

Survey: Sources, Distribution and Effects of Marine Pollution in the Monastir Bay (eastern of Tunisia, Central Mediterranean Sea)

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DOI: [10.21276/haya.2019.4.5.5](https://doi.org/10.21276/haya.2019.4.5.5)

| Received: 09.06.2019 | Accepted: 19.06.2019 | Published: 30.06.2019

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Abstract

The seas and oceans form integrated ecosystems giving life to many species and represent food and socio-economic benefits sources for millions of persons around the world. Unfortunately, nowadays these sources suffer from marine pollution which becomes a major problem that has negative effects on all of the planet's marine ecosystems. In the bay of Monastir (center coast of Tunisia), as many parts of the globe, economic development has been most active in this coastal zones, especially textile industry, fishing and aquaculture activities, putting enormous pressures on this coastal ecosystem. In this study, we tried to collect informations about the impact of marine water pollution in the bay of Monastir from sea users (fishermen, professional or not), and we tried to identify the main zones of pollution that may be potential zone for the intervention of protected area managers in the future.

Keywords: Survey, marine pollution, source of pollution, pollution impact, Monastir bay (Tunisia).

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INTRODUCTION

Marine ecosystems, upon which humans depend, are increasingly under pressure from anthropogenic activities. Coasts are particularly vulnerable to increasing exploitation, habitat alteration, pollution and climate change. Meanwhile, human populations are increasing in coastal areas [1]. Human have long used the marine environment as a source of food and other raw materials. The fisheries are invigorated, over-harvested some species to near extinction, and polluted several marine ecosystems beyond quick repair [2]. Marine ecosystem health is dependent on maintenance of biological diversity and ecological processes through the composition, structure, and function of that ecosystem. Currently, the health degradation of global marine ecosystems becomes more remarkable. Fish stocks have been decreased and some of it depleted due to lack of proper regulation, rapid improvements in fishing gear technology, and a growing human population's demand [2]. In the last 20 years, the aquaculture expanding raise questions of marine health and sustainability [3-6]. Marine pollution is an intergenerational and global environmental problem, and studies around the world caution that the problem is growing [7]. Bio-toxins accumulation, oil spills, and improper waste management contribute to this problem [2].

The Mediterranean Sea is among a vulnerable marine ecosystem on Earth. However, estuaries and coastal zone are characterized by the highly productive aquatic ecosystem of the world [8]. The Mediterranean Sea ecosystem is highly diverse. This diversity has contributed to human's connection with the sea due to their socio-economic valuable and ecological resources. Although the Mediterranean Sea covers only 0.7% of the world's ocean area, it is one of the major reservoirs of marine and coastal biodiversity, with 7.5% of the world's marine fauna and 18% of its marine flora. This sea is rich in islands and underwater beds and represents a major area of reproduction and migration [9].

In the central of the Mediterranean Sea, Tunisia occupying a widely into the sea, chiefly on its eastern shores. Tunisia overlook the Mediterranean Sea with a 2290 km of coastline, where 1566 km of continental linear, 457 km of linear island and 267 km of artificial linear (Harbor, Marina) [10], where the Tunisian coast represents one of the high diversity hot spots in the Mediterranean Sea [11].

The Monastir bay is characterized by high marine productivity due to its biogenic diversity, which

makes it a major resource for people. The Monastir Bay represents an important nursery side for numerous invertebrate and vertebrate species due to the high extent of seagrass meadows *Posidonia oceanica*. Accordingly, 44% of the national fish production from aquaculture and fishing takes place in the bay [5]. Nevertheless, the bay is reignited as a fragile area due to its reduced hydrodynamics [12, 13], sub-marine topography. At the same time, the Monastir Bay has known a significant anthropogenic expansion with an increase of urban density, dump of multiple wastewaters from the urban zone and industrial activities like agriculture, textile, fishing, and fish farming. These activities have severe impact on the coastal marine environment of the Bay of Monastir that induced its degradation [12, 13].

In order to survey the Monastir bay environmental and to protection marine resources and biodiversity, it is essential to investigate the essential sources, paths and effects of pollution in marine biodiversity in the Monastir bay using a survey study. This study based to provide a based data from mostly used coastal fishing and some trawling and longline vessels, to accord a socio-economic problem

and monitor, and determine the source, paths and effects of pollution generated in the Monastir bay.

MATERIALS AND METHODS

Study Area

The Monastir Bay (Fig-1) is located in the Eastern part of Tunisia (central Mediterranean) and extends for 38 km of littoral and about 130 square nautical miles of surface waters, with a complex shoreline and Great and Small Kuriat islands. The bay considered as a semi-enclosed lagoon, where it is delimited by two shoal structures as the Rass Dimes sand spit in the South-East and the El Enf sand spit in the North-West. The sub-marine topography highlights a basin depth of 0.9-3 m deep extending over 900 m and 2000 m, between Khniss and Sayada, and not exceeding 30 m at 10 km of the coast [13, 5]. The wind speed, in the Monastir bay, varied between 1 - 5 ms⁻¹, and dominated by W, NNE and E directions with an occurrence of 10.7%, 8.5% and 7.6%, respectively [23]. Kuriat islands (Great Kuriat and Small Kuriat) should have a protected statutes which this site are largely colonized by a vegetation of underwater phanerogams with high extent of seagrass meadows *Posidonia oceanica* [14] and represent the most important nesting site of the marine sea turtle *Caretta caretta* [15].

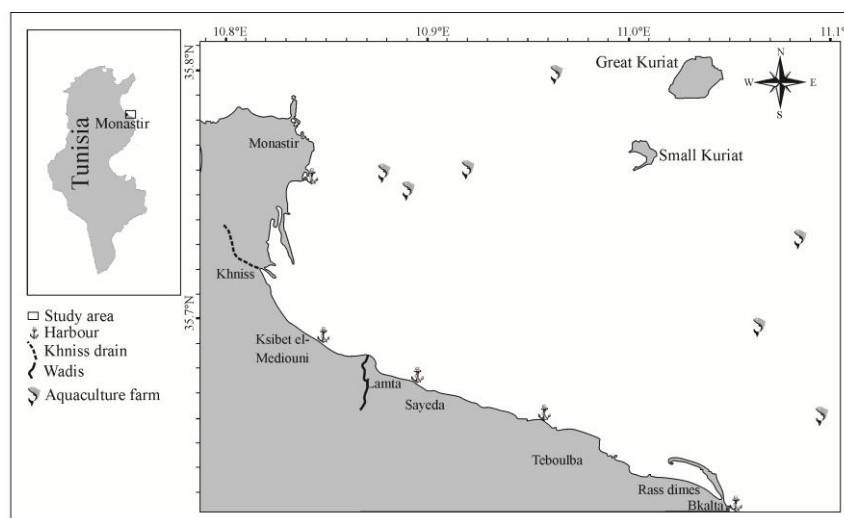


Fig-1: Geographical location of the study area

Monastir has remarkably experienced increase industrial activities (agri-business industry, textile, offshore fish farm...) and in urban density. The allochthonous inputs in Monastir are driven by fresh and waste-waters. Wastewaters are discharged directly in the sea via two wastewater of the El Frina and the Lamta_Sayada treatment plants stations (Figure-1). The average daily discharge of wastewater flow are 6500 m³ at El Frina station and 3000 m³ at Lamta_Sayada station [13]. Freshwaters are mainly drained via the Khniss drain that is in the same time collect industrial and domestic wastewaters. The Monastir bay encompasses ten active offshore fish farms, where 44% of the national fish production from fishing and

aquacultures takes place in the bay [5]. The Kuriat islands considered as an important source of coast fishing activity in the bay. The coastal fringe of the Monastir bay accounts seven harbors where one marina harbor (Monastir) and six fishing harbors with a single deep-sea harbor (Monastir), two coastal harbors (Sayada and Teboulba), two shelter sites (Ksibet El Mediouni and Bkaltia) and a landing point (Khniss).

Questionnaire Content

The methodology of this study was based on a questionnaire survey that targets fishermen, practicing coastal fish and yachtsman to draw their overview to determine the sources of pollution, the critical polluted

zone and the impact of pollution on the marine biodiversity. The questionnaire survey was affected in five harbors (Marina, Monastir, Ksibet El Mediouni, Sayada, Teboulba and Bekalta,). This data will be implemented within a scientific census.

Index cards of inquiries were prepared, as a support data to conducting the inquiry. The collect data concerned mainly the following aspects: (1) Sources of pollution; (2) draw the polluted zone; (3) impact of pollution in marine biodiversity and in the socio-economic status such as the quantitative and qualitative fish landings.

RESULTS

Socio-Demographic Profile

The 51 interviews were performed in five harbors as mentioned in Table 1. The age of the interviewed varied between 15 - 74 years with a work

experience between 4 to 50 years. From all the interviewed, we counted only 3 yachtsman (non-professional fishers) and 48 fishermen as professionals. In total, 4% of them have a work experience less than 10 years, 44% between 10 - 30 years, and 52% more than 30 years. 63% of fishermen confirmed practicing coastal fishing when they were questioned about the fishing type, 31% worked with trawling and only 2% practiced bigger fishing scales using tuna boats.

When the interviewed were asked about their areas of work, they defined almost three frequent zones; the first do not exceed 20 km, the second ranging between 21- 120 km, and the third beyond 120 km, with the percentage of 34%, 31% and 32%, respectively. However, 65% of the fishermen (professional or not) declared that they are active near the coast and the nearby Kuriat islands.

Table-1: Socio-demographic profile of questioned fishermen

Harbors	Number of interviewed	Ages of interviewed
Marina	4 interviewers	[27-39]
Monastir	15 interviewers	[22-66]
Ksibet El Mediouni	3 interviewers	[26-72]
Sayada	6 interviewers	[45-60]
Teboulba	17 interviewers	[22-71]
Bekalta	6 interviewers	[27-74]

Knowledge of the Environmental Status of the Monastir Bay

All the respondents reported existing marine environment pollution in the Monastir bay. To rank the current level of pollution, the interviewed fishermen had been asked to evaluate the pollution degree from

“1” to “10”, with “1” corresponding to “very low polluted” and “10” referring to “very high polluted”. The respondents reported that the pollution degree varied between 3 and 10, almost 76% of them noted that the degree in the Monastir bay was higher than “7” (Figure-2).

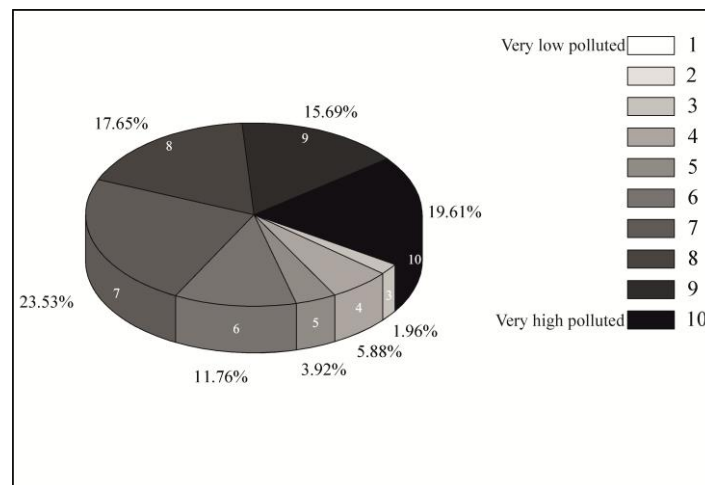


Fig-2: Pollution level in the Monastir bay

The majority of respondents (62.16%) consider that the pollution factors result from the absence of control. However, 27.03% of them think that regulation deficiency contributed to this situation and only 10.81% attributed that to population growth.

Source of Pollution

In order to determine the impact of pollution in the bay of Monastir, determining the pollution sources was the objective of this survey through investigations. The interviewed fishermen's responses (professional or not) shows a high perception of the pollution sources issues, and 100% confirmed that the

Monastir bay suffers from different sources of pollution. By analyzing the interviewees' answers, 11 common causes of pollution were deducted from 156 listed. The classification of the main sources of polluted revealed that fish farms represents the first source of marine pollution (26.92%), followed by discharge of wastewaters treatment plants (25.64%). Between 78% and 84% of the interviewed mentioned these two main

causes, followed by the industrial activity (10.26%), Wadis discharge, illegal fishing, and oil and hydrocarbon (8.33%), harbor activities and others sources of pollutions (5.33%) (Figure-3). Moreover, 2% of the interviewed perceived the bathymetry and the climate change to have an effect on the pollution spread in the bay.

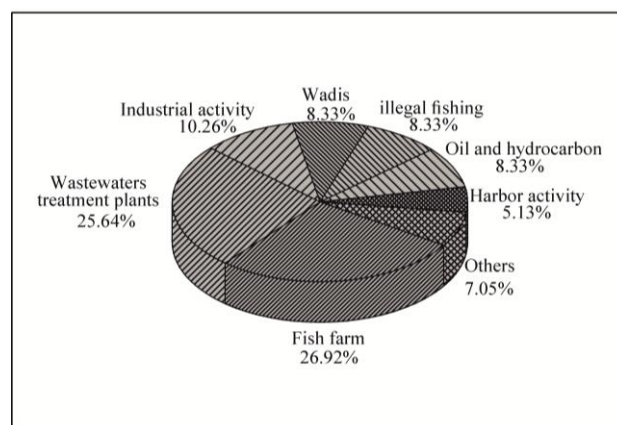


Fig-3: Sources of pollution in the Monastir bay

Distribution of Pollution and Delimitation of Polluted Areas

In order to determinate the pollution areas in the Monastir bay, the interviewed fishermen were invited to show these sites on the bay map. The results showed that according to fishermen perceptions, marine polluted areas are situated along the coastal fringe of the bay and around the fish farm cages,

located in the northern-western part of the bay. However, most of respondents (more than 80%) noted that polluted areas are mainly situated around the fish farms cages, in front of the Khniss drain and El Souk wadi, and around the Teboulba harbor (Figure-4). We also noticed that the speed and the common fishermen's response reflected their conviction of these pollution sources and areas.

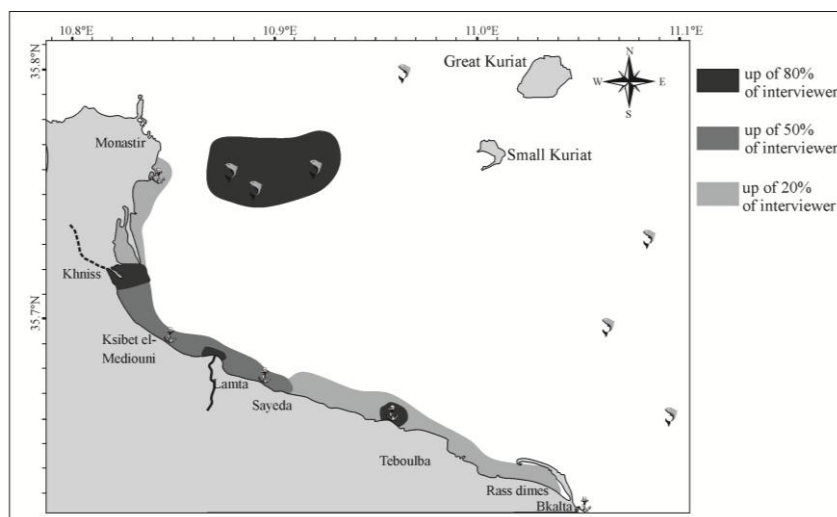


Fig-4: Polluted area in the Monastir bay

Effect of Pollution

The questionnaire survey has also a section treating the effect of pollution perception by marine users (professional or not). The interviewed declared that the marine ecosystem degradation in the Monastir bay, has begun since 35 years before, and 43% of answers revealed that the pollution effect have been

established since 7-10 years, considering the first fish farm installation in the Monastir bay 10 years ago.

All of interviewed noted that the pollution effect was observed through the quantity and quality decreasing of fish especially the *Sardasarda* species. A high mortality of *Posidonia oceanic* was declared under the fish cages and others species especially in summer.

Nevertheless, many other non-indigenous or indigenous species proliferated and invaded the bay, as the remarkable proliferation of *Ulva rigida* observed in Khniss area. All participants to the survey confirmed the invasion of *Halophila stipulacea* in all Monastir harbors and *Callinectes sapidus* in the eastern part of the bay. Interviewed fishermen responses indicated that perceived pollution negatively affects human health as the cutaneous allergy (major case) and to tourism for 64% and 67% of them, respectively.

DISCUSSION

The current study mainly explored the marine pollution perception in the Monastir bay by professional and non-professional fishermen. The oceans pollution caused by anthropogenic litter has been recognized as one of the major environmental threats of the twenty-first century [16]. The spatial distribution of marine pollution is dependent on some elements, including its origin (terrestrial and/or maritime), wind patterns, and sea currents [17]. Based on the data analysis, and according to the interviewed, the intensive coastal fish farming, which represents big business in the region, were considered harmful to environment and as the principal source of pollution in the bay, especially those located in the northern-western part. The European Commission declared that environmental impact of the pollution related to fish farming, differs with the farming technique, the depth and current conditions, and with the seabed communities' nature, as the different habitats did not have the same sensitivities to contamination [18]. In fact, and according to fishermen, the excess of nutrients, fecal materials and excretions, as well as antifouling products and medicines, in addition to the low depth under the fish cages which is not exceeding 24 meters, were the outlets of this source. Also, they mentioned that these sources may contribute to water, habitats and even fish contamination which is in accordance with study [19].

Moreover, the nearby treatment-plants wastewater, coming out El Frina and Lamta-Bouhjar stations, lead to the fishermen deduction that they are an additional reason for concern in the bay, as they discharged directly into the sea. In addition, two wadis (ephemeral streams) were considered as the main source of pollutants in the Monastir bay, drain of Khniss and wadi El Souk in Lamta-Bouhjar which collects domestic and industrial wastewaters from riverine discharges. It is well known that treatment techniques include chemical, physical and biological patterns producing residual substances involving potential contaminants that may finish into the sea and induce physiological, biochemical and histopathological alterations in fishes [20, 21]. In addition, the service industries that produce extensive amounts of waste include dry cleaners and laundry plants [22], which is the case in the Monastir bay.

Besides, plastic wastes were mentioned by fishermen as an important source of pollution. The plastic bags of fish nutrients that were signaled often thrown into the sea, as well as the illegal fishing using plastic creels and nets, lead to marine pollution and biodiversity destruction. According to [24], the wastewater treatment plants seem to be even a key source of microplastic pollution in river catchments.

With their potential impact on socio-economic situation and health of fishermen and the public of the Monastir bay generally, the identified sources of marine pollution are an undoubted environmental cost that imperatively need to be properly controlled. These sources should be taken in account by the government and civil society who must exercise the necessary political and social will to ensure all the polluting sectors are in line with the global strategy to be resilient face to climate change and human activities pressure.

CONCLUSION

In our survey, most of the identified causes by professional and non-professional fishermen were attributable to socio-economic challenges activities in the Monastir region such as aquaculture, textile industries, etc. According to the interviewed, human activities are significantly the most impactful pollution player in Monastir bay. This study highlights the urgent need for supervising marine ecosystem evolution in addition to investigation concerning the main activities in public and private sectors into the Monastir bay in order to ensure public safety and marine biodiversity conservation for the actual and future generations.

ACKNOWLEDGEMENTS

We are very grateful to the members of Notre Grand Bleu for their help in the survey in ports. This work was funded by the CEPF project "Contribute to the conservation of Kuriat Islands and the bay of Monastir through the involvement of civil society and the private sector".

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