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Discussion

Future liaising of the lockdown during COVID-19 pandemic: The dawn is expected at hand from the darkest hour

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ABSTRACT

The lockdown during COVID-19 pandemic has converted the world into new experimental laboratories, which may reveal temporal or spatial comparative analysis data. However, some startling information is gathered in terms of reduced premature mortality cases associated with air and water quality improvement, enhanced e-learning on a broader platform, work from home, and successful e-health. The decline in vehicular density on roads and congestion leads to reduced energy consumption and associated greenhouse gases (GHG) and other pollutants emission. The lockdown has also been identified as a possible emergency measure to combat severe air pollution episodes. Similarly, industrial pollution has been recognized as one of the primary causes of water resource pollution and would, therefore, bring change in policy vis-à-vis groundwater pollution control. Our findings suggest that the results of successful e-learning and work from home would be a permanent shift from conventional modes in the near future due to a drastic reduction in socio-economic cost. Our critical analysis also highlights that with such temporary lockdown measures acute/chronic ill-effects of anthropogenic perturbations on planet earth can be effectively estimated through sociocultural, socioeconomical and socio-political/technological nexus.

1. Introduction

The human race is the ultimate preserver and destroyer of the planet earth: the abode of millions and millions of inhabitants. Human beings are considered as one of the potential threats to the sustainable environment, where the nonjudicious use of environmental resources lead the researchers and policymakers to ponder about eco-restoration of our mother earth. The critical analysis of evolutionary pathways of the Anthropocene era reveals the fact that the unprecedented occurrence of human induced activities on earth triggered the quest for environmental and natural resource management on local, global and regional scales. The negative consequences of human impacted environment reflected in the emergence of Renaissance, when Black Death, a pandemic that affected over half of the population of Europe (>1.4 million people) from the year 1347–1351 (Bu et al., 2020; Bukhari and Jameel, 2020). The occurrence of Bubonic Plague in 1815 had marked a paradigm shift in the socio-cultural developments and a sharp decline in the agricultural food and land prices, which created a socio-economic crisis that advocated the empowerment of low-wage worker group (Cohn, 2008). The changes in the socio-economic infrastructures challenge and monitors social living of the weaker section of the society so that the global socio-economic trends act as automatic stabilizers for the global health crisis. Peter Temin, a noted author of Handbook of Cliometrics had pointed out that the high wages and low power costs lead to the

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Industrial Revolution in the 18th century, which was also partly stimulated by the Black Death and the European marriage pattern (Bukhari and Jameel, 2020). The cross-over of economic development suggests that demography influences and lessons from socio-economic history can reform current policy decisions, if not implemented correctly (Fang et al., 2020).

The coronavirus disease outbreak (COVID-19) pandemic and global lockdown have projected a major historical unprecedented event that would begin a process of fast-paced changes in the future outlook and reassess economic conditions, social protections, ideas of progress, and so-called human “supreme” abilities. As humankind suffers the greatest threat since World War II, the COVID-19 has made us aware of our individual and global interactions with the environment. The ongoing pandemic COVID-2019 has created a global health emergency in more than 200 countries around the globe and infected a large number of hosts (more than 3.5 million people) with a mortality rate of more than 3.6% (Kumar et al., 2020a, b). Unfortunately, to what extent and with what quantum of damage it will be to the entire humanity is still unknown and can only be speculated partially (Khan et al., 2020). Even animals are getting infected from this deadly virus, as reported from the Bronx zoo in New York City, USA where four tigers and three lions were found COVID-19 positive (New York Post, April 22, 2020). We have seen how socially and economically vulnerable we are by confining individuals and families to tackle a global pandemic, but also by using global social networks and media to survive social distancing. We have seen how relentless inequality makes chronically disadvantaged communities more vulnerable to a virus that attacks every single human being. Across the globe and within small communities, the pandemic caused by this virus triggers changes in educational, technological, and social aspects that depict the uneven risks and people, communities, and countries’ response and resilience (Lipsitch et al., 2020). At this juncture of gloomy period there is an urgent need to find a way out of this global crisis, though a silver lining had begun to appear and is currently observed across the world as possible solutions to the Anthropocene epoch, which were our key concern before the pandemic virus outbreak. Environmental degradation, ozone layer depletion, pollution, water resource management, and climate change were amongst the top challenges of the 21st century (Kumar et al., 2020b). A collective basic and applied research efforts (such as wastewater based epidemiological approach for virus monitoring) are still needed to advance foundational understanding, engineered approaches, and innovative solutions for environmental quality monitoring, management, and progress in environmental sustainability to formulate efficient policy papers and overcome associated environmental maladies (Kumar et al., 2020c).

Although there is an ample literature resources on the sustainability of human life, population growth, and environmental conservation aspects, still the deep insights on local and global socio-political relations and economic growth after an uncertain incubation period are need of the hour. The cluster lockdowns as a result of the COVID-19 pandemic has however forced us to ponder about the self-revival ability of the earth, an aspect which have been taken for granted by humans since centuries. More than half of the nations (developing and developed) and economic growth after an uncertain incubation period are need of environmental restoration and environmental planning (Sjodin et al., 1998). The two most readily observed aspects have been recorded in the context of ecological disturbances (air and water pollution).

### 2. Vehicular traffic

Even with a partial lockdown, the reduction in road traffic was almost 40–60%, and with complete lockdown, it has gone to an unprecedented level recently. More than 1.25 million people die in road accidents each year; on an average, 3700 people lose their lives every day on the roads. An additional 20–50 million suffer from non-fatal injuries, often resulting in long-term disabilities (Zhang and Batterman, 2013). The probable rate of road fatalities in India is 26.1/100,000 inhabitants, while the global calculated road fatalities are 155.8/100,000 motor vehicles (Rodrigue, 2016). Around 414 deaths occur daily in India due to road accidents (Bu et al., 2020), a number which has now become negligible due to lockdown. This traffic effect will show significant changes with the shifting of a major portion of the education and partial office work to online mode of operation. The higher vehicular activities and traffic congestion increase vehicular greenhouse gases (GHG) and black carbon emission, which degrade the ambient air quality and increase the global warming potential. Recent studies have shown an excess number of morbidity and mortality cases for drivers, commuters, and individuals living near major roadways and traffic intersections due to acute and chronic exposure to air pollution (Krzyzanowski et al., 2005). The increase in the number of vehicles further leads to an increase in on-road traffic congestion, which escalates travel time, air pollution emissions, and carbon/pollutant emissions exposure on a per-vehicle basis. The presence of traffic congestion (average speed of 21 km/h) results in 4-fold, 3-fold and a 2-fold increase in Carbon Monoxide (CO), Hydrocarbon (HC) and Oxides of Nitrogen (NOx) emissions, respectively; which goes considerably down under less congested conditions (average speed of 61–70 km/hour) (Rodrigue, 2016).

Transportation sector plays a fundamental role in the lives of individuals and societies as a whole. Transportation is a multidimensional activity, which impacts history, politics, economics, and above all environment. The patterns of people interactions - work, play, organizing production, urbanization, and access to services, amenities, and goods - are inextricably linked to the development of mobility and the decision making process of these people. The important consequences of transportation manifest are its effect on air and water quality, noise level, and public health. These impacts fall within three categories of direct, indirect, and cumulative effect (Lipsitch et al., 2020). These developments and the demands generated by markets, however, often disregard the ensuing consequences in terms of increased fuel consumption, higher emission of air pollutants, and greater exposure of masses to hazardous conditions causing severe and chronic health issues.

The increased intensity of dependency on transport also increase the risk of road traffic injuries, exposure to noise and, sedentary lifestyles. An increasing body of evidence points to the magnitude of these adverse effects on health and the need to identify solutions that both reduce risks to health and meet the requirement for mobility (Fang et al., 2020).

### 3. Greenhouse gases (GHGs) and air pollution emissions

The European Environment Agency (EEA) estimates that road transport contributes to excessive concentrations of about 70% for Nitrogen Dioxide (NO2) and about 30% for particulate matter (PM). It is estimated that around 7% of the EU urban population is exposed to NO2 levels above the EU/WHO guideline value and that more than three-quarters of the urban population is exposed to PM2.5 levels exceeding the WHO guideline value (Gianis et al., 2020). In the USA alone, transportation accounted for the most significant portion (29%) of total U.S. GHG emissions in 2017. The on-road vehicles account for 82% of GHG emissions, whereas air travel contributes only 9% of total GHG emissions (Khan et al., 2020; Luan and Ching, 2020). These numbers indicate that any reduction in vehicular traffic on roads would create a significant decrease in GHG emissions (Luan and Ching, 2020), as it is already being recorded under the lockdown. Air pollution levels, which authorities across the world seemed unable to control despite a plethora of efforts, have automatically gone down as a result of the lockdown. The PM10 and PM2.5 (particulate matter having less than 10 µm and 2.5
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μm aerodynamic diameter respectively) levels have recorded their lowest statistics, making lockdown a legitimate measure in case of severe air pollution episode. The Covid-19 pandemic has caused a significant drop in GHG and air pollution across the globe and moving towards a record annual dip of 5% GHG emission (from fossil fuels burning) around China, Europe and, the USA (Bukhari and Jameel, 2020). In China, the emission has been dropped by 25% due to lockdown, which resulted in a 40% reduction in coal consumption, shutting down industries, and stay at home. The good quality air days have been increased up to 11.4% in 337 cities around China in comparison to the last year’s similar months (Casanova et al., 2010). Moreover, NO2 emissions fell significantly in Italy, Spain, and the UK, referring to satellite images in Europe (Bu et al., 2020). The probability of the ozone layer restoring itself has increased, primarily because of the drastic reduction of vehicular traffic both on road and air.

Another important point which many of us are not noticing that COVID 19 also increased the probability of indoor air pollution event in low-income society. About 40% (3 billion) of the total global population uses polluting cooking fuels (i.e., firewood, cow-dung, crop-residue, and kerosene) (Khan et al., 2020). Many of these people spend their day due to working-schooling-outdoor activities outside their home, which leads to less exposure to high indoor air pollution. However, due to lockdown, these low-income people have to spend the whole day in an indoor environment, which leads to high exposure to air pollution.

4. Water pollution

The second most significant area of rapid pollution and the rapid area of research is related to water based resources. The global media captured the clearing of the Venetian canals with a spark of hope in an otherwise fatal condition of the COVID-19 pandemic. In India as well, authorities and citizens both have observed a reduction in pollution levels of Ganges and Yamuna rivers in the northern part of the country. The dissolved oxygen level in the Ganges was recorded to be 8.9 mg/L in upstream and 8.3 mg/L in downstream, significantly above the level of 7 mg/L, which constitutes the beginning range for healthy water (Boone et al., 2020; Yunus et al., 2020). The real-time monitoring data collected by Central Pollution Control Board (CPCB) revealed that the water quality of river Ganges at twenty-seven different points was satisfactory for bathing purposes and dissemination of wildlife and fisheries (Bu et al., 2020; Ramasamy et al., 2017).

The rivers seemed to be cleaning itself, without any effort, although sewage load has not reduced (Asselman, 1999). However, the drastic reduction in industrial pollution, which is one of the major causes of river water putrefaction, is proving sufficient for the rivers to restore themselves (Vinita et al., 2017; Li et al., 2020). Moreover, there has also been a remarkable reduction in the number of funeral activities as reported by various crematoriums, which has also led to a decrease in load on the rivers. The number of dead bodies are coming to Delhi’s Nigam Bodh Ghat (Hindu crematorium) situated on the banks of Yamuna has come down already by 25–30% (Gaunt and Templeton, 2010). Similarly, Varanasi Ghats are receiving just one third to one-fourth of average corpses for cremation. The situation is almost the same in the burial ground (crematorium) and similar places of other religions (based on verbal communication from the source).

5. Ecological footprint

These changes are bound to have a massive impact on the ecological footprint. The eco-footprint is based on every human induced activity, no matter how small it is. If a country does not possess enough ecological resources within its territory compared to its consumption, it leads to the local ecological deficit, and the country becomes an ecological debtor country. If the opposite stands true and the country possesses an ecological reserve, then it is called an ecological creditor country.

Life first appeared on this planet some 3800 million years ago, and since then the humans have left their ecological footprint. However, the world has accounted for a 104% increase in its population since the year 1970s, with a 58% decline in the average population size of vertebrate species, which means that since 1970, almost 60% of humanity’s ecological footprint has been nothing but carbon (Li et al., 2020; Khan et al., 2020). If everyone in the world bears the similar lifestyle alike Australians and Americans, we would need 5.4 and 4.8 Earths respectively, to support humanity. In fact, we already need 1.75 planet Earth to support humanity’s demand on the Earth’s ecosystem (Gaunt and Templeton, 2010; Asselman, 1999).

These developments led to the conception of the idea of Earth Overshoot Day by Andrew Simms of the UK think-tank New Economics Foundation and is now an active initiative under the Global Footprint Network (Boone et al., 2020). Earth Overshoot Day marks the date when humanity’s demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year. This deficit is calculated by liquidating stocks of ecological resources and accumulating waste, primarily carbon dioxide in the atmosphere. The environmental changes being observed under lockdown and the self-healing process that nature seems to have initiated due to a decrease in active human exploitation and intervention has the potential for bringing about a positive change in eco-footprint.

6. e-learning

At present many activities are altogether stopped due to lockdown, but some are running at a partial pace. Some activities are stepped up at a much higher pace than what they were earlier prior to the spread of the COVID-19 pandemic, for instance, online education, online health care, online business (Kumar et al., 2020b). Usually, people feel very skeptical about education in distance mode, i.e., online; however, now there is a shift in opinion about its effectiveness what it was presumed earlier. This lockdown has, for the first time, provided an opportunity to experience and implement many such sectors under the online mode, and the results are visible.

Why should we consider online education as a viable option? Well, it brings along many benefits. It guarantees convenience and flexibility to study at any hour of the day. The online tutorials help to log in at any time and simply study according to mood and convenience. Students can choose to undertake training in many courses simultaneously, as it offers diverse options. It also provides an opportunity for networking with faculty and students all across the world, so it cuts down on unnecessary transportation costs and helps to save the environment too. The online courses are available at an affordable prices and are cheap in comparison to classroom teaching.

Digital education was already flourishing; however, present immovability provides an opportunity on larger canvass. The number of massive open online courses (MOOCs), for example, has surged since they first appeared in the year 2000. MOOCs are now mainstream, and the number of available courses was reported in 2016 to be growing daily (Zhang and Batterman, 2013). The number of MOOCs has increased by more than 683 percent, with only 1200 MOOCs in 2013, while the total number of learners enrolled in MOOCs has rose up to 81 million from 10 million. The number of universities offering MOOCs has also increased tremendously (Khan et al., 2020).

The demand for education won’t be curbed by economic growth. The number of people in middle-income brackets is expected to increase almost 10-fold within two decades, from 50 million people in 2010 to 475 million people in 2030 (Gaunt and Templeton, 2010). In Bangladesh, meanwhile, an estimated 30 million to 40 million people will join the ranks of the middle class by 2025, thereby demanding for more affordable education. India, for instance, has one of the largest education systems in the world, with a network of more than 1 million schools and 18,000 higher education institutions (Fang et al., 2020). More than half of the country’s 1.3 billion population falls in the target market for education and related services. Looking at the demand, the
public and private sectors in India cannot cater to the requirements of such a vast demand through conventional modes of schools, colleges, and universities. It is only the online education sector, which can do this wonder, and this corona period has proved it to test on such a large scale that too, with the minimal available infrastructure. It is expected that the facilities would also be boosted up with the expansion of this sector (Krzyszowski et al., 2005; Sjodin et al., 1998). In 2017 it was assessed that the online Education Market is proliferating over 24% of annual growth rate and is expected to reach approximately USD 423 billion by the end of the forecast period. However, given the Corona disaster, this share would increase by leaps and bounds (Fetzer et al., 2020).

It is not so that the entire education sector would be transformed, but it would experience significant change. The conventional component of the traditional education would confine to experimental/laboratory work, research protocols, viva-voce, presentations, theatres, etc., which may account for less than around 25-30% infrastructure (Gaunt and Templeton, 2010). The only raw material for online education is internet facilities with seamless, uninterrupted signals with proper bandwidth in every nook and corner and recourse persons. The consequential financial savings would significantly reduce the cost of education. However, the rural sector would face initial hardship due to the restricted availability of the internet at desired speed and hardware; nevertheless, the necessity would pave its way sooner or later. In lieu of these initial shortcomings, the consequential financial savings would greatly reduce the cost of education.

7. Conclusions

The COVID-19 Pandemic will leave a lasting impact on our lives, and most definitely, a negative one. Only time will reveal the quantum of human sacrifice and economic set back that we may suffer because of it. Ironically, the only certainty about the coronavirus is its uncertainty. However, one more thing is sure in these times, that the world is going to witness an age of drastic change - not just in the environment around us and our interaction with nature and issues of climate change, sustainability, water resource management, and pollution control both air and water-borne; but also in the field of education, health care, hygiene maintenance, work, and employment models, economic setup, consumption patterns and the overall behavior and psychology of the human race. In any case, tropical areas might have the potential to become a reservoir of such pandemic outbreak during the entire period of winter in October, and November 2020 as per spatio-temporal modeling data analysis by a group of researchers in the developed nations. A global consensus/human intervention is needed intern of policy and socio-economic measures to combat such pandemic outbreak which is rapidly spreading over the human populations and has potentially opened the Pandora’s box of pathogenic viruses.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gsd.2020.100433.

References

Asselman, N.E., 1999. Suspended sediment dynamics in a large drainage basin: the River Rhine. Hydrol. Process. 13 (10), 1437-1450.
Boone, L., Haugh, D., Pain, N., Salins, V., 2020. 2 Tackling the fallout from COVID-19. Econ. Time COVID-19 37.
Bu, J., Peng, D.D., Xiao, H., Yao, Q., Han, Y., Lin, Y., Hu, G., Chen, J., 2020. Analysis of Meteorological Conditions and Prediction of Epidemic Trend of 2019-nCoV Infection in 2020. medRxiv.
Bukhari, Q., Jameel, Y., 2020. Will Coronavirus Pandemic Diminish by Summer? Available at: SSRN 3556998.
Casanova, I.M., Leon, S., Rutala, W.A., Weber, D.J., Sobsey, M.D., 2010. Effects of air temperature and relative humidity on coronavirus survival on surfaces. Appl. Environ. Microbiol. 76 (9), 2712-2717.
Cohn, S.K., 2008. A epidemiology of the back death and successive waves of plague. Med. Hist. 52 (S27), 74-100.
Fang, L., Karkulikalis, G., Roth, M., 2020. Are patients with hypertension and diabetes mellitus at increased risk for COVID-19 infection? Lancet. Respirat. Med. 8 (4), e21.
Fetzer, T., Hensel, L., Hermle, J., Roth, C., 2020. Coronavirus Perceptions and Economic Anxiety arXiv preprint arXiv:2003.03848.
Gaunt, Eleanor R., Hardie, Andrew, , Eric CJ Claas, Peter Simmonds, Templeton, Kate E., 2010. Epidemiology and clinical presentations of the four human coronaviruses 229E, HKV1, NL63, and OC43 detected over 3 years using a novel multiplex real-time PCR method. J. Clin. Microbiol. 48 (8), 2940-2947.
Giannis, D., Ziogas, I.A., Gianni, P., 2020. Coagulation disorders in coronavirus infected patients: COVID-19, SARS-CoV-1, MERS-CoV and lessons from the past. J. Clin. Virol. 104362.
Khan, N., Fahad, S., Faizal, S., Naushad, M., 2020. Quarantine Role in the Control of Corona Virus in the World and its Impact on the World Economy. Available at: SSRN 3556940.
Krzyszowski, M., Kuna-Dibbert, B., Schneider, J., Eds.), 2005. Health Effects of Transport-Related Air Pollution. WHO Regional Office Europe.
Kumar, M., Kuroda, K., Dhangar, K., 2020. The Most Eagerly Awaited Summer of the Anthropocene: A Perspective of SARS-CoV-2 Decay and Seasonal Change. Groundw. Monit. Dev., p. 100400.
Kumar, M., Takii, K., Ghahot, R., Sharma, A., Dhangar, K., 2020. A Chronicle of SARS-CoV-2: Part-I-Epidemiology, Diagnosis, Prognosis, Transmission and Treatment. Sci. Total Environ., p. 139278.
Kumar, Manish, Patel, Arbind K., Shah, Anil V., Raval, Janvi, Rajpura, Neha, Joshi, Madhvi, Joshi, Chaitanya G., 2020c. The first proof of the capability of wastewater surveillance for COVID-19 in India through the detection of the genetic material of SARS-CoV-2. medRxiv. [https://doi.org/10.1101/2020.06.15.20132215].
Li, L., Li, Q., Huang, L., Wang, Q., Zhu, A., Xu, J., Liu, Z., Li, H., Shi, L., Li, R., Azari, M., 2020. Air Quality Changes during the COVID-19 Lockdown over the Yangtze River Delta Region: an Insight into the Impact of Human Activity Pattern Changes on Air Pollution Variation. Sci. Total Environ., p. 139282.
Lipshitz, M., Swordlow, D.L., Finelli, L., 2020. Defining the epidemiology of Covid-19—studies needed. N. Engl. J. Med. 382 (13), 1194-1196.
Luan, P.T., Ching, C.T.S., 2020. A Reusable Mask for Coronavirus Disease 2019 (COVID-M). Archives of Medical Research, NewYorkPost, 22th April. https://nypost.com/2020/04/22/seven-more-big-cats-at-bron-x-zoo-positive-for-coronaviruses/.
Ramasamy, E.V., Jayasooriya, K.K., Chandran, M.S., Mohan, M., 2017. Total and methyl mercury in the water, sediment, and fishes of Venbanad, a tropical backwater system in India. Environ. Monit. Asses. 189 (3), 130.
Rodrique, J.P., 2016. The Geography of Transport Systems. Taylor & Francis.
Sjodin, A., Persson, K., Andreasson, K., Arlander, B., Galle, B., 1998. On-road emission factors derived from measurements in a traffic tunnel. Int. J. Veh. Des. 20 (1-4), 1437-1450.
Salins, V., 2020. Meteorological Conditions and Prediction of Epidemic Trend of 2019-nCoV Infection in 2020. medRxiv.
Vinita, J., Revichandran, C., Manoj, N.T., 2017. Suspended sediment dynamics in Cochin estuary, west coast, India. J. Coast Conserv. 21 (1), 233-244.
Yunas, A.P., Masago, Y., Hijinkia, Y., 2020. COVID-19 and Surface Water Quality: Improved Lake Water Quality during the Lockdown. Sci. Total Environ., p. 139012.
Zhang, K., Batterman, S., 2013. Air pollution and health risks due to vehicle traffic. Sci. Total Environ. 450, 307-316.