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# Introduction

Air pollution is one of the major environmental issues in the recent years all over the globe, with so many contaminants that pollute the air (Li et al., 2017). It is essential but quite difficult to maintain the quality of air, thus, United Nations declared it as one of the sustainability targets that is necessary to maintain for human survival. For instance, the SDG 3.9 SDG target states the reduction of impacts to health through the air pollutants that could be hazardous and the reduction of cities causing an impact on the human health as declared by SDG 11.6 (Rafaj et al., 2018). The air pollution is creating space for the emergence of new diseases, due to which people are suffering from serious illness that are even fatal in extreme cases (Kampa & Castanas, 2008)

In Canada, Sulfur dioxide (SO2), fine particulate matter (PM2.5) and ozone (O3) are among the three major outdoor air pollutants causing harm to environment and human health (Burnett et al., 2004). However, throughout the world, organization and concerned authorities are making efforts for improving the quality of air, such as, Canada. Even Ontario has been able to improve the condition of air over the last decade through banning certain activities that were damaging the air and using coal as a source of generating energy. Moreover, a ban was imposed on using the caps that contained Nitrogen oxide and Sulfur dioxide. New policies and regulations were set in order to maintain the quality of air in the region. The level of emission from various sources was controlled so that the activities may continue but causing less harm to the environment. (Air Quality Ontario, 2010). Thereby, due to the essential need of reducing the air pollutants and the potential harms to human health, it is important to control the air pollution and its harmful effects through effective mitigation measures. This study will discuss in detail different questions that will help comprehend the concept of air pollution in detail specifically focusing on Ontario, Canada.

# Major sources of pollutants in southern Ontario and their formation

In southern Ontario, some contaminants such as, fine particulate matter, O3, NO3, SO2 are among the major air pollutants reported from Windsor and Peterborough station that are damaging the atmosphere and causing climate change (Bates & Sizto, 1987). These air pollutants including carbon monoxide, nitrogen dioxide, Sulfur dioxide, PM2.5, PM10, and ozone needs to be controlled as they are spreading as a pandemic globally and are harmful for the environment that surrounds us and for human health causing cardiovascular diseases (Akbarzadeh et al., 2018).

A study conducted in Hamilton, Canada by Wallace et al., (2009) reveals that the air pollution is increasing due to flourishing population, industry and increased traffic. This study examined the sources of these pollutants, use mobile monitoring and states that Nitrogen oxides and Sulfur oxides emerge from the industries and traffic in a very high concentration. The Concentration of NOx exceeds 600ppb whereas the concentration of SO2 levels exceed 249ppb near industries. These concentrations are considered lethal as they are exceeding the hourly maxima which are recorded by fixed monitors. Environment Canada has estimated that in 2005, the industries were responsible for 82% Sulfur emissions and the nitrogen was emitted around 64% from the traffic source only.

Moreover, these gases are formed from different sources such as the Particulate matters (PM) that consist of solid and liquid particles are those which emits from the smokestack of electrical power plants in Canada and contains liquid as well as solid matters. Whereas, the secondary PM formed by multiple physical and chemical reactions and includes the gases such as Sulfur and nitrogen oxides, sulphates nitrates and particles of ammonium. This particulate matter can be primary and secondary based on their source of emission and compounds present in them (Canada.ca, 2013).

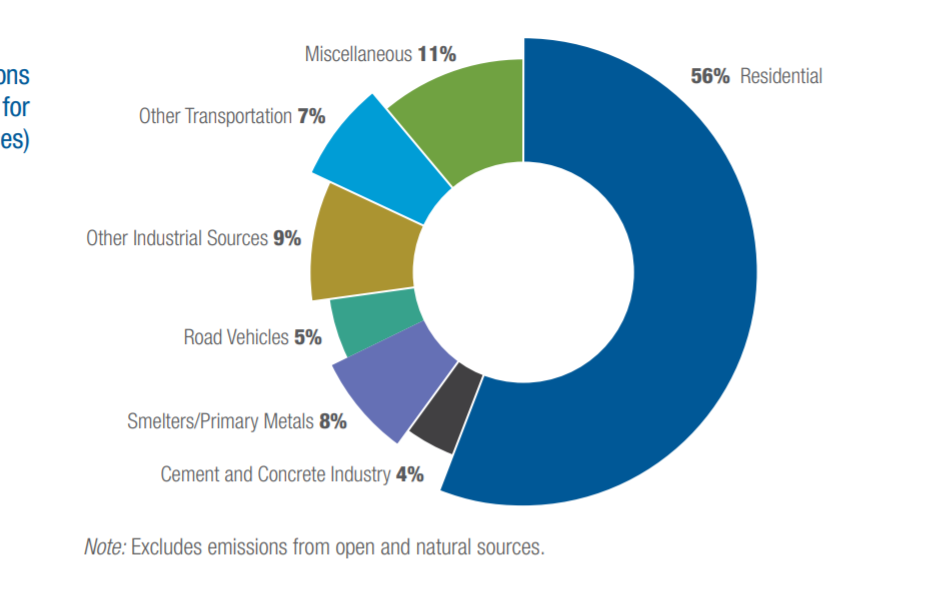


Figure 1. Source of particulate matter emissions in Canada (Environment and Climate Change Canada, 2018)

The ground level ozone is harmful for living beings. It is considered an irritating gas that is colourless and formed just above the earth’s surface (Liu et al., 2018). The ground level ozone is highly prevalent in Canada especially during summers due to heat and vegetation. Moreover, the industrialized regions and the clear sky anticyclonic conditions are the common emitter of ozone in Canada (Ramos et al., 2018). Ozone is the secondary pollutant as it is formed by the chemical reactions of already present nitrogen gases and volatile organic compounds in the air. These pollutants when reacts with sunlight forms ozone through chemical reactions. These Nox and VOCs are formed by the anthropogenic activities such as the burning of fossil fuels including coal gasoline and the oil which is burnt in the industries and power plants of Canada. Some of it also emerges from the natural sources such as the coniferous forest found in abundance in Canada (Canada.ca, 2016).

Sulfur Dioxide is the common pollutant in Canada due to the natural gas production with elevated emissions at immediate vicinity (Islam et al., 2020). It is also produced from fuels containing Sulfur and undergoes combustion in coal-burning power plants. Regions in Canada that are highly populated produce this gas and are subjected to the harms it provides. An overwhelming amount of the Sulfur dioxide in air is manmade. SO2 is emitted in the atmosphere when humans burn fuels containing Sulfur, such as coal and oil, through industrial processes. Some smaller sources include volcanic processes, metallic ore extraction processes, and vehicles that burn fuel with high Sulfur content (Carlsten et al., 2020).

# Long-term trends in average annual concentrations of pollutants in Windsor and Toronto, Comparison with Ontario guidelines for protection of human health

The National Air Pollution Surveillance (NAPS) program generated the report of annual concentration of air pollutants through Air Quality Health Index including the trends in Windsor and Toronto of the pollutants such as fine particulate matter, ozone and sulfur dioxide (Canada.ca, 2020)(Table 1).

Table 1. Trends of average annual concentration of pollutants in Windsor and Toronto, Canada (Environment and Climate Change Canada, 2018)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Area | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| **Fine particulate matter** | | | | | | | | | | | | | | | |
| Toronto, ON | 8.6 | 8.4 | 7.8 | 9.0 | 7.6 | 7.7 | 7.1 | 5.6 | 6.1 | 6.4 | 6.3 | 8.3 | 8.8 | 8.5 | 7.0 |
| Windsor, ON | n/a | 9 | 9 | 10.5 | 8.7 | 9.7 | 8.6 | 7.3 | 7.8 | 7.8 | 7.5 | 9.6 | 10.4 | 9.5 | 8.3 |
| **Ozone (O3)** | | | | | | | | | | | | | | | |
| Toronto, ON | 36.9 | 35 | 32.8 | 36.5 | 33.8 | 36.4 | 35.1 | 33.9 | 35.4 | 34.2 | 36.6 | 34.7 | 34.8 | 34.9 | 36 |
| Windsor, ON | 35.5 | 35.5 | 33 | 39.5 | 36.5 | 39.5 | 38 | 36 | 38.5 | 38.5 | 40 | 37.5 | 38 | 38 | 39.5 |

Table 2. The concentration levels of Sulfur dioxide in Windsor and Toronto (Ministry of the environment and climate change, 2016)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | City |  | Percentile | | | | | |  | Maximum | | No. of times above criteria | | |
|  |  | Valid h | 10% | 30% | 50% | 70% | 90% | 99% | Mean | 1h | 24h | 1h | 24h | 1y |
| 12008 | Windsor | 8749 | 0 | 0 | 0 | 1 | 3 | 13 | 1.1 | 44 | 12 | 0 | 0 | 0 |
| 35125 | Toronto | 8686 | 0 | 0 | 1 | 1 | 1 | 3 | 0.6 | 10 | 3 | 0 | 0 | 0 |

The Ontario, Canada established guidelines are for the exposure limitation of pollutants and protection of human health through the major decisions taken for the outdoor air pollution reduction (Wheeler et al., 2011). The long-term trends (year-to-year) in the Canada air quality was assessed for the SO2, O3 and Fine particulate matter that shows that the average concentration for these air pollutants is decreasing with time especially in 2020 due to Covid19 and restricted human activity (Adams, 2020). Moreover, the Air Quality in Ontario Report (2016) demonstrates that the quality of air in Ontario has improved with a decrease in these harmful pollutants because in recent years Canada has implemented measures that helps in controlling the air quality of certain areas. For instance, Ontario has strict regulation on automobiles that emit these pollutants into the air, the release of gases because of nearby industries is monitored and these factories and industries have to make sure that they mitigate any pollution coming from their activities, otherwise they have to adopt practices that are environment friendly. Ontario keeps a strict check on the CSR score and rating of companies, Corporate social responsibility is a newly developed business model that helps organization structure their activities according to these development goals. Organizations need to be socially responsible and make sure that they give something back to the society in order to attain a sustainable society (Deguen et al., 2018). The companies that have good CSR score and ranking are liked by the people and their products as well as services are more purchased by the people. The guidance document is remarkable as it focuses on health effects through these air pollutants, air quality emissions, interventions and policies for the clean air (Craig et al., 2008).

# Effect of sunlight on the levels of air pollutants

The air pollutants such as particulate matters, sulfur dioxide and ozone are affected by sunlight directly or indirectly. For instance, it is reported by Sharma et al., (2018) that the ozone level in summers is comparatively higher as the sunlight elevates the level of ozone in air. The particulates matters and oxides of sulfur are the major source and cause of the formation of ground level ozone. The reason is the chemical reactions which takes place in the presence of sunlight creates the ozone (Figure 2). In Canada, the summers are the main emitter season of ozone when it is at highest levels as stated by Ramos et al., (2018). Moreover, it is revealed that sulfur dioxide in the presence of sunlight act as a precursor of volcanic smog and thus harm climate (Hildebrandt, 2013). The solar radiations elevates the level of sulfur dioxide in atmosphere that is hazardous for human health whereas as per Wu et al., (2020), the sunlight lowers the concentration of sulfur dioxide as assessed in the rainy season of Beijing when the solar radiations decreased the level of SO2. In addition to it, it is revealed by Wang et al., (2019) that the sunlight protective covering is affected by the presence of PM2.5 higher concentration. However, Hameed, Mohammed & Jawad, (2020) reported that sunlight helps in the reduction of PM from the atmosphere.

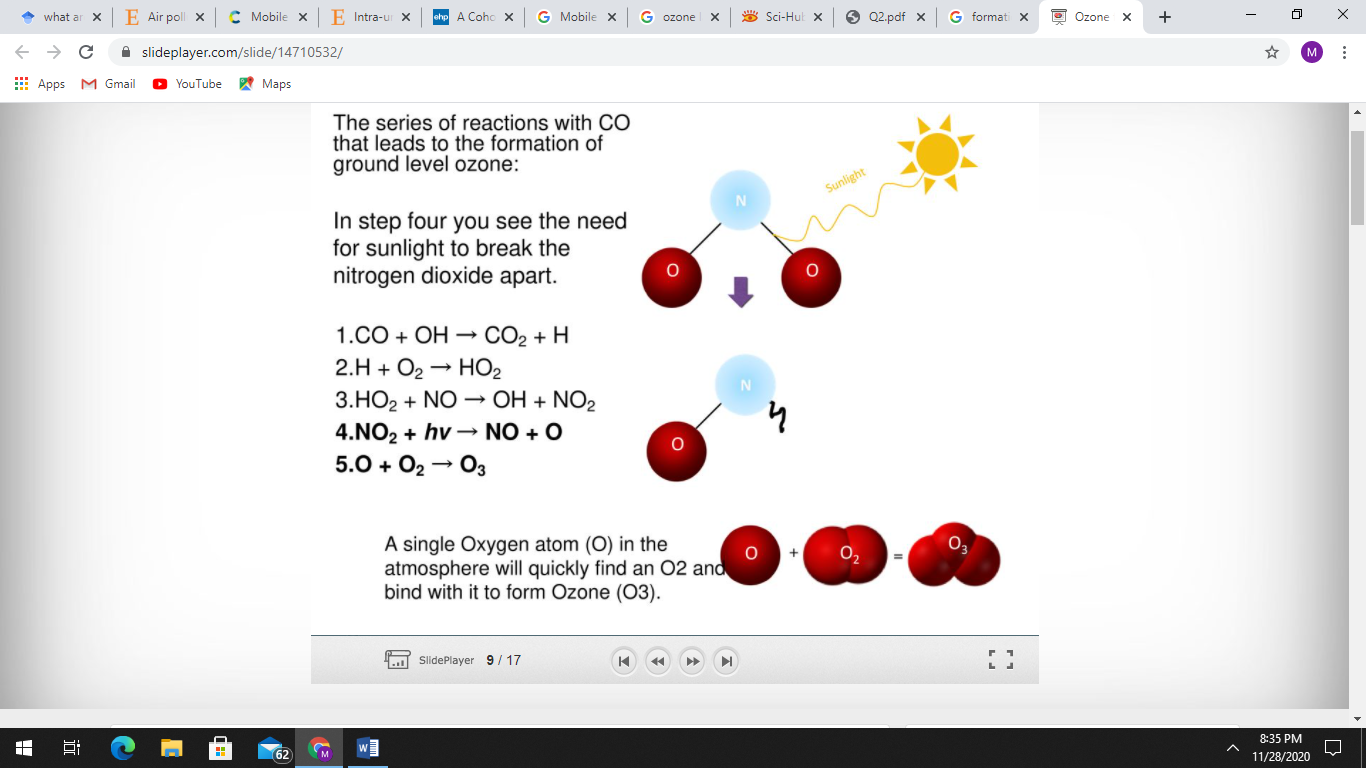


Figure 2. Reaction of ozone formation in the presence of sunlight (Chandler, 2018)

# Air quality standards set for 1 hour, 8 hours, 24 hours and 1 year exposures

The air quality standards are recognized based on the criteria set for the required air quality keeping in view the technological and economic considerations and especially the welfare and health of public. Through these standards, the emissions reduction levels are recognized through jurisdictions and policy makers judgments (Bachmann, 2007). Air quality standards are set on the basis of hourly monitoring data for the 1 hour, 8 hours, 24 hours and 1 year exposures to air pollutants (Bell & Ellis, 2003). The set criteria is divided in different time measurements as these pollutants levels are different in varying conditions and time, thus, for determining the concentration level for SO2, O3 and fine particulate matter, certain time criteria is preferred for accurate results. The average time is set for each country with ambient air quality standards set for pollutants such as PM2.5 with 24-h as well as an annual, ozone with 1-h mean as well as 8 h average and sulfur dioxide with 10 minutes, 24 hours and annual average for evaluating the exposure and to keep environment and living beings safe (Vahlsing & Smith, 2011).

Table 3. Air quality standards on hourly basis (United States Environmental Protection Agency, 2016)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pollutant [links to historical tables of NAAQS reviews] | | Primary/ Secondary | Averaging Time | Level | Form |
| Ozone (O3) | | Primary and secondary | 8 hours | 0.070 ppm | Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years |
| Particle Pollution (PM) | **PM2.5** | primary | 1 year | 12.0 μg/m3 | annual mean, averaged over 3 years |
| secondary | 1 year | 15.0 μg/m3 | annual mean, averaged over 3 years |
| primary and secondary | 24 hours | 35 μg/m3 | 98th percentile, averaged over 3 years |
| **PM10** | primary and secondary | 24 hours | 150 μg/m3 | Not to be exceeded more than once per year on average over 3 years |
| Sulfur Dioxide (SO2) | | primary | 1 hour | 75 ppb | 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years |
| secondary | 3 hours | 0.5 ppm | Not to be exceeded more than once per year |

Table 4. Air quality criteria of Ontario air pollutants (MECP, 2020)

|  |  |  |  |
| --- | --- | --- | --- |
| Contaminant | Ambient Air Quality Criteria (Ontario) | Time | Basis |
| NO2 | 200 (0.10 ppm) | 24-hour | Health |
| 400 (0.20 ppm) | 1-hour | Health |
| CO | 36,200 (30 ppm) | 1-hour | Health |
| 15,700 (13 ppm) | 8-hour | Health |
| SO2 | 40 ppb | 1-hour | Health |
| 67 ppb | 10-Minutes | Health |
| 4 ppb | Annual | Vegetation |

# Types of air pollutants emitted by a coal fired power plant without adequate pollution controls, their dispersal and their impacts on ecosystems

The major pollutants that are created by the coal fired power plants include heavy metals, lead, copper, Chromium, mercury, lead, Sulphur dioxide, nitrogen oxides along with other environmental pollutants (Nagajyoti et al., 2010). Canada relies on 33.4% natural gas, 45% on crude oil, 6.6% on hydro, 6.2% upon coal, 1.6% upon nuclear, 3.7% on NGLS and 3.5% upon other renewable resources (BP Statistical Review of World Energy, 2019). The production of energy through coal fired power plants is damaging the whole eco-system through high level of greenhouse gas emission that could be controlled through the effective implementation of modern technologies. These emissions could have adverse effects on human health such as respiratory issues and carcinogens. Moreover, the lands are disrupted and climate change disturbs the seasonal changes (Dzikuć & Piwowar, 2015). Additionally, Sulphur dioxide emissions are the main contributor in causing Acid Rain that affect our eco-system, also, when this rain water flows into the rivers, seas and oceans, it harms the aquatic life thus disturbing the eco-system (Yun et al., 2019).

Nitrogen oxides are responsible for the respiratory diseases that are spreading all over the country, it is also responsible for the global warming, because of that the water levels all over the world are rising with the threat that many nations might go under sea. When mercury is released into the environment, it accumulates in water laid sediments where it converts into toxic methylmercury and enters the food chain (Paoletti et al., 2019). From food it enters into the blood stream of human beings as a result it has a direct impact on the human health. In addition to it, this toxic pollutant effects the wild life, the animals that consume fish are also affected by it and it leads to even death (Driscoll et al., 2013).

Lead has been a main contributor in air pollution as it was being used in fuel and this was impacting the human brain other than that Soils near highways, freeways, and smelting facilities have higher levels of lead than soils in other areas because of their exposure to lead dust, which accumulates over time. Children were most likely to be impacted by lead in the air, all these pollutants are dangerous for the eco-system and in order to prevent them from causing further damage certain steps need to be taken (Lovett et al., 2018).

# Major sources of air pollution in Dhaka, Bangladesh, comparison with Toronto

The air pollution levels reported in the city of Dhaka, Bangladesh is extremely high this is because the major revenue of the country is generated through their manufacturing sector that produces large amount of pollutants into the air (Chowdhury & Imran, 2010). (Azad & Kitada, (1998) indicates that the brick fields and the Motor vehicles are main cause of emissions in the region and since the regulation authorities are weak in the country, factories get away with their activities. The residential activities, traffic congestion and system of commerce are another sources of NOx and SO2 in Dhaka. The region control the pollutants in the city as the recent reports declared less amount of NO2 and SO2 traces than the guidelines provided but with an increase in the population, environment could get polluted (Salam et al., 2008). The level of air pollution levels in Dhaka is however, comparatively very higher than Toronto as declared by the reports of World Health Organization (Numbeo, 2020). Additionally, Toronto has been able to control their levels of pollutions quite well as they are at 53 AQI Moderate, this can be made further better by taking it below 50 AQI (IQAir, 2020).

Table 5. Data of air pollution Toronto and Dhaka (Numbeo, 2020)

|  |  |  |
| --- | --- | --- |
| World Health Organization data | | |
|  | **Toronto** | **Dhaka** |
| PM10 | 16 | 104 |
| PM2.5 | 9 | 57 |
| PM10Pollution Level: | Low | Very High |

The residents in both the cities deal with the pollution differently, though there are distinct mitigation strategies in place in Bangladesh, even then they are exposed to numerous diseases. By reducing the amount of pollution in air, many lives can be saved, thus, the Brick Burning Act in 1989 was introduced by Government of Bangladesh (GoB) as bricks industry was the major emitter of air pollutants. This act was renewed in 2005–2006 with different policy implications as well as cleaner energy efficient technologies to manufacture bricks was introduced to reduce emissions (Guttikunda & Khaliquzzaman, 2013). Moreover, about eleven of the Continuous Air Quality Monitoring Stations (CAMS) were adapted by the total eight cities for air pollution monitoring and for generating the data such as air quality index (Hoel, 2014). Whereas, in Toronto, the actions are taken through public cooperation and co-ordination, their trust and actions in this regard due to the emotional attachment with the residential areas (Wakefield et al., 2001). Moreover, they are working on vehicles modifications to eradicate the chances of emissions through traffic congestion or overpopulation (Hatzopoulou & Miller, 2010).

# Potential human health impacts of air pollutants

The vehicular emissions due to the air pollutants including the emissions of PM, SO2, CO, NO2 and other heavy metals causes bad health impact causing serious illnesses. The short term and long term effects of these pollutants are reported that includes the respiratory syndromes, malfunctioning of lungs, asthma, irritation, fatigue, headache or high blood pressure if short-term and exposure for longer term could result in cancer, cardiovascular diseases and even lead to death. For instance, the lead exposure by children or adults could cause cognitive impairment, high blood pressure, central nervous system damage and in some cases child intelligence is reduced (Salam et al., 2008; Schwela, 2000). The fine particles emissions also needs to be controlled as if they are inhaled could result in mortality, thus, are a threat to human health (Salam et al., 2008).

The major effect of air pollution is climate change, it is a trending concept under debate all over the world, as the situation of ozone layer is getting worse day by day and the temperature of the whole planet is rising. A huge hole in the ozone layer was discovered over the North Pole that elevates the sea level all over the globe posing a threat to many nations that could drown under the sea (Manisalidis et al., 2020). Canada is one of those countries under risk as chances of flood rise with global warming and changes in climate are increasing affected by human activities. Heat ways in European countries are also rising due to the uncontrolled industrialization as well as both land and air temperature is rising (Ford & Smit, 2004). This increased climate change is the major “health inequity” in the region increasing the burden of diseases and vulnerability of masses especially poor people (Patz et al., 2007). The resulted extreme weather conditions and exposure to the toxic gases is hazardous for human health increasing chances for the deaths due to heatwaves, heatstroke, heart attacks and others (McMichael et al., 2006). Canada is very close to the artic bay and that region has been effected the most by global warming, these areas are cold and with rise in temperature they are getting warmer this is disturbing the lives of people there because they are accustomed to the cold. Animals in these regions are also going extinct, thus the entire eco-system is being disturbed, this is also changing the hunting cycles all over the world (Brauer et al., 2017). The vulnerability approach referred explicitly to the UN framework convention on climate change, where commitments are made by different countries should be used to promote adaptation to address region and people that are vulnerable (Ford et al., 2006).

# Conclusion

World is trying to cope with the challenges for sustainable development goals. UNFCCC has taken different action plans as COP21 has asked the signatory countries to develop INDC to reduce emissions. The sustainable issue Canada is facing recently is air pollution that is effecting its environment, however, it is working on the development of energy using the renewable energy resources such as wind, solar and water and are becoming more socially responsible.

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