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Survey of Marine Debris on the Southern Coasts of the Caspian Sea and Pattern of Spreading

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ABSTRACT

One of the major environmental problems in the southern coasts of the Caspian Sea is that the marine and coastal debris is being deposited and accumulated due to industrial, urban and tourism activities. Study, sampling and analysis on the type, size, amount and origin of human-made (anthropogenic) waste in the coastal areas of this sea can be very effective in implementing management, cultural and informative programs to reduce marine environmental pollutants. Investigation on marine litter distribution under impact of seawater dynamics was performed for the first time in this research. The rate of entry and distribution of marine and coastal pollutants and wastes, which are mainly of urban, tourist and hospital origin, has multiplied on the southern shore of the Caspian Sea in the last decade. According to the results, the two most important sources of hospital waste in the coastal areas are Tonekabon and Mahmoudabad. In this case, the effect of dynamic parameters of seawater such as flow (with speeds of up to about 1 m/s) and waves, as well as the flow of rivers leading to the shoreline are also influential factors in the distribution of marine litter in the region. Marine litters in the southern coastal region were transported from west to east by the shallow waters of the southern Caspian Sea. In other words, the marine debris density has been observed more in the eastern part.

1. Introduction

One of the newest environmental problems in the coastal communities is the distribution of marine litter and consequently, spread of pollution in swimming areas, along the coastline and seawater adjacent to the coast. Marine and coastal debris is mainly pronounced as one of the utmost pervasive marine environmental pollution problems, for the reason that it is observed from the most remote beaches in the world to the most visited and accessible beaches [1]. The spread of marine debris not only pollutes the environment, but also affects the tourism industry and fishing economic activities. For many years, marine debris has been known and considered and recognized as a marine pollution and problem [1-3]. Due to the increase in population and the growing trend of waste production, environmental problems are still observed [1]. Marine litter or marine debris is described by United Nations Environment Program (UNEP) as discarded or waste persistent material in the coastal and marine areas [4]. Marine debris is any produced or processed waste material that enters from any source to coastal zone or marine environment [2,3,5-7]. The accumulation of debris, especially types of plastic in the world's oceans and seas is a main concern now and amount of marine debris shown a steady increase in time [2,3,5,8-11]. Marine debris has both marine and coastal sources. Sea-based waste is mainly the result of offshore activities such as shipping, sailing, fishing, and aquaculture, in-sea industries (oil and gas, military). Land based debris remained through tourists, local people, industry, construction, agriculture activities, which are mostly not decomposed and marine currents transfer them to other areas. Ocean current patterns, tides, and the proximity to urban, industrial and recreational areas, shipping lanes, and fishing grounds are affecting the Floating Marine Debris (FMD) composition, distribution, and density [2,3,5,8-12]. In most studies

reported that a huge portion of marine debris has land-based sources [13-14]. Recently, due to increasing the human societies on the coasts and developing human activities along the boundaries of the seas and oceans, the production and dispersal of anthropogenic litters on the marine and coastal environments has extensively increased. Distribution of the beach and marine litters can act as a huge threat for the health of the world's seas and ocean environment [4,13]. All of mentioned pollutants including beach and marine debris introduce an important threat for marine biodiversity processes and coastal environment [13,15-17]. The distribution of floating debris in the ocean depends on its mass, floating and stability [18] also are distributed due to winds and ocean currents, which scatter. The floating marine debris is reported all over the world's oceans and seas [12,14,19-24]. Based on the literature review, there is no various studies has been carried out on the southern Caspian Sea marine debris. This study is the first work to study on distribution of the marine litter in the southern coastal waters of the Caspian Sea. The main goal of this research is to identifying significant litter issues on coastal and marine environments of the Caspian Sea.

2. Methods

2.1. Study Area

The study area covers the coastal areas and waters of the continental shelf on the southern border of the Caspian Sea (Fig.1). The mentioned area includes the mouths of large rivers such as Sardabroud, CheshmehKileh, Chalosroud and Babolroud. Monitored area is located between N36.6˚ and N37˚ latitude and between E47.7˚ and E53.2˚ longitude. The study method was based on field studies, coastal sampling and laboratory analysis at the Caspian Oceanographic Center (subdivision of Iranian National Institute for Oceanography and Atmospheric Science (INIOAS)). Physicochemical parameters of coastal waters were collected using Ocean Seven profiler device.

2.2. Coastal Sampling

The project implementation method was based on two methods of field operations (Oceanography department) and laboratory services (Environmental Laboratory in the Caspian Sea Oceanography Center) and using the facilities and knowledge available at the National Institute of Oceanography and Atmospheric Sciences. NOAA and CSIRO standard methods were used for sampling and analysis of results. Data of each site was counted and photographed along 4 transects. There was a distance of 200 to 250 meters from each other over the shoreline. The length of transect designed around 1000 meters from the shoreline. Some of the collected waste was transfer to the laboratory for more analyzing.

During the marine debris samplings, the following data were collected: time of record, GPS positions, sea conditions (wind direction and speed, swell, and visibility), and sighting effort (1=active sighting or 0= inactive sighting) also use binoculars to search for debris. As this is the first effort to analyze floating marine debris within Caspian Sea waters, the gathered results in the study area are important. Samples collected in areas near to Tonekabon, Nowshahr, and Amirabad ports. These samples were sent to laboratory, separated, counted and analyzed. During sampling, the boat was moving at a speed of 8 knots and its position was logged using a GPS system.

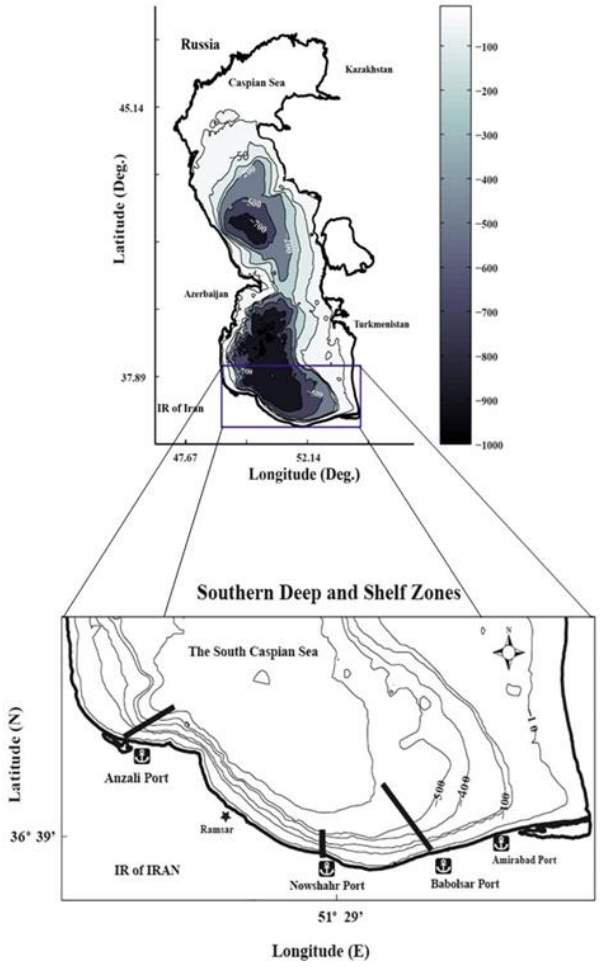

Figure 1. The southern basin of the Caspian Sea

The duration of sample collection was between 90 and 130 minutes. After each sampling all debris from bag were collected. The first monitoring of coastal waste in the southern boundary was carried out on the three selected sites in Mazandaran province. In addition, the data and samples of marine litter collected from four transects with 250m distant from each other. The length of transects was considered around 1km from the coastline. In order to collect the marine debris samples in the coastal waters a manta trawl was designed and used. The rectangular mouth of the trawl

dimensions were 80 cm height and 100 cm width. In addition, the net mesh size was selected about 3 mm with two wings for floating balance. The manta trawl was fixed at the end of the vessel. Following data were collected when FMD was sighted: time, GPS position, type, size, source, color, radial distance and angle (data taken with binoculars).

3. Results and Discussion

This research is based on a new method which is a combination of measurement (and evaluation of the dynamic pattern of the area) and environmental sampling and monitoring. Based on the field observations in recent years, marine litter has become one of the environmental problems of the Caspian Sea due to lack of proper waste management, irresponsible tourism, illegal or unauthorized construction, lack of proper management of rivers and coasts. In the southern coast of the Caspian Sea, litter has two sources: shallow waters over the continental shelf and coastal areas. Waste with marine source is mainly the result of offshore activities such as shipping, boating, fishing, aquaculture, offshore industries (oil and gas, military) and land source (offshore) mainly through tourists, indigenous peoples, industry, construction and They are instruments, agriculture, etc., which are mostly un-decomposed and remain the same, and the sea currents transfer them to other areas.

In recent decades, the study of marine litters has become a very important issue. Such studies are necessary to understand the effects of the distribution of such marine litter on living organisms and to assess the damage to the marine ecosystem in the short and medium term. Marine litter is man-made and used items that are dumped directly into rivers or the sea, or indirectly into the sea through sewage, rivers, winds, storms, or water currents. Marine and coastal litters pollute the environment for years, moves with the wind and enters rivers and water canals, resulting in clogged waterways and in many cases due to the static water reproduction of insects. Seawater pollution can play a role in the spread of infectious diseases, regardless of changes in the flora and life of the sea itself. In addition, visual pollution caused by marine litter can play a significant role in tourism. The transport of floating marine debris (FMD) by ocean currents is important in environmental science and oceanography because they can act as a trace of ocean currents, and conversely, our knowledge of ocean currents can help us find Contaminated pathways [25] as well as the study of invasive species [26] help. Extensive studies of large-scale FMD have also been performed in the North Pacific [25]. Another study examined the different effects of wind and water currents as well as recreational activities on large wastes on ISLE beaches. Distribution of this waste in the coastal area using D-GPS and aerial photography by drones and the results of this analysis showed that the characteristics of the bed and the presence of vegetation are both major factors influencing the distribution of this waste [27]. Winds, ocean surface currents and other factors cause the destruction of lightweight materials such as some plastics in the water and they float, and some of them are pressurized by wind as well as surface currents. These materials are known as windy.

The distribution of floating debris in the ocean depends on their mass, buoyancy, and stability (Moor, et.al, 2001), and their distribution is due to the influx of wind and ocean currents, which scatter them [28,29]. So far, no study has been done on Caspian Sea marine litter and the effect of surface currents on them, so this project tries to fill this gap and study the effect of these currents on marine litter in the Caspian Sea. So that the results It should be used for managerial purposes. Tonekabon site with manipulated sandy beach conditions for tourism was about 2000 m long. Marine litter including fishing gear abandoned in the water and some litter of plastic origin were found. Nowshahr site had rocky, sandy and untreated coastal conditions and the length of the beach was about 500 meters and most of the waste was local waste. At Babolsar coast in the eastern part of the border, large amounts of wooden pieces and ionolites were brought to shore by water flow. Remains of wood and burnt waste from the activities of tourists along the coast were visible. Due to the continuous rainfall area and river discharge in the sampling, a large amount of waste was observed. According the high rains and floods of the local rivers the movement and collecting the land-based wastes in the river mouths was increased.

The obtained results showed in figures 2-6. Figure 2a shows the percentage of total waste by material on each site. Amount of plastic waste covers a larger volume, which was at highest levels in Amirabad and Nowshahr sites. Figure 2b shows the amount of non-plastic waste by material at each site, of which glass, old clothes, rubber, metals were the highest in terms of amount, respectively. Figure 2c shows the amount of plastics in the sites in question that the type of Styrofoam in Nowshahr site was the most observed. The results showed that the amount of Styrofoam waste was due to construction. In addition, soft plastic waste was more than all the waste in each site in Nowshahr site.

According to the results, the highest percentage of Styrofoam type waste was found in Tonekabon site. Also, the amount of soft plastic was the most in Amirabad site. Waste sizing according to the NOAA standard (2013) used in this project is zero to 0.5 mm (micro), 0.5 to 2.5 cm (meso), more than 2.5 cm (macro), respectively.

The highest amount of micro size was observed in Amirabad and Babolsar sites. At all sampling sites, the amount and percentage of light-colored and colorless waste was more than dark-colored waste.

The amount of waste by marine or land source is shown in Figure 4a. The results of the analysis show that most of the waste at all sites was of land originated.

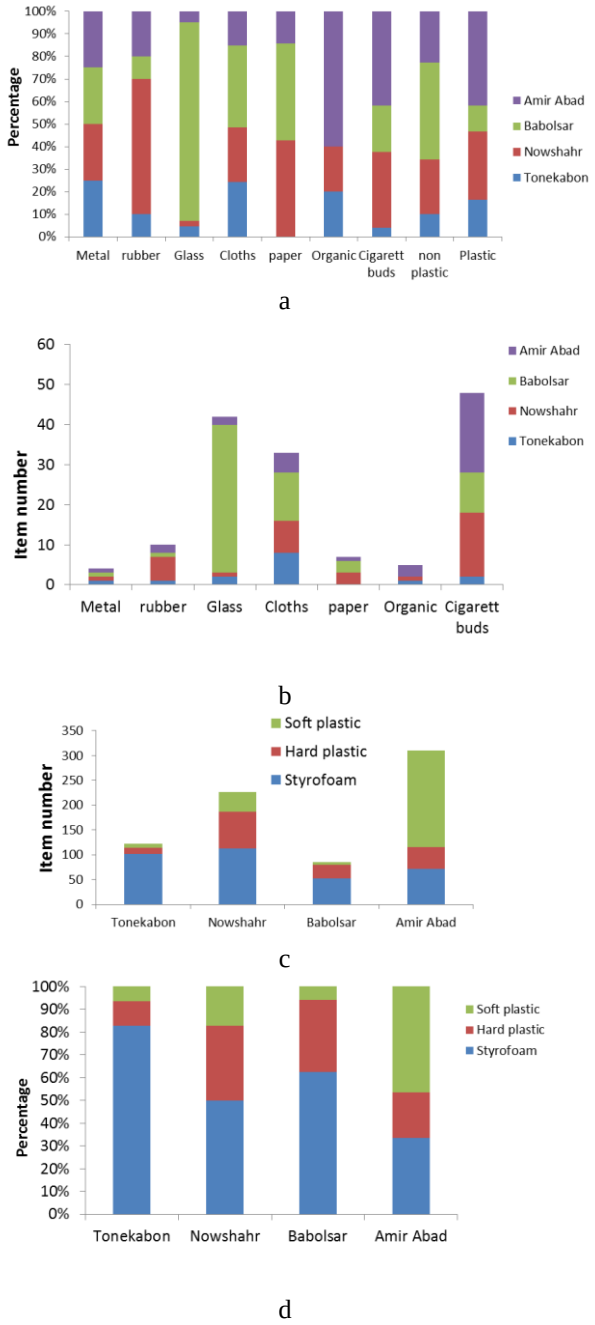

Figure 2. Waste quantities by material and type in different sampling sites in the southern coast of Caspian Sea

Figures showed the amount of waste per surface unit. The results show that the volume of plastic is higher than other types of waste in the study area. According to the fact that so far there was no documentation of the amount and type of marine litter in the Caspian Sea, the results of sampling and also the reports of local trustees indicate a high volume of litter in the southern Caspian Sea, especially plastic in micro and meso sizes, which is very dangerous for marine life.

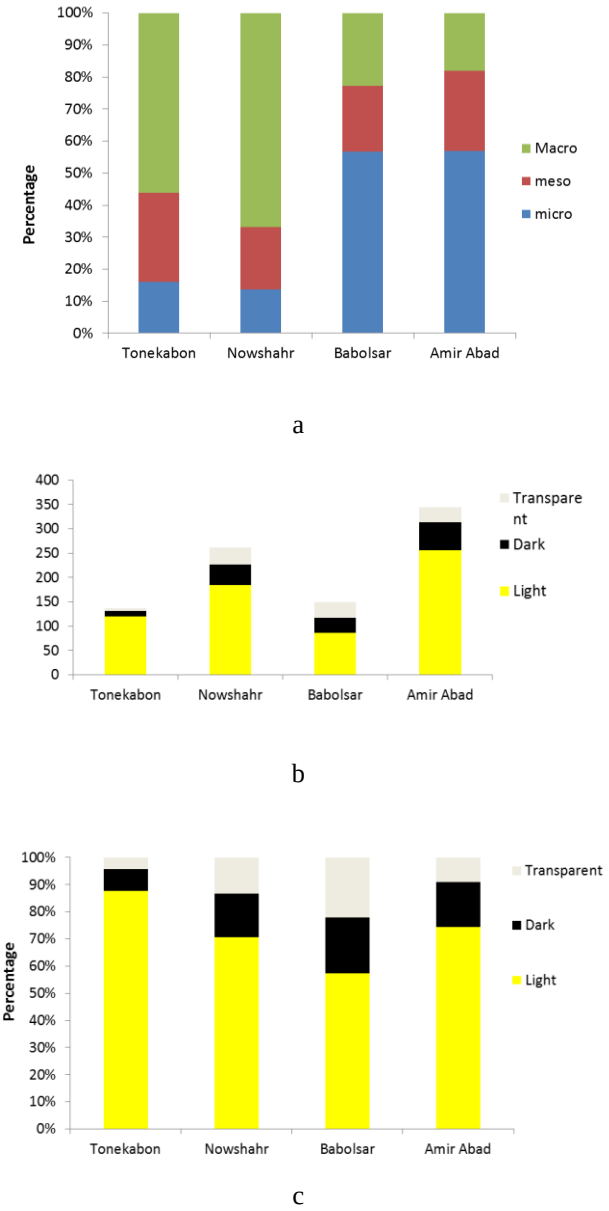

Figure 3. Evaluation of marine debris size in sampling sites of the southern Caspian Sea

In addition, the presence of sewage, unpleasant odor around Nowshahr and fish losses (which were observed on the water surface) even without laboratory results can indicate the large volume of urban and rural sewage entering these coastal areas. Coastal area management and marine environmental studies must be done. Large amounts of wood and felled trees from the previous rainfall and storms were

observed in the area during the sampling. Abandoned or proven fishing nets and equipment were also being a large part of the coastal waste that was observed in the sampling area of this project.

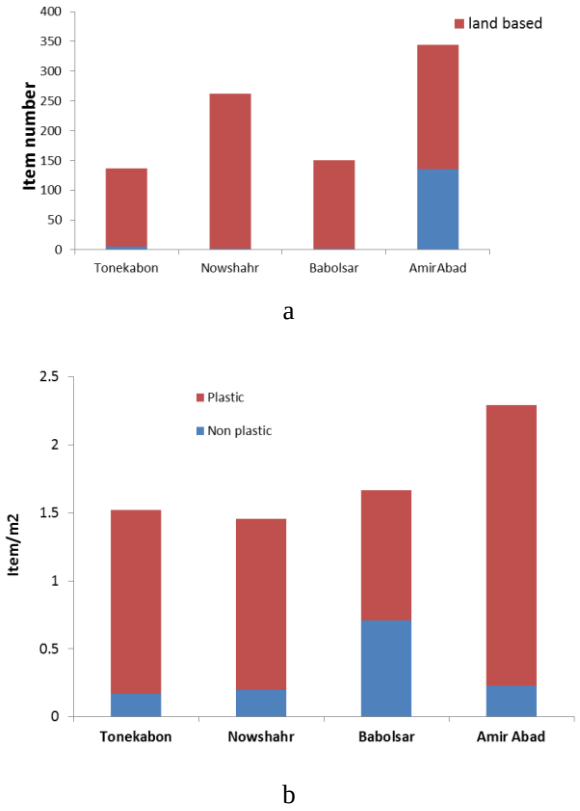

Figure 4. Marine and land litters in different sampling sites in the study area

Hospital waste, respiratory sprays and used syringes were among the wastes that were sampled as well as both coastal and floating debris. Based on the obtained samples, it can be understood that a large amount of waste is caused by restaurant activities (including organic materials and disposable tablecloths, plastic spoons and forks). It seems that due to the recreation centers in the tourist area, it is necessary to implement more serious management of coastal and tourist areas. In general, the large volume of plastic indicates the excessive and uncontrolled use of this material. Due to the dangers of spreading pollutants in the coastal and marine environment, it is recommended to take immediate action to address this problem by informing and increasing public culture.

The results of sampling showed that marine litters (soft plastic) by micro and meso sizes have mainly been observed in the eastern part of the region. However, macro size marine litters (hard plastic) have mostly been observed near areas of Nowshahr site. The analysis of the results raised the hypothesis that the soft and smaller-scale seawater litters can travel long distance by the current along the coast. The origin of the most coastal based and marine litters was tourist activities, which gathered in the middle and western parts of the southern shores (Tonekabon-Nowshahr).

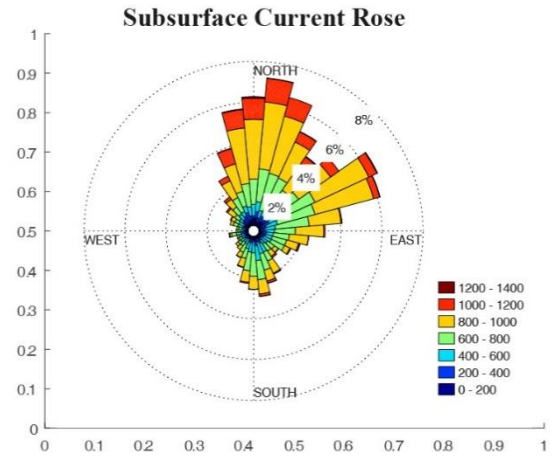

Figure 5. The general pattern of current in the southern coastal waters of the Caspian Sea

To date, very limited studies have been performed in the Caspian targeting to evaluate the quantities, composition and spreading of marine debris. Based on the scuba diving searches at the sampling stations in the coastal waters, it was observed that amounts of marine debris sink to the bottom (such as garbage patches, plastics, wood plats, fishing nets …) and accumulated on the sea bed. In addition, floating plastics and woods accumulated along the shore (Fig.6). The estimations and site monitoring confirmed that the litter in the southern Caspian Sea originates from land-based rather than sea-based sources. Marine debris on beaches in the Caspian originates from tourism and aquatic recreational activities are composed generally of plastics (bags, caps/lids, tire, bottles), aluminum (cans, pull tabs) and glass (bottles). Debris from smoking related activities may account for 40-45% (collected items on sampling sites in the beaches) which is considerably high. In terms of debris floating on the seawater, plastics and woods account for more than 75%. For debris on the sea-bed plastics, glass and woods were principal ranging from 35% to 80%. Fishing related litter including nets prevails in commercial fishing ports and near the mouth of rivers. Enhancing amounts of litter in the Caspian marine environment gives rise to a wide range of commercial and social impacts and harmful environmental effects are often also interrelated. General understanding of the mentioned

influences in the Caspian Sea remains limited. There is little or no consistent information and data on what the exact budgets are. The loss of tourism related incomes due to marine debris has not been estimated in detail.

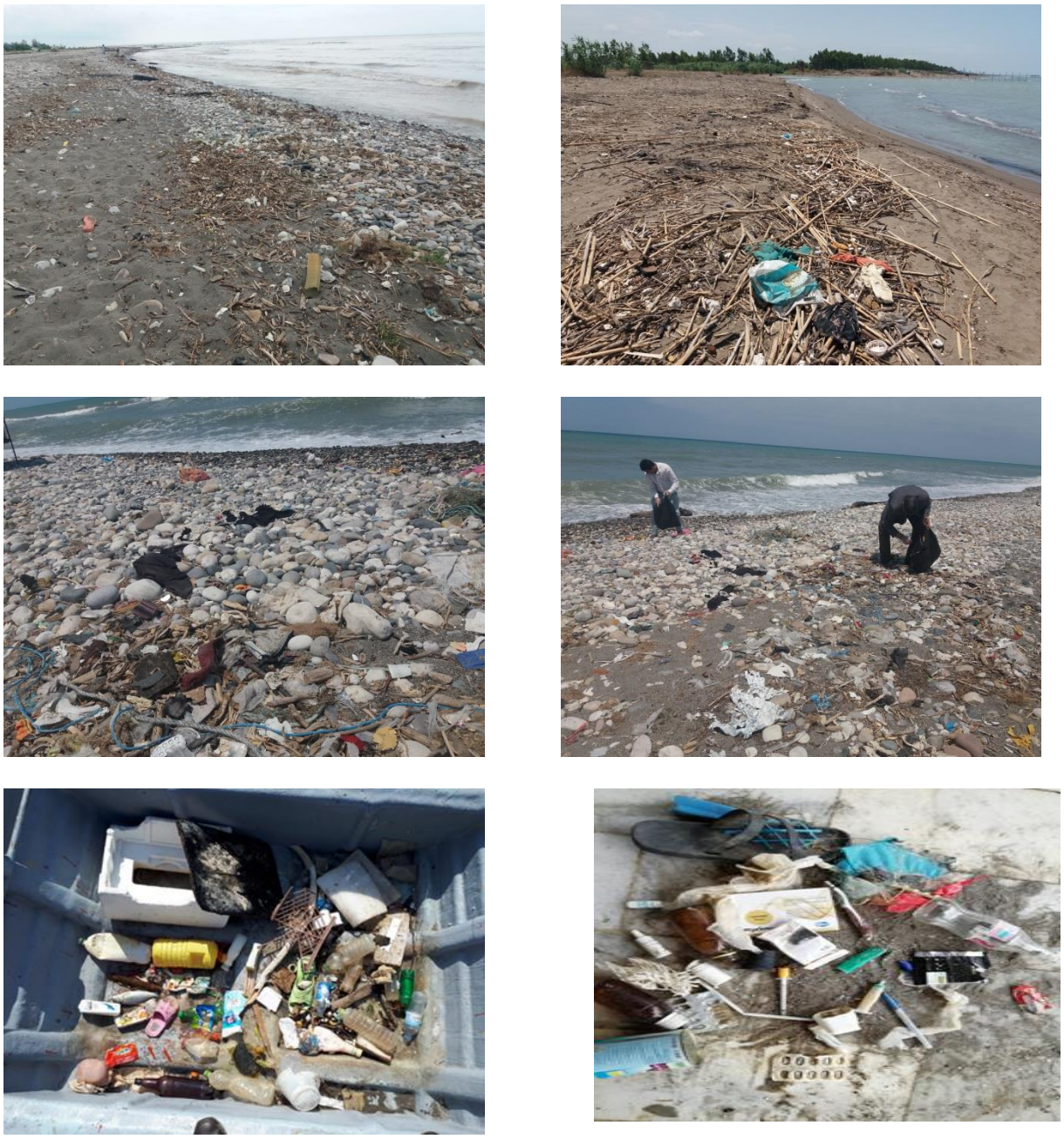

Figure 6. Photos of sampled marine debris collected in the boat during the field operation in the study area

The chronic problem of municipal and marine litter in the southern shores of the Caspian Sea has become a national threat. This requires a sufficient understanding of the situation to guide an optimal management approach. The spread of waste (urban and hospital litters) in coastal and marine environments of the Caspian causes many problems such as in human health, ecosystem life (health of migratory birds of Siberia, fish productivity) and coastal management aspect. Recently (during January and February 2021), a large number of migratory birds in Gorgan Bay and Miankaleh Wetland have died due to water botulism. Pollution of the seas has many destructive effects on humans and other living things. The most important impact of waste on wildlife has been reported through ingestion by birds and aquatic animals as well as entering the food cycle in the waters. The erosion of plastic waste by aquatic

animals and seabirds and the entry of micro plastics due to incomplete decomposition of waste in the marine food chain annually kill thousands of species of aquatic animals such as seals, turtles and seabirds. Involvement of organisms in plastic waste and their suffocation is also a more deadly risk [30].

Land based debris originated from beaches, local rivers (see [31-33]) and coastal villas while sea-based litters originated from commercial ships, harbor activities (such as Nowshahr and Amirabad ports) in the southern region. Depending on the size, composition and also the degree of buoyancy of the waste relative to the physical characteristics of the Caspian Sea water, marine litters travels by wave and current (Fig.6) along the eastward direction or sink on various depths of the continental shelf. According to the results, the two most important sources of hospital waste in the coastal areas are Tonekabon and Mahmoudabad. The effects of marine litter dispersion are so great and varied that review of existing scientific literature suggests that litter-free coastal and marine environments now look like a dream. Among the executive works and management of coastal areas to reduce pollution in the southern border of the Caspian Sea, the following can be mentioned.

- Evaluation of litters sources and transporting ways to the coastal zones
- Marine debris can influence the eco-tourism industry, especially in the southern coast if the Caspian Sea. Introduce the benefits of public efforts to reducing waste
- Introducing benefits use of degradable plastics by the governance and NGOs
- Identification of water sports and tourist areas by municipalities and governorates and transfer of their operation to the private sector
- Organizing incentive programs and increasing the level of public awareness by installing advertising posters to prevent the spread of garbage by swimmers and tourists
- Placing bins in tourist areas and forest parks near the coast
- One of the most effective ways is to encourage people to deliver their renewable waste to beachfront collection centers.
- Promote circular economy thinking in the community.
- Providing coastal and marine waste collection centers and transfer services.
- Trying to keep the beaches clean at all times. Pay money for the collection of debris.
- Change people's behavior and create a nature-friendly ethics.
- Creating financial benefits for coastal waste collectors.
- Offer and consider incentive tax on waste generating by restaurants and beach food courts.
- Require the companies that pollute to pay charges
- Establishment and operation of at least 2 waste incineration plants on the south coast (Sari and Nowshahr)
- Efforts to establish regional cooperation to achieving coastal and marine litter reduction target
- Establish incentive policies and grants for industries to use fewer plastic materials

The entire above-mentioned items can be done and achieved in the southern region of the Caspian Sea. Beach monitoring and coastal surveys in the southern boundary of the Caspian are widely viewed as the simplest method for evaluation of marine debris in the selected sites. It seems that it is the most cost-effective technique and consequently are the most frequently executed. During the last decade there is no significant monitoring of marine litter influences on aquatic environment and biota in the southern region of the sea, but we have started and aimed the scientific efforts and technical foundation to growing it. The use of NGOs and academic research projects for monitoring ingested litter in the Caspian Sea is suggested for enhancing general information and knowledge to decreasing marine debris.

4. Conclusions

Marine and coastal wastes dispersed in the southern coastal areas of the Caspian Sea were sampled, analyzed, and discussed. Also, the type, size, and origin of the collected marine litters were investigated. In the study area, rivers are one of the most important factors for transferring the coastal debris to the shallow water and near the shoreline. Coastal swimming and tourism areas were also some centers of which the waste is distributed in the region. Also, the discharge of the hospital garbage in the beaches of the sea has created many environmental problems. An executive solution for managing the distribution of marine litter along the coast and shallow water is the installation of garbage collection nets across the Chalosroud, Sardabroud, Tonekabon and Sefidroud rivers (that river is not suitable for sailing). Due to the establishment of a waste incinerator plant in the study area in the last two years, the collection and transfer of infectious and hospital waste was very effective factor in the managing of coastal and marine debris. Promoting of public culture in coastal and tourism zones was also one of the issues that have been practical and useful in recent years.

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