Quantity and types of plastic waste in Beaches: A case study of Al-Shuaybah beach, Saudi Arabia

Wahaj A. Khan¹*, Ali Alshehri², Albaraa Milibari², Hatim Matooq Badri² and Mohamed Osman Elamin³

¹Occupational Health and Safety Department, Faculty of Public Health and Health Informatics, Umm Al-Qura University, 24225 Alziziah Makkah, Saudi Arabia
²Environmental Health Department, Faculty of Public Health and Health Informatics, Umm Al-Qura University, 24225 Alziziah Makkah, Saudi Arabia
³Health Education and Promotion Department, Faculty of Public Health and Health Informatics, Umm Al-Qura University, 24225 Alziziah Makkah, Saudi Arabia

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ABSTRACT

Plastic pollution is one of the major environmental concerns that are known to negatively impact marine life and human health. An evaluation of the availability, quantity, and types of plastic waste was conducted at Al-Shuaybah beach, Saudi Arabia. A total of 1504 different plastic pieces were collected from the sampling site; (i) 27.8% un-identified pieces; (ii) 22.7% water bottles; (iii) 21.7% bottle caps; (iv) 12.2% plastic bags; 5.6% spoons; (v) 4.7% plastic cups; (vi) 3.8% plastic straws; (vii) 1% plastic masks; and (viii) 0.4% plastic fishing lines. The largest piece of plastic found was a bag with a dimension of 50 cm while the smallest was an un-identified piece with a dimension of 0.3 cm. The fishing lines were the heaviest (14.3 kg) followed by water bottles (5.2 kg) and water bottle caps (4.6 kg). Using CCI, the assessed beach was categorized as “extremely dirty” with plastic waste. The results indicate that beaches in Saudi Arabia are at risk of plastic pollution which could endanger marine life and indirectly affects human health. Increasing awareness on the harmful effects of plastic waste may assist in tackling this serious threat.

Key words: Environmental health, Plastic, Plastic waste, Plastic pollution, Saudi Arabia

Introduction

Plastics are defined as an artificial molding material consisting of diverse organic polymers and trace amounts of other substances. Plastics are widely employed in different sectors (building, packaging, automotive industry, construction and electronics) due to their unique characteristics such as being economical, convenient, light weighted, water resistant, and useful for electrical and thermal insulation and corrosion resistance (Hahladakis et al., 2018). Basically, plastics are categorized into two classes; thermo-set plastics and thermoplastics. Thermo-set plastics are known to harden upon heating in contrast to thermoplastics which soften.

Globally, production of plastic is estimated to be around 380 metric tons/year and is projected to reach up to 2000 metric ton/year by 2050 (Horton, 2022; Plastic Europe, 2021). According to the 2021 European report on plastic, plastic production in China, Japan and NAFTA countries (Mexico, Canada, and the United States) was 117.44, 11, and 69.73 metric tons/year respectively (Plastic Europe, 2021). The plastic production in Saudi Arabia is ap-
proximately 4.1 metric tons/year (Statista, 2020).

Plastic pollution is one of the major global environmental concerns due to the accumulation of plastic waste at lands, lakes, rivers and oceans. Plastics’ accumulation in terrestrial and aquatic ecosystems is thought to be caused by its continuous consumption, rapid production, lack of proper waste management, and low rate of recycling (Alhazmi et al., 2021; Geyer et al., 2017; Margallo et al., 2019; Nikiema and Asiedu, 2022). In addition, the persistent and hard-to-degrade nature of plastic has contributed to global plastic pollution (Barnes et al., 2009). Based on previous reports, estimated plastic waste in Latin America, Africa and Asia was 8, 17, and 52 million tons/year respectively (James et al., 2021; Lebreton and Andrady, 2019).

Plastic debris (micro and macro plastic) and other kinds of linked contaminants have been found to cause mutagenicity, carcinogenicity, and reproductive issues in humans (Gasperi et al., 2018). Also, it poses a threat to marine life, due to the ingestion of plastic debris and their entanglement with it (Gasperi et al., 2018; Thompson et al., 2004; Van Cauwenberghe et al., 2013).

The issue of plastic waste management, recycling, and pollution have been previously investigated in different ecosystems (Faure et al., 2015; Horton, 2022; Isangedighi et al., 2020; Ita-Nagy et al., 2021; Lahens et al., 2018; Strand et al., 2021). Many reports focused on the impact of plastic waste on the marine and extra-marine animals of aquatic ecosystems (Cyvin, et al., 2021; Galloway, 2015; Gasperi et al., 2018; Reddy, 2018; Thompson et al., 2004; Van Cauwenberghe et al., 2013; Wilcox et al., 2015). In Saudi Arabia, a few studies investigated plastic contamination in the marine environment, mixed surface, and treated wastewater (Hassan et al., 2022; Picó et al., 2021) but little information is available on the quantity and types of plastic waste on populated beach areas in Saudi Arabia. Hence, the purpose of this study is to determine the quantity and types of plastic waste in Al-Shuaybah beach in Saudi Arabia.

Materials and Methods

Study Area

The study was conducted at Al-Shuaybah beach in Saudi Arabia. A large section of the beach was randomly selected for sampling. The area for collection was around 65m*12.5m which equals to 812.5m². Anything other than plastic was not included in the analysis.

Sampling

All plastic waste was collected manually by the research team from the sampling area during winter-time, (January-February 2022). Any plastic, no matter how big or small, was eligible for collection (Wessel et al., 2016). Separation of plastic waste from non-plastic items was performed by recognizing the specific physical properties associated with plastic after the completion of collection. Finally, quantification and recognition of macro and micro plastic was carried out through visual sorting. Clean Coast Index (CCI) was used to objectively measure the amount of plastic waste following this equation (Alkalay et al., 2007):

\[
\frac{\text{Total plastic parts counted in line}}{\text{beach length (m) } \times \text{ beach width (m)}} = \text{Plastic parts/m}^2
\]

- 0–0.1 parts/m² (very clean, no litter is seen)
- 0.1–0.25 parts/m² (clean, no litter is seen over a large area)
- 0.25–0.5 parts/m² (moderate, a few pieces of litter can be detected)
- 0.5–1 parts/m² (dirty, a lot of waste on the shore)
- More than 1 part/m² (extremely dirty, most of the shore is covered with plastic debris)

Results

A total of 1504 plastic pieces were collected from the sampling area which were water bottles, bottle caps, bags, spoons, cups, straws, masks, and fishing lines (Table 1). The CCI calculations indicated that the beach was extremely dirty (1.85 Plastic parts/m²) and most of the shore was covered with plastic debris as seen in Figure (1 and 2). The quantity of unidentified plastic pieces, water bottles, bottle caps, bags, spoons, cups, straws, masks and fishing lines were 418 (27.8%), 342 (22.7%), 327 (21.7%), 183 (12.2%), 85 (5.6%), 71 (4.7%), 57 (3.8%), 15 (1%) and 6 (0.4%) respectively (Table 1). The fishing lines were the heaviest plastic piece (14.3 kg) followed by water bottles (5.2 kg) and bottle caps (4.6 kg) (Table 1). The largest plastic found was a plastic bag with a dimension of 50 cm while the smallest was an unidentified piece of plastic with a dimension of 0.3 cm (Table 1). The dimensions of the water bottles, bottle caps, spoons, cups, straws, masks and fishing lines...
were 8.1-42.4 cm, 3.2 cm, 7.5-16.5 cm, 9.8 cm, 9-20 cm, 32 cm and 25 cm respectively (Table 1).

**Discussion**

This study assessed the availability, quantity and types of plastic waste at a beach in Saudi Arabia. The collected plastic waste was found across 65m x 12.5m which equals 812.5 m². A total of 1504 plastic pieces were collected from the beach with a total weight of 24.1 kg. The calculation result of CCI indicated that the sampling location was extremely dirty. Most of the plastic waste was comprised of un-identifiable plastic pieces followed by water bottles, water bottle caps, and plastic bags, cups, straws, protective masks, and fishing lines. The heaviest waste was fishing lines followed by water bottles and water bottle caps. The dimensions of the plastic waste ranged from 0.3 cm to 50 cm with small un-identifiable plastic pieces to big plastic bags or big water bottles respectively.

A number of studies on plastic pollution monitoring using CCI were conducted previously in differ-

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**Table 1. Detailed information about collected plastic wastes from populated beaches**

<table>
<thead>
<tr>
<th>Type of plastic</th>
<th>Quantity (%)</th>
<th>Dimensions (cm)</th>
<th>Weight (kg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water bottles</td>
<td>342(22.7%)</td>
<td>8.1 – 42.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Fishing lines**</td>
<td>6(0.4%)</td>
<td>25</td>
<td>14.3</td>
</tr>
<tr>
<td>Bottle caps</td>
<td>327(21.7%)</td>
<td>3.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Bags</td>
<td>183(12.2%)</td>
<td>10 – 50</td>
<td></td>
</tr>
<tr>
<td>Straws</td>
<td>57(3.8%)</td>
<td>9 – 20</td>
<td></td>
</tr>
<tr>
<td>Masks</td>
<td>15(1%)</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Cups</td>
<td>71(4.7%)</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td>Spoons</td>
<td>85(5.6%)</td>
<td>7.5 – 16.5</td>
<td></td>
</tr>
<tr>
<td>Others***</td>
<td>418(27.8%)</td>
<td>0.3 – 7.8</td>
<td></td>
</tr>
</tbody>
</table>

*Total weight = 24.1 kg, and total quantity = 1504.

**Large chunks of fishing lines were found in six groups integrated together.

***Unknown plastic particles and pieces.

Note, (cm) = centimeters, and (kg) = kilograms.

The amounts of plastic listed above were found across 65m X 12.5m which equals 812.5 m².
ent places including Israel, Philippines, Indonesia, Slovenia, and the Amazon region amongst many others (dos Santos Lima et al., 2022; Laglbauer et al., 2014; Lessy and Nagu, 2020; Marin et al., 2019; Rangel-Buitrago et al., 2021; Sajorne et al., 2021). Rangel-Buitrago et al., 2021 conducted a study on plastic pollution on the Colombian central Caribbean beaches. The authors reported that the study area was categorized as “extremely dirty” (Rangel-Buitrago et al., 2021). Sajorne et al., 2021 investigated plastic pollution on beaches in the Philippines. The authors found that calculated CCI indicated that around 76% of sampling sites were classified as “dirty” and “extremely dirty” (Sajorne et al., 2021). Another recent report from Brazil indicated that around 68% of the studied sites were classified as “extremely dirty” (Marin et al., 2019). In comparison to other countries, results found in this study were relatively similar. This indicates how prevalent is plastic pollution globally.

Human activities such as fishing, solid waste disposal, coastal-industrial development, shipping, and tourism are the most likely sources of plastic waste in the ocean. The plastic waste collected at the beach could have arrived at the shore through waves stimulated by winds, surface current, and/or tides. Several lines of evidence demonstrated that plastic waste usually ends up at beaches by incoming tides, wind, and surface current (Caulton and Mocogni, 1987; Kitto and Sambhu, 2012; Neumann, 1966). Also, studies have shown that proximity to the beach, its location, type, slope, orientation, and physiography all affect the distribution of plastic waste (Dixon and Dixon, 1981; Thornton and Jackson, 1998; WADE, 1991; Whiting, 1998). Our investigation of the plastic pieces found on the beach led us to believe that they were most likely caused by inappropriate trashing of huge amounts of plastic materials like water bottles, bottle caps, bags, spoons, cups, straws, masks, fishing lines and other un-identifiable plastic pieces. One of the studies conducted on an 800 km shoreline of Oman and the Arabian Gulf indicated that the most prevalent ocean contaminant is plastic and mostly belongs to local origin (Khordagui and Abu-Hilal, 1994) which resonates with our findings.

It is well documented that plastic waste affects marine life and human health due to its continuous disposal in the ocean with an observed concentration of 5.8 lac pieces per km² (Barnes et al., 2009; Cózar et al., 2014; Law et al., 2010). Marine life is primarily affected by plastic through ingestion and entanglement. However, it impacts human health indirectly. A recent study conducted on 600 marine species (microorganisms to whales) found that plastic waste affects marine life largely through ingestion (Dias and Lovejoy, 2012). Many studies also showed the effects of plastic waste on seagull birds by impacting their reproduction and body condition (Gregory, 1978; Ryan, 2018; Wilcox et al., 2015). Moreover, previous studies demonstrated the toxicological effects of plastic waste on higher vertebrates of the ocean (Rochman et al., 2013; Talsness et al., 2009; Teuten et al., 2009). In addition, numerous reports showed that chemicals (phthalate and bis-phenol-A) employed in the formation of plastic had adverse impacts on human health, in general, and on the reproductive system, in particular (Lang et al., 2008; Swan, 2008; Swan et al., 2005). Finally, urinary concentration of phthalate has been found to be associated with a higher risk of cardiovascular disease, type II diabetes, and malfunctioning of liver enzymes (Lang et al., 2008).

Hence, the waste management of plastic is essential to avoid the issues associated with the human health and the environment. It can be achieved by law enforcement, initiating local waste management programs/campaigns, promoting the participation of agencies and spreading the awareness about the harmful effects of plastic waste. Also, it is crucial to enhance the interaction between environmental scientists and locals as well as replace our habits of using plastic items with more environmentally friendly items.

This study is the first to assess plastic pollution using an objective measurement (CCI) in Saudi beaches. Even though the study provided insight on the quantity and types of plastic waste, it had its limitation which was the use of one beach only and a small sampling area compared to other reports. However, it is an important cornerstone for future studies investigating plastic pollution in Saudi beaches.

**Conclusion**

Plastic waste is one of the biggest global concerns as it affects humans and the environment. This study assessed the quantity and types of plastic waste at a local beach of Al-Shuaybah, Saudi Arabia and found that most of the plastic is thought to be of local origin and owing to inappropriate disposal by visitors.
of the beach. Hence, decision makers must run regular campaigns to spread awareness among locals on the harmful effects of plastic waste on humans and the environment. Also, awareness must be raised regarding replacing plastic with other environmentally friendly materials.

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Conflict of interest

The authors declare no conflict of interest.

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