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Analysis and Prediction of Climate Change in Post-Covid19 India

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***Abstract*—Corona virus was first observed in Wuhan City of China in the end of the year 2019. In less than 3 months of its appearance, it turned out to be a global pandemic. The virus has affected more than 4.3 million of people across the globe till mid-month of May 2020. As a protective measure, many countries have enforced lockdown, which certainly reflected some beneficial effects on Nature. Lesser human-induced pollution has introduced us to a whole new healthy environment. This study is based on the observations of AOD (Aerosol Optical Depth) from the satellite Himawari-8. This study will also include the observation of tropospheric level of NO_2 with the help of an instrument Aura- OMI over the region of southeast Asia (SEA). This study also focuses on measurements at ground level across several stations of Malaysia, to check the changes in level of aerosol and air pollutants caused by this lockdown. This lockdown has caused a considerable decrease in the level of AOD across Southeast Asia and also in the pollution current in oceans, a notable decrease of 27 percent to 30 percent of NO 2 has also been observed in the troposphere. The respective amount of PM 10, PM 2.5, NO_2, SO_2, and CO has also decreased by 26–31%, 23– 32%, 63–64%, 9–20%, and 25–31%, in the region of Malaysia. Since, this reduction is favorable for our environment, it is also beneficial for one's health, and thus, it has become an interesting field of research related to health and pollution.**

***Index Terms*—Cloud data storage, machine learning**

I. INTRODUCTION

The first case of corona virus was first observed in the Wuhan city of China in the end of the year 2019.The disease was later called as SARS CoV-2. This disease spread in the other part of world quite soon and was declared a pandemic by WHO. This is an infectious disease which easily gets transmitted from one person to another, till the mid-month of May, there were 4300 confirmed positive cases of COVID-19.

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[1] According to some recent studies persistent exposure to air pollution can increase the death rates caused by COVID-19, this topic is under debate among Global Scientific Community, as no exact evidences has been found in favor of such claims. But there are some cases which shows that this virus can spread through the air as well, so disinfecting floors, sanitizing stuffs like mobile phone are advised as a precaution measure. Many South Asian Countries were also not devoid of this pandemic attack, although the death rates of these countries were lesser as compared to that of European and American countries. There were total 2078 deaths recorded out of 66,140 positive cases (May 16) Countries like Philippines, Indonesia and Malaysia accounted for the 94 percent of total positive Corona Cases and 97 percent of the total deaths due to Corona respectively. Since these countries are very crowded, they took several measures to stop the spread of the deadly virus, as a precaution they enforced lockdown, they banned transportation, inter-state and intra-state travelling was also banned by the SEA countries. School, colleges and offices were also closed. They banned the social gatherings and visits to holy places were also banned. Malls, Shops, Gyms and Cinema Halls were also closed. The first Case of COVID-19 was observed in the month of January 2020 in India. From the mid-march COVID-19 positive cases started increasing considerably and it was observed that till May 16th 2020, it had reached total number of 6855 positive cases, till then the Number of deaths were 112. The government of Malaysia had announced the Movement Control Order on 18th March, initially for just 2 weeks but due to the increasing cases of Corona Virus it was later extended till 9th of June. In this MCO the government banned the public transportation, they closed the parks and other places of Social Gatherings.

These lockdowns were proven to be favorable for Nature as a notable decrease in the air pollution and the level of NO_2 was observed in China and several other countries of America and Europe.[2] Researchers, have made many studies to detect the change in NO_2 level because of these lockdowns with the help of Ozone Monitoring Instrument (OMI) Tropospheric Monitoring Instrument (TROPOMI). One such study made by reported the notable reduction in the level of NO_2 it was about 20-30% in the countries like China, Spain, USA, France and Italy. Particulate matters of less than 2.5 micrometer (PM2.5) is the most dangerous form of pollution, these are basically emitted from Exhaust of vehicles and Industrial Gases. Some Cities of sea such as Quezon city, Kuala Lumpur and Bangkok have observed a considerable decrease of about 80% in this (PM2.5) in the lockdown period. The main reason of the air pollution in Big cities of SEA is the particulates and Gases which are released from the vehicles and industries besides these seasonal forest and agricultural fires are also responsible for the air pollution.[3]PM can cause respiratory problems, Birth defects and also cardiovascular mortality. Longer exposures can be even more fatal. Many big cities of SEA have crossed the air pollution level by 5 to 10 times, set by WHO which was equal to 10µg per m^3 Particulate Matter of size 2.5 microns and 20µg per m^3 for Particulate Matter of size 10 microns. In European Standards it is equal to 25 and 50µg per m^3 respectively, this has resulted in increase of death rates by 30-45 deaths per 100,000 capita. AOD is basically the estimation of the scattering or reduction of Solar Radiations or Solar rays due to the immersion of its rays by aerosols present in the atmosphere. Aerosols are basically fine liquid and solid suspensions present in the atmosphere. [4] The main cause of these aerosols over SEA is the gases like Sulfate, Nitrate and Ammonium emitted by the industries, volcanic ashes and burning of biological fuels, pre-monsoon forest and agricultural fires are also some of the main causes. So, by analyzing AOD we can detect the variations in the concentration level of pollutants mainly in the lower troposphere region. High level of pollution is the main cause of the environmental pollution and health related issues in SEA countries. For the good quality of air in SEA countries, we must study the extent of variation in the pollution level due to the lockdown in SEA countries. It has been attempted to make a Case Study to understand the consequences of the lockdown or MCO on the air quality/grade of the SEA region with the help of remote sensing Satellites and ground-based measurement keeping the main focus on Malaysia.

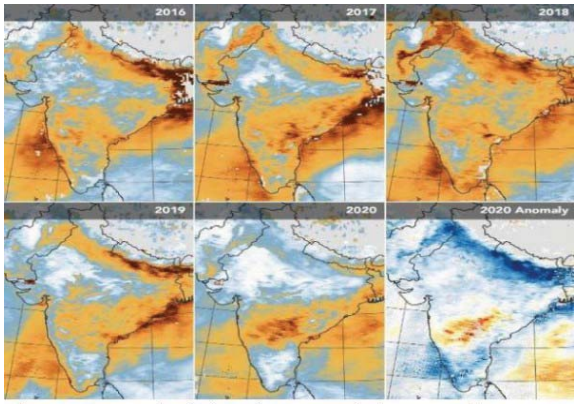

Fig 1: Map depicting the anomaly in 2020 climate.

II. TYPES OF POLLUTION AND THEIR RELATION WITH AIR QUALITY INDEX

AQI is basically used to monitor the air quality of a particular area. Mainly two steps are involved in the calculation of Quality Index. The first is by forming the sub-levels for each pollutant present.[5] The second is by compiling these values. By the 2nd step we can get the sum total value, i.e., Total AQI.

In India, AIO standards were set By the Central Pollution Control Board (CPCB), They gave it a name INAQS which stands for The Indian National Air Quality Standards.[6] It was basically based upon twelve parameters but here we are considering NITROGEN DIOXIDE, SULPHUR DIOXIDE, CARBON MONOXIDE, and also the PM that is PARTICULATE MATTER of size less than 2.5-micron, OZONE and the particulate matters of size less than 10 microns. AQI maintains a relationship know as Dose-response, between pollutants and the quality of Air. It is very important to keep an insight on this relationship for the good health.

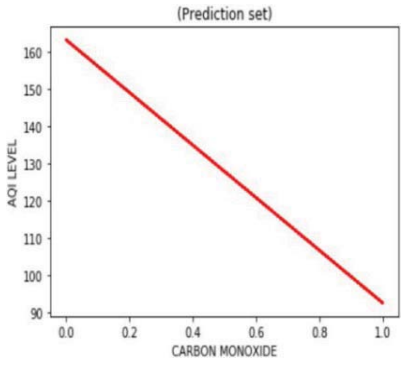

Fig 2:Graph showing the relation between AQI and CO

Carbon monoxide gas is basically emitted by the incomplete combustion of coals or other sources. It has abundance in the atmosphere thus it can be considered as one of the most important gas for the evaluation of AIQ. In human body, CO-poising is caused by the association of CO with the hemoglobin, and it is surprisingly noticeable that CO has more affinity than Oxygen for hemoglobin. The Association of CO with Hb is known as Carboxyhemoglobin. The symptoms of

CO poising include Nausea, headache,dizziness. Consistent exposure can cause loss of consciousness even higher exposure may lead to death.[7] According to INAQS for CO, the AQI is considered to be good at break point concentration of 1 mg m3 satisfactory at 2mg per m^3, moderate at 10 mg per m^3, poor at 17 mg per m^3, very poor at 34 mg per m^3 and for more than 34 mg per m^3 the AQI is considered to be serve.

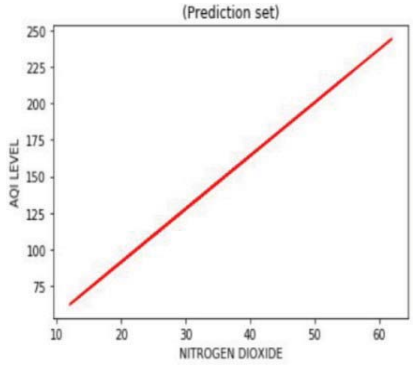

Fig 3:Relationship between AQI and NO_2

[euler]textgreek Another Gas which has abundance in the atmosphere is NO_2. Its level is already very high in India. The main cause of NO_2 is the smoke released by the vehicles, and due to the increase in numbers of vehicles in the country, the level of NO_2 is also increasing. Nitrogen Dioxide becomes injurious to health when its limit exceeds the boundary set by the WHO. Nitrogen dioxide causes irritations in the mucous membrane.[8] It causes several lung diseases; its prolonged exposure can decrease the capacity of function of lungs. It also causes asthma, even the exposure greater than the set limit for longer duration can be fatal for the health.According to INAQS for NO_2, the AQI is considered to be good at break point concentration of 40g per m^3, satisfactory at 80µg per m^3, moderate at 180µg per m^3, poor at 280µg per m^3, very poor at 400µg per m^3 and for more than 400µg per m^3 the AQI is considered to be severe.

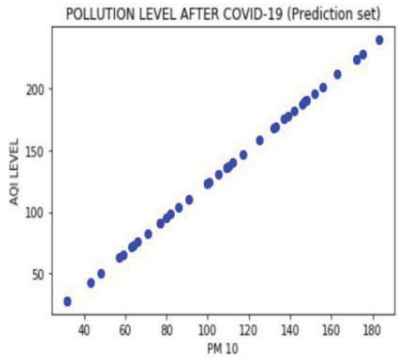

Fig 4:Pollution level with respect to relation between AQI PM10

The level of Particulate Matters in India has already crossed the set boundary, in fast it is four to five times higher than in the USA cities, which is alarmingly higher. Pm means particular matter. Pm 2.5 is fine dust particle or aerosols or droplet that are present in the air that have a diameter of 2.5 micrometre or smaller. Most of the dust gets filtered through the hair in our nose but Pm 2.5 is very fine hence it can reach the lung and cause irritation in our respiratory pathway. For patients having asthma and heart disease it can worsen the condition. Exposure to the fine particle can cause short-term health effects such as eye, nose, throat and lungs irritation, coughing, sneezing, runny nose and shortness of breath. It primarily come from car, trucks, bus and off-road vehicle. This can reduce visibility and cause the air to appear hazy when levels are elevated.

These levels can be injurious to public health. It has been proved by epidemiological studies that, particulate matters of 2.5 microns and 10 microns can cause severe problems like Acute and chronic respiratory diseases, premature mortality, asthma, and reduction in lung functioning.[9] Particulate matters of size 2.5 microns are even more fatal as it contains some toxic acids and metals too, it can easily pass the membranes too because its size is too small. According to INAQS for PM10, the AQI is considered to be good at break point concentration of 50µg per m^3, satisfactory at 100µg per m^3, moderate at 250µg per m^3, poor at 350µg per m^3, very poor at 430µg per m^3 and for more than 430µg per m^3 the AQI is considered to be severe.

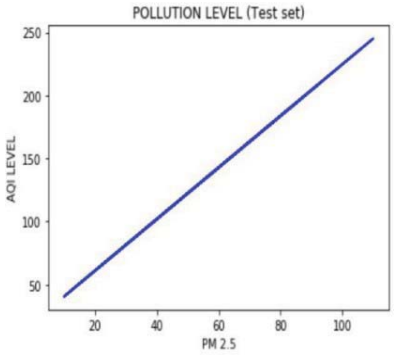

Fig 5:Relation between AQI and PM 2.5

In accordance with INAQS for PM2.5, the AQI is considered to be good at break point concentration of 30µg per m^3, satisfactory at 60µg per m^3, moderate at 90µg per m^3, poor at 120µg per m^3, very poor at 250µg per m^3 and for more than 250µg per m^3 the AQI is considered to be serve.

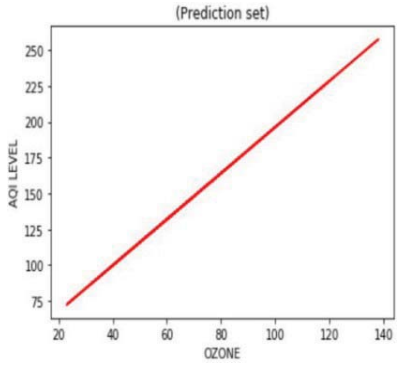

Fig 6:AQI and ozone relation

Ozone, it is basically a secondary pollutant, Ozone is highly oxidant in nature it can easily react with various biological components. It can cause irritations in respiratory system, it can provoke emphysema, bronchitis and some heart related problems too.With the standards of INAQS for O_3, the AQI is considered to be good at break point concentration of 50µg per m_3, satisfactory at 100µg per m_3, moderate at 168µg per m_3, poor at 208µg per m_3, very poor at 748µg per m_3 and for more than 748µg per m_3 the AQI is considered to be severe.

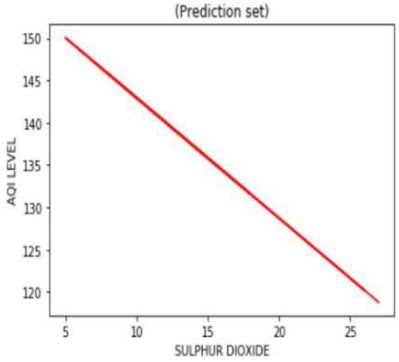

Fig 7:Relation between AQI and SO_2

Sulphur Dioxide is another such gas which can cause problems in Human body when its concentration crosses the set boundary or threshold limit. According to INAQS for SO_2. [10] The AQI is considered to be good at break point concentration of 40µg m3, satisfactory at 80µg/m3, moderate at 380µg per m_3, poor at 800µg per m_3, very poor at 1600µg per m_3 and for more than 1600µg per m_3 the AQI is considered to be severe.

III. METHODOLOGY

The project started with the beginning of collection of data back in January 2019.I found a way to store public satellite data from NASA.I also collected data in the form JSON from a site named API-Air Quality Programmatic APIs.[11] Firstly, we will know how I collected the data. The important part of the project is collection of data from NASA's pollution monitoring satellites like Aqua, Terra, Aura and Suomi-NPP. These satellites are a part of the Earth observation system created by NASA.[12] The first satellite Aqua which is on a sun-synchronous orbit focuses on Atmospheric Conditions, Weather Carbon Cycles, Climate Variability and Change and Earth surface and interior. Holding a special place among the system is the Terra satellite which have a thermal imaging spectrometer and various other weather monitoring devices but the most important of them is the MOPITT which stands for Measurement of Pollution in the Troposphere. It is basically a type of instrument which is made to study the interaction of the lower atmosphere with the ocean and lands. [13]It is specified in such a way that is collects the information about the transport, sources and sinks of CO from places like factories of urban areas, Cars or Buses and also the forest fires. Aura on other hand monitors the ozone layer along with air quality. These satellites are to name a few along with many others. These resources were collected mainly by generating Application Programmable Interface authorization from the websites api.nasa.gov and apicn.org. The data was collected daily in the form of batches to the Google cloud platform where it was received by Publisher/subscriber. publisher/subscriber is a type of communication in which the publisher creates the message in the form of classes, the subscribers who are interested in topic/class will immediately receive a message regarding the class and can read it.[14] The data was collected for one and half years. With the data in hand we had an idea to predict the change in climate scenario for the post Covid-19.[15] During the months of complete lockdown in India, that is from the month of March to June, the usual bustle in the cities came to a standstill. There were no vehicles on the roads due to which NO2 emissions decreased. The smokes from the factories and power plants did not pollute the skies.[16] Harmful pollutants like SO_2, CO, CO_2 decreased and the air quality index normalized. These facts can be proved by running a machine learning program in python. In the python program, the first step is to import machine learning libraries like NumPy, Matplotlib.pyplot, Pandas and scikit learn. NumPy have a large number of mathematical functions used on big arrays of data and matrices. Pandas, on the other hand offer operations and Data Structures for maintaining time series and numerical tables.[17] The executing part of the program requires scikit learn which have functions classification, clustering algorithms and regressions including support vector apparatus.[18] At the end matplotlib is as plotting tool in the language. After including the libraries, the data which was downloaded from the cloud is imported to the program. [19] The data should be split between a dependent variable and independent variable for a single variate linear regression model. [20] The variable, that is month, should be encoded with integer because python programming does not understand string. It is done by importing label encoder imported form scikit learn library. Then, the dataset is divided into the training (60%) and test (40%) set. With the function train-test-split included from sklearn library; we train the set using simple linear regression model which is also an embedded function of scikit learn.[20] Now we will pass an object to the newly created regression model using the regressor.fit function and predict the results. The results are then plot using the pyplot.plot function from matplotlib library. The results are shown in the next section.

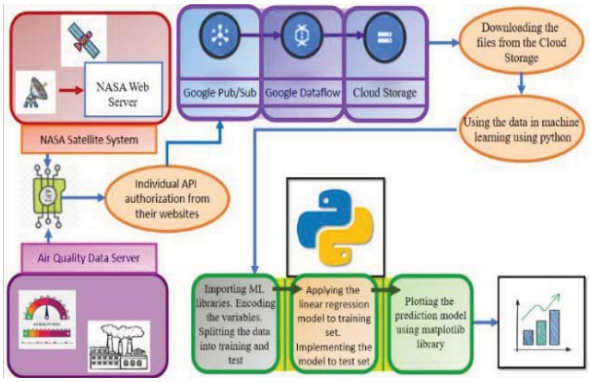

Fig 8: Flow diagram of the entire project

The above diagram defines the entire the methodology and the project chronology. The conversion of high-end NASA satellite data represented into graphs produced by machine learning is colorfully depicted in this flowchart

IV. Result Analysis

The lockdown which was enforced globally due to the Pandemic of COVID19 improved the quality of Air.[21] According to Carbon Brief an environmental website the emission has fell Considerably by 1.4% that is approximately equal to thirty million tons in India. It has also said that the emission of Carbon Dioxide has also decreased by the amount of 15 percent. which further reduced to 30% in the, month of April. In Delhi, which is considered to be the most polluted city of India has witnessed a noticeable improvement in the pollution concerns.[22] The AIQ in Delhi was satisfactory for the first 18 days in the month of April and May comparing to just one day of the last year Data. There were total 41 such Days compared to 26 in previous year data. There were total 34 days which were poor or say very poor during the month of April and May in the year 2019.Particulate Matters of size 10 and 2.5 have shown the most significant drop of more than fifty percent as compared with the period before the enforcement oflockdown. If we compare the decrease in the level of these particulate matters with previous year data, it is found that it is 60% for PM10 and 39% for PM2.5 higher.[23] Level of other pollutants like nitrogen dioxide and carbon dioxide has also reduced by 52.68 percent and 30.35% respectively. Surprisingly 40 to 50% of improvement was noticed in the quality of Air just after the 4 days of Lockdown enforcement. Now the world is slowly coming out of the months long COVID hibernation. The transportation and industrial sector are steadily gaining their pace as we are in the unlock procedure. So, the real question is what happen to the air quality now?[24] For this we have built a liner regression set (ML) about a single variant procedure in python by importing functions from scikit learn which predicts the future or post lockdown AQI in the form of concentration-time curve.

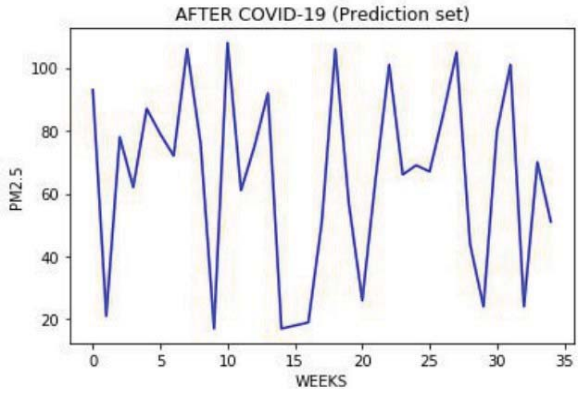

Fig 9: Prediction of data for PM 2.5

For PM2.5 as we can see from the prediction set a sudden rise in concentration occurs, with passage of time the local maximas are slowly falling downward the curve which shows that a sudden unlock in a populated country like India can again boost up the pollution which is causing the anomaly in the environment.[25]

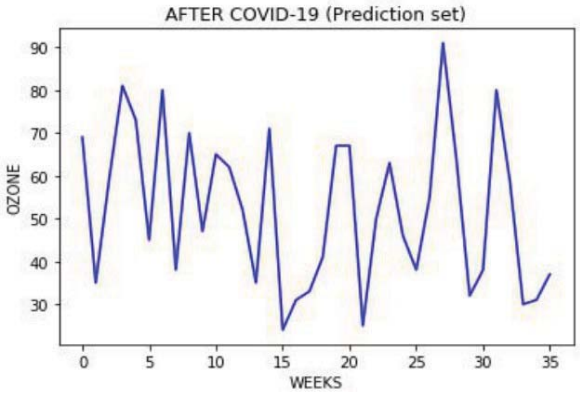

Fig 10: Analyzation of data for O_3 and prediction depicted in the graph

In the case of ozone(O_3) it is seen that in the post lockdown period it suddenly increases, in the followed weeks its concentration falls a bit and then the local maximas goes on rising.

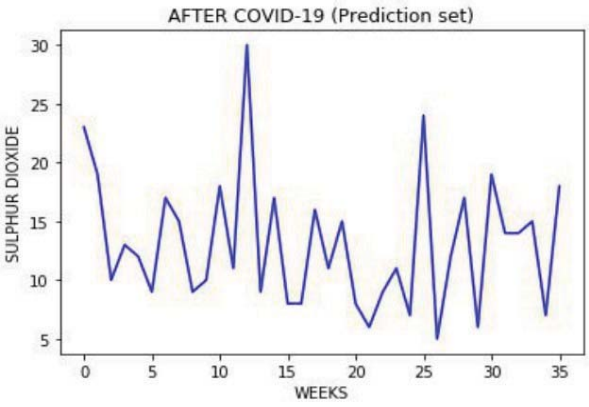

Fig 11: Data for SO_2 in next 35 weeks

India is one of the largest producers of Sulphur dioxide. Keeping that fact in mind our regression set shows quite a positive prediction results for the emission of Sulphur dioxide.[26] The fact that the industries which are the primary source of Sulphur dioxide emission will take some time before they start running with full efficiency, keeps the Sulphur dioxide profile low for the first few weeks then slowly Sulphur dioxide concentration starts increasing.

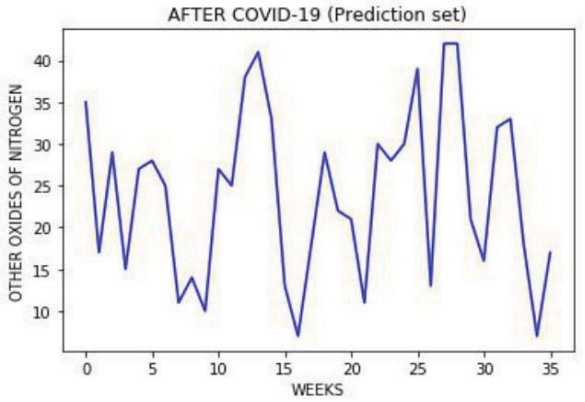

Fig 12: Outcome of results for other oxides of Nitrogen

Similar to SO_2, nitrogen dioxide or NO_2 is also an important pollutant to be considered for determining the AQI.[27] From our prediction set model is seen that the levels of NO_2 are quite high. vehicles, transportation industries and combustion of fuels are the major sources of nitrogen oxides. during the lockdown also the transportation industries had operated in a small scale and now as we are in the unlock procedure more and more vehicles can be spotted on the roads every day.[28] This is the reason for high levels of nitrogen dioxides or other oxides of nitrogen. The overall AQI curve remains somewhat fluctuating and difficult to understand its trend although if we observe the local maxima's and local minimal of the curve, it can be seen both are gradually giving higher values.

V. Conclusion

In this Paper we have studied the positive impact of Lockdown which was enforced due to the spread of corona virus on Pollution, Our study was based on spatio-temporal changes of chief atmospheric pollution causing agents over the region of SEA, Specially in Malaysia used main gases of atmosphere like SO_2, CO, O_3 and NO_2 along with the aerosols such as AOD,PM(10) and PM(2,5),We gathered all this data from Himawari-8 satellite, Aura-OMI and ground stations of Malaysia. A significant decrease in the amount of AOD was observed/noticed from Himawari-8 over the Southern SEA,Brunei,Malaysia,philippines and Singapore value of industrial and urban region of Malaysia was observed to fall(40% and 70%) between the month of March-April 2020(comparing with the levels in 2019 and 2018),But contrary to this AOD was observed to be very high in the northern region of Peninsular SEA.AOD did not decrease in these reasons because of the extensive forest fires and burning of lands after agricultural activity. In fact NO_2 concentration was also high in this region(4 and $8\ 10^{-15}$ mol per cm_2).A considerable deduction in the level of NO_2 was seen(27 percent–34 percent)in the cities of SEA, except in Yangon and Ho Chi Minh.This deduction was basically because of the continuous efforts made by the countries to stop the movements of people and industrial and business movements. In fact, few countries like Malaysia, Singapore and Brunei took some aggressive measures like inhibiting mass gatherings, border closures, restricting religious gatherings. Some countries like Indonesia, Laos, Thailand, Myanmar and Cambodia could not take appreciable measures they took limited measures. In Malaysia, strict movements taken by the Government and also the MCO established on 18th of March caused a considerable decrease in PM 2.5 (23– 32% at urban sites and by 28–39% in the industrial sites) and PM 10 (28–39% in the industrial and by 26–31% in the urban areas) comparing to previous year data. Most significant decrease was observed in the level of NO_2,it reduced by 64% in urban centers and by 33-46% in the industrial sites. Comparatively lesser deduction was noticed in the amount of CO and SO_2,no changes was observed in the level of O_3.This study reflected the impact of lockdown on the air pollution because of the higher level of aerosols and also because of pollutants which are non-industrial. It was really challenging to estimate the effect of lockdown due to COVID-19 on the quality of Air over SEA region particularly during pre-monsoon (between the month of March and April), forest fires, agricultural fires and also the vegetation and peat fires are observed in these months. The role of meteorology has not been studied or evaluated in this study, so more detailed studies are expected in future.

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