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Short Communication

Unprecedented plastic-made personal protective equipment (PPE) debris in river outlets into Jakarta Bay during COVID-19 pandemic

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HIGHLIGHTS

• Riverine debris releases into Jakarta Bay during the COVID-19 pandemic were monitored.
• Riverine debris increased by abundance while decreased by weight during the pandemic.
• Plastics dominated riverine debris at 46% by abundance and 57% by weight.
• The presence of plastic-made personal protection equipment was unprecedented during the pandemic. Plastic-made personal protection equipment accounted for 15–16% of the collected river debris.

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ABSTRACT

Increased plastic uses during COVID-19 pandemic challenges efforts to reduce marine plastic debris. Despite recent observations of increased plastic-made personal protection equipment (PPE) waste in coastal areas, comparative data before and during the pandemic lacked. We present in situ monitoring data on riverine debris releases into Jakarta Bay, Indonesia, during COVID-19 pandemic relative to the 2016 baseline data. River debris at two river outlets—the Cilincing and Marunda Rivers, revealed a 5% increase in the abundance of debris and a 23–28% decrease in the weight of debris releases in March–April 2020 compared to March–April 2016, suggesting a compositional shift towards lighter debris. Plastics continued to dominate river debris at 46% (abundance) or 57% (weight). Unique to the pandemic, we observed an unprecedented presence of PPE (medical masks, gloves, hazard suits, face shields, raincoats) that accounted for 15–16% of the collected river debris of 780 ± 138 items (abundance) or 0.13 ± 0.02 tons (weight) daily. The observed increased plastic-made PPE in river outlets urges for improved medical waste management of domestic sources during the prolonged pandemic.

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Credit author statement

Muhammad Reza Cordova: Writing – original draft preparation, Writing – review & editing, Conceptualization, Resources, Investigation, Methodology, Formal analysis, Visualization, Data curation. Intan Suci Nurhati: Writing – original draft preparation, Writing – review & editing Conceptualization, Resources, Formal analysis, Investigation. Etty Riani: Resources, Investigation, Methodology, Formal analysis, Writing – review & editing. Nurhasanah: Resources, Investigation, Methodology, Funding acquisition. Marindah Yulia Iswari: Formal analysis, Investigation, Data curation.

1. Introduction

The COVID-19 pandemic modifies our environmental imprints on the short and long terms. The novel SARS-CoV-2 coronavirus, which contracted more than 7.3 million people in 215 countries and territories by mid-June 2020 or mere three months after being
declared a pandemic (World Health Organization, 2020a), have polarizing environmental repercussions. Air quality improved prominently in urban (He et al., 2020) and highly populated areas such as in Southeast Asia (Kanniah et al., 2020), and global greenhouse gas emissions such as atmospheric CO2 dropped temporarily due to lockdown measures (Le Quéré et al., 2020; World Meteorological Organization, 2020). However, there have been increased demands for using plastic-made items such as surgical masks (Aragaw, 2020) that persist in the marine environments for centuries (Turner et al., 2020). Public health concerns associated with exposure to the coronavirus add challenges to mitigate macro and microplastics in the environments, existing recycling programs and medical waste management (Aragaw, 2020; Klemes et al., 2020; Prata et al., 2020).

Increased plastic uses raise concerns over leakages into marine environments, particularly from coastal areas with high population and plastic waste emission but low recycling rates. The global annual land-to-ocean plastic waste may range from 1.15 to 12.7 million metric tonnes per year (Mt/ly), in which Indonesia may contribute significantly to land-to-sea debris releases (Jambeck et al., 2015; Lebreton et al., 2017). The capital city of Jakarta and perimeter areas that make up the Greater Jakarta area with about 30 million population have been the epicenter of COVID-19 in the country since the first confirmed cases on March 2, 2020. The nation-wide was urged to stay at home on March 16 which was followed by lockdown policies in Jakarta on April 10 and the Greater Jakarta area by April 18, 2020. The Bantar Gebang landfill, a major landfill serving the area, registered a declining trend in daily received waste from 9346 tons (March 1–15) and 8485 tons (March 16–April 9) to 6342 tons (April 10–June 4) during the lockdown (DLH DKI Jakarta, 2020). However, the Indonesian Ministry for Environment and Forestry (2020a) projected increased medical waste by 30% during the pandemic. A consumer survey showed increased online purchases, particularly PPEs from 4.6% to 34.6%, with 96% of online packaging contained plastics in the Greater Jakarta area (Nurhati et al., 2020). Despite numerous visual accounts of increased PPE waste reported by environmental groups and the media, there had been no comparative quantification of wastes in the environments before and during the pandemic.

We provide updates on river debris monitoring data into Jakarta Bay to detect changes in land-to-sea waste leakages during the COVID-19 pandemic. Based on in situ monitoring data, Cordova and Nurhati (2019) characterized major sources and monthly variations of river debris releases from nine river outlets into Jakarta Bay between June 2015–June 2016. Plastics emerged as the most common debris, representing 59% (abundance) or 37% (weight) of the total collected debris. The study reported a daily plastic debris release of 8.32 ± 2.44 tons from the Greater Jakarta area or 8–16 times less than global-scale model estimates, highlighting the importance of in situ monitoring (Jambeck et al., 2015; Lebreton et al., 2017). Here, we repeated the measurements in two out of the nine river outlets into Jakarta Bay in March–April 2020 to assess the amount of debris entering marine environments from river outlets in Jakarta due to the COVID-19 pandemic. Due to the lockdown situation, it was impossible to repeat the study in all the nine river outlets. Nevertheless, the updated monitoring data provides a valuable glimpse of river debris releases from the Greater Jakarta area to elucidate the urgency of improved medical waste management from domestic sources during the prolonged pandemic.

2. Materials and methods

We characterized debris every ~10 days (March 19, March 28, April 7 and April 15, 2020) at two river outlets into Jakarta Bay — the Cilincing and Marunda Rivers (Fig. 1). Following the method in Cordova and Nurhati (2019), a 75 m-long, 1.5 m-deep net with a 5 cm mesh size were placed across each river during low tides for 15 min for four replicates. The debris was grouped into 7 types (plastic, metal, glass, wood/paper, cloth/fiber, PPE and others) and 47 categories (Table 1). Cilincing River is 44.97 km long within the Cakung watershed of a 142.85 km2 area with more than 2.75 million population. Marunda River is 28.88 km long within the Blencong watershed with an 80.81 km2 area and more than 1.3 million population. The Cilincing and Marunda Rivers have river discharges of 6.84–13.91 m3/s and 32.94–42.83 m3/s, respectively (Cordova and Nurhati, 2019). The watersheds belong to Jakarta and Bekasi municipalities. As of April 15, 2020, there were 214 confirmed COVID-19 cases in the Cakung and Blencong watersheds (Pemprov DKI Jakarta, 2020).

The collected river debris was dried, quantified by abundance and weighted on-site using a Harnic Heles HL-340 digital scale with a maximum capacity of 5 kg and an 0.1 g accuracy. Daily debris releases were estimated following:

\[
D = \frac{n \times 24 \times 60 \text{ minutes}}{t \text{ day}}
\]

where \(D\) is land-derived debris accumulation (items or ton per day); \(n\) is item (number) or weight (ton) of debris observed, and \(t\) is observation time (debris per day).

3. Results and discussion

Our monitoring data showed slight increases in the abundance of river debris and a decreased debris weight compared to the 2016 baseline data of the same months and locations, hinting at the shifted composition of river debris towards lighter debris (Fig. 2). The abundance of daily debris releases increased by 5% at both sites, from 9312 items in March 2016 to 9768 items in March 2020 and from 9696 items in April 2016 to 10,176 items per in April 2020. At both sites, daily debris releases by weight decreased by 23% in March from 2.30 to 1.78 tons daily, and by 28% in April from 2.19 to 1.58 tons daily. More specifically, the observed increased abundance but decreased weight of river debris was more pronounced at Marunda. The abundance of daily debris releases increased by 2% (March) and 4% (April) at Cilincing, and by 9% (March) and 6% (April) at Marunda. The weight of daily debris releases decreased by 9% (March) and 21% (April) at Cilincing, and by 32% (March) and 34% (April) at Marunda. It is worth noting the consistent observations of reduced plastic debris by weight at the Bantar Gebang landfill and riverine environments in the Greater Jakarta area.

Plastics remained the dominant debris entering the Jakarta Bay (Fig. 3). Plastics accounted for 43–47% by abundance or 50–62% by weight of the collected river debris in March–April 2020. Debris under the wood/paper category represented the second most abundant (16–19%) river debris after plastics. In terms of weight, our data showed increased glass waste at Cilincing that accounted for 9–12% of the river debris during the study period. Within plastics, styrofoam was dominant at Cilincing (8–15% by abundance), while rope and fishing rod were prevalent (22–34% by weight) at Marunda (Table 1). Meanwhile, policymakers have devised regulations to reduce plastic waste, their implementation and enforcement face challenges (Cordova et al., 2020). For instance, Jakarta has banned single-use plastic bags since July 2020. While many supermarkets and chain restaurants have complied, the use of plastic bags is still commonly by small businesses. At the national level, the Ministry of Environment and Forestry has outlined a waste reduction roadmap by manufacturers that includes the prohibition on using single-use plastic from polystyrene,
Fig. 1. Study sites at the Cilincing and Marunda river outlets into Jakarta Bay.
Our data confirmed an unprecedented presence and variety of PPEs during the pandemic. PPEs, which were not present before the pandemic, represented 16% of the collected river debris or 780 ± 138 items (696 ± 102 items daily in March and 864 ± 136 items daily in April 2020). Medical waste found in the river outlets has become more diverse during the pandemic, adding to the types of medical waste previously found (i.e., medical wrap, contraception, etc.). In March–April 2020, we found seven more types of medical waste, which were cotton mask, sponge mask, medical mask (surgical, N95), medical gloves, hazard suit material, face shield and raincoat as a substitute for hazard suit (Table 1). Our data indicated that masks (cotton, sponge and medical), which represented 9.83% of the total debris or 492 ± 99 items daily, dominated the PPEs. During our monitoring period, there was an increase in the
abundance of mask debris at the two river mouths from 432 ± 68 items per day in March to 552 ± 102 items per day in April 2020. Furthermore, we assessed the relationship between the number of COVID-19 cases in the watersheds and the unprecedented presence of PPEs at the river outlets, and found moderate correlations ($R^2 = 0.50$ in Marunda and $R^2 = 0.49$ in Cilincing, statistically insignificant at a 90% confidence interval).

Increased lightweight plastic-made PPEs that could travel the distance in the environments with health and environmental concerns highlight the need for managing domestic PPE wastes, which differs from sources from regulated medical facilities (Vanapalli et al., 2021). The chemical composition of plastic-made PPEs may consist of polypropylene, polyurethane, polyacrylonitrile, polystyrene, polycarbonate, polyethylene or polyester (Potluri and Needham, 2005). Prior to the pandemic, the Indonesian Health Research and Development Agency (Badan Penelitian dan Pengembangan Kesehatan, 2019) reported an increase in managed medical waste that resulted in reduced medical waste leakages into the environments from 3.9% to 1.5%. Nevertheless, the surge of waste generated from medical facilities during the pandemic would require adapting to the current waste level (Klemes et al., 2020). The Indonesian Ministry of Environment and Forestry has provided guidance for managing medical waste from hospitals and domestic sources (Kementerian Lingkungan Hidup dan Kehutanan, 2020a, 2020b; World Health Organization, 2020b), and the use of reusable cloth masks for non-medical personnel have been encouraged to ensure the availability of medical-grade PPEs for medical workers.

Moving forward, the pandemic could serve as a foundation for improved waste management and minimize leakages to environments in the long-term. Plastics, including styrofoam and PPE, are sources of microplastics into the environments as they degrade by mechanical and photodegradation processes (Aragaw, 2020; Yousif and Haddad, 2013) and carriers of toxic and carcinogenic pollutants within ecosystems (Graca et al., 2014; National Research Council, 2014; Thaysen et al., 2018).

Upon the end of the COVID-19 pandemic, there will be time to consider the suitability of existing systems and the possibility of examining alternatives. Substitute single-use PPEs with reusable would reduce the amount of waste, although new problems will arise due to the use of chemicals for cleaning and sterilization. River cleanups using floating net booms and by the public facility worker force have been fruitful but unsustainable as they are remedial solutions. Moreover, reinforcing critical research thinking to provide environmentally friendly alternative solutions while enhancing an efficient waste management system can help find a sustainable solution to PPEs and plastic pollution. More than ever, active community participation is key in reducing single-use plastics and reducing leakages into the environments during the pandemic.

4. Conclusion

Global health concerns associated with exposure to the COVID-19 virus and the increased reliance on plastic-made PPEs are among the most relevant environmental issues facing our societies today. This study presents data on riverine debris releases into Jakarta Bay in March and April 2020 during the COVID-19 pandemic when the stay at home and lockdown policies were in place. Our monitoring data suggest a slight 5% increase in the number of debris releases.
with changes in the composition of riverine debris towards lighter debris, thus the 23–28% decrease in the weight of debris releases during the pandemic relative to 2016. The observed PPEs, including medical masks, gloves, hazard suits, raincoats and face shields, are unprecedented and accounted for 16% of the collected riverine debris during the study period by abundance and 57% by weight. Altogether, the study provides evidence of increased PPEs in riverine debris as resulted from the COVID-19 pandemic by taking advantage of available in situ monitoring data before and during the pandemic in Jakarta, Indonesia.

Future works are needed to monitor plastic waste during and after the pandemic to identify effective waste solutions. It is uncertain how the medical waste level would change as we enter the current phase of “new normal” when the use of reusable cloth mask for non-medical workers would help reduce single-use plastics in the environment. One critical question is how the emergency measures introduced to contain the outbreak could lead to long-term waste management solutions. The pandemic could serve as a foundation for improved waste management and minimize leakages to environments considering the compounded health and ecological risks.

**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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