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Baseline

Occurrence of COVID-19 personal protective equipment (PPE) litters along the eastern coast of Palawan Island, Philippines

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ABSTRACT

The emergence of the COVID-19 pandemic has caused worldwide health constraints. This study was conducted to establish a baseline monitoring survey to describe the distribution of PPE litters during the COVID-19 pandemic in the province of Palawan, Philippines. A total of 386 COVID-19-related PPE items were present in 83% of coastal sampling sites with over a cumulative area of 48,200 m², with a density of 8 × 10⁻³ items m⁻². The facemask (98%; n = 377) was the primary type of PPE, followed by face shield (2%; n = 9). Meanwhile, the daily density of PPE litters in San Manuel, Puerto Princesa ranged from 0 to 9.9 × 10⁻² items m⁻², with a mean density of 8 × 10⁻³ items m⁻². The accumulation rates of PPE items ranged from 3.27 × 10⁻¹ items to 1.143 items d⁻¹, with an average rate of 7.29 × 10⁻¹ items d⁻¹.

In late 2019, a novel coronavirus (SARS-CoV-2) that was originally identified in China has become a pandemic that infected people worldwide. This virus, also known as COVID-19, causes more severe cases of infection, leading to pneumonia, severe acute respiratory syndrome, and sometimes death (Elezkurtaj et al., 2021). As of April 2022, about 500 million people have been confirmed infected with the COVID-19 virus (WHO, 2022). The highest confirmed cases were recorded in the United States of America (47.6%), followed by Asia (31.22%), and Europe (17.26%) (WHO, 2022). To prevent the virus transmission, the use of personal protective equipment (PPE), including disposable gloves, surgical masks, and N95 facepiece respirators (WHO, 2020), has become a necessity and has been mandated by authorities throughout the pandemic. This caused the demand for PPE to increase significantly worldwide (Cohen and Rodgers, 2020; Burki, 2020).

The use of PPE is considered one of the most efficient and affordable ways to prevent the transmission of the virus. However, its mismanagement and improper disposal have resulted in increased plastic pollution problems (Ardusso et al., 2021; Selvaranjan et al., 2021). These COVID-19-related waste materials also contribute to and generate a multitude of plastic wastes eventually deposited from a wasteland into rivers, beaches, and coast resulting in the intrusion of plastic litters in marine environments (Benson et al., 2021). There are worldwide anecdotal reports of improper disposal and occurrence of PPE litters in various coastal areas (De-la-Torre et al., 2021; Mghili et al., 2022), and cities in Europe (Prata et al., 2020). These COVID-19-related waste materials also contribute to and generate a multitude of plastic wastes eventually deposited from a wasteland into rivers, beaches, and coast resulting in the intrusion of plastic litters in marine environments (Benson et al., 2021). Evidences have also indicated the occurrence of different types of PPE in coastal cities in America (Ardusso et al., 2021; Thiel et al., 2021), lakes and beaches in Africa (Ben Haddad et al., 2021; Okuku et al., 2020; Aragaw et al., 2022; Hassan et al., 2022; Mghili et al., 2022), and cities in Europe (Prata et al., 2020). Recent reports also revealed that abandoned PPE litters are potential sources of microplastic fibers through physical and chemical degradation (De-la-Torre et al., 2022b; Pizarro-Ortega et al., 2022) and can be an emerging source of secondary
microfibers and MP particles in the marine environments (Akhbarizadeh et al., 2021).

In the Philippines, nearly 3 million confirmed cases have been recorded as of February 2022 (Department of Health, 2021). With this high frequency of confirmed COVID-19 cases, different community quarantine classifications were imposed in the country in addition to the minimum public health standards such as wearing facemasks and face shields and social distancing. Developing countries, like the Philippines, are vulnerable to PPE contamination because of the increased waste generation, indiscriminate disposal, and improper solid waste management systems (Ardusso et al., 2021). With this, a recent news report revealed that COVID-19-related waste was becoming a threat to the country’s ocean as divers discovered coral reef areas covered with single-use facemasks (BBC News, 2021). They also found that the detached facemasks are consumed by marine wildlife. With this finding, divers believe that plastic pollution in the country has worsened during the pandemic. However, no systematic study determines the prevalence of PPE litters in coastal areas in the Philippines. Abreo and Kobayashi (2021) reported the presence of PPE litters on an urban beach on Mindanao Island, located in the southern Philippines. Still, that study was conducted in a small area (283 m²) and did not include information on the accumulation of PPE wastes through time.

Aiming to provide a comprehensive study on the current status of PPE pollution in the Philippines, including its abundance and distribution, this study was conducted to investigate the occurrence of COVID-19-related wastes in Palawan Island, Philippines. Specifically, this study aimed to: a) determine the density of PPE litters; b) identify the types of PPE litters and c) quantify the accumulation rate of PPE litters in a week along the eastern coast of the island. This study will establish baseline data and help implement desirable PPE management strategies procedures during pandemic events. To the best of our knowledge, this is the first monitoring of PPE litters on the island of Palawan.

Palawan is the largest province in the Philippines with an area of ~1.5 million hectares (5% of the Philippine area), a coastline of almost 2000 km, and is composed of 1780 islands (NEDA, 2022; Cayabo et al., 2021). It has a population of 939,594. This province is a UNESCO Biosphere Reserve, plays a vital role in the country’s marine biodiversity, and is considered the Last Ecological Frontier of the Philippines (Gonzales, 2013; Sumeldon et al., 2021). A recent study reported that the east coast of the capital city Puerto Princesa has a higher plastic density compared to the west coast (Sajorne et al., 2021) due to its greater population density in the western area of the city (PCSD, 2015). Thus, this study was conducted on the eastern coast of the province spanning 31 sampling sites in Taytay (n = 2), Roxas (n = 1), Puerto Princesa (n = 8), Aborlan (n = 2), Narra (n = 6), Espanola (n = 4), Brooke’s Point (n = 5) and Bataraza (n = 3), (S1 to S31) as it was observed that a majority of municipal coastal centers are located in the sites (Fig. 1) (Table 1).

Transects were established in each sampling site according to the beach size and morphology. The coordinates and survey area of each site were recorded using GPS (Table 1). The largest area (4368 m²) was recorded in San Manuel, Puerto Princesa (S4) while the smallest area (224 m²) was in Taytay (S2). Private areas and establishments on beach fronts which conduct everyday clean up were excluded from the sampling. PPE collections were conducted during the lowest tide of the day. Sampling was done by visual identification and collecting COVID-19 PPE items by walking along the established transects in each sampling site (Okaku et al., 2020; De-la-Torre et al., 2021). PPE litters were collected within a 2 m wide area along the length of the transect line. After collection, the PPE sampled were classified into one of the following categories: facemask, face shield, glove, or other types of PPE (De-la-Torre et al., 2021). The activities in the sites were also noted. PPE sampling was only conducted once in each sampling site in September 2021 during low tide.

Meanwhile, to monitor the accumulation rate of COVID-19 PPE-related items, seven days of consecutive sampling was conducted in San Manuel, Puerto Princesa City (S4). This is a residential site and is also known for various activities such as fishing, swimming, and other recreational activities. Seven segments (S4-A to S4-G) were established to cover the entire beach area (Fig. 1b). Sampling was conducted daily during low tide for seven days from September 23 to 29, 2021.

Implemented safety measures and protocols were followed to discourage the health risk associated in the data collection during pandemic. Social distancing and wearing of a facemask was maintained throughout the collection. The collection was conducted every 6:00 in the morning when fewer people were in the area. PPE litters were safely collected using a metal tong and hands covered with gloves to prevent direct contact. Hand sanitizing using 70 % alcohol solution was occasionally performed during the surveys. The collected PPE was double bagged, securely tied, and sanitized before transporting to the laboratory.

Fig. 1. (A) Map of Palawan, Philippines showing the sampling sites; S1-S2: Poblacion Taytay, S3: Roxas, S4- San Manuel, Puerto Princesa City, S5-S9: Tacduan, Puerto Princesa City, S11- San Juan, Aborlan, S11: Tigman, Aborlan, S14-S15: Panacan Bliss, Narra, S16–S19– Antipuluan, Narra, S20-S22: Pulot, Sofronio Espanola, S23: Iraray, Sofronio Espanola, S24-S26: Balacan, Brooke’s Point, S27-S28: Buligay, Brooke’s Point, S29-S31: Bataraza; (B) Map of San Manuel in Puerto Princesa (S4) showing the segments/sampling sites.
The density of PPE items was determined by dividing the quantity of PPE items per unit area (Okuku et al., 2020):

\[
C = \frac{n}{a}
\]

where \(C\) is the density of PPE per \(m^2\), \(n\) is the number of PPE counted, and \(a\) is the surveyed area.

Meanwhile, the accumulation rate was computed by dividing the mean counts of PPE items per frequency of sampling in a week (Ammendolia et al., 2021). The total count and density of PPE items collected from each segment were also determined, including the minimum, maximum, mean, and standard deviation (SD) (Table 3). The daily mean count of PPE items was computed by dividing the total counts of PPE items per day surveyed. The cumulative density was determined by dividing the total counts by the area surveyed. Moreover, the daily mean density was computed by dividing the cumulative density per day surveyed (Ammendolia et al., 2021).
Statistical data analysis was performed using IBM SPSS 25. Values were reported as the density (items m$^{-2}$) ± SD. Meanwhile, the accumulation rate was reported as items d$^{-1}$. The map graph was generated using the free Quantum Geographic Information System (QGIS) software, version 3.2.0. Bonn ran under the laptop.

A total of 386 COVID-19 PPE-related waste items were collected over a cumulative area of 48,200 m$^2$, with a density of $8 \times 10^{-3}$ items per m$^{-2}$. Among the sampling sites, 28 sites showed PPE litter occurrences (Table 1). The highest density was recorded in areas S25 (6.1 x 10$^{-2}$ items m$^{-2}$), followed by S24 (3.6 x 10$^{-2}$ items m$^{-2}$), and S26 (1.8 x 10$^{-2}$ items m$^{-2}$), all from the Municipality of Brooke’s Point, located in southern Palawan. These sites were considered residential and also known for fishing and recreational activities. Meanwhile, sites from Puerto Princesa City (S11), Narra (S18, S19), Espanola (S22, S23), and Bataraza (S29) showed no presence of PPE.

The collected PPE litters were classified and revealed that only two types of PPE were present in the sampling sites (Fig. 2). The facemask accounting for 98% total (n = 377) of them was considered the most abundant type of PPE, followed by the face shield, which only accounted for 2% (n = 9) of the entire PPE litters (Fig. 3a). Furthermore, out of the total items of facemasks, 98% (n = 370) were surgical masks, while only 2% (n = 7) were cloth masks (Fig. 3b). Furthermore, in the beaches recorded in Puerto Princesa City (S4-S11), the density of facemask ranged from 0 to $8 \times 10^{-3}$ items m$^{-2}$, with a mean density of $3 \times 10^{-3}$ items m$^{-2}$ (Table 2).

In addition, the site in San Manuel, Puerto Princesa (S4) was monitored for seven consecutive days to quantify the PPE litters observed over one week. The daily density of PPE ranged from 0 to $9.9 \times 10^{-2}$ items m$^{-2}$, with a mean density of $8 \times 10^{-3}$ items m$^{-2}$ (SD = 0.095) (Table 3). The average densities among surveyed segments ranged from $6 \times 10^{-2}$ items m$^{-2}$ (SD = 0.007) to $4.2 \times 10^{-2}$ items m$^{-2}$ (SD = 0.036), with mean density of $1.4 \times 10^{-2}$ items m$^{-2}$ (SD = 0.013). The accumulation rates of PPE items ranged from $3.27 \times 10^{-3}$ items d$^{-1}$ to 1.143 items d$^{-1}$, with an average rate of $7.29 \times 10^{-4}$ items d$^{-1}$.

Meanwhile, it revealed that day 1 of the collection was found to have the highest density ($2.3 \times 10^{-2}$ items m$^{-2}$) (n = 102), while the lowest density ($2 \times 10^{-3}$ items m$^{-2}$) (n = 2) was on day 7 (Fig. 4). It was also observed that the prevalence of PPE litters decreased over time. However, there was a remarkable increase in PPE density ($1.1 \times 10^{-2}$ items m$^{-2}$) on day five, which was noted to be a Monday. Moreover, the total number of PPE litters was found to be higher during weekends compared to weekdays (Fig. 4).

We investigated the COVID-19 PPE-related litters in beaches of Palawan, the Philippines, spanning an area of 48,200 m$^2$. We have confirmed the presence of PPE litters in most of the sampling sites considered residential, fishing, and recreational beaches (Table 1). This result has supported the study of Sajorne et al. (2021), where the majority of plastic litters were also found in residential areas. As the COVID-19 pandemic started, it was mandated by the Inter-Agency Task Force (IATF), a government body instituted by the Philippines during the pandemic, through resolution no. 88, to wear facemasks or other PPE when outdoors to minimize the transmission of the virus. During the PPE sampling, the province of Palawan was under modified general community quarantine (MGCQ), while Puerto Princesa City was under General Community Quarantine (GCQ). However, during the quarantine, many people were still observed in beach areas, particularly in San Manuel, Puerto Princesa City. Residents were participating in recreational activities such as swimming and jogging. Most of the residents were observed to be wearing facemasks while those wearing face shields were very few. With the high number of people on the site, the number of COVID-19-related wastes was also observed to increase. Conversely, some areas with no PPE were also collected (S19, S22, S29) (Table 1). These areas were classified as non-residential and seldom visited by beachgoers as these are remote areas and cannot be accessed easily. A recent study proved that a high number of people in an area would also result in high demand for consumable products that later would become litters (Alabi et al., 2019).

The most collected PPE litters were facemasks. These results are similar to the studies realized in different countries like Kenya, Peru, Chile, and Bangladesh (Okuku et al., 2020; De-la-Torre et al., 2021; De-la-Torre et al., 2022a; Thiel et al., 2021; Rakib et al., 2021). This may be due to strict implementation of the wearing of facemasks when outside households, while face shields were only required in closed and crowded public areas. Surgical masks are considered one of the commonly available and recommended types of PPE, including N95 and KN95 respirators, designed for maximum filtration of aerosols and infectious airborne particles known to protect from respiratory diseases including COVID-19 (US FDA, 2020). In addition, almost all of the facemasks were classified as surgical facemasks, which was highly recommended by the Philippine Department of Health (DOH) over cloth masks to protect against the transmission of the COVID-19 virus (CNN Philippines, 2021). Aside from its better filtration, local communities prefer single-use surgical mask because it is lighter, breathable, individually cheaper, and widely accessible compared to cloth mask and other kinds of the mask. Meanwhile, face shields though seldom used in recreational areas like beaches provide additional eye protection (Salimnia et al., 2021) by blocking the initial forward motion of respiratory droplets (Verma et al., 2020). However, it was found that using face shields and masks together does not significantly enhance the protection offered by wearing surgical mask alone (Salimnia et al., 2021). In terms of numbers of PPE, Palawan was found to have a lesser density compared to the first and only COVID-19-related litters study.
recorded in the Philippines (Abreo and Kobayashi, 2021) (Table 2). The survey of Abreo and Kobayashi (2021) was conducted using aerial drones in a small but densely populated area of 282 m². Our study has a much more extensive area coverage spanning almost the entire east coast of the province, covering one city and six municipalities. Compared to other countries, Palawan has lower PPE litter density than in Egypt and Saudi Arabia (Hassan et al., 2022) (Table 2). This is expected as many areas sampled in these countries are more populated than Palawan, Philippines.

However, the province of Palawan has a higher PPE litter density than Peru, Argentina (De-la-Torre et al., 2021; De-la-Torre et al., 2022a), Chile (Thiel et al., 2021), Bangladesh (Rakib et al., 2021), Canada (Ammendolia et al., 2021), and Brazil (Ribeiro et al., 2022) (Table 2). The majority of these published studies collated PPE litters over a 12-week period, while this study only conducted a single survey campaign. We are also considering how the government implemented levels of quarantine during a pandemic. Based on other countries (De-la-Torre et al., 2021), there was a stricter implementation of beach restrictions applied to beach goers compared to San Manuel, Puerto Princesa (S4), Philippines. It was noted during the collection that despite the General Community Community Quarantine directive, there were still many beach goers in the sampling site during the survey as this area frequently visited by the resident due to its accessibility. Aside from conducting recreational activities, the site was also known as a fishing ground and area for gleaners, considering that fishing is one of the critical livelihoods in the province (Madarcos et al., 2021). Other than that, we also believe that this variation may be influenced by population and classification of sampling areas (Sajorne et al., 2021), weather conditions, population density (Alabi et al., 2019), and COVID-19 restrictions and protocols (Ben Haddad et al., 2021).

Regarding accumulation rate, we also found a remarkable increase in the density of PPE litters on day 5, which was reported to be a Monday. We believed the collected PPE litters were from day 4 (Sunday) of the week. It was also remarkable that in a spanned of only two days during weekends; it still has a higher sum total of PPE litters collected than five days on weekdays (Fig. 5). This may be due to the “weekend effect,” where during these days, the number of people in the beach areas increased, and there was an increase in the number of visitors to the site for relaxation and other recreational activities (Elliot et al., 2018). Our findings were also similar to the results of Hassan et al. (2022), where they also revealed that the amount of PPE litters increased by 76 % and 48 % during weekends in Alexandria, Egypt and Jeddah, Saudi Arabia, respectively. Thiel et al. (2021) also found a similar result in Chile. Ben Haddad et al. (2021) also pointed out that beach goers and visitors are the primary source of pollution in beach areas. This scenario became evident in Morocco, where the occurrence of PPE items was few during lockdowns and suddenly increased just after the beaches were reopened to the public. Overall, the findings of this study have a lower accumulation rates than study conducted in a metropolitan city in Canada (Ammendolia et al., 2021).

Table 2
Comparison of PPE density in Palawan compared to other cities in the Philippines and other countries.

| Country | City/province | Environment | PPE density (items m⁻²) | Most abundant type of PPE | Reference |
|---------|---------------|-------------|-------------------------|---------------------------|-----------|
| Philippines | Palawan | Beach | 8 × 10⁻³ | Facemask | This study |
| Philippines | Digos | Beach | 1.4 × 10⁻² | Facemask | Abreo and Kobayashi, 2021 |
| Morocco | Tetouan | Beach | 1.2 × 10⁻³ | Facemask | Mghili et al., 2022 |
| Morocco | Agadir | Beach | 1.13 × 10⁻⁵ | Facemask | Ben Haddad et al., 2021 |
| Kenya | Kwaale and Kiñfi | Beach | – | Facemask | Okuku et al., 2020 |
| Peru | Lima | Beach | 6.42 × 10⁻⁵ | Facemask | De-la-Torre et al., 2021 |
| Chile | Nationwide | Beach | 6 × 10⁻² | Facemask | Thiel et al., 2021 |
| Bangladesh | Cox’s Bazar | Beach | 6.29 × 10⁻³ | Facemask | Rakib et al., 2021 |
| Iran | Bushehr | Beach | – | Facemask | Akbarzadeh et al., 2021 |
| Iran | Caspian Sea | Beach | 1.02 × 10⁻⁴ | Facemask | Hatami et al., 2022 |
| Canada | Toronto | City/urban | 1 × 10⁻³ | Facemask | Ammendolia et al., 2021 |
| Peru | Nationwide | Beach | 6.6 × 10⁻⁴ | Facemask | De-la-Torre et al., 2022a |
| Argentina | Nationwide | Beach | 7.21 × 10⁻⁴ | Facemask | De-la-Torre et al., 2022a |
| Ethiopia | Bahir Dar | Lake | 1.54 × 10⁻⁴ | Facemask | Aragaw et al., 2022 |
| Egypt | Alexandria | Beach | 2.79 | Facemask | Hassan et al., 2022 |
| Egypt | Hurghada | Beach | 2.9 × 10⁻¹ | Facemask | Hassan et al., 2022 |
| Saudi Arabia | Jeddah | Beach | 8.6 × 10⁻¹ | Facemask | Hassan et al., 2022 |
| Brazil | Santos Bay | Beach | 7.46 × 10⁻⁵ | Facemask | Ribeiro et al., 2022 |

Fig. 3. Percentage of the (A) types of PPE and (B) types of masks collected from sampling sites.
Table 3

| Survey segment | Area | Number of days sampled | Survey frequency (number of surveys per week) | Survey count | Total count | Daily min. density (items/m²) | Daily max. density (items/m²) | Daily mean density (items/m²) | Daily SD | Accumulation rate (items/d⁻¹) | Daily min. | Daily max. | Daily mean | Daily SD |
|----------------|------|------------------------|-----------------------------------------------|--------------|-------------|-----------------------------|-----------------------------|--------------------------------|---------|-----------------------------|-------------|-----------|-----------|---------|
| S4-C | 604 | 7 | 7 | 12 | 4.429 | 0.123 | 4.036 | 6.876 | 0.000 | 0.048 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 |
| S4-G | 608 | 7 | 7 | 39 | 2.286 | 0.000 | 2.094 | 3.094 | 0.000 | 0.033 | 0.023 | 0.000 | 0.000 | 0.000 | 0.000 |
| S4-E | 1176 | 7 | 7 | 32 | 1.111 | 0.000 | 1.030 | 3.718 | 0.000 | 0.026 | 0.000 | 0.004 | 0.014 | 0.008 | 0.000 |
| S4-F | 1296 | 7 | 7 | 56 | 1.111 | 0.000 | 1.030 | 3.718 | 0.000 | 0.026 | 0.000 | 0.004 | 0.014 | 0.008 | 0.000 |
| S4-F | 280 | 7 | 7 | 31 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

The lack of local and national strategies in PPE waste management has also affected the progress toward achieving the key components of the UN’s Sustainable Development Goals (SDGs). The pollution caused by improper disposal of PPE in beach areas directly affects the SDG 6 clean water and sanitation, together with SDG 14 or the life below water. With the emerging number of COVID-19-related wastes in the marine environments, records on its threats to the marine life become more rampant (Neto et al., 2021; Hiemstra et al., 2021). The first ever case of facemask ingestion by Magellanic penguin (Spheniscus magellanicus) that caused its mortality was recorded in the coast of Brazil (Neto et al., 2021). Recent report has also shown how the Philippine coral reef areas were covered with single-use facemasks (BBC News, 2021). These disposable facemasks and other types of PPEs are also considered potential sources of microplastic fibers (Aragaw, 2020; Fadare and Okoffo, 2020) and secondary micro/nanoplastics (MPs/PNPs) (Aragaw, 2020; Kwak and An, 2021). With this, the evidence and strategies on the presence of microplastic in gastrointestinal tracts of biota, particularly in fishes (Kalaiselvan et al., 2022; Bucol et al., 2020; Borges-Ramirez et al., 2020; Adhikari et al., 2021), will continue to rise. Through these records of plastic ingestion in biota, the SDG 12 responsible consumption and production and SDG 3 or good health and wellbeing of the people also become vulnerable as they are considered the top consumer in the food web.

It shall be noted that this study has some limitations. The collection of PPE litters were only conducted on the east coast of Palawan as our previous study found out that this coast has a higher density of plastic litters (Sajorne et al., 2021). The PPE litters only visible on the surface of sediments were collected and the others that may have been buried in the sediments were not considered. In addition, given the lack of established international guidelines for monitoring litters during pandemic, this study was unable to use standardized protocols that were widely used by different organizations. During the sampling, this study only focused on collecting PPE litters and disregarded other plastic litters that were mismanaged during the pandemic. This study could also be improved by conducting long-term surveys in other sampling sites and increasing the replication of sampling in different seasonal periods.

Overall, we believe that PPE litter pollution is caused by the lack of environmental awareness and initiatives. The LGUs and national government offices and agencies must develop proper disposal management strategies particularly of hazardous PPE. Some countries, particularly in Toronto, Canada, have already developed and implemented city’s waste management division through Special Waste Disposal Instructions for residents on proper disposal of personal and sanitary hygiene wastes during COVID-19 (e.g., wipes, tissues, napkins, paper towels, and other sanitary and hygiene products) (City of Toronto, 2020). Local and national policymakers should also require the manufacturers, particularly the PPE producing companies, to release minimum recycling content of PPE. The polymers of PPE have been found as fuel conversion alternatives via pyrolysis (Aragaw and Mekonnen, 2021). If not recycled, the improper disposal of PPE contributes substantially to hazardous environmental pollutants. They may consider green technologies for much environmental friendly PPE products through redesigning a conventional PPE that is composed of natural biodegradable materials.

Also, promoting reusable yet effective masks is one of the remarkable ways to reduce the amount of biomedical wastes generated. Government initiatives such as information, communication, and education (IEC) campaigns should be intensified among the general population to promote appropriate PPE stewardship integration into policy implementation, monitoring, and enforcement. To mitigate the presence of PPE in the beach areas of the city of Puerto Princesa and province of Palawan, it is recommended to disseminate signposts and bins for the correct PPE disposal within the vicinity. Future studies should consider the solid waste perception, awareness, and practices of coastal communities, local government units and businesses.
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CRediT authorship contribution statement

Recca E. Sajorne: Investigation, Formal analysis, Writing – original draft. Genese Divine B. Cayabo: Investigation, Writing – review & editing. John Roderick V. Madarcos: Investigation, Writing – review & editing. Karen G. Madarcos: Investigation, Writing – review & editing. Dawin M. Omar: Investigation, Writing – review & editing, Software.

Lucio B. Ardines: Investigation. Serdon A. Sabtal: Investigation. Jhonanie M. Mabuhay-Omar: Investigation, Writing – review & editing. Victoria Cheung: Writing – review & editing. Lota A. Creencia: Funding acquisition, Writing – review & editing. Hernando P. Bacosa: Conceptualization, Supervision, Investigation, 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.

Data availability

No data was used for the research described in the article.

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