



Environmental Analysis and the Dual Grand Challenge of COVID-19 and Sustainable Development

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INTRODUCTION

In 2015, the United Nations (UN) adopted the 2030 Agenda with 17 Sustainable Development Goals (SDGs) to improve people's lives and the natural world by 2030 (United Nations, 2015). The outbreak of Coronavirus disease 2019 (COVID-19) occurred in 2020, right at the beginning of the "decade of actions" aiming to cover implementation gaps on delivering SDGs. The pandemic affected the core focus of the SDGs by triggering an economic crisis of large proportions and restricting mobility and migration (Shulla et al., 2021). COVID-19 and the ensuing implications have demonstrated the fragility of SDGs and their interconnections. As the world recovers from this pandemic, the importance of environmental health and resilience as a critical complement to public health is underscored. Rebuilding requires countries to succeed in transitioning to green economies and protection against future disruption from global stressors.

From an environmental perspective, the pandemic created both problems and opportunities, each time emphasizing the importance of delivering the SDGs. They also highlighted the need for a multidisciplinary system-thinking approach to explore interconnections between the environment, wildlife, and humans. The COVID-19 pandemic and the 2030 Agenda for Sustainable Development are a dual grand challenge that can only be addressed by everyone as part of a transition to an inclusive and sustainable future. On this basis, environmental analysis is critical in understanding and mitigating current environmental changes at a global level. In a less physically-connected world and an unstable setting where new types of pollution rise fast, environmental analysis must find the pace and tackle this dual grand challenge. Admittedly, this unprecedented time represents an opportunity for environmental analysis to examine the impact of human activities on the natural world and gather information that will protect human health, biodiversity efforts, and help towards combating climate change.

UNDERSTANDING THE IMPACT OF COVID-19 ON SDG PLANS

The implemented lockdowns drastically curtailed industrial activity, ground transport, and air travel for several months, and resulted in a remarkable improvement in air quality (Espejo et al., 2020; Venter et al., 2020). During this period, ground and satellite observations recorded cleaner air in the world's major cities, demonstrating how fast and how far human efforts can bring down pollution when anthropogenic emissions are collectively reduced (Siddique et al., 2021). Nonetheless, the long-term impact of COVID-19 on air quality is yet to be assessed as a number of countries have since reported a rapid return to rising levels of air pollution (Shulla et al., 2021). Environmental analysis has the right tools to help towards revealing new insights on the complex phenomenon of air

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pollution. Monitoring variation trends of air quality levels during the pandemic, and lockdowns in particular, can link air pollution to emission sources (Mor et al., 2021). Even more, intensive monitoring of air quality can protect human health, as higher levels of local air pollution were reported to exacerbate morbidity and mortality from COVID-19 (Kumar et al., 2021; Isphording and Pestel, 2021).

Before the pandemic, progress on the SDG6 related to water and sanitation was slow with over three billion people being at risk because the environmental status of their rivers, lakes, and groundwater was unknown. The decrease in human, economic, agricultural, and industrial activities had a direct impact on water quality, with studies from different regions reporting significant improvements (Yunus et al., 2020; Tokatlı and Varol, 2021). However, similarly to air quality trends this is expected to be a temporary phenomenon and water pollution is foreseen to increase once economic activity resumes. In relation to COVID-19, the recent multi-fold surge in water demand for health and hygiene to reduce virus transmission, urges for intensive monitoring of water quality. At the same time, the concentrations and diversity of drugs in domestic and hospital wastewater have increased due to the higher demand by patients (Espejo et al., 2020). Investigations dealing with the presence and fate of COVID-19 related chemicals in the environment should be intensified. In this direction, traditional targeted analytical approaches using highly sensitive analytical instrumentation will find wide application. These studies should be complemented with untargeted analysis aiming to identify new pollutants and their interactions with humans and biota, using the latest developments in mass spectrometry and multidimensional chromatographic separations. The global challenges beyond COVID-19 have to be addressed as soon as possible to avoid the consequences of water resources over-abstraction and prevent the use of poor-quality water. This is particularly important for ensuring access to safely managed drinking water and sanitation services to the most disadvantaged in both OECD and non-OECD countries (United Nations, 2020).

The sudden rise of certain types of solid waste became an unquestionable reality during the pandemic. Although recent evidence shows that solid waste in public places, natural and urban areas has been reduced (Zambrano-Monserrate et al., 2020), domestic and hospital solid wastes have increased (Espejo et al., 2020). The latter reflected the upsurge demand in single-use plastics for managing the virus (Espejo et al., 2020; Okuku et al., 2021), stepping back recent regulations and progress towards the reduction of plastic waste. This type of solid waste is particularly problematic due to the need to destroy residual pathogens, and with some countries reducing their recycling in order to protect workers from possible virus infection (Klemeš et al., 2020). With only a part of the plastic waste being recycled, the rest goes to landfills or is thrown into the environment. Admittedly, the rise of personal protective equipment (PPE) pollution and more recently, the application of population-wide rapid antigen testing, induced “new” types of land- and water-based pollution (Espejo et al., 2020; Klemeš et al., 2020; Sullivan et al., 2021), the environmental impacts of which require intensive monitoring and detailed evaluation.

REMOTE AND AUTOMATED MONITORING OF ENVIRONMENTAL SYSTEMS

Current widespread approaches to monitoring environmental pollutants are heavy on personnel hours and demand physical presence. During lockdowns, activities in laboratories were minimized, if not stopped, and trips were generally banned. This delayed laboratory-based analysis and made field studies a challenging task. The COVID-19 pandemic taught us that modern society is fragile, and supply chains are not as reliable as we thought they were. Society depends heavily on environmental analysis, and laboratories must be able to stay fully operational during future crises and threats. As the world recovers from this pandemic, remote and automated monitoring of environmental systems is more relevant than ever. It is foreseen that post-pandemic research efforts will be intensified towards improving robustness and independence of analytical systems. Contactless sampling and analysis using e.g., aerial robots (Koparan et al., 2018; Grandy et al., 2020) low-cost sensors, or automated laboratory methods with all steps integrated, will undoubtedly appear more frequently (Pena-Pereira et al., 2021). The development of more sensitive and selective analytical technologies can be valuable to elucidate environmental and health issues of non-regulated compounds, monitoring their presence in different environmental compartments as well as study their fate once released in environmental bodies. In spite of the progress achieved so far, the degree of compliance with current requirements is highly dependent on the type of pollutants considered. Thus, while a considerable number of such methodologies are reported, there is still plenty of room for the development of methods capable of accurately determining different groups of emerging environmental pollutants (Pena-Pereira et al., 2021). The rise of connectedness and low-cost sensor technologies used for chemical measurements, as well as the push to improve the transparency and accessibility of science, will require a lot of scientific development; yet the research community is willing to tackle this challenge.

PRACTICING ENVIRONMENTAL ANALYSIS IN A SUSTAINABLE MANNER

Environmental analysis has always been an important tier in the protection of the environment. Although essential for evaluating the environmental status, it can contribute to further environmental problems due largely to the consumption of energy and the use/generation of hazardous substances during all stages of analysis (Anastas and Warner, 1998). To address the negative side of analytical chemistry in the environment, the concept of Green Analytical Chemistry (GAC) (Anastas, 1999) was established soon after the introduction of Green Chemistry (Anastas and Warner, 1998). GAC was later formulated in the form of 12 main principles that expressed the willingness to care for the environment and human safety as part of the development and application of analytical procedures (Gałuszka et al., 2013). Twenty years after the introduction of GAC, the analytical

community largely sees GAC as a separate branch in Analytical Chemistry (Koel, 2016). The opportunity to reinvent the focus and mission of Analytical Chemistry to make it fit for purpose in the twenty-first century was missed and triggered a cascade of events. The majority of official analytical methods still rely on old-fashioned and hazardous analytical procedures. Private and industrial laboratories see sustainable or more eco-friendly analytical chemistry as an extra burden rather than a new opportunity for effective management and for efficient and cost-effective, as well as socially responsible, practice.

The pandemic highlighted the urgency in which sustainability issues must be addressed. Green recovery from the pandemic requires individual commitment but also strong and cooperative commitment at all levels, including from scientific disciplines like analytical chemistry. The application of environmentally benign analytical methods is one of the social responsibilities of analysts as it aligns with pollution abatement and the principles of Sustainable Development. Admittedly, a number of challenges are to be addressed when implementing the GAC principles; the most important being balancing greenness with the analytical properties of the method, i.e., sensitivity, selectivity, accuracy, precision, robustness, and, in turn, with the quality of the analytical information obtained (Pena-Pereira et al., 2020; Nowak et al., 2021). However, regardless of these challenges, the modification of analytical methods to fulfill the GAC requirements without losing their key analytical properties should be a priority as it reduces the environmental cost of analysis for the benefit of the society.

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CONCLUSION

Environmental analysis has always been a very broad and creative research area, capable of adjusting quickly to critical new topics. In the past, research challenges manifested in different ways: some reflected advancements in analytical instrumentation, others the rise of new environmental or societal challenges, whilst few represented well researched topics that rose in importance. At any instance it has become increasingly clear that reaching out to other disciplines and promoting problem-driven research is key to addressing the world's increasingly complex and interconnected environmental problems.

There is growing evidence that climate change may lead to more frequent outbreaks and epidemics. The dual grand challenge of the COVID-19 pandemic and the 2030 Agenda combined with the social implications at the global level, requires the improvement and development of analytical tools that will protect human health and the environment and serve as a guide for policy measures, prevention, and control regulations. Shedding new light on current and future environmental challenges will certainly drive the work of Frontiers Specialty Section in Environmental Analysis.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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