JJBS
Jordan Journal of Biological Sciences

Volume 4, Number 3, September 2011
ISSN 1995-6673
Pages 129 - 136

Micromycetes in Sand and Water along the Algerian Western Coastal Areas

Amaria Matallah-Boutiba[1,*], Nadjet Benmessaoud[1], Zakaria Benmansour[2] and Ziouni Boutiba[1]

[1]*Laboratoire Réseau de Surveillance Environnementale LRSE, Département de Biologie Faculté des Sciences, Université d'Oran ,*
[2]*Laboratoire de Parasitologie- Mycologie, CHU d'Oran, Algérie.*

Received 16 February 2011; received in revised form 19 April 2011; accepted 26 April 2011

Abstract

The littoral represents the final compartment of the entropic rejections generating great quantities of organic matters. These areas represent an ideal place for the development of saprotrophic fungal communities. The distribution and diversity of microfungi in the littoral region of the Algerian Western Coast was investigated for the first time. Sixty four samplings of sand (surface and 5 cm deep) and water (surface and 1 m deep) were carried out during the dry and rainy seasons. From the study, more than 250 strains belonging to 15 different genera had been isolated from water and sandy beaches. Data indicated a clear abundance (85%) of *Penicillium*, *Aspergillus*, Muccorales, *Cladosporium*, *Trichoderma* and *Fusarium* in the littoral region of the Algerian Western Coast.

Keywords: Filamentous fungi, sea water, sand beaches, Algerian western coast, littoral.

1. Introduction

In the seas and oceans, the fungus occupied all the habitats of surface water, and some fungal biotypes are adapted to living deeply in the ocean. There are many environmental problems, like marine erosion, pluvial water and domestic waste disposal on the beach, causing the water to be inappropriate for bathing and contact sports in some areas.

Fungi are important components of ecosystems as they are cosmopolitan and usually isolated from tropical, subtropical and temperate countries (Smith and Berry, 1975). They are considered the most active microorganisms in the decomposition of organic compounds both in sand and water (Moore-Landecker, 1996). When compared to thousands of fungal species known from terrestrial environments, only 500 have been described for oceans and estuaries although they comprehend the largest part of the Earth's surface (Kohlmeyer and Kohlmeyer, 1979; Kohlmeyer and Volkmann-Kohlmeyer, 1991). The described species are mainly the anamorphous of Ascomycota and Basidiomycota, including some marine yeast. Some of these marine filamentous fungi are parasites of marine algae or marine angiosperms, or they grow symbiotically with brown algae (Kingham and Evans, 1986). Most of the publications referring to filamentous fungi in marine environments are centered on Europe and North America (Dabrowa *et al.*, 1964, Kishimoto and Baker, 1969; Kirk, 1983; Tan, 1985). However, in Brazil, studies such as Faraco and Faraco (1974), Mattede *et al.* (1986), Purchio *et al.* (1988), Pinto *et al.* (1992), and Sarquis and Oliveira (1996) may be highlighted. Very recently, a special interest, by certain scientists in the world, was established to investigate marine fungi because of their important utility in agroalimentary and health and their great harmful effects through producing toxic substances that cause digestive dysfunctions to humans.

By following up the causes behind many food poisoning cases recorded in Canada and France, researchers identified marine fungi as the only reason behind these pathological signs that usually appear in individuals who consume seafood containing shells (Brewer *et al.*, 1993). Many authors emphasized that fungal species in marine environment are known to produce mycotoxins. Among those authors, Landreau (2001) studied the metabolites of *Trichoderma koningii Oudemans*; Grovel (2002) and kerzaon *et al.* (2008) characterized the gliotoxin secreted by *Aspergillus fumigatus*; Petit *et al.* (2004) investigated the griseofulvin of *Penicillium waksmanii*, and Mohamed-Benkada (2006) evaluated the fungal risk in conchylaceous zone of *Trichoderma* genus.

Oran city has approximately two million inhabitants and about 70% of the population is served by a sewage collection system. The sewage is discharged in the sea without treatment. Ain Eturk, Eden, Andalouses, and Madagh represent the main beaches in Oran. However,

[*] Corresponding author: zitouniboutiba@yahoo.fr

they present serious environmental problems as they are intensively visited by tourists and local visitors (Boutiba *et al.*, 2003). The mycota of these beaches is practically unknown, especially with respect to human pathogens. Therefore, considering the lack of studies on the diversity of filamentous fungi in Oran beaches, the aim of this work was to isolate and identify filamentous fungi from four sandy beaches during the dry and rainy seasons.

2. Material and Methods

2.1. Study area

Oran city is approximately 2121 km² located at 35°43’N 0°37’W. The beaches of Ain Eturk (S1), Eden (S2), Andalouses (S3), and Madagh (S4) are the main beaches in Oran (Fig. 1). As urban beaches, they are intensively visited by tourists and locals, and present serious environmental conflicts (Boutiba *et al.*, 2003).

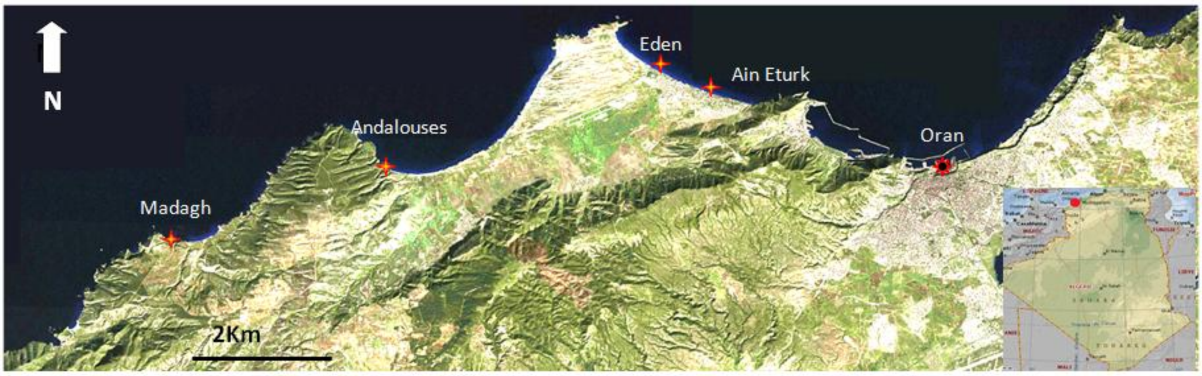

Figure 1. A map showing the study area, Oran city and its main beaches.

The sampling points were chosen in the regions that have the greatest access of bathers and the highest release of domestic sewage.

2.2. Sand and water samplings

Sand and water samplings were concomitantly collected in Ain Eturk, Eden, Andalouses and Madagh beaches, during rainy season (December/2008 and January/2009**)** and during dry season (June and July/2009). Sixty four sand and water samples were concomitantly collected. The sand sampling in each site was carried out using a little garden shovel, in mid-seashore at one meter from the tideline. Samples were taken from surface soil and below at 5 *cm* deep. The samples were placed in labeled plastic bags.

In each sampling site, water samples were collected from surface water and 1 *m* deep using sterile labeled glass tubes. The sand and water samples were kept at room temperature and transferred to the laboratory for later experimental work.

2.3. Isolation, purification and identification of filamentous fungi

Each sand sample (50 g) was diluted in 90 ml of sterilized distilled water, with addition of some drops of Tween 80 making it possible to suspend the spores which could adhere to the grains of sand. The solution was centrifuged at 2500 r/min for 15 min, and then 0.5 ml of the supernatant was spread, in triplicate, onto Petri dishes containing Sabouraud’s dextrose Agar (SDA) with chloramphenicol (500 mg/l). Each water sample (0.5 ml, undiluted) was also spread onto Petri dishes as above. The cultured plates were incubated at 27 °C (±2 °C). As soon as the first colonies were developed, they were transferred to test tubes containing SDA. After the purity of the colonies was confirmed, they were subcultured onto Potato Dextrose Agar, or Czapeck’s Agar, in glass tubes. Fungal identification was carried out by macroscopic and microscopic observations of colonies and when needed, mainly for identification of species level, by microculture on a microscopic glass slides (Riddell, 1950; and Pitt, 1985)

2.4. Sand and water abiotic analysis

Sand and water pH and temperature were measured in the morning with a digital pH-Meter and digital thermometer (Hanna), respectively. Salinity was obtained using a handheld salinity refractometer.

3. Results and Discussion

3.1. Sand and water abiotic data for Ain Eturk, Eden, Andalouses and Madagh beaches

Factors such as water salinity, temperature and pH may influence the activity, abundance and distribution of marine fungi (Dix and Webster, 1995; Sridhar, 2009). Moulds can grow between 0 and 35°C. Certain species are able to grow with extreme temperatures; *Cladosporium herbarum* can develop with temperatures lower than 0°C, and *Aspergillus flavus* or *Aspergillus fumigatus* can tolerate temperature until 60°C (Bourgeois et al., 1996).

The water temperature of Ain Eturk, Eden, Andalouses and Madagh beaches ranges from 20.9 °C to 23.6 °C in the dry season (June and July). In the rainy season (December and January), the minimum water temperature was 13.3 °C while the maximum temperature was 18.2°C. The sand temperature in the dry season reached its minimum at 21.1 °C and maximum at 23.6 °C, and in the rainy season, it was between 13.1 and 19.4 °C. Salinity and the temperature are the most important factors affecting the marine fungi diversity (Booth and Kenkel, 1986).

In Ain Eturk, the water and sand salinity was of 24 and 38.1‰ in the rainy and dry seasons, respectively. Water and sand salinity in Eden was of 20 and 37.8% in the dry and rainy seasons, respectively. Water and sand salinity in Andalouses was of 24 and 37% for Madagh, water and sand salinity was between 15 to 37.4% (Table 1). All water and sand samples had a slightly alkaline pH, varying from 7.78 to 9.21.

In general, marine fungi need high temperatures (usually between 25 and 30 °C) to reproduce (Griffin, 1981). According to Gambale *et al*. (1977), salinity has a great influence in the microbiota of the estuaries. Different studies showed that salinity seemed to affect the metabolism of fungi, as unusual physiological or morphological effects were observed on terrestrial fungal strains when grown on media containing high sodium chloride concentrations (Tresner and Hayes, 1971). Sodium chloride also induced inhibition of cellulolytic ability of fungi belonging to the genus *Aspergillus* (Malik et al., 1980), and Frisvad and Samson (2004) proposed the use of a culture medium with 5% of sodium chloride for the study of fungal secondary metabolites to enhance their production. The tolerance of fungal growth toward salt in the medium seemed to change from species to species and it appeared to be dependent on the culture temperature (Rai and Agarwal, 1973; Mert and Dizbay, 1977; Mert and Ekmekci, 1987).

Table 1. Temperature, pH and salinity of the water and sand from Ain Turk, Eden Andalouses and Madagh beaches.

	Sampling date	Ain Turk						Eden					
		water			Sand			water			Sand		
		pH	T (°C)	S (%)	pH	T (°C)	S (%)	pH	T (°C)	S (%)	pH	T (°C)	S (%)
Rainy saison	12/04/08	7.84	13.3	30	8,15	15,2	25.0	7.78	14.3	29	8,36	13,1	20
	12/20/08	7.87	13.3	31	8.60	16.5	26.0	7.88	14.5	28	8.70	15.2	20.5
	01/03/09	7.88	13.4	29.5	8.61	18.9	24.0	7.94	13.6	27.5	8.85	13.9	30
	01/29/09	7.94	17.0	32	8.70	19.4	28.0	7.94	18.2	30	8.80	14.0	36
Dry saison	06/04/09	8.12	21.0	37	8.82	21.1	26.0	7.98	20.9	36	8.85	22.0	37
	06/23/09	8.17	21.3	37	8.80	21.9	32.0	7.97	22.0	36.2	8.83	22.3	37
	07/01/09	8.25	21.5	37.5	8.85	22.5	36.5	8.12	22.2	36.5	8.85	23.4	37.5
	07/18/09	8.56	22.2	38	9,18	22,9	38.1	8.22	22.3	37.4	9,21	23,6	37.8

	Sampling date	Andalouses						Madagh					
		Water			Sand			Water			Sand		
		pH	T (°C)	S (%)	pH	T (°C)	S (%)	pH	T (°C)	S (%)	pH	T (°C)	S (%)
Rainy saison	12/04/08	7.87	14.1	32	8.34	16.5	24.0	7.88	14.3	34	8.72	16.5	15
	12/20/08	7.84	14.3	31.5	8.60	16.4	26.0	7.98	14.0	33	8.75	16.7	20
	01/03/09	7.94	17.4	33	8.60	18.0	29.5	8.12	18.0	34	8.80	17.3	30
	01/29/09	8.07	16.0	34	8.65	18.4	32.0	8.22	18.2	35	8.82	17.0	33
Dry saison	06/04/09	8.12	21.5	35	8.72	23.0	35.0	8.94	21.9	36	8.88	22.3	36
	06/23/09	8.15	22.0	35	8.83	25.9	36.0	8.94	22.0	36.5	8.73	22.6	36.4
	07/01/09	8.46	22.3	36	8.95	23.4	37.6	8.97	22.3	37	8.95	23.4	37
	07/18/09	8.88	22.3	36.5	9.17	23.5	37.0	9.18	22.4	37.4	9.16	23.5	37.1

Furthermore, those strains from saline environment also showed a reduction in growth rate related to the increase of salt concentration in solid medium (Tresner and Hayes, 1971; Atapattu and Samarajeewa, 1990; Rojas *et al.*, 1991; Tepsic *et al.*, 1997).

Cantrell *et al.* (2006) found 86 isolates from hypersaline environments: *Cladosporium*, *Aspergillus* and *Penicillium.* In Portugal, Barata (2006) reported that the water temperature was (12 to 24°C), the pH (6.6 to 8), and the salinity (2.57 to 31.81). High salt concentrations also affected intracellular growth activities of a strain of *A. foetidus* grown successively on culture media with increasing salt concentrations. It was assumed that this phenomenon would result from the requirement of the organism to synthesize osmo-protective compounds for cell-wall integrity and vacuolar morphology (Thangavelu *et al.*, 2006).

According to Kerazon *et al.* (2008), while fungal development is limited to *A. fumigatus* strains occurring in marine environment, their excretion of gliotoxin is stimulated by a salinity of 33 g/L which would lead to an amplification of toxin release in marine surroundings. In Brazil, Gomes *et al.* (2008) found that the temperature range of water and sand in both rainy and dry seasons was (24.3 to 28.8°C); however the range of pH was 7.70 to 8.22 and the range of salinity was 15 to 40%.

Table 2. Number of strains isolated from each sample collected from the Algerian western coastal areas. S1: Ain Eurk, S2: Eden, S3: Andalouses , S4: Madagh.

			Water								Sand							
			Rainy season				Dry season				Rainy season				Dry season			
	Total	%	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Penicillium	105	41.66	3	1	2	1	3	2	2	1	19	10	13	6	15	11	7	9
Aspergillus	49	19.4	2	1	1	−	1	1	1	2	9	7	6	4	5	4	2	3
Muccorales	29	11.50	2	−	−	−	1	−	−	1	4	3	2	3	5	3	1	4
Cladosporium	16	6.34	2	1	−	−	2	−	2	1	2	2	1	0	2	0	1	0
Trichoderma	8	3.17	−	−	−	−	−	−	1	−	3	2	1	0	0	0	0	1
Fusarium	7	2.77	−	−	−	−	−	−	−	−	2	3	0	0	1	1	0	0
Alternaria	6	2.38	−	−	−	−	−	−	−	−	2	1	1	0	1	1	0	0
Pullularia	4	1.58	1	−	−	−	−	−	−	−	2	0	0	0	0	0	0	1
Verticillium	3	1.19	−	−	−	−	−	−	−	−	1	1	0	0	0	0	0	1
Geotrichum	3	1.19	−	−	−	−	−	−	−	−	2	1	0	0	0	0	0	0
Scopulariopsis	3	1.19	−	−	−	−	−	−	−	−	1	2	0	0	0	0	0	0
Gliocladium	2	0.79	−	−	−	−	−	−	−	−	1	0	0	0	1	0	0	0
Phialophora	2	0.79	−	−	−	−	−	−	−	−	1	0	0	0	1	0	0	0
Acremonium	1	0.39	−	−	−	−	−	−	−	−	1	0	0	0	0	0	0	0
Chrysosporium	1	0.39	−	−	−	−	−	−	−	−	1	0	0	0	0	0	0	0
Unknowns	13	5.15	2	1	1	−	2	−	1	3	0	0	0	0	1	0	1	1
Total	252		12	4	4	1	9	3	7	8	51	32	24	13	32	20	12	20

About 252 fungal strains were isolated (Table 2, Figure 2) and identified from Algerian Western coastal areas for all types of samples combined, belonging to 15 genera of Ascomycetes subphylum. Fungal communities were represented predominantly by strains of *Penicillium* (41.66%), *Aspergillus* (19.44%), Muccorales (11.50%), *Cladosporium* (6.34%), *Trichoderma* (3.17%), *Fusarium* (2.77%), *Alternaria* (2.38%), *Pullularia* (1.58%), *Verticillium* (1.19%), *Geotrichum* (1.19%), *Scopulariopsis* (1.19%) *Gliocladium* (0.79%), *Phialophora* (0.79%), *Acremonium* (0.39%), *Chrysosporium* (0.39%), and "unknowns" (5.15%). These results are in agreement with Oliveira (1996) who particularly studied the diversity of filamentous fungi on Ipanema beach, Sarquis and isolated 34 genera and 170 species. The genera with the most frequent species were: *Aspergillus* (30.4%) and *Penicillium* (16.2%). In Brazil, fifty seven species were isolated with *Aspergillus*, and *Penicillium* were the most frequent genera in both sand and water, with a total of 11 and 19 species, respectively (Gomes *et al.*, 2008). Similar to the present study, Tauk-Tornisielo (2005) isolated soil filamentous fungi from the Ecological Park of Juréia-Itatins, finding that *Aspergillus* and *Penicillium* were the genera with the highest diversity of species. Studying the incidence of anemophilous fungi isolated from Praia do Laranjal, Pelotas, RS, Bernardi and Nascimento (2005) identified 18 genera. The authors found that *Cladosporium* (18.22%), *Alternaria* (13.84%), *Penicillium* (10.20%), *Curvularia* (7.47%) and *Aspergillus* (3.28%) were the genera with the species most frequently found. Moreover, Migahed (2003) studied the fungal genera of highest incidence and their respective numbers of species, concluding that *Penicillium* and *Aspergillus* were the most. Thirty-two manglicolous marine fungi belonging to 23 ascomycetes, 1 basidiomycete and 8 mitosporic fungi were observed from South India coast (Gayatri *et al.*, 2008). It should be noted that a large number of strains isolated from seawater samples could not be identified because their mycelium remained sterile (Gomes *et al.*, 2008).

During the dry and rainy seasons, from sea water and sand, 104 isolate of filamentous fungi, mostly anamorphous, were isolated and identified from S1, 59 from S2, 47 from S3 and 42 from S4 (Figure 2). Some species were common for all the beaches, like *Penicillium, Aspergillus*, Muccorales *and Cladosporium.*

The number of genera in S1 was higher than that in other beaches; this may be due to the fact that this beach is more frequently visited by tourists and local bathers than the other beaches. It may be also due to the proximity of this site to sources of waste water rejections, which certainly contributes to increasing pollution. Similar facts were observed in a study carried out by Purchio *et al.* (1988) and Gomes *et al.* (2008). Conversely, the opposite was found by Mattede *et al.* (1986). The authors evaluated dry and wet sand samples from polluted and non-polluted beaches of the city of Vitória, Espírito Santo and found that the incidence of fungal genera was greater in non-polluted beaches (55%) than in polluted ones (45%).

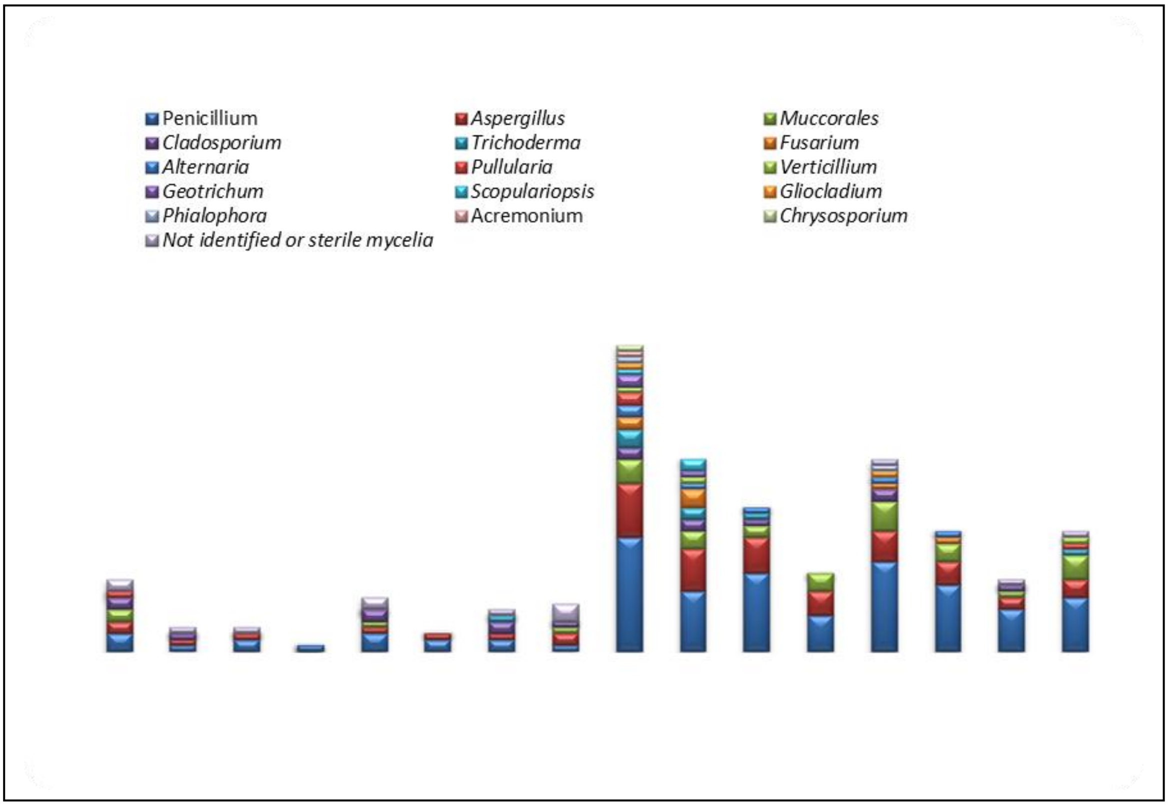

Figure 2. Micromycetes isolated from the four studied beaches of Algerian Western coast.

S1: Ain Eturk, S2: Eden, S3: Andalouses and S4: Madagh

The comparison of the total number of strains isolated by sample type (Table 2) shows that the strain diversity of individual samples was less in seawater (20%) than that of sand (80%). A comparison of the strains found in sand with those isolated from water sand samples had a greater number of strains in which *Penicillium* spp, *Aspergillus* spp, *Cladosporium* spp, Mucorales and *Trichoderma* spp were presented in all types of samples including both sand and water. The similarity in species composition and abundance suggests that these genera are adapted to the marine environment. Genera like *Fusarium, Alternaria, Pullularia, Verticillium, Geotrichum, Scopulariopsis, Gliocladium, Phialophora, Acremonium* and *Chrysosporium* were isolated only from sand samples (Table 2). Thus, the strains found in sand would appear to be more representative of those really present and well-established in the marine environment (Sallenave, 2000). The number of isolates from samples collected during the rainy season (56%) is greater than that collected during the dry season (44%). The results obtained in the present study agreed with similar studies (Gomes *et al.*, 2008). Harrison and Jones (1975) clearly showed that many mould saprolegniales from fresh water cannot reproduce with salinity higher than 30%. During the dry seasons, when the salinity is raised, marine fungi prevail, contrary to that is the case of the rainy season when the salinity is low and the terrestrial fungi are dominant (Sadaba, 1996).

The investigation carried out by Jessica (2004) on three beaches in Bay Mayagüez to Puerto Rico revealed elevated levels of fungi species during the rainy season. The author correlated this distribution with salinity. Salinity variations had a significant effect upon abundance of fungi, especially during the months of May through August, when the temperatures were higher, causing an elevation of salinity levels in sand due to seawater evaporation.

The main pathogenic fungi to humans and animals can be found within the anamorphic fungi. These fungi are saprophytic and occasionally pathogenic, and can be isolated from water, soil, animals and humans. Species of *Aspergillus, Cladosporium* and *Penicillium*, are found in these beaches, and can be a source of infection for superficial and deep mycosis (Sidrim and Moreira, 1999).

In conclusion, this study shows that Algerian Western coastal areas could represent a wide source of fungal communities. Thus, it would appear that littoral coast represents a large fungal reservoir whose role is little understood but is possibly important for animals, plants and the marine and terrestrial ecosystems. Ain Eturk had the highest number of filamenous fungi contamination (41.2%), followed by Eden (20.6%), Andalouses (17.5%), and Madagh (16.6%). The presence of some toxinogenic moulds in marine environment, such as *Penicillium* and *Trichoderma* strains, could represent a potential risk of toxicities for shellfish, involving contaminations and possibly intoxications of shellfish consumers (Sallenave *et al*., 2000). It would be interesting to evaluate the toxicity of some micromycetes isolated from these coastal areas by realising a bioassay screening.

References

Atapattu R and Samarajeewa U.1990. Fungi associated with dried fish in Sri Lanka. Mycopathologia **111 (1)**: 55–59.

Barata M. 2006. Marine fungi from Mira River salt marsh in Portugal. Rev Iberoam Micol., **23**: 179-184.

Bernardi E. and Nascimento, JS. 2005. Fungos anemófilos na Praia do Laranjal, Pelotas, Rio Grande do Sul, Brasil. Arq. Inst. Biol. **72(1)**: 93-97.

Booth T. and Kenkel N. 1986. Ecological studies of lignicolous marine fungi: a distribution model based on ordination and classification. In: **The Biology of Marine Fungi** (Ed. S.T. Moss). Cambridge University Press, Cambridge, pp. 297-310.

Bourgeaois CM, Mescle JF. and Jucca J. 1996. Microbiologie alimentaire, Tome 1 : Aspect microbiologique de la sécurité et de la qualité des aliments. Lavoisier Tech et Doc, France.

Boutiba Z, Taleb M Z. and Abi Ayad SM. 2003. **Etat de la Pollution Marine de la Côte Oranaise**. Ed. Dar El Gharb (Oran-Algérie): pp. 69.

Brewer D, Greenwel M. and Taylor A. 1993. Studies of *Trichoderma* sp. isolated from Mytilus eludis collected on shores of cap breton and Prince Edward islands. Proc.N.S.Inst.Sci., **40 (1)**: 29-40.

Cantrell A, Casillas-Marti´Nez L. and Molina M. 2006. Characterization of fungi from hypersaline environments of solar salterns using morphological and molecular techniques. Mycological Res., **110**: 962-970.

Dabrowa N. 1964. A survey of tide – washed coastal area of Southern California for fungi potentially pathogenic to men. Mycopathol. Mycol., **24 (1-4):**137-150.

Faraco BF. and Faraco AF. 1974. Poluição hídrica micológica. Rev. Bras. Med., **33**: 385-388.

Frisvad JC. and Samson RA. 2004. Polyphasic taxonomy of *Penicillium* subgenus *Penicillium*. A guide to identification of food and air-borne terverticillate Penicillia and their mycotoxins. In: ***Penicillium* Subgenus *Penicillium*: New Taxonomic Schemes, Mycotoxins and Other Extrolites, Studies in Mycology**, vol. 49. Centraalbureau voor Schimmelcultures, Utrecht, the Netherlands, pp. 1–174.

Gambale W, Purchio A. and Croce J. 1977. Flora fúngica anemófila da grande São Paulo. Rev. Microbiol., **8**:74-79.

Gayatri R, Nambiar K. and Raveendran N. 2009. Manglicolous marine fungi on *Avicennia* and *Rhizophora* along Kerala Coast (India). Middle-East J of Sci Res., **4 (1)**: 48-51.

Gomes DN, Cavalcanti MA, Fernandes MJ, Lima DM. and Passavante JZ.2008. Filamentous fungi isolated from sand and water of "Bairro Novo" and "Casa Caiada" beaches, Olinda, Pernambuco Brazil. Braz. J. Biol., **68(3)**: 577-582.

Griffin DH. 1981. **Fungal Physiology**. Canada: John Wiley & Sons. pp 383.

Grovel O. 2002. La gliotoxine métabolite cytotoxique d'une souche *d'Aspergillus fumigatus* de zone conchylicole: mise en évidence, production en milieu marin, développement de méthodes de détection et d'évaluation. These. : Pharmacie: Nantes : 272 p.

Harrison JL and Jones EB. 1975. The effect of salinity on sexual and asexual sporulation of members of the *Saprolegniaceae.* Transactions of the British Mycol Soc., **65:** 389-394.

Jessica Y, Ruiz-Suárez. 2004. Arenicolous filamentous fungi in mayagüez bay shoreline, western Puerto Rico. Mém. Master , Univ. Puerto Rico, Mayagüez Campus: 73p.

Kerzaon I, Grovel O, Monteau F, Le Bizec B, Nourisson MR, Biard JF. and Pouchus YF. 2009. Structural investigation and elucidation of new communisis from marine-derived *Penicillium expansum* Link by liquid chromatography/electrospray ionization ion trap tandem mass spectrometry. Rapid Commun. Mass Spectrom., **23(24):**3928-3938.

Kerzaon I, Grovel O, Robiou T, Pont D, Le Pape P. and Pouchus Y-F. 2008. Effects of seawater on growth and gliotoxin excretion of marine strains of *Aspergillus fumigate.* Fres Toxicon., **51(3):**398-405.

Kingham DL. and Evans LV. 1986. Pelvetia – *Mycosphaerella* interrelationship. In Moss, ST. (Ed.). **The Biology of Marine Fungi**. Cambridge: Cambridge University Press. pp 177-187.

Kirk-J, PW. 1983. Direct enumeration of marine arenicolous fungi. Mycol., **75**: 670-682.

Kishimoto R. and Baker Ge.1969. Pathogenic and potentially pathogenic fungi isolated from beach sand and selected soil of Oahu, Hawai. Mycol., **61**: 537-548.

Kohlmeyer J. and Kohlmeyer E.1979. **Marine Mycology: The Higer Fungi**. London: Academic Press.

Kohlmeyer J. and Volkmann-Kohlmeyer B. 1991. Illustrated key to the filamentous higer marine fungi. Bot. Mar., **34 (1)** :1-61.

Landreau A. 2001. Métabolites d'une souche de *Trichoderma koningii Oudemans* isolée du milieu marin : Etude chimique, biologique et risques pour les coquillages en culture . Theses : Pharmacie : Université de Nantes 201 p.

Malik KA, Kauser F. and Azam F.1980. Effect of sodium chloride on the cellulolytic ability of some aspergilli. Mycologia **72 (2) :** 322–328.

Matallah-Boutiba A. 2009. Inventaire des espèces fongiques des eaux marines du littoral occidental algérien. Thèse. Doct, Univ Oran, Algérie : 143p.

Mattede M, Nascimento F, Mattede A. and Junior L.1986. Flora micótica das praias oceânicas poluídas e não poluídas em clima de verão. Cienc. Cult., **38(4):** 664-670.

Mert HH. and Dizbay M. 1977. The effect of osmotic pressure and salinity of the medium on the growth and sporulation of *Aspergillus niger* and *Paecilomyces lilacinum* species. Mycopathologia **61 (2)**: 125–127.

Mert, HH. and Ekmekci S. 1987. The effect of salinity and osmotic pressure of the medium on the growth, sporulation and changes in the total organic acid content of *Aspergillus flavus* and *Penicillium chrysogenum*. Mycopathologia **100 (2)**: 85–89.

Migahed F. 2003. Distribution of Fungi in the Sandy Soil of Egyptian Beaches. Mycobiology **31(2)**: 61-67.

Mohamed-Benkada M. 2006. Evaluation du risque fongique en zone conchylicole : substances toxiques de souches marine du genre *Trichoderma*. Thèse Faculte des Sciences Nantes: 140 p.

Moore-Landecker E. 1996. **Fundamentals of the Fungi**. New Jersey: Prentice Hall Inc. pp574.

Petit KE, Mondeguer F, Roquebert M F, Biard J F. and Pouchus YF. 2004. Detection of griseofulvin in a marine strain of *Penicillium waksmanii* by ion trap mass spectrometry. J Microbiol Methods **58(1)**: 59-65.

Pinto I. Cavalcanti, M. and Passavante, J. 1992. Hongos filamentosos aislados desde el suelo y el agua en la playa de Boa Viagem, Recife, Brasil. *Bol. Micol.*, **7(1-2)**: 34-45.

Pitt Ji.1985. **A Laboratory Guide to Common *Penicillium* species**. Australia: Academic Press. pp182.

Purchio A, Gambale W. and Paula Cr. 1988. Molds from some beaches in the Southern area of São Paulo state (Baixada Santista), Brazil. Rev. Microbiol., **19(2)**:??

Rai JN. and Agarwal SC. 1973. Salinity optima as affected by temperature for some ‘‘Usar’’ soil *Aspergilli*. Mycopathol. Mycol. Appl., **50 (4):** 307–312.

Riddell RW.1950. Permanent stained mycological preparations obtained by slide culture. Mycologia, **42(2)**: 265-270.

Rosas-Acevedo JL, Boucias DG, Lezama R, Sims K. and Pescador A. 2003. Exudate from sporulating cultures of *Hirsutella thompsonii* inhibit oviposition by the two-spotted spider mite *Tetranychus urticae*. Exp. Appl. Acarol., **29 (3–4)**: 213–225.

Ruiz N, Petit K, Vansteelandt M, Kerzaon I, Baudet J, Amzil Z, Biard J-F, Grovel O. and Pouchus Y-F. 2010. Enhancement of domoic acid neurotoxicity on Diptera larvae bioassay by marine fungal metabolites. Toxicon. , **55(4):** 805-810.

Sadaba RB. 1996. An ecological study of fungi associated with the mangrove associate *Acanthus ilicifolius* in Mai Po, Hong Kong. Ph.D. Dissertation, Department of Ecology and Biodiversity, University of Hong Kong, Hong Kong.

Sallenave C. 1999. Etude de la flore fongique des zones conchylicoles de l'estuaire de la Loire, recherche de souches toxinogènes. Theses : Pharmacie : Université de Nantes, 194 p.

Sallenave-Namont C, Pouchus YF, Robiou du Pont T, Lassus P. and Verbist JF. 2000. Toxigenic saprophytic fungi in marine shellfish farming areas. Mycopathologia **149**: 21-25.

Sarquis MIM . and Borba CM. 1997.*Fusarium* species in sandy soil from Ipanema beach, Rio de Janeiro, Brazil. J Basic Microbiol, **37**: 425–429.

Sarquis MIM. and Oliveira PC. 1996.Diversity of microfungi in the sandy soil of Ipanema beach, Rio de Janeiro, Brazil. J Basic Microbiol, **36**: 51–58.

Sidrim J. and Moreira J. 1999. Fundamentos clínicos e laboratoriais da micologia médica. Rio de Janeiro: Guanabara Koogan. 287 p.

Smith J. and Berry D. 1975. **The Filamentous Fungi. I. Industrial Mycology**. London: Edward Publications. 340 p.

Tan TK. 1985. Observations on marine fungi in Singapure and Penang (Malaysia). Trans. British Mycol. Soc.,**85(4):**726-727.

Tauk-Tornisielo SM, Garlipp A, Ruegger M, Attili DS. and Malagutti E. 2005. Soilborne filamentous fungi in Brasil. J. Basic Microbiol., **45(1):** 3-93.

Tepsic K, Gunde-Cimerman N. and Frisvad JC. 1997. Growth and mycotoxin production by *Aspergillus fumigatus* strains isolated from a saltern. FEMS Microbiol. Lett., **157 (1)**: 9–12.

Thangavelu V, Tang J, Ryan D. and Valix M. 2006. Effect of saline stress on fungi metabolism and biological leaching of weathered saprolite ores. Miner. Eng., **19 (12)**: 1266–1273.

Tresner HD. and Hayes JA. 1971. Sodium chloride tolerance of terrestrial fungi. Appl. Microbiol., **22(2)** : 210–213.