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A REVIEW OF ATMOSPHERIC CHANGES AMIDST COVID19 PANDEMIC IN THE LIGHT OF IPCC SPECIAL REPORT 2018 AND COP24 CONFERENCE

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author RK designed the study with valuable suggestions and inputs from author AKS, retrieved the raw data figures, performed the data analysis and interpretations part and managed the literature searches. Both authors contributed towards writing the first draft of the manuscript, its proofreading and subsequent revisions. Both authors read and approved the final manuscript.

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Review Article

ABSTRACT

Earth has an inbuilt mechanism of keeping balance among its structural and functional components. Extreme anthropogenic activities like overexploitation of natural resources and rapid industrialisation are interfering with the regulatory functions of the ecosystem. Increase in concentration of greenhouse gases in the atmosphere mainly due to human activities has led to increase in global temperature after industrial revolution. Carbon dioxide is a major driver of global warming. Recognising the underlying threats of global warming on humanity as well as Earth's biodiversity, Paris Agreement mandated the participating countries to limit the global carbon emission so as to not let increase the global temperature above 2°C in near future with respect to pre-industrial levels and also to keep pursuing efforts to attain the 1.5°C. In this regard, IPCC presented a special report on the assessment of the impacts of rise in temperature up to 1.5°C above pre-industrial levels on the environment and the world in 2018 which revealed many horrifying facts associated with global warming in near future. In this report, IPCC also provided recommendations to mitigate this problem. Moreover, this report formed the background of COP24 which was held in order to assure the full implementation of Paris Agreement by the participating countries. COVID19 pandemic associated restrictions imposed by different counties all around the globe has shown some positive changes in the environment with respect to carbon emission and atmospheric concentrations of other pollutants. In this review article, authors have made an attempt to assess the impacts of

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this lockdown on the atmosphere in light of the recent IPCC report and outcomes of COP24. Coupling solutions of social and economic issues together with environmental issues during the process of development has been suggested as a sustainable way to achieve holistic national growth in a greener way.

Keywords: Homeorhesis; radiative forcing; climate change; IPCC; SR15; COP24; COVID19.

1. INTRODUCTION

Every ecological system is endowed with its own inbuilt mechanisms to maintain the balance among its structural and functional components. For instance, many ecologists have considered planet Earth as a super-organism because like a living organism, Earth has capability to maintain balance among its structural and functional components. Ecologists have suggested the term Homeorhesis for Nature, a term homologous to the Homeostasis which is used for living organisms [1]. The major difference between these two terms lies in the extant and range of regulation. Homeotasis is the tendency of living organisms to maintain a constant internal environment within a narrow range, whereas homeorhesis is the tendency of a system like an ecosystem to maintain itself in a pulsing state of equilibrium which results due to the interplay of biogeochemical cycles and energy flow along with subsystem feedback mechanisms [1]. Homeorhesis is the self-correcting ability of the nature. According to Gaia hypothesis, the Earth's atmosphere would not have been supporting life if it were not regulated by the totality of life in the biosphere. For example, the present level of oxygen in the air that is available for respiration to aerobic organisms is supposed to be derived mostly from photosynthetic organisms that evolved mechanisms to use water molecules for photosynthesis millions of years ago. Any ecological system on Earth possesses either of the two types of stability, resistance and resilience, each having its specific role to play in the regulation of life forms. For instance, resistant systems are difficult to get perished but once these get destroyed, they take considerable span of time to resurrect. On the other hand, resilient systems are prone to damage but they can heal quickly [1, 2, 3]. Different populations, even if they are occupying a common ecosystem, may possess different types of stability. Resistant populations like those of woody trees form the backbone of tropical and temperate forests, the resilient populations like those of herbivorous plants provide constant source of food to the herbivorous animals which in turn are food of carnivorous animals. Therefore, nature has its own complex and intricate regulatory mechanisms to maintain itself in a proper functioning state.

Mahatma Gandhi once said, "Earth provides enough to satisfy every man's needs, but not every man's greed" [4]. Nature has ability to support its life forms. As already mentioned, nature has its own regulatory mechanisms. But "greed" of human beings has disturbed this regulatory framework. Overexploitation of natural resources and excessive pollution has crippled Nature's ability of self-correction. In this review article, an overview of the effects of industrialisation on global climate with a brief discussion on important points of IPCC Report 2018 and outcomes of COP 24 meeting has been provided in subsequent paragraphs with special consideration of the impacts of COVID19 pandemic on the atmosphere, particularly, the air quality and the carbon emission, with special reference to the state of Bihar, India followed by some other important recent developments.

2. INDUSTRIALISATION AND CLIMATE CHANGE

Greenhouse gases are the major drivers of climate change [5]. Industrial revolution has led to manifold increase in the concentration of greenhouse gases in the atmosphere apart from the release of various harmful pollutants in huge concentrations [6]. This increase has led to the observable climate change. Greenhouse gases have potential of inducing global warming [5,6]. Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and water vapour are the major greenhouse gases [6]. Although CO_2 is not a very potent greenhouse gas but evidence suggests of its role in increase of global temperature [6]. CO_2 has significant contribution towards radiative forcing. According to Intergovernmental Panel on Climate Change (IPCC, 2007), radiative forcing is a measure of the influence caused by a given climatic factor on the retention of a specific amount of downward-directed radiant energy falling on the surface of Earth. Positive forcing value is an indication of involvement of the climatic factor in global warming while a negative value indicates the involvement of a climatic factor in global cooling [7]. Radiative forcing values are calculated using 1750 as the reference year [7]. These values are the values of influence caused by a climatic factor between 1750 to present. The radiative forcing is measured in watts per square meter (Wm^{-2}) of surface. In 1750, the gaseous abundance of CO_2 in the atmosphere was 278 ppm, which increased to 365 ppm in year 1998. For this span of time, the radiative forcing value for CO_2 was found to be 1.46 Wm^{-2}

which is highest among all the greenhouse gases [8, 9, 6].

Oceans are the biggest reservoir and sink of CO_2 but dissolution of CO_2 in oceans is temperature dependent [10]. At warmer temperature the process is reversed. Due to anthropogenic activities, mainly industrialize-tion, the concentration of greenhouse gases are constantly increasing. This increase is responsible for the rise in global temperature which in turn reduces the dissolution of CO_2 in the oceans which further leads to entry of more CO_2 into the atmosphere. Excessive use of fossil fuels for electricity generation, transportation, cooking, etc. and deforestation for agricultural purposes, setting new industries, urbanisation, etc., further contributes to increase in atmospheric CO_2 concentration as trees remove CO_2 by photosynthesis by converting and storing it in its different body parts in the form of carbohydrates and other carbon compounds [6, 11]. Apart from CO_2, anthropogenic factors, particularly large scale industrialization, are also associated with the rising atmospheric concentrations of other greenhouse gases and harmful pollutants [6].

Now the question arises regarding the effects of global warming. Why is rising global temperature a matter of concern? Evidence suggest clear correlation of global warming with melting of glaciers and rising sea levels which may lead to submergence of islands and coastal cities in future, frequent flooding and drought which directly affects global food production and security, extinction of many species, more powerful storms, frequent wildfires, more intense heat waves, spread of deadly vector borne or zoonotic diseases as warmer and wetter climate favours growth and breeding of the disease carrying vectors, etc. [6, 12, 13, 14].

3. ABOUT IPCC

Recognising the underlying threats to humanity associated with increasing global temperature, Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by joint venture of the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO) for assessment of scientific and technical research pertaining to the issue of global climate change and for proper evaluation of potential impacts so that possible options regarding adaptation and mitigation may be sought. Currently IPCC has 195 members from all across the world [15]. IPCC prepares an evidence based report which is drafted by the efforts of thousands of contributors around the globe based on the input from thousands of scientific papers published each year to provide a comprehensive summary related to different aspects of global climate change [15]. Since 1988, IPCC has published 5 comprehensive assessment reports and a number of special reports on particular topics [16]. The 5th and the latest assessment report was published in 2014 and a special report was put forward in 2018 following the commencement of United Nations Climate Change Conference COP21 (Conference of Parties 21) in Paris in 2015 and adoption of Paris Agreement in 2016 [16, 17].

4. IPCC SPECIAL REPORT 2018 AND COP24 CONFERENCE

During Paris Agreement 197 countries committed to limit global rise in temperature below 2°C with respect to pre-industrial levels in coming years and promised to keep pursuing efforts to attain the 1.5°C. Alongside COP21, IPCC was invited to provide a special report on the assessment of the impacts of rise in temperature up to 1.5°C above pre-industrial levels on the environment and the world [16]. In this regard, IPCC published the Special Report on Global Warming of 1.5°C (SR15) in October 2018. The report was approved in Incheon, South Korea during the 48th session of IPCC [17]. Through this report IPCC has suggested the actions the world needs to take to prevent global average temperatures from rising beyond 1.5°C as compared to pre-industrial times. In this report, IPCC has stressed upon the fact that limiting global warming to 1.5°C would require rapid, far reaching and unprecedented changes in all aspects of society. This report compares the impact of global warming of 1.5°C and 2°C. This report served as the key scientific input for the 2018 United Nations Climate Change Conference (COP24) held in Katowice, Poland to review the Paris Agreement to tackle the climate change [18]. The report further highlights that climate change could have "irreversible" and "catastrophic" impacts if the global temperatures are allowed to rise beyond 2°C as world is already witnessing the consequences of 1°C of global warming in the form of more extreme weather, rising sea levels and diminishing Arctic sea ice and many more. The report suggests to accelerate the international efforts to tackle climate change in order to limit rise in global temperature. The report warns about the higher climate related risks for natural and human systems. The report also points out the fact that investment in physical and social infrastructure can prove to be a key enabler in enhancing adaptive capacity as well as resilience. Poorly designed and implemented adaptation projects can increase greenhouse gas emissions and water use, increase gender and social inequality, undermine health conditions, and encroach on natural ecosystems. Hence, adaptation efforts must group poverty alleviation with sustainable development. These

efforts need financial support. Adaptation needs have been supported by public sector sources, multilateral development banks, and UNFCC channels. NGOs and private funding also have a significant role to play. According to the report, there is a need to integrate disaster management and adaptation to reduce vulnerability. The report has also identified options of "educational adaptation" which motivate adaptation through building awareness. A more participatory approach towards adaptation, especially for vulnerable population, will be to formulate adaptation action based on knowledge of indigenous communities. These people are threatened by cultural modification, dispossession of land rights and land grabbing, rapid environmental and social changes. Therefore recognition of indigenous rights, governance systems and laws is central to adaptation, mitigation and sustainable development. Local governments are important. They help enabling more participative decision-making by involving wider community in preparation and implementation of adaptation policies. The IPCC report suggests possible pathways to attain the target of 1.5°C. Much sharper and quicker emission cuts would be required by the big emitters like China, the US, the European Union and India. The modern technologies with low carbon footprints can be a game changer. Therefore, the pathways suggested be IPCC heavily depends on the success of the carbon removal technologies. These pathways to some extant are based on Carbon Dioxide Removal (CDR), which involves physical removal of CO_2 in quantities between 100 to 1000 gigatons from atmosphere to reduce its concentration. CDR technologies are still in developing stage. The IPCC report recommended to reduce global net anthropogenic CO_2 emission by 45% from 2010 levels by 2030, and net-zero around 2050 in order to achieve 1.5°C target. The report also recommended to cut non-CO_2 emissions seriously. In this regard, reduction of global methane and black carbon emission was suggested up to 35% and more by 2050 with respect to 2010 levels. Investments in efficient and low carbon technologies has been recommended. Use of coal has to be decreased for industrial activities and has to be reduced to 0% by 2050 for electricity generation. 75-90% emission cuts are required from industrial sectors by 2050 with respect to 2010 levels [19, 20]. Apart from these major recommendations, many other recommendations were also put forward by IPCC in this special report to mitigate climate change by achieving 1.5°C objective in near future.

The 24th Conference of the Parties (COP24) to the United Nations Framework Convention on Climate Change (UNFCCC) or the 2018 United Nations Climate Change Conference was held in Katowice, Poland in December 2018 with objective of the full implementation of Paris Agreement. This conference is also called Katowice Climate Change Conference. IPCC Special Report 2018 forms the basis of COP24. Apart from welcoming IPCC report, the major outcome the of COP24 includes the Paris Agreement Rule Book which provides an elaborate and comprehensive explanation of the rules which govern the reporting of carbon emissions, regular assessment and reporting of the progress of mitigation, adaptation, financial inputs, addressing losses, and a commitment to stick to, pursue and fulfill the ambition and goals of Nationally Determined Contributions (NDCs) by each nation [18,21,22,23,24].

Though recent scenario presents a challenge in attaining ambitious goals set by IPCC Special Report 2018 and COP24, the recently imposed lockdown amidst COVID-19 (Coronavirus Disease 2019) pandemic has somehow provided a way to achieve these targets.

5. IMPACTS OF COVID19 PANDEMIC ON THE ATMOSPHERE WITH SPECIAL REFERENCE TO BIHAR

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a coronavirus, which causes COVID-19 disease, has created havoc in year 2020 all around the globe. There are 213 countries and territories directly affected by this virus in year 2020 [25]. Due to its high transmission rate and infectivity, World Health Organisation (WHO) has declared it as a pandemic by considering this pandemic a global threat to mankind [26]. To prevent large scale transmission, governments of many counties all around the globe have imposed restrictions at multiple levels like traveling, social gatherings, vehicular transport, etc. Educational institutions and religious places have been shut down for many months. People have been suggested to stay at home as much as possible and follow social distancing. Only institutions and firms dealing with essential and emergency services have been allowed to operate by most countries. Due to this widely imposed and prolonged lockdown many Industrial activities are also at standstill. Due to sharp reduction in industrial activities, which are the biggest cause of environmental pollution, world has witnessed many positive changes in the environment which was otherwise impossible to observe under normal circumstances. Due to reduction in activities like vehicular transport and industrial production, air quality has significantly improved. As shown in Fig. 1, the National Air Quality Index (NAQI) values of the two most populous cities of Bihar, viz. Patna and Gaya has improved significantly amidst lockdown.

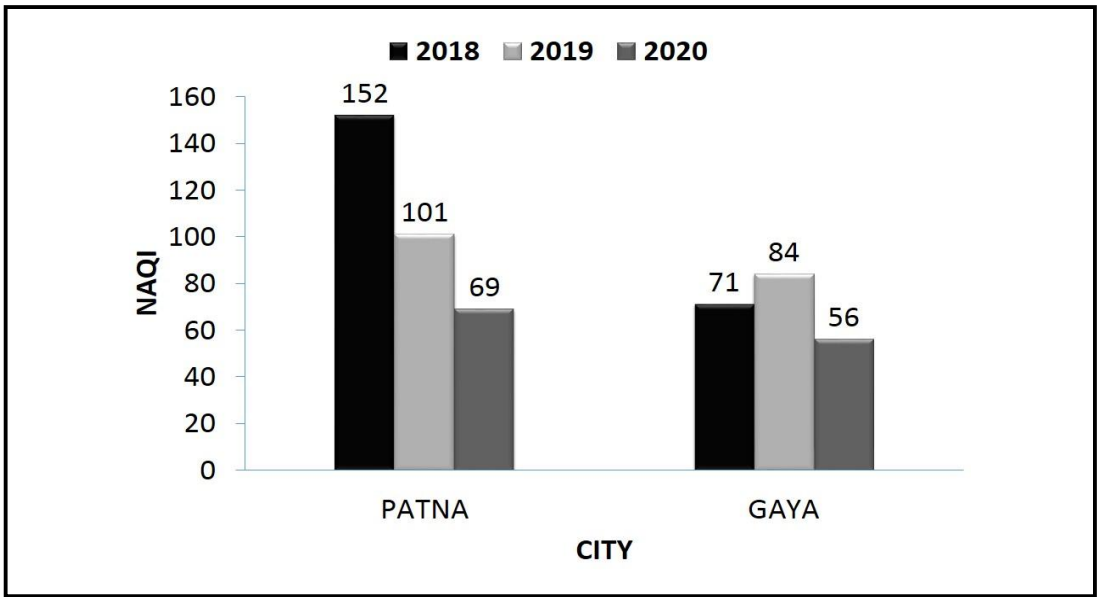

Fig. 1. Values of National Air Quality Index (NAQI) from Patna (IGSC Planetarium Complex) and Gaya (Collectorate) at 8:00am on August 11, 2018; August 11, 2019 and August 11, 2020. It can clearly be observed that the value has dropped sharply in 2020, possibly because of the lockdown imposed due to COVID19 pandemic (Graph plotted using data retrieved from the website of Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India, https://app.cpcbccr.com/AQI_India/)

The air quality of other Indian cities have also improved significantly. There has been reports of appearance of clear blue sky and improvement of visibility due to reduction in the concentration of pollutants which were primarily responsible for the poor visibility. As shown in Fig. 2, the Aerosol Optical Depth (AOD) measurements obtained by NASA using Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite over India for the same period between March 31 and April 5 for five consecutive years from 2016 to 2020. Bihar has been indicated with red arrow. The drastic decrease in AOD value can be observed after imposition of lockdown. Aerosol optical depth is the measure of the absorption and reflection of light by airborne particles when it passes through the atmosphere [27]. If aerosols are present in high concentrations near the Earth's surface, an optical depth of 1 or above is observed which indicates very hazy conditions [27]. AOD value of less than 0.1 over the vertical column of entire atmosphere is considered "clean" [27]. Though greenhouse gases are not included while calculating values of air quality indices, reduction in carbon emission has also been observed in the lockdown [28]. Reduction in use of fossil fuels due to reduction in industrial activities and vehicular movements, both the quantities of suspended particulate matter and greenhouse gases have reduced sharply. Ecosystems are in the mode of recovery. There are also some reports telling about revival of the ozone layer to some extent [29]. These data suggests a positive impact of COVID19 associated lockdown on the environment particularly on the Earth's atmosphere [30,31,32,33]. But there is a cons side also associated with this lockdown. Loss of human lives should not be a cost for attaining these emission targets. Safe disposal of biomedical waste has also emerged as a challenge in this pandemic. Frequent use of incinerators by hospitals to get rid of these wastes also add greenhouse gases to the atmosphere. Electricity consumption has increased manifold as people are staying indoors. Frequencies of using Air Conditioners have increased sharply which in turn leads to the addition of more greenhouse gases and other pollutants like ozone depleting agents to the atmosphere. Scientists have also pointed out the possibilities of accelerated industrial production post-lockdown in order to compensate the economic loss incurred on countries during lockdown phase, which in turn would end up increasing the rate of carbon emission and generation of other pollutants sharply [34,35]. There is possibility of losing all the environmental gains achieved amidst COVID19 pandemic associated lockdown. Though some experts have suggested to impose lockdown once in a while to reduce carbon emission and combat pollution, it may not be a feasible way to tackle emission problems.

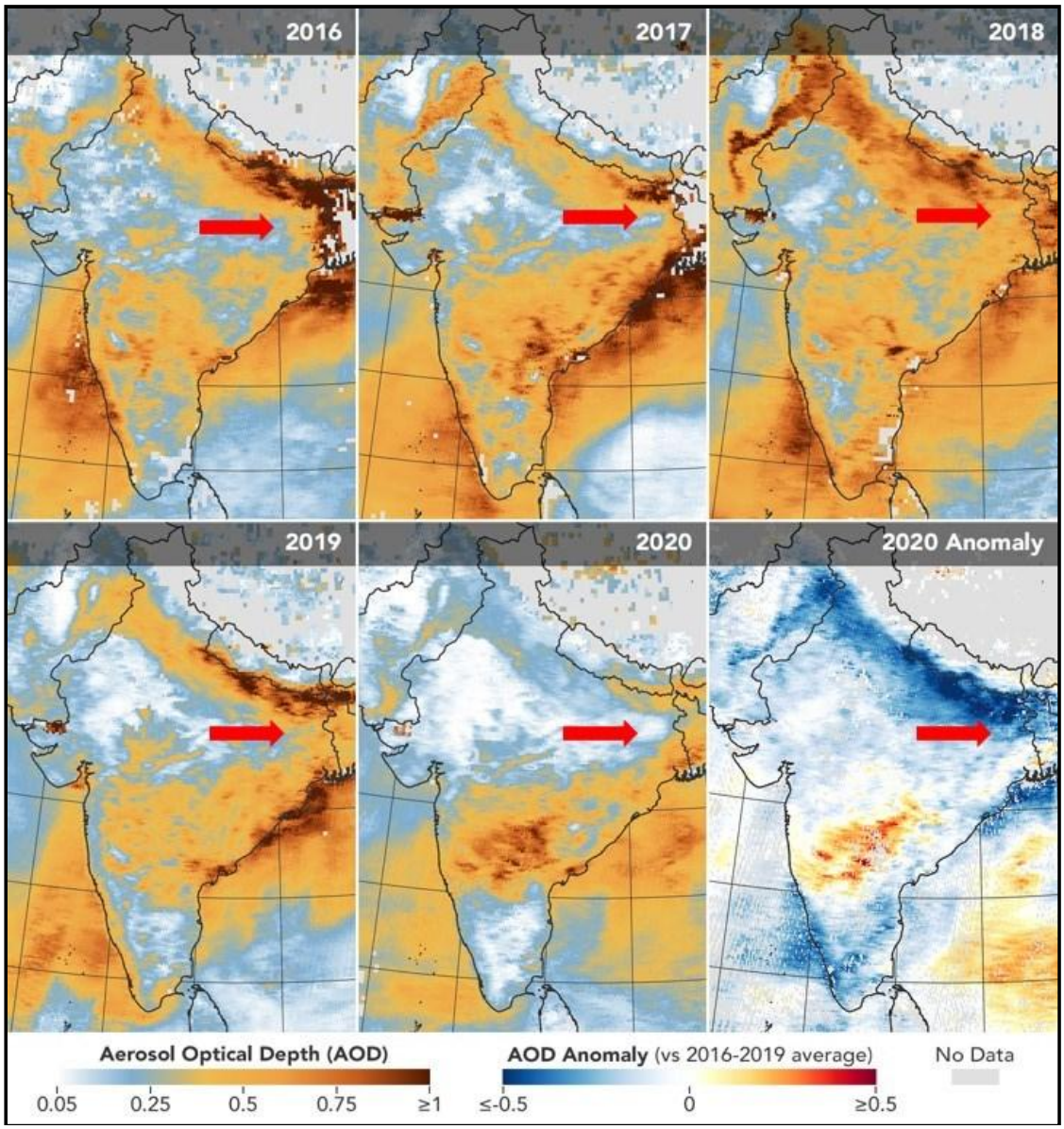

Fig. 2. The first five maps above are showing the aerosol optical depth (AOD) measurements over India during the period between same March 31 and April 5 for years 2016, 2017, 2018, 2019 and 2020. The location of Bihar has been indicated with red arrow over each map. The sixth map (anomaly) is showing AOD in 2020 compared to the average for the years 2016, 2017, 2018 and 2019

(Source: https://earthobservatory.nasa.gov/images/146596/airborne-particle-levels-plummet-in-northern-india)

6. CONCLUSION

As already discussed, Earth has its own inbuilt mechanism of correcting itself amidst any perturbation which threatens its structural and functional integrity. There is a famous saying among ecologists, "the solution to pollution is dilution [36]." It also refers to the same resurrecting abilities of the Earth (to dilute and detoxify pollutants in its system) but it does have its own limits of functioning too. Anthropogenic factors are drastically affecting Earth's self-correcting abilities. The pace of "creation" of pollutants has surpassed the Earth's pace of "dilution" of these pollutants. For instance, anthropogenic rate of carbon emission is far greater than the natural rate of carbon sequestering. Therefore, recognizing the underlying threats of anthropogenic carbon emission over global climate, Paris Agreement was held. The

goals put forward during Paris Agreement before the participating countries to slow down, control and limit global carbon emission appear ambitious but as per recommendations of recent IPCC special report SR15 and discussions during COP24, these are not impossible to achieve. Lockdown has shown a possible way of achieving reduction in global carbon emission but certainly it is not a logical long term solution. Use of efficient technologies with low carbon footprint in industrial setups can go a long way but it would require more research and development activities. Retrofitting old coal or other fossil fuel based production units which produce huge amount of greenhouse gases and pollutants with modern machines with low emission threshold is the need of the hour. Certainly it would also enhance the efficiency of the production units and increase the productivity. Development of technologies based on renewable sources of energy should be encouraged. But it would require huge financial investments. Although multiple investment channels have been suggested by global leaders during various meetings and conferences from time to time for tackling environmental issues, challenges like hunger, poverty, unemployment and poor health infrastructure get the first priority by any nation, particularly developing and underdeveloped ones. Therefore, there is a need to frame policies which would not hinder social and economic development while pursuing targets like reducing carbon emission. Social and economic issues should be tied up with environmental challenges while seeking an effective solution and sustainable development practices should be given priority from the beginning itself instead of correcting faults in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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