Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Perspective

Will the COVID-19 pandemic change waste generation and composition?: The need for more real-time waste management data and systems thinking

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Since the start of the pandemic, and resulting business and school closures, many of us are wondering how the COVID-19 pandemic may change waste generation and composition. One may hypothesize the pandemic will increase or decrease waste generation and it may depend on your location. On the one hand, major businesses and schools were closed that usually generate large volumes of waste. On the other hand, not all businesses completely closed, and household, medical, and agricultural waste generation has increased in some areas. We won't truly know the answers without systems modeling of waste management data. The goal of this perspective is to bring attention to the need for better real-time waste management data and systems thinking in the context of the COVID-19 pandemic and beyond.

Some preliminary news articles have documented the increase in recycling, household, and agricultural wastes. Cities in New York, Arizona, Ohio, and South Carolina have experienced increases in recycling at their facilities up to 45% from the previous year (Staub, 2020). Hardest hit by the pandemic initially, New York City had an increase in municipal solid waste of 3.3% and 13.3% organic waste increase from the previous year (Staub, 2020). With more people at home and unemployed, people increased spring cleaning efforts that overwhelmed collectors and increased co-contamination of recyclables (Staub, 2020). Many recycling facilities had to close or reduce capacity to protect workers and thus divert their items to landfills (Staub, 2020). Though mostly disposed on site, there have been large amounts of agricultural dumping and crop overturning with disruption of food supply chains (3.7 million gallons of milk, hundreds of thousands of euthanized animals, tons of crops, etc.) (Corkery and Yaffe-Bellany, 2020).

To truly understand changes in waste generation and composition, we will need to take a systems thinking and modeling approach (Sterman, 2000). In some areas, the pandemic has increased waste while in others there has been waste reduction. Casual Loop Diagrams (CLDs) and system dynamics modeling could help us better understand these changes (Sterman, 2000). COVID-19 social distancing measures led to business and school closures that reduced waste generation but shifted some of the waste generation to households. Furthermore, COVID-19 resulted in many Americans buying items online and food delivery which has more packaging waste. Americans also hoarded food and items which may result in some waste from spoilage. However, COVID-19 led to mass unemployment which decreased spending capacity and, most likely, waste generation among those unemployed. There is also the increase of medical waste and Personal Protective Equipment (PPE) related to COVID-19 but a decrease in elective surgeries.

Nevertheless, system dynamics modeling cannot be done in the absence of data which is often lacking locally and in real-time for waste management. During the COVID-19 pandemic we've had daily updates and global dashboards related to the number of cases and deaths as well as access to real-time air pollution monitoring data for rapid analysis. However, we do not have similar, widespread access to recycling and waste generation and composition data. This would have been useful to answer key research questions sooner as well as identify problems and solutions.

The Environmental Protection Agency (EPA) releases detailed waste generation and composition data for the United States but the most recent data is from 2017 (EPA, 2017). California, through CalRecycle, also reports landfill tonnage data but the most recent data is from 2019. Most landfills, institutions, and recycling facilities do not report recent if any tonnage data on their websites. Some institutions are using live waste tracking as part of their zero-waste planning but it isn't widespread yet. Geographic Information Systems (GIS) and remote sensing are used to site landfills and monitor landfill temperatures and methane emissions and could potentially be upscaled for waste quantification.

Moreover, it is near impossible to know the amount of agricultural waste on farms or at processing facilities. Instead we have to rely on reports from individual farms and sectors/organizations. Even county level data would be informative and help allocate much needed assistance. However, farmers and processers may be sensitive about reporting this data or referring to it as waste.

Furthermore, in waste management, Municipal Solid Waste is often considered, treated, and researched separately from agricultural and industrial wastes. This makes sense but these sectors are often interconnected and all add up to total waste generation and associated environmental impacts. How may changes in household food consumption during the pandemic impact agricultural food waste? We can use systems thinking and modeling to understand these interconnections

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between waste sectors.

Though at the end of May 2020 we are seeing some return back to normal with reopening of many cities, states, and countries, there will probably be long-term changes that will impact waste generation and composition. As we have seen with previous crisis, there will be long-term behavioral, economic, and societal changes (Sarkis et al., 2020). Sarkis et al. (2020) emphasized in their perspective piece on COVID-19 that we should not waste the opportunity of this pandemic to make needed, sustainable changes.

However, we've already seen a shift back to single-use plastic with suspension of plastic bag bans and fees. Shoppers may be hesitant to go back to reusable items for fear of negative health impacts. The recycling sector in the United States was already under threat with decreased international markets and the pandemic is accelerating their financial problems and closures. The pandemic is exposing underlying supply chain issues that we can hopefully address to design more resilient systems to future shocks.

In the coming months and this special issue we will see studies that look into the changes in waste generation and composition due to the pandemic but what if we had easier and quicker access to some of this data? Could we have acted quicker to reduce waste generation and to protect workers and neighboring communities? As we analyze the data, we should do so from a systems perspective and think of the interactions between the different waste sectors as well as promote new ways of real-time, waste management data monitoring and access.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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