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SPECIAL ISSUE

STUDY LITERATURE REVIEW : THE EFFECT OF LOCKDOWN ON THE COVID19 PANDEMIC PERIOD ON AIR QUALITY

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Abstract

Introduction: *Covid19 is an infectious disease caused by the corona virus. This virus was first detected in Wuhan China. Covid19 has been defined as pandemic by the World Health Organization (WHO) since March 11, 2020. So there needs to be a policy to overcome the pandemic by implementing lockdown. The effect on the health sector one of which is environmental health includes air quality. The purpose of this literature review study is to determine the effect of the lockdown policy during the Covid19 pandemic on air quality parameters.* ***Discussion***: *This research used a narrative literature review method. Selected journals that match the topic and inclusion criteria. The results of data analysis show that there is an effect of the lockdown policy during the Covid19 pandemic, namely an increase in AQI and O_3. Meanwhile, decreased concentration occurs in the PM_{10}; $PM_{2.5}$; NO_2; CO; and SO_2 parameters.* ***Conclusion***: *Lockdown policy provided a big influence on the air quality in Sale City Marocco and Sao Paulo Brazil. Lockdown policies during the Covid19 period strongly influenced the concentration of NO_2.6*

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INTRODUCTION

Covid19 is an infectious disease caused by the corona virus. This virus was first detected in December 2019 in Wuhan, China. Covid19 has been defined as a pandemic by WHO since March 11, 2020 after Covid19 has infected in 114 countries. Based on worldometers data on July 12, 2020 Covid19 has infected 12.897.213 people, caused the death of as many as 568.808 people, and had people underwent treatment in 7.517.940 cases. While in Indonesia until July 12, 2020 Covid19 has infected 75.699 people with 35.638 of people recovered and 3.606 of people died.

Covid19 is transmitted through people infected with the virus to others. Covid19 can be transmitted by the droplets from nose or mouth. Therefore it is important to maintain personal hygiene and minimize contact with other people. Efforts that can be done to prevent virus transmission some of which are such as washing hands and wearing masks and face shields to minimize exposure to nasal and mouth droplets splash from others(1). The use of masks need to follow the right guidelines, such as first, when wearing a mask, make sure to wash your hands second, when you are wearing a mask, it is not recommended to touch its front part, if you want to take it off, just hold the mask straps and take it off. Masks must be kept in a safe place so as not to be contaminated, and after wearing it, we should immediately take it off and discard it if it is a disposable mask. Meanwhile, cloth masks can be washed with detergent (1).

Transmission from Covid19 infected people can be symptomatic and asymptomatic. Symptomatic transmission includes symptoms such as headaches, nasal congestion, sore throat, pain, loss of taste and smell, and rashes on the skin (1). Some of Covid19 cases show no symptoms in the infected people so they are not aware of their Covid19 infection. People with no symptoms have a great risk of transmitting Covid19.

Our body's immunity will be very important to avoid getting infected with Covid19. Thus people who are vulnerable such as the elderly, infants, toddlers, people who have an illness history will be more susceptible to the virus and exacerbate their disease until death. People with a history of serious illnesses such as diabetes, cardiovascular and respiratory disorders will be more easily infected with Covid19. Meanwhile, people who have good immunity will be easier to recover if infected with Covid19 and can even recover on their own (1).

The growth of positive cases of Covid19 which is increasing every day causes the need for policies to tackle the pandemic. One of the policies carried out by various countries to stop the spread of the virus is lockdown. Lockdown is done to minimize the interaction between people. Lockdown makes many people do their work from home so as to minimize the occurrence of an uncontrolled crowd(2). Another effect of the lockdown is the effect on economic, social, health, and education .

The lockdown effect on the economy is a decline in the economy and people's purchasing power due to a decline in people's income. Many companies are affected by the lockdown effect so there are production stops. This condition eventually makes the company to reduce staff. The transportation industry is experiencing a negative effect from the lockdown policy as well, because there are restrictions on community mobility(3). This causes a declining number of vehicles in operation. The food and beverage industry, such as cafès and restaurants, has decreased revenue as well because it is only allowed to take a take away order. In addition, informal sector workers are the most impactful because they cannot do work from home. The positive effect of lockdown in the economic field is that it increasingly enhances online-based entrepreneurship(4).

The lockdown also affects the social sector both positively and negatively. On the positive side, lockdown has increased people's empathy by helping and supporting one another such as providing free food for people in need, distributing free masks, distributing free hand sanitizers, and giving knowledge to the public about Covid19 (how to wash hands properly, how to use masks, and transmission of Covid19). Meanwhile, negative effects such as limiting social interaction due to restrictions on community mobility. Thus, causing several social events that allow gathering a lot of time must be postponed or canceled (5).

Furthermore, the lockdown effects on the health sector is an increase in the number of patients resulting in increased working hours of medical staffs/workers. Other than that, PPE needed for medical staffs/workers is increasing, resulting in scarcity and price increases(6). In addition, in the environmental health sector, there is a lockdown effect due to the reduction in community mobility, which causes a decrease in the amount of pollution and an improve in the air quality (7).

The lockdown effect on education both positively and negatively. The positive effect on the education sector is the effort applied to adapt to the Covid19 situation, making teachers and students to be more creative in fulfilling existing competencies. Meanwhile, the negative effect that occurs is the closure of the school because it can be as common as the Covid19 transmission site. Thus, causing a decrease in student interest in learning because of learning from home. There are some constraints on learning activities from home such as lack of technology mastery, additional internet

quota costs, signal constraints where not all places have good internet connections, there are additional jobs for parents in assisting children in learning, communication and socialization are reduced (8).

Air quality has been declining so far due to high community mobility. Such as the high number of vehicles causing vehicle gas emissions that can disrupt air quality in the region. In addition, air quality is also influenced by the industry activities. Thus, the lockdown condition during the Covid19 pandemic improves air quality due to the decline in community mobility, closure of some industries, and decrease in the amount of vehicle density on the road/highway(9). Air quality can be seen through several parameters such as Particulate Matter (PM_{10}), Particulate Matter ($PM_{2.5}$), Sulfur dioxide (SO_2), Carbon monoxide (CO), Ozone (O_3), and Nitrogen dioxide (NO_2). Based on these parameters we can find out the level of air quality in the environment(10). Air quality can affect public health such as respiratory diseases(11). So there needs to be an effort to maintain air quality in order for the people to remain safe. The purpose of this literature review study is to determine the effect of the lockdown policy during the Covid19 pandemic on parameters air quality.

DISCUSSION

The increased number of Covid19 cases that are spread to many countries lead to the application of lockdown policies. Lockdown causes a decreased amount of community mobility and industry shutdown. Community mobility and industrial activities are strongly related to air quality. Consequently, it is interesting to know the influence of lockdown policy during the Covid19 pandemic on air quality. The researchers conducted a literature review known as a narrative literature review. The process of selecting journals can be seen as followed (figure 1).
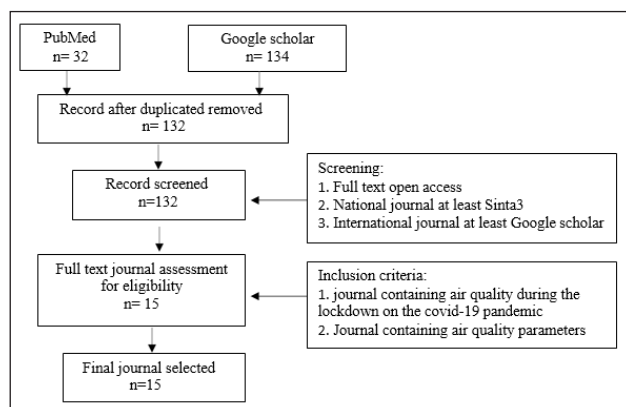

Figure 1. Journals Selection Process

The researchers performed the search of journals in PubMed and Google Scholar by using environment, impact, Covid19, air pollution, and air quality as the keywords. Based on those keywords, it had been collected 166 journals. The first screening was conducted to select the same journals, and the total journal that had been passed the first screening was 134 journals. The second screening was based on the national journal with, at least, a Sinta score of 3 or international journals indexed by Google Scholar and the full text of open access journals. According to the second screening, 132 journals had been collected. The third screening based on the inclusion criteria included the journals discussing the air quality during the lockdown in the Covid19 pandemic and the parameter of air quality. Based on the inclusion criteria, 15 journals that would be analyzed. Those journals were conducted in many countries.

Based on table 1, 15 journals had been selected and it was mentioned that there was an influence of lockdown policy during the Covid19 pandemic against the parameter of air quality. The parameter of air quality included the parameter including the concentrations of PM_{10}; $PM_{2.5}$; NO_2; CO; SO_2; and O_3. The lockdown policy strongly influenced the parameter of NO_2. It could be seen that from the 15 journals that had been analyzed, 14 journals showing the decline.

The Effect of Lockdown on the Covid19 Pandemic Period on Air Quality Indeks (AQI)

AQI is a means of government communication about air quality to the community. AQI can provide information about the effects of air quality on health. AQI describes the status of air quality quantitatively which consists of 6 parameters, such as PM_{10}; $PM_{2.5}$; NO_2; CO; SO_2; and O_3. The lockdown policy during the Covid19 pandemic caused AQI to decline, which means better air quality.

Air quality research during the Covid19 pandemic in Central China (Anqing, Hefei, and Suzhou) shows a decrease in AQI of 45,1%. The decrease is based on data from February 2020 compared to February in 2017 to 2019. Based on data from 2017 to 2019, AQI from the lowest starts point is in Anqing, Hefei, and Suzhou cities (7). Research in Northern China shows similar results as in Central China which is, during the lockdown due to Covid19 pandemic, AQI experienced a decline. AQI's weekly decline in Northern China was 19,4 points or 18%. The lockdown policy in Northern China is divided into 2, namely total lockdown and partial lockdown. The total lockdown area has an AQI decreased by 25%. Meanwhile, in the partial lockdown area, experienced a decrease in AQI by 8,8 poin or 7% (2).

Research results from India is in line with research results in China, there is a decrease in AQI

Tabel 1. Journal Review

Author	Tittle	Population	Method	Result	Summary
Dr Ben Anderson and Dr Kim Dirks	A Preliminary Analysis of Changes in Outdoor Air Quality in The City of Southampton During The 2020 COVID-19 Outbreak to Date	Southampton	Quantitave research	Covid-19 Lockdown in Southampton starts Tuesday, March 23, 2020, the results of lockdown was NO_2 parameter level 92% lower than the 2017-2019 average. Significant changes in NO_2 parameters due to the influence of the wind direction.	There was a significant decrease in NO_2 concentration during lockdown.
Li Li, QingLi, LingHuanga, QianWanga, Ansheng Zhu, JianXua, Ziyi Liu, Hongli Li, LishuShi, Rui Li, Majid Azari, Yangjun Wang, Xiaojuan Zhang, Zhiqiang Liu, Yonghui Zhu, Kun Zhang, Shuhui Xue, Maggie Chel Gee Ooi, Dongping Zhanga, Andy Chan	Air Quality Changes During The COVID-19 Lockdown Over The Yangtze River Delta Region: An Insight into The Impact of Human Activity Changes on Air Pollution Variation Pattern	Yangtze River Delta Region	Quantitave research	Data were analyzed based on three periods, namely Pre-lockdown (1st January to 23rd January 2020), Level I response (24th January to 25th February 2020), Level II response (26th February to 31st March 2020). During the level I and level II decreased SO_2 by 16-26%, and $PM_{2.5}$ by 27-46%. $PM_{2.5}$, NO_2 and SO_2 concentrations in the level I period compared to the same period in 2019 decreased by 31,8%, 45,1% and 20,4%. whereas, $PM_{2.5}$, NO_2 and SO_2 concentrations in the level II period compared to the same period in 2019 decreased by 33,2%, 27,2% and 7,6%.	There was a decrease in the parameters SO_2, $PM_{2.5}$, NO_2. the highest decrease is the NO_2 parameter in the period I level.
Kaijie Xu, Kangping Cui, Li-Hao Young, Ya-Fen Wang, Yen-Kung Hsieh, Shun Wan, Jiajia Zhang	Air Quality Index, Indicatory Air Pollutants and Impact of Covid-19 Event on The Air Quality Near Central China	Anqing, Hefei, and Suzhou near Central China	Quantitave research	The results show that during February 2020, in the cities of Anqing, Hefei and Suzhou; average ambient air concentration of $PM_{2.5}$ was 41,9 µg/m³, PM_{10} was 50,1 µg/m³, SO_2 was 2,18 ppb, CO was 0,48 ppm, and NO_2 was 8,97 ppb. $PM_{2.5}$, PM_{10}, SO_2, CO, and NO_2 concentrations decreased when compared with the same period in 2017 to 2019, amounting to 46,5%, 48,9%, 52,5%, 36,2%, and 52,8%. However, an average O_3 of 80,6 ppb did not show significant fluctuations and even slightly increased by 3,6%. The study also analyzed and compared the five highest daily AQI from February 2017-2019 with 2020 for the three cities. The average AQI for 5 days with the highest daily AQI of 122,6 in February 2020 was 45,1% lower than in February 2017-2019 of 223,2.	$PM_{2.5}$, PM_{10}, SO_2, CO, and NO_2 concentrations decrease. The highest decrease is the NO_2 parameter.
Pierre Sicard, Alessandra De Marco, Evgenios Agathokleous , Zhaozhong Feng ,Xiaobin Xu, Elena Paoletti, José Jaime Diéguez Rodriguez, Vicent Calatayud	Amplified Ozone Pollution in Cities During The Covid-19 Lockdown	South Europe (Nice, Roma, Valencia and Turin) and Wuhan	Quantitave research	Compared to the same period in 2017-2019, the average daily O_3 concentration increased at urban stations 24% in Nice, 14% in Rome, 27% in Turin, 2.4% in Valencia and 36% in Wuhan during lockdown in 2020. A strong reduction in the average NO_2 concentration was observed in all European cities, 53% at city stations, comparable to Wuhan 57%, and 65% at traffic stations.	The highest O_3 increase in Wuhan. The highest drop in NO_2 in Europe occurred at traffic stations.
Jesse D. Berman and Keita Ebisu	Changes in U.S. Air Pollution During The Covid-19 Pandemic	U.S	Quantitave research	The lockdown period in the US occurs from March 13 to April 21, 2020. Data during the lockdown period will be analyzed by comparing with pre-lockdown data from January 8 to March 12, 2020 and compared to the same period from 2017 to 2019. A decrease in NO_2 significant 25,5% with an absolute decrease of 4,8 ppb. Meanwhile, $PM_{2.5}$ also showed a decrease of 11,3%.	The highest decrease is the NO_2 parameter during lockdown in US
Sneha Gautam	Covid-19: Air Pollution Remains Low as People Stay at Home	Asian countries (i.e., China and India) European countries (i.e.,Spain, Italy, and France)	Quantitave research	NO_2 reduction during lockdown occurred in India by 70% and in China by 20-30%. Meanwhile, in European countries (i.e., Spain, Italy, and France) there was a NO_2 decrease of 20 to 30%.	The highest NO_2 reduction in India
Guojun He, Yuhang Pan, and Takanao Tanaka	COVID-19, City Lockdowns, and Air Pollution: Evidence from China	China	Quantitave research	Air quality increased by 25% (28,2 points decrease for AQI, and 22,3 µg/m³ for $PM_{2.5}$). $PM_{2.5}$ concentrations in control cities decreased by 8,40 µg/m³, and city locking further reduced $PM_{2.5}$ in lockdown cities by 13,9 µg/m³ resulting in a total of 22,3µg/m³	During lockdown the air quality increased by 25%

Author	Tittle	Population	Method	Result	Summary
Kasturi Devi Kanniah, Nurul Amalin Fatihah Kamarul Zaman, Dimitris G. Kaskaoutis, Mohd Talib Latif	Covid-19's Impact on The Atmospheric Environment in The Southeast Asia Region	Malaysia	Quantitave research	The lockdown period starts from March 18 to June 9. PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO concentrations decrease when compared with the same period in 2018 and 2019, which are 26-31%, 23-32%, 63-64%, 9-20%, and 25-31%.	The highest decrease in Malaysia is the NO_2 parameter
Rui Bao, Acheng Zhang	Does Lockdown Reduce Air Pollution? Evidence from 44 Cities in Northern China	44 kota di Northern China	Quantitave research	Data from 1 January and 21 March 2020. Reduction of air pollution is highly related to travel restrictions during this pandemic, on average, the Air Quality Index (AQI) fell 7.80%, and five air pollutants SO_2, $PM_{2.5}$, PM_{10}, NO_2, and CO decreased by 6.76%, 5.93%, 13.66%, 24.67% and 4.58%	The highest decrease in North China was the NO_2 parameter.
Susanta Mahato, Swades Pal, Krishna Gopal Ghosh	Effect of Lockdown Amid Covid-19 Pandemic on Air Quality of The Megacity Delhi, India	Delhi, India	Quantitave research	Lockdown was implemented in India from March 24 to May 3, 2020 and compared with the same period in 2019. PM_{10} and $PM_{2.5}$ concentrations experienced a reduction of around 60% and 39%. Other pollutants, NO_2 was 52,68%, CO was 30,35%, and SO_2 was 17,97%. Air quality increases around 40% to 50% only after four days of lockdown	The reduction in PM_{10} concentration is the highest in Delhi India during lockdown.
Shubham Sharma, Mengyuan Zhang, Anshika, Jingsi Gao, Hongliang Zhang, Sri Harsha Kota	Effect of Restricted Emissions During COVID-19 on Air Quality in India	India	Quantitave research	Data were analyzed from 16 March to 14 April 2020 and compared with the same period in 2017 to 2019 in 22 cities covering various regions of India. There was a decrease in $PM_{2.5}$ by 43%, PM_{10} by 31%, CO by 10%, and NO_2 by 18%. Meanwhile, the O_3 parameter increased by 17%. The air quality index (AQI) is reduced by 44%, 33%, 29%, 15% and 32% in north, south, east, central and western India.	The highest decrease in India is the parameter $PM_{2.5}$ and the best air quality in East India.
Anas Otmani, Abdelfettah Benchrif, Mounia Tahri, Moussa Bounakhla, El Mahjoub Chakir, Mohammed El Bouch, M'hamed Krombi	Impact of Covid-19 Lockdown on PM_{10}, SO_2 and NO_2 Concentrations in Salé City (Morocco)	Salé City (Morocco)	Quantitave research	The analysis period is before lockdown (March 11 to 20) and during lockdown (March 21 to April 2). Continuous measurements of PM_{10}, SO_2 and NO_2 are carried out before and during the Covid-19 lockdown period. There was a decrease for PM_{10} by 75%, SO_2 by 49%, and NO_2 by 96%.	The highest reduction in Salé City, Marocco is the NO_2 parameter.
Pratima Kumari and Durga Toshniwal	Impact of Lockdown Measures During COVID-19 on Air Quality a Case Study of India	India : Delhi dan Mumbai	Quantitave research	Data were analyzed by comparing at the pre-lockdown (01 March to 24 March 2020) and at the lockdown (25 March to 15 April 2020). The parameters that experienced a decrease in Delhi were PM_{10} by 55%, $PM_{2.5}$ by 49%, NO_2 by 60%, and SO_2 by 19%. The parameters that experienced a decrease in Mumbai were PM_{10} by 44%, $PM_{2.5}$ by 37%, NO_2 of 78%, and SO_2 by 39%.	The highest decrease in Delhi and Mumbai is the NO_2 parameter.
Laurent Menut, Bertrand Bessagnet, Guillaume Siour, Sylvain Mailler, Romain Pennel, Arineh Cholakian	Impact of Lockdown Measures to Combat Covid-19 on Air Quality Over Western Europe	Eropa Barat	Quantitave research	Decrease in NO_2 concentrationsfrom 30% to 50% in all Western European countries.	Decrease in NO_2 concentration is highest in Portugal.
Liane Yuri Kondo Nakada, Rodrigo Custodio Urban	Covid-19 Pandemic: Impacts on The Air Quality During The Partial Lockdown in São Paulo State, Brazil	São Paulo State, Brazil	Quantitave research	Significant reduction in concentration NO_2 of 54.3% and CO 64.8% was observed in urban areas during partial lockouts compared to the five-year monthly average. In contrast, a 30% increase in O_3 concentration	The highest concentration reduction was NO_2 parameter of 54.3%. O_3 concentration increased by 30%.

during the lockdown in the Covid19 period. This research was conducted in 22 cities in India. AQI decline in India was divided into 5 regions, which are North India by 44%, South India by 33%, East India by 29%, Central India by 15% and West India by 32%. The decrease is based on data comparing from March 16 to April 14 from 2017 to 2020 (12). AQI can be influenced by the high mobility of the people, especially those who use private transportation and cause congestion. The construction of infrastructure facilities in high traffic areas such as the construction of educational facilities can cause risks for people in the area. The risk is that people who live in high traffic area is 2,8 times more likely to be affected by respiratory disorders than people who live in low traffic (13).

The lockdown policy in China can reduce air pollution by up to 25%. This happens because of the industrial closure and it can be seen that industrial activities are a source of air pollution. The impact of the application of locdown in cities with high industrial

activity will increasingly decrease air pollution (14). The concentration of AQI is not only influenced by the lockdown policy which causes a decrease in community mobility and closure of various industrial fields. The concentration of AQI is also influenced by the temperature wherein during the summer the concentration of AQI will be low. On the contrary, in the winter, AQI concentration will be high (7). The season will affect the concentration of AQI, this is shown in researches, such as in a research conducted in Anqing, Hefei and Suzhou; it is found that in the summer the AQI will decrease which means that air quality is getting better (7).

The lockdown policy during the Covid19 pandemic has proven to have an influence on AQI. AQI becomes lower which means better air quality. This is proven by 3 studies conducted. In addition, a full lockdown policy has a higher impact on air quality than a partial lockdown.

The Effect of Lockdown on the Covid19 Pandemic Period on Particulate Matter (PM$_{10}$)

Particulate Matter (PM$_{10}$) used to determine the number of particles with a diameter of less than 10 µm in air(10). Based on the analyzed journals, it is found that the existence of lockdown can help to reduce PM$_{10}$ concentrations so as to minimize health problems such as respiratory disorders. There are 7 journals that discussed the reduction in PM$_{10}$ concentrations during the lockdown on Covid19 pandemic. The research sites were in 4 countries namely China (Central China and Northern China), Malaysia, India and Morocco. Based on the time of data collection for analysis, three methods were applied, namely at the time of the previous year.

The highest decrease in PM$_{10}$ concentration occurred in Sale City, Morocco. PM$_{10}$ concentration before lockdown was 114,6 µg/m^3 and at the time of lockdown it became 28,3 µg/m^3. Reduction in PM$_{10}$ concentration in Sale City, Morocco, was found out to be 75%. These data were analyzed based on the time before the lockdown (11 March to 20 March 2020) and at the time of lockdown (21 March to 2 April 2020) (15). This happened because the lockdown policy was implemented, causing a reduction in the number of vehicles and traffic density.

This research is in line with research conducted in Delhi, India. The lockdown policy (March 25 - April 15, 2020) can cause a reduction in PM$_{10}$ concentration by 55% when compared to pre-lockdown (March 01 - March 24, 2020) (16). Meanwhile, there are other studies whose data were analyzed in the same period in different years from research in Delhi India, PM$_{10}$ concentrations decreased by 60%. Data is taken at lockdown (March 24 to May 3, 2020) and compared with the same period in 2019 (17). The data analysis in this study is in line

with research conducted in 22 cities in India, where NO$_2$ decreased by 31%(12). Apart from the lockdown policy, the level of decline in PM$_{10}$ concentration can also be influenced by meteorological factors(18).

The lockdown policy is also implemented in Malaysia with the term Movement Control Order (MCO). The MCO was starting from March 18 to June 9 2020. MCO had decreased community mobility due to the closure of public transportation and public facilities. Decreasing community mobility in Malaysia has led to a decrease in NO2 concentration by 26-31% when compared to the same period in 2018-1019(19). The lockdown policy that was carried out in Northern China has also led to a decline in community mobility. The reduction in mobility was 69,85% and causes a decrease in NO$_2$ by 13.66%(2). In addition, it the reduction in mobilty was also caused by the dismissal of several industries and construction work that could be a source of dust so far (15). PM$_{10}$ is produced mainly from vehicle exhaust and road dust (2).

The lockdown policy during the Covid19 pandemic has proven to have an effect on concentration PM$_{10}$. All of the research that have stated that the lockdown policy caused a decrease in PM$_{10}$ concentration. The decrease in PM$_{10}$ concentration was between 13% and 75%.

The Effect of Lockdown on the Covid19 Pandemic Period on Particulate Matter (PM$_{2.5}$)

Particulate Matter (PM)$_{2.5}$ used to determine the number of particles with a diameter of less than 2.5 µm in air(10). Based on the analyzed journals, it is found that there are 9 journals that discussed the decrease in PM$_{2.5}$ concentration due to lockdown implementation. The research sites were in 4 countries, namely China (Yangtze River Delta Region, Central China and Northern China), United States of America, Malaysia and India. Based on the time of data collection for analysis, three methods were applied, namely at the time of lockdown, at the time before lockdown and at the time of lockdown, and in the same period as the previous year.

The highest decrease was in Delhi, India, which was 49%. The decrease was seen from the time pre-lockdown and after lockdown. PM$_{2.5}$ may experience a decrease in concentration due to the implementation of lockdown where in the industry was not operating normally and there were decreasing number of vehicles which caused decreasing level of dust concentration from traffic, and as well as decreasing level of dust concentration from housing (9). Meanwhile, another research that was also conducted in Delhi India had decreased PM$_{2.5}$ by 39%. This happened because the data during the lockdown was compared to the same

period in 2019(17). This is in line with research conducted in 22 cities in India that there was also a decrease in $PM_{2.5}$ during lockdown when compared to the same period in the previous year of 43%(12).

$PM_{2.5}$ concentrations can come from vehicle gas emissions. There is a correlation between the number of vehicles passing with $PM_{2.5}$ concentration (20). Meanwhile, research conducted in the US did not show a significant decrease in $PM_{2.5}$ compared to other research of 11.3%. Research in the US shows the decline in $PM_{2.5}$ is more significant in urban areas where lockdowns are imposed in rural areas where there are lockdowns(21). Reducing $PM_{2.5}$ concentrations by 31.8% in the Yangtze River Delta Region, China has led to reduced emissions sources such as industry, cellphones and dust (9). Reducing $PM_{2.5}$ concentration corrects delays in countries that are too late to close business(21).

Significant reduction $PM_{2.5}$ in Central China if compared to the same period from 2017 to 2019 by 46.5%(7). This is in line with research conducted in China, the decline in $PM_{2.5}$ is proportional to the lockdown policy. The decrease in $PM_{2.5}$ in lockdown cities in China was 13.9µg/m^3. Meanwhile, $PM_{2.5}$ in control cities in China was 8.40µg/m^3(14). This happened because of the government's policy to implement lockdown. In addition, Chinese New Year holiday activities at the end of January 2020 have lowered the $PM_{2.5}$ parameters. Then it was lengthened with a lockdown policy that caused a decline in community mobility which eventually lead to the closure of $PM_{2.5}$ producing sources such as industry and vehicle gas emissions (7).

The lockdown policy during the Covid19 pandemic has proven to have an effect on $PM_{2.5}$ concentrations. All research discussed stated that the lockdown policy caused a decrease in $PM_{2.5}$ concentrations. The decrease in PM10 concentration was between 11.3% and 49%.

The Effect of Lockdown on the Covid19 Pandemic Period on Nitrogen dioxide (NO_2).

NO_2 is an indicator of air quality. NO_2 can come from the combustion process. High NO_2 concentrations can cause health problems such as coughing, red eyes, sore eyes, dizziness, and shortness of breath. This condition will worsen if people who are exposed to NO_2 are old so that they are more susceptible to experience health problems. NO_2 with high concentrations can cause increased sensitivity in people with asthma and bronchitis. Decreased NO_2 concentrations were found in 14 analyzed journals during the Covid19 pandemic. Research sites were in Southampton, England, China (Young River Delta Region, Central China and Northern China), United State of America, Southern Europe, Malaysia, India (Delhi and Mumbai), Morocco, Western Europe, and Sao Paulo State Brazil.

The highest drop in NO_2 concentration was found in Sale City, Morocco. The decrease was seen based on the data pre-lockdown and after lockdown. The decrease was 96% from NO_2 concentration of 5.6 µg/m^3 to 0.2 µg/m^3 (15). This research is in line with research conducted in Delhi, India. The lockdown policy (March 25 - April 15, 2020) can cause a reduction in NO_2 concentration by 60% when compared to pre-lockdown (March 01 - March 24, 2020) (16).This happened due to the effect of the lockdown policy so that had made activity and mobilization of the community was stopped. The increase in NO_2 concentration is directly correlated to the number of vehicles (22). So, the lockdown policy that was implemented automatically would reduce the number of vehicles so as to reduce the NO_2 concentration.

High NO_2 concentrations will cause aerosol nitrate formation and acid rain. NO_2 in Morocco showed a significant decrease because the lockdown policy implemented caused the cessation of industrial activities and transportation as the main contributor to NO_2. The reduction in NO_2 concentration is higher in Asian countries than European countries(23). This happens because Asian countries first apply lockdown.The decrease in NO2 concentration is higher in cities that do a total lockdown. As for the city of Turin with a high industrial sector and many food industries that cannot be locked so the decline is not significant (24). The highest reduction in April 2020 occurred in Jakarta with a contribution of 34%. Meanwhile, to compare with previous years in Sumatra and Kalimantan, NO_2 changes were not so noticeable due to forest fires (19).

NO_2 concentration can also be affected by meteorological parameters such as temperature, humidity, and air velocity. The increase in temperature will be directly correlated to the increase in concentration of NO_2. If the humidity is high and the temperature decreases it will affect NO_2 concentration(22). This is in line with the research carried out in Southampton England at the time of the Covid19 pandemic, where in the results show that the NO_2 parameter's concentration is influenced by wind speed. In that research, there were 3 different wind speed firstly, wind speed that causing low NO_2 if the wind was dominated from north-east northeast to north; secondly, causing high NO_2 if the wind was dominated by east wind; and lastly causing the lowest NO_2 if the wind blows from north to east (18).

The lockdown policy during the Covid19 pandemic has proven to have an effect on NO_2 concentrations. All research discussed stated that the lockdown policy caused a decrease in NO_2 concentrations. The decrease in NO_2 concentration was between 18% and 96%.

The Effect of Lockdown on the Covid19 Pandemic Period on Carbon monoxide (CO)

CO is one of the parameters of air quality which has a more dangerous effect than the other parameters. CO is the third smallest carbon after CO_2 and CH_4. CO can cause chemical changes in the blood that can cannot be detected and increased cardiovascular symptoms both in smokers and nonsmokers. CO can cause pneumonia health problems in toddlers (11). CO can come from incomplete combustion such as factory heating furnaces, electricity generators, and vehicle gas emissions.

Decreased CO concentrations were analyzed in 6 journals during the Covid19 pandemic. Research sites in the journal were in China (Central China and Northern China), Malaysia, India and Sao Paulo State Brazil. The highest decline occurred in Sao Paulo State, Brazil. The decrease in CO concentration during lockdown was 64.8% compared to the data obtained for the same period from the last five years. The data analysis period were taken from four weeks pre-lockdown and four weeks during lockdown then these data were compared with the data from February to April in 2015 -2019 . The decrease in CO in Brazil was due to the lockdown policy of the local government wherein closures were made in areas that allowed crowds to occur, such as shopping centers, industries, offices, and educational facilities. Thus, decreasing the community mobility and, eventually, reducing CO concentration(25). Meanwhile, there are other studies whose data were analyzed in the same period in different years from research in Malaysia, CO concentrations decreased by 25–31%. Data is taken at lockdown (March 18 to June 9, 2020) and compared with the same period in 2018 to 2019 (19).

Research that shows the effect of the lockdown policy during the Covid19 pandemic on CO concentrations occurred in China and India. Research in China during the lockdown period decrease in CO concentration was between 4.58% and 36.2%. Meanwhile, Research in India during the lockdown period decrease in CO concentration was between 10% and 30.35%.

The lockdown policy during the Covid19 pandemic has proven to have an effect on CO concentrations. All research discussed stated that the lockdown policy caused a decrease in CO concentrations. The decrease in CO concentration was between 4.58% and 64,8%.

The Effect of Lockdown on the Covid19 Pandemic Period on Sulfur dioxide (SO_2)

SO_2 is one of the parameters of air quality. SO_2 can come from burning coal and petroleum containing sulfur. SO_2 can cause health problems such as allergies and increased sensitivity in people with asthma and bronchitis (10). Decreased SO_2 concentrations during the Covid19 pandemic were found in 7 analyzed journals. The research sites in the journals were in China (Young River Delta Region, Central China and Northern China), Malaysia, India (Delhi and Mumbai), and Morocco.

The highest SO_2 decline occurred in Central China. SO_2 concentration during the Covid19 pandemic, which is in February 2020, amounted to 2.18 ppb. Then an analysis is conducted, in which the data obtained were then compared to the data from the same month in 2017-2019, the results show a decrease of 52.5%. SO_2 concentrations decreased significantly in Central China in January to March 2020 compared to the same period of the last 3 years. This happened because of the lockdown policy which caused the suspension of production for the Chinese New Year and production restrictions(7). This research is in line with research conducted in 44 cities in northern China. The lockdown policy (January 1 and March 21 2020.) can cause a reduction in SO_2 concentration by 6.76%(2).

SO_2 can come from industrial activities, transportation, and also housing(26). So that when India imposed a lockdown there was a decrease in SO_2 concentration. There were 2 studies located in India and all showed decreased SO_2 concentrations during lockdown. Research in Delhi India shows a 19% decrease in SO_2 when compared to pre-lockdown data(16). In addition, an effort to reduce SO_2 concentrations can be done by expanding green open space.

The MCO policy implemented by the government caused a 9-20% decrease in SO_2 when compared to the same period in 2018-2019(19). The decrease in the amount of SO_2 concentration also causes a decrease in the number of people with Acute Respiratory Infections (ARI) (26). This is in line with the research conducted in Surabaya area wherein the results show that there is a relationship between the amount of SO_2 concentration and the level of ARI sufferers (27).

The lockdown policy during the Covid19 pandemic has proven to have an effect on SO_2 concentrations. All research discussed stated that the lockdown policy caused a decrease in SO_2 concentrations. The decrease in SO_2 concentration was between 6.76% and 52.5%.

The Effect of Lockdown on the Covid19 Pandemic Period on Ozone (O_3)

O_3 concentration is influenced by temperature, in which the formation of O_3 is affected by photochemical reactions. A low NO_2 concentration will cause a low concentration of NO_x. Thus reducing the possibility of O_3 accumulation. The change in NO_x concentration and

O_3 concentration in the urban area have a negative correlation. The lockdown policy can reduce vehicle gas emissions so that the NO_2 concentration decreases. So, the O_3 concentration increases because there is no reaction (7).

The implementation of the lockdown policy during the Covid19 pandemic caused an increase in O_3 concentration. 3 journals that discussed this matter were analyzed. The research sites were in Southern Europe (Nice, Rome, Turin and Valencia), India, and Sao Paulo State Brazil. The highest increase in O_3 concentration was found in Sao Paulo, Brazil. Increased O_3 concentration was found to be 30%, compared with the data obtained for the same period from the last five years. Time for the data analysis was four weeks pre-lockdown and four weeks lockdown (24 these data were then compared with the data from February to March and April in 2015-2019. This research is in line with research conducted in 22 cities in India. The lockdown policy (March 16 to April 14, 2020.) can cause an increase in O_3 concentration by 17%. when compared to the same period from 2017 to 2019 (12). Meanwhile, the average concentration of O_3 in Southern Europe during lockdown increased between 2.4% and 27% and Wuhan during locdown increased 36%, when compared to the same period from 2017 to 2019 (24). The highest average O_3 concentrations, reaching 90 $\mu g.m^{-3}$ in summer, are collected in Turin and Wuhan. 66Increasing the concentration of O_3 as a secondary pollutant will be taken from the publication of primary pollutants (24).

The lockdown policy during the Covid19 pandemic has proven to have an effect on O_3 concentrations. All research discussed stated that the lockdown policy caused a decrease in O_3 concentrations. The decrease in O_3 concentration was between 2.4% and 36%.

CONCLUSION

The air quality at the time of lokdown during Covid19 pandemic improved. AQI has decreased, which means we have better air quality. The highest decline in AQI was found in Central China (Anqing, Hefei, and Suzhou) by 45.1%. AQI on the total lockdown policy more decreased of the partial lockdown. Lockdown policy provided a big influence on the air quality in Sale City Marocco and Sao Paulo Brazil. The concentrations of PM_{10} and NO_2 were decreased significantly in Sale City, Marocco. Meanwhile, in Sao Paulo, Brazil, the concentration of CO was decreased significantly and the concentration of O_3 was increased significantly compared to other countries. Consequently, it can be found that the increase in air quality during the Covid19 pandemic is based on the decreased concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO. Meanwhile, the concentration of O_3 was increased. Lockdown policies during the Covid19 period strongly influenced the concentration of NO_2.

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