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Facemask: Protection or threat?

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ABSTRACT

Facemasks were widely used as a protection against SARS-COV-2, which significantly reduced COVID-19 transmission during the pandemic. However, concerns have been raised regarding its adverse impacts on human health due to intense use and mismanagement. Although rampant plastic littering was the norm before the pandemic, the magnitude of the problem is worsening as potentially COVID-19-infected facemasks are thrown along the shoreline. This study assessed the discarded facemasks on the most popular beach destinations in Mati City, Davao Oriental, Philippines. A total of $N = 284$ discarded facemasks were found in a cumulative area of 22,500 m^2, with an average density of 8.4×10^{-4} items/m^2. The surgical facemask (82 %; $n = 234$) was the most abundant type of facemask found in the areas, followed by KF94 (16 %; $n = 45$) and KN95 (2 %; $n = 5$). The Analysis of Variance (ANOVA) showed significant differences in the visual counts of facemasks on the three beaches ($p < 0.05$).

1. Introduction

Plastics are considered to provide more advantages than traditional materials for packaging and other purposes as they provide numerous societal benefits (Mckeown and Jones, 2020; Retama et al., 2016). Plastics are polymers primarily made of synthetic materials and can be molded to whatever shape is necessary (Evode et al., 2021; Worm et al., 2017). In 2010, 192 coastal countries were studied, which generated 275 million metric tons (MT) of plastic waste, with 4.8 to 12.7 million MT ending up in the ocean. The Philippines was previously identified as the third largest contributor of plastics to the marine environment, producing over 750,000 MT of plastic litter annually (Jambeck et al., 2015). Plastic was also widely reported as a substantial threat to the world's oceans and seas (Pierdomenico et al., 2019; Roman et al., 2021.; Senko et al., 2020). The dangers of plastic pollution to the marine environment have been studied for a long time and are well documented (Bhagat et al., 2021; De-la-Torre et al., 2021; Everaert et al., 2020). By 2050, plastics are expected to outweigh fish in the ocean (Baron and Sparks, 2020; Guillard et al., 2018; Hakuzimana, 2021; Jambeck et al., 2015; Kehinde et al., 2020; Ugoeze et al., 2021).

Rampant plastic littering was the norm before the pandemic. However, the magnitude of the problem worsens as the COVID-19 pandemic spreads worldwide. The World Health Organization (WHO) and other national disease control centers have issued various guidelines to reduce the spread of COVID-19 from human-to-human transmission, including social distancing, frequent handwashing, and proper respiratory etiquette. Originally, personal protective equipment (PPE) such as medical gloves, facemasks, and aprons have been recommended for essential service workers (e.g., doctors, nurses, caregivers, etc.) and other people handling patients infected with COVID-19 (Hantoko et al., 2021; Nzediegwu and Chang, 2020; Siwal et al., 2021). Unfortunately, due to the rapid spread of COVID-19, it is now widely used by the general public. As a result of these recommendations, millions of PPE are manufactured and used daily during the pandemic (Haque et al., 2021; Kutralam-Muniasamy et al., 2022; Shruti et al., 2020; Nzediegwu and Chang, 2020; Olatayo et al., 2021). It is estimated that >129 billion facemasks and 65 billion gloves are used monthly worldwide (Adyel, 2020; Aragaw and Mekonnen, 2021; Prata et al., 2020). Although single-use PPE effectively combat COVID-19, there are growing environmental concerns about their contribution to plastic waste leaking into the environment (Ammendolia et al., 2021; Okuku et al., 2021; Silva et al., 2021b; Uddin et al., 2021). Recent reports have indicated the occurrence

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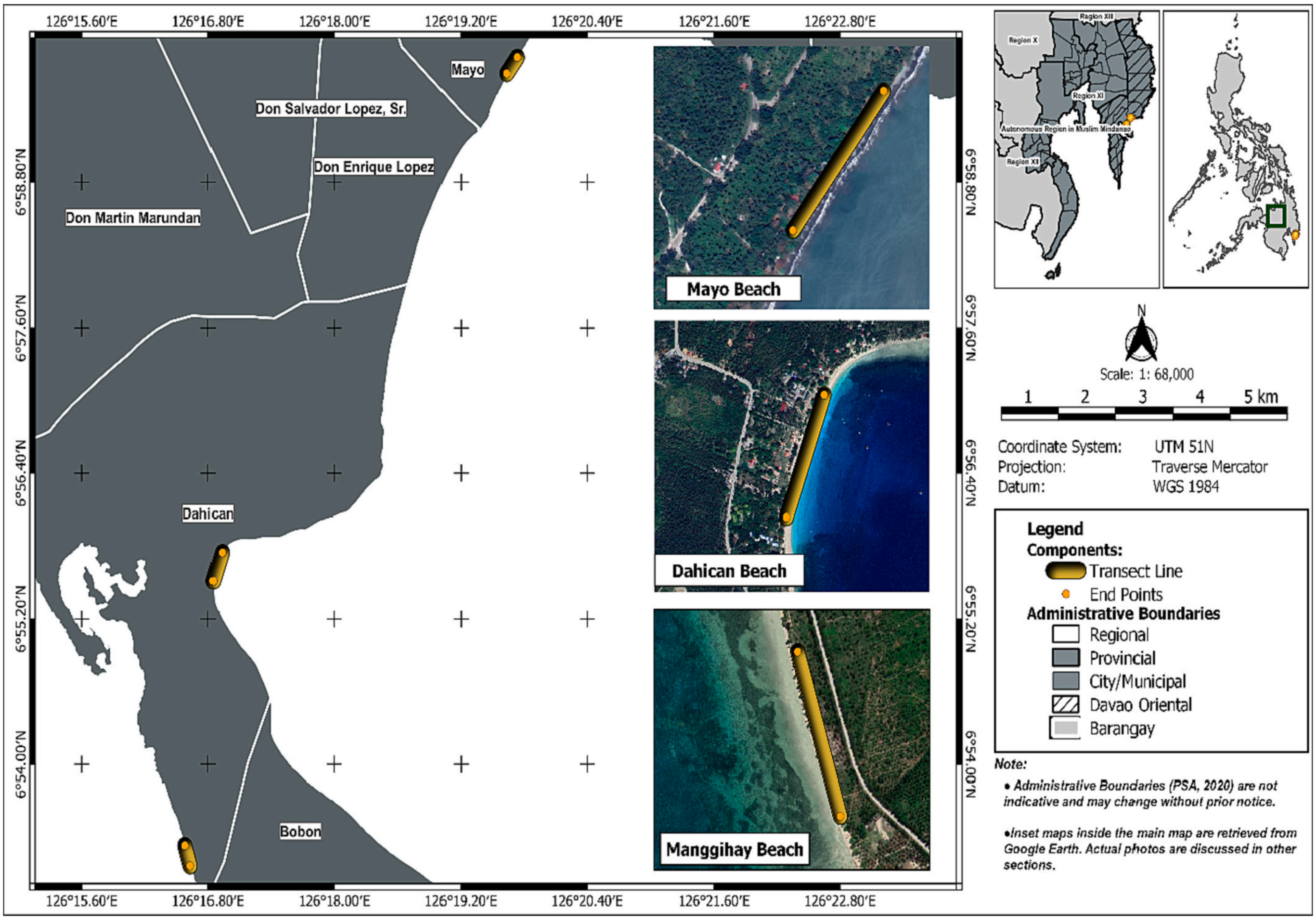

Fig. 1. Map of the sampling sites in Mati City, Philippines.

of PPE in the marine environment (Akhbarizadeh et al., 2021; Ammendolia et al., 2021; Ardusso et al., 2021; De-la-Torre and Aragaw, 2021; Dioses-Salinas et al., 2022; Okuku et al., 2021; Prata et al., 2020). Mismanaged PPE deposited on land or in landfills can find their way into marine environments through various routes (De-la-Torre et al., 2021; Okuku et al., 2021; Rakib et al., 2021). Facemasks, surgical gloves, splashproof garments, and other PPE items were found stranded on the beaches, coastlines, and rivers (Canning-Clode et al., 2020; De-la-Torre and Aragaw, 2021). These items are typically made of synthetic single-use plastic products (Patel et al., 2017). Facemasks, on the other hand, are the most common type of PPE found on beaches (Akhbarizadeh et al., 2021; Haddad et al., 2021; Chand et al., 2021; De-la-Torre et al., 2021; Rakib et al., 2021; Ribeiro et al., 2022; Silva et al., 2021a; Thiel et al., 2021). It consist of three layers designed and constructed as follows: the outer layer is made of a non-absorbent material that protects against liquid splashes, the middle layer is made up of non-woven and non-absorbent fabrics created through a melt-blowing process, which prevent droplets and aerosols through an electrostatic effect, and the inner layer is made of absorbent material such as cotton to absorb vapor (Aragaw, 2020; Fadare and Okoffo, 2020; Xu and Ren, 2021). Upon entering the environment, the facemask is subjected to weathering conditions such as sunlight exposure, abrasion from wave action and collision with natural substrates, and biological interaction. These conditions cause the polymeric material to degrade chemically and physically (De-la-Torre et al., 2022b; Pizarro-Ortega et al., 2020). In the scientific literature, the possible risks posed by facemasks as a source of microplastics and/or nanofibers have already been highlighted by several authors (Aragaw, 2020; Du et al., 2022; Fadare and Okoffo, 2020; Rubio-Armendáriz et al., 2022; Saliu et al., 2021; Silva et al., 2021a).

The generated PPE waste from this pandemic is a new phenomenon of which we have no prior knowledge and lack established waste management practices (Adusei-Gyamfi et al., 2022; Ammendolia et al., 2021; Kutralam-Muniasamy et al., 2022). Their presence in the natural environment is expected to increase if no mitigation strategies are adopted or implemented, posing a threat to humans and marine wildlife (Ogunola et al., 2018; Silva et al., 2021b). The current pandemic exacerbates the reports of improper facemasks disposal worldwide, making it vital to distinguish the potential threats posed by this new type of plastic pollution. This study has been conducted to determine the extent of facemask pollution and provide baseline data for Mati City by investigating the occurrence of facemasks associated with the novel COVID-19 pandemic. Specifically, this study aimed to: a) examine the abundance and density of facemasks; b) visualize the distribution of discarded facemasks; c) determine the types and composition of facemasks found in the study sites, and d) ascertain if the beach facilities/infrastructure provide signages and trash bins for the proper handling and disposal of facemasks. The findings may also serve as baseline information for the concerned agencies to launch a clean-up drive and the regular monitoring of the study areas for compliance with PPEs' proper disposal. The Local Government Unit (LGU) should formulate and strictly implement policies regarding the disposal of facemasks and give special consideration to vulnerable groups during the pandemic.

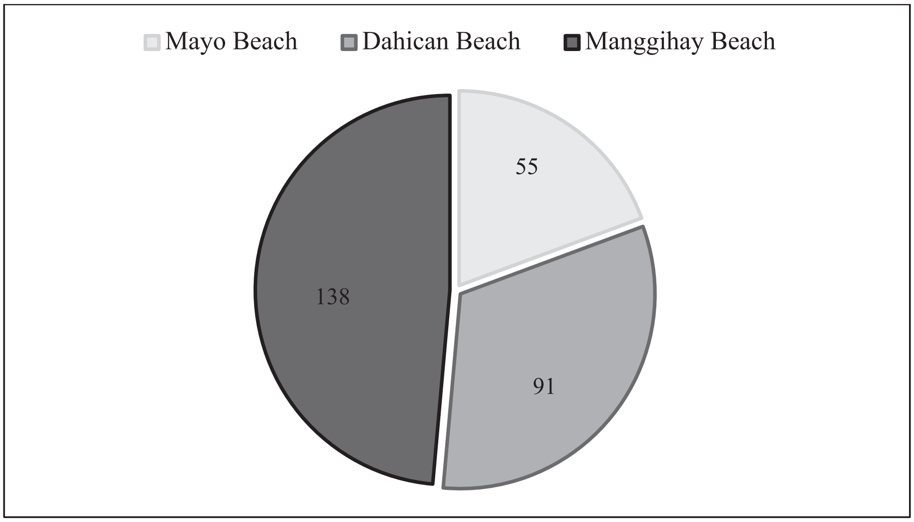

Fig. 2. The number of facemasks found in the study sites.

2. Materials and methods

2.1. Study area

Davao Oriental is a province in the Philippines located in Davao Region in Mindanao. Mati City is the capital and the only city in Davao Oriental. It has been known as a beach destination located in the Southeastern part of Mindanao. It has approximately 588.63 km^2 or 227.27 mile^2, constituting 10.36 % of Davao Oriental's total area. The study was conducted along the three (3) most popular beach destinations in Mati City. These are the beaches of Mayo, Dahican, and Manggihay (Fig. 1). The presence of intensive human activities such as fishing, gleaning, sightseeing, swimming, and tourism were the factors considered in selecting these beaches.

The pandemic has brought a global-scale impact, and Mati City is no exception. In this regard, the city government announced the temporary closure of most beach resorts within the three beaches to strengthen the prevention against the spread of the virus. After almost three (3) months of closure, it was reopened to the public on June 16, 2020. Nonetheless, health and safety precautions were strictly enforced according to the guidelines of the Inter-Agency Task Force for the Management of Emerging Infectious Diseases (IATF-EID).

2.2. Sampling protocol

Sampling stations per study site were laid out to cover 300 m as the survey length and 25 m as the survey width. Prior to sampling, this quadrat was divided into three segments (100 m × 25 m) with no interval between segments using a transect line. The sampling survey was conducted for fifteen (15) consecutive days in June 2022 during low tide. The sampling strategy consists of walking along the transect line, visually scanning the surroundings, determining whether the visible facemask samples from the eye level of the researchers are single-use or reusable cloth, taking note of the possible sources of facemasks, and taking photographs of each found facemask using the GeoCam® Software Application. Dumpsites near the beach were investigated. The

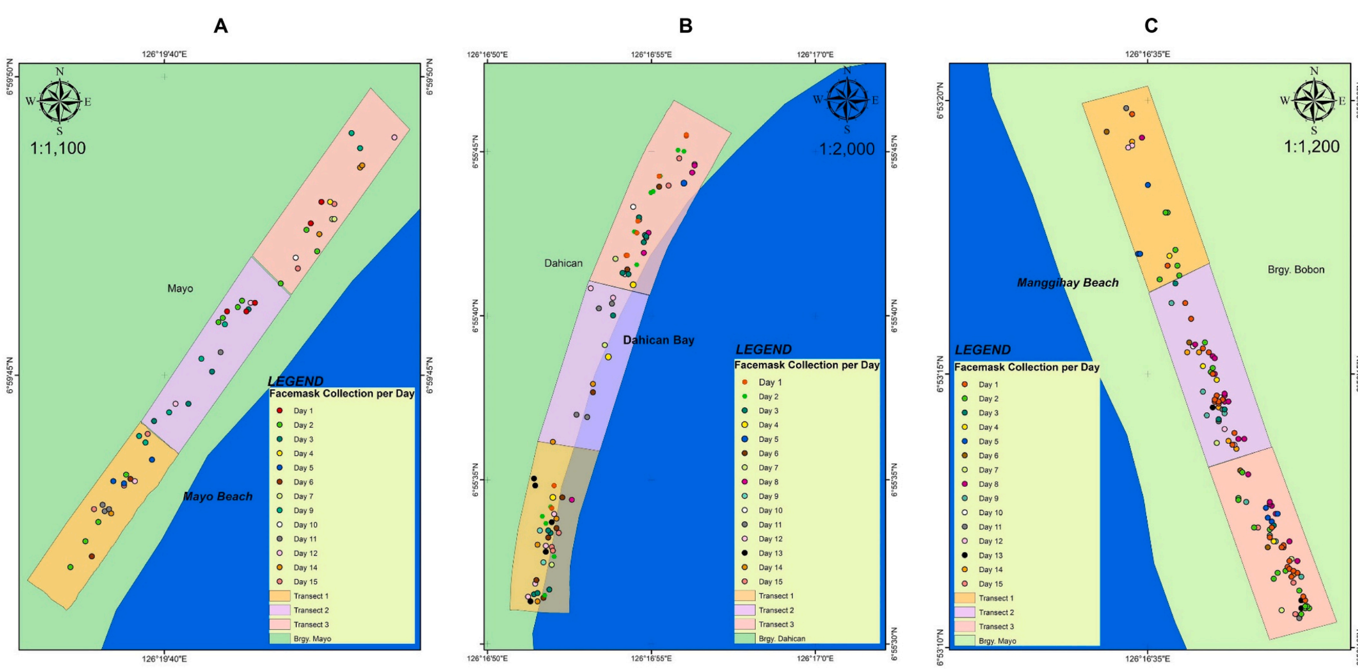

Fig. 3. Distribution of discarded facemasks on Mayo Beach (A), Dahican Beach (B), and Manggihay Beach (C).

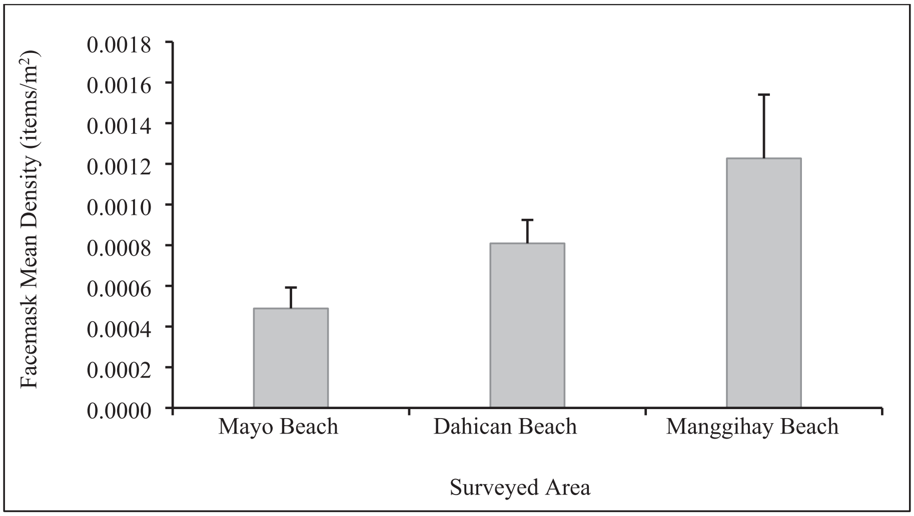

Fig. 4. The mean density of counted facemasks across the study sites. The error bars indicate the standard error of the mean.

presence of trash bins and signages about the proper handling and disposal of PPE wastes in the three study sites were also observed on-site and were photo-documented.

The abundance was measured, adhering to the objectives of the study, by recording the count data on every survey day at each location to determine the total number of facemasks found in each study site. The density of facemasks was calculated at each station using the following equation (De-la-Torre et al., 2021; Okuku et al., 2021):

$$C = n/A$$

where n is the number of facemasks and a is the surveyed area used to calculate the facemasks density per m^2 (C).

2.3. Data analysis

The results were expressed in mean facemask density (items/m^2) in each sampling site. The total number of facemasks was analyzed by pooling the data of the collected samples to determine the differences among and between the three (3) sites using One-Way ANOVA. The data were first examined by checking their QQ (quantile-quantile) plots and normal distribution by plotting them on a scatterplot diagram. The data's normality was further examined using the Kolmogorov-Smirnov test, which revealed significant differences in the population. The homogeneity of variance was also checked using Levene's test, which showed significant differences. As a result, data transformation using log-10 transformation was used to satisfy the requirements of ANOVA (Underwood, 1997). In this case, the data was still not normally distributed, but the variance was already equal ($p > 0.05$). Then, a one-way ANOVA was used to compare the data, and boxplots were constructed, including a post-hoc test using Tukey-Kramer for the significantly different pairs of comparison.

3. Results and discussion

3.1. Abundance of facemasks

The authorities made the use of facemasks mandatory to prevent the transmission of SARS-CoV-2 in the city. Entering the beach premises requires the same policy since it effectively combats the spread of COVID-19. Beachgoers used single-use PPE, such as facemasks, as they entered the beach. Compliance with protocol or fear of being penalized could have been the main reason. These plastic litters become waste after a single use and should be disposed of in waste bins. However, many are scattered on the ground. The three most popular beaches in Mati City were surveyed for fifteen consecutive days during low tide, and a total of $N = 284$ discarded facemasks were found. Immense quantities of discarded facemasks, $n = 138$, were found along the shoreline of Manggihay Beach, followed by Dahican Beach with a total of $n = 91$. In contrast, Mayo Beach has the least number of discarded facemasks, $n = 55$ (Fig. 2).

Facemask wastes have been dumped higher up on the beach, where most beachgoers spend the day (Fig. 3). The number of facemasks in the supralittoral zone outnumbered those in the intertidal zone, which implies that most of these wastes were left by beachgoers (De-la-Torre et al., 2021; Mghili et al., 2022). However, some of the discarded facemasks found in Dahican Beach were seen in the infralittoral zone (Fig. 3B), where they are more likely to be washed away and end up in the ocean. As a result, various marine organisms are exposed to a high level of pollution, including entanglement, entrapment, and ingestion (Abreo et al., 2016; Hasan et al., 2021; Hiemstra et al., 2021; Ray et al., 2022; Sun et al., 2021). In June 2021, a facemask (14 cm × 9 cm) was found in the feces of a juvenile green sea turtle on the northeast coast of Japan (Fukuoka et al., 2022). This is the first detection since facemasks had never been found in the area before the pandemic. Fourier Transform Infrared Spectroscopy (FTIR) analysis identified the mask as polypropylene, a common material used in disposable facemasks (Chen et al., 2022; Chua et al., 2020; Fukuoka et al., 2022). Although sea turtles can excrete small amounts of plastic (Tomas et al., 2002), the accumulation of these tiny plastic materials can cause blockage in the digestive tract. An obstruction in the digestive tract is a leading cause of death for marine organisms, resulting in emaciation and severe starvation (Abreo et al., 2016; Lazar and Gracan, 2011). This terrible incident becomes alarming since a turtle hatchery is present in one of the study sites. Olive Ridley Turtle *(Lepidochelys olivacea)*, Green Turtle *(Chelonia mydas)*, and Hawksbill Turtle *(Eretmochelys imbricata)* mainly lay their eggs in Dahican Beach.

Discarded facemasks along the shoreline will weather further when exposed to natural factors such as sunlight (including UV irradiation), sand abrasion, and sea waves (De-la-Torre and Aragaw, 2021; Wang et al., 2022). Laboratory tests, but not done in this study, confirmed the release of microplastics, nanoplastics, and chemical pollutants from different facemasks (De-la-Torre et al., 2021; De-la-Torre et al., 2022a; Morgana et al., 2021; Saliu et al., 2021; Shen et al., 2021; Sullivan et al., 2021; Wang et al., 2022). These particles can persist in the environment and continue to jeopardize human health through inhalation as humans' primary route of biological entry. It was reported that exposure to airborne MPs could cause inflammation, immune disorders, and neurodegeneration (Prata et al., 2020). Moreover, aquatic organisms easily

Table 1
Summary of facemask surveys including the item counts, densities (items m^{-2}), and accumulation rates (items/day) in three surveyed beaches in Mati City, Davao Oriental, Philippines. Also presented are standard deviation (SD), daily minimum (min.), and maximum (max.) counts and densities.

Survey information				Counts						Densities (items/m^2)					
Location	Segment	Area surveyed (m^2)	Number of days sampled (n)	First-day count (n)	Total count (n)	Daily min. count (n)	Daily max. count (n)	Daily mean count (n)	Daily SD count (n)	Cumulative density (items m^{-2})	Daily min. density (items m^{-2})	Daily max. density (items m^{-2})	Daily mean density (items m^{-2})	Daily SD density (items m^{-2})	Accumulation rate (items/day)
Mayo Beach	S1	2500	15	0	22	0	4	1.47	1.46	0.88	0	0.16	0.0587	0.0583	0.0980
	S2	2500	15	3	20	0	5	1.33	1.59	0.80	0	0.20	0.0533	0.0635	0.0887
	S3	2500	15	2	13	0	3	0.87	0.99	0.52	0	0.12	0.0347	0.0396	0.0580
Dahican Beach	S1	2500	15	2	21	0	5	1.40	1.55	0.84	0	0.20	0.0560	0.0620	0.0933
	S2	2500	15	4	26	0	4	1.73	1.16	1.04	0	0.16	0.0693	0.0465	0.1153
	S3	2500	15	3	44	0	6	2.93	2.02	1.76	0	0.24	0.1173	0.0807	0.1953
Manggihay Beach	S1	2500	15	15	62	1	15	4.13	4.88	2.48	0.04	0.60	0.1653	0.1953	0.2753
	S2	2500	15	10	52	0	10	3.47	3.18	2.08	0	0.40	0.1387	0.1273	0.2313
	S3	2500	15	7	24	0	7	1.60	2.06	0.96	0	0.28	0.0640	0.0825	0.1067

ingest facemasks, affecting the food web that could end up in the human diet (Aragaw, 2020; Bradney et al., 2019; Chen et al., 2022; Dharmaraj et al., 2021; Issac and Kandasubramanian, 2021; Ray et al., 2022; Zhao et al., 2022). It mainly concerns coastal populations, which rely heavily on seafood as their primary protein source (Bene et al., 2016; Mendoza et al., 2021; Rodrigues and Villasante, 2016). This type of improperly managed waste has been distinguished as one of the primary causes of plastic pollution in the marine environment (Macusi et al., 2019). Meanwhile, transect 1 was found to have more discarded facemasks than the other two transects on all three beaches. The location of the transect could influence this finding. Transect 1 is commonly the beach's entrance area, where most beachgoers take off their facemasks.

3.2. *Densities of facemasks*

The mean density of counted facemasks in Manggihay Beach (1.2×10^{-3} items/m^2) was higher than in Mayo Beach (4.9×10^{-4} items/m^2) and Dahican Beach (8.1×10^{-4} items/m^2) (Fig. 4). Expectedly, more discarded facemask items were found on urban beaches than on remote beaches, contrary to the results of Okuku et al. (2021). The high density of facemasks in Manggihay Beach could be attributed to higher levels of compliance with governmental regulations, i.e., the mandatory wearing of facemasks, as opposed to remote beaches such as Mayo Beach, which had a lower facemask density. Aside from frequent recreational activities in Manggihay Beach, the site is also known as a fishing ground and a gleaning area, considering fishing as one of the city's most important sources of income (Madarcos et al., 2021).

The daily density of facemasks in Mayo Beach ranged from 0 to 1.5×10^{-3} items/m^2, Dahican Beach ranged from 1.3×10^{-4}–1.6×10^{-3} items/m^2, and Manggihay Beach ranged from 4×10^{-4}–4.3×10^{-3} items/m^2 (Table 1). Moreover, it was discovered that Day 1 of the collection had the highest density in Manggihay Beach (4.3×10^{-3} items/m^2), Day 2 of the collection in Mayo Beach (1.5×10^{-3} items/m^2), and both Day 2 and 3 of the collection had the highest density in Dahican Beach (1.6×10^{-3} items/m^2). Meanwhile, the average accumulation rate of discarded facemasks was 0.0816 items/day in Mayo Beach, 0.1346 items/day in Dahican Beach, and 0.2044 items/day in Manggihay Beach. It was also observed that the occurrence of facemasks varied over time (Fig. 5).

Contrary to Hassan et al. (2022); and Sajorne et al. (2022), the total number of facemask litter was unexpectedly higher during weekdays than on weekends. This could be influenced by the implementation of telework or work-from-home guidelines in many governments and non-government offices as one of the effects of the COVID-19 pandemic (Ipsen et al., 2020). As the outbreak of the COVID-19 pandemic swept the globe and social distancing was necessary to reduce the spread of SARS-CoV-2, many governments strongly encouraged or mandated minimizing physical presence at work. Previous studies have revealed several multifaceted implications and advantages of teleworking for individuals, organizations, and society (Perez et al., 2003). One benefit includes increased family and leisure time (Aczel et al., 2021; Beck & Hensher, 2022; Purwanto et al., 2020). Furthermore, most families in the city spent their free time at the beach, particularly on the beaches where sampling was conducted, which caused more discarded facemasks during the weekdays.

Table 2 shows the result of the Analysis of Variance (ANOVA) comparing the frequency of the facemasks found in the study sites. The data used were $\log_{10}$ transformed to approximate a normal distribution and equal variances of the count data. The results showed significant differences in the counts of facemasks found among the three beaches ($p < 0.05$). Furthermore, a *post-hoc test* showed that Manggihay Beach was significantly different ($p < 0.05$) from Mayo Beach, with a mean difference of 2.25 facemasks but not from Dahican Beach ($p > 0.05$). However, there was no significant difference between the facemask counts in Mayo Beach and Dahican Beach, respectively ($p > 0.05$).

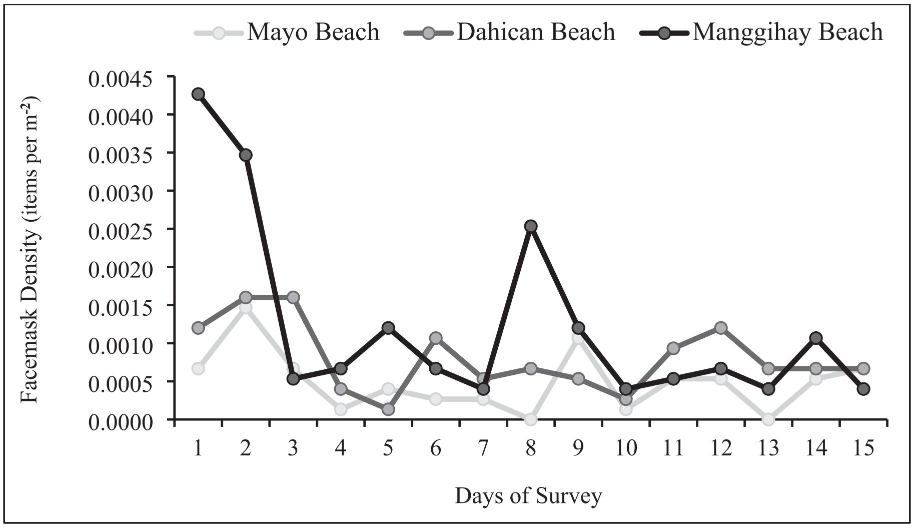

Fig. 5. Change in facemask density each day.

Table 2
One-Way ANOVA table of counted facemasks in the three beaches.

Source	Mean square (MS)	Degree of freedom (DF)	F-statistic (F)	*p*-Value
Station	0.490	2	4.53	0.0166*
rror	0.108	42		
Total	0.126	44		

* Significant at the 5% level of significance.

3.3. Type and composition of facemasks

Proper disposal of used facemasks in the city has become a significant issue since they were littered indiscriminately along the beaches rather than being disposed of properly in appropriate trash bins. The facemasks found can be classified into three types: Surgical facemask, KF94, and KN95 (Fig. 6). This attitude and scenario can be attributed to the lack of environmental education and knowledge about this new type of plastic pollution.

The surgical facemask was considered the most abundant type of facemask found in the study sites, accounting for 82 % of the total ($n = 284$), followed by the KF94 (16 %) and KN95, which accounted for only 2 % of the total collected facemasks (Fig. 7). The finding of this study was also similar to the results of De-la-Torre et al. (2021); and Sajorne et al. (2022). Surgical facemask is highly recommended by the Philippine Department of Health (DOH) since it is lighter, breathable, individually cheaper, and widely accessible compared to cloth facemask and other types of facemasks (Sajorne et al., 2022). Commercially available 3-ply surgical facemasks are primarily composed of polypropylene (PP). In contrast, different types of facemasks contain other synthetic polymers, such as polystyrene (PS), polycarbonate (PC), polyethylene (PE), and polyester (Aragaw, 2020; Chua et al., 2020; Fadare and Okoffo, 2020). The polypropylene (PP) weight in a single surgical mask is 4.5 g (Abbasi et al., 2020). These polymers contain a diverse range of chemical compounds, including plasticizers and flame retardants, some of which have been reported to be toxic to human health (Ganesapillai et al., 2022). This alarming yet poorly understood form of plastic pollution will potentially promote a spike in plastic pollution (De-la-Torre and Aragaw, 2021).

3.4. Beach infrastructures related to COVID-19

Signages were observed on the beaches of Mayo and Dahican but not in Manggihay. It provided a singular instruction on reducing the transmission of COVID-19, including the mandatory use of facemasks, frequent handwashing, social distancing, and avoiding crowded places (Fig. 8A). The signage was strategically placed and easy to locate and read. However, they were ineffective in conveying their messages, as most beachgoers were seen without facemasks during the field survey. These results imply that the COVID-19 signages were ineffective (Thiel et al., 2021) or require additional information or punitive actions from the beach management and/or government officials. Beach management should strive to maintain or improve the beach's condition as a recreational resource while maintaining its cleanliness and sanitation to benefit those who will use or visit the beach (Retama et al., 2019).

The current study observed various signages recommending

Fig. 6. Photographs of different facemasks found in the study sites: (A-B) Surgical facemasks, (C) KF94 facemask, and (D) KN95 facemask.

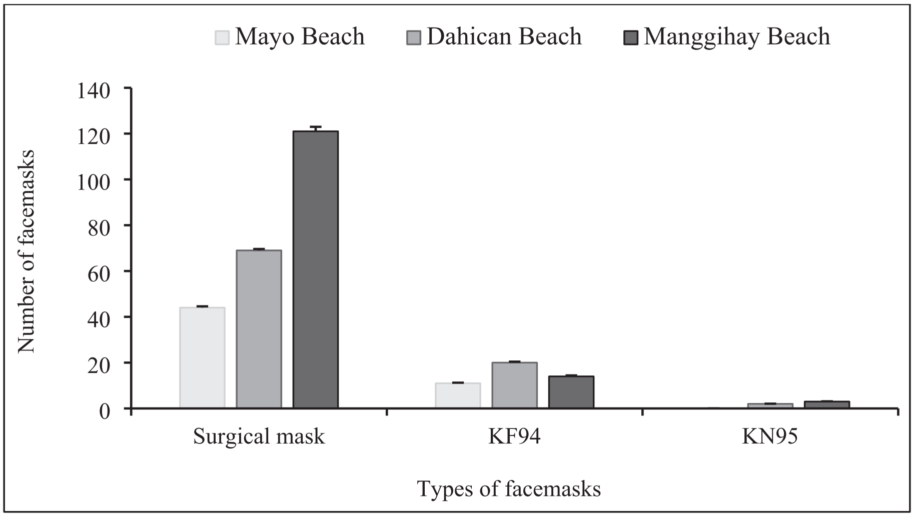

Fig. 7. Type of facemasks found in the study sites. The error bars indicate the standard error of the mean.

Fig. 8. Signage about COVID-19 preventive measures, including mandatory use of facemasks (A), General waste sign and bin (B, C) Informally designated bins (D).

facemasks for personal protection. However, they need to provide additional information or instructions on how to dispose of the facemask once used. This could explain the high number of improperly discarded or lost facemasks on the beach. In general, infrastructure for proper handling and disposal of infectious wastes continues to be deficient, posing a problem during the pandemic (Ardusso et al., 2021). Regarding trash bins, two out of three surveyed beaches had bins for general waste (Fig. 8C). However, there were no designated bins for facemasks that were classified and ought to be handled as infectious waste (Klemeš et al., 2020). In addition, it was noticeable that proper waste segregation was not applied in all surveyed beaches (Fig. 8D). The COVID-19 pandemic challenged the established solid waste management systems worldwide to deal with the massive production, use, and disposal of PPE (De-la-Torre and Aragaw, 2021; Rhee, 2020; Saadat et al., 2020). The Philippines is still struggling to address the problem of solid waste despite having a comprehensive 22-year-old law on solid waste management (Republic Act No. 9003 or the Ecological Solid Waste Management Act of 2000) (Abreo and Kobayashi, 2021). The frequency of services and the level of activity of municipal solid waste management in the city have been no different before and during the pandemic. Exposure to COVID-19 through improper waste disposal is an occupational risk for garbage collectors and other waste management operators (Prata et al., 2020). These workers are among the most vulnerable since they come in direct contact with used facemasks during collection.

Experts have also expressed concerns that discarded facemasks may be collected, washed, and resold as new by unscrupulous traders. One store in Thailand was caught reselling used facemasks and sold up to 200,000 pieces of recycled ones (Trillanes, 2020). If this situation continues unabated, it could cause a new surge in COVID-19 infections.

4. Limitations of the study

The study mainly focused on facemasks as these were widely used and more clearly related to the recent COVID-19 measures than other types of PPE (e.g., gloves, disinfectant wipes, etc.). The use of facemasks was also the only mandatory health protocol in the city that involved using PPE during the study. Facemasks that were only visible from the eye level of the researchers were collected, and others that may have been buried in the sand were not included during the sampling. In addition, given the lack of established international guidelines for monitoring litter during the pandemic, this study was unable to use standardized protocols that different organizations widely used. This study could also be improved by conducting long-term surveys in other sampling sites and increasing sampling replication in different seasonal periods.

5. Conclusion

The most fundamental question raised in this study was, will facemasks protect against the spread of COVID-19, or will they be an environmental menace? Facemasks undeniably reduced the COVID-19 transmission during the pandemic. However, their increased use and production, along with the lack of clear guidelines on proper disposal, have created severe problems. The present study found and counted a total of $N = 284$ discarded facemasks items over a cumulative area of 22,500 m^2. It revealed that only three types of facemasks were present in the area, with surgical facemasks (82 %) dominating them. The disturbing fact is that most beaches have signages instructing how to reduce COVID-19 transmission. Unfortunately, recommendations and specific trash bins for proper disposal of facemasks were missing in all the beaches surveyed. The current data showed the importance of signages that would direct or provide clear instructions to the public on how and where to dispose of the used facemasks. This study has demonstrated that the irresponsible throwing of facemasks on beaches, while initially protecting individuals from infection and virus transmission, may exacerbate plastic pollution with the accompanying threat to marine organisms and, eventually, humans.

6. Recommendations

Based on the results, it becomes apparent and imperative that the local government unit install signages urgently calling for the proper disposal of facemasks and provide "facemask-only" trash bins in strategic locations. It will be labeled as "infectious wastes" to serve as a visible warning sign for waste pickers. Discarded facemasks must be cut or shredded before disposal to prevent unscrupulous traders from reselling them. The provision of mandatory hazardous waste management training for beach personnel wearing complete safety equipment could alleviate the burden on waste pickers. The adverse health risks of waste pickers have not, to date, been given much attention — an urgent need to monitor waste pickers' health at all levels. Thus, providing a free check-up clinic can serve as the first point of care for waste pickers. More awareness programs that can assist waste pickers in identifying key health symptoms early on are encouraged. Massive Information, Education, and Communication (IEC) campaigns are urgently needed to raise awareness of the dangers posed by the new type of plastic pollution in the area. Nonetheless, to reduce and address plastic pollution, there is a dire need to strengthen the program on SWM, especially on waste minimization. It is highly recommended to use reusable yet effective facemasks for the general public to replace or reduce the use of disposable plastic facemasks. Strict regulations and efficient enforcement of these regulations may help reduce the threat to incoming tourists, as regular beach cleaning may not be sufficient to safeguard the safety of the environment and the people.

CRediT authorship contribution statement

Ilah Dianne G. Morales, Ruben F. Amparado, Jr., Hernando P. Bacosa: Conceptualization, Methodology. Ilah Dianne G. Morales, Ruben F. Amparado, Jr.: Investigation, Writing – Original draft. Ilah Dianne G. Morales, Ruben F. Amparado, Edison D. Macusi: Visualization, Analyses. Ilah Dianne G. Morales, Ruben F. Amparado, Jr., Hernando P. Bacosa, Edison D. Macusi, Jaime Q. Guihawan, Manuel Anthony P. Jondonero: Writing – Review & Editing. Ruben F. Amparado, Jr., Edison D. Macusi: Supervision.

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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