



Municipal solid waste management during the SARS-COV-2 outbreak and lockdown ease: Lessons from Italy

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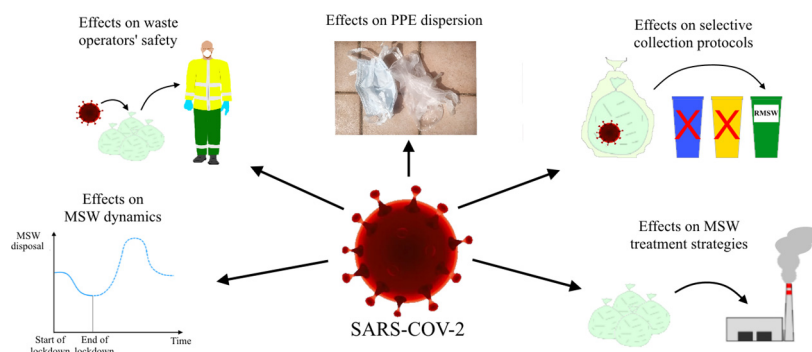
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HIGHLIGHTS

- The literature on waste management during COVID-19 is still scarce.
- The paper studies waste management in Italy, the first European country affected.
- Selective collection, operators' safety and infected waste dispersion are critical.
- The overall weight of used masks is not critical for MSW management.
- Recommendations on appropriate waste management measures are provided.

GRAPHICAL ABSTRACT



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ABSTRACT

The literature on municipal solid waste in relation to COVID-19 is scarce. Based on the experience of Italy, the present article contributes to the strategies aimed at preventing a second virus outbreak. In fact, the mismanagement of municipal solid waste could undermine the strategies during the ease of the lockdown. During the SARS-COV-2 outbreak in Italy, there was a general decrease in the selective collection rate (–15% in one municipality with a well-developed door-to-door collection system). Delays in the publication of guidelines on waste management impacted on the safety of the operators collecting potentially infected waste. Contrarily to expectations, single-use masks and gloves do not have significant impact on waste management, accounting for <1% of the residual municipal solid waste collected annually. However, the dispersion of abandoned masks and gloves outside indoor environments is creating environmental problems. Recommendations on waste management and the protection of waste operators are discussed. Finally, guidelines on the most appropriate waste treatment are presented and analyzed. The results presented in this article show that the MSW management sector has found useful solutions to tackle COVID-19; however, these solutions are not being shared sufficiently. The case study analyzed in the present work could help define strategies for preventing or controlling similar future epidemics or pandemic episodes.

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1. Introduction

Approximately three months after the official declaration of the World Health Organization (WHO) that classified the 2019 coronavirus disease (COVID-19) as a pandemic (WHO, 2020a), the number of scientific papers on the new coronavirus (SARS-COV-2) increased

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dramatically. However, the emergency character of the pandemic left the sector of municipal solid waste (MSW) unprepared, even in countries with a longer tradition of sustainable waste management. Although a new approach has been adopted by the wastewater sector in monitoring the spread of COVID-19, consisting in novel wastewater-based epidemiology approaches for the surveillance of COVID-19 in communities (Ahmed et al., 2020; Hart and Halden, 2020), the literature on the MSW sector, however, is still scarce.

COVID-19 has been reported as having contrasting effects on the environment (Saadat et al., 2020; Zambrano-Monserrate et al., 2020). General reductions in greenhouse gas emissions, environmental noise, water pollution and air pollutant concentrations in ambient air have been reported. However, these effects are expected to be temporary. The reduction in air pollutant concentrations is more clearly visible in areas characterized by high pollution levels (e.g., metropolitan areas in China, the Po Valley in Italy and Madrid in Spain) (ESA, 2020a, 2020b). However, there is a potential increase in the generation of municipal solid waste, a potential reduction in selective collection (SC) rates and, above all, an increase in medical waste production (Saadat et al., 2020; Zambrano-Monserrate et al., 2020). The increase in medical waste is due to the demand for personal protective equipment (PPE) and, in general, to the increase in hospitalization rates with the spread of the infection.

The generation of waste during the pandemic has also raised concerns regarding the potential role of waste residues in spreading the infection. In addition to a set of best practices for the safe handling of medical waste that have been proposed (Qian et al., 2020; Wang et al., 2020a, 2020b), some international organizations, such as the International Solid Waste Association (ISWA) and the European Centre for Disease Control (ECDC), have started publishing guidelines on the correct management of the waste produced at home (ECDC, 2020; ISWA, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h). These guidelines have been integrated or concurrently developed by national and supranational health authorities worldwide (Association of Cities and Regions for Sustainable Resource Management, 2020), in order to limit the diffusion of SARS-COV-2 via the contact with MSW. As reported by scientific papers (Kothai and Arul, 2020; Shereen et al., 2020; Zhang et al., 2020) and the WHO (WHO, 2020b), the main transmission route of the virus is the inhalation of respiratory droplets released by infected individuals. Fecal-oral transmission has also been considered as a possible (though minor) route of exposure (Tian et al., 2020; Wu et al., 2020) and the presence of SARS-COV-2 RNA in feces has contributed to the further development of wastewater-based epidemiology (Daughton, 2020; Mao et al., 2020; Martínez-Puchol et al., 2020; Núñez-Delgado, 2020). However, people can also come into contact with SARS-COV-2 by touching surfaces contaminated by the droplets and aerosols of infected people (Yeo et al., 2020). The long persistence (up to 9 days) of coronaviruses on the surface of metal, glass and plastic objects reported by Kampf et al. (2020) has highlighted a new indirect transmission route. This has also led to the idea that waste collection and waste handling may pose a risk to MSW operators if exposed to waste contaminated by infected individuals. COVID-19 and MSW thus appear to be interconnected: COVID-19 affects MSW production, composition and treatment, while MSW handling has potential implications on the transmission of the disease.

At the beginning of June 2020, Italy resulted as the sixth country globally in terms of confirmed cases, and the second country in terms of deaths attributable to COVID-19 (WHO, 2020c). Among the Western countries, Italy was one of the first nations to face this new emergency, making it an important case study. Italy also has a long tradition of waste recycling and recovery. According to the Italian Institute for Environmental Protection Research (ISPRA), in 2018 Italy achieved a 58.1% SC rate (ISPRA, 2019), with some areas reaching 80% thanks to curbside collections. According to the Organization for Economic Co-operation and Development (OECD), Italy is the fifth most efficient country in terms of recycling and recovery (OECD, 2020). Since the end of February 2020, new MSW dynamics have been developed, new safety measures

have been adopted by healthcare professionals, workers and citizens, and new best practices and guidelines have been shared in order to continue on the path towards SC targets and, meanwhile, protecting the health of waste operators.

Despite the potential impact on infections and the waste sector, there have been few investigations into the relationship between MSW management and COVID-19. The purpose of the present paper is thus to shed light on the mutual implications of waste management and COVID-19, with specific regards to MSW in Italy. The paper discusses the dynamics of MSW, the impacts of PPE disposal on waste management and the environment, and the procedures adopted in Italy for waste disposal and collection. Lastly, recommendations and preliminary considerations on waste treatments are discussed. Additional information from other European Union countries is also integrated with findings from the Italy.

2. Materials and methods

The present paper analyzes the situation in Italy during the SARS-COV-2 outbreak and the consequent lockdown imposed by the government. Starting from the day the first patient was diagnosed with COVID-19 in Italy (02.21.2020), the paper discusses the measures imposed by the government, culminating with the announcement of the lockdown (03.09.2020) by the Prime Minister, and the recommendations issued by national (ISS, 2020), European (ECDC, 2020) and world health authorities (WHO, 2020a, 2020b, 2020c) until the beginning of June 2020. The situation in other European countries tackling the pandemic was also examined together with the management of waste generated during this critical period (Association of Cities and Regions for sustainable Resource management, 2020). National (ISPRA, 2019; ISTAT, 2020; Trento Municipality, 2020) and European statistics (Eurostat, 2020) on waste management were analyzed, as well as the relevant scientific literature published from the beginning of the COVID-19 outbreak in China.

3. Results and discussion

3.1. Effects on MSW dynamics

The SARS-COV-2 outbreak has led to changes in the composition and amount of MSW, as well as special and hazardous waste, with potential criticalities in the management of waste at the collection and treatment stages.

Focusing on the MSW sector, the town of Trento (Italy) represents an interesting case, where a particularly effective curbside collection is in operation (Rada et al., 2018). An important characteristic of the collection strategy is the presence of material collection centers located in the town, where citizens can directly take specific fractions of MSW that are not suitable for curbside collection: e.g., bulky waste, hazardous waste generated at home, green waste, etc.

In March 2020, the production of MSW in the Municipality of Trento was 4058 tons, 18.5% lower than the average in March over the last 10 years (4978 tons). This amount was also considerably lower than March 2019, when the waste produced was 4701 tons (Trento Municipality, 2020). This decrease is the effect of the hard lockdown that in Italy started early in March and forced bars, restaurants and most production activities to stop. However, focusing on the MSW production during a lockdown can give misleading information if the analysis is limited to the months of hard lockdown. In fact, where curbside collection is integrated with material collection centers, citizens accumulate the amount of MSW bound for those centers at home, postponing their transportation. Thus, a peak in transportation should be taken into account during the easing of lockdown (with the reopening of the collection centers) and solutions preventing the gathering of citizens at the centers should be

planned. In the case of Trento, when the material collection centers reopened, the lack of experience led to huge queues of cars at the entrances of the material collection centers, with a subsequent risk of a lack in social distancing. The solution could be to introduce access according alternate license plates. This approach could help in managing the easing of lockdown in the European Union where curbside collection is widely adopted.

The official data for Trento for March 2020 show an 82% SC, similar to data for March 2019 (Trento Municipality, 2020). It is incorrect to conclude that nothing had changed, because the rate for March 2020 applies to an amount that is 81.5% (100% - 18.5%) of the normal one. Thus, the amount of waste selectively collected (t/month) was significantly lower during the period of hard lockdown.

Other effects of the lockdown in Italy, related to MSW, were:

- a higher production of light packaging from online purchases and home delivery;
- an additional production of waste at home, in compliance with the regulations for infected users;
- a lower production of waste assimilable to MSW;
- a lower amount of green waste from parks with potential implications for composting;
- the absence of tourism with a subsequent improvement in SC in areas where the pressure from tourism lowered the quality of source separation.

Of course, outside the sector of MSW, there is a higher production of medical waste and a lower production of special waste. The present article focused solely on the MSW sector.

3.2. Masks and MSW management

3.2.1. Personal protective equipment and waste collection operators

The Italian Health Institute (Istituto Superiore di Sanità, ISS) recommends the adoption of PPE for waste operators, in particular FFP2 or FFP3 (facial filter) masks (ISS, 2020). In the light of the scientific knowledge available and the main transmission routes of the virus (droplets and contact), the appropriately certified and preferably the IIR-type surgical mask or equivalent, which is capable of protecting the operator from splashes and sprays, is considered as adequate protection in most cases. In addition, the ISS recommends the use of disposable gloves under normal non-disposable work gloves, in order to prevent skin contact with work clothes and masks. The ISS also recommends undressing at the end of the work shift as described below:

- remove non-disposable work gloves;
- remove safety shoes;
- remove overalls without shaking clothes;
- remove masks and throw them in the special containers designed for the unsorted collection;
- remove disposable gloves by turning them inside out and throwing them into the containers designed for unsorted collection.

Moreover, the ISS recommends that waste operators carry out the following:

- the cleaning of overalls and work clothes, minimizing the risk of dispersing the virus in the air (no shaking of clothes), by washing them at a temperature of at least 60 °C, using common detergents and disinfectant products that do not alter the high visibility characteristics of clothing needed for the job;
- the replacement of non-disposable work gloves, due to the difficulty of sterilizing them, whenever the operator reports that he/she has handled a broken and/or open bag;
- sanitizing and disinfecting the driver's cab of the vehicles used for the collection of MSW after each work cycle, paying particular attention to the fabrics (e.g., seats), where the virus is able to persist.

Additionally:

- equipping the driver's cab with hydroalcoholic gel;
- the ISS recommends not using compressed air and/or water under pressure for cleaning, or other methods that produce splashes or aerosolize infectious material in the environment;
- vacuum cleaners must be used only after adequate disinfection;
- The use of disinfectants is also recommended in a spray package.

The fact that these criteria were issued a few days after the start of the hard lockdown exposed the MSW collection sector (a strategic sector for public hygiene) at the risk of strike. The perception of the risk is higher in systems based on curbside collection, as the operators can come into close contact with paper, plastic and metals on whose surfaces the virus can survive for long periods. An indirect lesson learnt in Italy is that the time factor for making decisions is crucial when the MSW collection needs to be protected. On the other hand, the focus was preliminarily placed only on the main ways of contagion (droplets), thus underestimating the risks from the dysfunction of the MSW collection system and the related impact on hygiene.

3.2.2. Comparison between PPE disposed and total MSW produced

The large number of masks used by the population could represent a matter of concern in view of the resulting flow of RMSW generated. Wang et al. (2020a, 2020b) estimated that the Chinese population, during the COVID-19 pandemic, might be wearing about 900 million single-use masks per day, i.e., two thirds of the whole population. By adopting the same assumption for Italy, with population of 60 million (ISTAT, 2020), the whole population would dispose of about 40 million masks daily. Considering that a surgical mask weighs about 3 g, the total amount of masks used annually would correspond to about 44,000 tons, i.e., 0.14% of the national total MSW production in 2018 (Eurostat, 2020) and 0.35% of the national RMSW production of the same year (ISPRA, 2019). Including 40 million pairs of nitrile or latex single-use gloves would increase the mass percentage of PPE used by citizens in terms of national MSW and RMSW production to 0.59% and 1.39%. Such data demonstrate that the impact of the huge amount of masks and gloves that would be disposed of as RMSW during one year of the COVID-19 pandemic is of minor concern in the management of MSW at a national level. On the other hand, to date, the literature has not reported any verified recycling options for single-use masks, with the exception of a novel type (Zhong et al., 2020). This aspect, combined with the low waste production, does not depict a circular economy scenario for such equipment at present. However, reusable masks are now available on the market.

3.2.3. Dispersion of masks outside supermarkets

Government administrations in Italy (both centrally and regionally) have issued regulations that oblige people to wear masks and single-use gloves when shopping at supermarkets. The incorrect disposal of masks and gloves by customers and the possible presence of wind may lead to the dispersion of PPE in the environment at the exits of such places. In Italy, for many years, several supermarket chains have already obliged customers to wear polypropylene single-use gloves in the produce section. Following the new regulations on COVID-19, many supermarkets have decided to provide free polypropylene gloves to the customers at the entrance, which are lighter than nitrile/latex gloves and can be blown away more easily by the wind. In order to prevent the dispersion of PPE (and the consequent potential diffusion of SARS-COV-2), a dedicated waste bin has generally been placed outside each supermarket, monitored by the personnel who regulate the flow of people entering the store. In spite of this, a general dispersion of PPE has been detected in supermarket carparks and other sites where the use of PPE is compulsory. In order to tackle this incorrect behavior, some mayors have issued local ordinances and imposed a fine up to 500 Euros (ANSA, 2020).

3.3. Management of contaminated MSW

3.3.1. Disposal and collection

The MSW produced by quarantined people is classified according to the ISS guidelines (ISS, 2020) that are based on the content of the technical report of the European Centre for Disease Prevention and Control (ECDC) of 30 March 2020 (ECDC, 2020). The ISS guidelines state that, in the case of dwellings with the presence of people infected by the SARS-COV-2, the SC of MSW must be suspended. Each type of waste must be regarded as residual MSW (RMSW) and disposed of in a separate bag by the users. This is motivated by the need to simplify the disposal procedure for the users and to avoid errors that may compromise the health of the waste operators. Each bag for RMSW collection must be inserted in at least one other bag. When closing the bags, the user must wear single-use gloves and dispose of them in the next bag for RMSW collection. Whenever a new case of positive infection is confirmed, the local health district has to inform 1) the waste management company in charge of MSW collection, which should activate a special collection protocol, and 2) voluntary associations, which, in the case of curbside collection, will remove the waste from the home of those testing positive and make it available for collection by the waste operators. The same protocol applies to waste users subject to preventive quarantine. In contrast to other countries (e.g., Ireland and Great Britain), in Italy infected users are not asked to store the RMSW in their houses before making it available for removal by volunteers or waste operators (Association of Cities and Regions for Sustainable Resource Management, 2020).

As stated by the ISS (2020), those not testing positive living in houses with no infected people should continue with the normal SC protocol. However, as a precautionary measure, the users must dispose of handkerchiefs or kitchen paper in the bag dedicated for RMSW collection. The latter must also be used to collect single-use gloves and masks. However, this might expose waste operators to the risk of contracting COVID-19 when dealing with waste produced by infected users not tested by the health authorities. The role of asymptomatic (Wei et al., 2020), presymptomatic (Li et al., 2020) and paucisymptomatic (Nicastri et al., 2020) people in the transmission of COVID-19 has been documented by the recent literature on the topic. Considering the crucial role of SC in waste management, governments and local authorities need to quickly adopt some strategies (similar to the one of Section 3.2.1) to protect waste operators rather than taking steps backwards in the sustainable management of waste.

3.3.2. Waste treatment

ISS (2020) recommends incineration (without any pre-treatment or selection) as the priority option for contaminated RMSW. If no thermochemical waste treatment plant is present in the area, the contaminated RMSW should be sent to a mechanical-biological treatment plant (with no manual selection), to a MSW landfill (without any pre-treatment and reduced waste handling) or should undergo sterilization. The absence of a nearby MSW incinerator is expected to increase the export of waste to other waste-to-energy plants, if local authorities are aiming for high sustainability levels even in an emergency situation. However, the export of waste and the related emissions from transport might declassify MSW incineration in terms of environmental sustainability.

Given the recommendations on limited waste handling at waste treatment plants, no minimum storage time has been established for contaminated MSW in Italy. Other countries (e.g., Spain, Portugal, Estonia) have set a minimum storage time of 72 h to protect against the risks from waste handling (Association of Cities and Regions for Sustainable Resource Management, 2020). Imposing a minimum storage time for virus inactivation would reduce the risk of transporting the virus to other locations. In fact, in some situations (e.g., mechanical-biological treatment plants), the waste is separated into different streams that may be sent to other plants.

According to recent investigations, SARS-COV-2 can remain on different materials for up to nine days (Kampf et al., 2020). Thus, a broad

mapping of positive-tested cases is crucial to limit the diffusion of the virus and the infection of waste operators. At the treatment stage, the risk for operators could be reduced by limiting the handling of waste and forbidding manual sorting. In the case of food waste management, anaerobic digestion and composting plants can be reasonably considered as safe, especially if combined or if anaerobic digestion is carried out under thermophilic conditions (Wong et al., 2016; Seruga et al., 2020). Such processes do not require manual operations of the waste and significantly reduce the content of pathogens. On the other hand, mesophilic anaerobic digestion should be regarded with caution, due to the inefficient removal rate of pathogens (Wong and Xagorarakis, 2012).

3.4. Additional information from European Union countries

In order to integrate the findings from the Italian situation, the different approaches adopted by other European Union countries were analyzed. The area studied was limited to the European Union as its members have the same regulatory framework for waste management. We only focused on measures that are unique to the individual countries. Clearly, some measures are common to all countries.

In Austria, employees in charge of collecting MSW have been reinforced with the employees usually in charge of street sweeping (who were reduced by over 50% to help out in more urgent fields of work such as waste collection services). This also enabled a fair number of workers to be at home and to be reachable, in case they were needed to replace others currently working in the streets. Older employees and employees with immunodeficiencies stayed at home (ISWA, 2020b).

In Belgium, concerning the extra health and safety precautions taken to ensure the safety and wellbeing of the waste workforce, the starting times of the different collection teams have been distributed over time in order to prevent a concentration of workers in the workplace (ISWA, 2020c).

In Greece, by special communications with the general public, most municipalities asked to their citizens to make fewer trips to the recycling stations or to avoid trips to the tips/drop-off centers to get rid of bulky waste items (ISWA, 2020d).

In the Netherlands, increasing problems were observed in the processing and recycling of waste: the markets for sorted textile and plastic packaging began to incur financial difficulties because of a lack of demand for the recycled products. Thus, some of the clothing collection and sorting companies asked the public not to donate clothing; others would only collect at a higher price (ISWA, 2020e).

In Portugal, in the areas not covered by incineration, the operations of mechanical-biological treatment plants were suspended if cases of COVID-19 were identified in the area, for the workers' safety (ISWA, 2020f).

In Romania, people have been asked to separate masks and possibly contaminated waste into separate bags before putting them into the residual MSW (ISWA, 2020g).

In Spain, when needed, cement works authorized for waste co-incineration may be asked by the public authorities to co-incinerate residual MSW (BOE, 2020). This option was stipulated the Health Ministry but without technical specifications which would actually have helped to avoid mismanagement.

In Sweden, in the case of local reduced workplaces, co-operation with neighbouring municipalities and the regional authority is recommended in order to guarantee the local operations of waste management (ISWA, 2020h).

4. Conclusions and future developments

To date, the sector of MSW management has received limited attention during the COVID-19 emergency, in spite of its strategic impact on public hygiene. The case study from Italy highlights various criteria that could contribute to strategies aimed at preventing a second virus outbreak or, more in general, similar epidemic or pandemic episodes in

the future. What emerges from the analysis is the lack of adequately detailed protocols at the beginning of the crisis. For example, quarantined people were not allowed to leave their homes, yet MSW collection required people to move the waste out of the house. The lack of detailed information can contribute to the anxiety during an already stressful period. The sectors of applied research and urban hygiene services therefore need to make more effort to be ready for the next emergency.

CRediT authorship contribution statement

Marco Ragazzi: Supervision. **Elena Cristina Rada:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Marco Schiavon:** Methodology, Investigation, Writing - original draft, Writing - review & editing.

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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