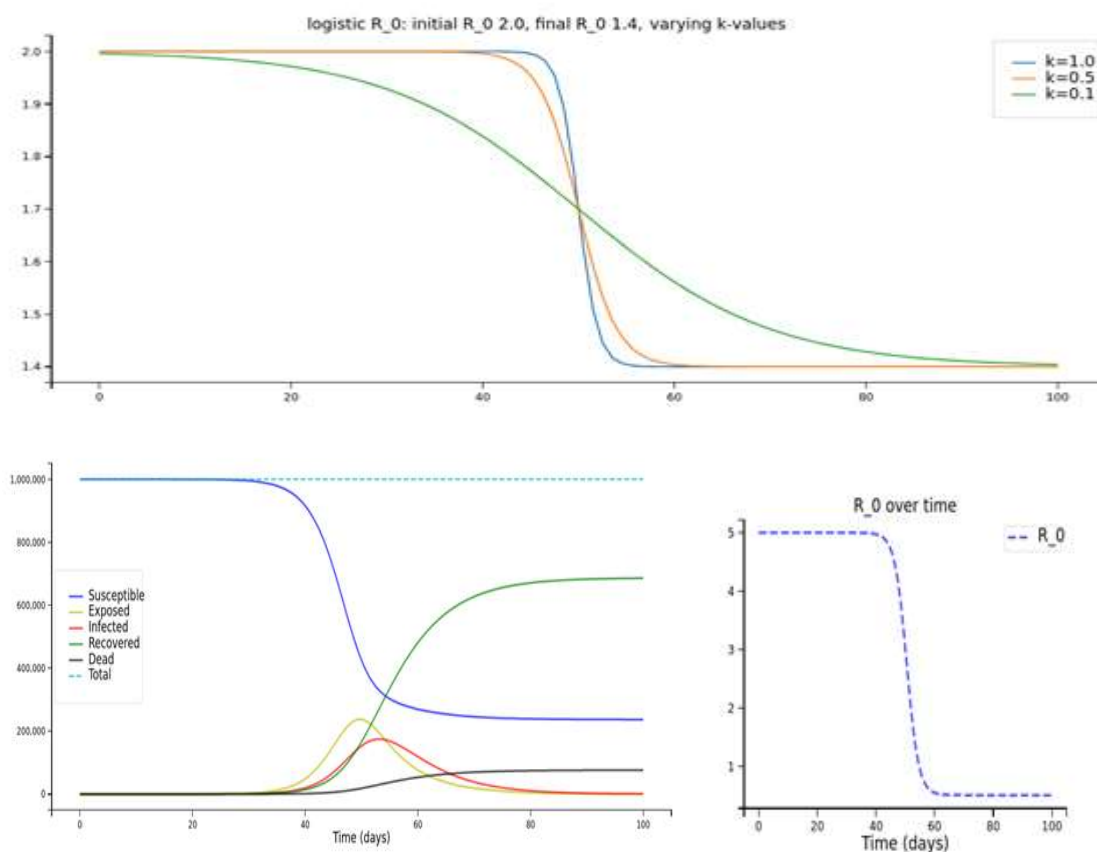


Fig.-1: Response Surface Methodology for Time-dependent Variable R_0 for $K=1, 2, 3$ so on for COVID-19 spread with a flattened curve

Again, varying the code accordingly showed in (Fig.-1)

We allowed R_0 to rapidly fall from 5.0 to 0.5 until day 14 and we can now see the slopes flattening after day 14 (Effect of enforcing curfew lockdown in the state of Andhra Pradesh)

RESULTS AND DISCUSSION

The SEIR Model is tested in two scenarios. Case A was modeled with data up to the 13th of February 2021, whereas Case B was exhibited with data until 19th of April 2021. The difference between the two datasets is that Andhra Pradesh imposed a curfew on May 1, 2021, after realizing that a likely societal transmission of COVID-19 cases had begun and needed to be controlled rather quickly to flatten the curve.²²

In Case A, the number of COVID-19 instances steadily rose within the restrictions of the available datasets. Table-2 and (Fig.-2) show the outcomes of Case A. The model calculates $S[t+1]$, or for the day plus one, using $S[t]$ data from COVID-19 instances in Andhra Pradesh.

Table-2: Simulation Result -SEIR Model for Case A

DATE	$S(t+1)$	$E(t+1)$	$C(t+1)$	$R(t+1)$
13-Feb	1200	2100	102	0
20-Feb	1500	4521	206	0
26-Feb	2100	5684	510	0
05-Mar	11000	17584	765	20
13-Mar	15201	18956	810	371
21-Mar	18620	21585	2497	845
29-Mar	22010	27548	4723	1245
05-Apr	23140	28000	10500	2100
12-Apr	25031	31000	18514	3154

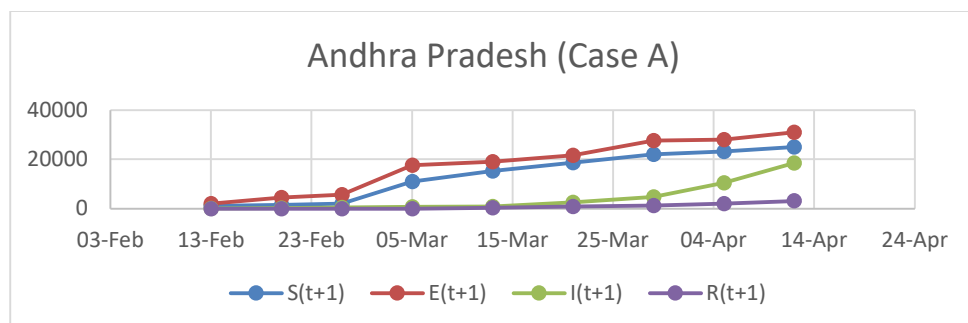


Fig.-2: Movement of rise and decline in cases -SEIR model (Case A)

Table-3: Simulation Result-SEIR Model for Case B.

DATE	S(t+1)	E(t+1)	Ct+1)	R(t+1)
19-Apr	15001	16548	4586	61
24-Apr	18543	21054	7864	165
29-Apr	21531	26587	19012	345
04-May	40012	52468	27546	658
09-May	36541	41245	23548	1245
14-May	34587	36584	21546	1458
19-May	32548	35468	19654	1524
24-May	26879	30124	18285	2541

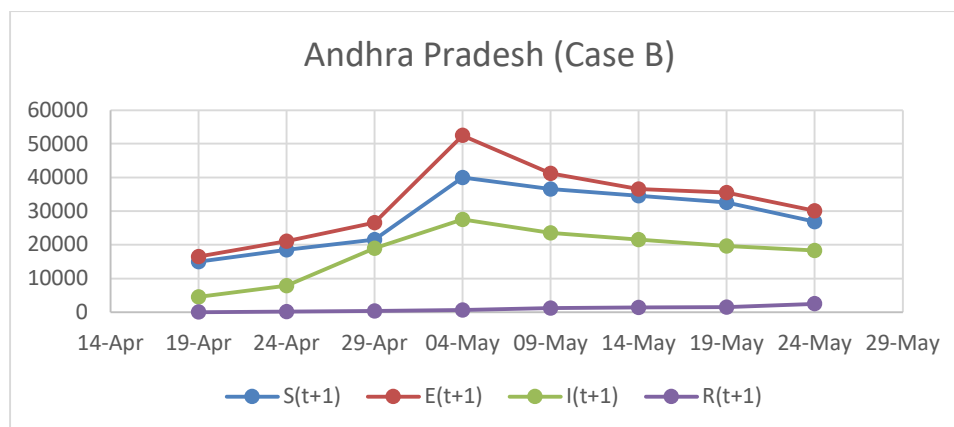


Fig.-3: Movement of rising and decline in cases -SEIR Model (Case B)

Imposing Lockdown, social distancing, and the closing of movie theatres and shopping malls have started the stage of reducing the death tolls and infections in Case B studies. The decline in the figure of SEIR cases in Case B is attributed to Andhra Pradesh's alleged strict lockdown. (Fig.-3) illustrates that the number of infected patients increased in tandem with the number of infections until the 04th of May 2021, when the lockdown was imposed, and cases began to decline with a moderate recovery rate.

Environmental parameters

Temperature and relative humidity (RH) averaged across the state of Andhra Pradesh are used to investigate their association in COVID-19 instances each day. Table-4 shows the spectrum of parameters under investigation in the state.

Table-4: Series of Variables and Coded Units

Environmental Factors	Temperature (Celsius)		Relative Humidity (%)	
	Lowest	Highest	Lowest	Highest
Standards in Coded Unit	-1	+1	-1	+1
Real standards (6 days moving Avg.)				
Andhra Pradesh State	25.000	36.405	18.830	89.530

Temperature and relative humidity were used as environmental variables, with their limits coded between -1 and +1 for the AP state. All environmental factor values are averaged linearly, with -1 indicating the parameter's minimum value (Min.) and +1 indicating the parameter's maximum value (Max.).

CONCLUSION

At a stage, where COVID-19-affected state in India is seeking to reduce and ease the virus's spread, it's more important than ever to look at the connection between COVID-19 cases recorded each day and environmental factors. Besides seeking concentrated medicinal treatments, India, like other nations, is striving to control the transmission of the infection through safety considerations lockdowns and imposing social distancing. In a country with a population of over a billion people, such as India, social isolation is impossible. The current study used the SEIR model to simulate various cases in order to investigate the influence of social distance on the increasing number of cases in Andhra Pradesh. The model concluded that, with the commencement of likely community spread, a breach of social distancing by those engaging in crowded meetings could result in a longer period to control the spread. The state government of Andhra Pradesh's decision to impose a curfew lockdown was timely in slowing the spread of the virus, but other steps are needed to guarantee that the pandemic slope continues to increase at an average that does not strain medical resources. SEIR's findings support the conclusion that social distance is now one of the finest instruments available to governments for controlling the spread of this disease. For four weeks, the SEIR methodology has been validated and provides a significantly better knowledge of viral spread patterns.

According to studies, a hot environment should inhibit COVID-19 from spreading due to the well-known function of increased temperatures in breaking the lipid layer of coronaviruses and maybe other viruses of the same kind, but the relationship with RH has never been seen or proven. According to the current research, environmental variables affect COVID-19; nevertheless, further supervised laboratory experiments and modeling studies are needed to determine the true relevance of these parameters. Environmental elements should be included in modeling techniques such as SEIR to accurately demonstrate their effects on COVID-19 spread and control.

The data collected in the article is visibly open:

<https://news.google.com/covid19/map?hl=en-IN&gl=IN&ceid=IN%3Aen>

https://hmfw.ap.gov.in/covid_dashboard.aspx

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