Marine litter at (Al-Ghandoor area) the most northern part of the Jordanian coast of the Gulf of Aqaba, Red Sea

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ABSTRACT
Composition and abundance of submerged marine litter at one selected site within a coral reef area along the Jordanian coast of the Gulf of Aqaba has been estimated. The litter was collected in a clean up voluntarily campaigns that took place in the period 19 September 2006. A total of 14,613 items weighing 4112.2 kg were collected during the survey. Mean litter density in the individual sampling sites varied between about 1 and 6 items/m² with an over all mean density of 2 items/m². The mean weight of the collected items per sampling site varied between 0.06 and 1.81 kg/m² with an overall mean of 0.85 kg/m². Cans accounted for 41% of the collected items, plastic was the second most popular (38%) while glass litter was the third most abundant item (17%). By comparison, other items formed only 4% of the total items collected during the campaigns. Approximately 46% of the plastic litter consisted of fragments followed by bottles bags and containers (18%). Potential sources are pointed out and recommendations and actions to deal with the problem are suggested.

Keywords: Marine Debris; Marine Litter; Gulf of Aqaba; Clean up Dive

1. INTRODUCTION
Marine litter composition, abundance, distribution and quantification of the types and amounts on beaches have been studied and reported from many parts of the world [1-19].

The main sources of marine litter are the: sea-borne sources which include industrial and domestic wastes disposed off at sea, and the land-based sources which include litter originating from visitors to the coast, whether small items such as drink cans and containers, or those originating from the unauthorized dumping of large items such as landfill materials [5,16,20-28].

Benthic marine debris may also have detrimental effect on coral reef ecosystem by damaging of corals covered by debris [29]. Movement of fishing gear can cause damage to coral substrate comprising the reef structure; some nets recovered had 20% of their weight attributable to broken coral fragments. Movement of fishing gear across shallow reefs destroys other benthic reef flora and fauna and entangles macrofauna, including threatened and endangered species [30].

2. MATERIALS AND METHODS

2.1. Clean Up Sites
Submerged debris was removed and collected from one underwater site within coral reef areas at the most northern tip of the Jordanian coast of the Gulf of Aqaba (Figure 1). Site was selected based on the type of usage and activities that take place at the site. The North beach (Al-Ghandoor) is located at the most northern part of the Gulf of Aqaba, and characterized by heavy tourism activities and by the presence of many public cafés. However, diving, snorkeling and swimming activities are permitted within this site.

2.2. Method of Clean Up Survey
The clean up campaign has been conducted in 16 September 2006. Site was divided into one segments/transect (one squares) of 20 m × 20 m; the total area of site was 400 m². All litter at the site was collected by 60 SCUBA divers moving along the transect, to ensure that
all debris within the transect were collected. Divers pick up debris free from the substrate/sea bottom using care to avoid disturbing the sea bottom agitating the sediments, stepping on marine biota or causing coral damage. Pieces of nets found fully incorporate into the reef structure, and no longer an entanglement hazard, were left in place to avoid additional coral damage and preserve associated-coral growth. Removed debris was lifted to the sea surface by using lifting bags carried by the two divers. Snorklers on the sea surface were helping in collecting the filled bags. All debris was then transported to the beach where it was sorted into broad categories: glass, metals, plastic, cardboard, rubber, fishing gear and others. Each category was further sorted into more subcategories: cups, bags, containers, etc., which were counted and weighed. Total amount of debris in each site was determined by summing the amount of litter for each liters bag.

Table 1. Clean up participants and total number of divers participated in clean up dive.

<table>
<thead>
<tr>
<th>Clean up participants</th>
<th>Number of Divers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqaba Marine Park Center of ASEZA</td>
<td>4</td>
</tr>
<tr>
<td>Royal Navy</td>
<td>20</td>
</tr>
<tr>
<td>Marine Science Station</td>
<td>6</td>
</tr>
<tr>
<td>Jordan Royal Ecological Diving Society (JRES)</td>
<td>10</td>
</tr>
<tr>
<td>Private diving centers</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
</tr>
</tbody>
</table>

for the whole study area (Figure 3).

When the type of litter was considered metal cans showed the highest litter occurrence 41% compared with the rest items (Figure 4). Plastic accounted for 38% of the items counted, while total glass was the third most important item and constituted 17%. Other item was the fourth most important item. Within the plastics when the weight is considered, about 36% consisted of bottles and 36% of Fragments, whereas, containers bags accounted for 28% and 2% respectively (Figure 5).

4. DISCUSSION

A significant amount of literature is dedicated to beach litter types, distributions, and temporal variations [7], but almost no exist with respect to submerged (benthic) marine litter by the 1990s [31]. In comparison, only few studies have recently been published with regard to submerged and subsurface near shore litter on the global level ([20,32-35]).

Searching the literature, we did not fined a single report on this subject in the whole Red Sea region including the Gulf of Aqaba. The first single published report was by [36] on the litter pollution on the Jordanian shores of the Gulf of Aqaba. In that report we hinted very briefly to the presence of marine debris in the coastal waters and among the corals of the Jordanian side of the Gulf of Aqaba.

Knowing the seriousness of the problem we felt it is urgent to follow up this issue, investigate the magnitude of the problem, and try to provide information that can help the official authorities and decision makers to dealing with the issue and solving the problems related to it. Therefore, we participated in the clean up dive campaigns, identified, categorized, and enumerated the collected items and finally reported the results of the campaigns.

The results indicate a high diversity of litter collected from the studied site. The most likely explanation for this diversity is related to the uses of the selected site. The higher counts of items found at Al-Ghandoor site is...
Figure 2. Total number of litter per m² and its percentage in clean up site.

Figure 3. Total weight (kg/m²) of litter and its percentage in clean up site.
attributed to the fact that this site is popular and most accessible site to local public and tourists. The litter items found in the waters of these sites, particularly plastic bottles and bags, metal cans, and pieces of glass are associated with and indicative of the activities of beach goers.

Variations in the distribution and differences in the composition of debris on recreation and non-recreation beaches of the same study area have been noted and discussed by [36] who indicated that the waste discarded from the Aqaba (Jordan)-Nweibi (Egypt) ferry boat is a major source of litter found on the beach of the protected area within the Marine Science Station beach at the southern edge of the passengers port.

The results in the present study indicated that metal cans and plastics were the numerically dominant litter item within the whole study area followed by glass was the third dominant item. These results are similar to what has been reported from many parts of the world. Among these are the results of [7] who studied the submerged marine debris at Curacao West Indies waters, and found that plastics were the dominant litter items (47% of the total debris) followed by glass and metals. Similarly, [37] found that plastic was the most abundant debris (79% - 83%) followed by metal (7.5% - 8.5%) in two enclosed gulfs in Western Greece. Plastic in a form of bags and bottles were the most common (70%) submerged debris on the sea floor along the European coast [32]. Plastic and metal were also the most common items of benthic marine debris in many locations surrounding Kodiak Island, Alaska [38]. According to the same report fishery related submerged plastic were also common. Plastics were the most common type of anthropogenic debris on a wide area of the continental shelf of the southern California Bight [35]. [29] reported the results of multi-agency divers clean up survey that took place in two northwestern Hawaiian Islands. Fourteen tons of derelict fishing gear was removed in addition to other types of reef debris.

In a previous report on the beach litter of the present study area, we have concluded that most of the litter on the Jordanian coastline of the Gulf of Aqaba results from recreational and shipping activities; it was not easy to differentiate between flotsam and litter left by beach visitors; and that much of the letter onto the beaches was of local land-based or close offshore origin [36]. It is accepted that each of these sources requires a different management action to affect a reduction in marine debris [39].

In the present study, we have tried to benefit from the coordinated efforts of volunteer divers and researcher to clean the Al-Ghandoor the most popular area for the tourist and the local visitors from debris in waters of less than [29,36], and collect information on their types, and distribution. The results of the present and other multi-agency cleanup campaigns [39] show that these campaigns are useful and can help producing good scientific data and reports, which are useful for decision-makers and environmental managers. This is also true for those in the Red Sea and Gulf of Aqaba region, which has been designated under the terms of regulation 10 of MARPOL and its Annexes as a “special area”. Annex V, in particular prohibits and restricts the disposal of all garbage from ships in any special area. However, it is believed that the following actions can be useful in reducing the debris in the study area.

- Educational programs that are directed at reducing all litter including land-based sources.
- Educational and public awareness programs targeting users of the marine environment including commercial and recreational fishers, boaters including glass boats, beach goers, divers, school teachers, students.
- Educational tools must be made widely available and distributed free to all targeted users. Tools may include brochures, leaflets, stickers and posters.
- Multi-agency clean up campaigns must be maintained the year around and data of the campaigns made avail-
able to the participants, decision makers, stakeholders, and the public.

- Put suitable regulations and enforce the already adopted ones to ensure the compliance of marine and each user with these regulations.
- Cooperation and coordination with other riparian countries along the Red Sea and the Gulf of Aqaba to take the necessary measures and actions including cleaning campaigns that can help keeping the Gulf of Aqaba waters and reefs free from marine debris.

5. CONCLUSIONS

Composition and abundance of submerged marine litter at one selected site (Al-Ghandoor) within a coral reef area along the Jordanian coast of the Gulf of Aqaba has been estimated. The results indicated that metal cans and plastics were the numerically dominant litter item within the whole study area followed by glass was the third dominant item. The high diversity of litter collected from the study site is attributed to its popular and most accessible site for local public and tourists. The results of the present and other multi-agency cleanup campaigns show that these campaigns are useful and can help producing good scientific data and reports, which are useful for decision-makers and environmental managers.

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