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Functional diversity of the macro-invertebrate community in the port area of Kerkennah Islands (Tunisia)

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Abstract

The harbour area of Sidi Youssef in Kerkennah islands is characterized by specific anthropogenic pressures linked to fishing activities. To study the functional diversity of benthic macro-invertebrates, 10 stations located around the port and along the ship canal were sampled by SCUBA diving. Collected invertebrates were identified, counted and preserved. For the functional organization of the community, the most common biodiversity indices and functional groups were assessed at each station, and main physical and chemical parameters were measured. Results showed that the main apparent anthropogenic stress, that could lead to negative impacts on the studied area, was related to dredging/harbour activities. Suspension feeders, consisting essentially of polychaetes, which may be disturbed by water turbidity, dominated the stations farthest from the port, where the intensity of harbour activities is obviously reduced. On the contrary, carnivores dominated inside the port, possibly benefiting from fish-scraps discarded at the area, while stations close to the port appeared to be more balanced trophically. The applied biotic indices showed that the area is in good ecological status, except of the navigation channel and the port entrance, which were slightly degraded.

Keywords*:* Kerkennah islands, benthic invertebrates, biodiversity, trophic structure, ecological status.

Introduction

Ecological studies are difficult to conduct in marine areas due to the complexity of factors, environmental and anthropogenic, that govern the ecosystem functioning. These factors create a pressure leading benthic communities to several reactions; some species are disturbed and cannot develop naturally, and others, more resistant, impose their opportunistic strategy of life and exclude more sensitive and less competitive species (Glémarec, 1993). In general, cases where only one or just a few factors govern marine life are rare; this prevents from discriminating the effect of each factor (Anonymous, 2004; Afli *et al.*, 2008a).

Ecological studies relying only on physical and chemical approaches to assess the impact of pollution on marine communities can be confusing (Afli *et al.*, 2008b). On the contrary, the concomitant use of biological, physical and chemical approaches is an efficient way to understand ecosystem functioning and distinguish predominant factors (Puente *et al.*, 2008, Afli *et al.*, 2008b). In fact, the cause-effect relationships between environment and community parameters allow the diagnosis of habitat quality through the study of local communities. The distribution of each population in the marine ecosystem depends on environmental factors (Afli *et al.*, 2008b). For instance, a good ecological status is manifested by permanent and strong relationships among the different populations and also between them and their habitat including its physical and chemical characteristics. But, as soon as a disturbance occurs, these relationships alter, and some populations are temporarily favoured over others (Glémarec, 1993). This stimulates their further development until resources are exhausted and the whole system breaks down. Between these two extreme cases, intermediate situations are usually observed when monitoring benthic assemblages. For this examination, benthic invertebrates are the most appropriate biological tool (Simboura & Reizopoulou, 2008). This is because they consist of numerous species exhibiting different tolerances to stress, are almost sedentary and have relatively long life-spans, which allows them to reflect water/sediments quality conditions (Glémarec & Hily, 1981; Borja *et al.*, 2000; Salas *et al.*, 2004).

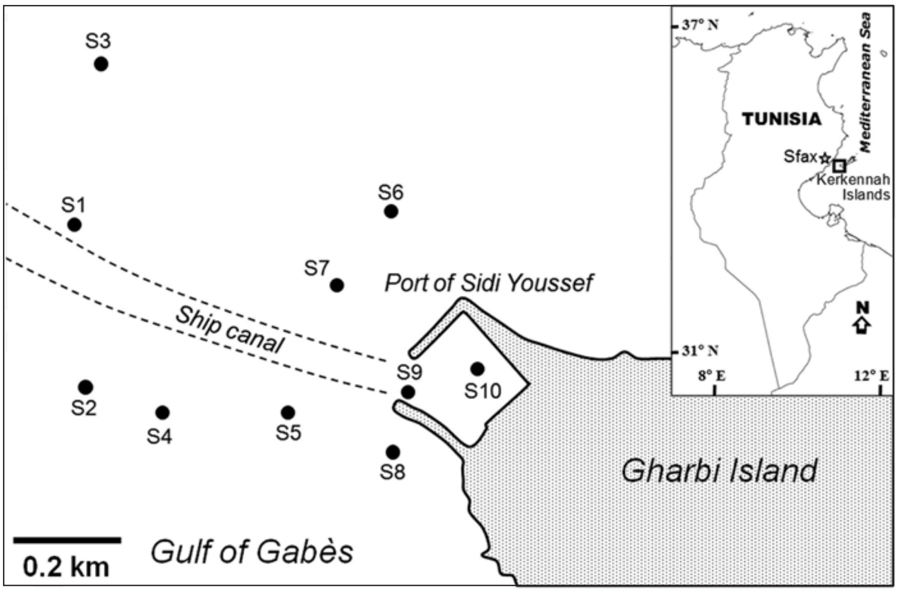


Fig. 1: Map of the study area showing the location of the sampling stations.

Considering all the above, the aim of this work is to study the functional diversity of the benthic macrofauna in a harbour area subject to specific anthropogenic stressing conditions. Based on taxonomic, trophic and ecological approaches, this study intends to reliably estimate the general status of the ecosystem in the Kerkennah harbour and to identify the contribution of the main environmental/anthropogenic factors that determine current benthic community organization.

Material and Methods

Study site

Kerkennah is located in the Gulf of Gabès (Fig. 1), of great importance for the Tunisian fishing sector. The gulf contributes about 65% of the fish production and concentrates about 75% of trawlers and almost two thirds of the total fishing fleet (Anonymous, 2008). Kerkennah includes principally two islands: Gharbi (or Mellita) in the west and Chergui (or Kerkennah El-Kbira) in the east, with about 15,000 inhabitants, and 12 unoccupied islets. It is located at about 12 miles from Sfax (around 300,000 inhabitants). Kerkennah, with only a few potential point sources of pollution, is considered less subject to anthropogenic impacts compared to the Sfax coasts and to the island of Djerba, situated in the southern coast of the same gulf. In general, the important industrial, urban and maritime development along the littoral of the Gulf of Gabès has lead to an increase of pollution, impacting marine systems and changing the structure and functioning of benthic communities (Hamza *et al*., 2000). Several faunal groups have been recently studied in the Gulf of Gabès, such as the summer phytoplankton bloom (Bel Hassen *et al*., 2008; Drira *et al*., 2009) and the copepod (Drira *et al*., 2010) and ciliate distribution (Kchaou *et al*., 2009), but data on benthic macro-invertebrates are lacking.

Sampling and laboratory procedures

In total, 10 stations located around the port of Sidi Youssef and along its ship canal were sampled for this study (Fig. 1). Samples were collected on April 1997 by SCUBA diving with three replicates at each station, which corresponds to 1 m² total sampled surface. The sediment' nature and the presence/absence of vegetation were noted (Table 1). In the laboratory, heavy metals contents (Zn, Pb, Cd, Cu, As, Ba and Hg) were estimated after digesting the sediment in aqua regia (HCl-HNO_3-H_2O) at 95°C, and analysing them by Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) and Mass Spectrometry (ICP-MS) (Yoshida *et al.*, 2002). Organic carbon and mineral carbon concentrations were measured according to Knap *et al.* (1994) using a Shimadzu TOC-5000 carbon analyzer following the method of high-temperature catalytic combustion. Transparency was measured using the Secchi disk. Fauna samples were sorted out with fresh water using a square mesh (mesh opening 1 mm). Then, the collected invertebrates were preserved in diluted alcohol (70%), identified, most of them up to species level, and counted.

Data analysis

Data allowed to calculate at each station abundance (ind./m²) and the most common biodiversity indices, i.e. specific richness (number of species), Shannon index (H') and Pielou's evenness (J') (Pielou, 1966). The iden-

Table 1: Main characteristics of the sampled stations: P: *Posidonia oceanica*, C: *Cymodocea nodosa*, Cp: *Caulerpa prolifera*.

Station	Coordinates (latitude / longitude)	Depth (m)	Bottom	
			Vegetation	Sediment
S1	34.6592° N / 10.9614° E	5.65	no	medium sand
S2	34.6567° N / 10.9615° E	1.65	C, P	fine sand
S3	34.6618° N / 10.9619° E	2.20	C	fine sand
S4	34.6562° N / 10.9630° E	2.30	P	medium sand
S5	34.6562° N / 10.9654° E	2.35	C, P, Cp	fine sand
S6	34.6594° N / 10.9674° E	3.00	C, P	fine sand
S7	34.6582° N / 10.9663° E	1.80	C, P	fine sand
S8	34.6556° N / 10.9673° E	1.00	C, P	fine sand
S9	34.6562° N / 10.9676° E	0.90	C, Cp	medium sand
S10	34.6569° N / 10.9690° E	4.40	no	undefined

tified species were classified into trophic groups using the feeding guilds established for polychaetes by Fauchald & Jumars (1979), and thereafter used and expanded to other taxonomic groups by Grall & Glémarec (1997) and Afli *et al.* (2008a), as follows: Herbivores (H): algae-feeding organisms (e.g., some echinids), Scavengers (N): feeding on carrions deposited on the bottom, Detritus feeders (Dt): feeding on particulate organic matter, essentially vegetable detritus, Carnivores (C): predatory animals, Micrograzers (µG): feeding on benthic microalgae, bacteria and detritus, Suspension feeders (SF): feeding on suspended food in the water column, Selective deposit feeders (SDF): feeding on organic particles settled on the sediment, Non-selective deposit feeders (NSDF): burrowers ingesting sediment from which they take their food.

For the assessment of environmental quality, collected species were assigned to the five ecological groups (EG_I: sensitive species; EG_{II}: indifferent species, EG_{III}: tolerant species, EG_{IV}: second-order opportunistic species; and EG_V: first-order opportunistic species) according to Glémarec & Hily (1981). Then the two most widely biotic indices based on the ecological groups, namely AMBI (Borja *et al.*, 2000) and BENTIX (Simboura & Zenetos, 2002) were calculated, as well as the calibrated Shannon index H' (Labrune *et al.*, 2006) (Table 2). These

Table 2. Summary of characteristics of the biotic/diversity indices used to qualify the ecological status using benthic invertebrates (modified from Borja et al. (2000), Simboura and Zenetos (2002) and Labrune et al. (2006)). EGi: ecological group i, ni: number of individuals of the species i, N: total number of individuals (A), S: number of species, GS: sensitive species in BENTIX and GT: tolerant species in BENTIX.

Biotic index	Algorithms	Index value	Ecological status
AMBI	$\frac{(0 \text{ x } EG_I + 1.5 \text{ x } EG_{II} + 3 \text{ x } EG_{III} + 4.5 \text{ x } EG_{IV} + 6 \text{ x } EG_V)}{100}$	0.0-1.2	High
		1.2-3.3	Good
		3.3-4.3	Moderate
		4.3-5.5	Poor
		5.5-7.0	Bad
BENTIX	$\frac{(6 \text{ x } GS + 2 \text{ x } GT)}{100}$ where $GS = EG_1 + EG_{11}$ and $GT = EG_{III} + EG_{IV} + EG_V$	4.5-6.0	High
		3.5-4.5	Good
		2.5-3.5	Moderate
		2.0-2.5	Poor
		0	Bad
H′	$-\sum_{i=1}^{s} \frac{n_i}{N} - \log_2\left(\frac{n_i}{N}\right)$	> 4	High
		3-4	Good
		2-3	Moderate
		1-2	Poor
		< 1	Bad

Table 3: Values of the physical and chemical parameters measured at sampling stations: As: Arsenic, Ba: Barium, CM: Mineral Carbon, D: Depth (m), T: Temperature (°C), Tr: Transparency, Zn: Zinc. N.B.: Cu, Pb, Cd and Hg are in all stations below the detectability limits, i.e. Cu <0.3 μg.g^{-1}, Pb <0.2 μg.g^{-1}, Cd <0.1 μg.g^{-1}, Hg <0.02 μg.g^{-1}.

Characteristics	Station									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Depth (m)	6.65	1.65	2.2	2.3	2.35	3	1.8	1	0.9	4.4
Temperature (°C)	17.3	17.7	17.5	17.7	17.4	17.2	17.5	16.2	16.5	16.7
Transparency (m)	5.6	>1.6	>2.2	>2.3	>2.3	>3.0	>1.8	>1.0	>0.9	1.8
Organic carbon (%)	-	-	-	2.05	2.77	-	-	1.52	1.21	-
Mineral carbon (%)	11.97	8.79	9.59	9.69	9.34	8.99	9.58	10.59	8.82	9.71
Zn (μg.g^{-1})	6.1	6.2	2.4	1.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
As (μg.g^{-1})	4.3	5.3	8.9	6	7.5	14.7	10	9.6	7	4.3
Ba (μg.g^{-1})	2.2	45.1	45.8	37.9	55.3	49.2	59.7	43.1	33.8	19.8

indices qualify the ecological status within a five-class scale of pollution (high, good, moderate, poor and bad). To link fauna variability (taxonomic groups, trophic groups and ecological groups) to environmental parameters Principal Component Analyses (PCA) were applied using Primer 5 software.

Results

For physical and chemical parameters, only one measurement has been carried out. A synthesis of the results, by station, is reported in Table 3. Organic carbon concentrations were measured only at four stations (S4, S5, S8 and S9). Zn contents are less than 0.1 μg.g^{-1} at 6 stations (S5, S6, S7, S8, S9 and S10), while Pb, Cd, Cu and Hg contents are relatively low at all stations. The values of other parameters ranged from 0.9 to 6.65 m for depth, 16.2 to 17.7 °C for temperature, 0.9 to 5.65 m for transparency, 8.79 to 11.97 % for mineral carbon, 4.3 to 14.7 μg.g^{-1} for As and 2.2 to 59.7 μg.g^{-1} for Ba.

The Principal Component Analyses established on environmental parameters (missing values were not considered in PCA) show that S1 is separated from the rest of the stations, mostly due to its highest values of mineral carbon concentrations (CM), depth (D), transparency (Tr) and Zn contents, and its lowest values of As and Ba contents (Fig. 2). Stations S8, S9 and S10 seem to be opposite to temperature since they correspond to lowest registered values, respectively 16.2°C, 16.5°C and 16.7°C.

The taxonomic identification of the collected invertebrates produced a list of 77 species, unequally distributed among sampling stations (Appendix 1). The estimated faunistic parameters showed ample variations, 6 to 96 ind./m² for abundance, 4 to 41 species for specific richness, 0.64 to 0.97 for evenness and 1.28 to 4.55 bits./ind. for Shannon index (Table 4). BENTIX and AMBI indices gave consistent results classifying all stations in high ecological status with the exception of S9, which is classified in good ecological status. Shannon index H' appeared to be more discriminating, since it has classified

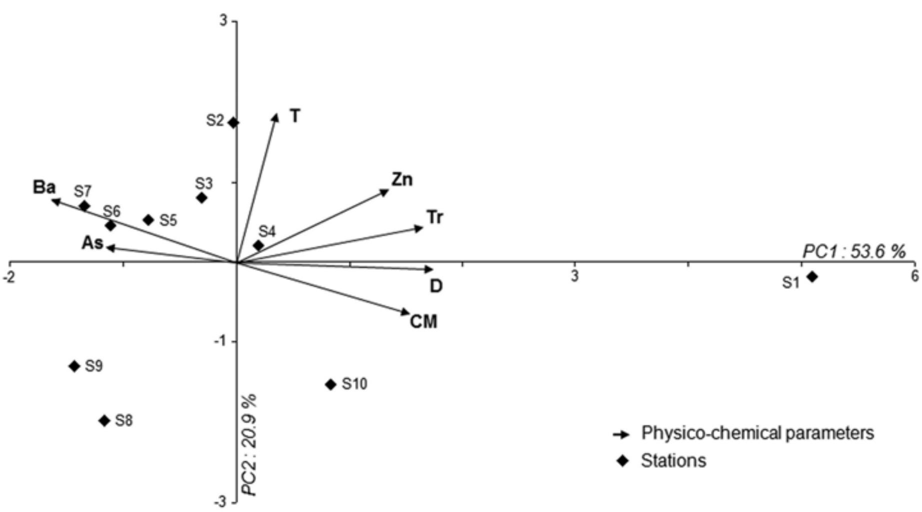


Fig. 2: PCA established on the values of the main environmental parameters registered at sampled stations. As: Arsenic, Ba: Basalt, CM: Mineral Carbon, D: Depth (m), T: Temperature (°C), Tr: Transparency, Zn: Zinc.

Table 4: Calculated values of the main biodiversity and biotic indices at each sampled station, and their position on environmental quality scale.

Station	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
A (ind./m²)	11	86	64	96	17	35	59	71	13	6
S (number of species)	4	22	15	41	8	14	20	23	9	5
J'	0.64	0.79	0.71	0.85	0.88	0.89	0.84	0.90	0.92	0.97
H' (bits/ind.)	1.28	3.54	2.77	4.55	2.65	3.38	3.63	4.08	2.93	2.25
BENTIX	5.45	5.72	5.88	5.65	5.76	6.00	5.86	5.10	4.15	6.00
AMBI	1.09	0.45	0.13	0.44	0.62	0.39	0.29	0.63	1.73	0

environmental quality	high	good	moderate	poor	bad

stations in more ecological statuses.

In general, polychaetes dominate at stations S1 (73%), S2 (47%), S3 (50%) and S9 (46%), gastropods at S5 (82%), S6 (49%) and S10 (83%), bivalves at 51% at S7; S4 and S8 seem to host a more balanced community (Fig. 3a). The PCA showed that polychaete abundance was related to temperature and mineral carbon concentrations; gastropod abundance to depth, Zn contents and transparency, and the other taxonomic groups were related to Ba contents, temperature and mineral carbon concentrations (Fig. 3b).

The trophic structure analysis showed that S1, S2, S3, S4 and S7 are dominated by suspension feeders (SF), S10 by carnivores (C), while S5, S6, S8 and S9 were more balanced (Fig. 4a). The PCA showed that, contrary to carnivores (C), micrograzers (μG) and suspension feeders (SF), the majority of trophic groups (N, H, DF, NSDF and SDF) were positively related to depth, transparency, mineral carbon concentrations and As and Zn contents, and negatively to temperature and Ba contents (Fig. 4b).

The analysis of the relative dominance of the ecological groups showed that the majority of stations were

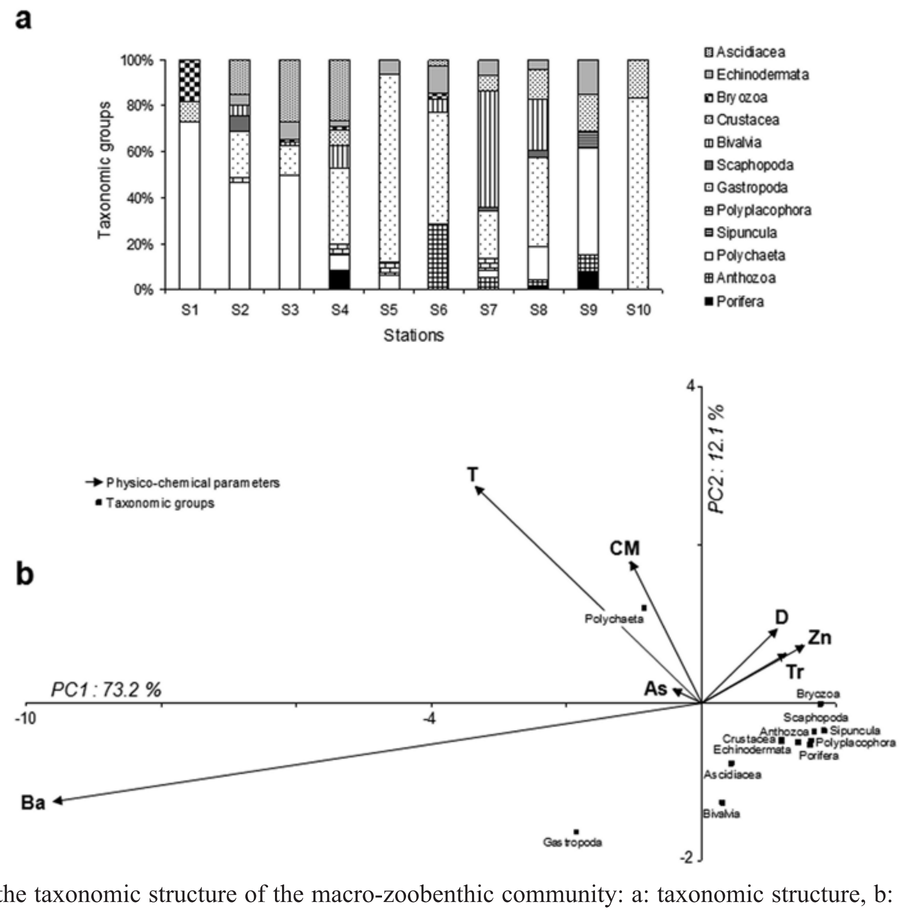


Fig. 3: Analysis of the taxonomic structure of the macro-zoobenthic community: a: taxonomic structure, b: PCA established on taxonomic groups and environmental parameters. As: Arsenic, Ba: Barium, CM: Mineral Carbon, D: Depth (m), T: Temperature (°C), Tr: Transparency, Zn: Zinc.

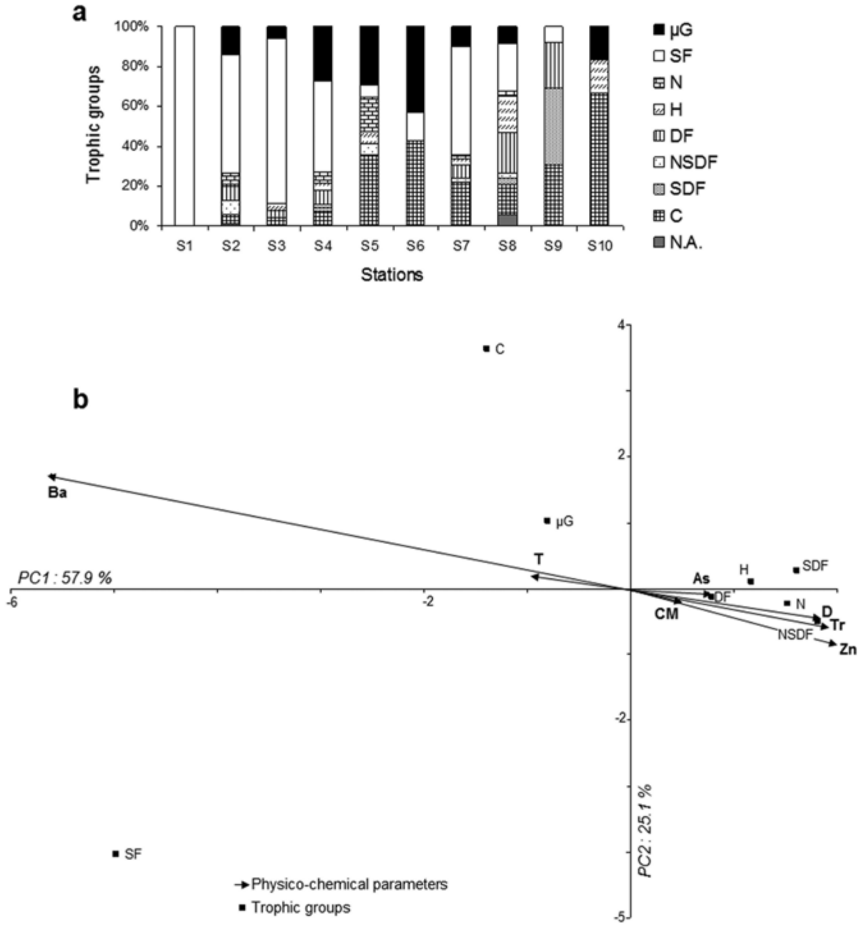


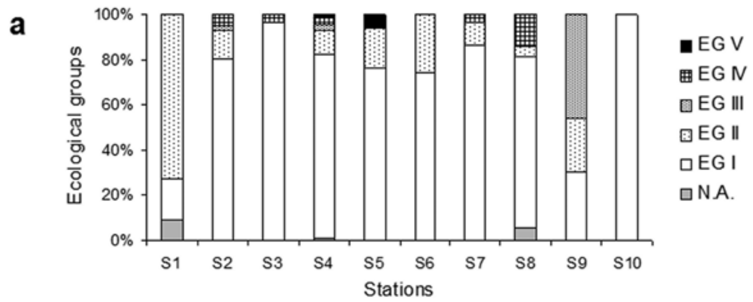
Fig. 4: Analysis of the trophic structure of the macro-zoobenthic community: a: trophic structure, b: PCA established on trophic groups and environmental parameters. As: Arsenic, Ba: Barium, CM: Mineral Carbon, D: Depth (m), T: Temperature (°C), Tr: Transparency, Zn: Zinc.

strongly dominated by EG_{I} (sensitive species), except of S1 and S9, which are dominated by EG_{II} (73 %) and EG_{III} (46 %), respectively (Fig. 5a). The PCA showed that, contrary to EG_{III}, EG_{IV} and EG_{V}, EG_{I} was negatively related with depth, mineral carbon concentrations and As and Zn contents, and positively related with Ba contents. EG_{II} was not related with any of the studied environmental parameters (Fig. 5b).

Discussion

Taking into account the strong correlation between contaminants concentrations and the fine fraction component of the sediment (Caeiro *et al.*, 2005), the fine/medium sands in the studied area seem capable to accumulate metallic/organic pollutants. This allows us to subdivide the sampled stations into three groups. The first group consists of the deepest station S1, located relatively far from the harbour area but in proximity to the ship canal, which appears different from the other stations. Peculiarly, the sediment is relatively more loaded with mineral carbon and Zn, and the water column is more transparent at this station. The second group includes S8, S9 and S10, which are closest to the harbour; these stations are separated from the others in the PCA analyses, notably because of relatively low temperatures. Also, within this group, S10 is relatively less loaded with As and Ba. The third group is formed by the rest of stations, which are more or less homogeneous in term of the environmental characteristics studied, and are relatively more loaded with As and Ba.

In the studied harbour, the recorded values of metallic/organic contaminants are lower than those registered in the north of Tunisia, i.e. Bizerte lagoon, (Afli *et al.*, 2009) and in many other Mediterranean areas (Serbaji, 2000; Ponti & Abbiati, 2004; Magni *et al.*, 2005; Smaoui-Damak *et al.*, 2006), except perhaps Ba content, which appears to be higher. Chouba & Mzoughi-Aguir (2006) showed that heavy metals contents in the Gulf of Gabès are generally low, except in some limited areas facing point sources pollution near Sfax and Gabès cities, where the accumulation of pollutants through time may affect benthic communities. Thus, and taking into



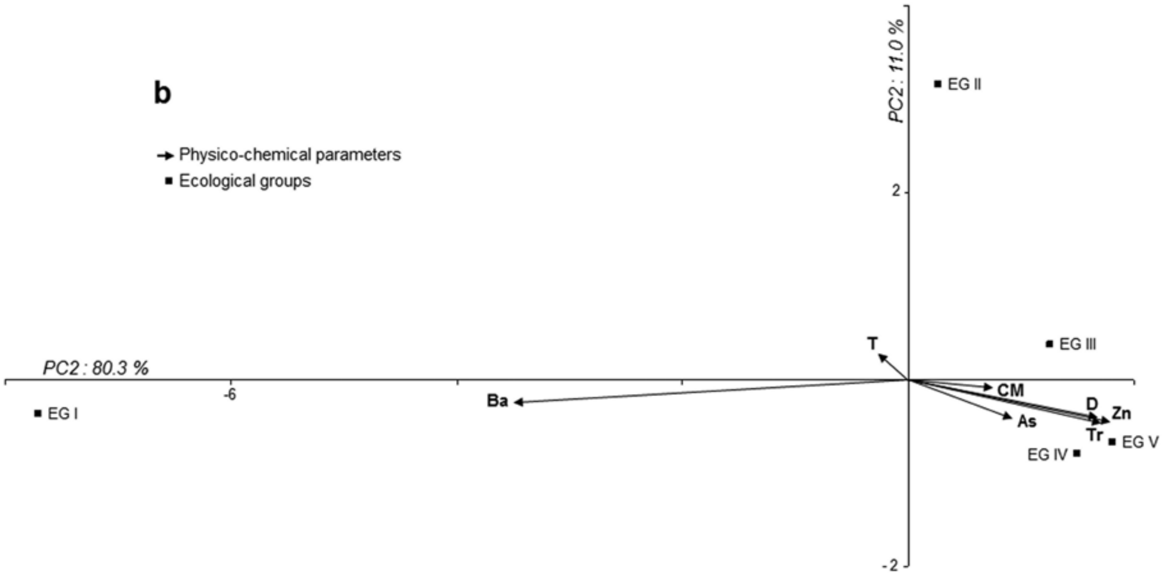


Fig. 5: Analysis of the ecological status of the macro-zoobenthic community: a: trophic groups at sampled stations, b: PCA established on ecological groups and environmental parameters. As: Arsenic, Ba: Barium, CM: Mineral Carbon, D: Depth (m), T: Temperature (°C), Tr: Transparency, Zn: Zinc, EG_I, EG_{II}, EG_{III}, EG_{IV} and EG_V : Ecological groups I to V.

account the recorded values and the absence of metallic pollution sources, the main anthropogenic stress, which could lead to negative impacts on the studied area, is linked with the dredging activities conducted for enlarging and deepening the entrance channel and the harbour basin. This activity causes the destruction of benthic habitats and increases the seawater turbidity, a situation worsened by the deposit and accumulation of dredged materials on both sides of the harbour (along north and south docks).

Despite its productive/ecological importance, the Gulf of Gabès is currently subjected to increased industrial, touristic and leisure activities (Hamza-Chaffai *et al.*, 1997; Smaoui-Damak *et al.*, 2006).

Generally, in coastal areas, several environmental/ anthropogenic factors act together and concurrently on benthic populations, and the instant structure of the community results from the success of adaptation processes (Glémarec, 1993). Therefore, it is very difficult to partition the global effect for each factor separately in the current structure of communities (Puente *et al.*, 2008). In this study, polychaetes dominate at stations farthest from the port (S1, S2 and S3), where the intensity of harbour activities is obviously reduced. On the trophic plan, these stations are dominated by suspension feeders (SF) which may be hampered by the turbidity of the harbour water, which may damage their filtration system. Speaking of the station inside the port (S10), it is dominated by carnivores that probably benefit from fish scraps discarded in the water. These mobile species are more resistant to turbidity disturbance (Afli *et al.*, 2009). Nevertheless, their dominance reflects more a general poverty of the community than a high abundance of carnivore species, since at this station only 5 species were identified with a total abundance of only 6 ind./m². The stations close to the port (S5, S6, S7, S8 and S9) appear to be trophically more balanced, since many trophic groups are represented with various proportions. In fact, it appears that approaching the harbor, where the water is turbid, suspension feeders are increasingly disturbed and other trophic groups start to colonize bottom sediments. Speaking about ecological groups, the strong representation of sensitive species indicates that the Kerkennah area is generally in good ecological status, except maybe the navigation channel (S1), where indifferent species such as the polychaete *Ficopomatus enigmaticus* are largely dominant, or the entrance to the port (S9), where tolerant species such as the polychaete *Eupolymnia nebulosa* dominate. It should be noted that these ecological categories are based on the sensitivity of benthic invertebrates to the organic pollution gradient, and not to other types of disturbance (Glémarec & Hily, 1981); thus, biotic indices based on these groups (e.g., BENTIX and AMBI) are not well adapted to study different types of pollution, such as the physical pollution or the metallic contamination (Reiss & Kröncke, 2005; Afli *et al.*, 2008b; 2009). According to the results of the present study, the calibrated Shannon index H' seems to be more appropriate, since it is based on the diversity of the specific community structure. In fact it appears to be more severe than the other two indices, better discriminating among stations and often reducing them to more degraded status (bad-poor-moderate) (Afli *et al.*, 2009). The two stations with bare sediments, S1 and S10, present the lowest diversity values, although S1 seems to be less affected by the physical disturbances of the port. Thus, these low diversity values can be related more to the sediment type than to pollution conditions.

Concluding, since the factors governing marine life in coastal areas include both environmental and anthropogenic disturbances, studying their effects on ecosystems requires multidisciplinary approaches. Indeed, each discipline brings a contribution more or less large, but necessary, to understand the functioning of the ecosystem. Thus, the use of several approaches in the harbor area of Kerkennah allowed the preliminary assessment of the functional diversity of the benthic community. Ecological, taxonomic and trophic data analyzed together with environmental ones showed that the major factor leading to negative impacts, at only a few stations situated in the navigation canal and within port, is probably linked with physical disturbances due to fishing/harbor activities.

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APPENDIX 1: List of collected species: TG: trophic groups, EG: ecological groups.

Species	TG	EG	Species	TG	EG
Porifera			*Neverita josephinia* Risso, 1826	N.A.	I
Chondrilla nucula Schmidt, 1862	SF	I	*Scaphander lignarius* (Linnaeus, 1758)	C	I
Crambe crambe (Schmidt, 1862)	SF	I	*Tricolia pullus* (Linnaeus, 1758)	H	I
Hemimycale columella (Bowerbank, 1874)	SF	I	**Scaphopoda**		
Ircinia variabilis (Schmidt, 1862)	SF	I	*Antalis dentalis* (Linnaeus, 1758)	NSDF	I
Oscarella lobularis (Schmidt, 1862)	SF	I	**Bivalvia**		
Spirastrella cunctatrix Schmidt, 1868	SF	I	*Arca* sp.	SF	I
Tethya aurantium (Pallas, 1766)	SF	I	*Modiolus barbatus* (Linnaeus, 1758)	SF	I
Anthozoa			*Modiolus modiolus* (Linnaeus, 1758)	SF	I
Actinia equina (Linnaeus, 1758)	C	I	*Pinctada imbricata radiata* (Leach, 1814)	SF	I
Alcyonium palmatum Pallas, 1766	C	II	*Pinna nobilis* Linnaeus, 1758	SF	I
Anemonia sulcata (Pennant, 1777)	C	I	*Solen marginatus* Pulteney, 1799	SF	I
Polychaeta			*Tellina tenuis* da Costa, 1778	SDF	I
Capitella capitata (Fabricius, 1780)	NSDF	V	**Crustacea**		
Eupolymnia nebulosa (Montagu, 1818)	SDF	III	*Carcinus aestuarii* Nardo, 1847	C	III
Ficopomatus enigmaticus (Fauvel, 1923)	SF	II	*Balanus amphitrite* Darwin, 1854	SF	N.A.
Hediste diversicolor (O.F. Müller, 1776)	Dt	IV	*Gammarus aequicauda* (Martynov, 1931)	Dt	I
Perinereis cultrifera (Grube, 1840)	Dt	III	*Gammarus* sp.	Dt	I
Serpula vermicularis Linnaeus, 1767	SF	I	*Idotea* sp.	H	N.A.
Sipuncula			*Maja squinado* (Herbst, 1788)	C	I
Golfingia (Golfingia) elongata (Keferstein, 1862a)	SDF	I	*Orchestia gammarellus* (Pallas, 1766)	Dt	I
Polyplacophora			*Processa edulis* (Risso, 1816)	Dt	I
Chiton (Rhyssoplax) olivaceus Spengler, 1797	µG	I	*Sphaeroma serratum* (Fabricius, 1787)	C	II
Lepidochitona (Lepidochitona) cinerea (Linnaeus, 1767)	µG	I	*Talitrus saltator* (Montagu, 1808)	Dt	I
Gastropoda			**Bryozoa**		
Cerithium vulgatum Bruguière, 1792	µG	I	*Electra posidoniae* Gautier, 1954	SF	I
Fissurella sp.	µG	I	*Schizobrachiella sanguinea* (Norman, 1868)	SF	I
Haliotis tuberculata f. lamellosa Lamarck, 1822	µG	I	**Echinodermata**		
Haliotis tuberculata Linnaeus, 1758	µG	I	*Acrocnida brachiata* (Montagu, 1804)	C	I
Nassarius reticulatus (Linnaeus, 1758)	N	II	*Asterina gibbosa* (Pennant, 1777)	C	II
Aplysia depilans Gmelin, 1791	H	N.A.	*Astropecten spinulosus* (Philippi, 1837)	C	I
Calliostoma zizyphinum (Linnaeus, 1758)	H	I	*Holothuria (Holothuria) tubulosa* Gmelin, 1791	SF	I
Cantharidus sp.	N.A.	I	*Holothuria (Panningothuria) forskali* Delle Chiaje, 1823	SF	I
Diodora italica (Defrance, 1820)	µG	I	*Ophioderma longicauda* (Bruzelius, 1805)	C	I
Euspira sp.	C	II	*Ophiothrix fragilis* (Abildgaard, in O.F. Müller, 1789)	SF	I
Gibbula albida (Gmelin, 1791)	H	I	*Ophiura ophiura* (Linnaeus, 1758)	C	II
Gibbula ardens (Von Salis, 1793)	H	I	**Ascidiacea**		
Gibbula divaricata (Linnaeus, 1758)	H	I	*Aplidium proliferum* (Milne-Edwards, 1841)	SF	I
Gibbula varia (Linnaeus, 1758)	H	I	*Botryllus schlosseri* (Pallas, 1766)	SF	I
Hexaplex (Trunculariopsis) trunculus (Linnaeus, 1758)	C	I	*Ciona intestinalis* (Linnaeus, 1767)	SF	I
Hypselodoris picta (Schultz in Philippi, 1836)	C	I	*Clavelina lepadiformis* (Müller, 1776)	SF	I
Mitra (Mitra) cornicula (Linnaeus, 1758)	H	I	*Phallusia fumigata* (Grube, 1864)	SF	I
Monodonta sp.	µG	I	*Phallusia mammillata* (Cuvier, 1815)	SF	I
Nassa sp.	N	II	*Polycitor crystallinus* (Renier, 1804)	SF	I