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ABSTRACT: Urban air pollution is a major problem with known negative health implications, such as respiratory and cardiovascular diseases. Lockdown measures have caused the reductions of various urban pollutants, such as nitrogen dioxide (NO_2), particulate matters (PMs), and polycyclic aromatic hydrocarbons (PAHs). COVID-19 pandemic has also established remote-working as an antidote to declining economic activity due to lockdown measures. The environmental health implications of the new hybrid-working model, which drastically reduces the number of circulating vehicles, appear to be positive enough to reveal an emerging opportunity. Since this hybrid model may have started becoming a widely accepted working model, the current situation has revealed the opportunity of remote-working arrangements to serve as a supplementary mitigative and adaptive measure against urban environmental deterioration. Also, a remote-working carbon-saving footprint may be introduced in order to evaluate a firm's carbon footprint reduction due to remote-working arrangements. These workings arrangements may be accompanied by improvements and expansions of urban green spaces and with broader use of electric vehicles, transforming our cities into more sustainable, safe, healthy, and worth-living environments.

KEYWORDS: Remote-working, carbon footprint, carbon-saving footprint, COVID-19, lockdown, urban environment, environmental health

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Introduction

COVID-19 pandemic has established remote-working as an antidote to declining economic activity due to lockdown measures. Furthermore, a kind of technological modernization has undoubtedly been introduced in many households since usual house rooms had to be converted into spaces able to widely support working from home. Moreover, given the long duration of the pandemic, the modern "remote workers" have adapted to this working model, and have developed the relevant know-how of remote-working, and various relevant technological and communication skills.

Urban air pollution is a major problem with known negative health implications, such as respiratory and cardiovascular diseases.[1] Road traffic is a large contributor to the deterioration of the urban air quality, and its impact is being determined, amongst others, by meteorological conditions and topographical characteristics.[2] As regards the impact of vehicles, the negative contribution of the number of circulating vehicles has become evident during strikes, when urban air quality temporarily increases.[3,4]

Lockdown Measures and Urban Air Quality

Lockdown measures have caused the reductions of various urban pollutants, such as nitrogen dioxide (NO_2), particulate matters (PMs), and polycyclic aromatic hydrocarbons (PAHs), and the reduction of noise levels.[5-8] However, there are important ecological problems that have been intensified, such as the increased medical and plastic waste production, that require proper management and solutions.[9] Indeed, these environmental health problems must be immediately addressed since they constitute an emerging ecological risk that must not be ignored.

Moreover, the ongoing pandemic has allowed the natural environment and wildlife to "bounce back" up to a certain level.[10] The images and videos of wildlife wandering around urban areas have fed a significant number of discussions regarding urban ecology issues.[11] The forced lockdown has brought back on the surface neglected aspects of the closed and mutually interactive relationship between man and environment, either it is an urban environment or not. Also, the known and well-studied linkages between environment and human health reveal unique opportunities for action toward the promotion of environmental health.

Lockdown has improved the urban air quality of many cities around the world, and in some cases the improvements were remarkably important. For instance, a study in the megacity of Delhi has revealed that the concentrations of inhalable particulate matters (PM_{10}) and fine particulate matters ($PM_{2,5}$) were reduced by more than 50% in comparison to the period before the lockdown.[12] Also, a study in the 2 largest cities of Spain, has revealed that the lockdown measures have caused a 62%

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reduction in NO_2 concentration in Madrid, and a 50% reduction in NO_2 concentration in Barcelona during March 2020.[13] Moreover, another study that was conducted in the capital city of Ecuador—the city of Quioto—showed a 68% reduction in the NO_2, a 48% reduction in the sulfur dioxide (SO_2), a 38% reduction in the carbon monoxide (CO), and a 29% reduction in the $PM_{2,5}$ concentration respectively.[14]

Furthermore, the strict lockdown measures have significantly improved the air quality in East Asia. Especially in the Chinese city of Wuhan, the relevant satellite remote sensing data has revealed an 83% reduction in the column density of NO_2, a 71% reduction in the column density of SO_2, an 11% reduction in the column density of formaldehyde (HCHO), and a 4% decrease in the column density of CO in February 2020 compared to February 2019.[15] Of note, a separate study, that confirmed reductions in ozone (O_3) and $PM_{2.5}$ in California (USA), has estimated thousands of air pollution-related premature deaths prevented annually in California, due to an assumed persistence of the ongoing air quality improvement.[16]

Therefore, it becomes obvious that the improvement of the urban air quality can be easily controlled by simple interventions, and proper traffic management. Remote-working, since it drastically reduces the number of vehicles moving in the cities, may serve as an indirect traffic management control measure. It may also contribute to the reduction of traffic congestion which significantly impacts human health.[17]

The Remote-Working Carbon-Saving Footprint

A remote-working carbon-saving footprint may be introduced in order to evaluate a firm's carbon footprint reduction due to remote-working arrangements. It can be calculated easily by subtracting a firm's carbon footprint based on a hybrid working model, that is, combination of office- and remote-working, from the carbon footprint based on the traditional working model. Since the hybrid model may have started becoming a widely accepted working model,[18] this carbon-saving footprint may serve as a new tool for its ecological evaluation, and, why not, for the relevant comparisons between the ecological profiles of modern firms.

This proposed remote-working carbon-saving footprint may also measure individual carbon-savings of the employees who work remotely. Moreover, firms may offer training seminars and easy-to-apply advice to their employees on how to reduce their everyday carbon footprint while working remotely, increasing the overall positive impact on the environment.

Conclusion

The environmental health implications of the new hybrid-working model appear to be positive enough to reveal an emerging opportunity. Indeed, the current situation has revealed the opportunity of remote-working arrangements to serve as a supplementary mitigative and adaptive measure against urban environmental deterioration, based on the urgent need for urban air quality improvements. This measure may be accompanied by improvements and expansions of urban green spaces and with broader use of electric vehicles, transforming our cities into more sustainable, safe, healthy, and worth-living environments.

COVID-19 pandemic has revealed amongst others the urgent need for creating resilient and adaptive communities, sustainable living environments for all social groups, and new pathways toward sustainability. The proposed remote-working carbon-saving footprint may be totally compatible with the "15 C's Pathway of Sustainability in Environmental Health Management" that was recently presented.[19]

Author Contributions

SM proposed the idea, wrote the first draft, prepared the revised versions, and approved the final version of the manuscript. IGP and NK critically reviewed the first draft and the revised versions, and approved the final version of the manuscript.

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