Marine biotopes of Askar coastal area, east of Bahrain

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**Abstract**

The scope of the present work has covered the area located at the east coast of Bahrain along the Askar coast associated with depth mostly < 10 m, extending for approximately 5Km. This coastal area is subjected to several sources of industrial and domestic pollution. The marine survey was conducted in May 2018 within an area of ~5.27 km² covering the intertidal and subtidal zones. A drop-down video camera (DDV) was used within an equidistant station grid spaced by 300 m and entailed 69 stations. SCUBA diving was performed at eight locations representing different biotopes for qualitative and quantitative analysis based on epi-benthic flora and fauna. Five biotopes were identified representing silty sand, silty sand with seagrass, mud, rock with sand veneer and macroalgae. A lack of conspicuous flora and fauna characterized most of the sites investigated. The seagrass habitat was found to be of less cover across the study area represented by patchy forms (<1%). The high concentration of alluvium discharged by the sand wash plant heavily impacted the water clarity, where fine particles were driven by currents during the ebb cycle toward the Askar coast. The DDV survey showed that most of the bottom layers are turbid and numerous dead bivalve shells of Pinctada sp. were observed. The current monitoring program needs to be rescheduled to cover further locations to minimize the vulnerability of traditional fisheries.

**Keywords:** Marine habitat, Biotopes, Coast, Species richness, Bahrain, Arabian Gulf

**1. Introduction**

The marine and coastal environment of the Kingdom of Bahrain cover 7,510 km²~92% of the kingdom's total area (Directorate of Environmental Assessment and Planning, 2009), characterized by a wide ecosystem's variety. These ecosystems cover sensitive marine habitats such as seagrass beds, coral reefs and mangroves. These habitats are of great importance supporting marine biodiversity providing nursery, spawning and feeding grounds for broad scale of fishery species (Loughland and Zainal, 2009). Bahrain witnessed rapid growth and economic expansion in the coastal areas. These activities generated substantial pressures on the marine environment. The coastal process due to dredging/reclamation since 1963 increased the area from 662.8 km² to 765.3 km² in 2007. Such urban sprawl-provided opportunities for several industrial, economic, residential and recreational activities occurred. Therefore, the marine ecosystems are being heavily exposed to considerable deterioration in the last few decades due to anthropogenic pressures mostly sourced from land-based sources. Most of the human related pressures are along the eastern coast of Bahrain, represented by oil and chemical industries, sewage outfall, desalination and massive dredging/reclamation for coastal development projects. All these activities are located along the limited coast affecting the most productive marine habitats in Bahrain (Loughland and Zainal, 2009). Due to these pressures, the marine environment physically and chemically affected, and the impact extent reflected on the seabed particularly benthos, which largely contribute the base of the marine trophic pyramid as indicated by Al-Hassan et al. (2000), Al-Madany and Al-Sayed (2001) and Naser (2011).

The coastline of Askar village extends for ~3 km. The coastal area is associated with shallow depth (<10 m). The coastal area is subjected to several sources of pollution. These sources include by BAPCO’s refinery, Gulf Petrochemical Industries Company (GPIC), sewage treatment plants (STP) at South alba Askar village, sand wash plant, alba power plant, Aluminum industries (alba), desalination plants at Ras Abou Jarjoor and alba. In the south, there is National Mariculture Centre (NaMaC) at Ras Hayan. The NaMaC has a significant role in supporting the fish stock in Bahrain by releasing a hundred thousand fish fingerlings annually.

The coast of Askar is considered as one of the common fishing grounds in Bahrain. Fishing is exerted by traditional methods using
barrier traps, locally known Hadra located at the intertidal and subtidal zones along Askar village coast and metal-wire fishing traps, locally known Gargoor where hundreds are deployed at different sites throughout the coastal area. These fishing traps represent a part for the traditional fisheries sector supporting local consumption in Askar and the country as well.

The present study is part of research project (Project Code: NR_AK_2017) funded by the Arabian Gulf University (BD 12,000 = $ 32,000) on the integrated environmental assessment for the Askar environ conducted by the Department of Natural Resources and Environment at the Arabian Gulf University, including urbanization, socioeconomic, air quality and noise, waste management, water resources and marine environment (El-Kholei et al., 2020). The project attempts to assess the impact of urbanization on the environment, especially on natural resources and local ecosystems and the impact it has on the quality of life in Askar.

2. Materials and methods

2.1. Land-based activities

The Askar coastal area is exposed to several discharges sourced from different land-based activities along the coast as presented in Fig. 1.

![Location map of Askar coast indicating sites of land-based activities.](image-url)
BAPCO, approximately 1.5 km to the north of Askar village is representing the major industrial activity close to the study area. BAPCO was started exporting in 1934 and refining in 1936 with a capacity of 260,000 bls/day (National Oil and Gas Authority, 2012). The discharge rate from BAPCO is estimated to be 693,974 m$^3$/day of ammonia, Chlorine, Fluor, Hydrocarbons, Organic carbon (National Oil and Gas Authority, 2012).

Askar sewage treatment plant (STP), which was constructed during 1985 is located approximately 0.5 km from the village (Fig. 1). The STP treated the sewage by activated sludge as secondary treatment receiving 410 m$^3$/day, which represent overload by 42%. Therefore, sewage is discharged either as raw materials or partially treated (Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2009). Another sewage treatment plant (South Alba) is located to the north of Askar village at a distance ~3 km with a capacity of 2500 m$^3$/day with approximately actual flow of ~1340 m$^3$/day (Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2009). Moreover, a considerable algal bloom has been observed near the STP outlet. Due to the secondary treatment a huge amount of sludge is accumulated within the STP outlet vicinity (Fig. 2).

NaMaC in the south was constructed in 1980 and initiated the production during 1994. Thousands of most important commercial fish fingerlings, such as Siganus canaliculatus (Safi), Sparus hasta (Subaiti), and Epinephelus coioides (Hamoor) were released into the local water annually to enhance fish stock.

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Alba (Aluminium Bahrain) at the north of Askar village produces 0.032 mcm/day of fresh water by applying Multi-Stage Flush (MSF) desalination plant technology constructed in 2002 (Ministry of Electricity and Water, 2014). Another water desalination plant is constructed at Ras Abu Jarjoor north of Askar village since 1984, producing 0.057 mcm/day of fresh water by desalination of ground water from AlRus and Umm Er Radhuma Formations using the Reverse Osmosis (RO) technology (Ministry of Electricity and Water, 2014).

Sand wash plant at the north of Askar coast heavily affect the coastal areas due to a huge fine sediment discharged, which potentially impact water quality, particularly the reduction of oxygenation and light penetration.

A small island known Shaikh Island is located against the Askar coast provides a nesting ground for different sea bird species. Many sea birds have been observed particularly during February-March along the Askar coast including Flamingo, Socota Cormorant, Greater Crested Tern, Lesser Crested Tern, White-cheeked Tern, Black Backed Gull, Grey Heron and Eurasian Curlews. All these species are recorded by Kavanagh (2014) over the past 20 years.

A considerable part of Askar population are fishermen or interested in fishing. Along Askar coast ~50 fishing traps locally known as “Hadhra” are constructed. Fishing speed boats constitute the main part of the fishing sector anchored around the old jetty at the center of the city. New coastal reclamation processes have been noticed at the north of Askar. Several constructions are implemented where considerable quantities of sand and rock revetment are used.

### 2.2. Study area

The scope of work is covered the area located at the east coast of Bahrain along Askar coast associated with shallow depth, mostly < 10 m, extending for approximately 5 km from the refineries...
of Bahrain Petroleum Company (BAPCO) in the north to the National Mariculture Center (NaMaC) at Ras Hayan in the South. The marine survey was conducted in May 2018 within an area of \(\approx 5.27 \text{ km}^2\) as illustrated in Fig. 3 covering the intertidal and subtidal zones along Askar coast.

To develop a detailed habitat map of Askar coast, the biotopes covering both the intertidal and subtidal zones have been surveyed. Drop down video camera (DDV) was used within an equidistant location grid spaced by 300 m and entailed 69 locations, as shown in Fig. 4.

On 8th 2018 DDV was conducted at identified sites located within the survey area of Askar coast extending from BAPCO refinery outlet at the north NaMaC at the south. At each location, notes were taken of key observations, including the habitat type, water depth. On 9th May 2018, a SCUBA diving was performed at 8 selected locations representing the different biotopes for qualitative and quantitative analysis based on the presence of flora and fauna species by cover% and number. The results of the DDV survey allow the identification of different biotopes within the study area and allows for a targeted and informed approach to conducting subsequent tiers of the survey work.

Classification of marine habitats within the study area has been made with reference to key sources (Khan, 2002) to provide a continuation of surveys previously conducted in Bahrain. It is common to see the level of mixing of biotopes within small areas (Vousden, 1985), which potentially affect the level of species interaction present.

3. Results

The biotope at each site was described in detail. Accordingly, eight sites (T16, T19, T30, T38, T51, T56, T58 and T67) were...
selected to represent the identified biotopes for ground truthing (Table 1).

Five biotopes were identified including silty sand (37 sites), silty sand with seagrass (11 sites), mud (11 sites), rock with sand veneer (5 sites) and macroalgalge (2 sites) as presented in Fig. 5. These biotopes are located within the depth range < 0.5 m to 6.0 m as presented in Fig. 6. Only three sites (T28, T29 and T42) have not been surveyed due to the shallow depth.

A general lack of conspicuous flora and fauna has been observed at most sites, except for the rock with sand veneer and macroalgae habitats. The mud habitat is differentiated from the silty sand habitats as typically found at deeper locations with a more stable seabed associated with a distinct algal biofilm on the surface. Low growth of seagrass cover was observed across the study area. None of the areas would be classified as ‘seagrass’ habitats. The coverage of seagrass was extremely patchy with low density from observations (<1%).

3.1. Silty sand

This biotope predominated the study area representing by 37 sites (~56% of the study area) associated with different depths (<0.5 m–5.8 m). The sand is found to be of a coarse fraction covered by a silty top layer, which is attributed to the discharge of sand wash plant.

As illustrated in Fig. 7, this habitat in general is composed of patches of an algal biofilm. A considerable amount of rubble is found on the bottom surface. No conspicuous flora and fauna were observed. Numerous erect sponges (T11 and T52), few finger sponges (T46) and some macroalgae assumed to be drift and tangle with sponges. In some sites, broken shells were found on the bottom and the seabed is predominantly bare sand. As found at sites T12 and T13, the bottom is slightly composed of rippled sand with some pits and burrows on the surface of the sediment. At several sites, particularly those associated with shallow depth (e.g., T25, T26, T31 and T32), the seabed is not visible due to huge of suspended materials in the water column. At site T44, some small Cerith shells were observed with predominant bare sand bottom. Some patches of green algae Caulerpa sertularioides and some drift algae (Spyridia filamentosa) were identified at site T64. Although of extremely strong currents at site T68 affecting the DDV quality, extensive sponges (T11 and T52) were identified at site T64. Although of extremely strong currents at site T68 affecting the DDV quality, a crab (Portunus pelagicus) was noticed on the bottom.

3.2. Silty sand with seagrass

Eleven sites represent this biotope located at a depth range 0.3 m–2.6 m. Two sites of relatively dense seagrass are located close to Ras Abu Jarjur desalination plant at the north of Askar, six sites of less dense seagrass are opposite to residential area and further three at the south of Askar. Silty sandy texture covered most of the sites of this habitat with sparse patches seagrass of Halodule uninervis (Fig. 8). In some sites, epiphytes were visible on seagrass H. uninervis. Algal biofilm, drift algae and sponges are also presented on the seabed, which is mostly bare sand with scattered debris and no conspicuous flora or fauna. Some rubble, small pits/burrows and rocks in the background were observed.

The waste of high concentration of alluvium discharged by the sand wash plant located to the north of Askar heavily impacted the water clarity. These find particles driven by currents, particularly during ebb cycle toward Askar coast and locally settled down on the bottom burring the seagrass and other habitats. The DDV survey clearly showed that most of the bottom layers are so turbid, and the benthic species were difficult to identify and numerous dead bivalve shells mostly Pinctada sp. were observed.

3.3. Mud

The mud biotope was observed at 11 sites located at depths of 4 m–6 m. Distinct algal biofilm characterized this habitat with no conspicuous flora or fauna (Fig. 9). However, some drift algae were presented. The bottom is characterized by some large pits and burrows. The seabed at site T49 is slightly more stable than other sites.

3.4. Rock with sand veneer

Five sites have been identified as rock with sand veneer located to the south of Askar. Two sites are nearshore, and the three others are located at 1.2 km–1.5 km from the shore. This habitat is characterized by silty sandy seabed with some exposed rocks on which some sponges and macroalgae are attached (Fig. 10). The green algae Caulerpa sertularioides and sparse patches of seagrass H. uninervis were observed. Much scattered rubble is also found in some sites. Numerous erect finger sponges were noticed particularly at site T59. The rocks with variable sand veneer are distributed in patches with sediment up to 15 cm deep and in other locations up to 20 cm, which is attributed to the sand wash discharge. The Atlantic pearl oyster, Pinctada radiata is the most common among

| Sites | Notes | Habitat Type |
|-------|-------|--------------|
| T 19  | Silty seabed with numerous pits and burrows in surface of sediment. Patchy algal biofilm on surface of sediment. | Mud Silty Sand |
| T 38  | Relatively compact and coarse sand with a silty top layer. Lots of drift algae caught on the sponges (unattached). Polychaeta casts observed on sediment surface. | Silty Sand |
| T 67  | Rock with variable sand veneer with exposed bedrock in places. Some patches with sediment up to 15 cm deep. Seabed has scattered rubble and rocks and numerous dead bivalve shells. Most Pinctada sp. shells were dead. Seabed has patches of macro algae and sponges. | Rock with Sand Veneer |
| T 56  | Rock with variable sand veneer, with deep patches of sand in places up to 20 cm. Seabed superficially looks like the silty sand habitat, however there are distinct places with a very thin sand veneer. Seagrass presence is extremely patchy and present in those areas with thicker sand. As with the majority of the survey site the surface of the sediment is silty. Seagrass has epiphytes on the blades. | Rock with Sand Veneer (seagrass present) |
| T 30  | Coarse grained sand with a silty top layer consistently deeper than 20 cm throughout. General lack of conspicuous flora or fauna with the exception of a few patchy blades of seagrass. Some drift algae present. Seagrass blades have epiphytes. | Silty Sand (seagrass present) |
| T 16  | No photos as visibility was too poor for the camera to focus. No conspicuous flora or fauna. Seabed consists of silty sand. | Silty Sand (seagrass present) |
| T 58  | Sporadic patches of seagrass on a silty sandy seabed with some occasional ‘finger’ sponges present. Seagrass blades have epiphytes. | Silty Sand (seagrass present) |
| T 51  | Rocky seabed dominated with mixed macro algae. Very few patches with exposed seabed. Seabed consists of bedrock with rocks, rubble and broken shells. | Macro Algae |
the eight species recorded in Bahraini waters. The rocky habitat provides a surface allowing oysters to anchor; however, the fine sediment deposition reduces the space of such surfaces to attract the oysters to associate with the rocky beds.

3.5. Macroalgae

This type of habitat occurred at sandy seabed with some rocky outcrops dominated with mixed dense coverage of macroalgae including Caulerpa sertularioides, Spyridia filamentosa and Padina (Fig. 11). Broken shells and some possible live bivalve aggregations were also observed.

A total of 34 marine algae species have been classified throughout Bahrain. The algal growth coexists with other marine ecosystems, e.g., seagrass, coral reefs, mud flat. The macroalgae habitat can be noticed during summer. Relatively, this habitat was observed to thrive independently in deep water.

3.6. Species richness

The species richness is based on quantitative analysis at each site for the combined conspicuous macro-fauna and macro-flora species identified during the SCUBA surveys. The values obtained for species richness serve as an indicator of epi-benthic biodiversity at a particular biotope. The highly mobile species, e.g., fishes that are not associated with the biotope have been excluded and the species richness represents only those truly associated with the biotope.

The highest species richness was observed at sites T67 and T51 (Fig. 12). A total of 11 species are associated with the location T67.
(Rock with sand veneer), which are represented by gastropod, crab and filamentous algae, however, 10 species have been observed in the location T51 (Macro algae) that mostly constituted of bivalves and filamentous algae. The lowest species richness was at T19 (Mud), which represented by existence of only algal biofilm and T30 (Silty Sand) represented by only one species (*H. uninervis*). The other locations are characterized by < 5 species associated with silty sand and silty sand with seagrass.

4. Discussion

In spite of the limited land area of Bahrain, the territorial waters of Bahrain includes diverse vital coastal and marine habitats, which are associated by endangered megafauna species (dugongs, green turtles and dolphins) and pearl oysters in addition to broad scale of shellfish and finfish species (*Preen*, 2004; *Naser et al.*, 2008; *Loughland and Zainal*, 2009). Several couples of dolphins have been observed within the Askar coast during the site visits. The marine habitats along Askar coast represent a part of the most productive habitats extending southward across Hawar Islands to UAE coasts, which characterize the ground for the second global herd of dugongs.

In addition to the megafauna, the shellfish represented by the pearl oyster is one of the most important species in Bahrain. The oyster species that produce pearls of high commercial value are classified within two main genera *Pinctada* and *Pteria*. The most common species in the Arabian Gulf are the Atlantic pearl oyster, *Pinctada radiata* and the Black-lip pearl oyster, *Pinctada margaritifera*. The former is the most common species in Bahrain representing one of the common grounds of natural pearl oysters in the world.

The Bahraini pearl oysters are associated with depths of approximately < 20 m. The Bahraini pearl is characterized by high quality and demands high prices. Natural populations of pearl oysters around Bahrain showed considerable spatial differences in their sizes concerning salinity. Large-sized oysters (75–80 mm) predominate at Ras Hayan (*Al-Sayed, 2019*), the southern tip of the Askar coast. The earlier survey on pearl oyster beds in Bahrain was conducted in 1985 to determine the status by determining population parameters (size, density and spawning season), exploring the frequency of occurrence and quality of natural pearls and investigating the limiting environmental factors (*Al-Rumaidh, 2019*).

*Naseeb et al.*, (2021) identified three success factors to be considered on a pearling trail in Bahrain to allow for future preservation projects to ensure upgrades for both urban regeneration and revitalization. These factors are represented by project expansion beyond UNESCO preservation requirements, focusing on sustainability and continuous use, and improved access to culture and cultural opportunities. Consequently, the Supreme Council for Environment recently declared the oyster beds throughout Bahrain a UNESCO World Heritage Site, subject to rules and regulations based on the ecosystem status.

The coastal and marine environment of Bahrain mainly includes seagrass beds, algal beds, rocky, sandy and muddy bottoms and in occasional coral reefs (*Loughland, and Zainal, 2009*). These habitats can be described as a productive environment for broadscale of benthic flora and fauna supporting the fishery resources represented by different finfish and shellfish species commercially important to Bahrain.

In general, the marine environments in the Arabian Gulf are heavily exposed to several impacts of land-based activities, which considerably affect the coastal zone. Accordingly, the marine protected areas (MPAs) were found to be the most crucial approach to minimizing these impacts. *Lamine et al.*, (2020) adopted coastal and marine key priorities in UAE for marine conservation across multiple planning scenarios that can be applied in the MPAs. Similar findings were highlighted by the State of the Marine Environment Report (SOMER) described by *Devlin et al.* (2019) in Kuwaiti waters. The report emphasized the environmental pressures generated by a rapid urbanization, particularly on coastal

![Habitat types:](image_url)

**Fig. 6.** Types of biotopes associated with different depths at Askar coast.
biodiversity and habitats. Due to the transboundary effect, the impacts may extend southerly towards a regional approach within ROPME Sea Area.

Bahrain is a member of the Small Island Developing States (SIDS), geographically located in the hottest subtropical region exposed to common challenges due to the vulnerability to extreme climate change and fragile environmental conditions (Abdulla and Naser, 2021). The anthropogenic land-based activities generate unprecedented pressures, including sand dredging, coastal development, domestic and industrial effluent discharges, and seawater desalination.

The major sources of coastal pollution in the Kingdom of Bahrain are domestic sewage, brine waters and industrial effluents, discharged from urban, rural and industrial areas. These effluents are discharged into the marine environment through numerous outfalls located along the coastal area, particularly on the east coast. For instance, the high levels of nitrate in Askar coastal waters as reported by Supreme Council for Environment (SCE, 2016) are attributed to the discharge of STP, particularly in the intertidal zone between Askar STP and NaMaC where the currents stagnant and less circulation due to the barrier arm construction of the fishing harbor. At this location huge sludge is accumulated within the STP outlet. An algal bloom growth was observed at different times of the year notably in May and October. Moreover, the very low chlorophyll-a concentrations in Askar indicated during the monitoring program (2007–2016) conducted by SCE on seasonal basis refer to low levels of primary productivity in Askar coastal area (SCE, 2016). However, the reduction of seagrass cover and algal beds affect the dissolved oxygen levels. High levels of dissolved oxygen are recorded around Durrat Al-Bahrain at the southern

![Fig. 7. Silty sand biotope at Askar coast.](image-url)
Fig. 8. Silty sand with seagrass biotope at Askar coast.

Fig. 9. Mud biotope at Askar coast.
tip of Bahrain over dense seagrass meadows (Atkins, 2004). However, the levels recorded at Askar are noticeably lower as a result of silty sand biotopes predominated Askar coast. The dissolved oxygen levels at Askar coast may largely contributed by patchy seagrass beds and macro algae habitats.

The coastal area of Askar is subjected to potentially polluted levels of petroleum hydrocarbon discharging from the BAPCO’s refinery located at approximately 1.5 km to the north of Askar village. Further chemical materials are discharged from the Gulf Petrochemical Industries Company (GPIC), which is located at the north of BAPCO refinery. Accordingly, this area is considered as one of the TPHs hotspots found in sediments (de Mora et al., 2010). The survey performed by Al-Khatlan et al. (2019) in 2013 covering the intertidal and subtidal zones of Askar to assess the TPHs in surface sediment samples indicated an existence of a couple of TPHs hotspots in the intertidal zone and some locations are characterized by tar balls associated with coastal sediments.

The levels of pollutants are positively correlated with sediment texture, where the higher levels are associated with fine particle size (mud and clay fractions). However, such a relationship is not a universal phenomenon as further factors control pollutant adsorption such as the type of oil, weathering, depth, velocity and hydrological factors including currents direction, wind and sedimentation rate. Generally, the pollutant levels in sediments of Askar coastal area are relatively low levels, which is attributed to the coarse sand grains predominated Askar coast as indicated by Al-Khatlan (2015). Although the water quality parameters of the Askar coast from 2007-to 2016 are generally within acceptable limits, as indicated by the study of Ali (2022). The study pointed out the importance of a hydrodynamic application to determine the extent of the pollutant’s dispersion in Askar coastal areas as part of coastal management to protect Askar fisheries, one of the commonest traditional fishing grounds in Bahrain.

The coastal habitats between Askar fishing harbor and NaMaC are considerably polluted due to less water circulation, which provides the opportunity to algal bloom existence as observed since the construction of Askar fishing harbor. A potential risk could be expected where some of the fishing traps are located within the

Fig. 10. Rock with sand veneer biotope at Askar coast.
TPHs hotspots as pointed out by Al-Khatlan et al. (2019) indicating potential bioaccumulation of these pollutants in the fish catch of these traps. Accordingly, it is of great importance that common finfish species, particularly rabbitfish, *Siganus canaliculatus* (locally known Safi) and emperor fish, *Lethrinus nebulosus* (locally known Sheari) and shellfish notably crabs caught by fishing traps at Askar coast need to be involved in prospective studies on marine pollution along the eastern coast of Bahrain.

The species richness of epi-benthic community represents an ecosystem function, which considerably focused on determining the impacts of dredging/reclamation process. The cumulative impacts of these activities on the marine ecology and land-use in the Kingdom of Bahrain have been investigated by Zainal et al. (2012). The species composition of macrobenthic fauna associated with seagrass beds has been analysed by Al-Wedaei et al. (2011) indicating that sediment particle size and salinity were the main environmental factors determining the benthic community patterns between the east and west coasts of Bahrain. The dredging/reclamation works during the construction of Askar fishing harbor 2010–2012 largely affect the bottom structure along Askar coast, reflecting on the abundance and species diversity, which used as a biological indicator to assess environmental impacts.

Regarding the strategic development plan 2030, Askar coast is one of the southern municipality sites involved in such a plan. Recently, construction works have been initiated along the southern Askar coast, including new coastal road to the south parallel to King Hamad highway. A new fishing harbour has been constructed in 2012 as part of strategic plan to develop the fishing sector in Bahrain, including further harbours constructed in Muharraq, Budai and Hidd. The study is expected to witness a big urban development due to the construction of Khalifa City south of Askar, where infrastructure services for electricity, desalination, sewage and coastal recreation areas will be substantially expanded.

A substantial part of Askar coast was lost due to the construction of Askar fishing harbour. The dredging/reclamation works around the harbour site at the centre of the coast impacted the marine habitats by new sedimentation accumulated, which gradually buried the seagrass cover and associated epi-benthic species. Moreover, the continuous discharge of sand wash plant affects the clarity along the water column, particularly within the outlet vicinity. The DDV survey showed that water layer near the bottom was too turbid. As a result, it is necessary to monitor the turbidity at further locations around Askar as the concentration of suspended matters within the water column being low, however noticeable new sedimentation is drifted southwardly and settled down at most of Askar coastal area.

5. Conclusions

The coastal area in Askar is exposed to many industrial outfalls and other sewage water discharge, which noticeably reflected on the water quality and primary productivity. Dredging/reclamation activities accompanying with coastal processes, considering the urban expansion of development plan 2030, impacted the coastline stability. The coastal habitats mostly characterized by poor productive biotopes such as seagrass, which represented by patchy forms associated with different depths. The less vegetation cover and the prevalence of sandy silt bottom synchronized with a lot of new sedimentation sourced by sand wash plant, noticeably increase the turbidity throughout the water column resulting in low species richness of epi-benthic species in comparison with adjacent habitats on the eastern coast. Askar and neighbor regions

![Fig. 11. Macro algae biotope at Askar coast.](image1)

![Fig. 12. Species richness associated with each biotope.](image2)
in the south are heading for major urban developments in the near coming years by establishing a large residential city that will be accompanied by development and expansion of sewage water and desalinization plants capabilities to meet the expected demand, which potentially reflected on the fragile coastal environment. Therefore, the current environmental monitoring program need to be considered to cover additional locations to minimize the vulnerability of traditional fisheries, which constitute an important part of fish catch in Bahrain.

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.

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