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Recent benthic foraminifer's distribution and their environmental correlation in Qeshm Island

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Abstract

In addition to introducing foraminiferal communities, this study aims to investigate the relationships of these communities with the environmental parameters of water and sediment. Nine sediment samples were collected in 2019, from three stations in Qeshm Island. Environmental conditions including temperature, DO, salinity, pH, grain size, TOM, and CaCO3 were measured. Our results revealed that grain size, TOM, and DO factors controlling the diversity and distribution of benthic foraminifera. Thirty-five species from 26 genera and 21 families of foraminifer's assemblages were identified where Quinqueloculina was the most abundant genus in all stations.

Keywords: Modern foraminifera, physic-chemical parameters, Diversity, Persian Gulf

1. Introduction

Foraminifera as an important member of different ecosystems is widely distributed in marine environments that their considerable taxonomic diversity gives them the potential for diverse biological responses to va rious pollutants and environmental stresses through time (Hallock et al., 2003). Identification of benthic foraminifera provide basic knowledge that can be used, as proxy for anthropogenic pollution (Carnahan et al., 2009; Martinez-Colon & Hallock, 2010), coral reef condition (Hallock et al., 2003) and other environmental changes (Mendes et al., 2004). (Hallock et al., 2003; Uthicke and Nobes, 2008; Arslan et al., 2016; Parsaian et al., 2018). However, precise taxonomic information provided by the foram specialists help resource managers for biodiversity conservation (Murray, 2013; Gooday and Jorissen 2012).

The distribution of these organisms is influenced by various abiotic and biotic factors, including light, temperature, salinity, oxygen availability, alkalinity, depth, organic matter, substrate, and water turbidity (Uthicke and Nobes., 2008). Changes in any of these factors are reflected in the alteration of foraminiferal assemblages (Murray, 1973, 1991; Debenay, 1988 Martins et al., 2019). This feature makes these organisms an important tool for identifying variations that have occurred in the environment (Martins et al., 2019).

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The environmental studies using foraminifera were begun by the end of the 1950s. For instance, a study of environmental factors such as currents activity, nutrients, salinity, characteristics of bottom sediments, and especially temperature should control the distribution patterns of the benthic species reported in Santa Monica Bay, California, Zalesny (McGann et al., 2003). several studies showed strong correlation of abundance and diversity of benthic foraminifera with the environmental fluctuations in the Persian Gulf (Sohrabi-Mollayousefy et al., 2006; Mooraki et al., 2013; Nabavi et al., 2014; Doustshenas et al., 2016; Parsaian et al., 2018).

In spite of several studies (Saidova, 2010; Nabavi et al., 2014; Amao et al., 2018) have been done on the Persian Gulf foraminifera, but foraminifera diversity of the region is still unknown especially in coral reef habitats (Maghsoudlou et al, 2019). Qeshm Island, as the largest island of the Persian Gulf, have a wide range of coastal and marine habitats, including coral reefs, mangrove forests, seagrass beds, estuaries, and rocky, muddy, and sandy shores (Naderloo et al., 2013). The present contribution aims to identify benthic foraminifer's communities of the Qeshm Island typically coral area as well as to investigate the relation of environmental factors with the biodiversity components of foraminifera.

2. Material and Methods

Sampling sites were placed at South and Southeast of Qeshm Island as following: 1) Zeytoon Park (26° 55′54″ N, 56°16′22″ E) a coral place near the coast and diving school, 2) Naz Island (26° 48′54″N, 56° 07′28″E) is also a coral place, but far from the coast and without the effect of coastal area and 3) Sandy site (26°49' 49.4"N 56°07' 34.6"E) with a sandy substrate near the Rigou harbor. (Figure 1) moreover, locations were determined by GPS. The sediment samples were collected from all stations by scuba diving in 2019 ranging in depth from 5 to 7meter.

The environmental factors including temperature, DO (dissolved Oxygen), salinity and pH were measured by portable analyzer HQ40d during each sampling time. However, nitrate, phosphate analyzed with Hach Method 8192 at Iranian National Institute for Oceanography and Atmospheric Science laboratory.

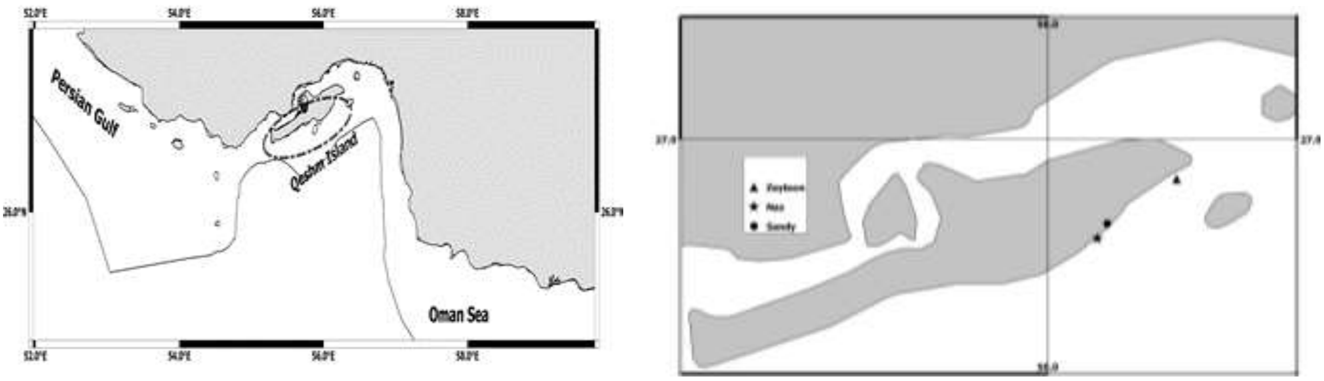

Fig. 1: The location of the sampling sites in Qeshm Island

2.1. Sediment analyses

For each stations, two samples were collected to study the sedimentary environment. The surface sediment (approximately 20–50 g) was taken and placed in an aluminum container to determine the sediment texture and total organic material. All samples were stored in a refrigerator at 4 ◦C until analysis. Grain size analysis was performed using laser particle size analyzer (HORIBA-LA950, France & Japan) Total organic matter (TOM) was measured by further weighting approximately 1.5–2 g of dried sediments (< 250 μm) after placing the samples in a furnace (NABERTHERM, P330, Germany) at 550 ◦C for 4 h. TOM was calculated by the following equation: TOM % = [(B − C)/B] × 100.

Calcium carbonate concentration was measured based on the reaction with HCl 25 g (W1) of dried sediment (70°C, 8 h) was mixed with HCl (0.1 N) and stirred (until no Co2 bobbles appearing) and allowed to soak (24 h). The upper liquid phase was discharged and the remaining sediments were filtered (by paper), dried (70°C, 8 h) and reweighed again (W2). Calcium carbonate percentage was measured by the following formula: CaCO3(%)=100(W1-W2)/W1

TOM, CaCO3 and grain size were measured at Iranian National Institute for Oceanography and Atmospheric Science laboratory based on the standard protocols.

2.2. Foraminifera laboratory procedures

All the sediment samples were preserved with 70% ethanol in plastic falcon tube. For determining foraminifera, each sample was washed with tap water through a 63 μm mesh sieve then dried in oven in 75ºC for 8 hours. Liquid of Tetra Chloride Carbon (CCL4) was used for floating and collection of foraminifera. The floated forams specimens were filtered by paper and allowed to be dried (Mooraki et al., 2013). Samples were identified and enumerated with stereomicroscope (Nikon SMZ1500) at Iranian National Institute for Oceanography and Atmospheric Science lab. The most important foraminiferal species were photographed using a scanning electron microscope (SEM) at Islamic Azad University Science and Research lab. The foraminifera samples of Loeblich and Tappan, 1964; Uthicke and Nobes, 2008; Debenay, 2012 and Horton et al., 2017 were consulted for generic level identification. Moreover, we use online open access databank for identification. (http://www.marinespecies.org/foraminifera/).

2.3. Statistical analysis

Benthic foraminifera data at each station were used to calculate species richness (S: number of different species in each station), Shannon-Wiener diversity index (H'), Evenness index e^H/S, and Margalef's Richness (d). All sample data were tested for normality using a Shapiro-Wilk test. Due to the non-normal distribution, we used a non-parametric Spearman correlation test was conducted for all parameters (physical, chemical, and biological) versus the foraminiferal taxa. Canonical Correspondence Analysis (CCA) was used to visualize foraminifer's distribution pattern in relation with environmental parameters. All of the above statistical analysis and diversity indices were performed using PAST v4.2 (PALeontology Statistic) software of Hammer et al. (2001).

3. Results

3.1. Abiotic data

Results of the measured environmental factors (i.e. water and sediment), including temperature, dissolved oxygen, salinity, pH, grain size, total organic matter, and calcium carbonate concentration, are shown in Tables 1 and 2. Water temperature, pH, dissolved oxygen, and salinity were not varied in all stations. The grain-size analysis showed that the seabed sediment in Naz Island(NI) was very coarse sand also in Zeytoon Park(ZP) and Sandy stations seabed sediments were coarse sand. The structure of the sediment samples mostly consisted of fine pebble, very coarse sand, medium sand and fine sand in all stations.

Table 1: Bottom water variables of the stations sampled

Station	$NO_{3(mg/L)}$	$PO_{4(mg/L)}$	Temperature(°C)	Salinity(PSU)	pH	DO(mg/L)
Zeytoon Park	0.02	0.08	32	37.6	8.2	6.2
Naz Island	0.02	0.09	32	37.6	8.2	6
Sandy	0.02	0.07	32	37.6	8.2	5.2

Table 2: Sediment variables of the station sampled

Station	Caco3	TOM%	Mean Grain Size	Dominant substrate type
Zeytoon Park	48.96	6	808.47(µm)	Coarse sand
Naz Island	54.4	3.6	1210.15(µm)	Very coarse sand
Sandy	43.38	3.7	963.64(µm)	Coarse sand

3.2. Foraminiferal assemblages

Benthic foraminifera in the study area yielded thirty-five species from 26 genera and 21 families. (Table 3) *Quinqueloculin*a and *Textularia* are abundant genera for coral reef stations (NI and ZP). *Quinqueloculina* and *Elphidium* were common genera in sandy station. In coral reefs stations Hauerinidae and Textulariidae were the most abundant families while in sandy station Hauerinidae and Elphidiidae were the most abundant families (Figure 2). Miliolida order shows the highest frequency in all stations, but Rotaliida is more diverse than other orders (Figure 3). Highest frequency of foraminifera recorded at ZP station.

Twelve genera were recorded but represent minor percentage (under 1%), such as *Spiroloculina*, *Ammonia*, *Heterostegina*, *Sorites*, *Discorbis*, *Siphonina*, *Eponides*, *Adelosina*, *Cymbaloporetta*, *Pyrgo*, *Edentostomina*, *Cibicides*, ten genera such as *Siphogenerina Trochammina*. *Pyrgo*, *Spiroloculina*, *Sorites*, *Eponides*, *Sigmoihauerina*, *Siphonina*, *cibicides* and *Heterostegina* were present only in coral stations in contrast *Edenostomina* only exists in the sandy station.

As indicated in Table 4, Shannon-Wiener and evenness indices had the highest value in sandy station, and the lowest evenness value was for ZP station. However, other indices such as Fisher alpha diversity of the species and Margalef were the lowest for sandy station and highest value for ZP.

3.3. Multivariate CCA analysis

The CCA analysis based on the foraminiferal species with six measured environmental variables is presented in Figure 4. The plot of CCA analysis showed that, the grain size had the most impact on foraminifera assemblage. The sediment with the larger grain size (coarse sand) had higher abundance of *Discorbis*, *Trochammina*, *Pseudobrizalina*, *Siphogenerina* and *Ammonia* genera. The NO_3 and TOM vectors are close together with negative correlation to mean grain size. In addition, these two vectors are positively correlated with abundance of *Peneroplis*, *Heterostegina* and *Asterorotalia*. The $CaCO_3$ and PO_4 are close together and showed correlation with *Textularia* frequency.

Table 3: Classification of recognized benthic foraminifera in all station.
All species were matched in WORMS (https://www.marinespecies.org/aphia.php?p=match)
to updated the their taxomomic status.

Order	Family	Genus	Recognized Species
Lituolida	Trochamminidae	*Trochammina*	*Trochammina Inflata*
Miliolida	Peneroplidae	*Peneroplis*	*Peneroplis planatus, Peneroplis pertusus*
Miliolida	Hauerinidae	*Pyrgo*	*Pyrgo* sp.
Miliolida	Hauerinidae	*Quinqueloculina*	*Q. costata, Q. seminula, Q. agglutinans Q. pseudoreticulata Quinqueloculina* sp.
Miliolida	Hauerinidae	*Sigmoihauerina*	*Sigmoihauerina bradyi*
Miliolida	Cribrolinoididae	*Adelosina*	*Adelosina* sp.
Miliolida	Hauerinidae	*Triloculina*	*T. inflata*
Miliolida	Spiroloculinidae	*Spiroloculina*	*S. excavate*
Miliolida	Soritidae	*Sorites*	*S.orbiculus*
Miliolida	Ophthalmidiidae	*Edentostomina*	*E. rupertiana*
Nodosariida	Lagenidae	*Lagena*	*Legana* sp.
Rotaliida	Ammoniidae	*Ammonia*	*A. tepida, A. beccarrii,*
Rotaliida	Rosalinidae	*Rosalina*	*Rosalina* sp.
Rotaliida	Cibicididae	*Cibicides*	*Cicibedes* sp.
Rotaliida	Elphidiidae	*Elphidium*	*E. excavatum*
Rotaliida	Bolivinitidae	*Bolivina*	*Bolivina* sp.
Rotaliida	Nonionidae	*Nonion*	*N. fabum*
Rotaliida	Murrayinellidae	*Murrayinella*	*M.murrayi*
Rotaliida	Bolivinitidae	*Pseudobrizalina*	*P. lobate*
Rotaliida	Cymbaloporidae	*Cymbaloporetta*	*C. bradyi*
Rotaliida	Discorbidae	*Discorbis*	*Discorbis* sp.
Rotaliida	Eponididae	*Eponides*	*Eponides repandus*
Rotaliida	Ammoniidae	*Asterorotalia*	*Asterorotalia dentata*
Rotaliida	Siphoninidae	*Siphonina*	*siphonina australis*
Rotaliida	Siphogenerinoididae	*Siphogenerina*	*Siphogenerina raphanus*
Rotaliida	Nummulitidae	*Heterostegina*	*Heterostegina depressa*
Rotaliida	Buliminidae	*Bulimina*	*Bulimina*.sp
Textulariida	Textulariidae	*Textularia*	*Textularia* sp. *T. agglutinans*

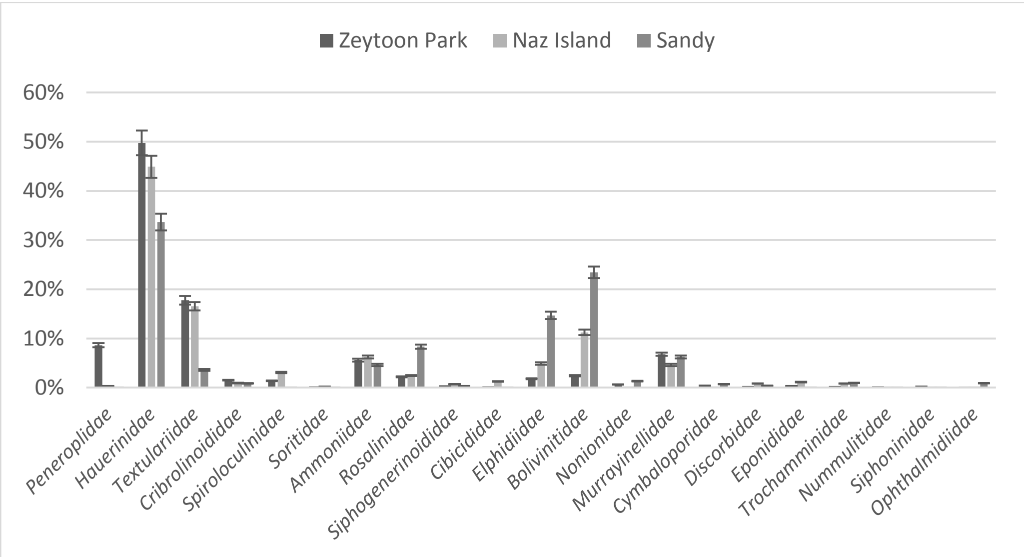

Fig. 2: The percentage composition at family level in all stations

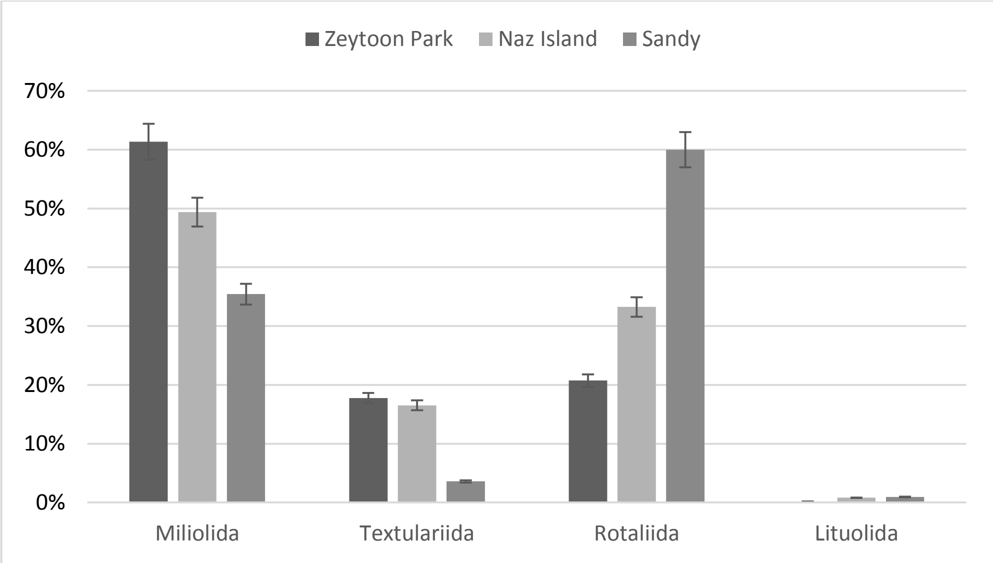

Fig. 3: The percentage composition at order level in all stations

Table 4. Diversity indices for all station

	Zeytoon Park	Naz Island	Sandy
Taxa_S	25	19	17
Shannon_H	2/17	2/11	2/18
Evenness_e^H/S	0/35	0/44	0/52
Margalef	3/54	3/117	2/12
Fisher_alpha	4/78	4/39	2/57

3.3. Multivariate CCA analysis

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4. Discussion

The Persian Gulf benthos are characterized by high abundance and low species richness where harsh environmental fluctuations such as light availability, DO, sediment grain size, organic carbon and nitrogen content of the sediments affected these communities (Al-Yamani et al., 2009; Sheppard et al., 2010, Uthicke and Nobes., 2008).

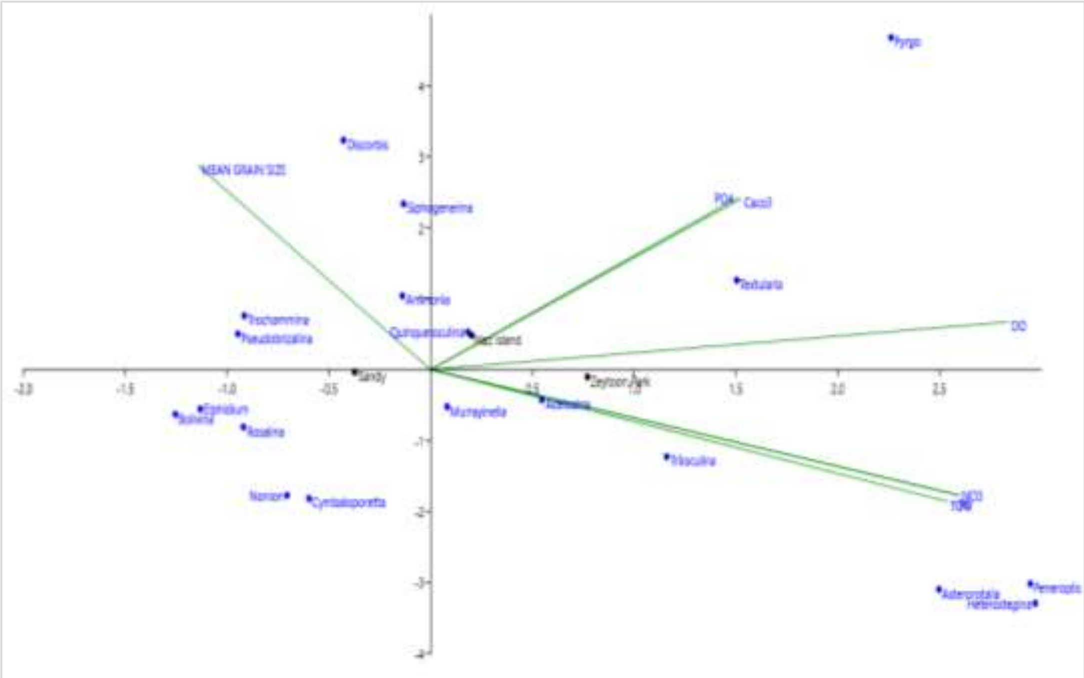

Fig. 4: Canonical carrespondence analysis based on abundant of foraminifera with environmental variables

Previous works on Persian Gulf benthos and their correlation with environmental factors indicated that grain size was the most contributed factor influencing frequency and diversity of foraminifera. DO and nutrient are also important factors in Foraminifera distribution (Sohrabi-Mollayousefy et al., 2006, 2011; Parsaian et al, 2018; Amao et al., 2018). For the first time in this study, we determined the effect of environmental factor on foraminifera's assemblages in Coral reefs of Qeshm Island. Also, we estimated the correlations of sediments properties (Grain size, TOM, $CaCO_3$) along with environmental factors (pH, salinity, temperature and dissolve oxygen). Our results were in consistence with the previous ones whose mentioned that grain size is the most important factor involved in foraminifera assemblage, however, we didn't find any significant correlation between pH, salinity and temperature with foraminifera assemblage in three studied stations. It can be due to similar environmental variables in Sandy, Zeytoon and Naz stations.

Sediments coarse is negatively correlated with nutrient and TOM. ZP is the most diverse station with the highest TOM in comparison with Naz and Sandy staions. Therefore, it is inferred that TOM is correlated with diversity of foraminifera assemblage.

Oxygen is one of the limiting factors towards benthic foraminifera in shallow region. Thus, benthic foraminifera can make an excellent indicator of sediments hypoxic condition (Mojtahid et al., 2006). Certain species of foraminifera are described as the opportunistic species. Opportunistic foraminifer's genera (i.e *Ammonia*, *Trochammina* and *Elphidium*) are known as stress-tolerant taxa. These genera can adapt to high pollution and oxygen-deficient environments (Mojtahid et al., 2006; Coccioni et al., 2009; Dimiza et al., 2016). In our study, the sandy station has higher abundance of opportunistic foraminifera with the lowest amount of dissolved Oxygen. It is suggested that there is a correlation between the abundance of opportunistic taxa and dissolved oxygen. On the other hand, we speculate for vicinity to harbor can affect the composition of this foraminifera.

Sohrabi-Mollayousefy et al. (2006) identified 54 species belong to 27 genera in the northwestern part of QI where mangrove forests are distributed. Based on their results, *Quinqueloculina* and *Ammonia* were the most abundant and diverse genera. Also, Doustshenas et al. (2016), recognized 44 species belonging to 31 genera and 25 families for the eastern part of QI, where *Quinqueloculina*, *Triloculina*, *Spiroloculina*, and *Ammonia* were the most frequent genera.

The most abundant genus was *Quinqueloculina* which was in consistence with previous studies in the region (Oladazimi et al., 2021, in press; Sohrabi-Mollayousefy et al., 2006; Saidova, 2010; Mooraki et al, 2013; Nabavi et al, 2014; Doustshenas et al., 2016; Parsaian et al, 2018; Amao et al., 2018). The mentioned genus is a heterotrophic Miliolids dominant in nutrient-rich areas with low water transparency and likely to be resistant to stress-tolerant (Uthicke et al., 2010). It is suggested that the porcelanous shell of *Quinqueloculina* can play an important role in its proliferation, because this special wall is effective in its adaptation to environmental changes such as salinity and temperature (Cherif, 1973).

We did not find any *Peneroplis* and *Sorites* and *Heterostegina* in the sandy site while the genera existed in the coral station (NI nad ZP). *Peneroplis* and *Sorites* and *Heterostegina* are an algal symbiont-bearing large foraminiferal thriving in warm, clear, nutrient-poor, shallow environments and are sensitive to environmental changes (Hallock et al., 2003). Symbiont-bearing foraminifera have host algal endosymbionts that prefer similar environmental conditions as corals, so they can be used as proxies of water quality in the coral reef ecosystem (Carnahan et al., 2009).

Finally, as stated many scientists, the distribution and diversity of benthic foraminifera was used to assess the ecological conditions and pollution status area. Several species of recent benthic foraminifera identified in current study can be used to monitor future change in coral reef condition. Therefore, providing more information about biodiversity of coral reef ecosystem is so helpful in determining the hotspot area for conservation as well.

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References

Al-Yamani, F., Boltachova, N., Revkov, N., Makarov, M., Grintsov, V., Kolesnikova, E., & Murina, G. V. (2009). Winter species composition, diversity and abundance of macrozoobenthos in Kuwait's waters, Arabian Gulf. ZooKeys, 31, 17.

Amao, A. O., Kaminski, M. A., Asgharian Rostami, M., Gharaie, M. H. M., Lak, R. & Frontalini, F,(2018). Distribution of benthic foraminifera along the Iranian coast. Marine Biodiversity, 49, 933--946.

Arslan, M., Kaminski, M. A., Tawabini, B. S., Ilyas, M., Babalola, L. O., & Frontalini, F. (2016). Seasonal variations, environmental parameters, and standing crop assessment of benthic foraminifera in eastern Bahrain, Persian Gulf. Geological Quarterly, 60(1), 26-37.

Carnahan, E.A., Hoare, A.M., Hallock, P., Lidz, B.H. and Reich, C.D., (2009). Foraminiferal assemblages in Biscayne Bay, Florida, USA: responses to urban and agricultural influence in a subtropical estuary. Marine Pollution Bulletin, 59(8-12), .221-233.

Cherif, O. H., (1973). Zur Klassifizierung der Miliolinellinae (Foraminifera). On the classification of the Miliolinellinae (Foraminifern). Neues Jahrbuuch f \ u r Geologie und Pal \ an ontologie, Monatshefte, 709-18.

Coccioni, R., Frontalini, F., Marsili, A. and Mana, D., (2009). Benthic foraminifera and trace element distribution: a case-study from the heavily polluted lagoon of Venice (Italy). Marine Pollution Bulletin, 59(8-12). 257-267.

Debenay, J. P. (1988). Foraminifera larger than 0.5 mm in the southwestern lagoon of New Caledonia; distribution related to abiotic properties. *The Journal of Foraminiferal Research*, *18*(2), 158-175.

Debenay, J.-P., (2012). A guide to 1,000 foraminifera from Southwestern Pacific.: New Caledonia. Marseille: IRD éditions, Institut de recherche pourle déveloement. Paris: Marseille, Publications Scientifiques du Muséum, Muséum national d'Histoire naturelle, 1–378.

Dimiza, M.D., Triantaphyllou, M.V., Koukousioura, O., Hallock, P., Simboura, N., Karageorgis, A.P. and Papathanasiou, E., (2016). The Foram Stress Index: A new tool for environmental assessment of soft-bottom environments using benthic foraminifera. A case study from the Saronikos Gulf, Greece, Eastern Mediterranean. Ecological Indicators, 60, 611-621

Doustshenas, B., Nabavi, S. & Sakhaei, N., (2016). Study of biodiversity and identification of foraminifera communities in the eastern Qeshm Island. Journal of Animal Research (Iranian Journal of Biology), 29, 1-17.

Gooday, A. J., & Jorissen, F. J. (2012). Benthic Foraminiferal Biogeography: Controls on Global Distribution Patterns in Deep-Water Settings. Annual Review of Marine Science, 4(1), 237–262. https://doi.org/10.1146/annurev-marine-120709-142737

Hallock, P., Lidz, B. H., Cockey-Burkhard, E. M. & Donnelly, K. B., (2003). Foraminifera as bioindicators in coral reef assessment and monitoring: The foram index. Environmental Monitoring and Assessment, 81, 221--38.

Hammer, Ø., Harper, D. A., & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. Palaeontologia electronica, 4(1), 9.

Horton, T., Gofas, S., Kroh, A., Poore, G. C. B., Read, G., Rosenberg, G., Sthr, S., Bailly, N., Boury-Esnault, N., Brando, S. N., Costello, M. J., Decock, W., Dekeyzer, S., Hernandez, F., Mees, J., Paulay, G., Vandepitte, L., Vanhoorne, B. & Vranken, S., (2017). Improving nomenclatural consistency: A decade of experience in the World Register of Marine Species. European Journal of Taxonomy, 130, 43-59.

Loeblich, A. R. & Tappan, H., (1964). Treatise on Invertebrate Paleontology, Part C: Protista 2, Sarcodina, chiefly Thecamoebians and Foraminiferida. Geological Society of America and University of Kanzas Press, Lawrence. Scientific Quarterly Journal, 32, 57-61.

Maghsoudlou, A., Momtazi, F., Nasiri, K., Pazooki, S., Molavi-Arabshahi, M., Sepahvand, V., Hekmatara, M. and Khaledi, H.,(2019). A review on the state of the biodiversity knowledge on Iran's southern seas: introducing a methodology to evaluate the validity of the reported cases. Marine Biodiversity, 49(2), 563-581

Martínez-Colón, M., & Hallock, P. (2010). Preliminary survey on Foraminiferal responses to pollutants in Torrecillas Lagoon Puerto Rico. Caribbean Journal of Science, 46(1), 106-111.

Martins, M. V. A., Yamashita, C., e Sousa, S. H. D. M., Koutsoukos, E. A. M., Disaró, S. T., Debenay, J. P., & Duleba, W. (2019). Response of benthic foraminifera to environmental variability: importance of benthic foraminifera in monitoring studies. In Monitoring of Marine Pollution. IntechOpen.

McGann, M., Alexander, C. R., & Bay, S. M. (2003). Response of benthic foraminifers to sewage discharge and remediation in Santa Monica Bay, California. Marine environmental research, 56(1-2), 299-342.

Mendes, I., Gonzalez, R., Dias, J. M. A., Lobo, F., & Martins, V. (2004). Factors influencing recent benthic foraminifera distribution on the Guadiana shelf (Southwestern Iberia). Marine Micropaleontology, 51(1-2), 171-192.

Mojtahid, M., Jorissen, F., Durrieu, J., Galgani, F., Howa, H., Redois, F. and Camps, R., (2006). Benthic foraminifera as bio-indicators of drill cutting disposal in tropical east Atlantic outer shelf environments. Marine Micropaleontology, 61(1-3), 58-75.

Mooraki, N., Moghadasi, B., Manoochehri, H. & Changizy, R., (2013). Spatial distribution and assemblage structure of foraminifera in Nayband Bay and Haleh Estuary, North-West of the Persian Gulf. Iranian Journal of Fisheries Sciences, 12, 654-68.

Murray, J. W. (2013). Living benthic foraminifera: biogeographical distributions and the significance of rare morphospecies. Journal of Micropalaeontology, 32(1), 1–58. https://doi.org/10.1144/jmpaleo2012-010

Nabavi, S. M. B., Moosapanah, S. G. R., Rajab Zadeh Ghatrami, E., Ghayyem Ashrafi, M. & Nabavi, S. N., (2014). Distribution, Diversity and Abundance of Benthic Foraminifera of the Northwstern Persian Gulf. Journal of the Persian Gulf. Volume 5 (16). 15-26.

Naderloo, R., Türkay, M., & Sari, A. (2013). Intertidal habitats and decapod (Crustacea) diversity of Qeshm Island, a biodiversity hotspot within the Persian Gulf. Marine Biodiversity, 43(4), 445-462.

Oladazimi, N., Mostafavi, P., Ghavam Mostafavi P., Maghsoudlou, A., Moghaddasi, B., Mashinchian Moradi, A. (in press). Study of coral reef benthic foraminifera assemblage in Qeshm Island, Persian Gulf. Iranian Journal of Fisheries Sciences.

Parsaian, M., Shokri, M. R. & Pazooki, J., (2018). The response of benthic foraminifera to aquaculture and industrial pollution: A case study from the Northern Persian Gulf. Marine Pollution Bulletin, 135, 682-93.

Prazeres, M., Martínez-Colón, M., & Hallock, P. (2020). Foraminifera as bioindicators of water quality: The FoRAM Index revisited. Environmental Pollution, 257, 113612.

Saidova, K. M., (2010). Benthic foraminifer communities of the Persian Gulf. Oceanology, 50, 61-66.

Sheppard, C., Al-Husiani, M., Al-Jamali, F., Al-Yamani, F., Baldwin, R., Bishop, J., Benzoni, F., Dutrieux, E., Dulvy, N. K., Durvasula, S. R. V., Jones, D. A., Loughland, R., Medio, D., Nithyanandan, M., Pilling, G. M., Polikarpov, I., Price, A. R. G., P, (2010). The Gulf: A young sea in decline. Marine Pollution Bulletin, 60, 13--38.

Sohrabi-Mollayousefy, M., Tehrani, K. K. & Momeni, I., (2006). Study of Benthic Foraminifera in Mangrove Ecosystem of Qeshm Island (Persian Gulf). J. Sci. I. A. U., 16, 10--19.

Uthicke, S. and Nobes, K., (2008). Benthic Foraminifera as ecological indicators for water quality on the Great Barrier Reef. Estuarine, Coastal and Shelf Science, 78(4), 763-773.

Uthicke, S., Thompson, A. & Schaffelke, B., (2010). Effectiveness of benthic foraminiferal and coral assemblages as water quality indicators on inshore reefs of the Great Barrier Reef, Australia. Coral Reefs, 29, 209-25.