Impact of large coastal Mediterranean cities on marine ecosystems

Impact des grandes métropoles côtières méditerranéennes sur les écosystèmes marins

Alexandria, Egypt, 10-12 February 2009

Alexandrie, Egypte, 10-12 février 2009

Workshop proceedings

Proceedings of the international workshop

Impact of large coastal Mediterranean cities on marine ecosystems

Alexandria, Egypt, 10-12 February 2009

Actes du séminaire international

Impact des grandes métropoles côtières méditerranéennes sur les écosystèmes marins

Alexandrie, Egypte, 10-12 février 2009

Organized by / *organisé par* : Michael Angelidis (UNEP/MAP – MED POL), Jean-François Cadiou (Ifremer), Suzan Kholeif (NIOF), Jae Oh (IAEA), Alessia Rodriguez y Baena (CIESM)

With the support of / *avec le soutien de* :

AERM&C – French Rhone Mediterranean & Corsica Water Agency ~ Agence de l'Eau Rhône Méditerranée & Corse www.eaurmc.fr

ASRT - Egyptian Academy of Science, Research and Technology ~ Académie des Sciences, de la Recherche et de la Technologie d'Egypte – www.asrt.sci.eg

CIESM - Mediterranean Science Commission ~ Commission Internationale pour l'Exploration Scientifique de la Méditerranée www.ciesm.org

IAEA/MEL – International Atomic Energy Agency/Marine Environment Laboratories ~ Agence Internationale pour l'Energie Atomique/Laboratoires d'Environnement Marin, www.iaea.org

Ifremer - French Research Institute for the Exploitation of the Sea ~ Institut Français de Recherche pour l'Exploitation de la Mer www.ifremer.fr

NIOF – National Institute of Oceanography and Fisheries, Egypt ~ Institut National d'Océanographie et des Pêches, Egypte www.niof.sci.eg

UNEP/MAP – **MEDPOL** – United Nations Environment Programme / Mediterranean Action Plan – Mediterranean marine pollution assessment and control programme ~ Programme des Nations Unies pour l'Environnement / Plan d'Actions pour la Méditerranée – Programme d'évaluation et de contrôle de la pollution marine en Méditerranée, www.unepmap.org

To be cited as / *référence* : Proceedings of the International workshop on the Impact of large coastal Mediterranean cities on marine ecosytems, Alexandria, Egypt – 10-12 Feb. 2009 / Actes du séminaire international sur l'impact des grandes métropoles côtières méditerranéennes sur les écosystèmes marins, Alexandrie, Egypte, 10-12 fév. 2009

Editors / *éditeurs* : Michael Angelidis, Frédéric Briand, Jean-François Cadiou, Suzan Kholeif, Jae Oh, Alessia Rodriguez y Baena, Michael Scoullos

Contact : Jean-François Cadiou, Ifremer, BP 330, F83507 La Seyne/Mer (France) – jfcadiou@ifremer.fr

Electronic version of the communications available on / version électronique des articles disponible sur : www.symposcience.org

CONTENTS

CONSENSUS REPORT

PREAMBLE

The present document reflects the input and results of interactive discussions of some 35 multidisciplinary, "large coastal cities" experts (i.e., scientists and stakeholders) from Mediterranean bordering countries and relevant International Organizations gathered in Alexandria from 10 to 12 February 2009 on the invitation of ASRT (Academy of Scientific Research and Technology, Egypt), CIESM (Mediterranean Science Commission), IAEA/MEL (International Atomic Energy Agency/ Marine Environment Laboratories), Ifremer (French Research Institute for Exploitation of the Sea, France), NIOF (National Institute of Oceanography and Fisheries, Egypt), and UNEP/MAP-MED POL (United Nations Environment Programme/Mediterranean Action Plan – Mediterranean marine pollution assessment and control programme).

SCOPE

On a general basis, this workshop and future synergies aim to promote the sharing of experiences and tools between main Mediterranean actors so as to better manage the marine environment, improve the quality of marine waters, sediments and marine biota communities in the vicinity of major cities, and enhance a more effective control of anthropogenic pressures.

INTRODUCTION

Mediterranean cities, the cradle of major civilizations, have contributed to the prosperity of the communities and the people of the region. However, modern large coastal cities exert strong pressures on the environment as a whole and especially on marine ecosystems. They also represent complex systems and hot spots that require special attention.

In this respect, Mediterranean cities need to be reinterpreted as unique systems which encompass the marine and land domains, together with the human activities carried out therein. Yet, the impact of coastal metropolises on the environment is still not fully assessed and understood, as vital data are lacking.

Many of the marine problems related to big cities stem from a lack of adequate knowledge regarding natural fluxes of, and human intervention on waters and sediments, major inputs of material and energy as well as marine ecosystem functioning.

Problems are further aggravated by the attitudes of citizens who live in these overcrowded and disturbed environments, mostly unaware of their negative impact on the environment and the fact that, at the same time, they are victims of their own behaviour.

A number of recent initiatives, *e.g.*, ICZM[1] protocol, MSFD[2], and H2020[3], may help in formulating efficient policies to address these problems. The present document attempts to contribute to the fulfilment of these efforts.

The discussions have employed the DPSIR (Drivers, Pressure, State, Impact, Response) model and the results are presented briefly herewith.

Drivers

Major drivers linking to pressures in large Mediterranean cities are population growth, particularly in the southern and eastern areas, and increasing -in number and intensity- anthropogenic activities, such as human settlements, big infrastructures, transport, energy production, and tourism.

The growth of urban settlements is difficult to stop. Often, Mediterranean cities are trapped between mountains and the sea. Consequently, they tend to expand along the coastline and towards the sea, reclaiming wetlands and the often narrow, shallow marine areas. This inevitably affects the distribution of sediments and coastal ecosystems.

People have some knowledge of their coastal lands, but know virtually very little about their marine environment, the associated threats and the functioning of its ecosystems. As a result, the general public is less prepared and equipped to defend the sea space in comparison to coastal land areas.

Furthermore, the rapid increase in the consumption of natural resources exacerbates anthropogenic pressures on coastal and marine systems.

Pressures

Pressures exerted by big cities include: material and energy inputs from domestic heating, transport (both on-land and off-road), energy production facilities, industries, urban runoff (episodic events), urban waste (from, *e.g.*, incinerators, landfills, waste water treatment plants, sewers), small rivers (*e.g.*, watershed and agriculture), coastal structures (*e.g.*, groins and beaches), and desalinisation plants. Many cities are linked with big harbours, which are specific or particular systems *per se,* and the activities carried out therein, such as shipyard operations, ballast waters handling, and dredging.

---

[1] Integrated Coastal Zone Management
[2] Marine Strategy Framework Directive
[3] Horizon 2020 initiative, http://ec.europa.eu/environment/enlarg/med/horizon_2020_en.htm

Other activities related to cities include: fisheries, structures in the open sea (which entail changes in water circulation), off-shore natural resources (*e.g.*, oil, gas, sand, and gravel) extraction, spill accidents (oil and Hazardous and Noxious Substances, HNS), ship-based pollution, *etc*.

State

As of today, most of the existing data and work carried out in the Mediterranean marine environment focus on coastal areas, many of which are directly affected by coastal cities. Despite the fact that we have started collecting these data more than 30 years ago, major gaps persist along with a general lack of connection between physical, chemical, biological and geological data on one hand, and emissions, other pressures, and socioeconomic aspects on the other. In the recommendation section of this document, basic prerequisites for a more efficient monitoring approach are listed.

Impact

A large amount of evidence is available on the important impacts of direct and indirect pressures exerted by cities on the Mediterranean marine environment and ecosystem. These include: the dramatic decline in fish stocks and biodiversity, the diminished resilience of the ecosystem to external stressors such as the intrusion of alien species, changes in physicochemical characteristics of water bodies, and the dramatic alteration of the position of the intermixing zone between fresh and saline waters. The link between impact drivers and responses needs to be further studied and a number of recommendations are included in the relevant section.

Response

Most of the responses until now are based on regulations and *ad-hoc* management which are poorly linked to long-term planning and monitoring of the effectiveness of the measures proposed and/or applied. Part of the failure is due to the minimum involvement of various actors, lack of coordination, and low awareness of the general public.

WORKSHOP RECOMMENDATIONS

Overarching approach

Integrated approaches and methodologies should be developed to evaluate the impact and the relative contribution of anthropogenic activities carried out in large urban areas on the marine environment and ecosystems.

Specific attention should be devoted to:

Scientific research

- Producing necessary information/data (status) on chemical pollution and marine litter.

- Evaluating the total fluxes of pollutants and investigating their pathways of transfer from all point and diffuse sources (including emissions from transportation, both inland and off-road) that are linked with anthropogenic activities in, and nearby coastal cities (via e.g. atmosphere, water, and sediment) to their final fate, including in organisms.
- Evaluating the extent of the areas (regional and/or local) under the effects of pressures.
- Assessing the state and the functioning of pelagic and benthic ecosystems affected by urban pressures, especially as regard eutrophication, Harmful Algal Blooms (HABs), diversity/quality of habitat, and food webs.
- Evaluating the impact of coastal structures, urban artificial beaches and outfalls on littoral morphodynamics, sea floor integrity, habitats, as well as socioeconomic activities.
- Evaluating the impact of complex activities associated with large harbours on the marine environment.

Impacts and responses could be studied through scenarios. Scenarios need to be built for complex coastal systems including coastal cities in an integrated way. Research should be performed to develop agreed methodologies so as to reduce uncertainties and increase comparability and coherence. Coupling of ecological and socio-economic aspects as well as the use of modelling are among the critical elements for the development of such scenarios, which requires an enhanced knowledge of hydrodynamics and sediment transport processes near large urban and harbour areas.

Management

- Impact on ecosystems must be addressed before and after response interventions.
- The cost of inaction should be compared with the value of goods and services provided by unharmed ecosystems.
- The effectiveness of response should be monitored by means of environmental, ecological, socio-economic, and cultural aspects and results made available to policy makers, local administrations, and the general public.
- Coastal and offshore monitoring programmes should be established, improved and sustained according to national/regional needs and commitments.
- The awareness of targeted groups of stakeholders and the general public should be raised, whilst keeping in mind that appropriate education should be based on comprehensive analysis and scientific methodologies.
- Free flow of information as well as data accessibility by all relevant parties should be ensured, at least at national level.
- Opportunities to construct synergies between sectorial activities in a preventive approach (for instance professional fishery and tourism) should be explored.

- Methodologies to produce decision-making tools to assess citizens' choices, thereby contributing to social well being and/or ecosystem health, should be developed.
- Advanced ways of governance based on public participation and involvement of stakeholders, urban managers, and scientists in decision making should be promoted.
- Demonstration projects should be developed and good practices disseminated in order to carry out targeted capacity building actions (see, e.g., the IAEA Technical Cooperation Programme), which aim at promoting a sound management of the impacts of Mediterranean cities on marine ecosystems.

Prerequisites for proper description of the state of the environment

- Existing data should be better gathered, quality controlled, harmonized and evaluated at national and international levels.
- Regional cooperation should be enhanced particularly as it concerns data for offshore waters and characteristics of sub-regions according to EU Marine Strategy Framework Directive (MSFD) and UNEP/MAP Ecosystem Approach.
- New measurements should address emerging needs (e.g climate change, species migration and intrusion of alien species).

RAPPORT FINAL

PREAMBULE

Ce document synthétise les contributions et les conclusions de l'atelier qui s'est tenu du 10 au 12 février 2009 à Alexandrie, à l'initiative de l'ASRT (Académie des Sciences, Recherche et Technologie, Egypte), de la CIESM (Commission Internationale pour l'Exploration Scientifique de la Méditerranée, Monaco), de l'AIEA/LEM (Agence Internationale pour l'Energie Atomique, Laboratoire d'Environnement Marin, Monaco), de l'Ifremer (Institut Français de Recherche pour l'Exploitation de la Mer), du NIOF (Institut National d'Océanographie et des Pêches, Egypte) et PNUE/PAM/MEDPOL (Programme des Nations Unies pour l'Environnement / Plan d'Actions pour la Méditerranée – Programme d'évaluation et de contrôle de la pollution marine en Méditerranée). Cet atelier a réuni quelque 35 participants, scientifiques de différentes disciplines et gestionnaires, disposant d'une expertise sur les « grandes métropoles côtières » et issus de divers pays méditerranéens et d'organisations internationales concernées par ce sujet.

OBJET

D'une manière générale, cet atelier et les collaborations futures ont pour but de promouvoir le partage d'expériences et d'outils entre les principaux acteurs méditerranéens de façon à mieux gérer l'environnement marin, améliorer la qualité des eaux marines, des sédiments et des communautés biologiques autour des principales métropoles, et assurer un contrôle plus efficace des pressions anthropiques.

INTRODUCTION

Les grandes villes méditerranéennes, berceaux de civilisations majeures, ont contribué à la prospérité des communautés et des peuples de la région. Cependant, les métropoles côtières modernes exercent de fortes pressions sur l'environnement en général et sur les écosystèmes marins en particulier. Elles constituent également des systèmes complexes et des « points sensibles » qui requièrent une attention particulière.

A cet égard, les métropoles méditerranéennes méritent d'être ré-interprétées comme des systèmes uniques qui englobent les milieux terrestres et marins ainsi que les activités humaines qui y sont exercées. De fait, l'impact des métropoles côtières sur l'environnement n'est pas toujours correctement évalué et est mal compris, faute de données essentielles.

De nombreux problèmes concernant le milieu marin bordant les grandes villes proviennent d'un manque de connaissances sur les flux naturels, les interventions humaines sur les eaux et les sédiments, les principaux apports de matière et d'énergie ainsi que sur le fonctionnement de l'écosystème marin.

Ces problèmes sont aggravés par les attitudes des citoyens qui vivent dans ces environnements surpeuplés et perturbés, généralement peu conscients de leur impact délétère sur l'environnement et du fait qu'ils sont, en même temps, victimes de leur comportement.

Un certain nombre d'initiatives récentes, telles que le protocole GIZC[1] Méditerranée, la Directive Cadre européenne Stratégie pour le Milieu Marin et Horizon 2020 peuvent contribuer à élaborer des politiques efficaces pour résoudre ces problèmes. Le présent document tente de contribuer à la réalisation de ces efforts.

Les participants ont utilisé pour la discussion le modèle DPSIR : Drivers, Pressure, State, Impact, Response (forces motrices, pressions, état, impact, réponses) et les résultats en sont présentés brièvement ci-dessous.

Forces motrices

Les principales « forces motrices » aboutissant aux pressions pour les grandes métropoles méditerranéennes sont la croissance de la population, en particulier dans les zones méridionales et orientales, et l'accroissement – en nombre et en intensité – des activités anthropiques telles que les implantations de populations, les grandes infrastructures, les transports, la production d'énergie et le tourisme.

La croissance des implantations urbaines est difficile à arrêter. Les villes méditerranéennes sont souvent situées entre les montagnes et la mer. En conséquence, elles ont tendance à s'étendre le long de la côte et vers la mer, colonisant les zones humides et la bande étroite des petits fonds marins. Cela affecte inévitablement les sédiments et les écosystèmes côtiers.

Les populations ont certaines connaissances sur les territoires côtiers mais savent très peu de choses de leur environnement marin, des menaces associées et du fonctionnement de ses écosystèmes. Elles sont en conséquence moins préparées et outillées pour défendre l'espace marin par rapport à l'espace terrestre côtier.

De plus, l'accroissement rapide de l'utilisation des ressources naturelles renforce le caractère critique des pressions anthropiques sur les systèmes marins et côtiers.

Pressions

Les pressions exercées par les grandes villes comprennent : les apports de matière et d'énergie en provenance du chauffage domestique, du transport (routier et autre), les installations de production d'énergie, les industries, le ruissellement urbain

[1] Gestion Intégrée des Zones Côtières

(notamment lors des événements pluvieux intenses), les rejets et déchets urbains (en provenance, en autres, des incinérateurs, des décharges, des stations d'épuration, des égouts), les petits cours d'eau (drainant un bassin versant et des zones agricoles), les aménagements côtiers (digues et plages artificielles) et les usines de désalinisation de l'eau de mer. De nombreuses villes sont associées à de grands ports qui sont, en eux-mêmes, des systèmes spécifiques sièges d'activités telles que la construction et la réparation navales, les opérations de ballastage ou le dragage.

D'autres activités liées aux villes comprennent : la pêche, l'implantation de structures en mer ouverte (qui peuvent influer sur l'hydrodynamisme), l'exploitation des ressources naturelles marines (pétrole, sables, graviers), les pollutions accidentelles (pétrole et substances toxiques), la pollution issue des navires, etc.

Etat

Actuellement, la plupart des données existantes et des études conduites sur l'environnement marin en Méditerranée se concentrent sur les zones côtières, dont un grand nombre sont directement affectées par les grandes villes côtières. En dépit du fait que nous avons commencé à collecter ces données il y a plus de 30 ans, des lacunes importantes persistent avec un manque général de lien entre les données physiques, chimiques, biologiques et géologiques d'une part et les émissions, les autres pressions et les aspects socio-économiques d'autre part. Dans la partie recommandation de ce document, les pré-requis fondamentaux pour une surveillance plus performante sont listés.

Impact

Un grand nombre d'éléments montrent que les impacts des pressions directes et indirectes exercées par les grandes villes sur l'environnement marin méditerranéen et l'écosystème sont majeurs. Ceux-ci comprennent : le déclin remarquable des stocks de poissons et de la biodiversité, la réduction de la résilience de l'écosystème à des stress externes tels que l'intrusion d'espèces invasives, l'évolution des caractéristiques physico-chimiques des masses d'eau et l'altération significative de la position de la zone de mélange entre les eaux douces et les eaux salées. Le lien entre les facteurs générateurs d'un impact et les réponses nécessite des études supplémentaires. Un certain nombre de recommandations dans ce sens sont formulées ci-après.

Réponse

La plupart des réponses sont basées, jusqu'à présent, sur des réglementations et une gestion de circonstance peu cohérentes avec une planification à long terme et sans véritable évaluation de l'efficacité des mesures proposées ou appliquées. Une partie de cet échec est due à une implication insuffisante des divers acteurs, à un manque de coordination et à une faible prise de conscience de la part du grand public.

RECOMMANDATIONS DE L'ATELIER

Approche générale

Des approches et des méthodes intégrées doivent être développées pour évaluer la contribution relative des activités anthropiques exercées dans les grandes zones urbaines et leur impact sur l'environnement et les écosystèmes marins.

Une attention spécifique sera portée à :

La recherche scientifique

- Produire des informations et des données nécessaires sur la pollution chimique et les déchets solides.
- Evaluer les flux totaux de polluants et mener des recherches sur les voies de transfert à partir des sources ponctuelles ou diffuses (y compris les émissions des transports terrestres et autres) qui sont liées à des activités anthropiques, dans et autour des grandes villes côtières (par ex. via l'atmosphère, l'eau et les sédiments) jusqu'à leur devenir final, y compris dans les organismes vivants.
- Evaluer l'étendue des zones (régionales et/ou locales) subissant l'effet de ces pressions.
- Evaluer l'état et le fonctionnement des écosystèmes pélagiques et benthiques affectés par les pressions urbaines, en particulier en ce qui concerne l'eutrophisation, les proliférations d'algues toxiques, la diversité et la qualité des habitats et les réseaux trophiques.
- Evaluer l'impact des structures côtières, des plages urbaines artificielles et des émissaires sur la morphodynamique du littoral, l'intégrité des fonds, les habitats et les activités socio-économiques.
- Evaluer l'impact sur l'environnement marin des activités complexes liées aux grands ports.

Les impacts et les réponses pourraient être étudiés à travers des scénarios. Ces derniers doivent être bâtis pour des systèmes côtiers complexes incluant les métropoles côtières de manière intégrée. Des recherches doivent être conduites pour développer des méthodologies approuvées de façon à réduire les incertitudes et à améliorer la comparabilité et la cohérence. Le couplage entre les aspects écologiques et socio-économiques ainsi que l'utilisation de la modélisation sont des éléments critiques pour l'élaboration de tels scénarios, ce qui nécessite une meilleure connaissance de l'hydrodynamique et des processus de transport sédimentaire autour des grandes zones urbaines et portuaires.

La gestion

- L'impact sur les écosystèmes doit être pris en compte avant et après la mise en place de mesures de gestion.
- Le coût de l'inaction doit être comparé avec la valeur des biens et services fournis par les écosystèmes non altérés.

- L'efficacité de la réponse doit être évaluée sous les aspects environnementaux, écologiques, socio-économiques et culturels. Les résultats doivent être rendus disponibles pour les décideurs, les administrations locales et le grand public.
- Des programmes de surveillance du milieu côtier et du large doivent être élaborés, améliorés et poursuivis en accord avec les besoins et les engagements nationaux et régionaux.
- La sensibilisation de groupes ciblés d'acteurs et du grand public doit être accrue, en gardant à l'esprit qu'une éducation appropriée doit être basée sur une analyse complète et des méthodes scientifiques.
- Un accès libre à l'information et aux données pour toutes les parties concernées doit être assuré, au moins au niveau national.
- Les possibilités de construire des synergies entre des secteurs d'activité dans une logique préventive (par ex. entre la pêche professionnelle et le tourisme) doivent être explorées.
- Des méthodologies doivent être développées pour produire des outils d'aide à la décision prenant en compte les choix des citoyens, contribuant ainsi au bien-être social et à la bonne santé des écosystèmes.
- Des modes de gouvernance avancés doivent être encouragés, basés sur la participation du grand public et l'implication des décideurs, des urbanistes ainsi que des scientifiques dans le processus de décision.
- Des projets de démonstration doivent être développés et les « bonnes pratiques » doivent être diffusées au moyen d'actions ciblées de formation qualifiante (voir par ex. le programme de coopération technique de l'AIEA), avec pour objectif la promotion d'une gestion intelligente des impacts des métropoles méditerranéennes sur les écosystèmes marins.

Pré-requis pour une description complète de l'état de l'environnement

- Les données existantes devraient faire l'objet d'un contrôle qualité et être mieux rassemblées, harmonisées et évaluées au niveau national et international.
- La coopération régionale devrait être améliorée en particulier pour ce qui concerne les données sur les eaux du large et les caractéristiques des sous-régions, en accord avec la Directive Cadre européenne Stratégie pour le Milieu Marin et l'Approche Ecosystémique du PNUE/PAM.
- Les nouvelles mesures devraient concerner les besoins émergents (par ex. le changement climatique, les migrations d'espèces et les invasions d'espèces exotiques).

Workshop Communications

Chemical contamination of coastal Mediterranean waters, the Mytilos/Mytimed projects

Bruno Andral, François Galgani and Jean-François Cadiou

Ifremer, Zone Portuaire de Brégaillon, 83507 La Seyne-sur-Mer, France

Keywords: biomonitoring, bioaccumulation, mussels, chemical contamination

Abstract

The MYTILOS and MYTIMED project were launched to draw up a preliminary report on coastal chemical contamination on a Western Mediterranean scale (continental coasts of the Balearic Islands, Sicily, Sardinia, Corsica and Maghreb) and a part of the Eastern basin (Southern Italian and Sicilian coasts, Greece), based on a standard methodology developed on the French Mediterranean coast by Ifremer and Rhone Mediterranean & Corsica water board since 1996. From 2004 to 2007, 174 mussel stations were installed and recovered 3 months later along the Mediterranean shores.

The analysis of 40 chemical substances has been carried out on mussel samples. The results show that the most highly impacted areas are urban and industrial centres and the mouth of major rivers. When going from the coast towards open sea a far higher dilution effect is observed for organic compounds than for heavy metals. For metals, levels measured offshore are generally found to be similar to those in natural shellfish populations living along the coast.

Résumé

Les projets MYTILOS et MYTIMED ont été initiés pour établir un état préliminaire de la contamination chimique des eaux côtières à l'échelle de la Méditerranée occidentale (côtes continentales européennes et du Maghreb, îles Baléares, Sicile, Sardaigne, Corse) et d'une partie de l'Est du bassin (du sud de l'Italie et la Sicile côtes, de la Grèce), sur la base d'une méthodologie standardisée développée sur la façade française par l'Ifremer et l'Agence de l'Eau Rhône Méditerranée et Corse depuis 1996. De 2004 à 2007, 174 stations de moules ont été installées sur les côtes méditerranéennes et récupérées 3 mois plus tard.

L'analyse d'une quarantaine de substances chimiques a été effectuée sur les échantillons de moules. Les résultats montrent que les sites les plus contaminés sont les zones urbaines, les centres industriels et l'embouchure des grands fleuves. Quand on s'éloigne de la côte vers le large, un effet de dilution nettement plus important est observé pour les composés organiques (par rapport aux métaux lourds). Pour les métaux, les niveaux mesurés en mer sont généralement similaires à ceux trouvés dans les populations naturelles de coquillages vivant le long des côtes.

INTRODUCTION

Most monitoring programmes now include the use of biological indicators. This is based on the assumption that levels of trace contaminants accumulated in biological tissues represent the time and space integrated value of these contaminants in the surrounding waters. High concentrations resulting from bioaccumulation of many chemicals in bio-indicator organisms make the measurement of contaminant concentrations technically simpler. Variations of contaminant levels in tissues may reflect the variations in dissolved and particulate contaminant concentrations, although biological variability can also affect tissue concentrations.

In the Mediterranean Sea, the species *Mytilus galloprovincialis* is widespread, but in some locations natural populations are rare or absent. The transplantation method compensated for this scarcity. It also allows controlling the source, age, and stage of sexual maturity of the samples. However, implementing it on a large geographic scale introduces factors such as variations in physiochemical characteristics and food availability in the stations. Although the measured concentrations in the tissue are a function of bioavailable pollutant levels, the bioaccumulation factor depends on mussel growth in relation to the primary food production, or trophic capacity, of the environment. Comparison of raw data on tissue concentration between sectors of different trophic potential may be misleading. A biometric parameter representing growth must be used to correct initial data and to produce reliable comparison at a large spatial scale.

The Condition Index (CI) is an efficient indicator of physiological state and growth resulting from the environmental effect. The results acquired by the RINBIO network show robust condition index / contaminant concentration correlations in all geographical zones for certain contaminants. It is therefore possible to determine a correction model for these contaminant families and obtain a concentration, notwithstanding the environmental effect, which is representative of bioavailable contaminant concentrations in the environment. At a large spatial scale, this model enables the adjustment of results to get "standard individual" normalized data, and result comparison notwithstanding the physiochemical and trophic heterogeneity of the target zones.

MYTILOS and MYTIMED are backed by the INTERREG III B / MEDOC programme, steered by Ifremer with the support of Toulon Var Technologies, in cooperation with ICRAM [1] (Italy), IEO [2] (Spain), PSTS [3] (Sicily), IMEDEA [4] (Balearic Islands), CSIC[5] (Catalonia), the Agencia Catalana del Agua, INSTM[6] (Tunisia), ISMAL [7] (Algeria), INRH [8] and University of Agadir (Morocco),

---

[1] ICRAM: Instituto Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare
[2] IEO: Instituto Español de Oceanografia
[3] PSTS: Parco Scientifico e Tecnologico della Sicilia
[4] IMEDEA: Instituto Mediterraneo de Estudios Avanzados
[5] CSIC: Consejo Superior de Investigaciones Científicas
[6] INSTM: Institut National des Sciences et Technologies de la Mer
[7] ISMAL: Institut National des Sciences de la Mer et de l'Aménagement du Littoral
[8] INRH: Institut National de Recherche Halieutique

ANEM- Tourist autority of Magnesia, HCMR [9] (Greece), HIMR [10] (Syria), CNRS [11] (Lebanon). MYTILOS and MYTIMED are also backed by the PNUE/PAM - MEDPOL and the Rhone Mediterranean & Corsica water board.

Materials and methods

Transplantation

The species used is *Mytilus galloprovincialis*. The batch is made up of adult mussels 18 to 24 months old, measuring about 50 mm long, sorted twice according to the height of the shell through 19-mm mesh. The 3-kilogram samples are stored in conchylicultural pouches mounted on PVC tubing. Subsurface moorings include a mussel bag attached to a 30 kg weight. Mussels are maintained in open water with an 11-litre float. The stations are installed with an oceanographic vessel at various depths and distances from the coast. Globally speaking, depth is around 20 to 50 meters according to coastal configuration, and the bags are attached at a depth of 8-10 meters. The aim is to install each station in an equivalent continental input dilution volume to avoid it being under the direct influence of one contamination source and then get good station relative representativity.

Recovery

After 3 months, retrieval of the samples at sea is carried out using an oceanographic vessel which provides vital logistics support (diving logistics, sample processing, vial preparation), including a zodiac equipped with detection instruments (sweep sonar, vertical echo sounder) for station retrieval operations.

On site, the mussels are separated and rinsed with seawater. Mortality and height of the shell are recorded. At each station, the samples are pre-processed according to standardized procedures. The mussels are opened raw and the flesh is scraped out of the shell with a stainless steel scalpel. Shells are dried at 60 °C in the oven for 48 hours, then weighed. Flesh is weighed after freeze-drying. The ratio of dry flesh weight to dry shell weight (FW/SW) is used to determine a condition index (CI) for each sample.

Mytilos I (2004) sampled a coastline stretching from Cartagena (Spain) to Orbelleto (Italy). Mytilos II (2005) covered southern Italy and part of southern Spain, with sampling along the coast of the Balearic Islands, Sardinia and Sicily. Mytilos III (2006) covered Corsica, the southernmost coasts of Spain and the Maghreb coasts (Morocco, Algeria, Tunisia), Mytimed (2007) covered the southern part of Italy, Sicily and the Greek coast.

Analysis

The following contaminants were analysed: Lead, Cadmium, Nickel Mercury,DDT+DDD+DDE, Hexachlorocyclohexane, Polychlorobiphenyles (PCBs), Polycyclical Aromatic Hydrocarbons (PAHs), non-ionic detergents such as nonylphenols (4-(para)-nonylphenol) and octylphenols (para-tert-octylphenol),

[9] HCMR: Hellenic Center for Marine Research
[10] HIMR: High Institute for Marine Research
[11] CNRS: Conseil National de la Recherche Scientifique du Liban

Dioxins, Brominated diphenyl ethers. All of the above compounds were analysed in mussel flesh in each station, excepted dioxins, brominated diphenyl ethers and non-ionic detergents, which were measured at around one 1 in 5 stations.

RESULTS

A total of 174 stations were retrieved out of the 207 stations deployed (84 %).

Contaminants

The raw concentration results show that growth has a major impact on contamination level distribution, in particular with regards to heavy metals. Some trace metals (Cd, Hg, Ni) showed systematically higher levels in the most highly oligotrophic areas, which are correlated with the mussel condition index. Concentrations of the vast majority of PCB congeners were lower than the limits of detection set at the study outset. CB 153 and 138 were the most reliable markers and were present in all samples; their distribution is similar to that of the sum of the 10 analysed congeners. Regarding PAHs, out of the 16 analysed compounds, a large majority did not exceed the analytical limit of detection. Compound distribution between stations was widely heterogeneous in comparison, for example, to that of PCBs. α HCH and γ HCH did not in any case exceed the limit of detection in coastal zones. Lastly, metabolites of DDT were the most commonly-found organic contaminants. Analyses of brominated diphenyl ethers and non-ionic detergents all showed results below the analytical limit of detection.

Models

For each contaminant, adjustment parameters have been calculated on the basis of the raw data collected from theses campaigns.

Models were significant (p-values < 0.05) for most contaminants, excepted for PAHs. The highest growth effect was observed for cadmium, mercury and nickel, with a variation of more than 50 % in results explained by sample growth.

Data adjustment

The value of the reference condition index is 0.11, which corresponds to the mean of the condition indices obtained from each sample. Raw data was adjusted using this value and the model parameters computed for every contaminant. However, data on PAH was not processed according to this method. For every contaminant, descriptive statistics were calculated and presented in table 1 among regional sub basins.

At the scale of the study, the distribution of lead adjusted data was relatively homogenous, with a median level of 1.49 mg/kg. However, two sites were pinpointed as being particularly impacted by lead: the Portoscuso industrial site (South Western sub-basin), with a maximum of 8.25 mg/kg and the zone spanning Portman to El Portus (Alboran sub-basin) from 5.3 to 6.25 mg/kg, which was home to a thriving mining industry with the dumping of 50·106 tons of waste-mining resulting from the intensive extractive activities carried out during the 1960-1990 period. The maximum levels observed in the North Western sub-basin are in the area of Barcelona (2.79 mg/ kg), in the Tyrrhenian sub-basin in Porto Ferrario at Elba island (3.05 mg/ kg) and in the Ionian sub-basin in Corinthos (2,69 mg/kg). For this heavy metal we can observe that the background in the Eastern basin is more elevated than in the Western basin.

Adjusted levels of cadmium were globally homogenous throughout stations, with an average of 1.32 mg /kg and a median of 1.32 mg /kg. A few stations showed relative peaks of around 2 mg/kg : Filicudi and Ustica stations in Tyrrhenian sub-basin (Sicily), Aguilas and Adra in Spain (Alboran sub-basin) and 4 mg/kg in Athens (Aegean sub basin). Nevertheless the background levels are similar in all the sub-basins.

Several sites were found to be impacted by mercury (Fig. 1): first and foremost the Portoscuso site in Sardinia (South Western sub-basin), with a maximum level of 0.31 mg/kg, witnessing significant contamination generated by a large industrial complex. To a slightly lesser degree, high levels are recorded in the South Western sub-basin in Skida (0.19 mg /kg), in the Tyrrhenian sub-basin especially in Palermo (0.22 mg /kg) and in the Ionian sub-basin in Augusta (0.20 mg/kg). For this metal we cannot observe differences between the Eastern basin and the Western basin for background levels.

Figure 1. Mercury in mussels (∑PCBi ng.g^{-1} dry weight)

Average adjusted concentrations of nickel were around 1.3 mg / kg, Extreme values were found in some sampling sites in the South Western sub basin especially in Tabarka (3.18 mg/kg), Oued Zhor (2.89 mg /kg), Oran (2.47 mg/kg), Nador (2.72 mg/kg), in the south of Spain in Fuengirola (2.44 mg/kg) and in the south of Aegean sea in Rhodos (4 mg/kg). For this metal the background in more elevated in the eastern part of the basin especially in the Aegean Sea.

The median value of the sum of DDTs compounds was 2.52 µg/kg at the scale of the study. Significant peaks were recorded in the North Western and Tyrrhenian sub-basin especially in front of Marseille (15.47 µg/ kg), Barcelone (15.17 µg/ kg) and Napoli (15.34 µg/ kg). In the South Western sub-basin Algiers also showed a high level (10.23 µg/ kg). The level recorded at the Algiers station was equivalent to the overall levels recorded at stations off the coast of the following rivers and streams: Ebro, Rhône and, to a lesser degree, Tet, Aude, Herault (North Western sub-basin) and Tevere (Tyrrhenian sub-basin). In the Eastern part of the basin the higher levels are observed in Thessaloniki (7 µg/ kg). For this contaminant’s family we can observe that the background is more elevated in the North Western and Tyrrhenian sub-basins.

Regarding the sum of the 10 congeners of PCBs (Fig. 2) and the CB153, the distribution shows a similar profile. The median value of the sum of PCBs compounds was 7.76 µg/kg. The results show some sites are significantly contaminated by PCBs : in the North Western sub basin (Barcelona [63.87 µg / kg], Marseille [103.52 µg / kg]) ; in the Tyrrhenian sea (Naples [91.48 µg / kg]) and on South Western coast (Algiers [51.13 µg / kg]). If there is a characteristic presence of PCBs in the vicinity of major urban centres, high values are also observed in the Tyrrhenian Sea at La Maddalena (58.49 µg / kg), at a station located close to a major naval base. To a lesser degree, we can also pinpoint inputs by the Ebro (20.37 µg / kg) and Rhône rivers (37.80 µg / kg). In comparison the higher concentration observed in the Eastern Mediterranean was 11.25 µg/kg in Thessaloniki. If the background levels are similar at the scale of this study, the maximum levels are always observed in the Western Mediterranean.

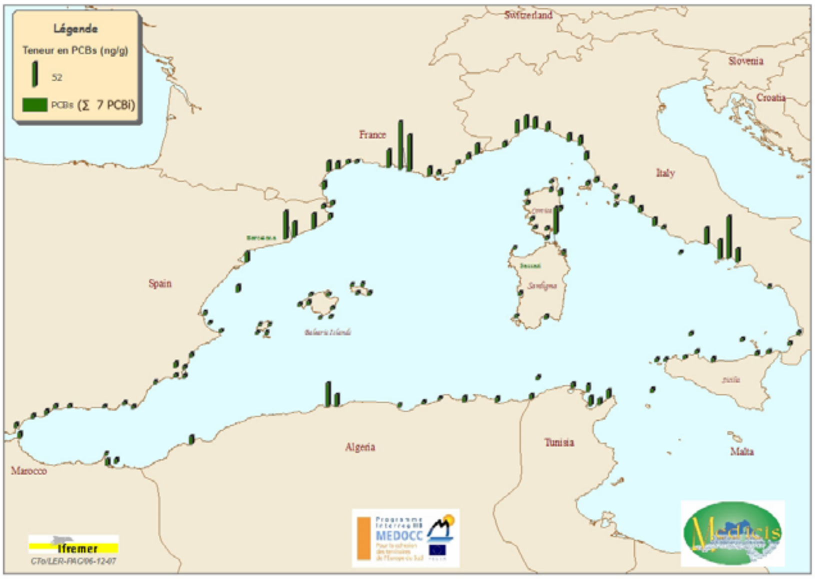


Figure 2. PCB in mussels (∑PCBi ng.g^{-1} dry weight)

Results related to the sum of the 16 analysed molecules for PAH are expressed in raw values. Wide data heterogeneity was observed at the scale of the study with a median value of 39.7 µg/kg. Two peaks have been identified in the North Western and Tyrrhenian sub-basins close to Marseille (105.5 µg/kg) and Piombino in Italy (80.8 µg/kg). Both are coastal cities associated with a large industrial complex. As for PCBs, the levels for these compounds are globally lower in the Eastern Mediterranean.

For dioxins, the median value is around 0.7 ng/kg (TEQ: Toxic Equivalent Quantity). One peak recorded in the Marseille area reveals the existence of significant inputs of these compounds (2.66 ng/kg). Moreover, it confirms the peak measured for PCBs, which belongs to the same organic halogenous compound family. On the project scale, the distribution observed for dioxins is similar to the one of PCBs, with highest values at Barcelone, La Maddalena, Napoli and Algiers.

DISCUSSION

The Mytilos-Mytimed projects confirmed the operational viability of the RINBIO methodology. The project's logistics, mooring structures and deployment / retrieval techniques enabled cost minimization, plus a highly satisfactory retrieval rate taking into account the shape and diversity of the studied coasts.

The condition index range is indicative of the trophic heterogeneity of the Mediterranean coastlines. Overall, the waters are richer in the North Western sub-basin, due to the high loads of nutrients brought by the Rhône (Minas, 1989) and Ebro rivers, and in the Alboran sub-basin. The condition index spread also provides some clues as to the levels of chemical contamination (excepted for PAH), especially in the case of trace metals. Regarding cadmium concentration, the raw values measured in Balearic Islands were two to three times higher than those measured at the mouth of the Ebro river and along the Spanish coast.

In a more general way, the significant connection between the condition index and levels of contaminants in mussel tissue allows to adjust the findings and get comparable data, to identify background levels in the different sub-basin and then to point out contaminated areas. The most highly-impacted zones were mainly located in front of urban and industrial centres and near the outlets of major rivers.

ACKNOWLEDGEMENTS

Thanks to experience-sharing, all project partners were able to judge the easy implementation of this methodology and familiarize themselves with its main concepts through active participation in all operations.

This research was supported by EEC (Interreg /Medocc IIIC) and the Rhône-Mediterranean-Corsica Water Agency. Partners from Morocco, Algeria, Tunisia, Syria and Lebanon were supported by UNEP/MAP/MEDPOL.

REFERENCES

Andral B., Stanisière J-Y., Damier E., Thébault H., Galgani F., Boissery P., 2004. Monitoring chemical contamination levels in the Mediterranean based on the use of mussel caging. *Marine Pollution Bulletin* 49: 704-712.

Andral B., Stanisiere J. Y., Thebault H., Boissery P., 2001. Surveillance des niveaux de contamination chimique et radiologique en Méditerranée basée sur l'utilisation de stations artificielles de moules. Rapport du 36ème congrès de la CIESM, Monaco septembre 2002. 36 (1), 107.

Borchardt T., 1983., Influence of food quantity on the kinetic of cadmium uptake by *Mytilus edulis*. Mar Biol. 85, 233 – 244.

Claisse D., 1989. Chemicals contamination of french coast : the result of a ten year mussel watch. Mar .Pollut.Bull. 20, 523 - 528.

Cossa D., 1989. A review of the use of *Mytilus* spp as quantitative indicators of cadmium and mercury contamination in coastal water. Oceanologica acta . 12, N° 14.

Fischer H., 1984. Cadmium body burden/Shell weight of mussel : a precise index for environmental monitoring. Comm Meet in Count Explor See CM - ICES/E. 41, 1 - 19.

Goldberg E.D., 1975. The Mussel Watch. Mar. Pollut. Bull. 6, 111.

Lobel P.B & Wright D.A., 1982. Relationship between body zinc concentration and allometric growth measurement in the mussel *Mytilus edulis*. Mar. Biol. 66, 145-150.

Phillips D. J. H., 1976. The common mussel *Mytilus edulis* as an indicator of pollution by zinc, cadmium, lead and copper. Effect of environmental variables on uptake of metals. Mar. Biol. 38, 59 - 69.

Soto M., Kortabitarte M., Marigomez I., 1995. Bioavailable heavy metals in estuarine waters as assessed by metal/shell weight indices in sentinel mussels *Mytilus galloprovincialis*. Mar. Ecol. Pro. Ser. 125, 127 - 136.

Wang W.X., Fisher N.S., Luoma S. N., 1996. Kinetic determination of trace element bioaccumulation in the *Mytilus edulis*. *Mar. Ecol. Prog*. 140, 91 - 113.

Development of Policies and implementation of measures to control pollution from large coastal cities in the Mediterranean Region

Michael Angelidis[1], Francesco Saverio Civili[1],
Fouad Abousamra[1] and George Kamizoulis[2]

[1]UNEP/MAP – MED POL, 48 Vas. Konstantinou Ave., 11634 Athens, Greece
[2]World Health Organization, 48 Vas. Konstantinou Ave., 11634 Athens, Greece

Keywords: Mediterranean, pollution, discharge, coastal cities, control measures

Abstract

MED POL is assisting the Mediterranean countries to implement programmes and measures to assess and eliminate pollution in the Mediterranean Sea. In the frame of the Strategic Action Programme, special attention has been given to pollution derived from coastal cities, which are responsible of a large pollution load emitted from urban as well as industrial sources. Specific measures have been proposed for the elimination or control of priority land-based target groups of substances and activities that are of global concern, following a specific timetable and using funds provided by national and international funding organisations.

Résumé

MED POL assiste les pays méditerranéens pour réaliser des programmes et mettre en œuvre des mesures pour évaluer et éliminer la pollution de la Méditerranée. Dans le contexte du Programme d'Action Stratégique, la pollution provenant des villes côtières est spécialement ciblée, à cause des quantités importantes de polluants que ces villes déversent dans le milieu marin côtier par le biais des rejets urbains et industriels. Des mesures spécifiques ont été proposées pour l'élimination et le contrôle des substances prioritaires et pour des activités d'intérêt global, suivant un calendrier spécifique et en utilisant des fonds nationaux et internationaux.

THE MEDPOL PROGRAMME

The Programme for the Assessment and Control of Marine Pollution (MED POL) is the scientific and technical component of the UNEP/MAP[1]. It assists the Mediterranean countries to implement programmes and measures to assess and eliminate pollution, as part of the implementation of the Barcelona Convention and

---

[1] United Nations Environment Programme – Mediterranean Action Plan

its Protocols. In particular, the MED POL Programme is in charge of the following up of the implementation of the Land Based sources Protocol, the Dumping Protocol and the Hazardous Wastes Protocol. During Phase I (1975- 980) and II (1981-1995), MED POL was mainly coordinating a pollution monitoring and research programme, concentrating its efforts on capacity building and on collection and analysis of sources, levels, pathways, trends and effects of pollutants relevant to the Mediterranean Sea. During MED POL Phase III (1996-2005), pollution control was made the new focus of the programme, while it retained the assessment of pollution and provision of support to national institutions (i.e., capacity building). MED POL Phase IV (2006 – 2013) is actually underway, having as objectives:

- to facilitate the implementation of the Convention and its Protocols by the Contracting Parties in matters of its competence, in particular in the reduction and elimination of pollution from land-based sources and activities and dumping activities;
- to assess all point and diffuse sources and load of pollution reaching the Mediterranean, and the magnitude of the problems caused by the effects of contaminants on living and non-living resources, including human health
- to assess status and trends in the quality of the marine and coastal environment;
- to assist countries, including capacity building, for the implementation of national action plans for the gradual elimination of pollution, for the mitigation of impacts caused by pollution and for the restoration of systems already damaged;
- to monitor the implementation of the action plans, programmes and measures for the control of pollution and assess their effectiveness;
- to contribute, in cooperation with other MAP components, to the application of the ecosystem approach to the management of human activities.

To combat more efficiently land-based pollution, the Contracting Parties to the Barcelona Convention set up a Strategic Action Programme (SAP) in 1997. In the frame of the SAP the Mediterranean countries are implementing specific measures for the elimination or control of priority land-based target groups of substances and activities that are of global concern, following a specific timetable (until 2025).

The operational tong-term output of the SAP was the implementation of country specific National Action Plans (NAPs) to combat pollution from land-based activities. All 21 Mediterranean countries have prepared NAPs, which have been formally approved by the competent national authorities. The NAPs, with the lists of priority actions for the year 2010, have also received political endorsement by the Contracting Parties to the Barcelona Convention at their Meeting in Porto Roz (Slovenia) in November 2005. The implementation of the NAPs is an ongoing process, which will be revised in 2011. Also a discussion is underway on the application of a temporal differentiation mechanism for the implementation of regional emission values (ELVs), based on BAT, and for the development of regional and/or sub-regional -as appropriate - Environmental Quality Objectives (EQOs) for the marine environment.

POLLUTANTS FROM LARGE MEDITERRANEAN COASTAL CITIES

After the entry into force of the LBS protocol in June 2008, action plans and programmes containing legally binding measures and timetables required by Art. 15 of the Protocol are under discussion. Reduction of organic load from municipal wastewater is among the priorities which are already under preparation because of the importance of coastal cities, as pollution sources. Out of 131 "pollution hot spots", which have been identified by the countries in the frame of the Strategic Action Programme (SAP), 82 % are urban centres, which discharge urban or combined urban/industrial effluents, leading to the degradation of the quality of the marine environment in many certain coastal areas, while the impact on the open Mediterranean Sea environment is still uncertain. The permanent population in the Mediterranean coast is at the order of 150 million inhabitants, but is doubled during the summer period, as the area is one of the most frequented tourist destination of the world. Along the Mediterranean coast, there are 1,699 cities with population above 2,000 inhabitants (Fig. 1 and Fig. 2) having a total resident population of 75 million (UNEP/MAP/MEDPOL, 2004 and UNEP/MAP/MEDPOL, 2008).

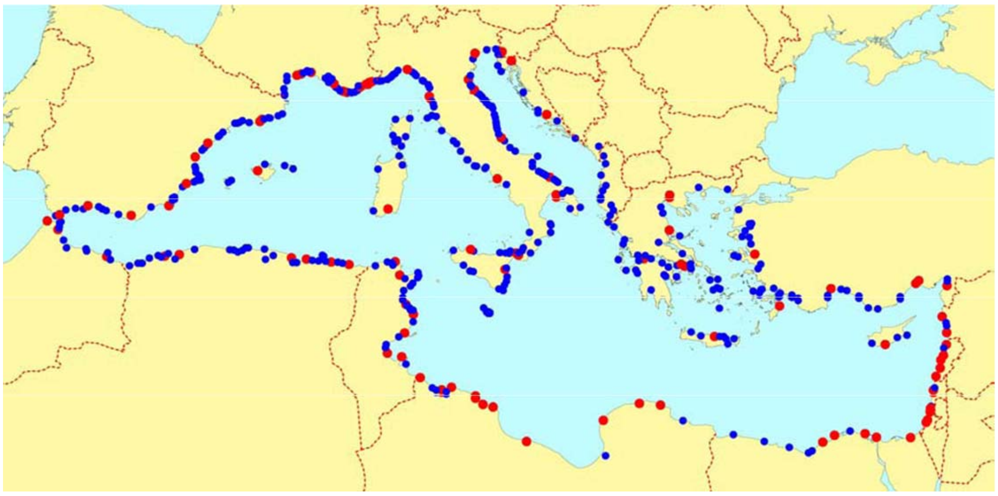


Figure 1. Mediterranean coastal cities (Red dots pop. >100,000, blue dots 10,000-100,000

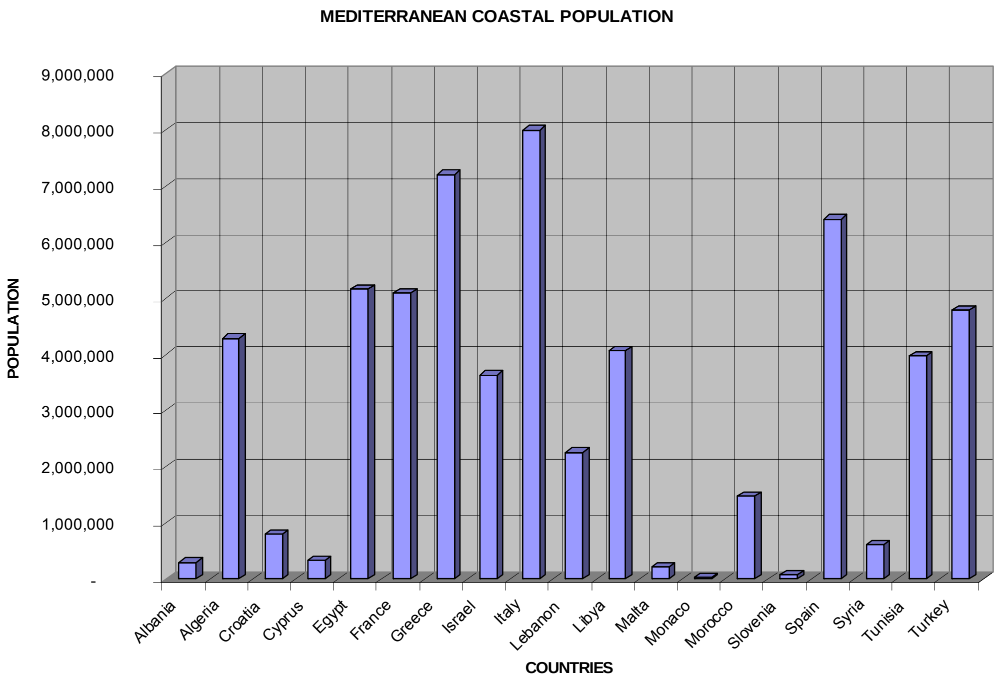


Figure 2. Mediterranean coastal population

Wastewater treatment plants (WWTP) are in operation in 60% of these cities, using mainly secondary treatment (75%), but also primary (20%) and tertiary treatment (4%), (Table 1).

Number of cities >2,000	Total population	Number of cities >2,000 served by WWTP	Permanent population served by WWTP
1699	74,854,000	1026	60,893,000

Table 1: Municipal wastewater treatment facilities in Mediterranean coastal cities > 2,000

In addition, MEDPOL developed, in 2003, an inventory of point sources of industrial effluents, mostly located in or on the skirts of urban coastal centres, which could reach, directly or indirectly, the marine environment. The inventory covers about 80 different substances or groups of substances and parameters and the database contains 6,700 entries and covers a large numbers of pollutants such as nutrients, metals and organics which are released from industrial point sources. The majority of data have been reported by northern Mediterranean countries (77% of records), while eastern and southern countries accounts for 12% and 11% of records, respectively (Fig. 3). Differences in the number of records can be related with the size and level of industrial development in each country, the regional and sectoral scope of the inventory, the availability of data, and the level of detail that each country operates its inventories. General parameters or non hazardous substances (such as BOD5, nutrients, VOC) accounts for the majority of records in the NBB database (68%),while substances of concern (such as heavy metals, chlorinated hydrocarbons and polyaromatic hydrocarbons) accounts for 32% of total records, although they represent 68% of the substances considered. This is not surprising, as general parameters like BOD or nutrients are commonly emitted and reported by many different sectors and countries, while substances of concern are more sector specific, and difficult to measure and report. Within the group of "substances of concern", more information (i.e., number of records) exists for metals, dioxins and phenols, than for PAHs and benzenes, and much less for organohalogens, for which very few records have been reported.

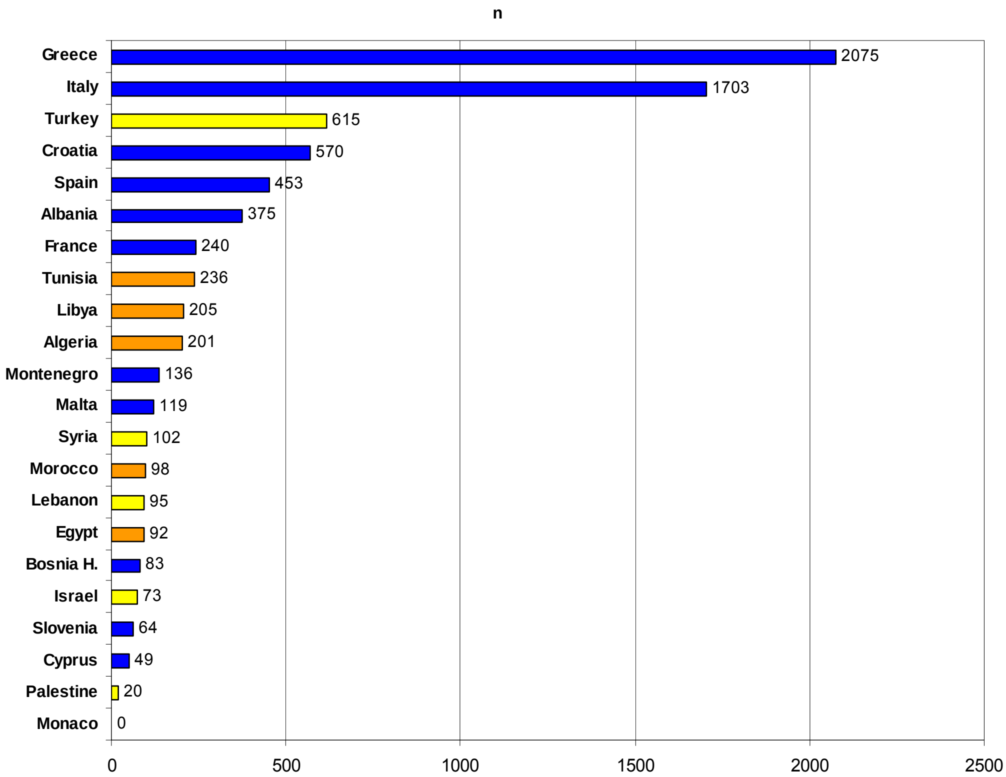


Figure 3. Number of data entries for pollutants discharged into the Mediterranean

To control pollution from urban centres, European Union countries, as well as some non EU countries, have in general, already established extended sewerage networks and WWTPs (secondary treatment) for most coastal cities. However, a very important part of urban effluents generated in the cities of North Africa, Eastern Mediterranean and East Adriatic coasts are still not treated before being discharged to the sea or surface waters. Only a part of the coastal population of these areas is connected to mainly primary treatment units (and few secondary treatment plants), but the largest part of the generated urban effluents are discharged untreated into the coastal marine environment. The rate of sewerage connection varies, and may reach impressively high rates (more than 70 percent) in some cities of these areas, but this should not be interpreted as an indicator of successful performance, since treatment plants are often inadequately operated and/or maintained. Furthermore, high urban population growth in the region has not only increased pressure on water resources, but it has also created a tremendous additional demand for urban water and sanitation infrastructure. Efforts by public utilities to increase their performance were usually unsuccessful, often because of the constraints to which public utilities are subjected, such as restrictions on tariff setting, (salary, and staffing. Although reuse of treated municipal wastewater is recognised by all countries in the region as a potential solution to both water shortage and wastewater management, in most countries of Middle East (with the exception of Israel), North Africa and Eastern Adriatic, the share of reused wastewater in the water balance is still low. However, a notable progress has been achieved recently in treated wastewater recycling, especially in water scarce countries, by integrating wastewater reuse into their national water schemes with emphasis on recycling industrial cooling water and reuse of treated municipal liquid waste for irrigation purposes.

In the framework of SAP, the proposed targets for urban effluents were to dispose all municipal waste water (sewage) in conformity with the provisions of the LBS Protocol by the year 2025. Meanwhile (by the year 2010), countries have to dispose sewage from cities and urban agglomerations exceeding 100.000 inhabitants and areas of concern, in conformity with the provisions of the Protocol. To that goal, the construction and/or upgrading of WWTPs, is included as a priority to most countries' NAPs. In the frame of the NAPs, at least 108 Wastewater Treatment Plants (WWTPs) are proposed to be built along the Mediterranean coastline and many more plants is planned to be upgraded (more advanced treatment, increase of treatment capacity, updating of equipment and process, etc). It is expected that the implementation of the NAPs will lead to an important reduction of the pollution load from these sources. However, there are important differences in priorities between countries. European Union (EU) countries have already established extended sewerage networks and WWTPs (secondary treatment) according to the EU Directives, for most coastal cities with population above 100,000. Furthermore, many smaller coastal towns with population above 2,000 are already connected to such treatment units. Out of the 108+ proposed new WWTPs in all the Mediterranean, only 15 are located in EU countries, serving in most cases towns with relatively small population (< 100,000). Also, the financing of the proposed actions seems assured in these cases and it is expected that the EU countries will have no problem to satisfy the SAP targets in the sector of Urban Sewage for the year 2010. On the other hand, a very important part of urban effluents generated in the cities of North Africa, Eastern Mediterranean and East Adriatic coasts is not treated before being released to the sea or surface waters. A part of the coastal population of these areas is connected to primary treatment units but very few secondary treatment plants are in operation.

The financing of these infrastructures is already under consideration. As an example, the Mediterranean Hot Spot Investment Programme (MeHSIP) of the European Investment Bank, using as background information the NAPs project priority lists, has identified 25 potentially bankable projects for the management of urban effluents (out of 44 total projects in the programme), with a preliminary estimated investment of 1.6 billion Euros.

REFERENCES

UNEP/MAP/MEDPOL/WHO, 2004. Municipal wastewater treatment plants in Mediterranean cities (II). MAP Technical Report Series, 157, pp.81.

UNEP/MAP/MEDPOL, 2008. Municipal wastewater treatment plants in Mediterranean coastal cities: Inventory of treatment plants in cities of between 2,000 and 10,000 inhabitants. MAP Technical Reports Series, No. 169, www.unepmap.org.

30+ years of marine waste water discharges – and related discussions – for small and large Mediterranean cities

Carlo Avanzini

MWWD[1] organization (Turkey & Italy) Cemiltopuzlu Cad. Bal Apt. 26-1 Kat:5 Daire:6,TR-34726 Çiftehavuzlar, Istanbul, Turkey

Keywords: waste water, discharge, treatment plant, coastal cities, Marmara

Abstract

My extensive experience as a consulting engineer has enabled me to monitor many studies and projects dealing with the protection of the marine environment. In the past years, my professional base has been Turkey. Istanbul and other Turkish coastal cities are a good example of a quickly developing environmental conscience and ongoing recovery of the local marine environment.

Résumé

Ma longue expérience comme ingénieur-conseil m'a permis de suivre la réalisation de nombreuses études et projets concernant la protection de l'environnement marin. Dans les années passées, ma base professionnelle a été la Turquie. Istanbul et d'autres villes côtières turques sont de bons exemples du développement rapide d'une conscience de l'environnement et d'une restauration progressive de l'environnement marin local.

Coastal waters, including estuaries, bays and wetlands represent a resource of enormous economic and environmental value, attracting industry, commerce, and human population to the coastal areas. The area within 200 km from the oceans' shorelines hosts more than 50% of the world population and UN projections show further increases.

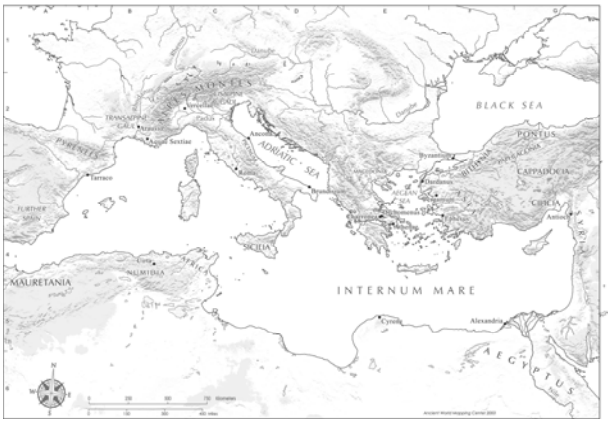
The resulting environmental pressures, in addition to the direct physical coastline alterations, strongly affect coastal water quality. Local economy suffers from the marine environment degradation and public health is endangered by polluted coastal waters, where beach closures are indicative of the dangers in water sports,

[1] MWWD: Marine Waste Water Discharges

affecting recreation and tourism. Choosing adequate techniques for regional needs and capabilities is an important step in coastal water quality management.

This is valid worldwide, but particularly for the Mediterranean Sea, the "mare nostrum" - our sea.

If we evaluate the impact of coastal cities on the marine environment, nobody needs to be reminded that the Med is, since millennia, a focal point of our civilization and therefore heavily subject to human influence and that few other coasts have been "lived" for such long time and with such density of population.



In our tiny, compared with the oceans, "pond", coastal villages and cities have been founded, have grown up, gained or lost importance, faded away or even disappeared with the passage of the centuries leaving however their traces in the history.

Coastal settlements have directed, to different extent and for different periods, the discharge of their human wastes in the marine environment; however, no heavy industrial pollution has taken place in the past centuries.

Also the millions of ships which have sailed on, or sunk in, the Mediterranean have certainly contributed to deteriorate the quality of the sea water, but in general the "quality" and "quantity" of the liquid and solid wastes has not been such to create dangerously polluted marine areas.

From the end of 1700 the situation has started to change, and the industrial use of oil, of dangerous or noxious elements, in few words of "polluting substances" has increased exponentially and, in many cases, industries – polluting or not – have been established near or on the coast (and rivers) due to the availability of water.

On the other hand, while till the start of the 19th century the population in the main coastal cities remained well under the million mark, the last two centuries have seen also an exponential growth of the population – the present situation sees cities and metropolitan coastal areas with population in the range of several millions.

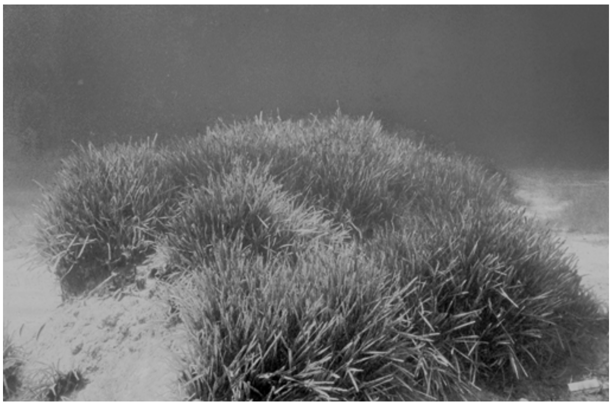
If something was being made in the early XX century, it was interrupted by the II WW, which caused a widespread pollution caused by the bombing and destructions. Luckily, the Mediterranean remained marginal in terms of sinking of commercial ships transporting dangerous substances.

At the end of the war, after the first steps of reconstruction, the first timid approaches to an environmental program concerning the marine discharges started to take place in the scientific circles, with discussions about eutrophication, marine waste water treatment, outfalls etc.

The development of a "marine ecological conscience" dates back already to the 60s and, since then, the growing concern on the Mediterranean pollution has brought to scientific and political initiatives, such as Mediterranean Action Plan (1975) followed by the Barcelona Convention (1976). The European Union and the Member Nations are also active in the issue of legislation and directives aimed to the protection of the marine environment, including the recent "Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)".

It is however known that quite often the political or legislative decisions or directives are the result of compromises and that the scientific community, deeply engaged in the evaluation of all the aspects of the marine pollution, is not always in full agreement on the measures and countermeasures to be taken or on their long term effects, the debates on the climate changes being a good example.

In the same time, the discussion about the coastal waste waters handling have continued, with the "fight" between the supporters of the marine waste water treatment (i.e. the discharge through outfalls) and the promoters of more complete treatment plants discharging near shore. The still ongoing debate is mostly due, in several countries, to the financial situation. However, I am convinced that outfalls will/shall represent a "safety valve" also for advanced treatment plants.



The debate on the "damages" of the discharges into the marine ecosystems is still ongoing, even if the usefulness – and the harmlessness - of well designed marine outfalls as a complement of the WWTP is now often recognized.

In the 70s and 80s, eutrophication was continuously "called in" to discuss or prevent quick decisions... while in the same time waste waters continued to be dumped into the sea.

Several international studies and monitoring campaigns have shown that the option of a wastewater treatment followed by a marine disposal can be the most effective in many regions where a strong increase of the sanitation coverage is needed and funds are lacking. The required level of treatment is determined by the nutrient needs and assimilative capacities of the receiving waters. Most coastal water bodies at open coast locations are capable to accept the nutrient inputs and this option allows coastal communities to reduce costs for expensive treatment systems, their maintenance and operation; this explains the worldwide increasing utilization of submarine outfalls as an important instrument for coastal water quality management.

Going around the Med, outfall are still under construction or planned for instance in Croatia, Turkey (Samsun), Lebanon (Tripoli), Morocco, while if we move to the Americas, we see outfalls under construction Argentina (Mar del Plata), and planned in Brazil (Sao Paulo), Chile....

Outfalls have been “recommended” for the sanitation of small and medium Mediterranean communities (i) and are indicated by WHO (ii) as a mean to reduce the hygienic risks in coastal waters.

At present, almost all Mediterranean coastal cities - just a few names: Barcelona, Marseille, Genova, Palermo, Split, Athens, Thessaloniki, Istanbul, Antalya, Tripoli (Lebanon), Tangiers – are equipped with outfalls discharging untreated (in few residual cases), partially treated or treated waters; some are as old as 30-40 years, some new, some still under construction or planned.

I do not want to be the advocate of the outfall (which apparently tend to be “banned” in the future), but I am still asking myself what will happen if there is a failure in a sophisticated treatment plant or in a disinfection system, or an overflow, without a mean of discharging the waste water in the “deep offshore”.

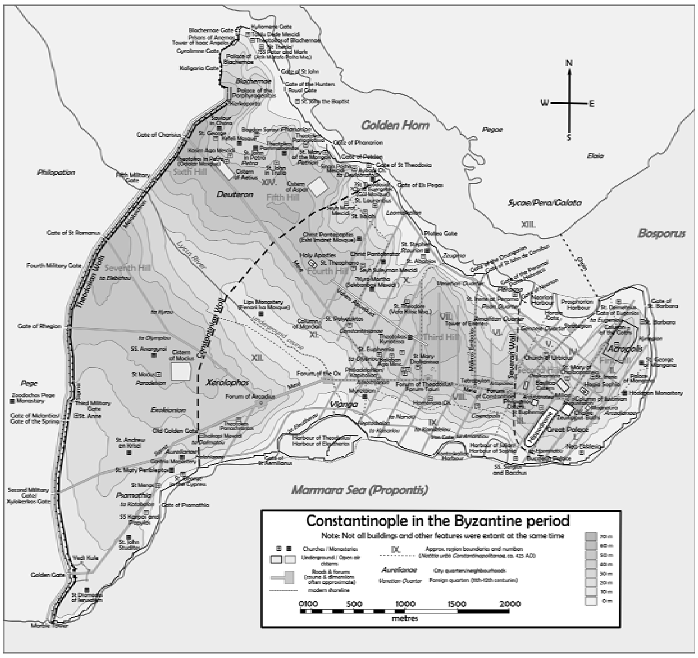
As a design engineer I have followed since the 70s – directly or indirectly - the development of waste water projects in several Mediterranean cities and the diffusion of the use of marine outfalls as “tool” for the waste water discharges. In addition, since 2000 I am organizing MWWD, a bi-annual specialized conference (iii) focused on the marine environment, which constitutes a ”meeting point” for the colleagues interested in the subject.

The effect of the waste water discharge in the marine environment – particularly in the Mediterranean – has been and still is a hot topic. A recent project, INSEA (iv) is dedicated to the development of technologies and knowledge for assessing eutrophication in coastal systems. INSEA is based on the hypothesis that combining (a) Remote Sensing, (b) In Situ measurements and (c) Modelling is the quickest and most economic way for assessing the trophic state of coastal waters and for planning management responses in case of necessity (v). This means that the problem is still actual... and in any case the full implementation of the present (and future) regulations will take still several years.

As a subject for the Alexandria Workshop, I have chosen Istanbul, where I am active professionally since several years and where I have my present residence.

Istanbul is, at present, the largest coastal city in the Mediterranean area; however, it is more correct to say that it gravitates between the Black Sea and the Marmara Sea, connected to each other through the Bosporus Straits, and influences the Mediterranean basin with the water moving through the Dardanelles.

While the direct appurtenance to the main Med basin may be discussed, from the point of view of the impact on the marine environment Istanbul is a suited example



... and no discussion about it being a large city, its population is reaching, in the metropolitan area, 11,5 million (2007 census).

The most recent number, and the numbers given in the previous years, may be questioned, due to the mobility of unregistered people coming to the city in search of occupation or leaving it as unemployed; a couple of millions more or less are nevertheless inessential: as Byzantium, then Constantinople, finally as Istanbul, the city has always been heavily populated.

Despite the fact that the evaluation of population in the early times is always a fair estimate (or a wild guess, depending on the points of view) Byzantium counted since the IV-V century more inhabitants than Rome itself and reached peaks of 550.000 (750.000 according to other sources) during the Byzantine empire, shrinking to 15.000 in 1477 (just after the conquest by the Ottomans) and finally growing up above 1 million starting in the 50s.

In times nearer to us, the growth has been quick: a paper written in 2002 (vi) was giving for Istanbul the following population data and forecast:

Year	Population (person)	Wastewater Flow (m^3/day)
1997	9,300,000	1,596,000
2010	15,160,000	2,601,000
2032	18,336,000	4,210,000

The 11+ millions of 2007 census are in line with the projections, and it can be expected that the trend continues – living in the city one sees a mushrooming of tall building and the expansion of new settlements in the 27 District Municipalities.

Istanbul gravitates on the water: not only the city extends along the Bosporus, the Golden Horn and at the fringes of the Black Sea, but also for several kilometers west – European side – and east – Asian side on the Marmara Sea.

The heaviest concentration of pollutants were, in the 60s, discharged in the Golden Horn and along the Marmara's West coast, where most of the tanneries were concentrated, while shipyards were occupying the coast towards the city borders at East.

Further East, outside the Metropolitan area limits, the Gulf of Izmit hosts the major concentration of industries (oil, chemicals) and the heaviest ship's traffic.

Disposal Strategies for Istanbul metropolitan area started to be studied in the early 70 with the DAMOC Master Plan (vii). Completed in 1971, it was the first master plan and feasibility study on the sewerage infrastructure for the city.

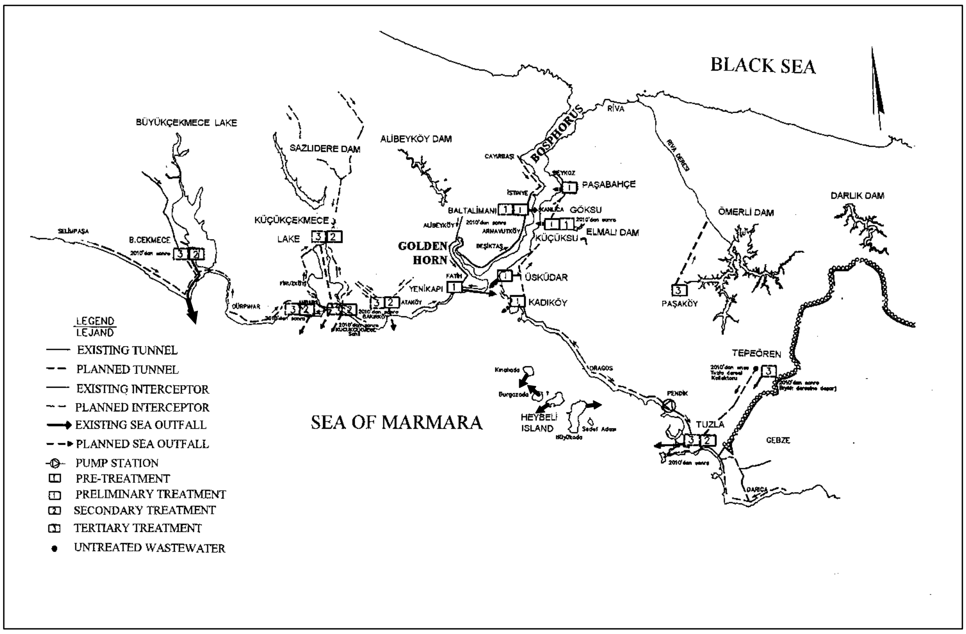
The report proposed the discharge of Istanbul's wastewater to the lower layers of coastal waters at selected disposal locations on the Asian and European sides of the Bosporus. Effluent was planned for discharge at a depth of 25 m in the Sea of Marmara and at the deepest section in the Bosporus. Preliminary treatment for removing the floating and particulate matter was proposed prior to discharge. An initial dilution ratio of 50:1 was considered acceptable in the Bosporus, in order to minimize local adverse effects at the discharge locations.

The study was followed by the Camp-Tekser Master Plan (viii), a revision to the DAMOC Report.

The report recommended that all Bosporus discharges should be made beneath the pycnocline, using diffusers to attain a dilution ratio of 50:1. Diffusers attaining a dilution ratio of 100:1 were proposed for the Marmara Sea discharges, with a minimum discharge depth of 50 m. Two or three staged outfalls were considered to be more economical than a single large diameter outfall, while preliminary treatment was considered essential prior to discharge, and discharges to the lower layer at locations where currents are slack were to be avoided.

In the following years, ISKI, the Istanbul Water and Sewerage Authority, started to implement the general plan, which included a total of 21 sea outfalls at the service of WWTPs.

The locations of the treatment plants and of the outfalls are shown in the figure below (from ISKI).



After a few unsuccessful starts (failed on account of economical problems), the construction of the principal new plants and outfalls started in 1985-86 (Yenikapi, Uskudar, Baltalimani, Tuzla ...) and is still going on.

In parallel, the revamping/construction of the main collectors and of the sewerage systems proceeded in order to transfer the waste waters to the treatment plants and to the discharge systems.

This involved extensive works of revamping/repairing of existing sewers, of tunnelling along the European coast of Bosporus and of the Golden Horn, of constructing new spine collectors, eliminating in the same time most of the local outlets discharging in the sea.

The planned actions – as it can be imagined – have been, during the years, slowed by the lack of funds. Not all the planned plants and outfalls have been completed, but the Great Municipality is pursuing the completion of the system.

A recent (2008) paper summarizes the situation as follows:

"Total length of sewerage network is about 12500 km with diameter ranging from 0.3 m to 4.5 m. There are 14 waste water treatment plants in Istanbul and 9 plants are either planned or under construction. In addition, there are oxidation-pool type treatment plants planned for villages on both the Asian and European side of the city. Total capacity of the existing treatment plants is 3.843.430 m^3/day. 50% of the treatment plants are pre-treatment, 35% biological treatment and 14 % advanced biological treatment plants. 84 % of the waste water treated in these plants goes through pre-treatment, 13% biological treatment and 3 % advanced biological treatment, but the situation is continuously changing. Discharge points of the pre-treatment plants are the Strait of Istanbul and for biological treatment plants is the Marmara Sea".

It is interesting to see that, while the population growth had remained more or less in line with the trend shown in the 2002 table, the waste water volume is already exceeding the 2010 one by about 50%. This derives from a more accurate recording of the utilization and from the better living conditions, which are bringing an increase in the consumption.

! The Golden Horn in 1996

However, to my opinion, some particular interventions undertaken in the past years have had a major impact on the safeguard of the marine environment around the city.

One of them – particularly effective - has been the relocation of the main polluting industries located along the coast of Marmara and Golden Horn (particularly tanneries and leather producers) to industrial areas created ad hoc and equipped with industrial pre-treatment systems.

Picture 1 The Golden Horn in 2003

This was followed by the sanitation of the land areas – a task which required, among others, the elimination millions of rats - and by the removal of several million m^3 of polluted sediments from the Golden Horn.

In parallel, many unaccounted discharges, mostly from abusive settlements, have been recorded and connected to the system – and the shanty housing areas "sanitized".

Another key action, less visible but extremely significant to reduce the stress to the sea, has been the strong reduction and the control of the indiscriminate sand extraction from the sea bottom.

The monitoring of the Bosporus and Marmara Sea is going on since several years and it is demonstrating an increasing “good quality” of the waters and the effectiveness of the measures undertaken by the Municipality through ISKI.

Both the physical-chemical and the bacteriological aspects, as required by the Turkish Law, are at present respected along most of the municipal coast and are continuously improving, despite the problems – and risks – posed by the heavy tanker traffic through the Bosporus and the Dardanelles. On this respect, the ongoing plans to bypass the Bosporus by transferring crude oil from Black Sea to Med with pipeline/s will contribute in the future to reduce the stress on the Istanbul waters.

Still, “hot spots” exist along the coasts but, altogether, a lot of small steps and an increasing “ecological mentality” in the public contributes to an increasingly livable environment ... a small example is given by the presence of the small garbage collection barges which “sweep” the marine waters.

For the citizens, one of the most evident results is the recovery of the water quality – i.e. normal physical-chemical characteristics, transparency, reduced quantity of floating garbage, hygienic standards – which since a few years has restored the balneability along most of the Marmara sea coast.

The reappearance of the Bosporus fishes on the local market stalls, after years of decrease in quantity, can be considered as a further index of good health.

Nevertheless, the most welcome effect for the “istanbulers” is the re-appearance of fishes at the mouth of the Golden Horn, the Galata Bridge - as well as many other stretches of coast - being a traditional fishing base for many residents

Still, huge gaps still exist in the understanding of the stresses acting on the marine environment. For instance, Istanbul is heavily relaying on ferries – marine transportation – to ease the city traffic. This traffic seems minor against the shipping through the Straits, but if and how this influences the sea is still uncertain. It means that it may be difficult (impossible?) to correlate all local situations into an unitary, generally valid, action scheme.

Istanbul is, to my opinion, a good example on how an administration, despite political changes and not without some errors, has been able to proceed towards a recovery of an environment that, not many years ago, seemed to be slowly decaying.

My profession has enabled me to monitor several studies and projects dealing with the protection of the marine environment along the Mediterranean coasts.

In the past years, my base has been Turkey, therefore I had the possibility to “live” the changes in the attitude of the coastal municipalities towards the marine environment. Apart Istanbul, which has been always privileged as the heart of Turkey, all other fast growing Turkish coastal cities are a good example of a quickly developing environmental conscience and ongoing recovery of the local marine environment.

If I can draw a personal conclusion from my experience is that the Mediterranean has suffered in the past years not only from the waste water discharges from small and large cities, but also from the stresses created by the increase in the urbanized areas, by construction of ports and marinas and by the navigation.

While several problems are being solved, others arise in a continuous run of modernization. Moreover, the climate changes may upset what has been done and ruin the best laid plans.

Nevertheless, the Mediterranean seems enough resilient to survive to the increasing human impacts and, thanks to the common efforts, is returning in several areas to pristine conditions.

Obviously, much shall still be done, and the priority shall be to focus on the main sources of negative impacts, the large coastal cities.

REFERENCES

i. Guidelines for submarine outfall structures for Mediterranean small and medium-sized coastal communities - MAP Technical Reports Series no. 112 / UNEP, 1966.

ii. Guidelines for safe recreational water environment, Volume 1: Coastal and fresh waters - World Health Organization, 2003.

iii. MWWD – International Conferences on Marine Waste Water Discharges and Coastal Environment (www.mwwd.org).

iv. INSEA (www.insea.info) is a GMES project funded by the 6th framework project (contract nº SST4-CT-2005-012336) and aiming to develop structural coastal management tools combining remote sensing, mathematical modeling and in-situ data.

v. Neves R. & al., 2008. INSEA presentation and papers – MWWD Proceedings.

vi. Eroğlu V., Sarıkaya H. Z., Aydın A. F., Öztürk İ., Altay A., 2002. Effluent discharge strategy and the marine outfalls of Istanbul City, – Proceedings, MWWD.

vii. DAMOC (1971). Master Plan and feasibility study report for water supply and sewerage for Istanbul region. Prepared for WHO, III, II.

viii. Camp-Tekser (1975). Istanbul Sewerage Project Master Plan revision.

The impact of human activities in Alexandria and Port Said Governorates on the coastal marine environment along the Egyptian Mediterranean coast

Ali I. Beltagy

National Institute of Oceanography and Fisheries, Kayetbay, Al Anfoshy, Alexandria, Egypt

Keywords: pollution load, effluents, coastal environment, Egyptian coast

Abstract

The two Governorates of Alexandria and Port Said embrace 12 coastal cities with a total resident population of ca 5.3 million (2004 estimate). Main cities of Alexandria and Port Said provide primary treatment as well as some secondary treatment of their wastewater. The treated wastewater discharged into rivers or into the northern lakes (Lake Maryut and Lake Manzala); there is no direct discharge of treated sewages into the sea. However, there remains the sink for some source for untreated sewage, but there is no adequate information to estimate either their quantities or ways of discharge. The effect of the wastewater discharge through the lakes on the coastal Mediterranean environment seems to be very localized and restricted to areas close to the source.

Résumé

Les Gouvernorats d'Alexandrie et de Port Saïd comptent à eux deux 12 villes côtières totalisant une population résidente d'environ 5,3 millions d'habitants (recensement de 2004). Les deux villes principales, Alexandrie et Port Saïd, assurent le traitement primaire de leurs eaux usées ainsi qu'un traitement secondaire partiel. Les eaux usées traitées sont déversées dans les fleuves ou dans les lacs du nord (Lac Maryut, Lac Manzala) ; il n'y a pas de déversement direct en mer des eaux usées traitées. Cependant, le milieu marin constitue toujours le réceptacle privilégié de certains rejets non traités, mais les informations disponibles ne sont pas suffisantes pour en estimer de façon fiable les quantités et modes de déversement. L'impact sur l'environnement côtier méditerranéen des déversements d'eaux usées dans des lacs communicant avec la mer semble très localisé et restreint aux régions proches des points de rejets.

INTRODUCTION

Alexandria Governorate extends for about 75 km along the Mediterranean coast of Egypt with a total area of 2,818.77 km^2. It is the main harbor of Egypt where 60% of the country's exports and imports going through it. The Governorate includes the main city, several other satellite suburbs and rural areas.

The permanent population is about 3,800,000 inhabitants with a population density of 1225 inhabitants/km^2. Being the first summer destination in the country, it receives an extra of 1,500,000 visitors in this season. Administratively, the Governorate is divided into six districts.

Alexandria hosts three harbors : namely the Western Harbor, which is the main harbor of the country, EI'Dekhiela Harbor just west of the Western Harbor, and the Eastern Harbor (fishing and yachting). It also hosts about 40% of the country's industries.

Port Said Governorate lies at the northern end of Suez Canal with a total area of 1,344.96 km^2 and a populated area of 1,320.68 km^2. It's bounded by North Sinai Governorate to the east; Damietta Governorate to the west; Lake Manzalah, Dakahlia, Sharkia and Ismalia Governorates to the south. The total population was 529,684 inhabitants in 2004. Administratively, the Governorate includes 7 districts. Activities in the Governorate are diversified as they range from agriculture, industry, to maritime services and shipyards. The agricultural land area in the Governorate was 40,000 feddans[1] in 2004 with rice, barely, wheat and alfalfa as the main crops. Industrial activities in the Governorate include metallurgical, textiles, petrochemicals and natural gas liquefaction, chemical (detergents, paints and cosmetics) and ceramics.

SOURCES OF POLLUTION AND COASTAL POLLUTION LOAD

The main industries are textiles, iron and steel, chemical, and foodstuff. Agriculture is of quite minor role in Governorate's economy as the cultivated area is limited to 1846 feddans.

The potable water production is 1,797,000 m^3/day. A good sewer and rainwater network and two waste water treatment plants (WWTP) of the primary-treatment type serve the main city with a total capacity of 1,320,000 m^3/day. The WWTPs serve all the districts of the Governorate including Abu Oir and EI'Agami. Except for industrial plants in Abu Oir Bay area which discharge their wastewater into the Bay either directly or through Amia Drain, all other industrial plants discharge their effluents into the sewer system which ultimately reaches the two WWTPs. Due to this, sewage effluents to the WWTPs are mixed in nature (industrial and

[1] 1 feddan = 4200 square meters

domestic). Effluents from the two WWTPs are discharged into the landlocked Lake Maruit southwest of the city. Water of the Lake is pumped to the sea through EI'Max Pumping Station.

In Abu Qir Bay, the industrial plant discharges directly into the Bay.

In Port Said, the potable water production was 163,672 m^3/day in 2005 with per capita of 209 l/day. Port Said is served by sewer network and a WWTP of the secondary type with the capacity of 190,000 m^3/day. Effluents from the WWTP are discharged into Lake Manzalah which is connected to the Mediterranean through El'Gamil outlet. Two WWTPs are under construction to serve Port Fouad district (37,000 m^3/day) east of Suez Canal, and El'Garabaa-El'Manasra area west of the city. A WWTP is under construction also in the industrial zone south of Port Said.

Administration Region	Source	Type	BOD	COD	T-N	T-P	TSS	Oil	Flow Rate m^3/day
Alexandria Governorate	Nubarya Canal	Freshwater	1018	4180	-	-	5815	-	$90x10^6$
	El-Umum Drain	Mixed (agriculture + domestic + industrial) wastewater	28470	175200	2081	2628	91433	-	$6x10^6$

BOD: Biological Oxygen Demand, COD: Chemical Oxygen Demand, T-N: total nitrogen, T-P: total phosphorus, TSS: Total Suspended Solids

Table 1. Effluents & pollution load at El'Max Bay (tons/year)

Industrial Company	BOD	COD	Total-N	Total-P	TSS	Flow m^3/day
Fertilizer production	362	5140			1770	16,000
Rakta for pulp and paper mill	20624	80470			78050	56,000
National paper	444	2573			377	12,000
Siclam	197	245	1095	913	180	300
Edfina for food preservation	354	347	1132	1971	363	2,800
Kaha company	14.2	48.7	1132	1971	26.3	300
Siouf spinning	622	1866	913	1131	362	5,300
United Arab for textile	2330	3355	913	1131	312.5	2,900
Oriental lines & cotton company	2.3	4.8	913	1131	5.5	2,500

Table 2. Industrial pollution loads to Abu Qir Bay from major industrial company (tons/year)

SURVEY OF THE MARINE ENVIRONMENT

A survey conducted in the coastal areas indicated that the water and sediments from the places of direct discharge are still in good condition.

NATIONAL PLANS TO MINIMIZE POLLUTION OF THE MARINE ENVIRONMENT

Several measures which are planned to minimize pollution from land-based sources have been taken.

CONCLUSION

Pollution sources observed and recorded along the Mediterranean coast of Egypt can be categorized as follows: agrochemical pollution; industrial pollution; municipal sewage and wastewater; effluents from thermal electric power plants; maritime transport and industries; air pollution and others. In the considered area, the main sources observed are sewage and industrial wastewater. Measures to minimize their effect are being taken. For the time being, levels of several pollution parameters indicate healthy environment outside the discharge areas showing that the pollution of coastal marine water and coastal sediments is very much localized.

Urban pressures on the Spanish Mediterranean coasts: ecotoxicological and ecological issues in marine ecosystems

Julián Blasco[1], Eduardo González-Mazo[2] and Antonio Tovar-Sánchez[3]

[1]*Instituto de Ciencias Marinas de Andalucía (CSIC), Campus Río San Pedro 11510 Puerto Real (Cádiz), Spain*
[2]*Departamento Química-Física, Facultad de Ciencias del Mar y Ambientales Universidad de Cádiz, Campus Río San Pedro, 11510 Puerto Real (Cádiz), Spain*
[3]*Department of Global Change Research, IMEDEA (CSIC-UIB) Instituto Mediterráneo de Estudios Avanzados, Miquel Marques nº71 07190 Esporles (Mallorca), Spain*

Keywords: waste water, chemical contaminants, groundwater, Spanish coast, ecotoxicology

Abstract

Spanish Mediterranean coasts support the pressures derived for the increasing of the population. This problem is not only related to the big cities located in the coastal areas, as Barcelona, Valencia and other medium size cities (e.g. Alicante, Málaga, Almería...) but to the general increasing of the population in coastal areas, especially in the last decades. Pressures of the urban nucleus on the marine environment can negatively affect marine ecosystems. Yet some important sources, as the nearly invisible submarine groundwater discharges (SGD), that are important supplier of pollutants to the coastal habitats and ecosystems, are ignored. The identification of sources and pollutants (surfactants, metals, etc.) are key points for the assessment of the environmental quality of marine ecosystems. However, recordings of pollutants in marine ecosystems do not provide information about their effects. An integrated ecotoxicological approach should be taken account for evaluating the anthropogenic risk on the marine ecosystems.

Résumé

La côte méditerranéenne espagnole supporte la pression de la croissance démographique. Ce problème n'est pas seulement lié aux grandes villes comme Barcelone, Valence ou aux moyennes villes comme Alicante, Malaga, Almeria mais aussi à la croissance globale de la population le long de la zone côtière, particulièrement depuis la dernière décennie. Les pressions exercées par ces centres urbains sur l'environnement marin peuvent affecter l'écosystème marin. Certaines sources importantes sont encore mal connues, comme les rejets d'eau souterraine sous-marine (submarine groundwater discharges, SGD) qui sont

quasiment invisibles mais qui représentent un apport important de polluants vers les habitats et les écosystèmes côtiers. L'identification des sources de pollution et de la nature des polluants (surfactant, métaux,..) est essentielle dans l'évaluation de la qualité environnementale des écosystèmes marins. Cependant, la mesure des concentrations de polluants dans les écosystèmes marins ne donne que peu d'informations sur leurs effets. Une approche écotoxicologique intégrée doit être conduite pour évaluer les risques liés aux impacts des activités anthropiques sur les écosystèmes marins.

In Spain, 44% of the population live in littoral areas although these areas are only the 7% of the country surface. Additionally, 80% of the tourists visiting Spain (approx. 48 millions) are accommodating in coastal areas during their holidays. The movement of the population to coastal areas has increased in the last years and it has generated a "littoralization" of the territory. The Spanish Mediterranean area is specially affected by this process and 80% of the land is considered as urban or built land (MMA, 2007). As a consequence of this urban pressure the coastal ecosystem is suffering a continuous degradation. A direct effect of the increase of the population is the rising of wastewater production, with an estimated volume of 126 L/person·day (UNEP, 1996). Although all the Spanish Mediterranean big cities have wastewater treatment plants (WWTPs), the wide distribution of the population along the coast makes difficult the depuration of the whole water before discharge. The main substances entering in the coastal ecosystem due to municipal wastewater discharges are: suspended and dissolved matter, organic matter and nutrients, detergents and other contaminants (e.g. metals, organohalogen compounds, antifouling, endocrine disruptors and pharmaceuticals).

Among the above mentioned contaminants, surfactants have one of the biggest production rates and they are used in industrial processes as well as in household. In Spain, the main anionic surfactant employed is the linear alkylbenzene sulphonate (LAS) which 80-85% is employed as household detergent. In coastal waters, its concentration is found below 50 µg/L (González-Mazo et al.,1998) and in marine sediments below 2 mg/kg. However, other surfactants have been recorded in hot spots in the Spanish Mediterranean areas, this is the case of non-ionic surfactants and their degradation products: nonylphenol ethoxylates (NPEOs) and nonylphenol (NP) with concentrations ranging from 620 to 1000 µg/kg. Special concern should be taken in account with NP due to its estrogenic effect (Petrovic et al., 2002). Although NPEOs are banned or restricted in Europe, they are still being used in some countries. In order to predict their long-term fate, it is interesting to continue to monitor their distribution in the environment (González et al., 2004). Other chemicals compounds which have attracted attention are the pharmaceutically active compounds (PhACs). The main route of their entry in the aquatic medium is discharged via wastewater, although their degradation varies widely between compounds. They can be considered as pseudo-persistent due to their continuous input. The information about the presence and discharges of these compounds in the Mediterranean coastal ecosystems is scarce. Recently, Gómez et al. (2007) analysed in the Mediterranean coast (Almería, Spain) the persistence of pharmaceuticals in the effluent of WWTPs showing that it represents a continuous input to coastal waters.

Metals are contaminants which presence in the coastal environments is well known and their inputs are associated to different anthropogenic activities. Nevertheless, the importance of other sources of metals, as submarine ground discharges (SGD) to coastal ecosystems are unknown and can represent an important input of metals to the coastal areas. Tovar-Sánchez et al. (2007) have recently evaluated the relevance of SGD in the coastal of Mallorca Island and chemically characterized the components that are diffusely supplied to the coastal waters through this pathway. The results suggest SGD could be an important source of nutrients and metals to the coast and could strongly influence the productivity and biogeochemical cycling of the coastal waters. Thus, Moore et al. (2008) estimated that submarine groundwater flux in the upper Atlantic Ocean account between more than 80% of the freshwater entering the Atlantic Ocean.

Despite persistent organic pollutants (POPs) have been identified as a group of the special concern within the Mediterranean Action Plan (UNEP/MAP, 1999a, b), information in many Mediterranean areas is scarce. Gómez-Gutiérrez et al. (2007) carried out the ecological risk assessment of POPs in the Mediterraneam sea sediments and they found that the level of toxicity for the benthic community was low and highlighted the importance of DDT contamination in the sediments.

Pollutant concentrations in the Mediterranean Sea are generally low, however hot spots can be found in coastal ecosystems, because contaminants distribution is not a homogenous process. The areas close to the big cities and population nucleus with untreated discharges are potential places where pollutant problems will be detected. Among environmental compartments, sediments are the main place for accumulation; they act as sink and reservoirs of contaminants although the changes in environmental conditions can produce their releasing and affect the benthic organisms.

The ecological risk assessment carried out in the Mediterranean basin to study the hazard induced by pollutants (Gómez-Gutiérrez et al., 2007) has identified gaps regarding the exposure and effects. There is a lack of information for specific regions and on-site ecotoxicological data. The monitoring activities should be increased and the development of the bioassay with species present in the Mediterranean area should be conducted. Hansen et al. (2007) revised the different species employed in EU to characterize dredged materials. Some of these species are present in the Mediterranean Sea and they can be useful as tools to analyze the toxicity of sediments: *Ruditapes philippinarum, Cylindrotheca closterium, Sparus aurata*. Other approaches to analyse the biological effect assessment as biomarkers have been applied in the Mediterranean basin in the framework of MEDPOL programme (MAP, 2006). However, the assessment of the environmental health of ecosystems should be carried out in the framework of weight of evidence assessment (WOE) which can include a combination of sediment chemical analysis, sediment toxicity, community structure studies, biomagnification, biomarkers, bioaccumulation and sediment stability, called lines of evidences (LOE). This holistic approach allows getting information with a greater utility than if it was extracted from individual components (Scrimshaw et al., 2007).

Finally, the ecotoxicological approaches to measure the environmental quality of the coastal ecosystems subjected to urban pressure should be carried out in the frame of the Water Framework and Marine Strategy Directives, because both of them have as goals to get a good environmental status for coastal ecosystems.

REFERENCES

Gómez-Gutiérrez A., Garnacho E., Bayona J.M., Albaigés J., 2007. Screening ecological risk assessment of persistent organic pollutants in Mediterranea sea sediments. Environ. Int., 33 :867-876.

González S., Petrovic M., Barceló D., 2004. Simultaneous extraction and fate of linear alkylbenzene sulfonates, cocconut diethanol amides, nonylphenol ethoxylates and their degradation products in wastewater treatment plants, receiving coastal waters and sediments in the Catalonian area (NE, Spain). J. Chromatogr. A 1052 : 111-120.

González-Mazo E., Forja J. M., Gómez-Parra A., 1998. Fate and distribution of linear alkylbenzene sulphonates in the littoral environment. Environ. Sci. Technol., 32 : 1636-1641.

Hansen P-D., Blasco J., DelValls T. A., Poulsen V., Van den Heuvel-Greve M., 2007. Biological analysis (Bioassays, Biomarkers, Biosensors). In Sustainable Management of Sediment Resources : Sediment Quality and Impact Assessment of Pollutants. (D. Barceló & M. Petrovic, eds.). Elsevier. 131-161 pp.

MMA. 2007. Estrategia para la sostenibilidad de la costa. 21 pp. (http://www.google.es/search?q=MMA.+2007.+Estrategia+para+la+sostenibilidad+de+la+costa&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:es-ES:official&client=firefox-a).

Moore W.S., Sarmiento J.L. , Key R. M., 2008. Submarine groundwater discharge revealed by 228Ra distribution in the upper Atlantic Ocean. Nature 1, 309-311.

Petrovic M., Rodríguez Fernández-Alba A., BorrulF., Marcé R. M., González-Mazo E., Barceló D., 2002. Occurrence and distribution of noionic surfactants, their degradation producs, and linear alkylbenezne sulphonates in coastal waters and sediments in Spain. Environ. Toxicol. Chem., 21 : 37-46.

Scrimshaw M. D., DelValls T. A., Blasco J., Chapman P. M., 2007. Sediment quality guidelines and weight of evidence assessments. In Sustainable Management of Sediment Resources : Sediment Quality and Impact Assessment of Pollutants. (D. Barceló & M. Petrovic, eds.). Elsevier.295-310 pp.

Tovar-Sanchez A., Beck A. J., Coffey R., Basterretxea G., Vaquer R., Garcia E., Garcia-Orellana J., Martinez-Ribes L., Duarte C. M., Agusti1S., Masque P., Bokuniewicz H. J. and Sañudo-Wilhelmy S., 2007. A Preliminary Survey of the Input of Contaminants Via Groundwater Discharge Into the Coastal Environment of Mallorca Island. International Symposium (IX ISAMEF). pp 9.

UNEP, 1996. Survey of pollutants from land-based sources in the Mediterranean. MAP Technical Reports Series No. 109. 83pp.

UNEP, 2006. Biological Effects Monitoring Program. MAP Technical Report Series No. 166. 244pp.

Contribution of coastal cities to the alteration of the marine environment quality

Pierre Boissery

Agence de l'Eau Rhône Méditerranée & Corse, Délégation de Marseille
Immeuble le Noailles, 62, La Canebière 13001 Marseille, France

Keywords: wastewater, runoff water, effluents, coastal zone

Abstract

Protecting coastal water quality and habitats has become a major challenge for public authorities and users of the coastal area. An integrated approach taking into account all the pressures is necessary. Pollutant inputs to the sea come form different sources. As show by the experience carried out in Toulon (France), besides sewage treatment plants and industrial effluents, it is important to consider intermittent flows from rivers and diffuse runoff from the coastal urban areas.

Résumé

La protection de la qualité des eaux et des habitats côtiers est devenue un enjeu majeur pour les pouvoirs public et les usagers de l'espace littoral. Une approche intégrée prenant en compte l'ensemble des pressions est nécessaire. Les apports polluants à la mer ont différentes origines. Comme l'a montré la démarche mise en œuvre sur la rade de Toulon (France), à côté des rejets des stations d'épuration, des effluents industriels, il est important de considérer les apports intermittents des fleuves côtiers et les apports diffus provenant du ruissellement pluvial dans les zones urbanisées.

The protection of coastal water quality has become in recent decades a subject of the most challenging for governments, local authorities and all users of the coastal zone. On the French Mediterranean coast, this has resulted in concrete actions by the implementation of management policies. These policies are usually driven by a commune or an inter-municipal structure. They cover all topics concerning the coastal areas and should ultimately lead to a local and operational management plan. If these approaches are developing today, it is because the classical thematic ones like waste water management although still essential, are no longer enough to guarantee an excellent quality of the water or of aquatic environment.

Coastal cities generate a significant number of pressures, both direct and indirect. It is necessary to take into account all of these pressures to ensure a good state of coastal waters.

Direct pressures on the hydromorphology relate to habitat destruction and modification of the natural hydrodynamic, hydrological and sediment transport functioning. They are often "historical" and "irreversible". It is also possible to point clean or polluted inputs to the coastal sea, coming from urban discharges, often intermittent coastal rivers, and storm water runoff which is one of the main current concerns.

As part of the implementation of the “Bay environmental strategic agreement” of Toulon[1], coastal zone integrated management operation has been initiated and an estimation of pollutants flux to the sea has been performed. It concerned inputs from waste water treatment plants, listed industrial installations, port areas as well as the contribution of the watershed.

The results of this study demonstrated the relative share of each type of source. Thus, for example, regarding the estimation of annual inputs into the sea of suspended particulate matter (in tons per year), the contribution of discharges from sewage treatment plants is 14%, the one of port areas is 5%. Industrial waste counts for 39% and catchment areas for 42%. These elements show that the only consideration of inputs from discharges of wastewater treatment plant (14% of the annual total amount) is inadequate to manage the issue of suspended particulate matter inputs to the coastal marine environment.

Given the results of this first study, a complementary phase[2] was launched on the land side of the French Mediterranean coast. That study made possible the assessment for each “reference area” (in this case corresponding to the “homogeneous zone” of the geographical framework of the Strategic planning scheme for the management of Rhone Mediterranean & Corsica basin waters[3]) the relative contributions of urban stormwater for following parameters (BOD5, TSS, NGL, Pt, Pb, Zn, HC)[4], of discharges from the sewage treatment plants and the industrial facilities (MO, MI, NR, MP, Metox)[5] and discharges from the marinas (BOD5, COD, TSS, NGL, PT)[6].

The findings demonstrated that the main source of inputs (excluding the Rhone River) is the coastal rivers, the diffuse coastal cities (storm runoff), urban discharges, industrial discharges and inputs related to port activity.

---

[1] Elaboration du contrat de baie de la rade de Toulon, BCEOM, Toulon Provence Métropole June 2002

[2] Etude des apports des bassins versants à la Méditerranée, hors Rhône (Study of inputs from watershed to the Mediterranean sea, excepted the Rhone river), SIEE, Agence de l'Eau Rhône Méditerranée et Corse, February 2003

[3] Schéma Directeur d'Aménagement et de Gestion des Eaux du bassin Rhône Méditerranée et Corse, Comité de Bassin Rhône Méditerranée et Corse, June 1996

[4] BOD5 : 5 days Biochemical Oxygen Demand, TSS : Total Suspended Solids, NGL : Global Nitrogen, HC, Hydrocarbons

[5] MO : Oxidizable Matter, MI : Inhibitive Matters (toxicity), NR : Reduced Nitrogen = NTK, MP=PT : total phosphorus, Metox : Toxic metals

[6] COD : Chemical Oxygen Demand

Since this work, a common methodology is used in order to define the restoration measures to be undertaken. Each step of the management plan of the coastal area addresses the issue of inputs from the catchment area with the support of expert studies, modelling work or, as in the case of the bay of Marseilles, by a specific scientific project.

Impacts of water treatment on marine ecosystems: a tentative approach for Barcelona

Françoise Breton[1], Emil Ivanov[1], David Saurí[2], Antoni Trujillo[2] and Antoine Mangin[3]

[1]European Topic Centre on Land Use and Spatial Information Universitat Autònoma de Barcelona (UAB), Bellaterra, Spain
[2]Department of Geography, UAB, Bellaterra, Spain
[3]ACRI-ST, 260 route du Pin Montard, 06904 Sophia-Antipolis, France

Keywords: Barcelona, wastewater, pollution, phytoplancton

Abstract

Reducing marine pollution is one of the main objectives of the new ICZM[1] Protocol for the Mediterranean, launched in January 2008. Moreover, and with the European Initiative Horizon 2020, the objective is to eliminate (totally) the pollution in the Mediterranean by 2020. To give support to these policies and achieve these objectives it is important to review what exists in terms of initiatives and their results for a good follow up of impacts on marine ecosystems. This paper focuses on the recent construction of an important waste water treatment plant, located at the mouth of Llobregat river (operative in 2003) and the enlargement (and application of tertiary treatment) of the Besos plant (operative in 2004) to complete the sanitation network in the Barcelona area and improve marine water quality. Starting from existing monitoring tools, we present a methodology to assess the impact on the marine ecosystems and discuss its benefits.

Résumé

Réduire la pollution marine est un des principaux objectifs du Protocole GIZC[2] en Méditerranée de janvier 2008. C'est aussi le but de l'initiative Horizon 2020 qui vise à éliminer totalement la pollution en Méditerranée en 2020. Pour apporter un soutien à ces politiques et contribuer à l'atteinte de ces objectifs, il est important de faire un bilan des initiatives en cours et des résultats obtenus. Cet article présente les actions mises en œuvre à Barcelone avec notamment la construction récente d'une importante station d'épuration à l'embouchure du Llobregat (en opération depuis 2003) et l'agrandissement d'une seconde station sur le fleuve Besos (opérationnelle en 2004). Ces projets ont permis de développer le réseau d'assainissement de l'aire métropolitaine de Barcelone et ont contribué à l'amélioration de la qualité des eaux marines. En se basant sur des outils de

[1] ICZM: Integrated Coastal Zone Management

[2] GIZC: Gestion Intégrée de la Zone Côtière

surveillance existants, nous présentons une méthodologie pour analyser l'impact de ces initiatives sur les écosystèmes côtiers et marins.

OBJECTIVE OF THE PAPER

The reduction of pollution of marine waters from land-based sources in the Mediterranean is the object of the Protocol of the Mediterranean Sea against pollution from land based sources. One of the priority objectives of the Mediterranean Strategy for Sustainable Development (MSSD) is to reduce the number of the coastal urban population with no access to sanitation (see http://www.planbleu.org/publications/smdd_uk.pdf). Reducing marine pollution is also one of the main objectives of the new ICZM Protocol for the Mediterranean, launched in January 2008. Moreover, with the Horizon 2020 initiative of the EU, the objective is to eliminate the pollution in the Mediterranean by 2020. To give support to these policies and achieve these objectives it is, therefore, important to review what has been implemented in support of the policy as well as what exists in term of monitoring tools and instruments, assessing their results to take the needed decisions.

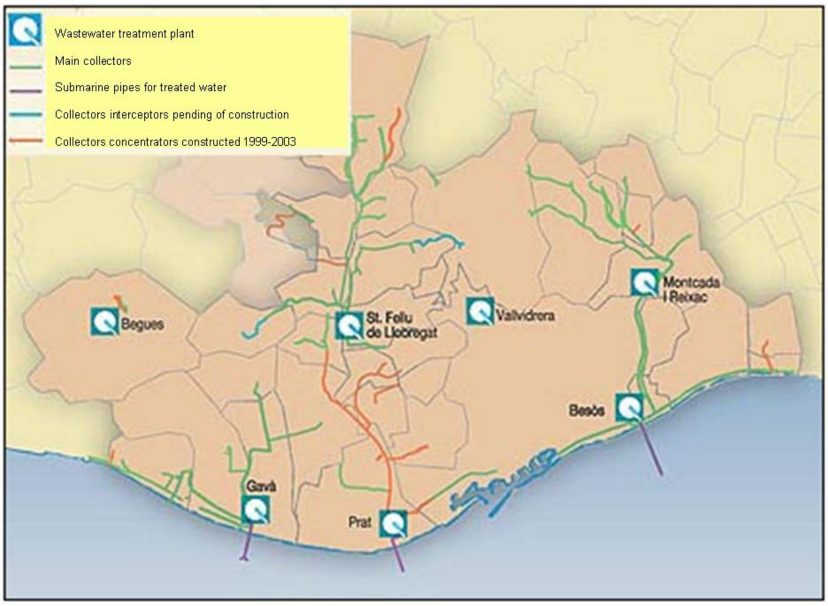


Figure 1. Map of sanitation infrastructure

We present here the case of Barcelona, one of the largest metropolitan areas in the Mediterranean basin. Two and a half million people, circa 35 % of all Catalan citizens, live in the Metropolitan Area of Barcelona according to the last census (2007), with a high density of population (5261 inhabitants/km^2 compared to the

148 inhabitants/km^2 of the Catalonia hinterland (IDESCAT[3], 2008). This paper reviews the impact of an important waste water treatment plant, located at the mouth of Llobregat river (operative in 2003) and the enlargement (and application of tertiary treatment) of the Besos plant (operative in 2004) for completing the sanitation network in the Barcelona area and recovering marine water quality. Starting from existing tools we present a methodology (work in progress) to assess the impact on the marine ecosystems. Our paper therefore examines the potential benefits of these two waste water treatment plants (see Fig. 1). We will attempt to ascertain whether the quality of marine waters has changed since the plants began to operate.

THE WASTE WATER TREATMENT PLANTS AND THEIR IMPACTS ON MARINE WATERS

The Besos river area is totally embedded in the urban tissue and therefore very artificialized. On the contrary, the Llobregat Delta is a more open area supporting inland agriculture, pine tree forest, wetlands and dunes near the coast.

The waste water treatment plants

Figure 2. View of one waste water treatment plant

Llobregat and Besos Water Treatment Plant. 2008: *in situ* measurements

Llobregat water treatment

Water treated: 287.000 m^3/day (approx. 1/3 of the population of Barcelona Metropolitan area). In operation since 2003, full potential in 2008).

Design Flow: 420.000 m^3/day

[3] IDESCAT: Instituto de Estadística de Cataluña

Parameter (mg/l)	In	Out 1 (Conventional Biological Treatment	Out 2 (Advanced Tertiary treatment (*)	Out 3 (Advanced Tertiary Treatment+ Reverse Osmosis (**)
Suspended solids	210	15	3.3	0
Biological Oxygen Demand (BOD)	221	6	1.2	0
Chemical Oxygen Demand (COD)	550	52	35	0
Total Organic Nitrogen (NTK)				0
Ammonia	46	2	1.9	0
Conductivity (µS/cm)	Not available	Not available	3000	Not available

(*) Reduction of nitrogen and phosphorus loads in order to allow for water reuse for irrigation, wetland conservation, instream flows, and the creation of a freshwater barrier against saltwater intrusion in The Llobregat Delta

(**) Very good quality. Reused for groundwater recharge

Note: the parameters of the "In" column can be used as a proxy of what was discharged directly into the sea before 2003.

Table 1. LLobregat Water Treatment Plant. Main parameters

Besòs Water Treatment Plant

Water treated: 525.000 m^3/day (approx. 2/3 of the population of the Barcelona Metropolitan area). In operation since 2004.		
Parameter (mg/l)	**In**	**Out**
Suspended solids	378	24
Biological Oxygen Demand (BOD)	298 (*)	11
Chemical Oxygen Demand (COD)	812	93
Total Organic Nitrogen (NTK)	73	47
Ammonia	48	

(*) Subject to large variations in rainy months

Source: Entitat Metropolitana de Serveis Hidràulics i Tractament de Residus

Table 2. Besòs Water Treatment Plant. Main parameters

The Besòs wastewater treatment plant serves a population of 1.7 million people with an estimated pollution load of 3 million people –equivalent. Design flow is 525.000 m^3/day and peak flow amounts up to 800.000 m^3/day. Once treated, water is conveyed to the sea through a 3 km long and 2-10 meter diameter pipe. Thus far, the water is not re-used.

Impacts on the ecosystems: an approximation

Impacts on coastal ecosystems

Coastal water quality improved dramatically once the sewage treatment plant started operating in 2003. In the Llobregat Delta this allowed for the recuperation of the coast and beaches for leisure, bathing and fishing. The sand in the beach has also improved in quality and the river bed in its last kilometres as its ecosystems have been restored. The water quality of the aquifer has also improved, with the pumping of clean water up the river to recharge the underground waters. In addition, more than 60 Millions Euros were spent in 2006 to remove nitrogen and phosphorous in the treated water so as to be able to use this water for agriculture and for wetland and lagoon recharge. Groundwater recharge is also used to build up a freshwater barrier in order to prevent salt water intrusion in the Delta.

Today the tertiary treatment phase of the plant is at work with a capacity of 3’25 m^3/second. With this treatment nutrients (nitrogen and phosphorus) are eliminated. Therefore water is re-used for feeding the coastal wetlands and the maintenance of ecological water inflow in the last part of the river, in the delta and the agricultural areas.

Additionally to the waste water plant impacts for recuperation of ecosystems, a number of actions were supported by the Llobregat Plan such as:

Knowing the forthcoming construction of the waste water treatment plant, coastal municipalities have put in place in the 1990’s, interesting beach management schemes to ‘re-naturalize the beaches’ and to regenerate the dunes and habitats (Breton and Esteban, 1995).

Later on, AENA invested to restore the coastal natural park between the airport and the coast, including natural high value areas. The Kentish Plover (*Charadrius alexandrinus)* breeding population area confers international importance to the site (SPA) which has some 3,704 meters of length and 300.000 m^2 of protected beach ecosystems that allow for natural preservation of this environment. This action would partly compensate for the loss of ecosystem due to the building of third airport run-away and a new airport terminal.

Impacts on marine ecosystems

To monitor the improvement, we have used ocean colour methods through MERIS, MODIS and SeaWiFS satellite images. MODIS on-board AQUA missions (NASA) produces daily 1 km resolution images from which Chlorophyll-a (CHL-a) concentration can be retrieved. The ESA product MERIS has been processed by

ACRI-ST in the frame of the GlobColour project supported by ESA. The three sources have been used.

The results according to these methodologies indicate that marine waters have improved in the 4 years period following the implementation of the waste water plants.

It has to be said that these maps on Chl-a concentrations are indicative. They cannot be used as absolute measures. They are on the contrary very important to observe trends. Chl-a concentration maps can be used to assess water quality in a context-specific way. In oligotrophic media like the Mediterranean when we observe fast increasing of Chl-concentrations, they are generally related with nutrients inputs and eutrophication.

The functioning of the waste water treatment plants of Barcelona since 2003/2004 shows clear trends of improvement based on in situ data. These results could also be seen on the MERIS images trends of 4 years for each average. Calculation has been done on the mean value of Chl-a concentration for the three summer months at different periods. The first image shows results for the period 1998-2002, before the functioning of the waste water treatment plants. The second one shows results for the same summer months since 2003 to 2007, when both waste water treatment plants are operative.

These rapid changes should be attributed to abundance of unicellular algae or phytoplankton. They bloom when large inputs of nutrients arrive. They consume it quickly and then they die by lack of nutrients. This can have strong impact on marine communities (although benthic is most affected by lack of light).

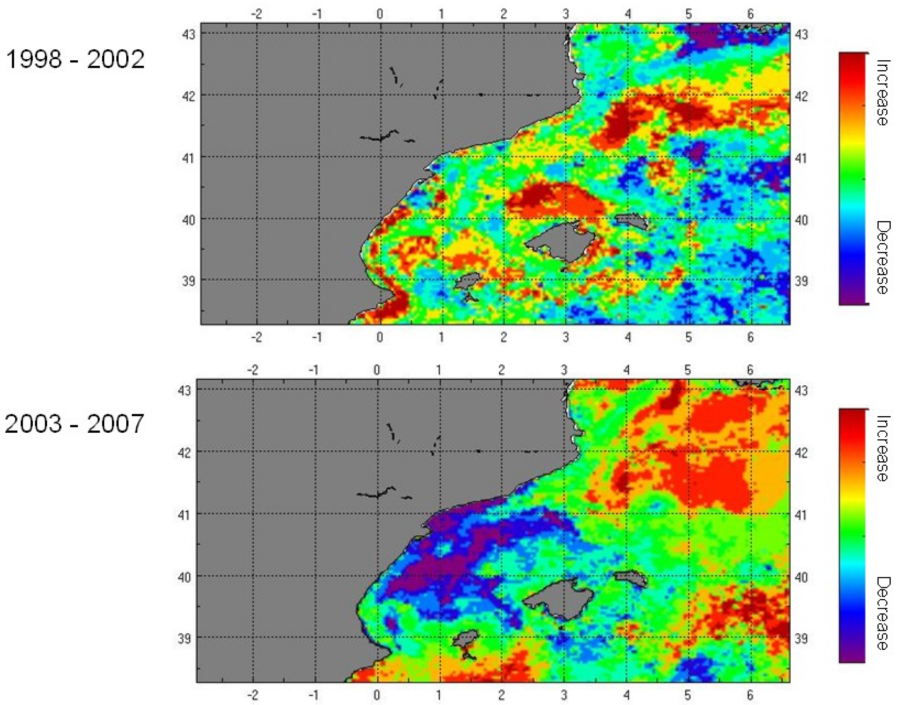


Figure 3. Statistical trend of change of Chl-a concentrations for summer months (June – August)

We can clearly see spots of increasing trends (red and yellow colour) in front of Barcelona coast for the earlier period 1998 – 2003 (Fig. 3). There is also a bigger one at the south, in front of Valencia. However it seems that Garraf coast has favourable water quality conditions, which probably can be explained by the role of coastal drift which operates in direction North-South. When looking at the picture for the second period, trends show decreasing probability of having algal blooms (blue and violet colours), which affect not only the Barcelona coast but is quite diffuse until south of Ebro Delta and in deep sea in direction to Balearic Islands. What is surprising is the extension of the phenomenon, which needs to be further analysed.

From MODIS daily images we have observed the occurrence of seasonal blooms despite the general trend of improvement of water quality. After reviewing all MODIS-aqua images acquired between 2002 and 2009 (Fig. 4) just these two exceptionally strong events of increased Chl-a concentrations were found, after big storms event, showing consistency with the above presented longer trends in water quality improvement.

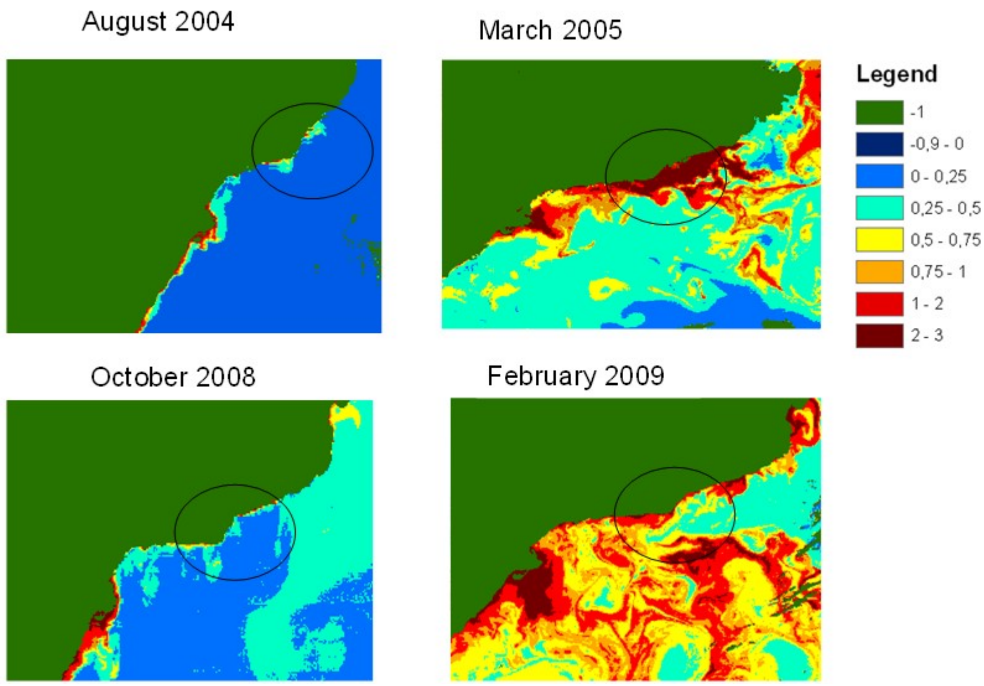


Figure 4. Chlorophyll-a concentration EOS-MODIS product (colour scale indicates the logarithm of Chl-a surface concentration)

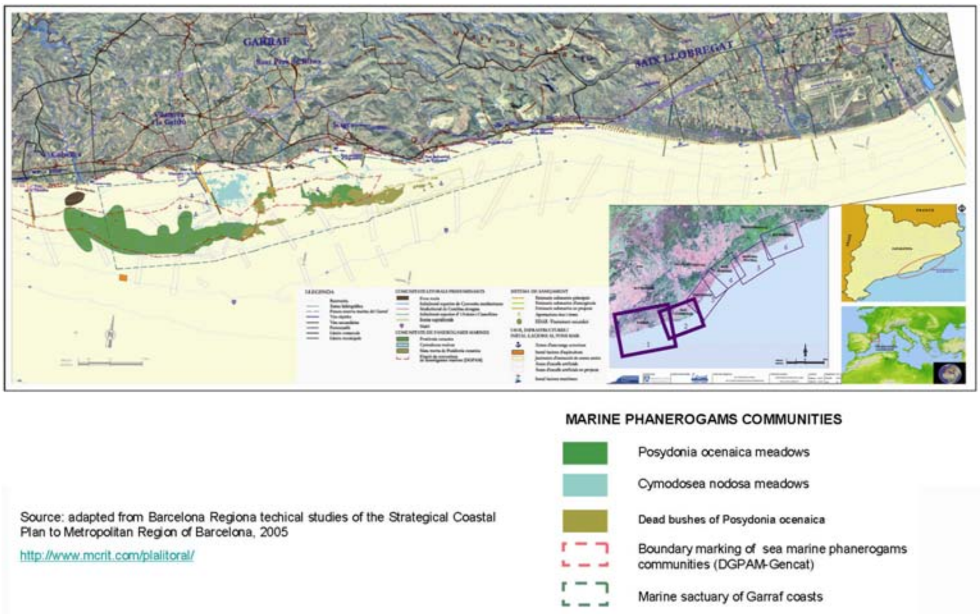


Figure 5. Marine Posidonia bottoms near Llobregat Delta by the year 2005

Posidonia at Garraf site and continuing to the south will benefit from the water quality improvement. This should be monitored from now and in the coming years (Fig.5).

CONCLUSIONS

We have shown how to assess improvement of coastal water quality due to installation and enhancement of sewage plans, by the indirect use of merged information on Chlorophyll concentration retrieved from Earth Observation space-borne sensors observations.

Waste water plants solved the problem for industrial and domestic pollution, but still other potential sources can be at play at certain moments such as sea storms and heavy rains or sporadic works and manipulation of sediments. Dog excrements (and generally all the waste from the increasingly large number of pets in big cities), has become a main source of organic pollution according to case studies (Ifremer, oral information). Water re-use can be a very important alternative during periods of drought. In Barcelona and at the height of the very severe drought of 2007-2008 a plan was prepared to pump treated wastewater of good quality upstream the Llobregat River so that it could be diverted to potabilisation plants. Rains finally arrived and this alternative was abandoned but many areas of the world (including Namibia, Singapore, Queensland in Australia, and Orange County in California) are increasingly looking at water re-use as an important option for the future.

REFERENCES

Breton F. and Esteban P., 1995. The management and recuperation of beaches in Catalonia. In Directions in European Coastal Management. pp. 511-517. 1995. Conf. of the European Union for Coastal Conservation (EUCC). Coastlines '95, Swansea (UK), 3-7 Jul 1995.

Environmental management in the Genoa harbour and ECOPORTS tools

Giuseppe Di Luca and Giuseppe Canepa

Genoa Port Authority, Genoa, Italy; ECOPORTS Organisation

Keywords: environmental management, harbours, regulation

Abstract

When a port and the surrounding urban area sit side by side, as is the case for Genoa and many other Mediterranean large costal cities, one can speak about "metropolitan port areas". In such areas, any environmental impact stemming from the industrial and commercial activities carried out in the port is amplified. Good environmental management is therefore essential for stakeholders, such as citizens and businesses, to continue their support for port operations. The Port Authority of Genoa has dedicated departments to tackle environmental issues and, since long, applies effectively an environmental management system, which is ISO 14001 certified since 2005. In 1993, the Port Authority of Genoa joined ECOPORTS, a well functioning network of actors from the port sector, involved in the implementation of environmental laws and regulations in daily practice. ECOPORTS has developed, and develops a series of dedicated tools to assist ports, businesses in the port sector and the logistic chain, as well as governmental bodies with tasks in their daily environmental management.

Résumé

Lorsqu'un port et la zone urbaine voisine sont intimement mitoyens, comme c'est le cas pour la ville de Gènes et beaucoup d'autres grandes villes côtières méditerranéennes, on peut parler de «zones portuaires urbaines». Dans de telles zones, tout impact environnemental causé par les activités industrielles et commerciales réalisées dans le port est amplifié. Une bonne gestion environnementale est dès lors essentielle pour que les différentes parties impliquées (e.g., les citoyens et les commerces) continuent à encourager les activités portuaires. L'Autorité Portuaire de Gènes possède des départements dédiés à la prise en compte des aspects environnementaux. Depuis longtemps, elle applique effectivement un système de gestion environnementale, système qui est certifié ISO 14001 depuis 2005. En 1993, l'Autorité Portuaire de Gènes a rejoint ECOPORTS, un réseau fonctionnel d'acteurs du secteur portuaire impliqués dans l'application de lois et régulations environnementales dans les pratiques quotidiennes. ECOPORTS a développé, et développe encore, une série d'instruments spécifiques pour assister les ports, les commerces du secteur portuaire et de la chaîne logistique, ainsi que les structures gouvernementales dans leurs taches de gestion environnementale quotidiennes.

PROFILE OF THE GENOA PORT

The Port of Genoa is located in Liguria, a region in north-west Italy; the port therefore enjoys a *strategic* position, laying between the Mediterranean Sea and central Europe. Genoa serves principally the northern Italian and southern central European industrial and consumer centres. The port and urban areas sit side by side, and the competition for/ compression of space is a key factor in the development of Genoa city-port dynamic interactions. The morphology of the Liguria territory is such that the city and the port have developed side by side, stealing space from each other; this close proximity has generated, in turn, considerable cohabitation problems. It is for these reasons that the city and the port have always developed port functions and large infrastructure projects by filling in the sea, a process which commenced in the early 1900s.

The Genoa Port Authority is responsible for supporting the development of industrial and commercial activities in a large area close to the city. Its aim is to increase cargo and passenger traffic by upgrading infrastructure and by stimulating cooperation with terminal operators, local authorities and other stakeholders. Every day the Port Authority deals with logistic problems, environmental impacts and the daily management of the port land.

Further to the recent Italian law of port reform in 1994, *ad hoc* management departments were established to tackle these problems, in order to i) prevent a negative environmental impact, ii) create a better environment for all the citizens living in the surroundings of the port, and iii) facilitate good relations and cooperation with the city and the local community.

The main services offered by the terminal operators and other private companies in the Port of Genoa are as follows:

- areas dedicated to cargo traffic;
- industrial areas employed by shipyards;
- areas dedicated to passenger traffic - ferries and cruises - in the historic port area;
- an area for petroleum products;
- areas for urban uses located mainly in the border zone between the port and the city.

The Port of Genoa handles a full range of commodities. From containers to perishable goods, from passengers to trucks, within an excellent network of short sea shipping, there are multipurpose terminals, forest terminals, mineral and vegetable oils, solid bulk terminal. (further details may be found at www.porto.genova.it).

ENVIRONMENTAL MANAGEMENT IN THE GENOA PORT AND THE ECOPORT TOOLS

The environment represents a key factor in the management of ports and of the logistic chain. Good environmental management is essential for stakeholders to continue supporting the port in general and logistic chain operations in particular.

A large and fast increasing number of environmental laws and regulations intend to preserve and improve environmental quality by applying the sustainability approach *sensu lato*. Port authorities and port company operators, as well as operators in the logistic chain, must all find ways to implement these laws and regulations. Many different solutions are found for the same issues, with different costs and different environmental effects. However, at times these solutions fail to give the expected results, especially due to differences in the managerial priorities set by ports and those opted for by the organizations/companies operating in the logistic chain.

For this reason, in 1993, the Port Authority of Genoa joined Ecoports, a well functioning network of actors from the port sector, involved in the implementation of environmental laws and regulations in daily practice. Ecoports assists ports, businesses in the port sector and the logistic chain, as well as governmental bodies, with tasks involved in daily environmental management. This is done by exchanging best practices and sharing solutions to common problems. This kind of experience is often not available commercially, but is only exchanged within a network of colleagues that are facing the same challenges in their daily work. Sharing solutions avoids inventing the wheel twice and provides important information on why certain solutions are useful in certain types of ports and businesses while others are not.

The Ecoports Foundation was set up in 1999 by nine European Seaport Authorities, as a formal structure for the exchange of experience in the areas of environment and sustainability. All founding partners are members of the European Seaports Organization, ESPO.

Ecoports has two main areas of activity. The fist one is related to the Ecoports Projects, the development of knowledge and tools for environmental and sustainable management. This is mostly done by means of cooperation projects, often funded by the European Commission. The second area, the so-called "Ecoports Tools", comprises the use of knowledge and tools in the daily port practice. This is done through i) the exchange of solutions, ii) the delivery of trainings on the use of the tools and iii) the certification of environmental management systems. The latter is carried out with the assistance of Lloyds Register in its capacity of independent auditor.

The General Secretariat and the secretariat of Ecoports Tools is located in Brussels and outsourced to the ESPO secretariat. The contact person is Mr Antonis Michail (antonis.michail@ecoports.com,antonis.michail@espo.be). The environmental tools offered by Ecoports can be summarized as follows:

1. Environmental Self Diagnosis Method (SDM), an environmental risk analysis and analysis to state environmental priorities. The analysis is based on ISO

14001 elements. The analysis is available in English, Spanish, and Italian. Once a selected port has provided the relevant information requested, the analysis then delivers:

a. A benchmark of the result of a selected port or company against the average of European ports;

b. A Strength-Weakness-Opportunities-Threats (SWOT) analysis of the result;

c. A strategic advice.

2. Port Environmental Review System (PERS), an analysis –also- based on ISO 14001 elements. PERS delivers several elements, such as: a standard description of the actual set up of an environmental management organization, an overview of the environmental aspects of the activities of a specific, a standard basis for an *ad hoc* environmental year report. PERS is available in English, Spanish and Italian.

3. PERS certificate. Ecoports offers the possibility to release a certificate of validation of a specific PERS analysis. The audit is done by the independent auditor, Lloyds Register. PERS is a basic certificate developed by ports for ports and port related companies. The work to be done by a specific port to become PERS certified is partly the same as has the work necessary to become ISO 14001-certified. Ports and companies who wish to go beyond the basic PERS certificate and aim for ISO certification can therefore take advantage of the work done previously for PERS.

4. Training workshops. Partly in English and partly in the national language. For SDM, PERS, and PERS certification.

5. Workshops on actual environmental topics (such as dredging). These workshops allow learning about environmental solutions from expert colleagues from another ports or port companies, and to acquire practical experience related to these solutions.

6. Yearly International Conference: Greenport, in Association with Ecoports. The conference is largely organized as a series of parallel workshops that cover the top 10 environmental port issues. This set up is intended to exchange practical experience on the implementation of environmental laws and on other environmental solutions in general. Experience has shown that the conference often leads to new project initiatives and reinforces the port-to-port assistance in the implementation of solutions.

Effect of untreated sanitary drainage on the marine ecosystem

Nureddin Esarbout

Marine Biology Research Center, P.O.B 30830, Tajura, Tripoli, Libya

Keywords: wastewater, pollution, monitoring, Libyan coast

Abstract

About 120 large cities are located along the coasts of the Mediterranean Sea, which is shared by several countries from three different continents. All these coastal cities discard untreated or partially treated wastewater into the Mediterranean basin. Furthermore, the lack of public awareness and the often misleading communication on environmental issues, encourage the inhabitants of these cities to continue using the Mediterranean Sea as a dumping place for sewage.

Due to the fast growing populations of Mediterranean coastal cities and the industrial and agricultural development, large quantities of biological (i.e. viruses, bacteria, and other parasites) and chemical contaminants (i.e. pesticides, detergents, hydrocarbons and other toxic materials) are released into the sea.

All these contaminants represent a great threat to the marine ecosystems; severe infectious diseases like cholera, typhoid, paratyphoid and some other endemic diseases have already been reported in many localities.

Therefore, disposal of untreated wastewater in the Mediterranean Sea should be stopped promptly or at least reduced. A joint monitoring strategy between the Mediterranean countries should be developed and implemented to face and control these problems.

Résumé

Quelques 120 grandes villes sont distribuées le long des côtes méditerranéennes appartenant à une vingtaine de pays de trois continents différents. Toutes ces villes côtières déversent des usées non traitées ou partiellement traitées dans les eaux méditerranéennes. Par ailleurs, le manque de conscientisation publique et les problèmes qui souvent liés à la communication sur l'environnement, encouragent les habitants de ces villes à continuer à utiliser la Méditerranée comme un dépotoir pour leurs déchets.

De part la rapide croissance démographique des villes côtières méditerranéennes et le développement des secteurs industriel et agricole, de grandes quantités de contaminants biologiques (virus, bactéries et autres parasites) et chimiques (pesticides, détergents, hydrocarbures et autres matériaux toxiques) sont déversés en milieu marin.

Tous ces contaminants représentent une sérieuse menace pour les écosystèmes marins ; de sévères maladies infectieuses telles que le choléra, fièvres typhoïde et paratyphoïde, et d'autres maladies endémiques ont déjà été rapportées dans de nombreuses localités méditerranéennes.

Pour ces raisons, le déversement d'eaux usées non traitées dans les eaux méditerranéennes doit être endigué le plus rapidement possible ou tout du moins réduit. Une stratégie commune aux pays riverains de la Méditerranée devrait être développée et mise en place pour faire face et contrôler ces problèmes.

STEPS THAT HAVE BEEN TAKEN IN LIBYA TO DETECT THE LEVELS OF SEA WATER POLLUTION

Alike other Mediterranean countries, Libya has its share of sea pollution. In order to study the levels of sea water pollution, three studies were carried out by the Marine Biology Research Center. These works concerned three large coastal cities (Tripoli, Benghazi and Misratah) and three other cities (Tajura, Khoms and Darna).

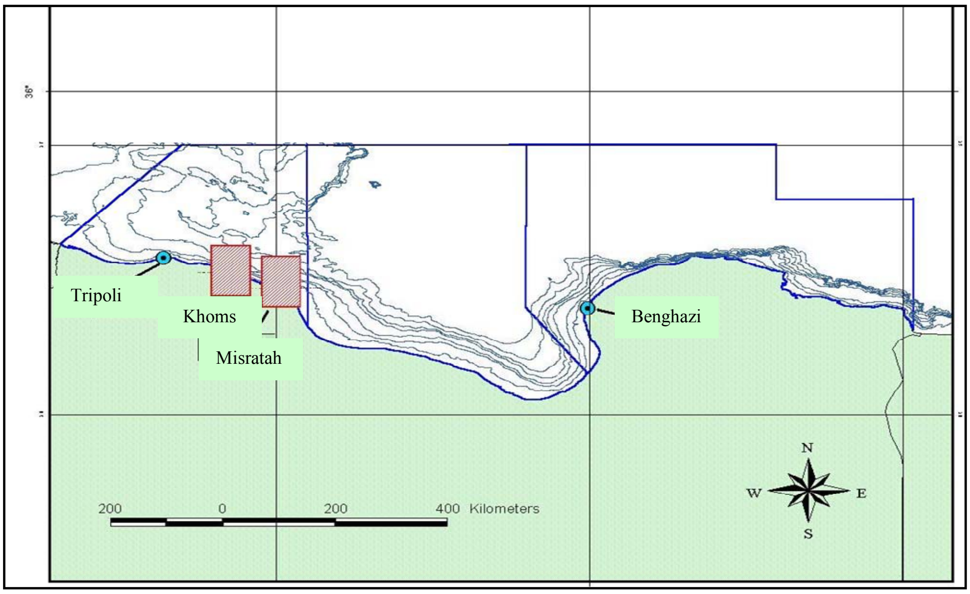


Figure 1. Location of study area

Tripoli, the capital of Libya, and Tajura are located in the western part of the country, whereas, Benghazi, the second largest city, and Derna are located on the eastern part of the country. Misratah and Khoms are located East of Tripoli (Figure 1).

These studies comprised measurements of microbiological and physiochemical parameters of the costal waters adjacent to the aforementioned cities.

Microbiological Parameters

The following microbiological parameters were measured:

- Total Coliform Count
- Thermotolerant (faecal) count
- Heterotrophic plate Count

Physiochemical parameters

The following physiochemical parameters were measured:

- Temperature
- Salinity
- pH

Sampling

Surface samples were collected seasonally along transects of fixed offshore stations in each city (Figure 2).

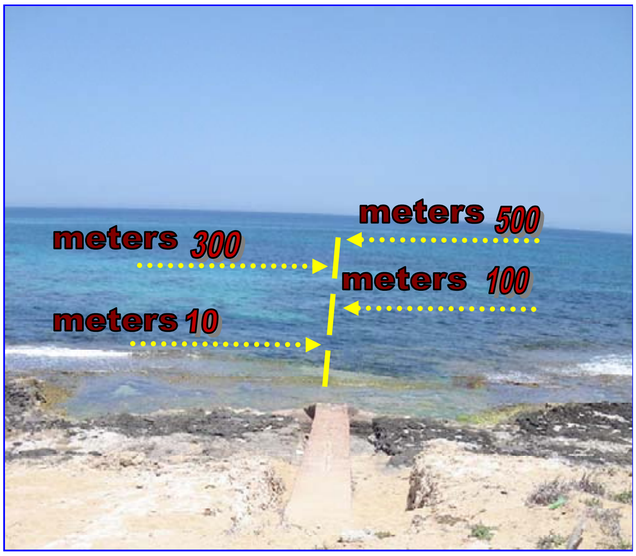


Figure 2. Sampling stations

The position of the first station was 10m north of each outlet, whereas the second, third and fourth stations were located 100, 300 and 500m north of the coast, respectively.

These surveys revealed variations in the contamination levels among the six cities. Nevertheless, the baseline data collected may prove very useful as to monitor the level of contamination in the vicinity of each coastal city selected.

RECOMMENDATIONS

This study allowed identifying the following outputs, which would enhance the sustainable management of marine ecosystems adjacent to large costal cities in Libya:

- Enforced application of national and international laws and legislation for the protection of the marine environment and the natural resources;
- Continuous maintenance of sewage treatment stations;
- Provision of support for research dealing with marine ecosystems;
- Development of joint monitoring programmes between/among Mediterranean countries.

Waste water management policy in the Marseilles town. A resolutely voluntaristic policy for a better preservation of our environment

Jean-Yves Guivarch

Marseille Provence Métropole, Direction de l'Eau et l'Assainissement
27 Boulevard Joseph Vernet, 13008 Marseille, France

Keywords: Marseilles, wastewater, WWTP, water treatment

Abstract

The area of Marseilles is part of a region marked by a large variety of natural resources on land as well as underwater. Since decades, investments have been continuously made to improve urban wastewater treatment. Meanwhile diagnostic studies on the state of existing networks followed by maintenance projects have been carried out and a policy aiming to establish agreements with industrial companies has been developed. In accordance to the EU Water Framework Directive implementation, future work will focus on a better control of toxic substances releases in the environment and on the improvement of the ecological status of the area.

Résumé

La ville de Marseille est située dans une région marquée par une grande variété de richesses naturelles tant sur terre qu'en mer. Depuis des décennies, des investissements ont été réalisés pour améliorer le traitement des eaux urbaines résiduaires. Des études de diagnostic sur l'état des réseaux existants suivies par des projets d'entretien ont été aussi effectuées. Une politique visant à établir des conventions de déversement avec les industriels a été développée. Conformément à la Directive Cadre sur l'Eau, les travaux futurs seront axés sur une meilleure maîtrise des rejets de substances toxiques dans l'environnement et sur l'amélioration de l'état écologique des espaces naturels.

INTRODUCTION

The Area of Marseille Provence Métropole (MPM) is part of a vast geographical group, marked by a large variety of natural resources on land as well as underwater: Marseilles-Cassis Creeks, Canaille Cape, coastal façade of a hundred kilometers including the Frioul and the Riou archipelagoes. All this is reinforced by a double coastal line with the Etang de Berre, the largest salt water expanse in Europe, along with the Etang de Bolmon, both being (as well as numerous other expanses) listed as ZNIEFF (Natural Zone of Flora and Fauna Ecological Interest), ZICO (Zone of Community Interest), Natura 2000 perimeter, as well as a land state management led by the Conservatoire du Littoral, concerning notably: Nerthe, Côte Bleue, Bolmon, Frioul, Riou, *etc*.). Thus, water is omnipresent on different levels throughout the area. This heritage, genuine identity of MPM, must be protected so as to perpetuate both the biodiversity and the living conditions of its inhabitants. The improvement and the upgrading of wastewater treatment to standard levels are basic projects regarding the protection of the environment. Actions to achieve this goal are part of a thorough management of water resources, meaning its preservation and its development.

BRINGING THE CONSTRUCTIONS INTO COMPLIANCE

At set dates as defined by orders of the prefect concerning the discharge from wastewater treatment plants (WWTPs), processing wastewater constructions (WWTPs) will have to be brought into compliance, and outrun the "physico-chemical" treatment type (commonly used on the French Mediterranean coast) to aim at a treatment called "biological" or secondary. Carry-Sausset les Pins, Cassis, La Ciotat-Ceyreste, Marseilles and 15 connected other cities are concerned by these operations.

Some of these WWTPs should also increase their processing capacity (Carry-Sausset/biological since the beginning of 2008, Cassis/biological since August 2006, La Ciotat-Ceyreste/biological since March 2006, Marseilles since 2nd semester 2007).

Important investments (up to 220 million euros) are necessary for these improvements. The total capacity of processing will be 2 million inhabitants. This capacity is larger than the one needed by the permanent inhabitants due to necessity to take into account the industrial discharges as well as the high increase of population during the touristic season.

MARSEILLES WWTP IN PARTICULAR

In the 80's, the "Programme d'Assainissement du Littoral[1]" was launched. In 1987, Marseilles opened a WWTP which treated with the first level only (the physico-chemical one). The equipment only allowed the processing of the suspended materials and moreover in an unfavorable place for that kind of construction, though quite privileged considering the already existing networks.

The making of the biological level is part of a particularly strict context: WWTP within the city, several buildings and existing dwellings (FFF, Department of Sports, close to the underground and dwelling places…)

[1] « Littoral quality improvement program »

This WWTP is one of the biggest underground WWTPs in the world, the techniques used will be among the most innovative. They include the sludge processing plant from which the treated water is no longer discharged into the sea but goes back to the plant through canalizations for reprocessing. A unique characteristic is that this plant was designed to partly treat detergents. The urban community has laid down respect of the environment to the builders. Thus, on the Sormiou site, nesting periods of some species stopped the construction works for several months.

Before the achievement of primary treatment in 1987, the plume of direct discharges into the sea could be seen in Cortiou where it stretched over 104 hectares. After 1987, the plume covered only 9 ha. And in 2008, the discharge is barely visible.

This construction costs the community 180 million euros including taxes. 15 cities other than Marseilles city are connected to this plant, 10 of which are located outside the MPM perimeter.

Besides, an invitation to bid has begun, having for purpose the stake in water capacity of a treatment plant at the end of the first semester of 2009. These extension works for a larger capacity and a better level of wastewater treatment are required by a national regulation, being itself an adaptation of recent European directives. Both promote an approach where the WWTP is considered as a part of the "treatment system" at the same level as the collecting and transfer networks.

OTHER ACTIONS LED BY MPM IN RELATION WITH WASTEWATER TREATMENT

- The set up of zoning maps (self-sufficient treatment – collective treatment). That document has been submitted to vote to the Council of MPM at the end of year 2005. It shows the areas where non-collective purification will be allowed. On the 1st of January 2006, a "Service Public de l'Assainissement Non Collectif[2]" was created by MPM.
- Diagnostic studies on the state of existing networks and the program for the restoration works. MPM cities were subjected to related inquiries through 3 deliberations taken between 2003 and 2004.
- The setting up and the follow-up of "Conventions Spéciales de déversement[3]" with the connected firms or willing to be, to the public network. That agreement allows a better knowledge of the quality and quantities of pollution from non-domestic discharges. A deliberation for a set of agreements was submitted to vote to the MPM Community Council in 2005. Marseilles city has already implemented this mechanism through its private operator (SERAM company).

[2] « Public service for non collective sewage treatment »
[3] « Special agreement for discharge »

- The environmental follow-up of the discharges of wastewater treatment plants. Different parameters, showing the flora and fauna quality are (some systems are already followed-up) and will be studied (other discharges haven't yet been submitted to any original studies), every one year or 3 years. This campaign starts this summer.
- WWTPs of La Mède and Bourmandel had been suppressed and the wastewater respectively transferred to the ones of Chateauneuf les Martigues in January 2006 and of Carry-Sausset in July 2005.
- The WWTP of Le Rove is going to be suppressed and the effluents transferred to the Marseilles plant (under construction).

Reducing the numbers of WWTPs lessens the consequences on the environment. Initially 13 plants were in operation in the MPM urban community. They are 11 today and will be 10 in the coming year.

The main goal of the EU Water Framework Directive is to recover a good quality environment in 2015, and particularly to reduce the levels of toxic chemical contaminants in water; sediment and biota. A protocol project to be contracted for several years is under preparation between the Rhone Mediterranean & Corsica Water Agency and MPM.

At the end of the 19th century, one of the first competences of urban communities was collecting wastewater, hygiene and public health. At the beginning of this 3rd millennium, protection of the environment and long term development are the new criteria to be integrated in wastewater management and it is in following this way that the Urban Community of Marseilles becomes resolutely involved throughout its area.

Impacts of urban activities on the coastal and marine ecosystems of Syria, and the adaptative measures

Amir Ibrahim

High Institute of Marine Research, Tishreen University,Lattakia, Syria

Keywords: urban pressures, habitat degradation, adaptative measures, Syrian coast

Abstract

This article describes various urban activities practiced along the Syrian coasts and assesses the relevant effects that these exert on the quality of marine ecosystems. Most affected species, habitats and ecosystems are presented. Many areas and species displayed effects apparently resulting from urban activities, which are reflected in the quality of Syrian coastal waters. Fish death, fish invasions, sea turtles, mammal strandings, change in behavior of many other marine species, and habitat degradation are signs of such effects. Selected adaptive measures to deal with this problem, along with national priorities for future initiatives are presented.

Résumé

Cet article décrit les différentes activités urbaines existant le long des côtes syriennes et évalue leurs effets sur la qualité des écosystèmes marins. La plupart des espèces, des habitats et des écosystèmes affectés sont présentés. Beaucoup de zones et d'espèces montrent des signes d'impact des activités urbaines, qui retentissent sur la qualité des eaux côtières de la Syrie. Des épisodes de forte mortalité de poissons, la présence d'espèces invasives, les échouages de tortues de mer et de mammifères, le changement de comportement d'autres espèces marines, et la dégradation des l'habitat traduisent ces effets. Les mesures prises pour faire face à ce problème, de même que les priorités nationales pour le futur sont présentées.

The Syrian coastal area measures 4200 km^2, stretches along 182 km of the coastline and accommodates 2.03 millions inhabitants. Nearly 25% of the coastal population lives in four coastal cities and many shoreline villages are densely populated. The coastal region, which represents approximately 2% of the country area, hosts more than 11% of the total population and contributes for more than 12% to the Gross National Product (GNP). Most of the economic activities that form the backbone of the national economy are located in the coastal zone (e.g. 38% of cement production and 50% of national oil refining). A substantial number of private properties, several public infrastructures and industrial sites are located there (Ibrahim, 2003). Four commercial ports (Lattakia, Tartous, Banias & Arwad) and 14 fishing harbours are distributed along the coast. The majority of the industrial establishments lack of appropriate treatment facilities and contribute to increasing BOD, COD, TSS, TDS as well as other more complex and harmful pollutants. Furthermore, the waste water discharge is not separated from industrial discharge making future implementation of treatment processes more complicated.

In addition to the urban activities that largely affect marine ecosystems, the Syrian marine waters is oligotrophic, characterized by high salinity (nearly 40 ppt), low productivity (for example, benthos=20g/m² at 45 m depth and 0.6g/ m² at 200 m depth, for example), reduced currents (13-17 cm/ sec.) and a small tidal range (approximately 40 cm in most cases). The reduced hydrodynamics slows the dispersion rate of pollutants deriving from various urban sources, thus increasing the impact on marine life in the coastal area.

In a study conducted in 2001 the cost for the degradation of Syrian natural resources (including ecosystems, water & land resources, deforestation) was estimated between 2.7 and 4.3% of total Gross Domestic Product (GDP) and the damage to the coastal zone accounted alone for 0.1% (Larsen & Bolt, 2003).

Wastewaters from various coastal municipalities are discharged in the coastal rivers and contribute largely to eutrophication of the estuarine and marine habitats. The areas most affected are those reached by currents channeling wastewater pollutants. The most affected estuaries are: Al-Kabir Al-Shimali, Al-Housen, Al-Kabir Al-Janobi and Al-Khamka and Al-Sakia.

Mortality episodes of entire fish schools (mostly mullet fingerlings) are frequent during summer due to wastewater discharges. This phenomenon is usually synchronous with high water temperature events, low oxygen concentration, high suspended matters and other unfavorable changes in the water quality. Such changes occur frequently during summer months in the shallow waters of Al-Azhari, the Blue Coast Gulf and other similar locations. In addition, bathing water quality in the adjacent coastal resorts is continuously deteriorating.

In the last few decades, habitat fragmentation and biodiversity degradation resulting from urban activities have affected many coastal areas, namely: Al-Bassit, Oum Attiur, Ibn Hani, Al-Azhari, Al-Kabir Al-Shimali river estuary, Joun Jablah, Jablah beach, Banias beach, Al-Housen river estuary, Tartous and Al-Nawras beaches.

The sandy beaches of the Syrian coast (only about 20% of the coastline) are limited to few main locations in Ras Al-Bassit, Oum Al-Tiur, Wadi Kandil, Joun Jablah and Al-Hamidiah. Sea turtles (the green turtle, *Chelonia mydas*, and the loggerhead turtle, *Caretta caretta*), which are known to reproduce on the Syrian sandy beaches, are highly impacted by pollution, maritime traffic, coastal development and tourism; such disturbance becomes particularly critical during the nesting and hatching season.

Stranding cases among cetacean species (whales & dolphins) became common during the last decade where 13 stranded dead individuals were recorded (Ibrahim 2008, unpublished data). The Mediterranean monk seal *Monachus monachus*, which is present on the Syrian coast, is most affected by human disturbance (Mo *et al.* 2003).

Species - especially fish species - extinction, migration and introduction of exotic species are becoming common events in the Syrian marine waters; this is most likely the response of the marine biota to the changes in the physical and chemical properties of the marine ecosystems (Ibrahim *et al.* 2002).

Due to the increased use of marine water for industrial purposes, the seawater temperature in the area facing Banias refinery raised considerably. As a result, an increased death rate of crustacean species was observed (NCSBS, 2002) and the distribution of the sand crab *Ocypode cursor* is now restricted to some isolated areas of reduced human activities (e.g. in Oum Al-Tiur area). Local extinction of this species is expected if climate conditions continue to change and water temperature keeps rising.

Sessile invertebrates are facing even more risk of local extinction due to their impossibility of migrating to less disturbed habitats. For example, fourteen sponge species (among which, *Axinella sp*. & *Ircina sp*, which are listed in Annex II and *Spongia officinalis*, which is listed in Annex III of the SPA Protocol[1]) are regarded as endangered due to various human activities (Ibrahim *et al*. 2007).

The dominant Levantine Vermetid Terraces are of great ecological & historical values in the eastern Mediterranean and form a good barrier against coastal erosion. Such terraces are vulnerable to changes in water properties, for example the expected increase in water acidification will lead to reduction in the calcification rate of these organisms. At present, the vermetid terraces located in the North of Syria have not been yet affected by pollution, as demonstrated by the presence and good status of *Cystoseira amentacea* and *Cystoseira compressa;* the two ecologically important algal species that are frequently used as pollution bioindicators (Mayhoub, 1976; Bitar, 2004). However, if the marine environment continues to degrade, this unique habitats will be eventually impacted; affecting a wide spectrum of species associated to vermetids, especially the calcifying organisms such as most molluscs (e.g. the already endangered gastropod *Dendropoma petraeum*), echinoderms, foraminifera and calcareous algae such as the red alga *Neogoniolithon notarisii.*

As an adaptive measure, reducing habitat fragmentation and increasing the connectivity between habitats through rehabilitation of the degraded areas will help restoring local marine biodiversity and reducing losses of genetic diversity. Furthermore, it is necessary to draw conservation plans for sustainable management of marine resources (such as marine fisheries and biodiversity). Such plans should take into account the prevailing situation and the expected future changes. A National Biodiversity Monitoring System should be developed in the country and a comprehensive inventory of the threatened species in the marine ecosystem should be produced; in particular, species that are already threatened and are becoming particularly vulnerable to urban pollution should be monitored.

[1] Specially Protected Areas protocol from the PAP/RAC (Priority Actions Programme/Regional Activity Centre of the Mediterranean Action Plan)

As fisheries parameters and species composition are changing due to the impact of urban activities, future expected impacts should be taken into account in the imposed fisheries regulations, such as timing of the closing season and the use of fishing gears.

It should be stated that the quantitative and/or qualitative data are very limited or even absent in many cases. This calls for more research to be done in the field of marine pollution along the Syrian coast. The Med-POL National Marine Monitoring Program (which focuses on trend and compliance monitoring of pollutants in marine water, sediment and biota) should be carried out in Syria to have a wider view on the present situation and monitor the future environmental changes. The Integrated Coastal Management Plan of the Syrian coast should be revised and developed in such a way to take into account the recent development issues in the area. Due to the financing deficiency in the country, a framework should be developed so as to use MPAs (Marine Protected Areas) as monitoring sites to evaluate current and future changes in various compartments of the marine ecosystem.

REFERENCES

Bitar G., 2004: A contribution study on fish and benthic assemblages on the Syrian coast: The local and migrating biodiversity. Tishreen Uni. Sci. J. 2004, Syria.

Ibrahim A., 2003: National Diagnostic Analysis (NDA) of Syria, Technical Report UNEP/MEDU.

Ibrahim A., Karroum M. and Lahlah M,. 2002: Marine fish biodiversity of Syria: Nine new records. J. Env. Res. and Sust. Dev.: Arab Univ. Union, 5: 68-93.

Ibrahim A., Ammar I. and Abbas G., 2007: Sponge species distribution in the Syrian waters, with special emphasis on the economic species and trace metal bioaccumulation. Joint Research Project with Lebanon (Contract No. 3 – Research no. 404- on 2005), Final Report, Supreme Council of Science, Syria.

Larsen B. & Bolt K., 2003: Cost of environmental degradation in Syria. METAP project in Syria.

Mayhoub H., 1976 : Recherches sur la végétation marine de la côte Syrienne. Etude expérimentale sur la morphogénèse et le développement de quelques espèces peu connues. Theses Doct. Etat, Univ. Caen, France: 286 p.

Mo G., Gazo M., Ibrahim A., Ammar I. and Ghanem W., 2003: Monk Seal presence and habitat assessment: Results of a preliminary mission carried out in Syria. Monachus Guardian, www.monachus-guardian.com.

NCSBS, 2002: National country study of biodiversity in Syria. Ministry of Environment.

The role of public participation in Environmental Impact Assessment: a case study from Egypt

Mohamed Ismail Ibrahim

Department of Environmental Sciences, Faculty of Science, Alexandria University
Moharam Bay 21511, Egypt

Keywords: environmental assessment, public involvement, participatory approach, industry

Abstract

This paper reviews the terms of reference of EIA (Environmental Impact Assessment) and highlights the importance of promoting public participation (and not only consultation) to make this process open, transparent and robust. Lessons learned from the application of EIA in Egypt have clearly shown that successful EIA studies should involve the public participation during the early phase of "Scoping" in order to gain the confidence of the public, to reduce possible conflicts through the early identification of the related issues and to avoid late opposition of the public that can have dramatic economic effects.

Résumé

Le présent travail synthétise les termes de référence de la procédure EIA (Evaluation d'Impact Environnemental) et souligne l'importance de la participation du public (et pas seulement sa consultation) pour assurer que l'EIA constitue une procédure ouverte, transparente et robuste. Les leçons tirées de l'application de l'EIA en Egypte ont montré clairement que, pour maximiser leurs chances de succès, les études EIA devraient impliquer la participation du public pendant la phase initiale de définition du champ du projet et ce, afin de gagner la confiance du public, de limiter les conflits potentiels par l'identification rapide des aspects concernés et d'éviter l'opposition tardive du public qui peut avoir des conséquences économiques désastreuses.

Public involvement is a fundamental principle of the EIA process. Timely, well planned and appropriately implemented public involvement programmes will contribute to EIA studies and to the successful design, implementation, operation and management of proposals. Specifically public involvement is a valuable source of information on key impacts, potential mitigation measures and the identification and selection of alternatives. It also ensures the EIA process is open, transparent and robust, characterised by defensible analysis.

Most EIA processes are undertaken through consultation rather than participation. At a minimum, public involvement must provide an opportunity for those directly affected by a proposal to express their views regarding the proposal and its environmental and social impacts.

The public has various rights: right to access to information, right to contribute to information and right to challenge decisions. Therefore, communication between the assessment team and the public is the key to public participation. So, the assessment team is well advised to communicate with the public as early as possible, to communicate with as many people as possible and to communicate through as many means as possible.

Public participation is an active and constructive exchange of information, meanings, and opinions. The public has many roles such as:

- Provide data and information that is essential for the assessment of impacts on the physical and social environment
- Reduce conflicts through the early identification of contentious issues
- Help to identify local citizens and groups with special expertise
- Identify local and regional issues
- Provide historical perspective to current environmental conditions
- Help to generate field data
- Provide criteria for evaluating the significance of identified impacts
- Suggest forms and help organizing mechanisms for public participation
- Help to define the scope of work and schedule for the overall assessment process
- Provide a link between the assessment team members and key organizations
- Identify and evaluate potential mitigation measures
- Increase public confidence in the EIA process.

Public participation can be achieved through several techniques:

1. Media techniques: radio, television, newsletters, and advertisements
2. Research techniques: sample polls, community profiles
3. Political techniques: citizen referenda
4. Large-group meetings.

The levels and forms of public involvement may include:

5. Informing – one way flow of information from the proponent to the public;
6. Consulting – two way flow of information between the proponent and the public with opportunities for the public to express views on the proposal;

7. Participating – interactive exchange between the proponent and the public encompassing shared analysis and agenda setting and the development of understood and agreed positions on the proposal and its impacts;
8. Negotiating – face to face discussion between the proponent and key stakeholders to build consensus and reach a mutually acceptable resolution of issues, for example on a package of impact mitigation and compensation measures.

The range of stakeholders involved in an EIA typically includes:

- The people – individuals, groups and communities – who are affected by the proposal
- The proponent and other project beneficiaries
- Government agencies
- NGOs and interest groups
- Others, such as donors, the private sector, academics etc.

CASE STUDY

Agrium Egypt for production of urea and ammonia - A petrochemical company denies relocation after local opposition.

In early 2007, Calgary-based Agrium announced a joint venture with three Egyptian state corporations to construct a plant with the capacity to produce 1.4 million tonnes of fertilizer. The plant, which is due for completion in 2010, is a nitrogen facility which should consist of two ammonia and urea trains working at a combined capacity of 1.3 million tons of urea and 100,000 tons of net ammonia.

Agrium petrochemical plant was proposed to be established in the governorate of Damietta in an area known as New Damietta near Ras El-Bar. It will be relocated because of the strong local opposition to the project. Inhabitants of the area are concerned by the risk of pollution the plant would generate. In this area the environment not only consists of residential housing, but is also the subject of a study to determine whether it will be considered as a protected site.

The plant was being built by "German technology, and has more safety features than any other petrochemical plant in Egypt. It is 6 km away from any residential area and contains all the necessary safety procedures" (EIA study Report).

The EIA report of this plant was reviewed and approved by academic reviewers. But due to the lack of public participation in the early stage of EIA procedure, the local people of the Damietta governorate was contradicted during the implementation phase of the project. Finally, the plant building was stopped and its location may be moved to a nearby area.

In Alexandria-Egypt, numerous industrial projects were approved and implemented with a good acceptance level because their EIA process have been achieved in cooperation with the public (e.g., Carbon Black, Sidpec, Alexfiber, etc).

CONCLUSION

It is shown that benefits can be expected with an approach where the local people have the right to access to information, the right to contribute information and the right to challenge decisions. Successful EIA studies should then involve the public during the early phase of "Scoping" in order to avoid local opposition, to gain people confidence and reduce conflicts through the early identification of the related issues.

Defining development trends and impact scenarios of large cities in the Mediterranean Basin

Oliver Keserue

UNEP MAP Blue Plan, Sophia Antipolis, 06560 Valbonne, France

Keywords: urban population, pressures, Mediterranean, pollution

Abstract

The Mediterranean is well covered by multilateral environmental agreements through the Barcelona Convention under the UNEP[1] Regional Seas Program. Notwithstanding its wide scope (see box below) the trends for the Mediterranean remain bleak. Prospective studies and institutes need to continue their search for rigorous data to help add political leverage to remedial measures and policies in all areas: law of the seas and fisheries policy; spatial planning; industrial pollution control, waste management and product stewardship, but also in knowledge creation for the broader yet pivotal purpose of environmental education.

Résumé

Dans le domaine de l'environnement, la Méditerranée est bien couverte par des accords multilatéraux au travers de la Convention de Barcelone placée sous l'égide du Programme des Mers Régionales du PNUE[2]. Malgré son champ d'application très large (cf. encadré ci-dessous), les perspectives pour la Méditerranée restent sombres. Les organismes concernés et les études prospectives doivent poursuivre la collecte de données de qualité pour assister les autorités dans la mise en place de politique et de mesures de remédiation dans de nombreux domaines : droit de la mer, gestion des pêcheries, planification stratégique de la gestion de l'espace, contrôle de la pollution industrielle, gestion des déchets et cycle de vie des produits, mais aussi dans le développement de connaissances à des fins plus large mais essentielles d'éducation environnementale.

The adoption of the integrated coastal zone management protocol of the Barcelona Convention signaled a much needed policy response to the management of marine ecosystems in the Mediterranean. This comes in the wake of the adoption of another Protocol on land-based pollution. These two, the other 5 Protocols of the Barcelona convention, and the Mediterranean Strategy for Sustainable

[1] UNEP : United Nations Environment Programme

[2] PNUE : Programme des Nations Unies pour l'Environnement

Development, are tools adopted by riparian countries collectively to address some of the main non-sustainable development trends of the Mediterranean. In this context the role of prospective studies remains central to anticipate looming crises through a multidisciplinary analysis covering socio economic and environmental trends. This is particularly true for large cities. The Blue Plan and UNEP/MAP continue to contribute to this process.

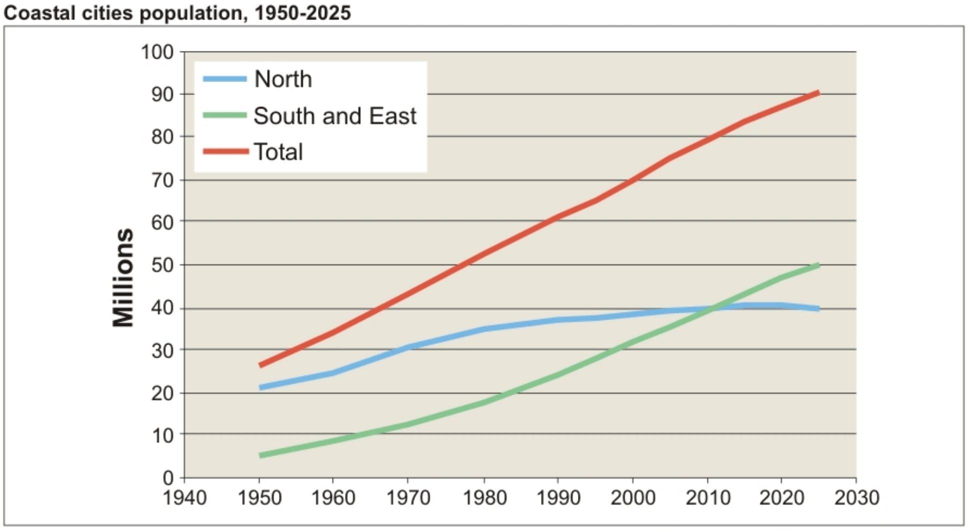
The Mediterranean became the first region to adopt an Action Plan (MAP) in 1975, just after the creation of the UNEP Regional Seas Programme in 1974. It was revised in 1995.

The Convention for the protection of the Mediterranean Sea against Pollution (Barcelona Convention) was adopted in 1976 (amended 1995) and entered into force in 1978 (amended version in force 2004), and a succession of six landmark protocols. Six Regional Activity Centres (RACs) are responsible for the implementation of respective components of MAP under the supervision of the Coordinating Unit (MEDU).

Associated protocols concern: Pollution by dumping from Ships & Aircraft (adopted 1976, in force 1978 (amended 1995)), Pollution from Land-Based Sources and Activities (adopted 1980, in force 1983 (amended 1996)), Specially Protected Areas and biodiversity (adopted 1982, in force 1986 (amended 1995, in force 1999)), Pollution from Ships and Cases of Emergency (adopted 1976, in force 2002), Pollution from Exploration and Exploitation of Continental Shelf and Seabed (adopted 1994, not yet in force) , Pollution by Transboundary Movements of Hazardous Wastes and their Disposal (adopted 1996, not yet in force).

The challenges facing the Mediterranean and its cities are all the more defying today than yesterday. The tragedy of the Commons, coined in 1968 by Garrett Hardin, to illustrate that individuals acting in their own self-interest can ultimately destroy a shared resource has found in uncontrolled urbanization and its impact on marine ecosystems the perfect case study.

Coastal cities population, 1950-2025



Source : Géopolis 98, Attané & Courbage; Plan bleu 2001

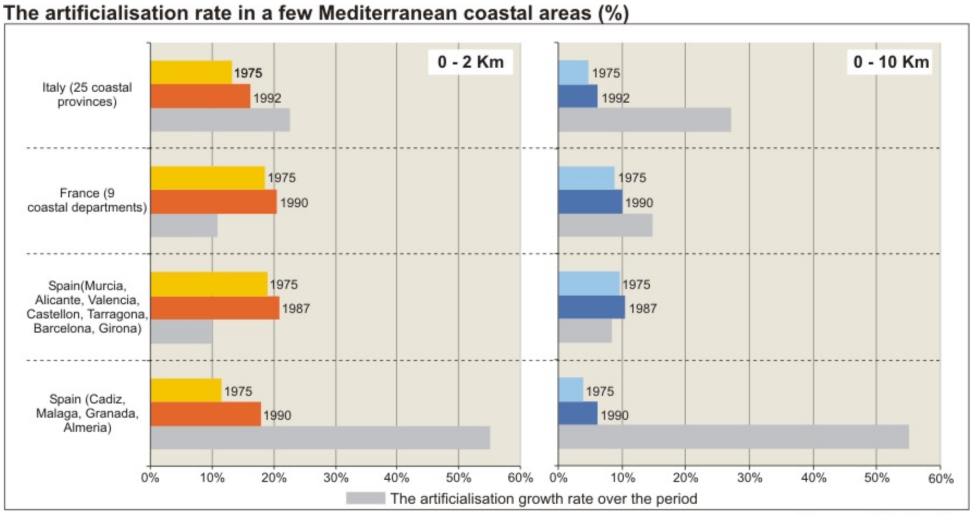
South and East Mediterranean Countries (SEMC), North Mediterranean Countries (NMC)

In the 21 Mediterranean rim countries, the total urban population (in towns > 10,000 inhabitants), passed from 94 million in 1950 (44% of the population) to 274 million in 2000 (64%). By 2030 the proportion is expected to be ¾. With nearly *100 million* extra city-dwellers between 2000 and 2025, including additional 23 million in Turkey, 36 million in Egypt, 10 million each in Algeria and Morocco respectively, the cities of the Southern and Eastern Mediterranean will be undergoing major social and environmental changes.

Coastal towns and cities accommodate already 143 million inhabitants in 234 coastal. To this one must add the pressures from tourism. By 2025 coastal cities and resorts will be receiving 312 million tourists. That is an additional 137 million tourists compared to today.

These trends will require investments in infrastructure and facilities on the coastal zones. Roads already run along vast swathes of coastline and generally within a kilometer of the shoreline.

The artificialisation rate in a few Mediterranean coastal areas (%)



Source : JRC, Plan Bleu

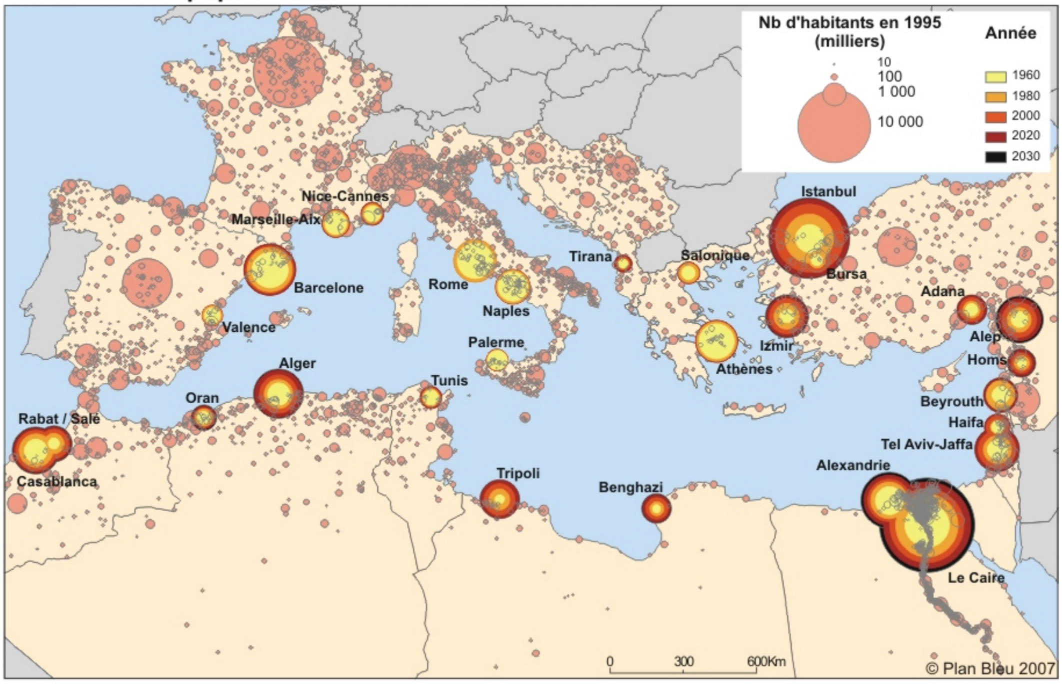
These roads, often constructed too close to the shores, disrupt the physical exchanges between land and sea and generate a linear urbanization along the coast. Certain airports, built on wetlands, contribute to the disappearance of ecosystems of great ecological and economic value. Some calculations estimate the environmental benefits provided by these ecosystems in the range of 2.4 million euros per km² per year).

In total for the year 2000, Plan Bleu recorded on the Mediterranean coastal areas 584 coastal cities, 750 yachting harbours, 286 commercial ports, 13 gas producing facilities, 55 refineries, 180 thermal power stations, 112 airports and 238 desalinization plants.

At sea we are also witnessing an increase in activity: shipping, raw materials extraction, fishing, and aquaculture. In the latter, the production of mollusks, fish and shellfish increased from 149,000 tons in 1990 to 359,000 tons in 2001, that is an increase of 140% over just a 12 year period; a rate of 8.3% per year.

The *artificial land cover* is expanding at an alarming pace: about 40% of the coasts are now paved due to urban sprawl, roads, tourist resorts and facilities, ports. According to Blue Plan projections, by 2025, the artificial land cover of the coastal strip (0-10 km) would reach values close to saturation in Spain, Egypt and Lebanon.

Small towns and large agglomerations

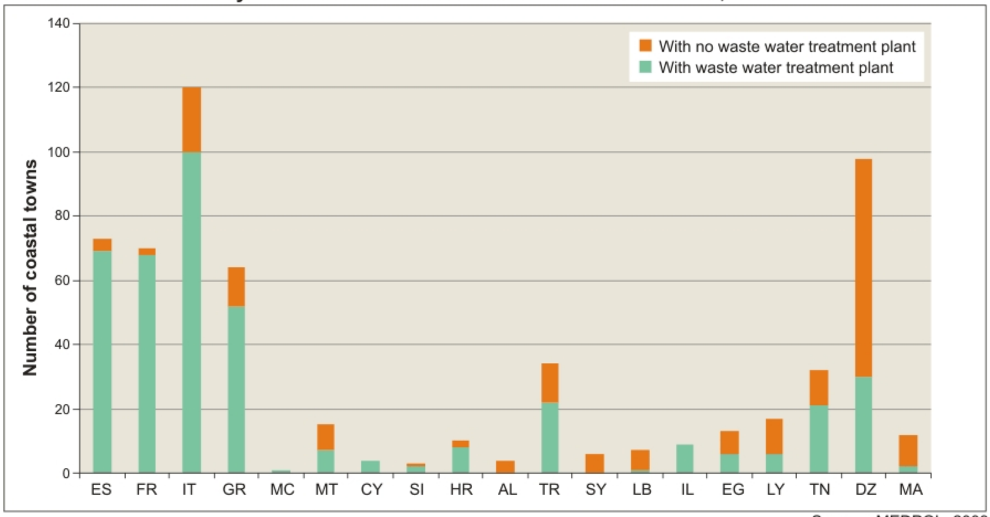


The trend-based scenario assumes an additional 200 km of built-up coasts per year, leading to a loss of about 5,000 kilometres of natural areas by 2025. Half of the Mediterranean coast may end up built-on, with large coastal conurbations extending over tens if not hundreds of kilometres. The destruction of farmland and shallow sea bottoms, disruption of water regimes with risks of devastating floods, exacerbation of coastal erosion, are the main impacts of the artificial land cover process on the coastal ecosystems and landscapes.

However, it is not only a question of loss of habitat due to the encroachment of man on land and at sea, *land-based pollution* now represent 80% of total pollution affecting coastal waters, the remaining 20% attributable to activities at sea. In the Mediterranean, the major sources of pollution relate to:

- Eutrophication (nitrogen and phosphorous nutrients stimulating the primary aquatic production) caused by diffuse agricultural discharges;
- Chemical contaminations, mainly due to industrial discharges;
- Organic and microbiological pollutions, from untreated sewage and industrial discharges;
- Municipal and hazardous waste (respectively 30 and 40 million tons of solid waste annually).

Wastewater treatment by coastal cities with more than 10 000 inhabitants, 2002



Source : MEDPOL, 2003

By 2025 solid waste from coastal cities will weigh some 71 million tons, most of this growth occurring in South and East Mediterranean countries. That is about twice the volumes of the year 2000.

Many countries have neither waste water treatment plants nor adequate solid waste treatment facilities. The prospect, therefore, remains very bleak.

For as long as this remains true, prospective studies and institutions dedicated to this purpose such as the Blue Plan, must bring to the negotiating table rigorous data to help add political leverage to remedial measures and policies in all areas: law of the seas and fisheries policy; spatial planning; industrial pollution control, waste management and product stewardship, but also in knowledge creation on the valuation of ecosystem services or for the broader yet pivotal purpose of environmental education.

The challenge is all the more urgent as we are no longer *just* facing a deteriorating environment with all other variables remaining constant; demography and global phenomena such as climate change will put to serious test issues of social equality which will drive political expedience.

The challenge in a world, which narrowly escaped financial doom but with a huge burden of debt, is to keep the momentum of recent successes in multilateral environmental agreements. But given the gravity of the diagnosis, measures must become more prescriptive and contain performance indicators or administrative measures such as strict licenses. Each actor must become conscious and responsible of his particular cause and effect relationship on the ‘Commons’, the Mediterranean Sea. Such measures taken with an understanding of the critical loads can avert the tragedy which is announced.

Impact of the anthropogenic activities on the deterioration of the coastal ecosystem of Beirut city

Gaby Khalaf[1,2], Milad Fakhri[1], Carine Abi-Ghanem[1], Marie Abboud Abi-Saab[1] and Roula Mina[1]

[1]Lebanese National Council for Scientific Research - Marine Research Center Batroun, Lebanon
[2]Lebanese University – Faculty of Sciences

Keywords: anthropogenic impact, wastewater, pollution, sediment, Beirut

Abstract

The city of Beirut counts almost the third of the Lebanese population and more than fifty percent of economical, industrial and touristic activities in Lebanon. The littoral, about 20 km, is affected by these activities from which the most important consequences are: i) the outflows of wastewater directly in the sea without any previous treatment ii) the public dump of Dora which is the source of aesthetical and chemical pollution iii) the embanking of 135 hectares of this littoral that has serious consequences on marine habitats and living communities of the Levantine Mediterranean basin.

Résumé

La grande ville de Beyrouth concentre le tiers de la population libanaise et plus de la moitié des activités économiques, industrielles et touristiques du Liban. Son littoral de 20 km subit l'effet néfaste de ces activités anthropiques dont les conséquences les plus importantes son : i) le rejet des eaux usées directement dans la mer sans traitement préalable, ii) la présence d'un immense dépotoir qui pollue esthétiquement et chimiquement l'eau de mer, iii) le remblaiement d'une surface de 135 hectares de la mer qui a détruit des habitats et des communautés vivantes spécifiques du bassin levantin de la Méditerranée.

INTRODUCTION

The big city of Beirut (figure 1), capital of Lebanon, counts about 1,500,000 inhabitants, almost one third of the Lebanese population and stretches along a 20 km coast line (ECODIT-IAURIF). The Beirut coastal line supports, for almost twenty years, the impact of illegal construction projects for industrial development and the effluents of industrial and domestic wastewater.

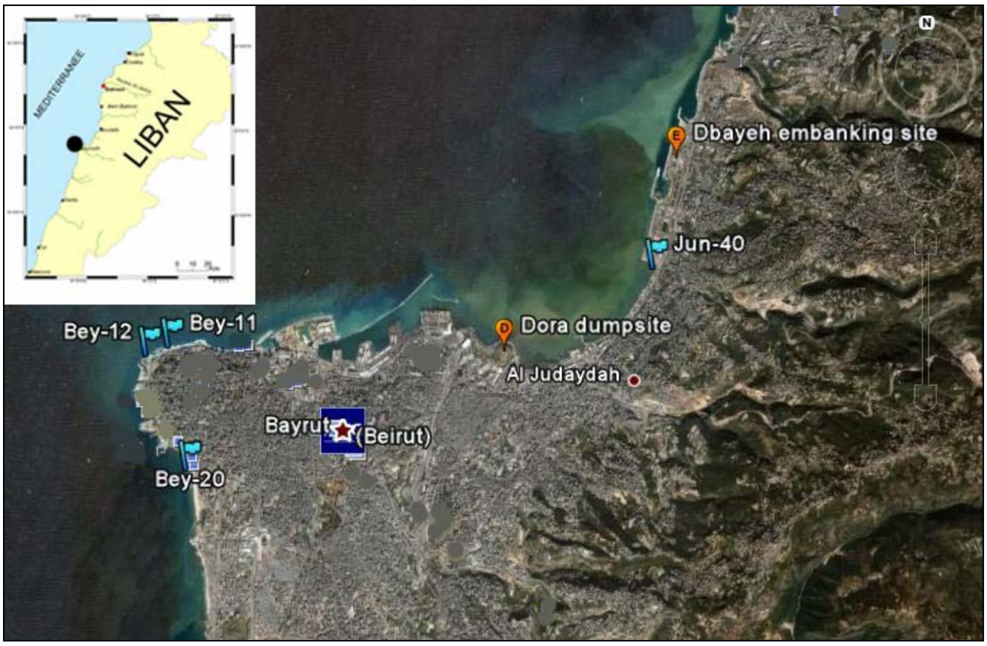


Figure 1: Google map showing the location of the different sites, Dora dumpsite and embanking site

Other touristic projects, seaside resorts, embanking, oil terminals and public dumps as well as the approvals for using the public sector, have abused and destroyed quite a large part of the coastline along with many beaches (ECODIT-IAURIF).

All these morphological changes as well as the ongoing human activities compromised, irreversibly, the coastal habitats along with the floral and faunal wealth of the marine environment.

This paper aims at presenting the observed impact of three sources of degradation of the coastal ecosystem; i) the wastewater effluents ii) public discharges in Dora iii) the uncontrolled management of the northern coast of Beirut.

PRESENTATION OF THE MAIN SOURCES OF THE COASTAL ZONE DEGRADATION

Wastewater

Apart from the wastewater treatment station of El Ghadir which is located in the south of Beirut and which treats the wastewater of 250,000 inhabitants according to primary and secondary technique, Lebanon is devoid of an appropriate wastewater treatment system and of a sewer collection network. This is why all liquid, industrial and domestic wastes are finally discharged to the sea.

In addition to the two rivers Nahr Beirut and Nahr Antelias, which are considered as the two main pathways for transferring polluted water from the interior zone of the country towards the sea, thirty three other sewers, of different flow intensities, are shed into the Lebanese coastal water (Khalaf *et al*., 2001 ; Saad *et al*., 2004).

The monitoring program of the coastal region implemented by the Marine Research Centre of CNRSL[1], shows that polluted waters have an impact on the variability of the physicochemical and bacteriological parameters and perturb the fauna and flora communities.

The dumpsite of Dora (North of Beirut bay)

It was opened at the end of the Eighties of the last century, it received 1500 -2000 tons of solid and urban industrial waste per day, until its closedown in 1998 (ECODIT-IAURIF). Its total surface is 18 hectares and its height about 50 m. Besides its visible aesthetical consequences due to daily release of solid wastes caused by the action of the waves, wind and rain, this huge discharge releases from its lower parts a brown liquid of very unpleasant smell, contaminating the marine environment in several ways, especially by trace metals (Abi-Ghanem, 2008; Nassif, 2006; Nakhlé, 2003).

Embanking of the littoral

At the beginning of the Eighties of the last century and because of the anarchy that reigned in the country due to the civil war, illicit promoters had undertaken a project to embank part of the littoral in the north of Beirut. A few years later, this project was legalized and privatized. With a total surface of 135 hectares, this protrusion in the sea had serious consequences on marine fauna and flora, and on their habitat (Abboud-Abi Saab & Nader, 2005).

ECOLOGICAL CONSEQUENCES

Organic water pollution

The contamination level of 4 sites along the coast of Beirut (figure 1) was studied.

Code	Longitude (E)	Latitude (N)
JUN-40	35º 34.970’	33º 55.020’
BEY-11	35º 28.518’	33º 54.120’
BEY-12	35º 28.225’	33º 54.024’
BEY-20	35º 28.760’	33º 52.767’

Table 1. The coordinates of the 4 studied sites along the littoral of Beirut

The mean values of the different physicochemical and biological characteristics (Table 2) allowed us to classify these sites as close to normal to extremely contaminate.

[1] Centre National de la Recherche Scientifique du Liban/Lebanese National Council for Scientific Research

	T°C	Salinity	N-NO_2^- µmol.L^{-1}	N-NO_3^- µmol.L^{-1}	P-PO_4^{2-} µmol.L^{-1}	FC[2]	FS[3]
JUN-40[a]	22.56	37.29	0.411	5.686	1.784	11599	19778
BEY-11[b]	22.39	39.21	0.099	0.486	0.200	145	182
BEY-12[c]	22.32	39.03	0.264	1.016	0.600	5141	2722
BEY-20[c]	22.52	38.90	0.319	1.498	0.874	5018	3803

[a] *sites close to normal;* [b] *sites moderately contaminated;* [c] *sites heavily contaminated*

Table 2. The mean values of the different physico-chemical and bacteriological parameters at the 4 studied sites along the littoral of Beirut

	T°C	**Salinity**	**N-NO_3^- µmol.L^{-1}**	**N-NO_2^- µmol.L^{-1}**	**P-PO_4^{2-} µmol.L^{-1}**	**FC**	**FS**
T°C	1	0.129	-0.235*	-0.020	-0.002	-0.025*	-0.012
Salinity		1	-0.930***	-0.595***	-0.854***	-0.594***	-0.838***
N-NO_3^- µmol.L^{-1}			1	0.552***	0.817***	0.594***	0.735***
N-NO_2^- µmol.L^{-1}				1	0.659***	0.593***	0.535***
P-PO_4^{2-} µmol.L^{-1}					1	0.751***	0.847***
FC						1	0.588***
FS							1

*P<0.05; **P<0.01; ***P<0.001

Table 3. Correlation matrix of the physicochemical and bacteriological parameters in 4 sites along the littoral of Beirut

The correlations among the different physicochemical and bacteriological parameters at the 4 studied sites (table 3) are conclusive as regards the pollution which is of organic origin. This organic pollution has a direct impact on the eutrophication of the marine environment (Abboud-Abi Saab *et al*, 2008), and also caused a disturbance on the level of meiobenthic fauna causing a fall in specific diversity and an abundance of some species of nematodes: *Rhabditis marina*, *Oncholaimus campylocercoides* (Mouawad 2005).

---

[2] FC = Fecal coliforms
[3] FS = Fecal streptococcus

Sediment chemical pollution

Samples of Dora sediment have high concentrations of Pb, Cd and Hg (table 4). These values, compared to other sediments in the world and to some uncontaminated Lebanese coastal sediments, reflect large anthropogenic inputs.

High Pb concentrations in the sediments of Dora were previously detected (Nassif, 2006). These high concentrations are consistent with the high Pb level in water, up to 360 $ng.L^{-1}$, measured by Nakhlé (2003), while natural concentrations in Mediterranean waters are lower than 50 $ng.L^{-1}$.

Cd concentrations are also superior to the average value of Cd in marine sediments 0.2 $\mu g.g^{-1}$ (Abi-Ghanem, 2008). These findings reflect large anthropogenic inputs mainly originating from i) the nearby enormous waste discharge, ii) thermoelectric centrals (Zouk central) which generates 1100 g Cd day^{-1} and from iv) Antelias river that receives industrial and urban waste water from Beirut and Dora and whose waters present a concentration of particulate Cd equal to 0.4-1.01 $ng.mg^{-1}$ (Nakhlé, 2003).

High HgT[4] concentrations which are typical of a contaminated environment are also expected. Samples of marine water from Dora site are especially contaminated with mercury (7-8 ng L^{-1}) (Nakhlé, 2003; Nassif, 2004). Mercury presence in Dora Bay is probably due to the nearby huge dumpsite, which is in direct contact with marine water.

Site	Pb ($\mu g.g^{-1}$)	Cd ($\mu g.g^{-1}$)	Hg ($\mu g.g^{-1}$)
Dora	70 - 101	0.6 - 0.94	0.1 - 0.5
Akkar	6.2 - 15.7	0.14 - 0.19	0.01 - 0.03

Table 4. Pb, Cd and Hg concentrations in sediments of two sites of the Lebanese coastal zone: Dora heavily contaminated by a dump site and Akkar away from direct sources of contamination (from Abi-Ghanem, 2008)

Dora polluted sediments can act as a source of trace metals that can bioaccumulate through the food chain. This trace metal behaviour was confirmed by Nakhlé (2003) who found high Pb concentrations in *Hippospongia communis* and in the mussels *Brachidontes variabilis*.

Direct consequences from littoral embanking

The most important direct consequences of the embanking of the littoral were i) the total destruction of the vermetid terraces characteristics of the Mediterranean Levantine basin which lodge a specific Lebanese fauna and flora (Abboud-Abi Saab & Nader, 2004), ii) the disappearance of sandy beaches, places of turtle nesting (Khalaf & Abboud-Abi Saab, 2005) and iii) the absence or the reduction of

[4] HgT : total mercury

several pelagic and benthic species like the herbarium *Cymodocea nodosa* or the brown algal *Stypopodium zonal* (Khalaf & Abboud-Abi Saab, 2005).

REFERENCES

Abboud-Abi Saab M., Fakhri M., Sadek E & Matar N., 2008. An estimate of the environmental status of Lebanese littoral waters using nutrients and chlorophyll-a as indicators. Leb. Sci. J., 9(1): 43-60.

Abboud-Abi Saab M. & Nader M., 2005. Establish conservation Strategies of Lebanese Coastal Habitats, 559-566, In: INOC 2005, Marine & Coastal Protected Areas ed. By Chouikhi, A. & Menioui M., 687pp.

Abi-Ghanem C., 2008. La "spéciation" de trois éléments trace mercure, plomb et cadmium dans les sédiments des zones cotières libanaises. Thèse doctorale, AgroParisTech, pp. 300.

ECODIT-IAURIF (Audit écologique – Institut d'aménagement et d'urbanisme de la région d'île de France) 2001. Council for Developpement and Reconstruction. State of the environment report. Prepared by ECODIT-IAURIF

Khalaf G., Slim K. & Kraiem M. M., 2001. Etude zoocénotique et qualité des eaux du Nahr-Beyrouth IEEE , No 00EX 493,133-139.

Khalaf G. & Abboud-Abi Saab M., 2005- Stratégie de la surveillance permanente de la diversité biologique marine et côtière au Liban. INOC-Marine & Coastal Protected Areas: 594-598.

Mouawad R., 2005. Peuplements de nématodes de la zone littorale des côtes du Liban. These de doctorat-Campus de Luminy, Marseille, pp 212+annexe.

Nakhlé K., 2003. Le mercure, le cadmium et le plomb dans les eaux littorales libanaises: apports et suivi au moyen de bioindicateurs quantitatifs (éponges, bivalves et gastéropodes). Thèse doctorale, Université Paris 7, Denis Diderot, pp.213.

Nassif N., 2006. Pollutions chimiques en milieu marin: essai de modélisation et approche réglementaire.GG/F (ed.), pp.352+annexe.

Saad Z., Slim K., Khalaf, G & EL Samad O., 2004. Impacts des rejets des eaux résiduaires sur la qualité physico-chimique et algologique du Nahr Antélias.Bull. Soc. Nechat. Sc. Nat. 127: 69-82

First observation of dinoflagellate cysts as bio-indicator in bottom sediments in Alexandria coastal water, Egypt

Suzan E.A. Kholeif

National Institute of Oceanography and Fisheries, Marine Geology Department Kayetbay, Al Anfoshy, Alexandria, Egypt

Keywords: Abu Qir, Anthropogenic activity, dinoflagellate cyst, palynology

Abstract

Bottom sediments were collected from 18 locations and one core, during May and December 2006, to study the distribution of dinoflagellate cysts in the costal waters of the Abu Qir Bay, which is located in the southeastern Mediterranean close to Alexandria, Egypt. The most common cysts that were detected (*inter alia*, *Alexandrium minutum*, *A. affine*, *Alexandrium spp*., *Gymnodinium catenatum*, *Protoperidinium denticulatum*) are capable of producing paralytic shellfish poisoning (PSP). As a result of severe industrial pollution and unstable hydrographic conditions, some of the localities in the coastal part of the Bay are barren of any organic-walled microplankton. This study reports for the first time the presence of dinoflagellate cysts in the Egyptian Mediterranean coast and suggests their use as indicators of pollution and climate variability in this area. The overall aim of this work is to formulate environmental considerations on the effects of anthropogenic, as well as hydrographic changes in the Abu Qir Bay.

Résumé

Dix-huit échantillons de sédiments de surface ainsi qu'une carotte ont été prélevés en mai et décembre 2006 pour étudier la distribution des kystes de dinoflagellés dans les eaux de la baie d'Abou QIR, située dans le sud-est de la Méditerranée près d'Alexandrie en Égypte. Les kystes les plus fréquemment détectés (entre autres, *Alexandrium minutum, A. affaine, Alexandrium spp. Gymnodinium catenatum, Protoperidinium denticulatum*) sont ceux d'espèces produisant des toxines paralysantes (PSP) susceptibles d'entrainer des intoxications par consommation de mollusques. En outre, à la suite d'une grave pollution industrielle et du fait de l'instabilité des conditions hydrographiques, les eaux d'une des localités côtières de la baie sont stériles de tout organisme microplanctonique à paroi organique. Ce travail décrit pour la première fois la présence de kystes de dinoflagellés à proximité de la côte méditerranéenne égyptienne et suggère leur utilisation comme indicateurs de pollution et de variabilité climatique. L'objectif global de ce travail est l'étude de l'évolution de l'environnement sous l'effet des pressions anthropiques, ainsi que les changements de la situation hydrographique dans la baie d'Abou QIR.

INTRODUCTION

Abu-Qir Bay (Figure 1) is a small semicircular shallow marine bay with a maximum depth of about 16 m and a shoreline about 50 km long, on the Egyptian Mediterranean coast. It is located between longitude 30° 50' and 30° 22' E and latitude 31° 16' and 31° 28' N (about 35 km east of Alexandria).

Abu-Qir Bay was considered, before 1965, as one of the most important breeding and nursery grounds for economically important fish and shellfish. The Bay receives considerable amounts of waste waters through three sources: i) polluted waters discharged from the El-Tabia pumping station (1.850,000 m^3/day), including drainage waters from the El-Behera province as well as industrial waste from several industries among which the Rakta and National paper factories are the most important; ii) brackish waters polluted by the agricultural run-off of Lake Edku discharged through Boughaz El-Madiya; and iii) river waters discharged from Rosetta branch of the Nile River (Tayel, 1992). Such pollutants have a drastic effect on various aquatic fauna and flora.

QUESTIONS

Is there any variability in dinoflagellate cysts types, abundance and distribution in the bottom sediments of the Bay? Can these cysts be used as bioindicators of the current effects of pollution on the marine environment of the Bay? Answering these questions is the main aim of the present work.

Studies of pollution and its effects on dinoflagellate cysts have often focused on areas exposed to direct pollution sources such as agricultural and domestic wastes, paper processing, oil-gas seepages, organic compounds, and pollution by heavy metals. Through the observation of the absence, presence, or abundance of selected genus or groups of species, dinoflagellate cysts may be useful bioindicators of pollution impacts. An increase in the number of cysts of heterotrophic dinoflagellates has been suggested as a signal of eutrophication and industrial pollution (Matsuoka, 1999, 2001). The decline in species richness and large fluctuations in total cyst abundances may indicate the presence of intensified anthropogenic disturbance in the watershed, notably induced by a high degree of eutrophication and inorganic pollution. Dinocyst species richness generally increases with nutrient level. However, do dinocysts disappear or does their number decrease in environments characterize by extremely high levels of nutrients (hypertrophic conditions) and chemical contaminants?

MATERIALS AND METHODS

Eighteen bottom sediment samples, from 18 stations covering nearly different sites of the Bay (Figure 1), were collected, during the end of May and December 2006, using a Van Veen grab sampler. The core sample (~25 cm length) was collected during December 2006 by a diver using a PVC tube. Selected bottom sediments and core samples were processed using standard palynological techniques for marine sediments (Ibrahim et al., 2003). Quantitative and qualitative results for dinocysts identification were based on previous studies such as those by Fensome et al. (1993), Williams et al (1998), Rochon et al. (1999) and Matsuoka and Fukuyo (2000).

RESULTS AND DISCUSSION

Available information on the presence and distribution of resting cysts in Egyptian coastal sediments, especially in most recent ones, is sparse. Thus, results presented herein cannot be critically compared against previously published data. Rather, the discussion of these results will focus on general observations regarding the distribution and abundance of cysts and on suggestions for further investigations.

Dinocysts abundance

Dinocysts abundance varied greatly among studied locations. The high number of cysts observed in the near shore stations could be explained as follows: **a)** At El-Mena (sample 1), extensive human activities led to the accumulation of muddy sediments. The cysts have a size equal to silt-mud particles and thereby display hydrodynamic properties similar to those of fine silt particles. Accordingly, rich cysts are usually found in muddy sediments and are lacking from sandy size sediments (Dale 1983, Wang et al., 2004). **b)** At the El-Tabia station (sample 3), the density of heterotrophic cysts (7646 cyst/g) was significantly higher than that of other stations. Heterotrophic cysts are known to have a high relative abundance in areas enriched with nutrients, in coastal areas, and in fronts between water masses (Dale, 1996; de Vernal et al., 1997, Wang et al., 2004). The El-Tabia site is characterized by the influence of domestic, agricultural and industrial sewages. The latter two comprise fertilizers and waste coming from food processing, weaving, paper, and cement baking plants. El-Tabia receives also brackish water drained from cultivated lands located at the northeastern part of the Nile delta through El-Amy Drain (Said et al., 1995). **c)** The El Madia station (sample 6) was characterized by high cyst abundance (8279 cyst/g). At this location, the density of heterotrophic cysts was slightly lower than that found in the El-Tabia station (Figure 2), while the number of autotrophic cysts -particularly *Alexandrium* spp.- increased. The high number of cysts in this station could result from a high input of nutrients, as the area is characterized by the discharge of nutrients and agricultural waste from Lake Idku, through the El-Madia channel, into the bay (Tayel, 1992). **d)** The total cysts concentration increase again (11823 cyst/g) towards the eastern part of the bay (station 18), most likely because of the outflow of Rosetta runoff, whereas the stations near the mouth of the Rosetta promontory (stations 11 and 15) had lower cysts concentration. The absence of cysts in the stations located in the center of the Bay is unexpected and in contrast with previously published works (e.g., Mousa, 1981; Frihy et al., 1994; Said et al., 1995). These advocate, indeed, that the fine sediments in the bay and on the shelf are deposited in the center of the bay, away from the Rosetta promontory and from Abu Qir head-land, because of opposing littoral and offshore bottom currents (Frihy et al., 1994). To get an insight into these controversial data, a core sample was taken at the same location as station 12, and cysts studied at different depths. All the 5-cm sedimentary layers analyzed, including the upper one, were found to be productive; the highest concentrations of cysts were found in the 5-10 cm layer (13837 cyst/g) and in the 15-20 cm one (10009 cyst/g). Heterotrophic cysts were dominant in all sediment layers. However, a bloom of *Alexandrium* spp., was observed in the sediments at 5-10 cm depth (1806 cyst/g). Seasonal variation and/or unstable hydrographic conditions could possibly explain the missing cysts in the center of the bay. Further investigations should nevertheless be conducted to confirm this hypothesis.

Overall, these results suggest that the abundances, types and distribution of dinoflagellate cysts could be used as bioindicators of pollution, hydrographic and seasonal variations.

General comments on harmful dinoflagellate cysts

The above discussion shows that there is a higher concentration of the toxic dinoflagellate *Alexandrium* (Figure 3) in the El-Mena, El Tabia, El Madia, and n° 18 stations as well as in the core samples at a depth of 5 to 15 cm. *Alexandrium* cysts are fairly preserved in the buried records of the core samples. This strongly suggests that high numbers of vegetative cells may have occurred in this area, several years ago.

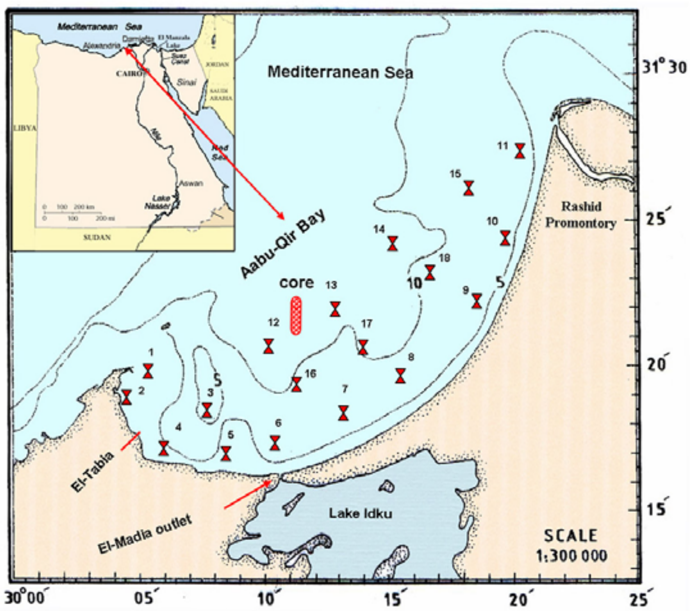


Figure 1. Location map of Abu Qir Bay, showing locations of core and bottom sediment samples

Furthermore, the absence of harmful algal blooms (HABs) in the present area could be explained by lack of observation and/or low frequency of sampling. An alternative explanation could be the transport of sediments from adjacent water bodies. This preliminary work undoubtedly calls for additional cyst studies in the region. High concentrations of the toxic cyst *Gymnodinium catenatum* (1075 cyst/g) were observed in the bottom sediments at the El-Mena station. Despite the high concentrations of toxic species (especially *Gymnodinium catenatum,* *Alexandrium minutum and A. affine)* found in the El-Mena and El Madia samples, which does suggest that the corresponding water bodies may be at environmental risk, these areas are among the main fishing grounds adjacent to Alexandria. *Alexandrium* cysts contain several fold higher PSP (Paralytic Shellfish Poisoning) toxin concentrations than those found in vegetative cells (e.g., Oshima et al., 1992; Wang et al, 2004). The consumption of seafood contaminated by these cysts could therefore represent a serious threat to human health. The setup of a monitoring program in the Bay would prove most useful to follow the occurrence and dynamics of toxic blooms.

Average adjusted concentrations of nickel were around 1.3 mg / kg, Extreme values were found in some sampling sites in the South Western sub basin especially in Tabarka (3.18 mg/kg), Oued Zhor (2.89 mg /kg), Oran (2.47 mg/kg), Nador (2.72 mg/kg), in the south of Spain in Fuengirola (2.44 mg/kg) and in the south of Aegean sea in Rhodos (4 mg/kg). For this metal the background in more elevated in the eastern part of the basin especially in the Aegean sea.

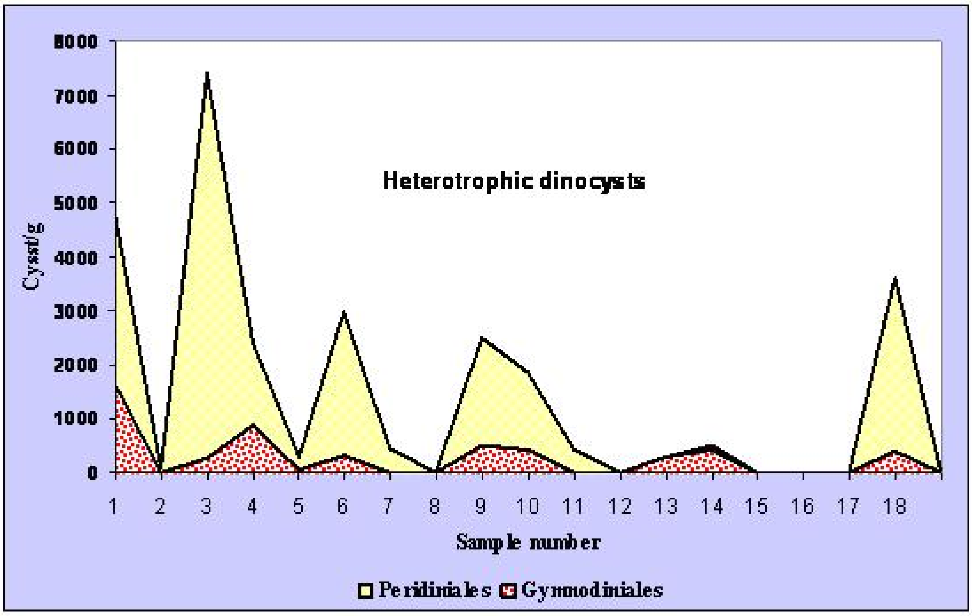


Figure 2. Diagram showing the concentration of heterotrophic cysts in the bottom sediments collected during May 2006

The median value of the sum of DDTs compounds was 2.52 µg/kg at the scale of the study. Significant peaks were recorded in the North Western and Tyrrhenian sub-basin especially in front of Marseille (15.47 µg/ kg), Barcelone (15.17 µg/ kg) and Napoli (15.34 µg/ kg). In the South Western sub-basin Algiers also showed a high level (10.23 µg/ kg). The level recorded at the Algiers station was equivalent to the overall levels recorded at stations off the coast of the following rivers and streams: Ebro, Rhône and, to a lesser degree, Tet, Aude, Herault (North Western sub-basin) and Tevere (Tyrrhenian sub-basin). In the Eastern part of the basin the higher levels are observed in Thessaloniki (7 µg/ kg). For this contaminant's family we can observe that the background is more elevated in the North Western and Tyrrhenian sub-basins.

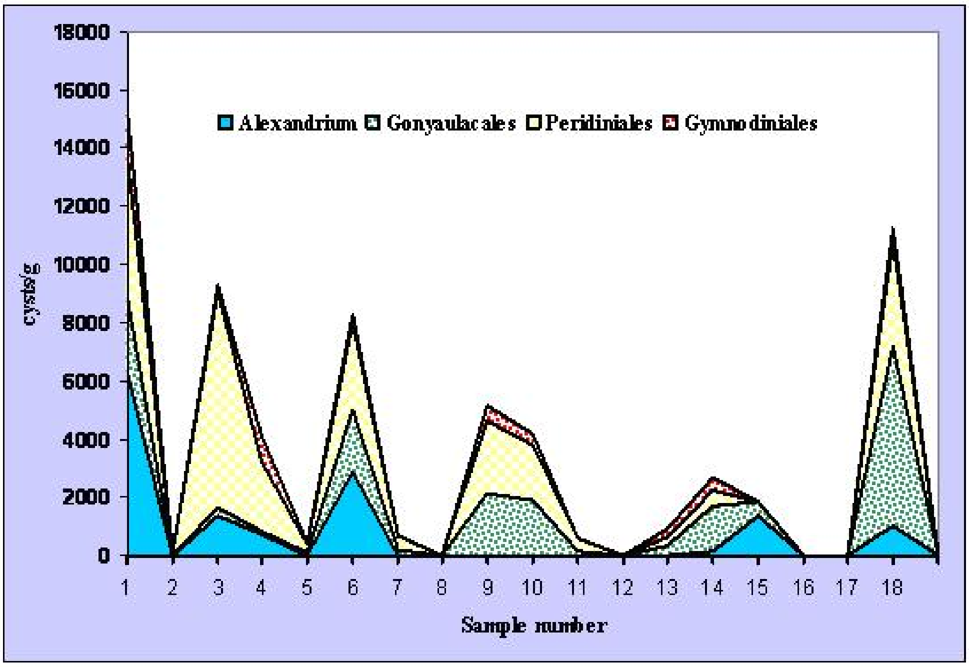


Figure 3. Diagram showing the concentration ofAlexandrium and other cyst orders in the bottom sediments collected during May 2006

Regarding the sum of the 10 congeners of PCBs (Fig. 2) and the CB153, the distribution shows a similar profile. The median value of the sum of PCBs compounds was 7.76 µg/kg. The results show some sites are significantly contaminated by PCBs : in the North Western sub basin (Barcelona [63.87 µg / kg], Marseille [103.52 µg / kg]) ; in the Tyrrhenian sea (Naples [91.48 µg / kg]) and on South Western coast (Algiers [51.13 µg / kg]). If there is a characteristic presence of PCBs in the vicinity of major urban centres, high values are also observed in the Tyrrhenian Sea at La Maddalena (58.49 µg / kg), at a station located close to a major naval base. To a lesser degree, we can also pinpoint inputs by the Ebro (20.37 µg / kg) and Rhône rivers (37.80 µg / kg). In comparison the higher concentration observed in the Eastern Mediterranean was 11.25 µg/kg in Thessaloniki. If the background levels are similar at the scale of this study, the maximum levels are always observed in the Western Mediterranean.

CONCLUSION

1. High concentrations and diversity of dinoflagellate cysts (a total of forty seven dinoflagellate cyst types representing 22 genera) were observed in Abu Qir Bay.
2. *Alexandrium* cysts have been seen in surface sediment layers in the vicinity of the most coastal stations. This species was the most abundant of the cyst types in the area. However, *Alexandrium* cysts were absent from, or showed lower

surface concentrations in, several stations of the center of the bay. At these latter locations, cysts were found buried in the sediment at a depth of 5-15 cm.

3. Cysts of three potentially toxic dinoflagellate species, namely *Alexandrium minutum, A. affin,* and *Gymnodinium catenatum*, were detected at E-Mena and El Madia in bottom sediments and between 5 and 15 cm in the core samples.
4. The high concentration and occurrence of dinoflagellate cysts in the Abu Qir Bay are thought to reflect serious changes in the environmental conditions and anthropogenic activities of the coastal area studied.
5. These results describe for the first time the presence of toxic dinoflagellate cysts in the Abu-Qir Bay and suggest that the abundance and distribution of cysts in this area might be related to industrial pollution as well as to the variability of hydrographic conditions.
6. Further studies are needed to confirm that dinoflagellate cysts can be used as bioindicators of marine pollution in bottom sediments of Abu-Qir Bay.

ACKNOWLEDGEMENTS

The author gratefully acknowledges both Dr Fabienne Marret, University of Liverpool, United Kingdom and Prof. Kazumi Matsuoka, University of Nagasaki, Japan for their help in the dinocysts identification.

REFERENCES

Dale B., 1983: Dinoflagellate resting cysts: "benthic plankton". In: G. A. Fryxell (Ed.), *Survival Strategies of the Algae*. Cambridge Univ. Press, Cambridge: 69–136.

Dale B., 1996: Dinoflagellate cyst ecology: modeling and geological applications. In: J. Jansonius & D.C. McGregor (Eds.), Palynology: Principles and applications. American Association of Stratigraphic Palynologists Foundation, Dallas, TX, 3: 1249–1275.

De Vernal A., Rochon A., Turon J.-L. and Matthiessen J., 1997: Organic-walled dinoflagellate cysts: palynological tracers of sea-surface conditions in middle and high latitude marine environments. Geobios, 30: 905–920.

Fensome R.A., Taylor F.J.R., Norris G., Sarjeant W.A.S., Wharton D.I., Williams G.L., 1993. A classification of living and fossil dinoflagellates. Micropaleontology Special Publication, 7: 351 pp.

Frihy O.E., Moussa A.A., and Stanley D.J., 1994. Abu Qir Bay, a sediment sink off the northern Nile Delta, Egypt. Marine Geology, 121:199-211.

Ibrahim M.I.A., Kholeif S.E.A., Al-Sadd H., 2003. Dinoflagellate cyst biostratigraphy and paleoenvironmt of the Lower-Middle Jurassic succession of Qatar, Arabian Gulf. Revista Española de Micropaleontologia 35: 171-194.

Matsuoka K. & Y. Fukuyo, 2000: Technical Guide for Modern Dinoflagellate Cyst Study. WESTPACHAB/WESTPAC/IOC, Japan Society of the Promotion Science, Tokyo.

Matsuoka K., 1999: Eutrophication process recorded in dinoflagellate cyst assemblage – a case of Yokohama Port, Tokyo Bay, Japan. Sci. Total Environ., 231: 17–35.

Matsuoka K., 2001: Further evidence for a marine dinoflagellate cyst as an indicator of eutrophication in Yokohama Port, Tokyo Bay, Japan. Comments on a discussion by B. Dale. Science of the Total Environment, 264: 221–233.

Moussa A.A., 1981. Sediment studies in Abu Qir Bay. In: Investigation of the level and effects of pollutions in saline lakes and littoral marine environment (Abu Qir Bay and Lake Idku).Report III, Alexandriam Institute of Oceanography and Fisheries, 211pp.

Oshima Y., C. J. Bolch & G. M. Hallegraeff, 1992: Toxin composition of resting cysts of *Alexandrium tamarense* (Dinophyceae). Toxicon, 20: 1539–1544.

Rochon A., de Verna, A., Turon J-L., Matthiessen J., and Head M.J., 1999. Distribution of recent dinoflagellate cysts in surface sediments from the North Atlantic ocean and adjacent seas in relation to sea-surface parameters. : American Association of Stratigraphic Palynologists Foundation Contribution No. 35.

Said M.A., Ennet P., Kokkila T., and Sarkkula J., 1995. Modelling of transport processes in Abu Qir Bay, Egypt. Proceedings of the sec. Int. Conf, on the Mediterranean coastal Environment, MEDCOAST, Tarragona, Spain, E. Ozhan (ed.), 95:24-27.

Tayel F.T., 1992. The physical and chemical conditions of Abu Qir Bay waters. Bull. High Instit, Pub. Health. XXII (1): 87-99.

Wang Z., Matsuoka K., Qi Y. and Chen J., 2004. Dinoflagellate cysts in recent sediments from Chinese coastal waters. Marine Ecology, 25(4): 289-311.

Williams G.L., Lentin J.K., and Fensome R.A., 1998. The Lentin and Williams index of fossil dinoflagellates; 1998 edition. American Association of Stratigraphic Palynologists Contributions Series 34, 817 p.

Status of pollution in the Izmir Bay (Eastern Aegean), 1996-2008: nutrients, heavy metals and total hydrocarbon concentrations

Filiz Kucuksezgin

Dokuz Eylul University, Institute of Marine Sciences and Technology
Inciraltı, 35340-Izmir, Turkey

Keywords: pollution, nutrients, metals, hydrocarbons, wastewater treatment, Aegean sea

Abstract

Izmir Bay (western Turkey) is one of the great natural bays of the Mediterranean. Nutrient concentrations were comparatively higher in the inner and middle of the Bay than the outer part of the Bay. Results showed a significant enrichment of metal concentrations in sediments from the inner Bay whereas the Outer and Middle bays showed low enrichments of heavy metal, the estuary of Gediz River being the only exception. The highest total hydrocarbon levels in sediments were found in the Inner Bay due to the anthropogenic activities. Heavy metal levels in fish tissues were lower than those reported from polluted areas of the Mediterranean Sea.

Résumé

La baie d'Izmir (ouest de la Turquie) est l'une des grandes baies naturelles de la Méditerranée. Les concentrations en nutriments sont relativement plus élevées dans les zones centrale et intérieure que dans la partie extérieure de la baie. Les résultats ont montré un fort enrichissement de la concentration en métaux lourds dans les sédiments de la baie intérieure, et un faible enrichissement dans les zones centrales et extérieures, l'estuaire de la rivière Gediz étant la seule exception. Les niveaux les plus élevés d'hydrocarbures totaux ont été observés dans la baie intérieure, signe d'une forte activité anthropique. Pour les tissus de poissons, les niveaux de métaux lourds mesurés étaient moins élevés que ceux mentionnés dans la littérature pour des zones polluées de la mer Méditerranée.

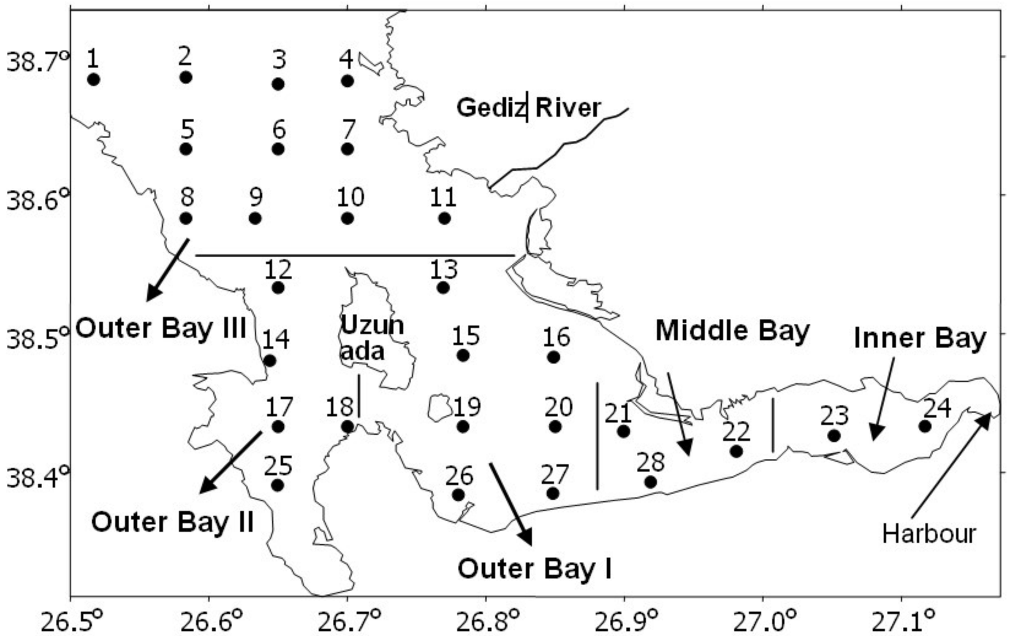


Figure 1. Location of stations in the Izmir Bay

INTRODUCTION

Izmir is an important industrial and commercial centre, and a cultural focal point. The Gediz River, which flows into the northern part of the Bay, is the second biggest river along the eastern Aegean coast. Gediz River is densely populated and extensive agricultural lands and numerous food and chemical industries are located. The streams and hundreds of small domestic discharge outlets flow into the Bay. The main industries in the region include food processing, beverage manufacturing and bottling, tanneries, oil, soap and paint production, chemical industries, paper and pulp factories, textile industries, metal processing, and timber processing. Most of the industries in Izmir are located in the inner Bay region. 105,000 m^3 day^{-1} of industrial and 308,000 m^3 day^{-1} of domestic wastewater were discharged to the Bay without significant treatment (UNEP, 1993) until 2000. In early 2000, the wastewater treatment plant (WWTP) began to treat domestic and industrial wastewater. The flow and loads of pollutants before and after construction of WWTP are presented in Table 1.

The main aim of this study was to monitor levels, temporal variability and distribution of nutrients, heavy metals and petroleum hydrocarbons in sediments and heavy metals in edible fishes of Izmir Bay before and after the construction of WWTP.

Parameter	Before WWTP	After WWTP
Flow m^3 day^{-1}	308,000	589,041
Population	1,757,414	3,370,866
COD (ton day^{-1})	-	30.86
BOD (ton day^{-1})	131.8	7.07
TSS (ton day^{-1})	158	11.78
Total N (ton day^{-1})	12.3	3.75
Total P (ton day^{-1})	3.50	1.95

Table 1. Pollutant loads of Wastewater Treatment Plant to Izmir Bay

Nutrient and heavy metal samples were collected during cruises of R/V K. Piri Reis between 1996 and 2008 at 28 sampling stations (Fig. 1). Nutrient analysis was carried out using a Skalar Autoanalyzer. Surface sediment samples were taken using Van-Veen Grab. Sediment samples were digested and all analyses were performed by flame, cold vapour and graphite furnace AAS (UNEP, 1985a, b, c, d). Sediment samples were freeze-dried and extracted in a Soxhlet apparatus for petroleum hydrocarbon analysis according to UNEP (1991). High-resolution gas chromatography (CHROMPACK) equipped with a split/splitless capillary injection system and FID were used for the petroleum hydrocarbon analysis. Fish (*Mullus barbatus*) samples were collected from the outer part of the Bay and heavy metals were analysed according to UNEP (1984) and UNEP (1985).

NUTRIENTS

The average concentrations from all depths in the outer Bay ranged 0.01-0.22, 0.10-1.8, 0.10-0.98, 0.30-5.9 µM for ortho phosphate (PO_4), nitrate+nitrite (TNO_x), ammonium (NH_4) and reactive silicate ($Si(OH)_4$), respectively. TNO_x and PO_4 levels were generally higher in autumn and winter than those in spring and summer periods because of low consumption of nutrients by phytoplankton. In the middle and inner Bay, the ranges of nutrient concentrations were 0.01-10, 0.12-27, 0.10-50, 0.43-39 µM for PO_4, TNO_x, NH_4 and $Si(OH)_4$, respectively. Concentrations were comparatively higher in the middle and inner Bay than the outer part of the Bay. Maximum levels of PO_4 and TNO_x values were observed during summer and autumn due to bacterial degradation in the inner Bay.

The mean atomic ratio of TNO_x to PO_4 ranges 8.3-11 in the outer Bay, while the range at stations in the middle and inner Bay is 1.6-6.7 owing to different characteristics of the seawater. The observed mean N:P ratio was significantly lower than the assimilatory optimal (N:P=15:1) in conformity with Redfield's ratio N:P=16:1 in the Bay and nitrogen is the limiting element in the middle and inner Bay.

The TRIX was used in the Izmir Bay for classification of trophic status according to Environment Law of Turkey. The mean values of TRIX varied 2.06-3.87 and 3.40-7.29 in the outer and middle-inner Bay, respectively. By analyzing the means of TRIX for the different parts of the Izmir Bay, "eutrophic" and "high eutrophication risk" status are highlighted in the inner Bay, while "no-high eutrophication risk" is established in the outer Bay according to Turkish legislation.

HEAVY METALS IN SURFACE SEDIMENT

The highest concentrations of metals were found in the inner Bay where heavily industrialized compared to the middle and outer parts of the Bay. The maximum level of Hg (1.3 $\mu g\ g^{-1}$ dry wt) and Cd (0.82 $\mu g\ g^{-1}$ dry wt) were measured in the inner part of the Bay. Pb and Cr are quite high in the sediments of middle-inner Bay. Until 1994, the leather tanning plants, which used large quantities of Cr in the tanning procedure discharged wastes directly into the inner Bay. Maximum levels of Cr were observed at stations 11, 13 and 15 due to Gediz River. The highest mean Cu values were measured during 2001. Heavy metal concentrations generally increased in 2001 in the all sampling stations. The concentrations of Cd, Cu and Pb in the outer Bay were generally similar to the background levels and mean concentrations from the Mediterranean and Aegean Seas (MAP, 1987; UNEP, 1978; Whitehead et al., 1985). The levels of heavy metals are lower in the inner Bay than polluted areas of Mediterranean Sea. The statistical comparison of metal concentrations demonstrated that, there are significant ($p<0.05$) regional variations during 1997-2008.

PETROLEUM HYDROCARBONS IN SURFACE SEDIMENT

In terms of Σ5 aliphatic and Σ16 polycyclic aromatic hydrocarbons (PAHs) concentrations range 84-4427 and 2.5-113 ng g^{-1} dry wt, respectively. The highest Σ5 aliphatic hydrocarbon levels were found in the inner Bay. High concentrations are probably related to anthropogenic sources. Maximum PAHs levels were found in the inner part of the Bay. The relatively high concentrations observed for the inner Bay and the port are probably linked to the greater industrialization and urbanization in this part of the Bay. In contrast, PAHs concentrations in most of the sediments in the outer Bay were low, and were typical of locations distant from extensive anthropogenic activities. According to Baumard et al. (1998), levels of PAHs can be characterized as low, moderate, high, and very high. Based on this classification, the sediments from Izmir Bay can be generally considered to be only slightly polluted, except for station 24.

HEAVY METALS IN FISH

Fish are widely used as bio-indicators of marine pollution by metals. *Mullus barbatus*, was recommended by FAO/UNEP (1993) as monitoring species. The concentrations of heavy metals found in *M. barbatus* varied, with the range of 14-520 for Hg, 0.10-10 for Cd, 2.6-478 for Pb, 22-270 for Cr, 178-568 for Cu, 2157-3772 for Zn in µg kg^{-1} wet weight in the Bay. The comparison of metal concentrations demonstrated that, there are no significant ($p<0.05$) regional variations during 1996-2008 except for Hg (df=4, F=6.034415, p=0.00025).

CONCLUSIONS

It is concluded that pollution in the outer Bay is not significant, but eutrophication of the inner Bay has already begun and might be spreading progressively to the outer Bay. Nutrient concentrations were relatively high at the surface layers of Gediz River estuary. The mean atomic ratios of TNO_x to phosphate indicate N-limitation in the Bay. The WWTP treated the wastewater about 60 % capacity between 2000-2001 and full capacity after 2001. The quality of the marine environment in the middle and inner parts of the Bay has not yet noticeably improved. Although the capacity of WWTP is sufficient for removal of nitrogen from the wastewater, it is inadequate for removal of phosphorus.

The concentration of heavy metals in sediments was generally similar to the background levels from the Mediterranean and Aegean Sea, except for the delta of Gediz River which is the major source of anthropogenic input into the outer Bay. The high concentration of heavy metals in sediment is observed in the inner part of the Bay and the levels of heavy metals gradually decreased over the sampling period.

Total petroleum hydrocarbon values measured in the outer Bay indicated that this area is not heavily polluted, while the considerable concentrations of hydrocarbons in some sediment sampled in the middle and inner Bay highlighted non-negligible anthropogenic inputs. High levels of total petroleum hydrocarbon levels were found in the inner Bay due to the anthropogenic activities, mainly combustion processes of traffic and industrial activities.

The mean concentrations of Hg, Cr, Cu, Zn in *M. barbatus* were increased, while Cd and Pb levels were decreased in 2008. According to MAFF (1995), the limit value for human consumption of metals are 500 µg kg^{-1} for Hg, 200 µg kg^{-1} for Cd, 2000 µg kg^{-1} for Pb, 100 µg kg^{-1} for Cr, 20000 µg kg^{-1} for Cu, 50000 µg kg^{-1} for Zn. Metal concentrations in muscle of *Mullus barbatus* appeared to be low.

REFERENCES

Baumard P., Budzinski H., Garrigues P., 1998. Polycyclic aromatic hydrocarbons in sediments and mussels of the western Mediterranean Sea. Environ. Tox.Chem., 17: 765–776.

FAO/UNEP, 1993. Report of the FAO/UNEP/IAEA training workshop on the design of monitoring programmes and management of data concerning chemical contaminants in marine organisms, Athens, 247pp.

MAFF, 1995. Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1993. Directorate of Fisheries research, Lowestoft, Aquatic environment monitoring Report no: 44.

MAP, 1987. Assessment of the state of pollution of the Mediterranean Sea by mercury and mercury compounds. Tech Rep Series 18, UNEP, Athens.

UNEP, 1978. Preliminary report on the state of pollution of the Mediterranean Sea. Ingovermental review Meeting of Mediterranean Coastal States on the Mediterranean Action Plan. UNEP/IG.11/INF 4.

UNEP, 1984. Determination of total Cd, Zn, Pb and Cu in selected marine organisms by flameless AAS. Reference Methods for Marine Pollution Studies 11.

UNEP, 1985. GESAMP, Cadmium, lead and tin in the marine environment. UNEP Regional Seas Reports and Studies 56.

UNEP, 1985a. Determination of total Hg in marine sediments and suspended solids by cold vapour AAS. Reference Methods for Marine Pollution Studies 26.

UNEP, 1985b. Determination of total cadmium in marine sediments by flameless AAS. Reference Methods for Marine Pollution Studies 27.

UNEP, 1985c. Determination of total chromium in marine sediments by flameless AAS. Reference Methods for Marine Pollution Studies 31.

UNEP, 1985d. Determination of total lead in marine sediments by flameless AAS. Reference Methods for Marine Pollution Studies 34.

UNEP, 1991. Determinations of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies 20.

Whitehead N.E., Oregioni B., Fukai R., 1985. Background levels of trace metals in Mediterranean sediments. Journ. Etud. Pollut. CIESM 7: 233-240.

Restoration potential of eutrophic waters adjacent to large coastal cities: lessons from the coastal zone of Croatia

Grozdan Kušpilić, Ivona Marasović, Nada Krstulović, Mladen Šolić, Živana Ninčević-Gladan, Natalija Bojanić, Olja Vidjak and Slavica Matijević

Institute of Oceanography and Fisheries, Šet. I. Meštrovica 63, Split, Croatia

Keywords: eutrophication, wastewater, restoration, Adriatic

Abstract

The marine environment in the coastal zone of Croatia shows relatively good ecological conditions in general. The only exceptions are the most northern part of the Adriatic which is strongly influenced by the River Po, and some semi-enclosed bays surrounded by industrialised areas, receiving untreated municipal wastewater from nearby cities, as well as fresh- or groundwater through rivers or submarine discharges. Most dramatic change of ecological status during the second part of the last century was probably established in the semi-enclosed Bay of Kaštela where severe eutrophication occurred due to intensive industrialisation and population growth. After frequent anoxia events and occurrence of red tides, the Croatian Government in collaboration with the World Bank and the European Bank for Reconstruction and Development decided to invest approximately 150 million Euros in water supply and sewage treatment systems which were finished in 2004. Restoration of the marine environment started immediately at the bacterial level while for zooplankton is still in progress.

Résumé

L'environnement marin côtier de la Croatie présente une relativement bonne condition écologique générale. Les seules exceptions sont la zone la plus septentrionale de l'Adriatique, qui est fortement influencée par le fleuve Pô, et quelques baies semi fermées situées à proximité de zones industrialisées, recevant également les eaux usées non traitées de municipalités voisines ainsi que des apports d'eaux douce et souterraines par l'intermédiaire de fleuves ou d'écoulements sous-marins. Les modifications écologiques les plus dramatiques qui ont été observées durant la seconde moitié du siècle dernier ont probablement eu lieu dans la baie semi fermée de Kaštela, où une eutrophisation sévère s'est installée à cause de l'intense croissance industrielle et urbaine. A la suite de fréquents événements d'anoxies et de marées rouges, le Gouvernement croate, en collaboration avec la Banque Mondiale et la Banque Européenne pour la Reconstruction et le Développement, a pris la décision d'investir quelque 150 millions d'Euro dans le système d'approvisionnement en eau et de traitement des

eaux usées, ce qui fut terminé en 2004. Le recouvrement de la qualité du milieu marin a commencé immédiatement au niveau bactérien. En ce qui concerne le zooplancton, l'amélioration est toujours en cours.

Croatia is a Mediterranean country situated in the south eastern part of Europe with a total population of 4,400,000 inhabitants. It is administratively divided in 21 Counties from which 7 are located at the Adriatic Sea. The population of 1,400,000 inhabitants in the coastal Counties lives in 2,500 settlements, 57 cities are more than 10,000 inhabitants and only 2 cities (Split and Rijeka) are more than 200,000 inhabitants. Main economic activities in this area are agriculture (wine and olive), fishery and fish farming, metallurgy, oil industry, construction, trade, shipbuilding, maritime affairs and tourism.

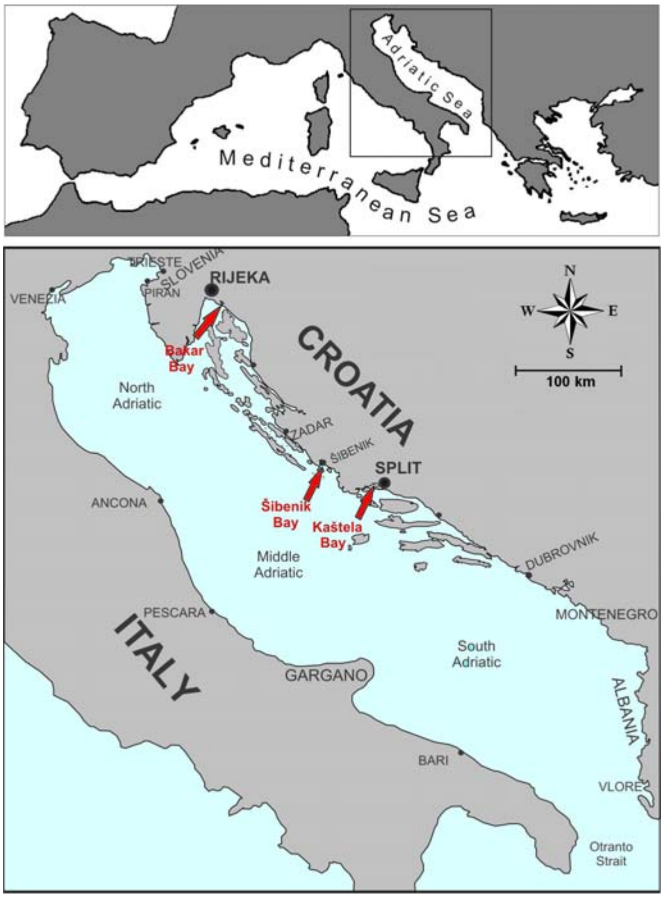


Figure 1. Location of endangered areas in the coastal zone of Croatia

Relatively low anthropogenic pressure, pristine rivers, low population density and a long coastal line of more than 6,200 km (including 1,246 islands, islets and cliffs) implies relatively good ecological conditions in the marine environment. Results of monitoring programmes supported this assumption in general with the exception of some areas where lower ecological status was established. These areas are the shallow, most northern part of the Adriatic, which is strongly influenced by the River Po, and some semi-enclosed bays like Bakar Bay, Šibenik Bay and Kaštela Bay located in the northern and central part of the coast. All of these bays are surrounded by industrialised areas, receiving untreated municipal wastewater from nearby cities, as well as fresh- and/or groundwater through river and/or submarine discharges.

Most dramatic changes during the second part of the last century was probably established in Kaštela Bay where classical eutrophication effects have occurred (increase of nutrient levels and primary production, oxygen supersaturation/hypoxia events, changes in phytoplankton community structure and seasonal cycle, occurrence of harmful algal blooms, mortality of shellfish and demersal fish, etc.) due to negative impacts of intensive industrialisation (cement, vinyl chloride, metallurgy, ship building and food processing), and population growth of the surrounding cities like Trogir, Kaštela and Split. These phenomena occurred most frequently during eighties, after which the Croatian Government, in collaboration with the World Bank and the European Bank for Reconstruction and Development, decided to invest approximately 150 million Euros in water supply and sewage treatment systems that would address the water quality issues in the whole Bay. This, so called EKO - Kaštela Bay Project, was the largest ecological project in the Adriatic and the Mediterranean at that time. The sewage treatment systems for more than 300,000 inhabitants, comprising a network of pipelines, pumping stations and a tunnel with treatment plants and submarine outfalls to the Brač channel were finished in 2004.

Restoration of the marine environment in Kaštela Bay was immediately recorded for bacteria. After the activation of the sewage treatment system, decrease in bacterial abundance and production, changes in their seasonal patterns, and structural and functional changes within microbial food web were established. Disappearance of nutrient and oxygen extremes was followed by significant decrease in primary production, especially during the summer time. Phytoplankton biomass was reduced and regular seasonal cycle of phytoplankton has been re-established. With respect to higher trophic levels, the analysis of recent zooplankton investigations in the central part of Kaštela Bay after 2004 period indicates a slight decrease in the abundance of zooplankton population, particularly the ciliate component. However, relatively high abundance of zooplankton size fractions (micro- and meso-zooplankton) is still characteristic for the areas of moderate to high trophic state. At the same time, monitoring results of the Brač channel as the new recipient of wastewaters, indicate minor influence of the outlet to the water column till now, while some sediment characteristics (organic carbon content and redox potential) are changing. It should also be emphasized that the process of national economic restructuration in the nineties and closure of many industrial plants around Kaštela Bay supported also these positive changes.

Encouraged by the positive effects of the EKO - Kaštela Bay Project, a new "Coastal Cities Pollution Control" Project was launched in 2004. The overall objective of this project is to improve the quality of Croatia's coastal waters in line with both the European Union environmental standards and the National Environmental Action Plan. The project is designed to address the problem of municipal and industrial wastewater discharge along the Adriatic Sea coastline, and remove its negative effect on ecology and public health, and develop potentials of Croatia's tourist sector. This project foresees comprehensive solution in the next few decades that will assure unhindered development of the tourism and general economy in the coastal area through realization of main project objectives: (1) protection and preservation of water quality; (2) creation of conditions for safe development of economy; and (3) maintenance and improvement of achieved level of environment protection.

Realization of this project is planned through use of different financial sources deriving from available funds of the Republic of Croatia (State budget, Fund for island development, Croatian Waters funds for protection of waters, etc.) while the remaining costs will be covered by loan from the World Bank for Reconstruction and Development. Implementation of the project is planned through three stages (each stage for 10 years) including construction of 47 sewage treatment systems which will positively change the present situation of only 40% of households and industrial wastewater connections to the sewage treatment systems.

A new governance for Marseilles's coastal area management and perspectives for exchange with Mediterranean cities

Jean-Charles Lardic

Ville de Marseille, Direction du Développement Durable
22 rue Léon Paulet, Marseille, 13008, France

Keywords: Marseilles, governance, ICZM, participatory approach, artificial reefs

Abstract

In 2000, the City of Marseilles launched a major project to install in the bay of Marseilles artificial reefs in order to create new habitats in poorly productive ecological areas. Particular attention was paid to the involvement of all stakeholders with the implementation of a participatory process from the beginning of the project. This approach has been a key point for a governance process on Marseilles costal areas aiming to bring synergies between all thematic policies

Résumé

En 2000, la Ville de Marseille a lancé un projet de grande envergure consistant à installer en rade de Marseille des récifs artificiels afin de recréer des habitats dans des zones écologiquement peu productives. Une attention particulière a été portée à l'implication de tous les acteurs concernés avec la mise en place d'un processus participatif dès le début du projet. Cette approche collective a été le point de départ d'un processus de gouvernance de la zone côtière marseillaise destiné à mettre en synergie toutes les politiques sectorielles.

In 2000, the City of Marseilles launched the 'PRADO REEFS' program involving the construction and submersion of underwater ecological habitats designed to repopulate, in a few years, previously unproductive sea beds. It was a national-scale pilot project; in fact. Nearly 30,000 m^3 of reef have been submerged at depths of 25 to 30 m, over an area of some 200 hectares, off the coast of Marseilles. This 6 million euro project was conducted in close dialogue with all stakeholders concerned. One concrete result of this successful cooperation was outside funding amounting to 80% of the total investment. On technical aspects, significant discussions and technical studies, based on two decades of experimentation and scientific survey of the area, were carried out. This resulted in the definition of seven types of reef, adapted to the conditions around Marseilles and guarantying the widest possible diversity of crevices and attachment sites for marine organisms. They took in consideration technological feasibility at affordable cost. After obtaining regulatory approvals from the state and following the public consultation in 2006, work began in March 2007, for completion in summer 2008. As planned from the project outset, a two year moratorium period came into force on the submersion of the final reef, giving users the opportunity to jointly define the future management of the area which is still to organise. Scientific monitoring is starting in 2009 to follow the development of the reefs and get greater knowledge regarding the local functioning of the marine environment and its relationship with these submerged structures.

The "Prado Reefs" project is a true sustainable development project, an example of what a community can do both to protect and enhance its environment, and to share new benefits in order to support its socio-economic activities instead of simply protecting natural resources. As it has helped to establish relations of trust and cooperation with all ocean management bodies and users, particularly professional fishermen, the successful participative method which was applied to the " Prado Reefs" program was extended at a larger scale in a " new governance" process involving all "shareholders" an "stake holders" on the whole maritime area of Marseilles : the so called " Plan de Gestion de la Rade de Marseille" (Marseilles coastal areas management plan), was officially launched in March 2006.

It includes islands and "Calanques"[1] management, coastal development and organisation, on both natural and urban areas. This "Plan de Gestion de la Rade de Marseille" appeared to be the "missing link" of urban planning processes, bringing synergies between all thematic policies established at a larger territorial scale. It allows their implementation through the good will and enthusiasm of all actors, sharing common goals or interests, and acting in confidence with one another on "Espaces d'engagement" (i.e. "involving areas") which is the term used in Marseilles to define those areas where actors will operate together on long term vision in the spirit of "shared quality of life", for a sustainable development.

This approach based on responsibility, respect and solidarity values not only completes and strengthens traditional thematic planning tools (such as SCOT[2], PADD[3], SDAGE[4]…) but brings new ways of thinking and acting together, and renews the policy making process. Dichotomy alternative between protection and exploitation is replaced by reasoned management of resources. Management is preferred to equipment. Voluntary behaviour changes are promoted before regulation tools. Actors are encouraged to develop synergies, and progress step by step together, instead of waiting for each other implication before acting.

[1] A « Calanque » is a rocky Mediterranean creek
[2] SCOT : Schéma de COhérence Territoriale = Territorial Coherent Management Plan
[3] PADD : Projet d'Aménagement et de Développement Durable = Sustainable Development Project
[4] SDAGE : Schéma Directeur d'Aménagement et de Gestion des Eaux = Water Management and Development Plan

Long term planning with heavy diagnostics is replaced by continuous improvements which are monitored by multidisciplinary studies and indicators.

This "cultural revolution", which provides "collective intelligence", needs to be accompanied by juridical research, mainly in terms of conceiving new contract schedules intending to give strength and durability to unilateral involvement, acted in a collective "context".

This experience of Marseilles could be shared with those of other Mediterranean cities willing to exchange on these new concepts of governance aiming to involve all stake-holders and share-holders in policy making and decision appliance, in a strongly monitored way with the help of scientists and socio economists.

These exchanges between cities could focus on:

- Improving methodological aspects of governance and ICZM[5], including organisational aspects to promote multidisciplinary planning and management.

- Constructing more effective monitoring systems including assessment of costs/benefits of human activities and ecosystem services on both human and environmental aspects.

- Building some simulation tools able to increase public awareness and involvement, by showing the possible effects of some development scenarios, including risk and uncertainty valuation.

- Putting forward best informal practices in social activities and behaviour in order to produce strengthened shared wellness.

- Adapting and testing all these governance methods and decision making tools in different cultural contexts.

---

[5] Integrated Coastal Zone Management

Analytical Quality Control Services (AQCS) for an accurate assessment of Mediterranean coastal contamination

Jae R. Oh

International Atomic Energy Agency – Marine Environment Laboratories (IAEA/MEL), 4 Quai Antoine 1er, MC-98000, Monaco

Keywords: interlaboratory comparison, chemical contaminants, quality assurance, quality control, reference materials

Abstract

The primary goal of the International Atomic Energy Agency's Marine Environment Laboratories (IAEA-MEL) in Monaco is to help Member States understanding, monitoring and protecting the marine environment. Thereby, the major impact exerted by large coastal cities on marine ecosystems is an issue of primary concern for the Agency and its Marine Environment Laboratories in particular. To this extent, it is noteworthy that marine pollution assessments depend on the accurate knowledge of contaminant concentrations in various environmental compartments. Two fundamental requirements to ensure the reliability of analytical results are quality control (QC) and quality assurance (QA). IAEA-MEL has been assisting national laboratories and regional laboratory networks through the provision of Analytical Quality Control Services (AQCS) for the analysis of radionuclides, trace elements and organic compounds in marine samples since the early 1970's. Relevant activities comprise global inter-laboratory comparison exercises, regional proficiency tests, and the production of marine reference materials.

Résumé

L'objectif premier de l'AIEA-LEM[1] est d'assister les Etats Membres pour les aider à comprendre, surveiller et protéger l'environnement marin. L'impact majeur exercé par les grandes métropoles côtières sur les écosystèmes marines est en conséquence une préoccupation majeure de l'Agence et en particulier de ses laboratoires marins. Il est notoire que l'évaluation de la pollution du milieu marin par les substances chimiques dépend de la connaissance précise des concentrations en contaminants dans les différents compartiments de l'environnement. Deux exigences fondamentales pour assurer la fiabilité des résultats d'analyse sont le contrôle qualité (QC) et l'assurance qualité (QA). Depuis les années 1970, l'AIEA-LEM assiste les laboratoires nationaux et les

[1] Agence Internationale de l'Energie Atomique – Laboratoire d'Environnement Marin

réseaux régionaux en leur donnant accès à ses services de contrôle qualité analytique (AQCS) pour l'analyse des radionucléides, des éléments trace et des composés organiques dans les matrices marines. Les activités associées comprennent des exercices d'inter-comparaison entre laboratoires, des tests de performance et la production de matériaux de référence marins.

INTRODUCTION

QA, QC and associated good laboratory practice should be essential components of all marine environmental monitoring. QC procedures are commonly based on the analysis of reference materials to assess reproducibility and accuracy. QA can be realized by participation in externally organized laboratory performance studies, also known as interlaboratory or intercomparison exercises, which compare and evaluate analytical performance.

The need for good QA/QC in the chemical analysis of marine environmental samples has been well recognised and has been tested in a number of international QA exercises. Such diligence needs also to be applied to other components of the monitoring exercise, since in many instances these may represent a greater source of error. Data that are not based on adequate QA/QC can be in error, and their misuse can lead to wrong environmental management decisions. In this regard, the IAEA has a long history of organizing interlaboratory studies, which have evolved to include an ever-increasing array of potential contaminants in the marine environment.

INTERLABORATORY STUDIES FOR MARINE POLLUTION STUDIES

The Marine Environmental Studies Laboratory (MESL), part of the IAEA-MEL in Monaco, has been assisting national laboratories and regional laboratory networks through the provision of AQCS for the analysis of trace metals and organic compounds in marine samples. Relevant activities comprise global interlaboratory studies, regional proficiency tests, and the production of marine reference materials. This data quality assurance programme started in the early 1970's with worldwide and regional interlaboratory comparison exercises for trace metal analyses. By 1976, it became apparent that data for the analysis of organic contaminants also lacked QA/QC support and a parallel series of interlaboratory studies was initiated. The organic pollutant series first focussed on organochlorine pesticides and polychlorinated biphenyls (PCBs). Petroleum hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), were added in 1988, and a couple of laboratory performance studies of sediments, IAEA-383 and IAEA-408, also considered sterols. Similarly, the interlaboratory studies for metals began to include methylmercury in the mid 1990's.

The AQCS for marine monitoring implemented by MESL was initially conducted in partnership with UNEP's Regional Seas Programme and the Intergovernmental

Oceanographic Commission (IOC) of UNESCO. MESL has for many years collaborated closely with regional organisations, having worked for over 30 years with the Programme for the Assessment and Control of Pollution in the Mediterranean Region (MED POL) and with the Regional Organization for the Protection of the Marine Environment (ROPME) in the Gulf and Gulf of Oman for more than 20 years. More sporadic associations have developed within the Black Sea region and the Caribbean Environment Programme (CEP). In recent years, MESL has assisted Global Environment Facility (GEF) International Waters projects in the West Indian Ocean, Black, Caspian, Red and Yellow Sea regions, notably through the implementation of regional proficiency tests.

As shown in Table 1 and 2, MESL has conducted many global laboratory performance studies in the past 30 years. There have been 18 interlaboratory comparison exercises for a range of organic contaminants and 12 interlaboratory comparison exercises for trace metals in the marine environment. Based on the above studies, several marine reference materials have been produced that can be obtained from the IAEA (http://www.iaea.org/programmes/aqcs/). The present availability of the various reference materials is also shown in Tables 1 and 2.

IAEA – Code	Sample Type	Analyte Groups	Year	Availability
IAEA-159	Marine Sediment	Organic Contaminants	2007	Yes
IAEA-435	Tuna Tissue	Organic Contaminants	2006	Yes
IAEA-432	Mussel Tissue	Organic Contaminants	2003	Yes
IAEA-417	Marine Sediment	Organic Contaminants	2002	Yes
IAEA-406	Fish Tissue	Organic Contaminants	2000	Yes
IAEA-408	Estuarine Sediment	Organic Contaminants	1999	Yes
IAEA-383	Coastal Sediment	Organic Contaminants	1998	Yes
IAEA-140/OC	Sea Plant Homogenate	Organic Contaminants	1997	Yes
IAEA-142/OC	Mussel Homogenate	Organic Contaminants	1996	No
IAEA-357	Hot Spot Coastal Sediment	Organic Contaminants	1992	No
IAEA-SD-M-2/OC	Marine Sediment	Organic Contaminants	1989	No
IAEA-MA-B-3/OC	Fish Tissue	Organic Contaminants	1989	No
IAEA–MA-A–3/OC	Shrimp Homogenate	Organic Contaminants	1989	No
IAEA-351	Tuna Fish	Organic Contaminants	1989	No
IAEA-SD-M-1/OC	Marine Sediment	Organic Contaminants	1986	No
IAEA-MA-M-2/OC	Mussel Tissue	Organic Contaminants	1986	No
IAEA-MA-A-2/OC	Fish Flesh	Organic Contaminants	1980	No
IAEA–MA-A–1/OC	Copepod Homogenate	Organic Contaminants	1980	No

Table 1. Interlaboratory studies and the resulting marine reference materials for organic contaminants produced in MESL and distributed through the Analytical Quality Control Services (IAEA, Vienna)

IAEA – Code	Sample Type	Analyte Groups	Year	Availability
IAEA-158	Marine Sediment	Trace metals & MeHg	2007	Yes
IAEA-436	Tuna Tissue	Trace metals & MeHg	2006	Yes
IAEA-433	Marine Sediment	Trace metals & MeHg	2004	Yes
IAEA-407	Fish Tissue	Trace metals & MeHg	2003	Yes
IAEA-405	Estuarine Sediment	Trace metals & MeHg	2000	Yes
IAEA-140/TM	Sea Plant Homogenate	Trace metals & MeHg	1997	No
IAEA-142/TM	Mussel Homogenate	Trace metals & MeHg	1996	No
IAEA-356	Hot Spot Coastal Sediment	Trace metals & MeHg	1994	No
IAEA-350	Tuna Fish	Trace metals	1992	No
IAEA-SD-M-2/TM	Marine Sediment	Trace metals	1991	No
IAEA-MA-M-2/TM	Mussel Tissue	Trace metals	1991	No
IAEA-MA-A-2/TM	Fish Flesh	Trace metals	1980	No

Table 2. Interlaboratory studies and the resulting marine reference materials for trace metals (TMs) and MeHg produced in MESL and distributed through the Analytical Quality Control Services (IAEA, Vienna)

Target pollutants for the interlaboratory exercises and proficiency tests of organic pollutants are shown in Table 3. Participants are requested to determine as many compounds as possible. For trace elements, participants are requested to determine as many elements as possible from the following suite: Al, As, Cd, Co, Cr, Cu, Fe, Hg (total Hg and MeHg), Li, Mn, Ni, Pb, Sb, Se, Sn, Sr, V, Zn.

Polycyclic Aromatic Hydrocarbons (PAHs)	Petroleum Hydrocarbons	Organochlorine Pesticides	PCBs
Naphthalene	PH equiv. Chrysene	HCB	PCB 8
1-Methylnaphthalene	PH equiv. ROPME Oil	α HCH	PCB 18
2-Methylnaphthalene	n-C12	β HCH	PCB 28
2,6-Dimethylnaphthalene	n-C13	Lindane	PCB 31
Biphenyl	n-C14	δ HCH	PCB 44
Acenaphthylene	n-C15	Total HCHs	PCB 49
Acenaphthene	n-C16	*pp'* DDE	PCB 52
Fluorene	n-C17	*pp'* DDD	PCB 66
Dibenzothiophene	n-C18	*pp'* DDT	PCB 87
Anthracene	n-C19	DDMU	PCB 95
Phenanthrene	n-C20	*op* DDE	PCB 99
2-Methylphenanthrene	n-C21	*op* DDD	PCB 101
1-Methylphenanthrene	n-C22	*op* DDT	PCB 105
Retene	n-C23	Total DDTs	PCB 110
Fluoranthene	n-C24	Heptachlor	PCB 118
Pyrene	n-C25	Aldrin	PCB 128
1-Methyl pyrene	n-C26	Dieldrin	PCB 138
Benz (a) anthracene	n-C27	Endrin	PCB 149
Chrysene	n-C28	*cis* Chlordane	PCB 153
Benzo [b] fluoranthene	n-C29	*trans* Chlordane	PCB 156
Benzo [k] fluoranthene	n-C30	*trans* Nonachlor	PCB 170
Benzo [a] fluoranthene	n-C31	Heptachlor epoxide	PCB 177
Benzo [e] pyrene	n-C32	Methoxychlor	PCB 180
Benzo [a] pyrene	n-C33	α Endosulfan	PCB 183
Perylene	n-C34	β Endosulfan	PCB 187
Indeno [1,2,3-c,d] pyrene	n-C35	Endosulfan sulfate	PCB 189
Benzo [g,h,i] perylene	n-C36		PCB 194
dibenz [a,h] anthracene	Pristane		PCB 195
Triphenylene	Phytane		PCB 201
Resolved aromatics	Squalane		PCB 206
Unresolved aromatics	Resolved aliphatics		PCB 209
Total aromatics	Unresolved aliphatics		Ar.1254
	Total aliphatics		Ar.1260

Table 3. Target organic pollutants for interlaboratory exercises and proficiency tests

CONCLUSIONS

MESL has assisted national laboratories and regional laboratory networks in assuring the analysis of trace metals and organic compounds in marine samples. Specifically, MESL has organized 18 laboratory performance studies for a range of organic contaminants and 12 intercomparison exercises for trace metals in the marine environment. Such interlaboratory studies have helped improving performance in individual laboratories and, in general terms, assuring harmonization of data from regional laboratory networks. Although such interlaboratory studies can help improving performance in individual laboratories and regional laboratory networks, the results highlight that problems remain for the determination of some metals and many organic contaminants. Of particular importance in these investigations and the resulting marine reference materials has been the inclusion of a wide range of organochlorine compounds and, notably, some sterols and methylmercury. Based on the above studies, several marine reference materials have been produced.

ACKNOWLEDGEMENTS

The Agency is grateful for the support provided to its Marine Environment Laboratories by the Government of the Principality of Monaco and MED POL.

Topographic characterization and matrix option in coastal sediment toxicity: sea urchin bioassays on sediment from Naples, Izmir and Mytilene

Giovanni Pagano[1], Marco Guida[1], Maria Kostopoulou[2], Rahime Oral[3] and Françoise Quiniou[4]

[1]Federico II University, Dept Biological Sciences, Hygiene Section I-80134 Naples, Italy
[2]University of the Aegean, Department of Marine Sciences GR-81100 Mytilene, Greece
[3]Ege University, Faculty of Fisheries, TK-35100 Bornova, Izmir, Turkey
[4]Ifremer, Department of Biogeochemistry and Ecotoxicology, Centre de Brest 29280 Plouzané, France

Keywords: bioassay, sediment toxicity, sea urchin

Abstract

Evaluation criteria in coastal sediment toxicity are reviewed regarding topographic distribution of contaminated sediment and the choice of the most appropriate matrix to be tested in sea urchin toxicity bioassays. The data point to non-linear trend in deposition of sediment offshore contaminated effluents, as in the case of Naples Bay consistent with previous results. Regarding sediment matrix to be tested for toxicity, we found highest reliability in testing whole sediment compared to its fractions, solid phase and pore water, as detected in Izmir Bay and in previous studies.

Résumé

Les critères d'évaluation de la toxicité des sédiments côtiers sont révisés quant à la distribution topographique des sédiments contaminés, ainsi que quant au choix de la matrice la plus appropriée pour les bio-essais avec des "oursins de mer". Les résultats ont montré une tendance non-linéaire dans la déposition des sédiments au large de rejets contaminés, comme dans le cas de la Baie de Naples, et sont en accord avec des données précédentes. Concernant la matrice sédimentaire à tester pour la toxicité, les données ont montré la meilleure fiabilité des tests ciblés sur le sédiment in toto, par rapport à la seule phase solide et à l'eau interstitielle, comme observé dans la Baie de Smirne (Izmir) et dans des études précédentes.

One of the major issues in the environmental impact of coastal urban areas consists of marine sediment pollution, due to multiple sources of anthropogenic sources and harbour facilities. Thus, an appropriate evaluation of sediment contamination and toxicity is of basic relevance to risk assessment and in planning amendment interventions. In evaluating sediment-associated toxicity, two relevant issues relate to contaminant dispersion in coastal areas, and to the choice of the most appropriate sediment matrix to be evaluated in toxicity testing. The present report is to review a dataset arising from recent and previous international studies of sediment toxicity testing in Mediterranean coastal areas close to Naples (Italy), Izmir (Turkey) and Mytilene (Greece) (Kostopoulou et al, 2009; Oral et al, 2009).

The data were both based on the analytical information on the levels of toxic contaminants (Ingersoll, 1995; Chapman et al, 2002; Ho et al, 2002) and on sediment toxicity testing, using sea urchin embryos and sperm (Pagano et al, 1986; 2001; Guida et al, 2009), also in agreement with previous data obtained from the Rade of Toulon (France) (Romaña et al, 1992) and from the Kiel Fiord (Germany) (Pagano et al, 2001).

Marine sediment was collected in three sets of sampling sites, and tested in sea urchin embryo cultures (developmental toxicity), and in sperm suspensions (changes in fertilization success). Sample aliquots were processed for inorganic (metals) and/or organic (PAHs) analyses (Pagano et al, 2001; Kostopoulou et al, 2009), whereas sea urchin bioassays were run by exposing developing embryos or sperm to sediment samples, namely 1% (dry wt/vol) whole sediment (WS), or its fractions obtained by a 10-min centrifugation (100 × g), i.e. 1% (dry wt/vol) solid phase (SP) or 1% (vol/vol) pore water (PW). Developmental defects and fertilization success were scored as reported previously (Pagano et al, 2001).

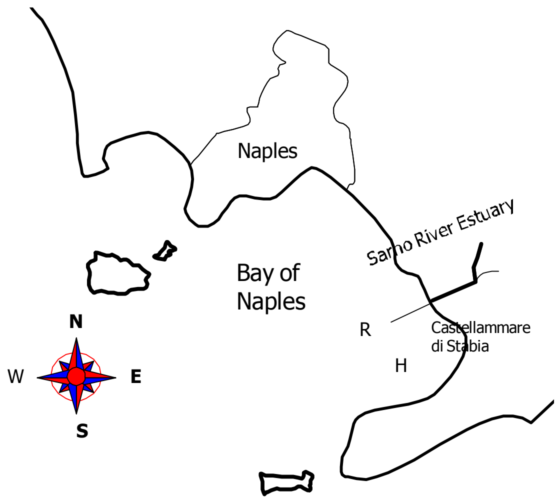


Figure 1. Sediment sampling area at the Sarno River estuary

The topographic distribution of sediment toxicity followed a non-linear trend in a sediment sample transect in the Bay of Naples from the Sarno River estuary (Fig. 1), with highest developmental toxicity of sediment collected at the estuary, which decreased along the transect from 250 to 1000 m from estuary, and then increased at 1500 m, as shown in Fig. 2. This trend was consistent with the finding of inorganic contaminants, namely Cd, Cr, Cu and Fe that peaked in sediment samples collected at sites located 1500 to 2000 m from the estuary.

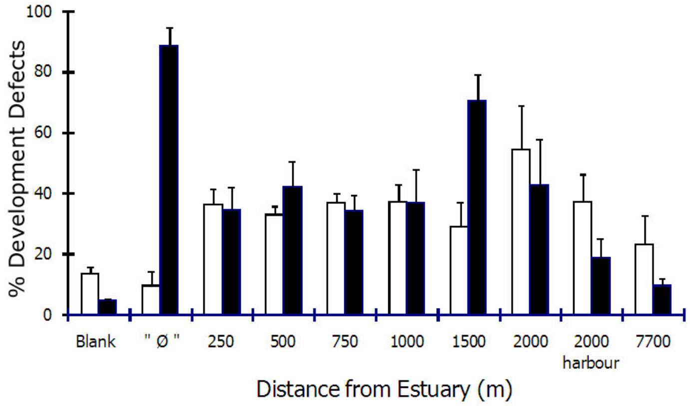


Figure 2. Sediment toxicity in a radial transect from the Sarno River estuary

Another major issue in evaluating sediment-associated toxicity relates to the roles for WS vs. its components, SP and PW. In fact, the microbial load of naturally occurring sediments usually impedes the implementation of WS toxicity testing. Thus, most bioassays for sediment toxicity are either run on organic extracts, or on elutriates, or on PW, leaving the questions unsolved as to: a) the realistic exposure conditions of sediment-dwelling biota, and b) the role(s), if any, of SP in whole sediment toxicity. Therefore, we compared embryo- and spermiotoxicity induced by WS vs. SP and PW from sediment samples collected from Izmir Bay and Mytilene harbour (Fig. 3). The results provided the following evidence: a) toxicity outcomes were consistent with the data of pollutant analyses (data not shown); b) WS exerted highest embryotoxicity compared to SP and to PW (the latter showing only minor, if any, toxicity), both in Izmir and in Mytilene samples, as shown in Fig. 4) also sperm bioassays showed higher toxicity of SP vs. PW (data not shown) (Oral et al, 2009).

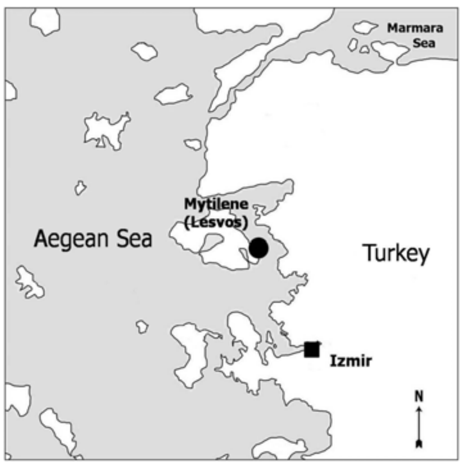


Figure 3. Sediment sampling area in the Aegean Sea

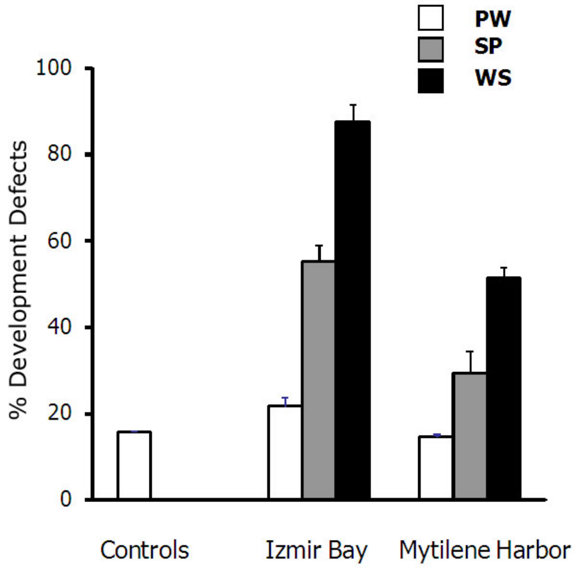


Figure 4. Whole sediment (WS) vs. solid phase (SP) and vs. pore water (PW) developmental toxicity in Izmir Bay and Mytilene harbor

Altogether, the present study provides further evidence for the applicability of sea urchin bioassays in evaluating sediment toxicity, comparable to bivalve toxicity testing (Quiniou and Alzieu, 1999; Geffard et al, 2001). The results suggest the need of testing sediment toxicity by following adequate topographic distribution of sampling sites, by taking into account non-linear trends in sediment contamination and toxicity. A major focus on sediment toxicity testing should point to the use of WS bioassays, as informative tools in view of a realistic evaluation of contamination/toxicity and of sediment amendment interventions. The use of PW, or elutriates might be questionable as a likely source of false negatives.

REFERENCES

Chapman P.M., Ho K.T., Munns W.R. Jr., Solomon K. and Weinstein M.P., 2002. Issues in sediment toxicity and ecological risk assessment. *Mar. Pollut. Bull.*, 44: 271-278.

Geffard O., Budzinski H., Augagneur S., Seaman M.N. and His E., 2001. Assessment of sediment contamination by spermiotoxicity and embryotoxicity bioassays with sea urchins (*Paracentrotus lividus*) and oysters (*Crassostrea gigas*). *Environ. Toxicol. Chem.,* 20: 1605-1611.

Guida M, Nappi C, Guida M and Pagano G. 2009. Sea urchin bioassays in evaluating developmental toxicity of mammalian teratogens. *Curr. Topics Toxicol.*, in press.

Ho K.T., Burgess R.M., Pelletier M.C., Serbst J.R., Ryba S.A., Cantwell M.G., Kuhn A. and Raczelowski P., 2002. An overview of toxicant identification in sediments and dredged materials. *Mar. Pollut. Bull.*, 44: 286-293.

Ingersoll C.G., 1995. Sediments test. *In:* G.M. Rand, G.M. (ed.), Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment. Second Edition. Taylor & Francis, Washington, DC, USA, pp. 231-255.

Kostopoulou M., Guida M., Nikolaou A., Oral R., Trifuoggi M., Borriello I., Vagi M., D'Ambra L., Meriç S. and Pagano G., 2009. Inorganic and organic contamination in sediment from Izmir Bay (Turkey) and Mytilene harbor (Greece). (submitted).

Oral R., Kostopoulou M., Guida M., Nikolaou A., Quiniou F., Borriello I., Russo F., Vagi M., D'Ambra A. and Pagano G., 2009. Whole marine sediment exerts highest toxicity to sea urchin early development compared to pore water and to sediment solid phase: A study of sediment from Izmir Bay (Turkey) and Mytilene harbor (Greece) (submitted).

Pagano G, Cipollaro M, Corsale G, Esposito A, Ragucci E, Giordano GG and Trieff NM., 1986. The sea urchin: Bioassay for the assessment of damage from environmental contaminants. *In:* Cairns, J., Jr., (ed.) Community Toxicity Testing. Association for Standard Testing and Materials, Philadelphia, pp. 67-92.

Pagano G., Korkina L.G., Iaccarino M., De Biase A., Deeva I.B., Doronin Y.K., Guida M., Melluso G., Meriç S., Oral R., Trieff N.M. and Warnau M., 2001. Developmental, cytogenetic and biochemical effects of spiked or environmentally polluted sediments in sea urchin bioassays. *In:* Garrigues P., Walker C.H. and Barth H. (eds.) Biomarkers in Marine Ecosystems: A Practical Approach. Elsevier, Amsterdam, pp. 85-129.

Quiniou F. and Alzieu C. 1999. L'analyse des risques chimiques appliquée aux dragages – Chapitre VII. *In:* Dragages et environnement marin, Etat des connaissances. Ed Ifremer, pp. 127-147.

Romaña L.A., Brisset P., Pagano G., Arnoux A., Martin Y., Caillot A. and Loarer R., 1992. Use of radioactive tracing techniques to identify particulate deposits and biological effects of urban effluents discharges from sewage outfalls. *Water Sci. Technol.*, 25: 115-122.

ACKNOWLEDGEMENTS

This review is based on some selected results from the NATO for Science Project # SA (EST.CLG.97861) and the EC-supported BIOMAR Project (# ENV4-CT96-0300).

Impact of Barcelona on the marine ecosystem

Albert Palanques, Jorge Guillén and Pere Puig

Institut de Ciències del Mar (CSIC). Passeig de la Barceloneta 37-49
Barcelona 08003, Spain

Keywords: chemical contamination, coastal urbanization, sediment

Abstract

The Barcelona coastal zone has been strongly affected by industrial and urban activities during the last centuries. As a result, this coast is one of the most contaminated areas of the Mediterranean, showing a complex situation with a variety of pollution sources and an historic contamination. During the last decades, the Barcelona coast has been affected by major transformations such as the construction of artificial beaches, new marinas, breakwaters and groins, wastewater treatment plants, storm sewers, and the enlargement of the city harbour. It is an exceptional case for studying the impact of large Mediterranean cities on the sea.

Résumé

La côte de Barcelone a été fortement affectée par les activités urbaines et industrielles du siècle dernier. En conséquence, cette côte est l'un des points les plus pollués de la Méditerranée. Elle présente une situation complexe avec de nombreuses sources de pollution et une contamination historique. Au cours des dernières décennies, la côte de Barcelone a été affectée par des transformations de grande envergure comme la construction et le renouvellement périodique de plages artificielles, la mise en place de nouveaux ports et de digues, l'élargissement du port principal de la ville et la construction de stations d'épuration d'eaux usées et de réseaux de tout-à-l'égout. Il s'agit donc d'un cas d'étude exceptionnel en Méditerranée pour l'analyse de l'impact des grandes cités sur l'environnement marin.

Barcelona and surrounding cities, with more than 4 million inhabitants, is one of the largest coastal Mediterranean urban areas. Its population has increased by almost one order of magnitude during the last century. It has about 30 km of open coast affected by different infrastructures, many of them built during the last decades. The emerged coast is mostly occupied by beaches, urban construction, harbour installations and some industries. The Barcelona airport is also very close to the coast.

The sea off Barcelona coast has a microtidal regime (<20 cm). Waves have a mean significant height (Hs) of 0.70 m and 5.7 s period. Wave periods exceeding 7-8 s are rare, although 10-12 s and Hs > 5 m can be exceptionally reached. The most persistent current direction is towards the SW, following the general counter-clockwise circulation pattern of the north-western Mediterranean with an average velocity between 5 and 10 cm s^{-1}. The seabed is sand and gravels near the coast and mud between approximately 10 and 80 m water depth. The water is oligotrophic, naturally enriched in nutrients by deep waters through winter mixing, and sporadically by freshwater runoff.

Figure 1. Google image of the Barcelona coast. Observe the harbour, marinas, groins, artificial beaches and high urban pressure along this coast. Or: Old river mouth

The beach of the northern area of the city had almost disappeared by the 1980s due to the invasion of urban and industrial areas, the decrease in the input of sediment to the coastal zone and the interruption of the sediment littoral drift mainly by harbours, marinas and groins. The beaches of this zone were artificially regenerated as part of the renewal plan for the 1992 Olympic Games. These beaches are now one of the city attractions and are occupied during most of the year by local inhabitants and tourists (Guillén et al., 2008). Although beaches are protected by groins, they must be periodically nourished (Ojeda and Guillén, 2008).

The Barcelona coast receives freshwater inputs mainly from the Besòs, and the Llobregat Rivers with a mean water discharge of 5 and 20 m^3 s^{-1} respectively, although their hydrographic regime is extremely variable (maximum values of more than 2000 m^3 s^{-1} during strong flood events). The watershed size is 5000 km^2 for the Llobregat and 1000 km^2 for the Besòs and both rivers traverse urban, industrial and rural settings.

The sediment discharged by these rivers forms muddy prodeltas that extend from the river mouth to about 60-80 m depth along the inner and mid continental shelf. The sediment of the proximal parts of these prodeltas is highly contaminated (Palanques and Díaz, 1994, Palanques et al, 1998; Puig et al., 1999; Palanques et al., 2008). The maximum concentrations of contaminants such as heavy metals are in the prodelta of the Besòs River and are among the highest ever measured in the Mediterranean Sea and in other oceans of the world. The levels of pollution decrease gradually offshore and alongshore although traces of the Barcelona contamination have been detected down to 1000 m depth in sediments and suspended matter from inside the nearby Foix submarine canyon (Puig et al., 1999; Palanques et al., 2008).

Some contamination already existed before the 20th century but the strong increase of the contamination in this area began in the 1920s continuing up to present days. This trend with sharp increases in the 1920s and the 1960s coincided with the evolution of industrial and demographic development in Barcelona. The highest pollution levels correspond to enrichment factors between 15 and 45 (Palanques et al., 1998; 2008).

In 1979 a wastewater treatment plant was installed near the mouth of the Besòs River, and this plant was discharging polluted mud and sewage sludge through a 4 km long submarine pipeline at a depth of 56 m. (Palanques et al., 1991). As a consequence, very much polluted sediment was also accumulated on the mid-shelf forming a sewage sludge seamount of several square kilometres of extension and several meters high. This discharge lasted until the early 1990s, when this pipeline for solid discharges was closed and a new pipeline was constructed but just for treated water discharge.

During the renewal plan for the Olympic Games, storm sewers were built in order to discharge the exceeding water drained through the city and transported through the sewage network during heavy rain events. In weak or moderate rain conditions, these waters are temporarily retained and their discharge is regulated by large tanks located at several points of the city of Barcelona, to be treated later by the wastewater treatment plant. However, when the rain is too intense, the excess water is discharged directly into the sea and the coast receives the impact of the storm sewers, besides that from the rivers, forming large plumes of polluted water. The area is also locally affected by the dumpsite for dredging material from the Barcelona harbour.

Recently, the lower course and the mouth of the Llobregat River was diverted some kilometres southward to allow the enlargement of the Barcelona harbour and a new wastewater treatment plant was built near this river. In addition, new harbours and marinas (the Olympic Harbour and the Harbour of Sant Adrià del Besòs) have been constructed in the north area (Fig. 1). These new harbours and the enlargement of the Barcelona harbour induced the increase of the maritime traffic and invaded coastal fishing grounds, creating some conflicts with traditional fishery, which is threatened by competition with other uses of the coastal zone.

The Harbour expansion, new groins have been built or will be built to protect the beaches of Barcelona against the most energetic eastern storms, changing the circulation, sediment dynamics and water quality of the coastal zone. In addition, increasing traffic of large vessels entering and leaving the harbour, planes landing along the coast to reach the Barcelona airport and heavy traffic of the littoral highway also contribute to increase the coastal anthropogenic impact.

The littoral system of Barcelona is an exceptional case for studying the impact of large coastal Mediterranean cities on marine ecosystems. The corrective measures that have been recently introduced in the industries and the urban zones should lead to reduce some negative impacts on the Barcelona coast, but it is necessary to advance in the knowledge of this strongly modified system, which will help introduce improvements in environmental management in accordance with the Water Framework Directive of the European Community.

REFERENCES

Guillén J., García-Olivares A., Ojeda E., Chic O., Osorio A. and González R. 2008. Long-term quantification of beach users using video monitoring. J. Coast. Res., 24 (6): 1612-1619.

Ojeda E. y Guillén J. 2008. Shoreline dynamics and beach rotation of artificial embayed beaches. Mar. Geol., 253, 51-62.

Palanques A., Díaz J.I, and Maldonado A. 1991. Impact of the Sewage Sludge discharged in the Barcelona continental shelf. Ocean. Acta, 11: 329-335.

Palanques A. 1994. Distribution and heavy metal pollution of suspended particulate matter on the Barcelona Continental Shelf (Northwestern Mediterranean). Env. Pol., 85: 205-215.

Palanques A., Sánchez-Cabeza J.A., Masqué P. and León L., 1998. Historical record of heavy metals in a highly contaminated Mediterranean deposit: The Besós Prodelta. Mar. Chem., 61: 209-217.

Palanques A., Masqué P., Puig P., Sanchez-Cabeza J.A., Frignani M. and Alvisi F. 2008. Anthropogenic trace metals in the sedimentary record of the Llobregat continental shelf and adjacent Foix Submarine Canyon (northwestern Mediterranean). Mar. Geol., 248: 213-227.

Puig P., Palanques A., Sánchez Cabeza J.A., Masque P., 1999. Heavy metals in particulate matter and sediments in the southern Barcelona sedimentation system. Mar. Chem., 63: 311-3.

Impact of large urban areas on the Mediterranean coastal zone: a DPSIR approach with a focus on atmospheric deposition

Nicola Pirrone

CNR-Institute of Atmospheric Pollution Research
Via Salaria Km 29.300-CP10, 00015 Monterotondo St, Rome, Italy

Keywords: DPSIR, atmospheric deposition, chemical pollution, coastal zone

Abstract

The Mediterranean Sea is extensively impacted by chemical pollution caused by the release of toxic substances from diffuse and point sources. These include large urban areas located in coastal zones, industrial activities, and maritime transport which represent the major drivers of environmental pressures on regional ecosystems. The response of the regional environmental policy to these issues is complex since social trends, lifestyles and governance vary regionally throughout Mediterranean countries. Among the key Pressure factors, atmospheric deposition is considered a major diffuse source of toxic substances entering the Mediterranean Sea. Major Drivers are primarily related to Transport systems (persons, goods; road, water, air, off-road); Energy use (energy factors per type of activity, fuel types, technology); Power plants (types of plants, age structure, fuel types); Industry (types of plants, age structure, resource types); Refineries/Mining (types of plant/mining, age structure); Waste Incinerators and Landfill activities; and a number of non-industrial sectors. Among major emission sources, ship emissions contribute substantially to atmospheric pollution over the Mediterranean region during the summer season, mainly in the Western Mediterranean. The summer mean sulfate aerosol deposition rate over the Mediterranean Sea is about 7.8 mg m^{-2}, whereas over the European domain, it is 4.7 mg m^{-2} on average. This paper aims at highlighting the major components of the DPSIR framework for the Mediterranean region, including socio-economic drivers affecting air quality in large urban areas and the deposition patterns of key atmospheric pollutants over the sea.

Résumé

La Mer Méditerranée est affectée à grande échelle par la pollution chimique due au déversement de substances toxiques depuis des sources diffuses et localisées. Celles-ci incluent les grandes zones urbaines côtières, les industries et les transports maritimes qui sont les principaux facteurs de pression responsables du forçage des écosystèmes de la région. La réponse en la matière en termes de réglementation environnementale est complexe du fait de la diversité des sensibilités, des modes de vie et des priorités gouvernementales dans les différents

pays méditerranéens. Les dépositions atmosphériques sont considérées comme l'une des principales sources diffuses d'apports de contaminants toxiques en Méditerranée. Les principaux facteurs forçant sont fondamentalement liés aux secteurs du Transport (transports routiers, fluviaux, marins, aériens et sur rail de personnes et/ou de marchandises), de l'Energie (utilisation – facteurs d'énergie par type d'activité, type de combustible, technologies – et production – type de centrale et âge, type de combustible –), de l'Industrie (type de structure et âge, type de ressources), notamment les raffineries et les mines, des Incinérateurs et de l'Agriculture, et à un certain nombre de secteurs non industriels. Parmi les sources démission majeures, les émissions des navires contribuent substantiellement à la pollution atmosphérique méditerranéenne durant la saison estivale, en particulier dans le bassin occidentale. Le taux moyen de déposition d'aérosols sulfatés est de l'ordre de 7.8 mg m^{-2} durant l'été en Méditerranée, alors qu'il est de 4.7 mg m^{-2} en moyenne sur l'ensemble de l'Europe. Cette présentation a pour objectif de souligner les principales composantes du contexte DPSIR pour la région méditerranéenne, y compris les facteurs socio-économiques affectant la qualité de l'air dans les grandes agglomérations urbaines et la déposition en mer des polluants atmosphériques-clés.

In the last decade a number of national and European research projects have been carried out with the aim to assess the impact of natural and anthropogenic sources on the Mediterranean Sea and elaborate on possible cost-effective strategies aiming to reduce the pressure of socio-economic activities on the marine environment. The DPSIR (Driver-Pressure-State-Impacts-Response) framework is a useful conceptual approach to analyze complex dynamic socio-economic-environmental systems. Drivers are largely economic and socio-political (industrial and agricultural activities, trade, regulations, subsidies, etc.) and often reflect the way benefits are derived from ecosystem goods and services; Pressures are the ways these Drivers burden the environment (agricultural run-off of nutrients, pollution discharges, bottom trawling, introduction of alien species, etc.); State change is a measure (or proxy) of the consequences of Pressures on species or ecosystems; Impacts are measures of changes (the costs) to human welfare as a result of State changes; and Response is the way society attempts to reduce Impact or compensate for it. The DPSIR framework shown in Figure 1 was developed in the framework of several EC funded projects (i.e., MAMCS, MERCYMS) aiming to elaborate on possible strategies suitable to reduce the impact of atmospheric mercury emissions on the Mediterranean Sea; it highlights how most policy decisions are a trade-off between the cost (social and economic) of Impacts, and the benefits derived from continued socio-economic activity. The Responses pose additional compliance costs that should also be considered in an overall analysis.

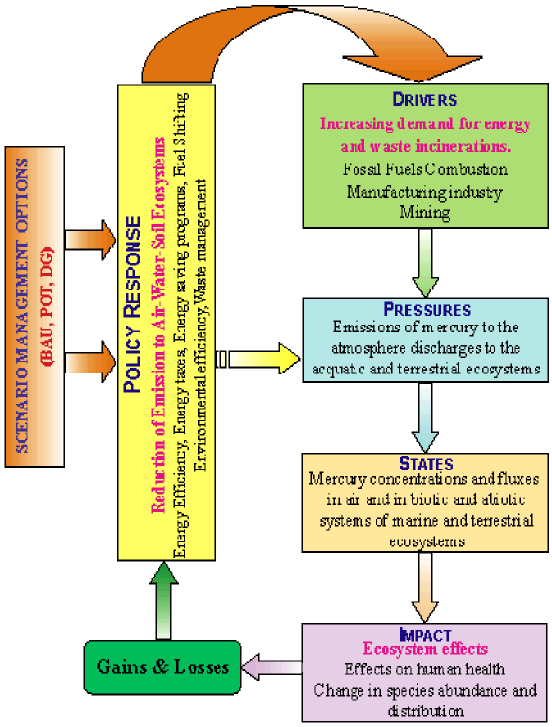


Figure1. Flow diagram summarizing a DPSIR framework developed to reduce the impact of atmospheric mercury emissions on the Mediterranean Sea

The Mediterranean Sea is extensively impacted by anthropogenic activities. Chemical pollution, increasing maritime transport and climate change are key Pressures causing environmental degradation of marine systems at both regional sea and local scales. Throughout the Mediterranean, extensive coastal development as a result of increasing urbanization and tourism has resulted in habitat loss and decreased biodiversity. As in other European seas, climate change is an emerging issue in the Mediterranean which requires further investigation. Political responses to these issues are complex as social trends, lifestyles and governance vary regionally throughout Mediterranean countries. However, these states are aware of their responsibility to preserve and develop the region in a sustainable way, and recognize the aforementioned threats to the marine environment. Several political actions have been launched to that effect including the Action Plan for the Protection and Development of the Mediterranean Basin (MAP), the Convention for the Protection of the Mediterranean Sea against Pollution (the "Barcelona Convention"), and the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources.

Atmospheric deposition is a major diffuse source of toxic substances entering the Mediterranean Sea. Major Drivers are primarily related to socio-economic activities of large urban areas in coastal zones and ports including: Transport (persons, goods; road, water, air, off-road); Energy use (energy factors per type of activity, fuel types, technology); Power plants (types of plants, age structure, fuel types); Industry (types of plants, age structure, resource types); Refineries/Mining (types of plant/minings, age structure); Waste Incinerators and Landfill activities; and a number of non-industrial sectors. Among major emission sources ship emissions contribute substantially to atmospheric pollution over the Mediterranean region during the summer season, mainly in the Western Mediterranean; indeed recent atmospheric modeling exercise have highlighted that their contribution reaches up to 60-85%. Summer mean sulfate aerosol deposition rate over the Mediterranean Sea is about 7.8 mg m^{-2}, whereas over the European domain, on average, is 4.7 mg m^{-2}. Recent assessments have shown how sulfur and nitrogen oxides in ship fuel can be reduced cost-efficiently by 60-83% and by 50 % respectively. The results of this study indicate that such a reduction would substantially improve air quality and reduce radiative forcing during the summer over the Mediterranean Sea. The aim of this paper is to highlight the major components of the DPSIR framework for the Mediterranean region, including socio-economic drivers affecting air quality in large urban areas and the deposition patterns of key atmospheric pollutants over the sea. It will also discuss future research needed to support European policy and international programs and conventions.

DPSIR applied to 4-large Turkish coastal cities: Mersin, Antalya, İzmir and Kocaeli

Çolpan Polat-Beken[1], Leyla Tolun[1], Gülsen Avaz[1], Aslı Dönertaş[1], Dilek Ediger[1], Fatma-Telli Karakoç[1] and Süleyman Tuğrul[2]

[1]*TÜBİTAK- Marmara Resarch Center, Institute of Environment Gebze-Kocaeli, Turkey*
[2]*METU, Institute of Marine Sciences, Erdemli-Mersin, Turkey*

Keywords: effluents, water treatment, pollution, monitoring, DPSIR, Turkish coast

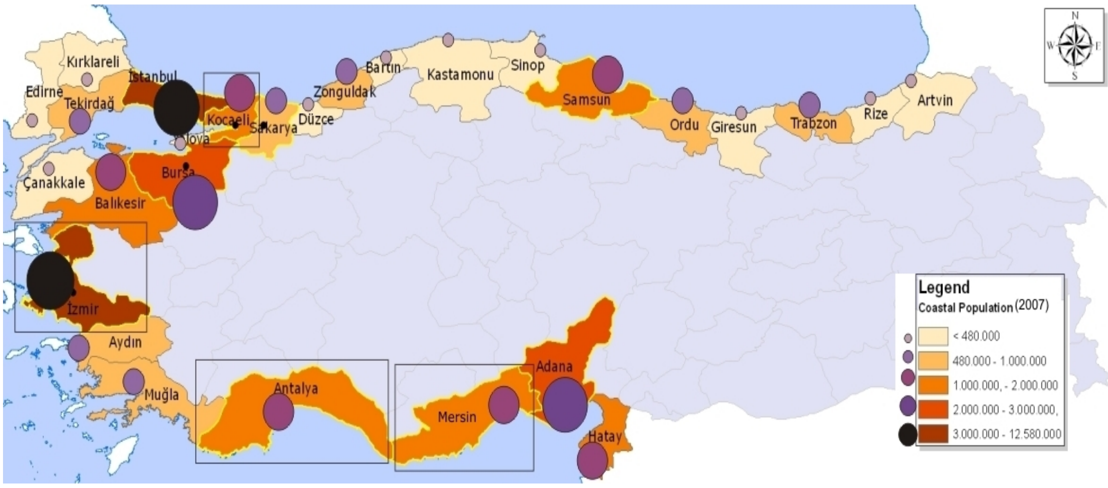
Abstract

Turkish coastal areas are under the pressure exerted by inputs of organic material, nutrients, and chemical pollutants derived from intense urbanization, industrial, maritime, and agricultural activities. The relative contribution and effects of diffuse sources are not yet clearly known. Monitoring activities, established by the Ministry and the Municipalities of few large cities, are extremely useful to understand the status of the coastal seas. Concurrently, impact variables of ecological status provide very clear indications of pollution effects and recovery and are therefore recommended for monitoring. Investments are made and planned to support the treatment of municipal and industrial effluents of coastal cities; inputs from rural settlements, touristic spots, and un-organized industrial areas are yet difficult to estimate and control. Legislative tools to control pollution and protect the marine environment are available; more efforts are needed to implement them.

Résumé

Les zones côtières turques subissent des pressions exercées par les apports de matières organiques, d'éléments nutritifs et de polluants chimiques issus de l'urbanisation intense, des activités industrielles, maritimes, et agricoles. La contribution relative et les effets des sources diffuses, sont encore mal connus. Les activités de surveillance, mises en place par le ministère et les municipalités de quelques grandes villes, sont extrêmement utiles pour comprendre l'état de la mer côtière. En complément, les paramètres d'impact sur l'état écologique fournissent des indications très claires sur les effets de la pollution et la restauration des milieux. Ils sont aussi recommandés pour le suivi. Des investissements sont réalisés et prévus pour le traitement des effluents industriels et municipaux des villes côtières. Les apports de l'habitat rural, des sites touristiques, et des zones industrielles peu organisées sont encore difficiles à estimer et à contrôler. Des outils législatifs pour lutter contre la pollution et protéger l'environnement marin sont disponibles, des efforts supplémentaires sont nécessaires pour qu'ils soient bien appliqués.

A spectacular urban development took place from 1950 to 1995 in the Mediterranean coastal area (UNEP/MAP Blue Plan, 2006); where this has been more pronounced in the eastern and southern countries revealing that Turkish coastal area has also had a pronounced increase in urban population. Map 1 shows a classification of Turkish coastal cities according to 2007 population statistics (TÜİK, Turkish Statistical Institute). According to the National Law of Municipalities of Large Cities (5216/10.7.2004), areas of populations over 750,000 inhabitants are considered as large cities. Another criteria considered in this categorization is the level of economic development which is measured by a set of socio-economic development indicators (like urbanization ratio[1], employement, human development index[2], etc). Based on that, 3 Mediterranean cities were considered as large coastal cities namely; Mersin, Antalya and İzmir. It is also found relevant to include one of the three large cities of the Sea of Marmara in this study namely Kocaeli.



Map 1. Classification of Turkish coastal cities according to the population

MERSIN

Mersin administrative region constitute 8 coastal towns (Tarsus, Central town, Erdemli, Silifke, Gülnar, Aydıncık, Bozyazı, Anamur) and it has an overall (urban+rural) population of 1,595,938 (2007) inhabitants where approximately

---

[1] Urbanization ratio is defined as the ratio of population residing in the city centers and towns to the total population which includes rural population

[2] Human Development Index combines measures of life expectancy, school enrolment, literacy and income to allow a broader view of a country's development (http://www.undp.org.tr/newsDocuments/Country%20Fact%20Sheets%20TR.doc

50% of the population reside in the central town and 95% at coastal towns. Urbanization ratio of Mersin is 73% and the rate of population increase is 29%. The region is affected by two basins; Seyhan River basin (affects Tarsus and Central town) and Eastern Mediterranean basin which includes Göksu river and estuary. The development index of Central town and Tarsus is 1 and 2 whereas it is 3 and 4 for others.

Drivers: Urbanization, agriculture and industry are the major ones. The sectorial contribution of them (at the basin scale) in terms of phosphorus and nitrogen generation (National Action Plan, 2005) are; municipal: 41 %(N), 65 %(P) in Seyhan basin and 36%(N), 46%(P) in E-Med basin and agricultural: 54 %(N), 35 %(P) in Seyhan basin and 56%(N), 25%(P) in E-Med where industry have the tertiary importance. 221.3 km^2 (2004-2006 annual means, TÜİK) of agricultural fields exist in the region where almost 50% of the fields is located around Tarsus town. There are intensive industrial activities around the central town and Tarsus basically on fertilizer, food, textile, petroleum loading and chemistry. Harbour facilities in the coastal area of Mersin are also quite intensive having various commercial activities at 10 harbors/quays mostly located around the central town. Tourism is another driver for the region. The tourist number visited Mersin area is about 280,000/year (2004-2006) where more than 50% of them visited the Central town. Second houses -used as summer resorts- intensively built at the coastal strip of Mersin has created unfavorable conditions for the coastal environment.

Pressures: The direct inputs to the coastal area are via rivers (Seyhan, Berdan, Lamas and Göksu) and point sources (municipal discharges of Mersin-central town and other towns and industrial inputs). Inputs from diffuse sources (urban and land runoff) have not been estimated yet. It appears that the riverine and atmospheric inputs (wet+dry) of nutrients to the North-Levantine basin are at comparable levels (Tuğrul et al., 2006). The importance of atmospheric inputs for the North Levantine basin has also been clearly emphasized by various scientists (Krom et al., 2004, Markaki et al., 2003, in press).

State: Mersin coastal strip shows different water quality characteristics when eutrophication state indicators proposed by MED POL are evaluated (UNEP/MAP MEDPOL, 2003). Since the easternmost area of Mersin coastal waters is under the influence of major rivers (Seyhan and Berdan) and municipal wastes of Mersin, chlorophyll-a concentrations are quite high, surface water oxygen saturation is above 100% and the TRIX range is 5-6 throughout the year. Secchi disk depths of 1-3 m clearly show the high turbidity levels. It might be expected that the lower layer dissolved oxygen may drop to <80% saturation values at certain locations of the Bay. Area is under the threat of eutrophication. At the area extending from west of Mersin bay, through Erdemli, reaching to Silifke, chlorophyll-a concentrations are low (<1.0 µg/L), concentrations of nutrients are low and any oxygen depletion has not been observed at the lower layer waters. SDDs[3] are high (>10 m) and the calculated TRIX values are usually below 3. This is also the case for the coastal area affected by the Göksu river since the water renewal time of this area is very short. Chemical pollution in biota has been monitored in the coastal waters of the

[3] SDD : Secchi Disk Depth

region since 1998 within the trend monitoring strategy of MED POL (UNEP(DEC)/MED WG.282/3, 2005). The analysis of these data sets indicated that there was a general downward trend of trace metals in the coastal waters of Mersin-centre and Erdemli, however this data needs to be re-analyzed with longer term findings and considering the pollution reduction measures taken.

Impact: Macro zoobenthos of the Bay was studied during 2005 to assess ecological status of the shallow zone of the Mersin Bay (Tuğrul et al., 2006). Abundance and biomass data of zoobenthos were examined by multivariate analyses and Bentix index (Simboura & Zenetos, 2002) to determine pollution levels of the nearshore waters of the Bay. Bentix scores showed that all the visited stations were moderately polluted and the area is both physically and ecologically disturbed.

Response: The treatment status of municipal waste waters generated in the towns of Mersin is quite poor and the wastes are discharged without secondary treatment (except 3 towns) with marine disposal systems. The biological treatment plant for the Mersin central town is being constructed and will be ready for the end of 2009. Silifke, Tarsus and Aydıncık have already established biological treatment plants. Compliance monitoring as well as state/trends monitoring are important tools to plan and monitor response actions. Therefore, it is required by the National MED POL Programme to monitor the compliance of discharge values to the set limits in the national legislation (By-Law on Water Pollution Control, 31/12/2004). The region is hosting a Specially Protected Area (SPA), Göksu Deltası, with 226 km^2 protected area for both marine and estuarine species.

ANTALYA

Antalya administrative region constitute 10 coastal towns (Gazipaşa, Alanya, Manavgat, Serik, Antalya-centre, Kemer, Kumluca, Finike, Kale, Kaş) and it has an overall population (U+R) of 1,789,295 (2007) inhabitants where more than 50% of the population reside in the central town and 94% at coastal towns. Urbanization ratio of Antalya is 84% and the rate of population increase is 46%. The region is affected by two basins; Antalya basin and Western Mediterranean basin having 13 small rivers and a few major lakes. The development index is 1&2 for the central town, Serik, Manavgat, Alanya and Kemer where the tourist income is maximum and 3 for the other towns which are smaller and dependent more on agriculture.

Drivers: Urbanization, agriculture and tourism are the major ones. The sectorial contribution of them in terms of P and N generation are; municipal: 40 %(N), 66 %(P) in Antalya basin and 25%(N), 55%(P) in W-Med basin and agricultural: 58 %(N), 31 %(P) in Antalya basin and 71%(N), 44%(P) in W-Med. 129.4 km^2 (2004-2006) agricultural area exist in the region. Tourism is another important driver for the region. The number of tourists visited Antalya region is about 7,011,225/year (2004-2006) where this figure increased to 9,093,071 in 2008. Use of summer houses is also common. Harbour facilities in the coastal area of Antalya are ongoing at 8 commercial harbours/quays. Besides, 8 marinas exist in the region to serve for yatch tourism.

Pressures: The direct inputs to the coastal area are via small rivers and municipal point sources. Neither the inputs from land and urban runoff nor atmosphere have not been estimated for the region.

State: The system is open to interactions with open waters of the Mediterranean and the water renewal is rapid. Concentrations of nutrients as well as the chlorophyll values are low (always less than 1 µg/L). Secchi disk depths are above 5m and the lower layer oxygen saturation values are greater than 90%. The river discharges are also small. All these indicate that the system is not considered under the eutrophication threat. However, the large number of coastal touristic facilities may create local disturbances especially in the vicinity of Manavgat and Alanya towns because the area is quite shallow. Since the region is not used for industrial facilities, chemical pollution is not expected and not visible. Effects of agricultural activities on the coastal waters are not known.

Impact: Losses of habitats and biodiversity have not been recorded in the area. Harmful phytoplankton species were not also reported.

Response: The wastewater treatment facility in the central town is at tertiary level and at primary level in five towns. The region is hosting 3 SPAs; Belek, Kaş-Kekova and Patara where all the measures required by the National Law (No: KHK/383/13 Nov 1989) are applied. The protected area is totally about 600 km^2 hosting coastal and forest endemic species as well as archeological heritage. There are good practices of eco-torusim in the region that is planned to be expanded with new projects.

İZMIR

İzmir administrative region constitute 12 coastal towns (Selçuk, Menderes, Seferihisar, Urla, Çeşme, Karaburun, İzmir-centre, Menemen, Foça, Aliağa, Bergama, Dikili) and it has an overall population (U+R) of 3,739,353 (2007) inhabitants where more than 70% of the population reside in the central town and 86% at coastal towns. Urbanization ratio of İzmir is 98% and the rate of population increase is 24%. Development index is 1 for the central town and Aliağa and 2 for other towns. The region is affected by two basins; K.Menderes River basin and Gediz River basin.

Drivers: The major drivers in the region are urbanization, agriculture, industry and tourism. The sectorial contribution of these drivers in terms of P and N generation are; municipal: 72 %(N), 87 %(P) in K.Menderes basin and 28%(N), 52%(P) in Gediz basin and agricultural: 27 %(N), 13 %(P) in K.Menderes and 57%(N), 43%(P) in Gediz. Contribution of industrial N, P in Gediz is, respectively, 15%, 5% and negligible in K.Menderes. Agricultural area is 104 km^2 (2004-2006) in the region where 75% of it is in Selçuk, Menemen and Bergama towns. Industrial activities are heavily established in Aliağa, Central town and Menemen, at moderate level in Bergama and Menderes and nearly absent in other towns. The number of tourists visited İzmir region is about 452,000/year (2004-2006), about 70% of them visited two towns; Çeşme and Selçuk. Harbour facilities in İzmir are ongoing at 13 commercial harbors/quays. 3 marinas exist in the region serving for yatch tourism.

Pressures: The direct inputs to the coastal area are via rivers, municipal and industrial point sources.

State: Information is given by F. Küçüksezgin in the same volume.

Impact: Benthic ecosystem disturbances and changes in İzmir Bay as a result of environmental pollution were well documented by various scientists. When the data obtained during 1996-97 is evaluated with historical findings, a deteriotion in benthic ecosystems was observed and basing on a Bentix evaluation on 1995-96 data, ecological status was found to be distintly changing from poor to good conditions from inner to outer Bay (Doğan et al., 2004, 2005). Diversity and evenness index values of soft bottom zoobenthos were high in the outer part of the bay, whereas azoic conditions occurred in the polluted inner part, particularly in summer and autumn of 1997 and 2001 but not in 2002 during which polychaetes other than its pollution indicator species were also observed. (Doğan et al., 2005, Ergen et al., 2006). In paralel to the new findings in 2002, species sensitive to pollution were also recorded in a study of 2004 (Çinar et al., 2006) in the innermost Bay indicating the recovery of the ecosystem after the 'Grand Canal Project of İzmir Municipality' became operational by the year 2000. However, a sudden increase in the number of exotics was also reported from the inner part of İzmir Bay coinciding with the improvement of water quality of the area (Çınar et al. 2006, 2008). The environmental instability occured by 2000 and intense maritime traffic make the area more susceptible to invasion by exotics. Occurences of harmful phytoplankton species/blooms in the İzmir Bay have been reported (Koray 2004).

Response: Grand Canal Project of İzmir Municipality is considered as a great step towards response to the cronic pollution problem started even at 60s. A full waste water collection and treatment system at tertiary level is operational since 2000. 5 towns have treatment facilities at secondary level (biological treatment) and at primary level in other towns. There is one SPA in the area, Foça, also a reserve for Mediterranean monk seals.

KOCAELI (İZMIT)

Kocaeli administrative region consists of 7 coastal towns (Kocaeli Center, Körfez, Karamürsel, Gölcük, Derince, Gebze, Kandıra) having an overall population (U+R) of 1,437,926 (2007) inhabitants where about 70 % of the population reside in two towns; Kocaeli central town and Gebze. Six of the towns are at the eastern coast of the Marmara Sea where one town lays by the Black Sea coast. Urbanization ratio of Kocaeli is 52% and the rate of population increase is 19%. The region is in the Marmara basin sharing the same basin with İstanbul Metropolitan area. The development index of Gebze, Körfez and the Central town is 1, 2 for Gölcük and Karamürsel and 3 for Kandıra.

Drivers: The major drivers in the region are industrial activities and urbanization. There are intensive industrial activities ongoing in Gebze, Körfez and Central town. Harbour facilities in the coastal area of Kocaeli are also quite intensive having various commercial activities at over 40 ports mostly located around heavily industrilized towns. Heavy shipping activities in the Bay pose a continuous risk of oil contamination due to loading and unloading activities and accidents.

Pressures: The direct inputs to the coastal area are via rivers (Dilderesi, Sarı Dere, Kilez Deresi, Ağadere, Asardere, Hamzadere), channels (Eastern Channel, Pektim Channel) and point sources (municipal discharge more than 40 points, industrial inputs 15 points). The major discharges are located in the northern part of the İzmit Bay. More than 1500 industrial plants established in Kocaeli include petrochemistry, chemistry (solvent, pesticide, paint etc), pulp and paper, fertilizer, food and manufacturing industries. As a result of the ongoing treatment and waste minimization activities BOD loads arising from industries were decreased to 9,9 (90% reduction) tons /day in 2002. Since most of the industrial treatment plants only remove organic matter, industry originated nutrient loads are still a problem for the Bay coastal waters. The 1999 Kocaeli earthquake created a huge damage on environment, collapsing more or less all the treatment facilities in the Bay and created a refinery fire.

State: Continuous monitoring activities were organized in the İzmit Bay during 1999-2002 and 2007-onwards. Deep water oxygen saturation values were determined as about 20% in the Western part and below 10% (< 1mg/l) in the Central and Eastern Bays indicating worse environmental status towards the inner bay. Maximum chlorophyl-a values were observed in the range of 5-20 ug/l during these monitoring periods. 2007-2008 data provided TRIX values for surface waters between 4.1 and 6.8. Toxicity tests applied to the surface sediments were consistently found to be toxic throughout the Bay (Tolun et al. 2001). After the 1999 Kocaeli earthquake PAH concentrations varied between 240 –11400 ng/g in the coastal sediments of the Bay (Tolun et al. 2006) whereas these values were 120-8900 ng/g before this catastrophic event.

Impact: Mussel feeding rates and lysosomal membrane stability of blood cells (biomarker) were clearly decreased after the earthquake (Okay et al., 2001) due to shock loads of PAHs to the system. It was also found that LMS is decreased from outer to the inner bay. Harmful algal booms have also been observed in the Bay (Okay et al., 2001). In October 2007, massive musilage formations were seen in the Bay lasting until January 2008 and repeated again in September-October 2008. As a result of all these disturbances, there is no commercial fishing activity in the Bay.

Response: As stated above, industrial effluent treatment facilities have been established since 1990s. However, they are not yet at a satisfactory level especially for smaller companies where they are located intensively around few rivers (e.g.Dilderesi). The treatment status of municipal waste waters is at tertiary level in Gölcük and Karamürsel where the Central town and Körfez are currently running with secondary level treatment. Tertiary treatment is also planned for these towns. In Gebze and Kandıra, there are no treatment facilities yet, a tertiary system is being planned for Gebze. In order to better control the pollution created by coastal industries and ships, aerial surveys are routinely performed by the municipality since the control points are too many at both sea and land. Penalties are applied when legislative measures are exceeded. DG Kocaeli of MoEF is also responsible of the control of implementation of these measures.

İzmit Bay is one of the test cases of the FP6 project, Science and Policy Integration for Coastal System Assessment “SPICOSA”, in which support tools will be developed for the assessment of policy options for sustainable management of environmental issues considering ecological, social and economic aspects of coastal zone systems. This is also considered to be a pilot ICZM application for the country being recognized by different stakeholder groups of the region. There isn’t a special regulation for ICZM in the country.

CONCLUSION

The pressure and deterioration created by unsustainable development activities are threatening fragile ecosystems of the Turkish coastal zones (more than 10 thousand km coastline including the islands) located near to the large cities. To employ an integrated coastal zone management program on a national basis seems a solution proposed to the overall problem. However, considering the dynamic nature of the coastal systems, to follow the casual chain framework analysis (DPSIR) would be a major challenge in developing national ICZM programs.

Among the examined cases, the most affected area is Kocaeli and oppositely Antalya coastal area is well protected. İzmir ‘Grand Channel project’ has been proven to be an efficient investment to improve the environmental quality of the İzmir Bay and its vicinity and therefore could be considered as a good example of management action.

REFERENCES

Çınar M.E., Katagan T., Öztürk B., Özdemir E., Ergen Z., Kocatas A., 2006. Temporal changes of soft-bottom zoobenthic communities in around Alsancak Harbor (İzmir Bay, Aegean Sea) with special attention to the autecology of exotic species. Marine Ecology, 27: 229-246.

Çınar M.E., Katagan T., Koçak F., Öztürk B., Ergen Z., Kocatas A., Önen M., 2008. Faunal assemblages of mussel *M. Galloprovincialis* in and around Alsancak Harbour (Izmir Bay, eastern Mediterranean) with special emphasis on alien species. Journal of Marine Systems, 71: 1-17.

Doğan A., 2004. Ecological quality assessment in İzmir bay using Bentix Index. Workshop on Marine Science and Biological Resources, Univ.Tishreen, Lattakia Syria.

Doğan A., Çınar M.E., Önen M., Ergen Z. and Katagan T., 2005. Seasonal dynamics of soft bottom zoobenthic communities in polluted and unpolluted areas of İzmir Bay (Aegean Sea). Senckenbergiana maritima, 35: 133-145.

Ergen Z., Çınar M.E., Dağlı E. and Kurt G., 2006. Seasonal dynamics of soft-bottom ploychaetes in İzmir Bay. Scientific Advances in Polychaete Research, Scientia Marina 70S3: 197-207.

Koray T., 2004: Potentially Toxic and Harmful Phytoplankton Species Along the Coast of the Turkish Seas. Steidinger, K. A., J. H. Landsberg, C. R. Tomas, and G. A. Vargo (Eds.). 2004. Harmful Algae 2002. Biogegraphy and regional events sessions. Florida Fish and Wildlife Conservation Commission, Florida Institute of Oceanography, and Intergovernmental Oceanographic Commission of UNESCO. 335-337

Krom M.D., Herut B. and Mantoura R.F.C., 2004. Nutrient budget for the Eastern Mediterranean: Implications of phosphorus limitation. Limnol. Oceanogr. 49(5): 1582-1592.

Markaki Z., Oikonomou K., Kocak M., Kouvarakis G., Chaniotaki A., Kubilay N. and Mihalopoulos N., 2003. Atmospheric deposition of inorganic phosphorus in the Levantine Basin, eastern Mediterranean: Spatial and temporal variability and its role in seawater productivity. Limnol. Oceanogr. 48(4): 1557-1568.

Markaki Z., Loye-Pilot M.D., Violaki K., Benyahya L., and Mihalopoulos N., (in press). Variability of atmospheric deposition of dissolved nitrogen and phosphorus in the Mediterranean and possible link to the anomalous seawater N/P ratio. Marine Chemistry.

Okay O.S., Tolun L., Telli- Karakoç F., Tüfekçi V., Tüfekçi H. and Morkoç E., 2001. İzmit Bay ecosystem after Marmara earthquake and subsequent fire: The long term data. Marine Pollution Bulletin, 42/5: 361-369.

Simboura N., and Zenetos A., 2002. Benthic indicators to use in ecological quality classification of Mediterranean soft bottoms marine ecosystems, indicating a new biotic index. Mediterranean Marine Science, 3/2: 77-111.

Tolun L., Okay O. S., Gaines A. F., Tolay M., Tüfekçi H., and Kiratli N., 2001. The pollution status and toxicity of surface sediments in Izmit Bay (Marmara Sea), Turkey. Environmental International 26: 163-168.

Tolun L., Martens D., Okay O., Schramm K. W., 2006. Polycyclic Aromatic Hydrocarbon Contamination in Coastal Sediments of Izmit Bay (Marmara Sea): Case Studies Before and After Marmara Earthquake. Environment International, 32: 758-765.

Tuğrul S., Ediger D., Kubilay N., Mutlu E., and Uysal Z., 2006. Eutrophication assessment in Turkish coastal waters of the Eastern Mediterranean. Submitted to MED POL.

UNEP/MAP MED POL, 2003. Eutrophication Monitoring Strategy.

UNEP/MAP Blue Plan RAC, 2006. A Sustainable Future for the Mediterranean.

Assessment of radiological and chemical pollutants and their effects on the marine ecosystems along the Egyptian Mediterranean coast

Abou Bakr A. Ramadan

Egyptian Radiation and Environmental Monitoring Network
Atomic Energy Authority, P.O. Box 7551, Nasr City 11762, Cairo, Egypt

Keywords: radionuclides, persistant pollutants, sediment, mussels

Abstract

The Environmental Monitoring Programme for the Egyptian coastal waters of the Mediterranean Sea was established to initiate a monitoring and data base system. This was done by applying quality control assessments to evaluate and protect the coastal zone, and ensure its sustainable use. An environmental risk assessment was performed, including a screening level ecological risk assessment (SLERA) and a human health risk assessment (HHRA). The aim of this SLERA risk assessment was to determine which classes of chemical pollutants could possibly cause adverse ecological effects to benthic species and to determine whether hot spots exist or not. Investigation of the sediments revealed that the region which extends from the Alexandria harbour area to Port Said City is enriched with trace metals, PAHs and organochlorine pesticides. PCBs were detected but in lower concentrations compared to the other organic compounds. The spatial distribution of the different contaminants investigated here showed that this region (i.e. the Nile Delta region) is more influenced by wastewater discharges than the rest of the Egyptian coastal regions. In addition to sediments, two mussel species (*Mactra corallina* and *Tapes decussate*) were successfully used as bioindicators of marine environmental quality. The concentrations of most pollutants investigated (except organochlorine pesticides, and some trace metals) were higher in the tissues of the mussels, especially *M. corallina*, than in sediments. The highest concentration of PAHs in sediments and mussels was observed in front of the Alexandria harbor and Nile Delta, possibly affected by shipping activities.

Résumé

Le Programme de Surveillance Environnemental des eaux côtières méditerranéennes d'Egypte a été mis en place pour initier la surveillance. Il comprend un système de gestion des données. Cela a été réalisé en appliquant les principes de contrôle de qualité pour évaluer l'état du milieu afin de protéger la zone côtière et d'assurer son utilisation durable. Une évaluation de risques environnementaux a été réalisée, en incluant une analyse de risques de type « screening level ecological risk assessment » (SLERA) ainsi qu'une évaluation des risques pour la santé humaine (HHRA). L'objectif de cette évaluation de risques

SLERA était de déterminer quelles classes de contaminants chimiques pouvaient avoir des effets délétères sur les organismes benthiques et de déterminer s'il y avait des « hot spots ». L'étude des sédiments a montré que la région qui s'étend entre le port d'Alexandrie et la ville de Port Saïd est plus contaminée en métaux traces, PAHs et pesticides organochlorés. Des PCBs ont été détectés mais en concentrations plus faibles que les autres composés organiques. La distribution spatiale des différents contaminants étudiés a montré que cette région (i.e., la région du Delta du Nil) est plus influencée par les déversements d'eaux usées que les autres régions côtières égyptiennes. En complément à l'étude des sédiments, deux espèces de moules (Mactra corallina and Tapes decussate) ont été utilisées avec succès comme bioindicateurs de l'état de santé du milieu marin. Pour la plupart des contaminants étudiés (à l'exception des pesticides organochlorés et de certains métaux traces), les concentrations étaient plus élevées dans les tissus des moules (en particulier chez M. corallina) que dans les sédiments. Les plus hautes concentrations en PAHs mesurées dans les sédiments et dans les moules ont été observées face au Port d'Alexandrie et au Delta du Nil, possiblement affectés par les trafics maritimes.

INTRODUCTION

Many classes of chemicals are introduced into the marine environment as a consequence of urban development. Trace elements, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), organochlorine and organophosphate pesticides, polychlorinated dibenzo-p-dioxins (PCDD) and furans (PCDF) have been widely detected in the atmosphere, water, soil, sediments, and biota. Concentrations vary worldwide depending on the degree of urbanization. Monitoring of the environmental quality is of great importance when determining the order of effectiveness of all the adopted governmental steps and when deciding whether further steps are required to improve the quality of the environment. Thus, the objectives of the present study are: a. the determination of the concentrations and the spatial distribution of natural radionuclides and persistent pollutants (organochlorines and metals) in sediments; b. the Quantification of the selected pollutants in tissues of benthic organisms (two bivalve species: *Mactra corallina* and *Tapes decussata*) in order to assess pollutants bioaccumulation in the region; c. the Evaluation of the extent to which pollutants can pose risk to benthic fauna (bivalves) in sediments of the region from Alexandria harbor area till Port Said City. This evaluation is performed by a screening-level ecological risk assessment process to objectively rank the risks of individual pollutants.

MATERIAL AND METHODS

Thirty surface sediment samples were collected from different locations covering the region from Alexandria harbor area till Port Said City. This region was selected because it receives the majority of the industrial, agricultural and urban effluents (land-based activities), and thus it is expected to be more contaminated than the rest of the Egyptian coastal regions. At the same time, two mussel species were collected from the region: *Mactra corallina* and *Tapes decussata*. Two species were needed because none of them can be found in the whole investigated region. The bivalve species were collected from the same sampling sites as the sediment samples.

Sediment samples were analyzed for metals (Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sn, V and Zn), PAHs (16 EPA priority PAHs), PCBs (PCB 28, 52, 70, 101, 118, 153, 138, 126, 156, 180 and 169), PCBz, HCBz, chlorpyrifos (organophosphate pesticide) and organochlorine pesticides (α-HCH, β-HCH, γ-HCH, δ-HCH, heptachlor, cis-heptachlor epoxide, trans-heptachlor epoxide, aldrin, dieldrin, cis-chlordane, trans-chlordane, α-endosulfane, β-endosulfane, o,p´-DDE, o,p´-DDD, o,p´-DDT, p,p´-DDE, p,p´-DDD, p,p´-DDT, methoxychlor and mirex). These pollutants were selected because either they were previously detected in the sediments of this area or because of the ecotoxicological risk associated with them. Bivalve samples were analyzed for the same trace organic pollutants but for 8 metals (As, Cd, Cr, Cu, Hg, Mn, Pb, Se and Zn). These selected metals are considered the most toxic for bivalve species (from literature) and for the human health [1, 2, 3].

RESULTS AND DISCUSSION

The investigated sediments were dominated by the sand fraction, except in the nearshore stations that were dominated by the fine fraction (silt + clay), where sediments are possibly affected by detrital and organic particles discharged by the land-based activities. For all the investigated classes of pollutants (except for PAHs), higher concentrations were always observed in sediments near the Alex Harbour, Abu Qir Drain, the Fertilizer Company, the Maadeya Outlet, El Gamil stations at the outlet from Lake Manzala and in some cases (as Pb and Cr) near the Electric Power Plant. Generally, Concentrations were found to decrease in the offshore direction except for the nearshore-offshore profile nearthe Petroleum Company, where relatively high concentrations of most of the investigated pollutants were observed in Abu Qir Bay and El Gamil stations, reflecting the role played by the water circulation pattern in distributing pollutants in sites away from the major sources of pollution inputs [4].

Activity concentrations of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K (Bq/kg dry weight) in the sediment samples are: For ^{238}U the specific activities range from 3.0 to 13.8 Bq/kg with an average of 8.0 Bq/kg. The specific activities for ^{232}Th ranged from 0.6 to 7.8 Bq/kg with an average of 2.1 Bq kg. The specific activities of 40K range from 10.0 to 86.1 Bq/kg with an average of 46.0 Bq/kg. Activity concentrations of ^{226}Ra (^{238}U serie), ^{232}Th serie and ^{40}K (Bq/L) in the Coastal water samples collected from Alexandria harbor area till Port Said City were measured. The specific activity of ^{226}Ra (^{238}U serie), ^{232}Th serie and ^{40}K ranged from < DL to 8.8±0.1, < DL to 4.5±0.1 and 41.1±0.2 to 138.8±0.1 Bq/l, respectively.

Concentrations of total Ni, Co, Cr, Pb and V showed close pattern of spatial distribution in the region sediments. Cu and Zn concentrations were much higher in front of the Abu Qir Drain, the Fertilizer Company and El Gamil stations. Hg and Sn total concentrations were higher in front of the Maadeya Outlet and in the offshore direction, reflecting also the influence of the discharged agricultural wastes and shipping activities. Most of the investigated metals (except Se and Sn) showed significant positive correlation with clay content. Results obtained from the sequential extraction procedure revealed that the majority of Ni and Co was incorporated in the residual fraction of the sediments, thus chemically inactive. The oxidizable fraction of Cu was found to be the dominant fraction which may indicate the association of Cu with organic matter in the region sediments. The anthropogenic influence on the investigated trace metals concentrations was identified in most of the investigated sediment samples, especially for Se, Cd, Hg and Pb. These elements were highly enriched in relation to Al, which was used as the normalizer(5, 6).

Concentrations of total metals were generally higher in the *Mactra corallina* than in *Tapes decussata*. Relatively higher concentrations of metals were generally observed in front of Alexandria harbor, Maadeya Outlet and El Gamil stations. Mn, Zn and Cu showed the highest concentrations of metals in both species. Concentrations of As, Cd, Cu, Se, Hg and Zn in some samples were higher than their corresponding sediment concentrations, indicating that these elements are possibly present in a more bioavailable form. Significant positive correlation was observed between concentrations of As, Cu, Se and Zn in sediments and tissues of *Mactra corallina*. Weak or no correlation was observed between concentrations of total metals in sediments and tissues of *Tapes decussata*. This could arise from the fact that concentrations of total metals in the sediments corresponding to the sampling sites of *Tapes decussata* were low, possibly lower than the threshold level that mussels can regulate the accumulation of these metals from the sediments.

Low concentrations of PCBs were observed in sediments of the selected region when compared with concentrations recorded in other coastal sediments worldwide or previously in Alexandrian Coast including Abu Qir Bay(7, 8). Sediments were dominated by the tetra, penta and hexa chlorinated biphenyls. Concentrations of PCBs in the mussels especially *Mactra corallina* were higher than concentrations recorded in their corresponding sediment samples. Like in sediments, the mussel tissues were dominated with the higher chlorinated chlorobiphenyls (9, 10).

Relatively high concentrations of DDTs, chlordanes, chlorpyrifos and HCHs were recorded in sediments. Other pesticides (dieldrin, aldrin, endosulfane, heptachlor and its epoxides) were detected in the sediments but at lower concentrations. Sediments were dominated by the metabolites of DDT (DDD and DDE) indicating that the detected DDTs in the sediments are old and not recently introduced into the costal region. At the same time, DDD concentrations were higher than DDE indicating possibly the preferred reductive dechlorination pathway of DDT in the sediments. In the mussel species, p,p′-DDE was the dominant metabolite, which could possibly be related to a metabolic pathway, depuration mechanism or a certain preferable uptake by the mussel species from the surrounding medium. Concentrations of dieldrin in the sediment samples were higher than aldrin possibly due to the metabolism of aldrin in the sediments, which is converted to dieldrin by epoxidation.

HCH concentrations were generally lower than DDTs and chlordanes in sediments and mussel tissues. HCHs were dominated by the γ-isomer, followed by the α-isomer in sediments and mussels. Calculated ratios for both isomers in the sediment samples revealed that lindane rather than the HCH technical mixture was used in the region. Relatively high concentrations of chlorpyrifos were observed in the sediments and mussels, which could possibly be due to the intensive application of organophosphate pesticides after banning or restricting the use of the organochlorine pesticides.

In contrast to all the investigated pollutants, the highest concentration of PAHs in sediments and mussels was observed near Alexandria harbor that probably affected by the shipping activities. Sediments and mussels were dominated by the higher molecular weight PAHs (4, 5 and 6-rings PAHs). Good correlation was observed between PAHs concentrations in sediments and mussels. In other locations there were some differences between detected PAHs in the mussels and their corresponding sediment samples, which could be attributed to the metabolic pathway in the mussels and /or different routes of PAH uptake from the sediments, contaminated food or water uptake.

The output of the SLERA (based on the consensus approach) revealed that Hg, Zn, Cd, DDD, DDTs, dieldrin, chlordane, lindane, heptachlor (all had PEC HQ > 1), Pb, p,p´-DDE and p,p´-DDT (TEC HQ > 1 > PEC HQ) could be considered as contaminants of potential concern and that adverse ecological effects are expected to occur for the benthic species when exposed to the region sediments. In the mussels, As, Cd, Cu, Hg and Zn concentrations were higher than the toxicity reference values which are set to protect of 95 % of the benthic species. This could be a sign of the probability of occurrence of adverse ecological effects. On the other hand, tissue concentrations of all the investigated pollutants in this risk assessment were lower than all toxicity data available for *Mytilus edulis* and *Mytilus galloprovincialis*. In the HHRA, it was concluded that except for As, no adverse threshold or nonthreshold health effects are expected to occur from the ingestion of both mussel species at the available ingestion rate and thus both species can be ingested safely[11].

REFERENCES

1. Abbassy M. S., 2000. Pesticides and polychlorinated biphenyls drained into north coast of the Mediterranean Sea, Egypt. Bulletin of Environmental Contamination and Toxicology, Vol. 64, pp: 508– 517.

2. Abd-Allah A. M., 1992. Determination of DDTs and PCBs residues in Abu-Quir and El-Max Bays, Alexandria, Egypt. Toxicology and Environmental Chemistry, Vol. 36, pp: 89-97.

3. Abdallah M. A. M. and Abdallah A. M. A., 2007. Biomonitoring study of heavy metals in biotal and sediments in the southeastern coast of the Mediterranean Sea, Egypt. Environmental Monitoring and Assessment, Vol. 8, pp: 766-782.

4. Abdel-Moati M. A. R., 2002. The Mediterranean mussel watch Egypt: case study. Mediterranean mussel watch. Designing a regional program, Marseilles.

5. Angelidis M. O. and Aloupi, M., 1997. Assessment of metal concentration in shallow coastal sediments around Mytilene, Greece. International Journal of Analytical Chemistry, Vol. 68, pp: 281-293.

6. Balls P. W., Hull S., Miller B. S., Pirie J. M. and Proctor W., 1997. Trace metal in Scottish estuarine and coastal sediments. Marine Pollution Bulletin, Vol. 34, pp: 42-50.

7. Barakat A. O., Moonkoo K., Yoarong Q. and Wade T. L., 2002. Organochlorine pesticides and PCB residues in sediments of Alexandria Harbour, Egypt. Marine Pollution Bulletin, Vol. 44, pp: 1421-1434.

8. Baumard P., Budzinski H. and Garrigues P., 1998c. Polycyclic aromatic hydrocarbons in sediments and mussels of the western Mediterranean Sea. Environmental Toxicology and Chemistry, Vol. 17, pp: 765-776.

9. EL-Deeb K. Z., Said T. O., EL-Naggar M. H. and Shreadah M. A., 2007. Distribution and sources of aliphatic and polycyclic aromatic hydrocarbons in surface sediments, fish and bivalves of Abu Qir Bay (Egyptian Mediterranean Sea). Bulletin of Environmental Contamination and Toxicology, Vol. 78, pp: 373-379.

10. EL-Nemr A., Said T. O. and Khaled A., 2007. The distribution and sources of polycyclic aromatic hydrocarbons in surface sediments along the Egyptian Mediterranean Coast. Environmental Monitoring and Assessment, Vol. 124, pp: 343-359.

11. Guitierrez A. G., Garnacho E., Bayona J. M. and Albaiges J., 2007. Screening ecological risk assessment of persistent organic pollutants in Mediterranean Sea sediments. Environment International, Vol. 33, pp: 867-876.

Impacts of large coastal metropolises on Mediterranean macrobenthos: benthic communities of Algiers harbour and the area of Tipaza

Chafika Rebzani-Zahaf

Faculté des Sciences Biologiques/USTHB, BP 32, 16111 Bab Ezzouar Alger, Algeria

Keywords: Algier's harbour, Tipaza, macrobenthos, coralligenous assemblages, ecology, pollution

Abstract

Along the Algerian coast, the largest urban and industrial zones are located at a distance of about 200 km from each other. Thereby, pollutants are emitted into the marine environment and inevitably perturb marine fauna and flora. The various types of pollutants act directly on the environment by undermining the balance of marine ecosystems and, in particular, the health of marine organisms. In the present work, two studies are presented: the first one relates to the macrobenthos of the Algiers harbour and the second to bio-concretions from three places of the Tipaza province, which is located 80 km west of Algiers.

Résumé

Les zones urbaines et industrielles côtières sont réparties le long des côtes algériennes à environ 200 km de distance les unes des autres. Il en résulte des apports de polluants vers le milieu marin qui perturbent inévitablement la faune et la flore marine. Les différents types de pollution agissent directement sur le milieu en perturbant l'équilibre des écosystèmes marins et en altérant l'état de santé des organismes qui y vivent. Dans ce travail, deux études sont présentées : la première s'intéresse au macrobenthos des substrats meubles du port d'Alger et la seconde aux bioconcrétionnements de trois sites de la wilaya de Tipaza situé à 80 km à l'ouest d'Alger.

THE ALGIER'S HARBOUR

Introduction

Algiers is a densely populated city and a major industrial and agricultural center.

A study on the Port of Algiers was undertaken to assess the effect of discharged contaminants on the benthic fauna and flora (Rebzani-Zahaf, 1990, 2003 and Rebzani et al., 1997). A total of 34 stations (Figure 1) were sampled seasonally in the basins of the Port of Algiers (Mustapha, Agha and the Vieux Port) between 1983 and 1997.

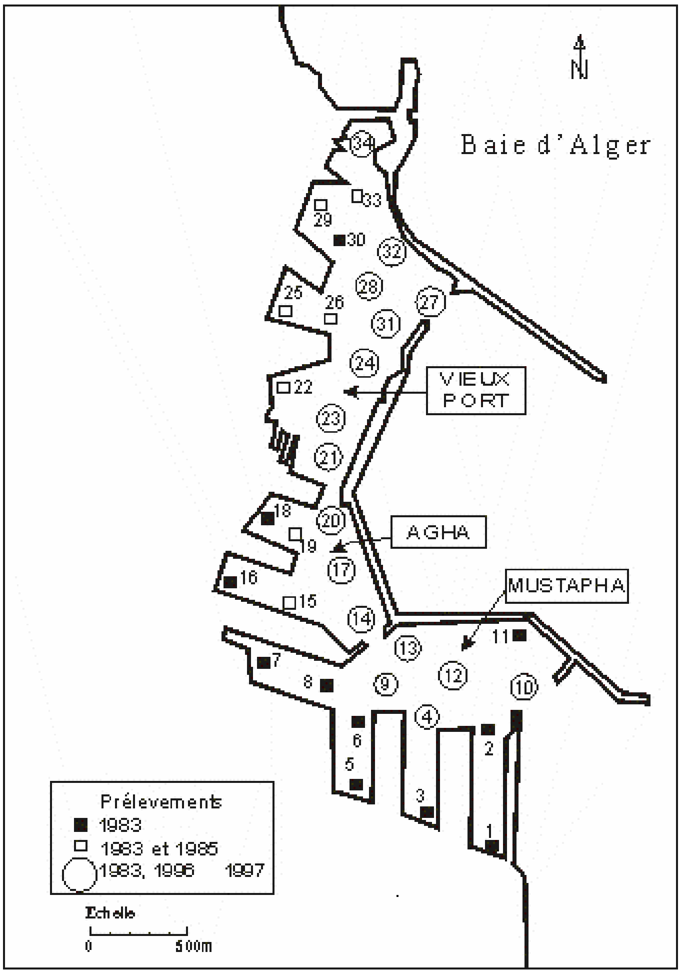


Figure 1. Sampling sites in Algiers harbour

Material and methods

Study area

Algiers harbour is located in the western part of the bay of Algiers and covers an area of 179 hectares. It is divided into three basins (Mustapha in the south, the Vieux port in the north, and the Agha basin between the two) and is connected to the bay via two communication channels.

Sampling

In the harbour of Algiers, macrofauna was sampled seasonally from December 1983 to April 1985, using an orange peel bucket (1/12 m^2). Additional samples were then collected in July 1996, 1997 and 2000 with a Van Veen grab (1/10 m^2).

At each sampling time, organisms were washed over a 1-mm diagonal mesh sieve and immediately fixed in formalin. The methods used in this study have been extensively described in a previous work (Rebzani-Zahaf 2003). The terminology and the definition of benthic communities used in this study area after Peres and Picard (1964).

Results

The benthos colonising the Mustapha basin is dominated by two species which are biological indicators of pollution of the order of 1 (IP1), i.e. high level of pollution (see Rebzani Zahaf *at al*., 1997 for more details). *Capitella capitata* is widely recognised as an indicator species for organic pollution (Reish, 1959; Bellan, 1967; Pearson and Rosenberf, 1978). In fact, dense populations of this species develop in areas characterized by high organic matter. In the Port of Alger, it is present throughout the year; however it occurs in the highest density in the Basin of Mustapha, where it may represent more than 85% of the collected polychaetes. Recruitment seems to start in the autumn, reaching its maximum density in the spring. The second species, *Scolelepis (Malacoceros) fuliginosus*, becomes abundant when conditions improve slightly, but both species can be considered biological indicators of these highly polluted environments (IP1).

In the basin of Agha, the two previously mentioned species are not as abundant, and they are replaced by *Audouinia tentacula, Polydora antennata*, *Nereis caudata* and *Staurechephalus rudolphii*; these species are typical of areas of moderate pollution and are indicators of the second order of pollution (IP2). They represent on average more than 75% of the total number of species present in the basin, and characterise benthic communities of soft sediments rich in organic matter.

In the basin of the Vieux Port, the dominant species group which is relatively tolerant of organic loads consists of *Eunice vittata*, *E. harrassi*, *Lumbrinereis latreilli*, and *Notomastus latericeus*. In the sediments, they can tolerate excessive organic matter (Hily, 1984), but they are sensitive to low levels of oxygen which limits their abundance and distribution.

Another abundant group of species is observed at higher depths, which are influenced by incoming oceanic water and the seabed is characterized by muddy sediments. This group is the most important one in the Vieux Port and includes *Tharyx marioni*, *Tharyx multibranchus*, and *Chaetozone setosa*. However, rapid fluctuations in their abundances occur in some parts of the basin, making it difficult to assess the importance of ecological factors such as depth in the range of distribution of these organisms. Further, these species appear to tolerate most of the sediment types.

A third group lives in sandy sediments and includes *Nephtys hombergii*, *Glycera convolita*, *G. alba* and *Prionospio malmgreni.*

These groups of species occur in the same habitat, and they compete with each other for food and space resources. This competition contributes, along with other abiotic factors, to their fluctuations over time, as shown in Fig. 2.

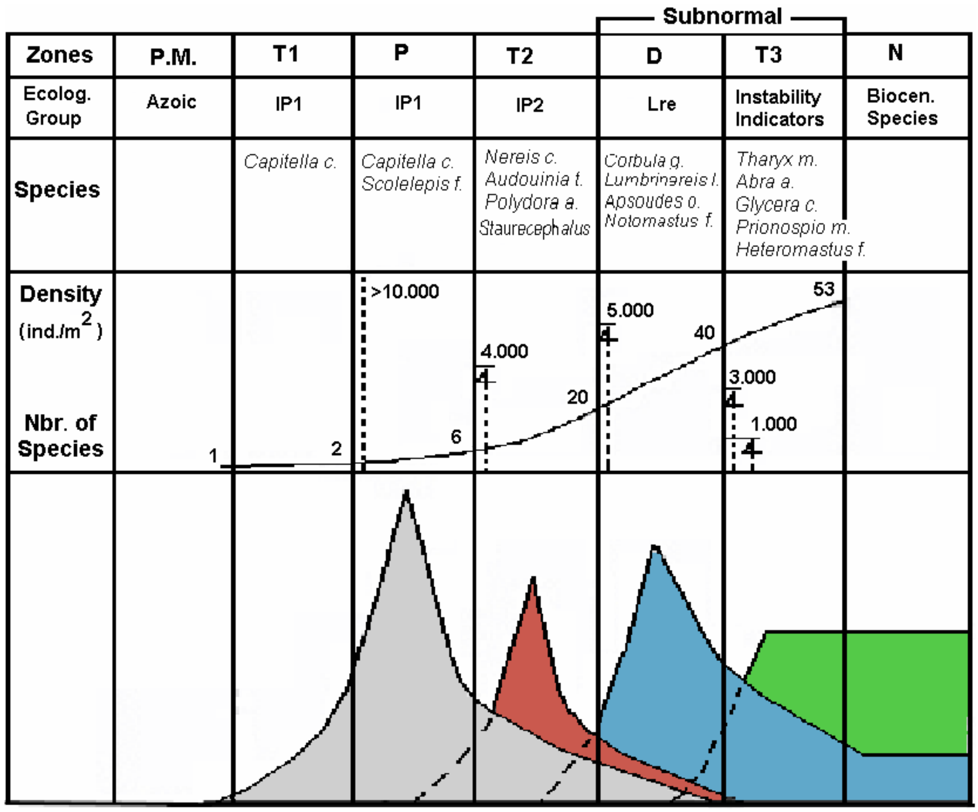


Figure 2. Distribution of species in different zones of Algiers' harbour

Conclusion

Four hundred and twenty seven species have been collected. Polychaetes were the most important ecological group in terms of species richness and number of individuals present in some stations. Seven areas of decreasing pollution are identified in the Algiers' harbour and each basin is characterised by particular levels of organic pollution and by particular species or groups of polychaete species. The settlement, abundance and distribution of macrofauna appear to depend on two decreasing gradients of pollution; the first is observed in each basin, while a second, more marked gradient is visible between the polluted basin of Mustapha, across Agha basin and the less polluted Vieux Port basin.

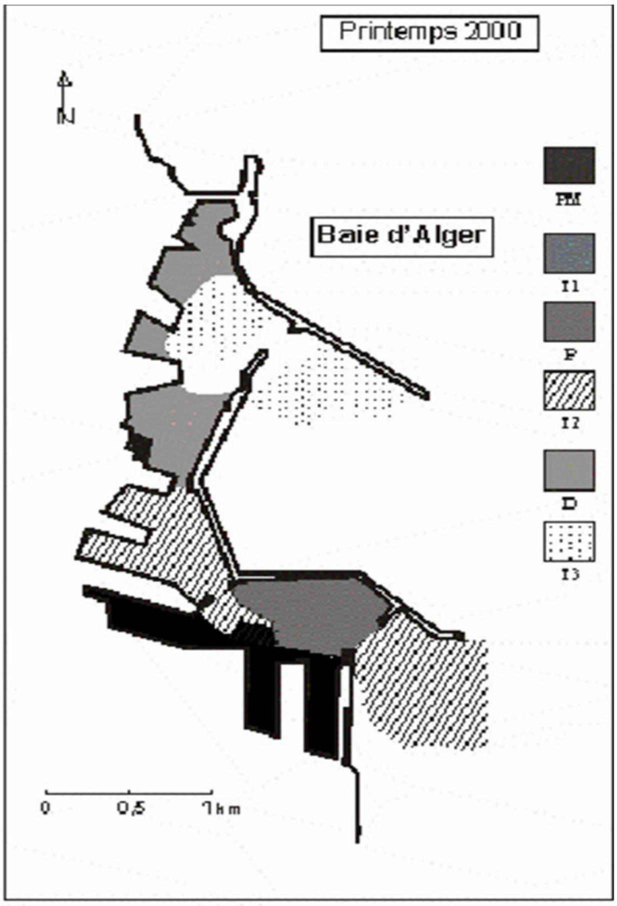


Figure 3. Zonation of Algiers' harbour

WILAYA DE TIPAZA : CHENOUA, ANSE OF KOUALI AND AIT TAGOURAIT (BERARD)

Introduction

The region of Tipaza is a site of major interest for the preservation and the protection of the biological diversity; however, it is also subject to increasing anthropological impacts due to: urbanization, agricultural and sea-food processing industries and tourism development in relation to a rich cultural and historic heritage. The study aims at identifying the different types of "bioconcretions" present in the area of Tipaza (west of Algiers, 80 kms away), namely: "trottoirs à vermets", made by the vermetid gasteropod *Vermetus triqueter*, a corallinales Rhodobiontes (*Corallina elongata*), and to a lesser extent of *Lithophyllum lichenoides* (Rhodobionte). The work was made in the following regions: Chenoua, Anse of Kouali and Ait Tagourait (Bérard), by establishing an inventory of the fauna and flora species associated with these remarkable biocenoses. This biodvieristy study will allow a better knowledge and characterization of these calcareous bio-structures.

Material and methods

Study area

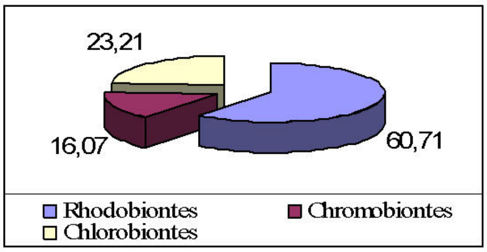
Nine stations were chosen on three sites, all characterized by similar geomorphological features and hydrodynamics: Ain Tagourait, Anse of Kouali and Chenoua.

Sampling

In summer 2008, three samples (20x20cm) of the above species were taken at each site, along the hard flat ledges of the mediolittoral zone. The species were collected by scraping the rock, then sorted them out and preserved in the formalin according to the method of Bellan (1969).

Results

In the three sites, the ‘trottoir’ of *Vermetus triqueter* was up to a metre wide; the average thickness was 2 cm in Ain Tagourait and in Kouali, while it reached 3 cm in Chenoua. Some important *Lithophyllum* bioconstructions were also observed, but these cannot be compared to the vermetid trottoirs because their thickness very rarely exceeds one centimeter. The presence of *Corallina elongata* is very marked in Chenoua. The very condensed corralligenous species forms concretions with mussels, in particular *Mytilus galloprovincialis* and *Perna perna*. Figure 4 and 5 show relative composition of algal and faunal communities characterising the three study sites. Preliminary results indicate that brown algae (chromobiontes) are the most common species in the marine flora inhabiting these sites, while polychaetes, crustaceans, molluscs and echinoderm represent the main faunal taxa.



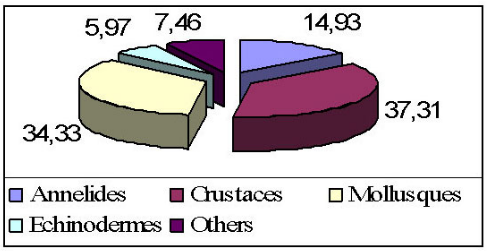


Figure 4. Composition (percentage) of flora Figure 5. Composition (percentage) of fauna

Conclusion

This inventory of the fauna and the flora, associated with the ‘trottoir’ of *Vermetus triqueter*, is a first part of the work. It consisted in listing all species and applying a multivariate analysis for a better differentiation between the studied sites according to the ecological affinities. Cystoseires (Chromobiontes), *Cystoseira stricta/mediterranea* are assemblage species constituting an excellent indicator of the quality of the environment. *Corallina elongata* (Rhodobiontes) and *Mytilus galloprovincialis* (bivalve mollusc) tend to replace species such as *Lithophyllum sp.*, *Vermetus triqueter* as well as *Cystoseira sp.*, reflecting a degradation of the environment by an enrichment in organic matter. The differences in trottoir thicknesses observed could be explained by a different degree of environmental disturbance in the three sites. Increasing anthropological impacts in the region could thus slow down the growth of the vermetid gastropod.

The macrobenthos and calcareous formation of biogenic origin are affected by the anthropological activities. The study of these communities is necessary to improve the management and the protection of coastal marine environment. Long term monitoring is crucial in the present and future assessments of coastal ecosystems.

REFERENCES

Bellan G., 1967. Pollution et peuplements benthiques sur substrat meuble dans la région de Marseille; 1ère partie: le secteur de Cortiou. Rev. Intern. Oceanogr. Med., 6-7, 53-87. 2ème partie: l'ensemble portuaire marseillais. Rev. Intern. Oceanogr. Med., Tome VIII, 51-95.

Bellan-Santini D. (1969) - Contribution à l'étude des peuplements infralittoraux sur substrat dur rocheux (Etude qualitative et quantitative de la frange supérieure) Rec. Trav. St. mar. Endoume, fasc.63, Bull. 47 : 5-294.

Benali M., Karali A , Rebzani Zahaf C., 2009. Contribution à la connaissance des bioconcrétionnements médiolittoraux de la wilaya de Tipaza (diversité taxonomique, caractérisation des peuplements associés) Actes du 1er symposium méditerranéen sur la conservation du coralligène calcaire. CAR/ASP publ., Tabarka, 15-16 janvier 2009. 163-165.

Glémarec M. et Hily C., 1981. Perturbations apportées à la macrofaune benthique de la baie de Concarneau par les effluents urbains et portuaires. *Acta Oecologica, Oecol. Applic*. Vol. 2, n° 2, p. 139-150.

Pearson T. H. et Rosenberg R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanogr. Mar. Biol. Ann. Rev.*, 16 : 229-311.

Peres J.M., Picard J. (1964) – Manuel des bionomies benthiques de la Méditerranée. Rec. Trv.St. mar. Endoume. 50p.

Rebzani-Zahaf C., 1990. Le peuplement macrobenthique du port d'Alger. Evolution spatio-temporelle. Impact de la pollution. Thèse de Magistère, ISN/USTHB Alger. 199 p., annexes A 146p.

Rebzani-Zahaf C., Bellan G., Bakalem A., Romano J.C., 1997. Cycle annuel du peuplement macrobenthique du port d'Alger. *Oceanologica Acta*, 20, 2, 461-477.

Rebzani-Zahaf C., 2003. Les peuplements macrobenthiques des milieux portuaires de la côte algérienne : Alger, Béjaia, Skikda. Thèse de Doctorat d'Etat ès Sciences, FSB/USTHB. 244p + annexes.

Reish D. J., (1959). An ecological study of pollution in Los Angeles Long Beach Harbors. Allan Hanckock Found. Publi. Occas. Papers 22, 1-117.

Seurat L. G. (1927) - L'étage intercotidal des côtes algériennes. Bull. Trav. Publiés par la station d'aquiculture et de pêche de Castiglione. Fasc 1. 1 : 22.

Nuclear applications for a sustainable management of marine waters adjacent to large Mediterranean coastal cities

Nafaa Reguigui

National Center of Nuclear Science and Technology, Technopole Sidi Thabet 2020 Sid Thabet, Tunisia

Keywords: radionuclides; ^{90}Sr; ^{137}Cs; ^{241}Am; Pu; Southern Mediterranean, trace elements, nuclear techniques, environmental samples

Abstract

Waters adjacent to major cities, which support several industries such as fishing, tourism, phosphate fertilizers and maritime transport, are threatened by rapid urban, industrial and tourism development. Special attention is required to protect the marine environment against contamination from land-based sources.

Nuclear and isotopic techniques provide a unique source of information for quantifying these contaminants, particularly radioactive traces, pesticide residues, PCBs, petroleum hydrocarbons and toxic metals and for understanding their fate. For example, radionuclide tracers help understand water and sediment dynamics, and dating of sediment cores using radio-analytical techniques is widely used in geochronological studies to investigate pollution histories.

This paper will review major applications of nuclear and isotopic techniques in the marine environment and show how these techniques can produce long-term environmental benefits for sustainable management of marine waters adjacent to large coastal cities.

Résumé

Les grandes villes côtières de la Méditerranée fédèrent plusieurs activités telles que la pêche, le tourisme, les industries dont la production d'engrais phosphatés et le transport maritime. Les eaux marines jouxtant ces métropoles sont menacées par leur développement rapide et les pressions urbaines et industrielles qui en résultent. Une attention particulière doit être accordée à l'environnement marin pour le protéger contre la contamination d'origine tellurique et anthropique.

Les techniques nucléaires et isotopiques représentent une source d'information unique pour la quantification de ces contaminants. Elles apportent des informations sur leur devenir dans l'environnement. Les substances concernées sont en particulier : les contaminants radioactifs, les résidus de pesticides, les PCBs, les hydrocarbures et les métaux toxiques. Les traceurs radioactifs aident par exemple à comprendre la dynamique de l'eau et des sédiments. La datation des

sédiments par des techniques radioanalytiques est utilisée couramment dans les études géochronologiques de la pollution.

Le présent document passe en revue quelques applications importantes des techniques nucléaires et isotopiques dans l'environnement marin et montre comment ces techniques peuvent contribuer au développement durable des grandes villes côtières et des eaux marines de leur voisinage.

INTRODUCTION

The Mediterranean is a relatively shallow, semi-enclosed water body with only limited water exchange which makes it a very fragile marine environment and potentially sensitive to human activity. Special attention is required to protect it against contamination from land-based sources or originating directly in the Sea. Understanding the sources, distribution, fate and effects of marine pollutants is central to sustainable management of marine waters.

Nuclear and isotopic techniques currently provide a unique source of information for identifying nuclear and non-nuclear contaminants, particularly pesticide residues, PCBs, petroleum hydrocarbons and toxic metals. Radionuclides are being used as tracers to better understand water and sediment dynamics, the behaviour of contaminants in oceans and seas and to trace their pathways in the environment. Dating of sediment cores is widely used in geochronological studies to investigate pollution histories.

In a country like Tunisia, pollution and its impact assessment is quite important considering the importance of the coastal zone to the country. Tunisian geographical position at midpoint between the western and eastern regions of the Mediterranean (with its 1,300 km-long coastline) makes it a vital point in the study and the control of the sea pollution.

Waters adjacent to major cities, which support several industries such as fishing, tourism, phosphate fertilizers and maritime transport, are threatened by intensive, seasonal fishing as well as urban, industrial and tourist development. These issues leave Tunisia faced with the challenge of finding ways of combining development on the coast of several activities and services, (urban development, tourism and industry) while preserving a fragile ecosystem.

Within this context, several joint projects, mainly supported by the IAEA were carried out to assess radioactive and non-radioactive contaminants using nuclear and isotopic techniques; to investigate marine processes in order to better understand water and sediment dynamics and the behaviour of contaminants; to synthesize data on levels of radioactive and non-radioactive contaminants (heavy metals, organic compounds) in water, sediment and biota; to investigate processes in the water column affecting primary productivity in the Sea and its potential impact on fisheries; to estimate spatial and temporal trends in contamination of the sea and to develop computer models to investigate dispersion of contaminants.

RADIOACTIVITY MONITORING IN THE MARINE ENVIRONMENT

Marine radioactivity found in the marine environment (in water, sediments and biota) finds its origins from a variety of sources: some are natural (originating from the earth's crust or the cosmos) and some are artificial, having been introduced by man (regular discharges from the nuclear fuel cycle or from explosions and accidental events). Some enhanced levels of naturally occurring radionuclides are also introduced into the marine environment as a result of discharges from industries such as phosphate and oil and gas.

Depending on the emitting properties of the radionuclide and its matrix, one can use one or more analytical methods to identify and quantify these radionuclides; gamma ray spectrometry for gamma-emitters, alpha spectrometry for alpha emitters, and beta counting or liquid scintillation counting for beta emitters.

TRANSPORT PROCESSES IN THE OCEAN THAT CAN BE TRACED WITH RADIONUCLIDES

Although radioactive contamination does not appear to be a problem in the Mediterranean Sea, except for some known hot spots, marine radioactivity studies and the use of isotopic techniques for the investigation of marine processes can effectively contribute to the better understanding of water dynamics and the behaviour of contaminants in the Mediterranean Sea. Natural radionuclides such as ^{232}Th, ^{238}U and ^{235}U and their descendents can provide useful information about the rates of many transport reaction processes. In an undisturbed environment, the parents of these major radioactive families usually are in equilibrium with their daughters. In a marine environment, isotopes of relatively soluble elements like U, Ra and Rn decay to isotopes of highly particle-reactive elements such as Th, Pa, Po and Pb which results in a disequilibrium in the decay chain. This disequilibrium can be used to measure the transport rates of the particulate and liquid phases relative to each other (Grasshoff 1999). The study of distribution of anthropogenic radionuclides (^{137}Cs, ^{90}Sr, $^{239,240}Pu$, and ^{241}Am) in the water and sediments can also help in identifying the major input sources to these compartments and can help in identifying key processes controlling the fate of pollutants in the sea. Data obtained can serve as a baseline for any impact assessment studies.

Not to be comprehensive, we can summarize the various applications as follows:

For the water compartment

^{3}H and ^{90}Sr are used to study water dynamics and transport processes ^{234}Th, $^{239,240}Pu$, and ^{241}Am are used to investigate various processes in the water column (scavenging, eutrophication, flux calculations from radioactive disequilibrium). Particle fluxes can be derived from the disequilibrium between a mobile parent and its particle-reactive daughter: Tracers in this group are produced in the water column and removed on sinking particles, a process called scavenging. They allow us to determine particle transport rates in the ocean (AWI, 2009).

^{228}Ra is produced everywhere in the sediment and it diffuses into the bottom water and can be used as a tracer of the transport of some elements from the continental shelves to open ocean.

^{137}Cs can also be used to the study the water dynamics and transport processes.

For Sediments

^{210}Pb and ^{226}Ra are used for sedimentation rate through the excess lead ($^{210}Pbex$) by using a given model such as the Constant Rate of Supply (CRS) model to ^{210}Pb and to reconstruct the history of contaminants (Carroll et al. 1995).

^{137}Cs and $^{239,240}Pu$ profiles provide information about both radionuclide deposition history and accumulation of modern sediments. The use of these tracers enables the estimation of sediment accumulation rates (SAR) in cases where the prerequisites of estimation methods are fulfilled.

U\Th dating of sediments enables scientists to establish an accurate chronology for Pleistocene marine sediments beyond the range of radiocarbon dating

^{230}Th and ^{231}Pa activities in sediment traps and in sediment cores are used to calibrate the collection efficiency of sediment traps and to determine to what extent sediments are redistributed before being buried at the sea floor. Their distribution in the sediment helps us determine the age of sediment layers and the changes that may have occurred to the settling rate of particles to the sea floor.

Other applications that concern the water-sediment interface include deep-sea mixing, i.e., the study of dispersion of material released from the seafloor into the bottom water, particle dynamics ranging from export production through aggregation of colloidal material and quantification of mass flux and water mass circulation (Grasshoff 1999).

Biota

Pollution monitoring programs based uniquely on measurement of contaminants in the marine environment are not sufficient. This monitoring is often complemented by investigating the bioaccumulation of pollutants such as toxic metals and radionuclides in living organisms. These biomonitors can provide information on the variation of the contaminant bioavailability over time and space. Sometimes, the use of biomonitors is preferable to measurements of contaminants levels in water and sediment because they take up only that fraction of the analyte that is bio-available, usually of interest to environmental managers. For example, several studies have shown that ^{210}Po is accumulated to exceptionally high levels in tissues of a variety of marine organisms. ^{210}Po is thus the major contributor to the radiation dose received by humans from the seafood consumption. Radioactive tracers can also be used on a laboratory scale to investigate bioaccumulation and retention of toxic metals in a variety of Mediterranean species.

CASE STUDY 1: CONTAMINATION ASSESSMENT OF THE SOUTH MEDITERRANEAN SEA

In the framework of the IAEA's Technical Co-operation project "Contamination Assessment of the South Mediterranean Sea (RAF/7/004)" the IAEA-MEL organized, in collaboration with several institutes from the North African countries, four expeditions to sample seawater, sediment and biota in the coastal waters of Morocco, Algeria, Tunisia and Egypt with the aim to investigate the distribution of anthropogenic radionuclides such as plutonium isotopes, ^{241}Am, ^{137}Cs, and ^{90}Sr in the marine environment. The study areas are shown in Fig. 1.

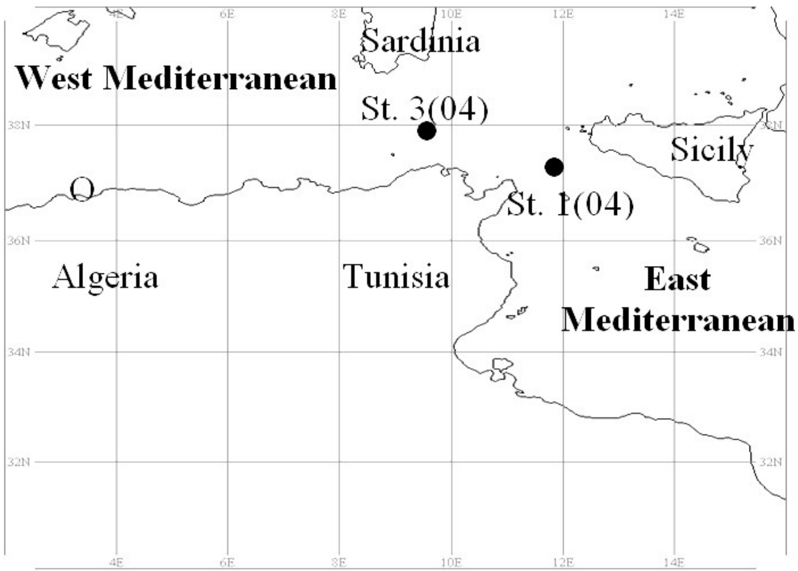


Figure 1. Sampling stations in the Southern Mediterranean Sea in 2004(•)

Results show that the inventory of $^{239,240}Pu$, ^{241}Am, ^{137}Cs and ^{90}Sr in the water columns of Southern Mediterranean is much lower than those found in the northwestern Mediterranean Sea as well as global fallout deposition in the same latitude (Lee et al, 2006).

Figure 2a gives the distribution of ^{137}Cs in the water column. A higher ^{137}Cs concentration is found at the surface layer in which Modified Atlantic Water (MAW) flow eastward, and the ^{137}Cs concentration gradually decreased with depth and then increased at the bottom layer in the Sicily Channel. The enrichment of ^{137}Cs in deep waters at the Sicily Channel could be caused by the influence of Levantine Intermediate Water (LIW) coming from the Eastern Mediterranean Sea. Figure 2b gives the distribution of ^{137}Cs in the top 10 cm of the sediments 600 m below water surface. The ^{137}Cs concentration is decreasing exponentially from the top surface of the sediment down to 10 cm except for two peaks. The first peak occurred around 3 cm and we believe this is due to the Chernobyl accident. The second peak is much more important and is detected between 5 and 6 cm. This is typical signature of major fallouts of the '60s resulting from the weapon explosion tests, having a maximum around 1963.

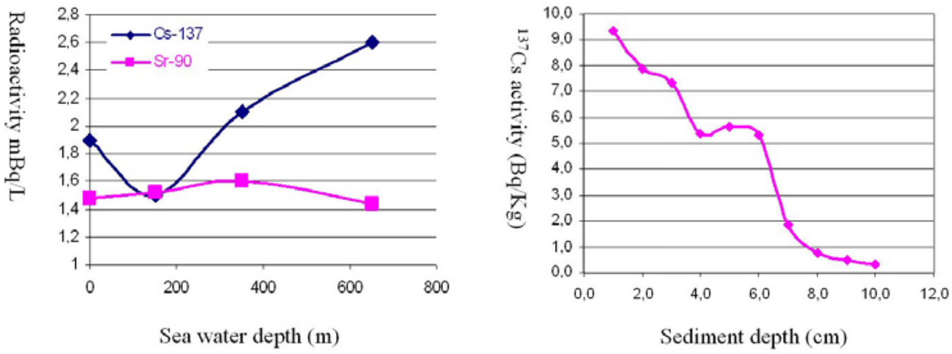


Figure 2. The profiles of (a) ^{137}Cs and ^{90}Sr in the water column and (b) ^{137}Cs in sediments in the Sicily Channel in 2004

CASE STUDY 2: DETERMINATION OF TRACE ELEMENTS USING NEUTRON ACTIVATION ANALYSIS

Among the wide range of toxic substances contaminating the aquatic environment, a major concern has been focused on heavy metals. Mercury, lead, cadmium and arsenic are non-essential elements occupying top positions in all lists of toxicants. Large predators, such as swordfish and bluefin tuna, are at the top of aquatic food chains, and hence they can accumulate large amounts of metals. Neutron Activation Analysis (NAA) presents a sensitive multi-element technique which is valuable for major, minor and trace element analysis due to its precision and accuracy. This technique was applied to investigate the elemental composition of beach sand samples along the coast of Tunisia and some soils for comparison. The distribution of the major and trace element concentrations is shown in Figure 3.

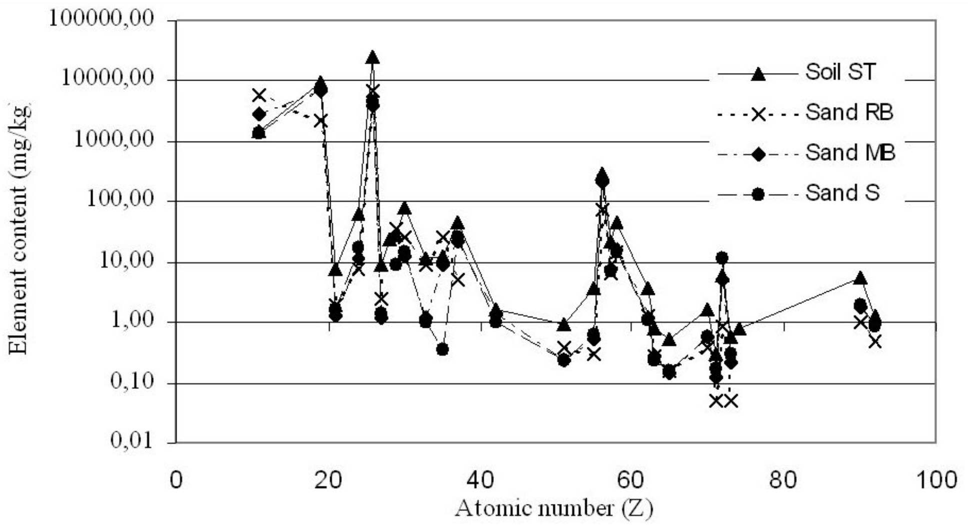


Figure 3. The distribution of the major and trace element concentrations in beach sand and soils in Tunisia. ST: Sidi Thabet, RB: Raoued beach, MB: Metouia beach, S: Sahara

A similar trend exists in element concentrations in the various matrices, although the individual levels may vary widely from one sample to another. The results indicate a close relationship between the beach sand and the clay soil from the region of Tunis in terms of trace element concentrations. Similarly, there is a close relationship between the trace element content in both samples from the south (the beach and Sahara sand). However, there is a difference about twofold in concentration of trace elements between the samples from the north and the samples from the south.

CONCLUSION

The ever-expanding coastal cities mean more contaminants will reach the marine environment, including metals and radionuclides. Sustainable development depends on maintenance of water quality within parameter ranges that do not create system overloads. The ability to monitor and to understand the marine environment is fundamental to a variety of industrial, regulatory and governmental bodies. A new policy of marine pollution monitoring is required. First there is a need for continued funding of regional projects that would last beyond the usual two or three year cycle. Second, there is a need for human resources development in radiochemistry especially for the southern countries of the Mediterranean where nuclear techniques are relatively new compared to their northern counterparts. The problem is not simpler in northern Mediterranean countries where interest in the field is declining and specialists in this field are getting retired.

REFERENCES

AWI, The Alfred Wegener Institute Web site, www.awi.de/en/home/ , accessed on january 2009.

Carroll J.L., Lerche I, Ibraham J.A., Cisar D.J., Model-determined sediment ages from depth profiles of radioisotopes: Theory and examples using synthetic data," Nuclear Geophysics, 9, 553-565, 1995.

Grasshoff Ehrhardt and Kremling (Eds), in "Methods of seawater analysis", 3rd edition, Verlag Chemie, Weinheim, Germany, 1999.

Lee S-H., Mantoura R.F.C., Povinec P.P., Mahjoub A., Benmansour M., Nouredine A., Reguigui N., 2006. « Distribution of anthropogenic radionuclides in the water column of the south-western Mediterranean Sea", in Radioactivity in the Environment Volume 8, éditeur P. Povinec, Elsevier.

ACKNOWLEDGMENT

Special thanks go to Dr. Jan Kucera from the Nuclear Physics Institute, Rez near Prague, Czech Republic, for helping with neutron activation analysis and to S.-H.Lee and, P. P. Povinec (ex-IAEA-MEL) for helping with the sampling cruises and the capacity building.

Coastal Metropoleis – Hotspots of Change

Alessia Rodriguez y Baena, Paula Moschella and Frédéric Briand

CIESM[1] – The Mediterranean Science Commission
16 bd de Suisse, MC-98000, Monaco

Keywords: biomonitoring, bioaccumulation, mussels, chemical contamination

Abstract

CIESM is directing increasing efforts and resources to foster and also harmonize initiatives on critical Mediterranean "hotspots of change", hence its support for, and active presence in, the Alexandria Conference. Coastal metropoleis rank high among such hotspots. Firstly, with their millions of inhabitants, they are a major source of insidious, highly toxic chemical contaminants that are discharged by urban consumers and industries in coastal waters. Further, when they host a major harbour, they also provide a main vector for "biological contamination" *sensu* invasion of alien species via ballast waters and ship hulls. In CIESM view and experience, the effective monitoring and management of the complex pressures exerted by coastal metropoleis on marine ecosystems require a cross-basin, long-term, multidisciplinary approach. To properly tackle these issues, just involving the research sector clearly shall not suffice. The time for the scientific community to act in splendid isolation is over; the time has come to work in close partnership with relevant, concerned actors of civil society and other key stakeholders, such as the maritime (including ports, ship-owners, oil and gas exploitation companies) and tourism industry. In this very perspective, CIESM has recently taken on the role of representative of the broad "pan-Mediterranean" marine research community in a new ambitious international Program, bringing together half a dozen key international organizations from various sectors (research, aquaculture, fisheries, industry, coastal users), and designed to advise the European Commission on long term maritime policy.

Résumé

La CIESM consacre de plus en plus d'efforts et de ressources pour encourager et harmoniser les initiatives sur les «points chauds du changement» en Méditerranée, de là notre présence à cette conférence d'Alexandrie. Les grandes métropoles côtières sont en bonne position parmi ces hotspots. En effet, avec leurs millions d'habitants, elles sont une source majeure de contaminants chimiques hautement toxiques et insidieux qui sont déversés par les consommateurs urbains et les industries dans les eaux côtières. Par ailleurs, lorsqu'elles accueillent de grands

[1] www.ciesm.org

ports, elles constituent également un important vecteur de «contamination biologique» (sensu espèces invasives) par l'intermédiaire des eaux de ballast ou des coques de navires. D'après la vision et l'expérience de la CIESM, la surveillance et la gestion des pressions complexes exercées par les grandes métropoles sur les écosystèmes marins nécessitent une approche à l'échelle du bassin, de long terme et multidisciplinaire. Pour ce faire, l'implication du seul secteur de la recherche n'est clairement pas suffisante. Les temps glorieux où la communauté scientifique agissait en solo sont dépassés, le moment est venu de travailler en concertation étroite avec les acteurs concernés de la société civile et d'autres tels que l'industrie maritime (notamment les ports, les armateurs, les compagnies pétrolières et gazières) et du tourisme. Dans cette perspective même, la CIESM a récemment pris le rôle de représentant de la communauté scientifique marine «pan méditerranéenne» au sens large dans un nouveau projet international ambitieux qui rassemble une demi-douzaine d'organisations internationales clés de secteurs variés (recherche, aquaculture, pêcheries, industrie, usagers des côtes) et qui a pour objectif de conseiller la Commission Européenne dans le cadre des régulations maritimes sur le long terme.

The Mediterranean Sea hosts one of the richest marine and coastal biodiversity in the world; it is however also highly vulnerable to changes, with 28% of endemic species, many of which already endangered. Anthropogenic activities associated to large coastal cities play a major role in driving such changes in coastal ecosystems and represent a serious environmental issue for many Mediterranean countries. These can be ascribed to three main pressures: shipping and related harbour activities, coastal development, and pollution by chemical contaminants and nutrients (eutrophication).

The increasing industrial and maritime activities surrounding large cities lead to more residential developments and infrastructures (e.g. harbours, roads, commercial centres) being built along the coastlines. Furthermore, to protect coastal cities from erosion (CIESM 2002a), which increasingly afflicts most sedimentary shores in the Mediterranean, sea defences (seawalls, rock groynes, jetties etc) have "hardened" large portions of natural coastline. As a result, natural habitats are replaced with artificial habitats that are often unfavourable or unsuitable to local species. Concurrently, these artificial substrates have been proven to facilitate colonisation and settlement by newly introduced species that may out-compete native species food and space resources.

The introduction of alien species in marine ecosystems has been recognized as one of the major threats to the maintenance of biodiversity and ecosystem functioning worldwide. The Mediterranean Sea is particularly susceptible to introduction of species, because of its geographic position between the Atlantic and the Red Sea, the great number of endemic species, the intense maritime traffic, and the increasing development of fish and shell-fish farms. To date, 620 alien species (macrobiota) have been introduced in the Mediterranean Sea, but the total number of introduced species is far greater, if we also consider marine micro-organisms

(Galil 2009). Since the opening of the Suez Canal in 1869, many tropical species from the Red Sea and Indo-Pacific have naturally migrated to the Levantine part of the Mediterranean Sea. Species introductions, however, do not occur only through straits and canals. Shipping is considered an important vector for the movement of alien marine species across the globe, and has been ascribed as the principal cause for dispersal of a large variety of organisms, from viruses and bacteria to macrophytes to fish (Galil 2007). In the Mediterranean, one fifth of the alien species have been first introduced via shipping (CIESM 2009; Galil 2009). Alien species (including algal spores and larval stages of invertebrates and pathogens) can be transported on ship hulls or in ballast waters and sediments that are often discharged from the ship in the destination harbours. To this extent, ports act as important recipients/gateways for introduction and spread of alien species, whether transported as fouling or in ballast waters of ships. Considering that more than 220,000 vessels cross the Mediterranean Sea each year, and that over 150 commercial ports encircle the basin, the probability of transfer of biota through ships is therefore very high (CIESM 2002b). In addition, the increasing demand for leisure boating boosted the development of large marinas which can get biologically contaminated by the adjacent harbours and thus further contribute to a secondary spread of exotic species via non-commercial vessels (Occhipinti-Ambrogi 2002).

Figure 1. The warty comb jelly Mnemiopsis leidyi

Some ship-borne aliens can spread very fast, extending their range of distribution to large parts of the Mediterranean Sea in a relatively short period of time. The establishment of alien species can have detrimental effects on the ecosystem, often leading to important economic losses. A striking example is *Mnemiopsis leidyi*, a comb jelly native of the western Atlantic that has been introduced via ballast waters in the Black Sea in the late 1980s. This zooplanktivorous species, which feeds mainly on fish eggs and larvae, became rapidly invasive in the Black Sea and contributed significantly to the crash of the anchovy stocks, already threatened by overfishing (Kideys, 2002). In the 1990s *Mnemiopsis* was recorded in several locations in the Aegean Sea and recently large swarms of this jellyfish appeared for the first time along the Israeli coastline, causing the blockage of the cooling water systems of several coastal power plants (Galil, 2009). During summer 2009, observations gathered through the CIESM Jellywatch Programme (http://www.ciesm.org/marine/programs/jellywatch.htm) reported large blooms of *Mnemiopsis* in the north-western Basin. The fast increasing maritime traffic and the development of new shipping routes and ports contribute primarily to the spread of this species across the Mediterranean Sea.

It has been clearly shown that a few large costal cities are responsible for a major fraction of the chemical contamination input to Mediterranean coastal waters (*e.g.*, UNEP 2002; UNEP/WHO 2003; EEA 2006). Concurrently, one of the keys to effectively fight chemical contamination in the marine environment is the optimisation of resources *sensu lato*. Synergising international initiatives and focusing efforts on identified contamination hotspots, such as large coastal cities, represents a natural shortcut towards the environmental sustainability of the Mediterranean Sea.

CIESM shares this very view and has a long track record in managing basin-scale, scientific programmes with a medium to long-term horizon, which aim to understand the processes and changes that govern the functioning of the Mediterranean Sea and affect its interaction with growing coastal populations. In this framework, CIESM animates a wide scientific network and enjoys regular cooperation with other international organisations active in the region, i.e., IAEA, Black Sea Commission, and UNEP/MAP/MedPol.

Among the different programmes coordinated by the Commission, the Mediterranean Mussel Watch programme, originally conceived by CIESM in 2002 (CIESM 2002c), now focuses on the radionuclide Polonium-210 and the PBDEs (polybrominated diphenyl ethers) family of emerging contaminants. These contaminants were selected as they may represent a serious health hazard to human beings and their concentrations are tightly correlated to anthropogenic activities (CIESM 2004, 2006). Early results from the Programme show that, in the Adriatic Sea, the highest Po-210 values were recorded in stations located close to cement and petroleum factories and/or intense agricultural activities (Rodriguez y Baena et al. 2009).

According to a recent report by the European Investment Bank (EIB 2008), one of the main factors hindering the transformation of Mediterranean pollution hotspots into "bankable projects" is the wide spectrum of institutional responsibilities involved in project implementation. To this extent CIESM, along with the other major international organisations active in the region, plays a key role in catalysing the collaboration among the scientific community and concerned actors of civil society and other relevant stakeholders. For instance, in 2008 CIESM joined a consortium of major European networks in marine research and industry to advise on the EU New Marine and Maritime policy. The consortium, which includes ICES, WATERBORNE, ESF-Marine Board, EFFARO, and the Venice platform among others, is developing a sustainable partnership Forum on Marine and Maritime Science and Technology to enhance the dialogue between research communities, civil society, industry and policy makers involved in marine, maritime and coastal zone issues. The consortium will test various dialogue and collaboration mechanisms and establish those appropriate for strengthening cross-sector and interdisciplinary research. The Forum will be a new way of reducing fragmentation and cope with complexity in the European marine/maritime research sector, which could prove most useful to effectively manage – for example – the impact of large coastal Mediterranean cities on marine ecosystems. The Forum will therefore contribute to a new governance model in research that will exchange views, seek consensus among the marine and maritime sectors and serve to facilitate dialogue with policy makers. Respecting its geographic mandate, CIESM will endeavour to help filling gaps of knowledge / expertise across the whole Basin and to consolidate marine cooperation between the European Union and its Mediterranean neighbours in an integrated, multi-lateral fashion rather than via segmented, bilateral approaches.

REFERENCES

Branch G.M. and C.N. Steffani, 2004. Can we predict the effects of alien species? A case-history of the invasion of South Africa by Mytilus galloprovincialis (Lamarck). JMBE, 300: 189-215.

CIESM 2002a. Erosion littorale en Méditerranée : dynamique, diagnostic et remèdes. F. Briand (Ed.), CIESM Workshop Series n° 18, 102pp., Monaco.

CIESM 2002b. Alien marine organisms introduced by ships in the Mediterranean and Black Sea. F. Briand (Ed.), CIESM Workshop Series N. 20, 136 pp., Monaco.

CIESM 2002c. Mediterranean Mussel Watch – Designing a regional program for detecting radionuclides and trace-contaminants. F. Briand (Ed.), CIESM Workshop Series, n°15, 136 pages, Monaco.

CIESM 2004. Novel contaminants and pathogens in coastal waters. F. Briand (Ed.), CIESM Workshop Series, n°26, 116 pages, Monaco.

CIESM 2006. Marine Sciences and Public Health – Some Major Issues. , F. Briand (Ed.), CIESM Workshop Series, n°26, 128 pages, Monaco.

CIESM 2009. Online Atlas of Exotic species, http://www.ciesm.org/atlas/.

EEA - European Environment Agency 2006. Priority issues in the Mediterranean environment. EEA Report N°4/2006.

EIB - European Investment Bank 2008. Horizon 2020 – Elaboration of a Mediterranean Hot Spot Investment Programme (MeHSIP). Luxembourg, European Investment Bank.

Galil B.S., 2009. Taking stock: inventory of alien species in the Mediterranean Sea. Biological Invasions, 11: 359-372.

Galil B.S., N. Kress and Shiganova T.A., 2009. First record of *Mnemiopsis leidyi* A. Agassiz, 1865 (Ctenophora; Lobata; Mnemiidae) off the Mediterranean coast of Israel. Aquatic Invasions, 4(2): 357-360.

Galil B.S., 2007. Alien decapods in the Mediterranean Sea - which, when, where, why? Rapp. Comm. int. Mer Médit., 38: 9.

Galil B.S., 2006. Shipwrecked – Shipping impacts on the biota of the Mediterranean Sea. In: The Ecology of Transportation: Managing Mobility for the Environment, J. Davenport and J.L. Davenport (Eds). 39-69.

Kideys A. E., 2002: Fall and Rise of the Black Sea Ecosystem. Science 297(5586): 1482-1484.

Mack R.N., Simberloff D., Lonsdale W.M., Evans H., Clout M., and Bazzaz F.A., 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecol. Appl., 10: 689-710.

Occhipinti-Ambrogi A., 2002. Susceptibility to invasion: assessing scale and impact of alien biota in the Northern Adriatic. CIESM, 2002. Alien marine organisms introduced by ships in the Mediterranean and Black seas. CIESM Workshop Monographs, n20, 136pp, Monaco.

Rodriguez y Baena A.M., Thébault H., Andjelic T., Andral B., Bylyku E., Conte F., Delfanti R., Fontani S., Galgani F., Kniewald G., Osvath I., Pham M.K., Rozmaric Macefat M., Salvi S., Scarpato A. and Strok M., 2009. ^{210}Po (^{210}Pb) survey in the Adriatic Sea: early results from the CIESM Mediterranean Mussel Watch Phase II. In: Proceedings of the International Topical Conference on Po and Radioactive Lead Isotopes 2009.

Ruiz G.M., Carlton G.T., Grosholz E.D. and Hines A.H., 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent and consequences; Am. Zool., 37: 621-632.

Ruiz G.M., Rawlings T.K., Dobbs F.C., Drake L.A., Mullady T., Huq A., and Colwell R.R., 2000. Global spread of microorganisms by ships - Ballast water discharged from vessels harbours a cocktail of potential pathogens. Nature, 408 (6808): 49-50.

UNEP - United Nations Environment Programme 2002. Mediterranean Regional Report. Regionally based assessment of persistent toxic substances.

UNEP/WHO - United Nations Environment Programme/World Health Organization 2003. Second Report on the pollution hot spots in the Mediterranean - Part II- Revised Country Reports. Meeting of the MED POL National Coordinators, Sangemini Italy, 27–30 May 2003. UNEP(DEC)MED WG.231/5b.

Challenges for the marine environment in the Mediterranean. A possible approach: the European Marine Strategy Framework Directive

Louis-Alexandre Romaña and Jean-François Cadiou

Ifremer, Zone Portuaire de Brégaillon, 83507 La Seyne-sur-Mer, France

Keywords: marine strategy, European directive, good ecological status

Abstract

The Mediterranean is a semi enclosed sea considered as a hot-spot for biodiversity. Its ecosystems are subjected to strong pressures due to human activities and climate change. An ecosystem approach is needed to address these challenges. The European Marine Strategy Framework Directive (MSFD) which aims to achieve good environmental status by 2015 is part of this logic. The MSFD concerns a wide range of descriptors including physical, chemical and biological parameters in order to assess the status and the various forcing exerted on ecosystems. In the Mediterranean Sea, an added challenge is to establish with non-European countries a shared view at the scale of eco-regions.

Résumé

La Méditerranée est une mer semi fermée aux caractéristiques particulières. Dotée d'une biodiversité très riche, ses écosystèmes sont soumis aux pressions importantes exercées par les activités humaines et le changement climatique. Une approche écosystémique est nécessaire pour affronter ces défis. La Directive Cadre européenne sur la Stratégie Marine (DCSM) s'inscrit dans cette logique et propose une démarche visant à atteindre le bon état écologique du milieu marin à l'horizon 2015. La DCSM s'appuie sur un panel élargi de descripteurs concernant des paramètres physiques, chimiques et biologiques et permettant de caractériser l'état et les pressions sur les écosystèmes. En Méditerranée, un enjeu est d'établir à l'échelle des écorégions une vision partagée avec les pays non européens.

Of all the waters that border European coasts, the Mediterranean is a particular sea with very specific characteristics. It is almost completely landlocked and acts as a concentration basin fed by Atlantic and Black Sea surface water. Twenty-one countries have a coastline on the Mediterranean Sea (400 million inhabitants). Its nutrient-poor waters are home to a wide range of species, approximately 30% of which are endemic. With shorter cycles (the water body is renewed in a few decades compared to a few centuries for the world's oceans), the Mediterranean is used as a veritable laboratory for the observation of major trends affecting the marine environment under the effect of anthropogenic and climate forcing. The Mediterranean Sea is subject to a high level of pressure in connection to human activity resulting from increases in coastal populations, maritime traffic, tourism and the development of industrialization. This increasing pressure results in the destruction and deterioration of coastal habitats, over-use of certain marine resources, an increase in accidental and chronic pollution (urban wastewater, industrial waste, refuse, pesticides, new chemical contaminants, etc.), and the introduction of alien species. The decline of coastal Mediterranean ecosystems is a significant risk for the services they perform for populations of riparian countries. Sustainably preserving the Mediterranean's capacity to provide such services requires an overall approach. Transport via ocean currents, exchanges through the atmosphere and migrating species all create interactions which make the impact of these disruptions to ecosystems felt across the entire basin.

To meet these challenges, scientific and technical projects should be conducted on a Mediterranean scale with a view to making progress in our knowledge of how its ecosystems operate, to attempting to anticipate its reactions to anthropogenic disturbances and ultimately to contributing to management, protection and restoration measures for natural marine areas. This approach is consistent with the Barcelona Convention and Horizon 2020, and specifically with the European strategy to protect the Mediterranean. It is necessary to curb and control pressure on the environment. Dialogue and coordination between players and the use of shared methodologies and homogenous databases play a key role in achieving this.

To reach that objective of protecting and preserving marine ecosystems, the European Commission has recently – in 2008 - adopted the Marine Strategy Framework Directive (MSFD, [1]), which applies to European Countries, is not limited to coastal waters and concerns offshore marine ecosystems. The MSFD follows the European Water Framework Directive or (WFD, [2]) from 2000 which aims to achieve by 2015 a "good ecological status" of inland and coastal waters. WFD concerns marine waters for a coastal strip of 1 nautical mile wide (except in respect of chemical status for which it concerns territorial waters) and has made mandatory the setting up of monitoring and control programs taking into account physicochemical, biological (phytoplankton and phycotoxins, benthos) parameters as well as chemical contaminants (list of 33 priority substances).

The main objective of the Marine Strategy Framework Directive is to achieve or maintain good environmental status of the marine environment no later than 2020. The waters under the jurisdiction of European states (except overseas) are concerned. Marine regions and sub-regions to be considered homogeneously are defined. And so in the Mediterranean Sea, four sub-regions were identified: the western Mediterranean, Adriatic, Ionian Sea, and Aegean Sea. An ecosystem approach is recommended taking into account the watersheds and socio-economic factors. Given this directive is very new, work on its implementation is just beginning. But a program to monitor environmental conditions and pressure has to be defined by 2015. The MSFD concerns a wide range of parameters. Descriptors selected for determining good environmental status are:

1. Biological diversity, quality of habitats
2. Levels of non-indigenous species introduced by human activities
3. Status of populations of commercially exploited fish and shellfish
4. Marine food webs
5. Human-induced eutrophication (harmful alga blooms, impacts on ecosystems)
6. Sea-floor integrity and benthic ecosystems
7. Permanent alteration of hydrographical conditions, effect on marine ecosystems
8. Concentrations of contaminants
9. Contaminants in fish and other seafood for human consumption
10. Properties and quantities of marine litter
11. Introduction of energy, including underwater noise in the marine environment.

Further work will be necessary to properly define relevant indicators and value them. To reach the aim of assessing the status of marine ecosystems in a meaningful way, it is obvious that it will be difficult to carry out these tasks without a good knowledge of the functioning of the ecosystems. Another important point in the Mediterranean region, in line with the Barcelona Convention, is to think at the eco-region level and therefore to define a strategy involving non-European countries in the process of implementing the MSFD.

REFERENCES

[1] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

[2] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Effects of the Nile damming on Alexandria coastal waters

Mohamed A. Said and Ahmed A. Radwan

National Institute of Oceanography & Fisheries (NIOF), Kayetbay, Al Anfoshy Alexandria, Egypt

Keywords: Nile damming, coastal waters

Abstract

The Alexandria region is considered an important, underutilized resource for agriculture, tourism and industrial activities in Egypt. The main pollution sources are comprised of domestic sewage, industrial wastes, agricultural runoff through lake outlets, river discharge, and oil pollution. The effects induced by the Nile River damming on the physical characteristics of coastal waters in the region have been investigated.

As a result of the erection of Aswan High Dam in 1965, the last natural discharge of Nile flood waters into the Mediterranean Sea took place in the summer of 1964. Furthermore, the annual cycle of the discharge has changed.

The most pronounced and direct effect of the Nile damming is reflected in the salinity of Alexandria coastal waters, which increased from less than 27 in 1964 before the erection of Aswan High Dam, to around 38 in the Seventies and more than 39 in 2008. Concurrently, the temperature of surface waters increased by about 0.62°C/decade over the last 20 years. Overall, the increase in temperature and salinity with time observed in the coastal waters of the Alexandria region may be attributed either to anthropogenic modifications, especially the Nile damming, or to local climatic changes.

Résumé

La région d'Alexandrie est considérée comme une zone où les ressources agricoles, les activités touristiques et industrielles sont importantes mais sous exploitées. Les principales sources de pollution sont les rejets d'eaux usées, les déchets industriels, les polluants agricoles déversés dans les lacs, les rivières et la pollution pétrolière. Les effets du barrage sur le Nil sur les caractéristiques physiques des eaux côtières ont été étudiés.

Le grand barrage d'Assouan a été construit en 1965 et le déversement naturel du Nil dans la Méditerranée a été interrompu à l'été 1964. Depuis cette date, des changements dans le cycle annuel de déversement du fleuve ont été observés.

L'effet direct le plus prononcé de la construction du barrage sur le Nil est l'augmentation de la salinité dans les eaux côtières d'Alexandrie qui est passé de

moins de 27 (en 1964 avant la construction du barrage) à environ 38 (dans les années 70) à plus de 39 en 2008. En parallèle, la température des eaux de surface a augmenté de 0.62°C par décade dans les 20 dernières années. De façon générale (ou globale) l'augmentation de la température et de la salinité avec le temps dans les eaux côtières de la région d'Alexandrie peut être attribuée soit aux modifications anthropogéniques (construction du barrage sur le Nil), soit au changement climatique local.

INTRODUCTION

The coastal zone of Egypt on the Mediterranean extends from El-Sallum in the west to El-Arish in the east for over 1200 km. Alexandria is the largest Egyptian city on the Mediterranean (more than 4 million inhabitants). It is the main summer resort of Egypt along the Mediterranean coast. 40% of the nations' industry surrounds the city from the southern and western borders. Alexandria region (Fig.1) includes Abu Qir Bay, Rosetta branch of the Nile River, Lake Edku and El-Max Bay. The study area receives various types of pollutants through several land-based sources. The major types of pollution sources are domestic sewages, industrial wastes and agricultural runoff through Lake Edku, Rosetta Branch of the Nile River and El-Umum Drain. Industrial wastes include petrochemicals, fertilizers, textile, dyes and weaving industries, food processing and canning, power plant, paper and cement industry.

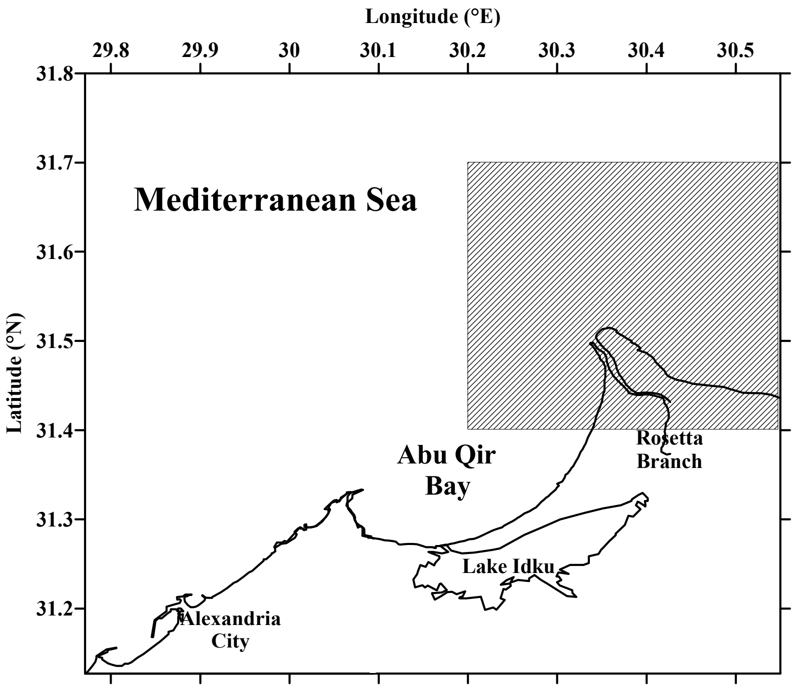


Figure 1. Alexandria region

Consequently, this region is presently facing the problem of water pollution at some level, which is expected to increase in the future. The aim of the present work is to study impact of the damming of the Nile River on the water characteristics of Alexandria region.

MATERIALS AND METHODS

The water discharge from the Rosetta Branch of the Nile River was taken from Irrigation Department of the Egyptian Ministry of Public Works and Water Resources (Cairo) during the period 1956-2007. Temperature and salinity data were taken from all the surveys carried out in the study area (hashed area) during the period 1964-2008 (Fig. 1).

RESULTS AND DISCUSSION

Before the High Dam, data of the Irrigation Department of the Egyptian ministry of public works and Water Resources indicated that the average yearly discharge of the Nile through Rosetta and Damietta branches for the period of 31 years (1912-1942) amounted to 62 km^3 (Gerges, 1976). As a result of the erection of Aswan High Dam in 1965, the summer of 1964 was the last time for the flood water to discharge into the Mediterranean. The average yearly discharge for the proceeding 10 years (1956-1965) amounted to 46.93 km^3.

From 1966 on the discharge remarkably decreased. Fig. 2 illustrates the yearly Nile water discharged to the Mediterranean through Rosette Branch. The average yearly discharge from 1966 to 2007, i.e. for 42 successive years, amounted to 3.92 km^3, representing about 8% of the average value for the period prior to 1965.

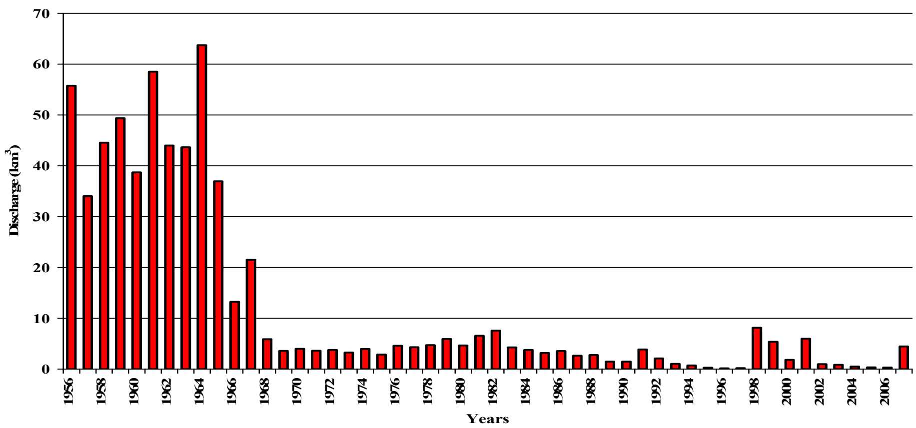


Figure 2. Yearly Nile River discharge (km^3) through Rosetta Branch during the period 1956-2007

Moreover, the annual cycle of the discharge has changed. The discharge usually occurred from July to August until December or January, the maximum discharge was observed on september-october with 25 to 30% of the total discharge (Gerges, 1976). At present, the discharge is only through Rosetta, and the maximum is recorded in winter months. About 65% of the total annual discharge flows into the sea during the three months of December, January and February. Such a change in the total amount and pattern of fresh water discharge to the Mediterranean would certainly affect the physical, chemical as well as the biological conditions of the south-eastern part of the Mediterranean Sea.

The most pronounced and direct effect of the damming of the Nile River is reflected on the salinity distribution in the coastal water of the Egyptian coast. The salinity distribution in this region is characterized by a great complexity due to the interaction between different factors: the intensive evaporation, the flow of Atlantic water of low salinity, the existence of Levantine water of high salinity and the river discharge. The last of these factors is now of a minor value, and hence any distribution of salinity is controlled by the other factors.

According to Gorgy (1966) and Halim et al (1967), the water discharge from the Nile caused a rise in sea level at the coast, particularly near the river outlet. The water slope led to a rise in the horizontal pressure gradient toward the north, which helped the waters from Rosetta to be moved in a northwest direction and spread by its own momentum in that direction to an area of about 50 km^2 from the outlet, before being deflected eastward by Coriolis force. Thus the "Nile Stream" was formed which in its way eastward received more flood water from Damietta and moved further to the east close to the coast with low salinity. At present, the Nile water does not cause such a rise in the water level near the coast. As a result, the horizontal pressure gradients are much less, and the Nile Stream has completely disappeared.

Fig. 3 illustrates the long term variation of surface salinity in the coastal water of the study area (Fig. 1) during 1964-2008. In 1964, the river discharge was the greatest since 1956, and the surface salinity was very low about 26.675. From 1966 on, a considerable decrease of fresh water discharge was recorded and a remarkable increase of salinity was observed. The salinity increased from 28.309 in 1966 to around 38 in Seventies and reached >39 in 2008. The temperature anomaly of the surface water of the study area fluctuated between negative and positive values with a general trend of increasing to reach 0.62°C/dec during the last 20 years (Fig. 4).

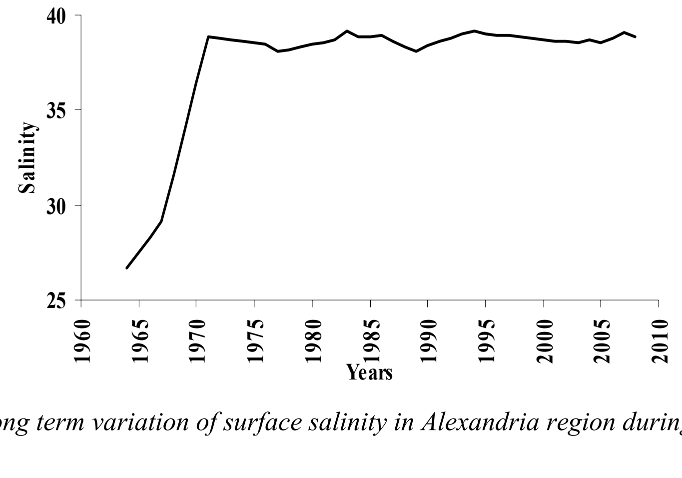


Figure 3. Long term variation of surface salinity in Alexandria region during 1964-2008

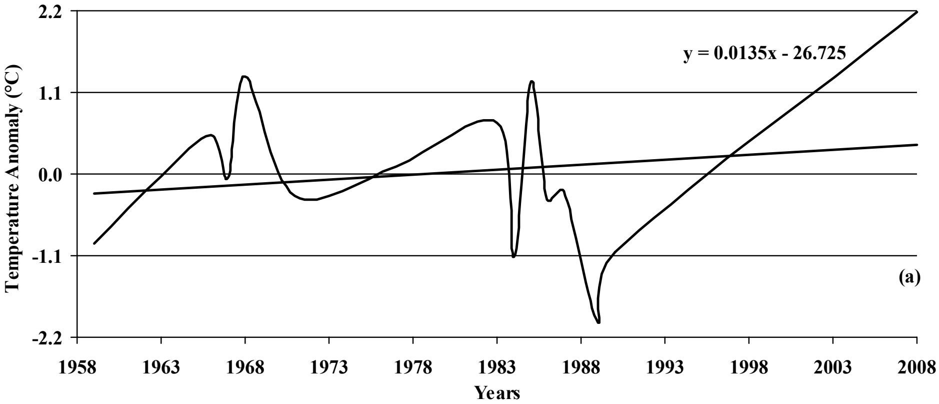


Figure 4. Temperature anomaly of the coastal water of Alexandria region during 1958 to 2008

CONCLUSIONS

Alexandria region is presently facing the problem of water pollution at some level, which is expected to increase in the future. The most pronounced and direct effect of the damming of the Nile River is reflected on the salinity distribution in the coastal water of Alexandria region. The salinity increased from 26.675 in 1964 to more than 39 in 2008. A considerable decrease of fresh water discharge and the resulting remarkable increase of salinity bring a corresponding change in water density in the coastal areas, and affect the stability conditions, the mixing processes and the current system in the area.

During the last 20 years, the temperature of the surface water increased by about 0.62oC/dec. This increase of temperature and salinity of the coastal waters of Alexandria region with time may be attributed either to anthropogenic modifications, especially the Nile damming or to local climatic changes.

REFERENCES

Gerges M.A., 1976. The damming of the Nile River and its effects on the Hydrographic conditions and circulation pattern in the southeastern Mediterranean and the Suez Canal. Acta Adritiaca, 18: 179-191.

Gorgy S., 1966. Les pêcheries et le milieu dans le secteur méditerranéen de la RAU. Res. Des Trav. Inst. Peches Marit., 30(1): 25-92.

Halim Y., Guergues S.K. and Saleh H.H., 1967. Hydrographic conditions and plankton in the South East Mediterranean during the last normal Nile flood (1964). Int. Revue ges. Hydrobiol., 52(3): 401-425.

Impact of large Mediterranean coastal cities on marine ecosystems: the case of the Gulf of Tunis

Cherif Sammari

Institut National des Sciences et Technologies de la Mer, 28 rue 2 mars 1034
2025 Salammbô, Tunisia

Keywords: gulf of Tunis, urban pressure, water and sediment quality, coastal habitats, remediation

Abstract

Lined by the biggest urban area in Tunisia, the Gulf of Tunis undergoes a strong anthropogenic pressure and, thereby, a strong impact on its coastal waters. Works, among the most recent, evoke changes in quality of the Gulf waters and surface sediments, as well as the regression of its biodiversity. This is all the more alarming since the dynamics of the waters masses in this gulf is mainly driven by winds and, consequently, its threshold of acceptability is easily reached in some places.

Recently, a study carried out within the framework of the program UNEP/MAP[1] has listed all sources of nuisances, established the ecological quality status of the gulf, and proposed the measures that should be taken. The survival of the now fragile ecosystems of the gulf of Tunis depends, to some extent, upon the capacity to put into effect these recommendations and the pace at which this is done.

Résumé

Bordé par la plus grande agglomération de la Tunisie, le golfe de Tunis subit une forte pression anthropique et donc une forte sollicitation de ses eaux côtières. De très récents travaux évoquent l'altération de la qualité de ses eaux et de ses sédiments de surface ainsi que la régression de sa biodiversité. C'est d'autant plus alarmant que la dynamique des masses d'eaux du golfe est contrôlée essentiellement par les vents et par conséquent il n'est pas étonnant de voir son seuil d'acceptabilité franchi par endroits. Récemment, une étude réalisée dans le cadre du programme PNUE/PAM[2] a répertorié toutes les sources de nuisances, établi l'état de santé écologique du golfe et proposé les mesures d'accompagnement nécessaires. De la capacité et la rapidité à mettre en œuvre ces recommandations dépendra en partie la survie des écosystèmes - désormais fragiles - qu'abrite le golfe de Tunis.

---

[1] United Nations Environment Programme/Mediterranean Action Plan
[2] Programme des Nations Unies pour l'Environnement / Plan d'Action pour la Méditerranée

Due to its key position between the western and eastern Mediterranean basins, the Gulf of Tunis plays a major role, not only in regard to the marine ecosystem of north Tunisia but also when considering the whole Mediterranean Sea.

This Gulf of Tunis is formed by a little gulf and a subjacent larger one. It is characterized by an heterogeneous structure (lagoons, bays and estuaries) and important river systems (Wadi Medjerda, lake of Tunis and its wadis, Wadi Méliane, Wadi ElBey, Wadi Bézirk et Wadi El Abid).

The gulf of Tunis is bordered by the largest city in the country as well as other smaller towns (see fig. 1). Therefore, it is under pressures resulting from : i) urban activities (domestic treated wastewater, discharges of untreated sewage and solid waste) ; ii) industrial activities (thermoelectric power plant's cooling water, industrial sewage and solid waste) tourism (hotels and marinas) ; iii) ports (Tunis, Radès and Goulette harbours) and shipping given 43% of the national maritime traffic pass through the Gulf of Tunis ; iv) agricultural activities (runoff waters containing fertilizers and pesticides) ; v) urban runoff waters coming from Tunis area.

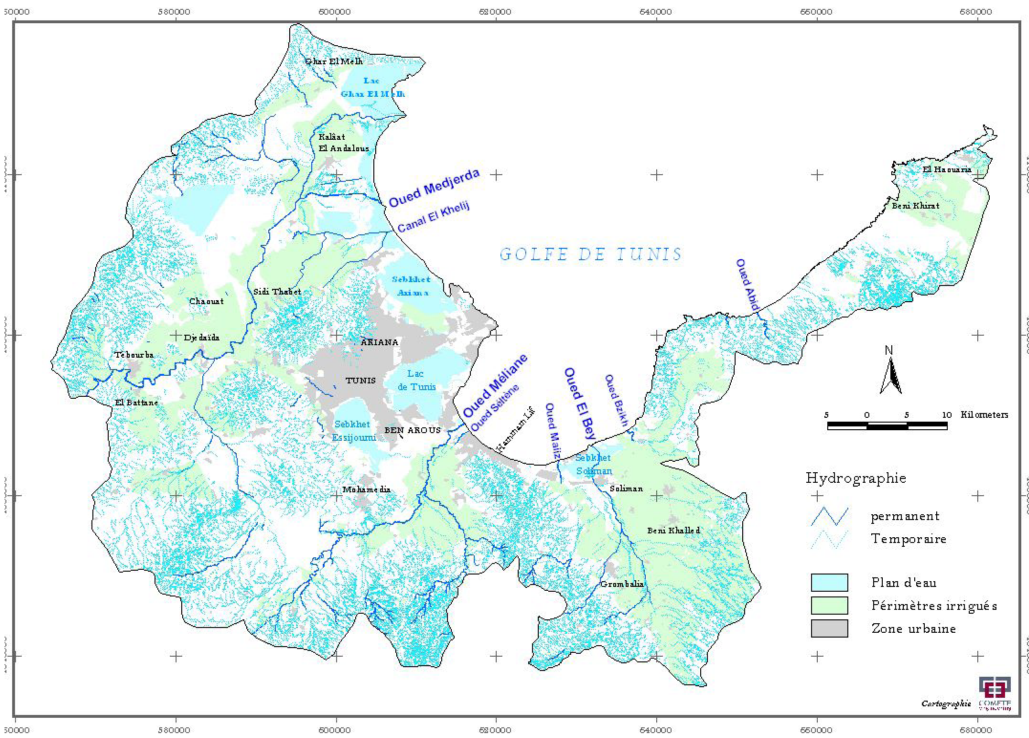


Figure 1. Map of the Gulf of Tunis

Other direct or indirect phenomenon such as those involved by the impact of urban and industrial development in the catchment areas or on the embankments of the gulf of Tunis (breakwaters, harbour, etc…) can also affect the ecological system. They can lead to a decrease in sediments inputs, to coastal erosion, to the creation of sludgy areas, etc. Despite this, the Gulf of Tunis is an important fishing area.

The bibliographical study of the gulf brings out the scarcity of data and especially the lack of recent information. However, all studies agree on the alteration of its ecological status. In recent years, more and more signs of eutrophication of the gulf (water coloration, turbidity, regression of Posidonia beds seagrass and blooms of nitrophilic algae) appeared.

This situation, yet not alarming, is a strong warning to show the necessity to study the Gulf ecosystems, to take preventive measures and to control the pressures exerted on coastal waters.

In a more comprehensive way, the works of Ben Mustapha et al, 2002, have shown the sensible decline in Posidonia beds in the gulf and the necessity to set up marine protected areas to preserve some sites being considered among the richest ones at the scale of the Mediterranean Sea. The data provided by Ben Mustapha in 1992 reveal the presence of a (now disappeared) barrier reef. They showed also that a Posidonia bed stretched up to 20 meter deep, when today its limit is at a depth of ten meters. These studies bring out the importance of stress factors in this area.

Jallouli (2005) has pointed the presence and abundance of toxic dinoflagellates, including in areas of Posidonia beds that could be considered as healthy.

By focusing on the ecological significance of the variability of polychaetes populations, Zaabi et Afli (2006), have detected in some areas of the Gulf the an initial imbalance which could be the first sign of a break.

Saidi et Brahim (2007) have shown that the sedimentary imbalance existing in the Gulf was mainly due to a sediment deficit caused by the trapping of particles in the dams built on several wadis, to the fixing of sand dunes resulting from seaside urbanization, and to the blocking of sediment transport by the port construction works.

Regarding fishing stock wealth, it is established that fishing yields tend to decline for years. In 1984, yields were about 102 kg/h (Gharbi et al. 1986), when at the moment they are only about 40 kg/h (Zarrad et al, 2007).

Besides, a strategic study conducted to quantify the impact of an accelerated rise in sea level on the coasts of Tunisia and their vulnerability showed that the various sections of the Gulf of Tunis are ranked at degrees between "vulnerable" and "very vulnerable".

A project named “Determination of priority actions for the development and implementation of the Strategic Action Programme in the Mediterranean" was launched by the Coordination Unit of the Mediterranean Action Plan (UNEP/MAP) and approved by the Board of the Global Environment Fund (GEF). The project's main objective is, in a long term view, to improve the marine environment in the Mediterranean area through better management of the land based sources of pollution. A first list of priority "Hot Spots" has been defined in close collaboration with concerned countries, based on a matrix of criteria. Tunisia is on the list of selected countries. The Gulf of Tunis was selected as a case study for pre-investment in pollution remediation.

The main objectives of the study are the identification and the characterization of sources of pollution in the Gulf of Tunis, the analysis of pressures exerted on environment, the analysis the response of the Gulf to these pressures and the suggestion of priority actions for the cleanup of the Gulf.

The results of this study are very new since they allow quantifying the impacts of human activities on the fragile ecosystem that is the Gulf of Tunis. We give below, in an illustrative and not exhaustive way, some of the findings of this study.

The east-west asymmetry in the transparency of coastal waters can be related to the configuration of the coast which is flat in the western side and rocky in the eastern part. Moreover, the degree of urbanization of the coast is important to the western part and in the Bay of Tunis and extremely low in the east side.

According to the total phosphorus content, it was concluded that the waters of the Gulf belong to the category of coastal waters affected by land-based pollution.

The bacteriological contaminations are recorded in the bathing areas and particularly around Ezzahra, where there is a large mass of dead rhizomes of Posidonia, close to the discharge of the Méliane wadi and near the discharge of canal Khalij.

According to the study mentioned above, the environmental situation in the Gulf has been read as a dramatic scenario, but unfortunately realistic. Even if the point of departure was a relatively healthy environmental situation.

This applies to the area 7 of Sidi Daoud that will clearly deteriorate, as the human activities pressure will increase. Even in its central part, the environmental situation can be considered as worrying due to high concentrations of TOC (Total Organic Carbon) which involve a risk of anoxia, in conjunction with an intense trawling pressure.

The Gulf dynamics has also been well studied and it was determined that in absence of wind, ocean currents are low and the pollution is concentrated near the discharge points, dispersal towards open sea being low and very slow.

The results of the simulations performed with an ecological model developed under this study, although very simple, shows that, from a discharge flow of about 1.3 m^3/s for Méliane wadi, the waters of Radès coastal zone would very probably be eutrophic or hyper-eutrophic according to the OECD (Organisation for Economic Cooperation and Development) classification.

As a conclusion, it is time now to take measures in order to mitigate or minimize the impacts of human activities on marine ecosystems. If several scenarios are suggested for the Gulf of Tunis, we must think about the effective capacity to implement them. Because, as usually, the compromise between the socio-economic and environmental constraints is not easy to find.

Finally, it is imperative to strengthen the scientific research programs and to collect observational data over long periods to remove the ambiguity about some conclusions drawn from incomplete data sets (*in situ* data sets are often too limited in terms of time and space range).

The use of the Research budget of the European Commission in order to increase the environmental knowledge of the Mediterranean Sea and to assure its broadcasting is more than ever imperative. It is moreover, one of the pillars of the euro-Mediterranean actions, in particular the one relative to the cleanup of the Mediterranean Sea.

REFERENCES

Ben Mustapha K. et Hattour A., 1992. Les Herbiers de posidonies du littoral tunisien. *Notes Inst. Nat. Scien. Tech. Oceanog. Pêches, Salammbô*. 2, 1- 42.

Ben Mustapha K., Afli A., 2007. Quelques traits de la biodiversité marine de Tunisie. Proposition d'aires de conservation *In* Report of the MedSudMed Expert Consultation on Marine Protected Areas and Fisheries Management. *MedSudMed Technical Documents*, N°3, GCP/RER/010/ITA/MSM-TD-03. Rome: pp: 32-55.

Etude de vulnérabilité environnementale et socio-économique du littoral tunisien face à une élévation accélérée des niveaux de la mer due aux changements climatiques et identification d'une stratégie d'adaptation, 2006. Bureau d'Etudes Ingénierie de l'Hydraulique, de l'Equipement et de L'Environnement.

Etude de pré-investissement relative à la dépollution du golfe de Tunis, 2008. phase-1 : inventaire des sources de pollution et caractérisation de l'état du golfe de Tunis. Groupement Comète engineering – BCEOM – IHE.

Jarboui O., Zamouri N., Missaoui H., Ben Hadj Hamida N., 2005. Study of the discards of benthic trawl fisheries of Tunisian coast. *National Research Activities, COPEMED project*.

Lotfi Ben Abdallah., 2007. Biomass estimation and mean sizes geographical distribution of the sardine (sardina pilchardus*)* and the european anchovy (engraulis encrasicolus) in the Tunisian water. *Les 9ièmes Journées Tunisiennes des Sciences de la Mer Tabarka*: 15–18.

Zaabi S. et Afli A., 2006. Signification écologique de la variabilité des polychètes dans le golfe de Tunis. *Bull. Inst. Nat. Scien. Tech. Oceanog. Pêches, Salammbô*, Vol 33, 29-35.

Pressure and state of the marine chemical contamination in the vicinity of a large coastal Mediterranean city, the case of Marseilles

Didier Sauzade[1], Bruno Andral[1], Jean-Louis Gonzalez[2], Ivane Pairaud[1], Romaric Verney[3], Mathilde Zebracki[1], Jean-François Cadiou[1] and Pierre Boissery[4]

[1]*Laboratoire Environnement Ressources Provence Azur Corse, Ifremer Centre de Méditerranée, La Seyne sur mer, 83507, France*
[2]*Laboratoire LBCM, Ifremer Centre de Méditerranée, France*
[3]*Laboratoire PhySed, Ifremer Centre de Brest, France*
[4]*Agence de l'Eau Rhône Méditerranée &Corse, Délégation de Marseille, France*

Keywords: Marseilles, pollution flow, contaminant inputs, wastewater, storm water run-off, modelling

Abstract

Marine pollution is one of the priority issues of the Mediterranean environment. This pollution comes from multiple sources including large coastal cities which are considered as hot-spots. The METROC project objective is to assess gross and net chemical contaminant flows related to large Mediterranean coastal cities, with a first application to the Marseilles area. The methodology consists of i) assessing the present state of the chemical contamination of the coastal environment; ii) assessing inputs to the sea from sewage, small rivers and storm water run-off; and iii) modelling the fate of some key contaminants, in order to attempt to establish a balance between inputs and exports towards the open sea. This short article presents a synthesis on these different phases.

Résumé

La pollution du milieu marin est l'un des problèmes prioritaires pour l'environnement méditerranéen. Cette pollution provient de multiples sources en particulier de grandes citées considérées comme des "points chauds". Le projet METROC a pour objectif d'évaluer les flux bruts et nets des contaminants chimiques issus des grandes métropoles côtières méditerranéennes en prenant comme premier cas d'application l'agglomération marseillaise. La méthodologie consiste à : évaluer l'état actuel du milieu marin ; évaluer les apports au milieu marin en provenance des rejets industriels et urbains, des cours d'eau côtiers et des déversoirs d'orage ; puis à modéliser le devenir de quelques contaminants clefs pour lesquels on tentera d'établir un bilan. Ce court article présente une synthèse des différentes phases du projet.

INTRODUCTION

Marine pollution is one of the priority issues of the Mediterranean environment. This pollution comes from multiple sources. The Mediterranean Action Plan has shown that few large cities were responsible for a major fraction of the inputs from urban areas and should be considered as hot spots. The METROC project objective is to assess gross and net chemical contaminant flows related to large Mediterranean coastal cities, with a first application to the Marseilles area. It comes from an Ifremer initiative and is supported by the Rhone Mediterranean & Corsica Water Agency, territorial communities and scientific partners. Methods consist of i) assessing the present state of the chemical contamination of the coastal environment; ii) assessing inputs to the sea from sewage, small rivers and rain water run-off; and iii) modelling the fate of some key contaminants, and establish the balance between input and export towards the open sea. This short article presents a synthesis on these different phases and their results.

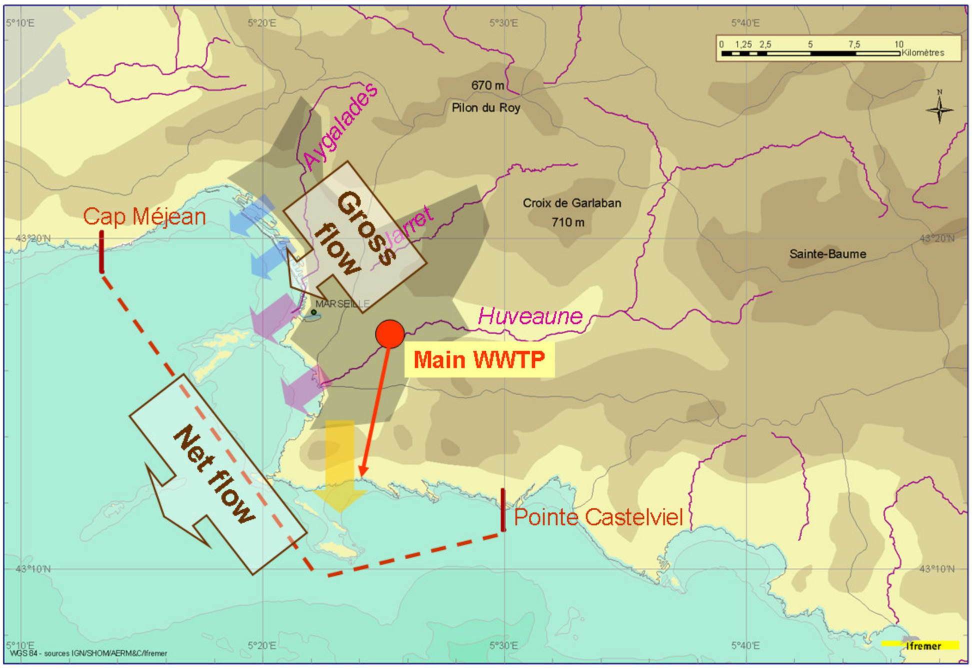


Figure 1. Pollution flows from the agglomeration of Marseilles, general map

The area under study is the Gulf of Marseilles, directly impacted by the chemical contamination inflows resulting from the Marseilles urban agglomeration (Fig. 1). These inflows concern mainly:

- Discharges of the sewerage network, which drains the domestic and industrial wastewater;
- The semi artificial water courses and untreated storm water drain outlets;
- Effluents of the main sewage system which are treated by a primary and secondary large wastewater treatment plant (WWTP), with a capacity of 1.8 million equivalent inhabitants This WWTP serves 16 communities consisting

of over one million inhabitants, for a total surface of about 520 km².

Water courses are primarily coastal rivers whose watersheds cover 560 km². The urban area is bordered by the Mediterranean on its Western frontage with a linear coast length of 50km (outside the islands). On the landside, the Gulf of Marseilles includes three principal sectors:

- The strongly urbanized northern harbour, with industrial and commercial facilities related to port activities;
- The southern harbour, urbanized with balneal activities, which receives the natural flow of the main river, Huveaune, only flowing during storm condition;
- The southern seafront with a very steep relief, which receives in the Cortiou creek both the main WWTP outlet and the Huveaune river flow in normal condition.

The continental shelf is narrow in this sector and the depth in the Gulf increases to reach 100 meters close to its outside limit.

METHODOLOGY

The general objective of this study consists in evaluating gross and net flows of chemical contamination stemming from the agglomeration of Marseilles. Gross flows are those which arrive to the sea, net flows are those which are exported offshore from the coastal zone and which feed the general contamination of the Mediterranean basin. The method consists of:

- Establishing a diagnosis of the marine environment chemical contamination. The contaminants in biota, sediment and in some cases water are measured, with complementary work using passive samplers;
- Measuring the land-based contributions in contaminants, by carrying out a sampling campaign in order to characterize these contributions for various weather situations (dry and rainy time) by distinguishing dissolved and particulate fractions;
- Modelling the fate of these contributions, by using 3D coupled models including an hydrodynamic model for the dissolved fractions and, a sediment transport model for the particulate fractions;
- Establishing assets of contaminant flows from the results of these models.

MARINE COASTAL CONTAMINATION STATUS

A campaign of surface sediment sampling with a box corer was carried out in November 2004, including 42 points, located on radials over a distance of about 15 km.

For biota, the active biomonitoring technique was used: mussels from a common origin were transplanted into oyster bags attached to buoys and installed for a period of about three months. Contaminants were measured in the whole flesh of mussels. 15 stations were placed on radials at 20, 40 and 70 m water depth.

Approximately, the same set of contaminants was measured in sediment and mussels:

- Metallic: Pb, Cd, Hg, Ni, and Al;
- Organic: 16 PAHs, DDT, DDD and DDE, CB 138 and CB 153 and, in mussels only, dioxins and furans.

In addition, following work was done:

- A campaign using experimental passive samplers;
- Ecotoxicological tests (oyster larvae test) on the sediment (35 points);
- Experimental measurements on emerging contaminants (akylphenol, polyethoxylates and pharmaceuticals) in the discharge plume of the principal urban outlet;
- The results were compared with previous studies. Maps of contamination were established, such as in Fig. 2 and Fig. 3. Results showed contrasted levels of contamination:
    - strong for lead, with very high levels (573mg/kg) in the area of Cortiou and, to a lesser extent, in other areas of the Gulf
    - significant for mercury, PAHs[1], DDT, and PCBs[2]
    - localized for dioxins and furans, as well as for emerging contaminants.

All of these results are presented in Sauzade *et al.* 2007.

[1] PAHs: Polycyclic Aromatic Hydrocarbons
[2] PCBs: Poly Chlorinated Biphenyls

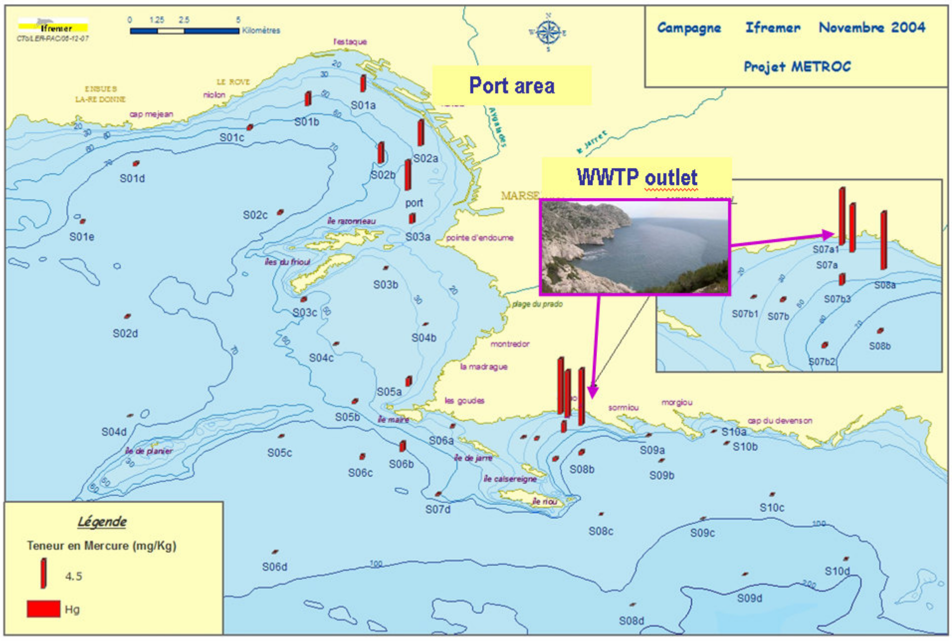


Figure 2. Mercury levels in superficial sediment

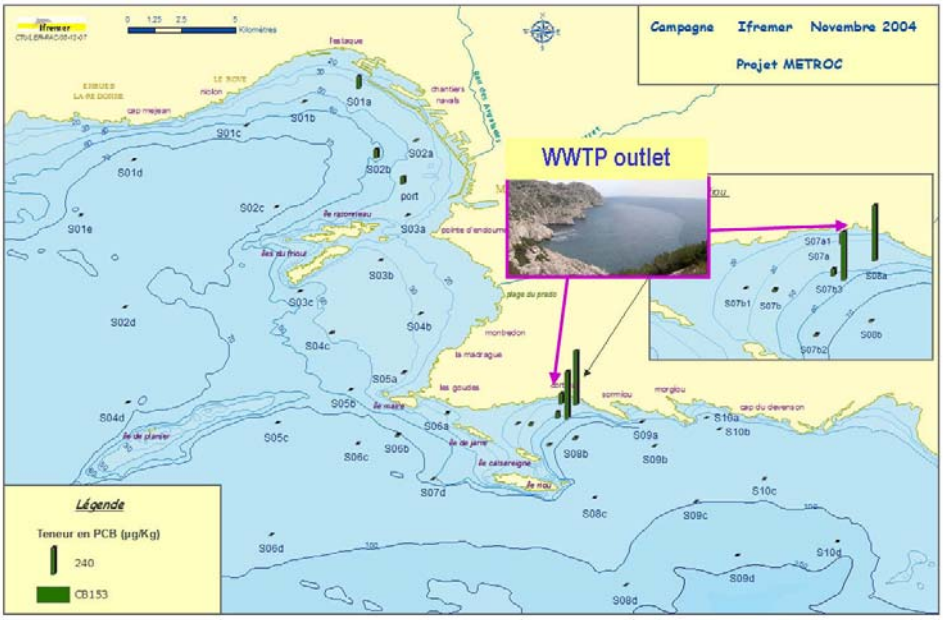


Figure 3. PCB levels in superficial sediment

ASSESSMENT OF INPUTS

The assessment of inputs to the marine environment is particularly difficult due to the number and diversity of inputs and the rapidly changing discharge patterns, strongly depending on flow rates during rainy periods. With the help of the Water and Sewerage Department of the Marseilles Provence Metropole Community Council[3] and the operating company SERAM, a sampling program is being defined.

A minima, it will include i) for dry weather condition, a sampling point in front of the wastewater treatment plant, a sampling point on each of the two largest coastal rivers; and ii) for wet weather condition, the same points plus two points on storm water drains.

Measurements of suspended matter (SM) and contaminants will be reported to concomitant water flows. Many previous measurements made for various weather patterns show that the annual flow of water is about 2,107 m^3, approximately half of which is processed by the wastewater treatment plant. Wet weather only accounts for 10% of the water flow but nearly 80% of the SM contribution (Le Masson, 1997).

Chemical contaminants selected for the first assessment of the flow are:

- Metal contaminants: Pb, Hg, and Ag
- Organic contaminants: PCBs, PAHs, and PBDEs[4]

MODELLING THE FATE OF CONTAMINANTS IN MARSEILLES COASTAL WATERS

The fate and bioavailability of contaminants in the marine environment are governed by various biological, chemical and physical processes. For a contaminant, the predominance of one of these processes will depend mainly on physico-chemical and contaminant variables (physical, chemical and biological) and environmental variables (current velocity, concentration and nature of suspended matters, concentration and nature of organic matter, sedimentation rate, *etc*.). These parameters are either known or modelled by a hydrodynamic and sediment model, supplemented by a biogeochemical model of organic matter recycling.

A 3D hydrodynamic model using MARS 3D (André 2005) is being validated (Fig. 4.) and a transport model of suspended matter is under development. Their calibration and validation require multiple measurements (current velocity, salinity, temperature, sediment altimetry, suspended matter concentration, sediment surface erodibility).

[3] Communauté Urbaine Marseille Provence Métropole
[4] PBDEs: Poly Brominated Diphenyl Ethers

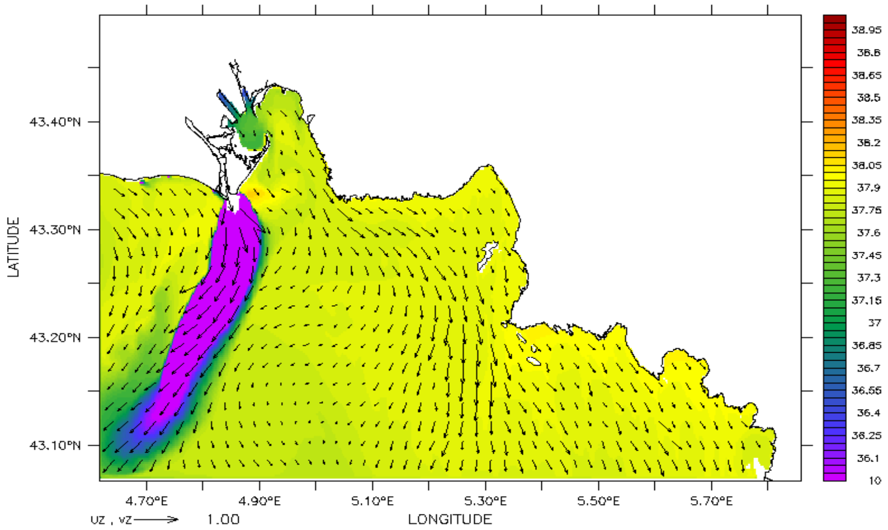


Figure 4. Rhone river mouth-Marseilles MARS 3D model output. Surface salinity (PSU) and currents, situation of strong northern wind (27-sep-2007)

The chemical dynamics model for selected contaminants is being defined. It will then be coupled with the previous models to build the final model of contaminant fate.

BALANCE OF THE CONTAMINANT FLOW

These models will make possible to compute balances between gross flows (incoming) and net flow (exported) for selected contaminants in homogeneous areas of the study site. Results will be compared with the marine environment status established in previous phases. The various sources of contaminants (effluents, rivers, runoff, and atmospheric deposition) will be ranked. Importance of different climatic conditions will be evaluated. A comparison with other known sources of contaminants to the north western Mediterranean (like the Rhone river contribution for instance) basin will be attempted. If realistic, these models can be used at a later stage to consider scenarios, depending on various assumptions such as decrease or increase in contaminants inflows.

CONCLUSION AND PERSPECTIVE

The METROC project for the assessment of gross and net flows of chemical contaminants from a large coastal city, Marseilles, began in 2003. Six years later, results have been obtained in terms of marine environment status, knowledge of inflows, modelling (hydrodynamics, suspended matter, fate and transfer of contaminants). These results also enabled to provide expertises for the benefit of territorial communities which support this project. Preliminary contaminant flow balances are expected for 2012. The long duration of this project is mainly due to its innovative parts, but the experience gained in the Marseilles case study should shorten and make easier further applications to other major Mediterranean coastal cities.

ACKNOWLEDGMENTS

This project was possible thanks to the support of the Water Agency of Rhone Mediterranean & Corsica. It also received the support from the managers of the City of Marseille, the Marseilles Provence Metropole Community Council and the concerned State administrations. It also fostered several scientific collaborations, especially with the Center of Oceanology of Marseille.

REFERENCES

Andral B., Stanisière J.Y., Sauzade D., Damier E., Thébault H., Galgani F., and Boissery, P., 2004. Monitoring chemical contamination levels in the Mediterranean based on the use of mussel caging. Marine Pollution Bulletin 49: 704-712.

André G., Garreau P., Garnier V., and Fraunié P., 2005. Modelled variability of the sea surface circulation in the North-western Mediterranean Sea and in the Gulf of Lions, Ocean Dynamics 55: 294-308.

Arfi R., Arnoux A., Bellan-Santini D., Bellan G., Laubier L., Pergent-Martini C., Bourcier M., Dukan S., Durbec J.-P., Marinopopoulos J., Millot C., Moutin T., Patriti G. and Petrenko A. (V. de Marseille), 2000. Impact du grand émissaire de Marseille et de l'Huveaune détournée sur l'environnement marin de Cortiou - Etude bibliographique raisonnée 1960-2000. 137 pp.

European Environment Agency, 2006. Priority issues in the Mediterranean environment. 88 pp.

Le Masson J. et *al*., 1997. Mesure de la pollution par temps de pluie à Marseille, Rapport SERAM pour la Direction de l'Assainissement de la Ville de Marseille, 21pp.

Sauzade D., Andral B., Gonzalez J.L., Galgani F., Grenz C., Budzinski H., Togola A., Lary S., Kantin R., and Cadiou J.F., 2007. Synthèse de l'état de la contamination chimique du golfe de Marseille, Rapport Ifremer DOP/LER-PAC/07-05 pour l'Agence de l'Eau Rhône Méditerranée & Corse, 209p.

Strazzulla J.Y., 1985. Bilan de la contamination chimique des sédiments du golfe de Marseille (thèse).

UNEP/WHO, 2003. Second Report on the pollution hot spots in the Mediterranean-Part II-Revised Country Reports. Meeting of the MED POL National Coordinators, Sangemini Italy, 27–30 May 2003. UNEP (DEC) MED WG.231/5b.

Wafo E., Sarrazin L., Diana C., Schembri T., Lagadec V., and Monod J.L., 2006. Polychlorinated biphenyls and DDT residues distribution in sediment of Cortiou (Marseille, France) Marine pollution bulletin 52: 104-120.

Strengthening the partnership between marine sciences and civil society with a special emphasis on issues related to large coastal cities in the Mediterranean

Michael Scoullos

Laboratory of Environmental Chemistry, University of Athens, Greece; MIO-ECSDE[1]; GWP-MED[2]

Keywords: ecosystem degradation, public awareness, education, participatory approach

Abstract

In the last 20 years large metropolitan areas, similar in structure and character, have increased all around the Mediterranean. The intensity of the anthropogenic activities in them contributes to major pollution and destruction of natural ecosystems, despite any efforts in operating wastewater treatment plants and urban solid waste management schemes.

The majority of Mediterranean people are cut off from nature, they know virtually very little about basic phenomena related to the functioning of marine /coastal systems and they do not see any direct connection between themselves and the management of the marine environment. Their preparedness for natural or man-made disasters affecting the coastal zone is minimal.

The various initiatives of marine scientists and academic research institutions in many countries are not enough. There is a need for a radical change in the concept of science and research accountability towards society on relevant issues and effective dissemination and communication strategy on science and research results. Drastically reformed education, a thoroughly revised media policy and a strengthened role of learned societies, institutions, professional associations and other types of NGOs and civil society organizations are needed to address the challenges of the new era.

Résumé

Au cours des 20 dernières années, de grandes métropoles se sont développées tout autour de la Méditerranée. Elles sont le lieu d'activités anthropiques intenses qui génèrent une pollution importante et contribuent à la destruction des écosystèmes

---

[1] MIO-ECSDE: Mediterranean Information Office for Environment, Culture and Sustainable Development

[2] GWP-Med: Global Water Partnership-Mediterranean

naturels, malgré les efforts faits pour mettre en place des installations de traitement des eaux usées urbaines et des déchets solides.

La majorité des Méditerranéens sont coupés de la nature. Ils savent peu de choses des mécanismes de base régissant le fonctionnement des écosystèmes marins côtiers et ne voient pas de relation directe entre eux et la gestion de l'environnement marin. Leur degré de préparation à des catastrophes naturelles ou causées par l'homme pouvant affecter la zone côtière est minime.

Les différentes initiatives des chercheurs en science marine et des institutions de recherche de nombreux pays ne sont pas suffisantes. Il faut que s'effectue un changement radical dans la conception de la responsabilité de la recherche scientifique vis-à-vis de la société pour ce qui concerne la pertinence des questions abordées, la diffusion effective des résultats et la stratégie de communication sur les travaux de recherche. Un dispositif d'enseignement significativement réformé, une révision en profondeur de la politique de communication, le renforcement du rôle des sociétés savantes, institutions, associations professionnelles, ONG et autres types d'organisations de la société civile sont nécessaires pour relever les défis qui s'annoncent.

Large cities (such as Athens-Piraeus which I know and their impact to the marine environment I have studied) have developed, within the last 20 years, into large metropolitan areas and have increased in numbers and size all around the Mediterranean region, particularly along the seashore. At the same time they become more complex with almost identical, anonymous infrastructures and rapidly growing mega-structures such as shopping centers, marinas, airports, hotels, port piers, etc which change their physiognomy as cities, "contaminate" their identity and heavily alter the landscape. In this way cities rapidly become less familiar, even to their native inhabitants. It might sound strange, but it is not, that citizens in modern cities, particularly the younger ones as well as the many new-comers, have extremely limited knowledge, memory and understanding of the functioning of the coastal zone, marine or terrestrial and its particularities. Wetlands and river deltas have disappeared, all river mouths are artificially regulated and modified and they are not different from man-made canals, municipal runoff outlets or even outfalls of sewage treatment plants

The atmospheric inputs from large or smaller scale industrial combustion plants, central heating and transport are very high and exceed for many substances, such as pyrolytic hydrocarbons, heavy metals etc, the input by runoff. However this fact escapes the attention of most citizens as the latter have become gradually used to the polluted atmosphere of big cities. The same is the case with the impact of colossal emissions of energy in the forms of light and noise to the marine environment. Marine litter has also as main source poorly managed municipal solid waste.

Most north Mediterranean large coastal cities now operate waste water treatment plants. Many of them provide treated effluents of reasonably good quality, though the situation varies from city to city and in many cases, particularly in the east and south of the Mediterranean, large quantities of raw or poorly treated municipal sewage finds its way to the marine environment, contributing to the complexity and seriousness of the problems of pollution, health, degradation of the biodiversity and downgrading the natural capital for tourism represented by unspoiled landscape and clean seas.

The vast majority of citizens in modern megacities know virtually very little about the seas impacted by their activities and choices and they do not see any direct connection between themselves and the management of the marine environment. Many have experienced some kind of contact and involvement with coastal environment e.g. as school children or boy scouts etc in clean-ups of beaches, as members of local councils or committees, NGOs or citizens groups or simply because the local seashore offers them opportunities for recreation, swimming, sports, angling etc. Though these numbers are considerable, it is surprising how small is the percentage of people with reasonably good knowledge about basic phenomena related to the marine environment and the functioning of marine /coastal systems such as the mobilization of the critical for human health iodine and other gases and aerosols with the action of waves; the precipitation and trapping of the majority of pollutants in the intermixing zones between fresh and marine waters, etc. Very limited is also their understanding about integrated management of the coastal zone as well as their preparedness for natural or man-made disasters affecting the coastal zone, such as floods or pollution from oil spills.

Marine scientists and academic research institutions in many countries have undertaken a number of initiatives and projects to approach and inform the wide public on crucial marine issues. The event recently organized by the University of Athens and the Association of Greek Oceanographers “Researchers Night” in Greece, an event organized as in many other countries with the support of the European Commission, offers an excellent example where scientists presented in simple ways the results of their research and of important phenomena to the public through lectures, discussions, happenings, etc.

However this is not enough. Citizens, particularly coastal residents, should be prepared to contribute to the abatement of major pollution incidents, such as oil spills. For this purpose contingency mobilization exercises should be organized by local authorities in co-operation with the Ministry of Merchant Marine and other competent bodies.

There is also a need for a radical change in the concept of science and research accountability towards society on one hand and dissemination and communication strategy on science and research results, on the other. This is easier for scientific areas close to the heart of people and familiar to them such as the marine issues.

Important for communication, is of course, the role of media. We have excellent examples of the pioneering work of TV through the films of Commandant Cousteau in the seventies. Today, more than thirty years later, we merely copy him. There are, of course, wonderful scientific films and popularized scientific publications but they represent small percentage of TV and radio emissions and publications reaching a relatively small part of the overall population. It is clear that the problem cannot be resolved through additional programs and references in media alone. Education should be drastically reformed according to the principles of the Education for Sustainable Development (ESD) and linked more closely with experience and deeper understanding of basic biogeochemical mechanisms in nature and their socioeconomic impact on populations. The impact of climate change on major cycles, including the water cycle, and the consequences for biodiversity, the economy and society offers a suitable example.

Apart from the media and education the role of learned societies, institutions, professional associations, popular/free/open Universities, municipal science and culture centers and various types of NGOs and civil society organizations (regional, national and local) is very important. Through these forums scientists could popularize, discuss and interpret scientific knowledge and the results of research thus contributing to the creation of a critical mass of people within the Civil Society who could not only understand but also play a social control and support role to science and research of the future.

Impact of Athens metropolitan area sewage outfalls on the Saronikos Gulf ecosystem

Ioanna Siokou-Frangou, Evangelia Krasakopoulou,
Georgia Asimakopoulou, Antonia Giannakourou, Harilaos Kontoyiannis,
Kalliopi Pagou, Panayotis Panayotidis, Alexandra Pavlidou, Nomiki
Simboura, Argyro Zenetos, Christina Zeri and Soultana Zervoudaki

Institute of Oceanography, Hellenic Centre for Marine Research
19013 Anavissos, Greece

Keywords: nutrients, phytoplankton, zooplankton, phytobenthos, macrozoobenthos, sewage, water treatment, Aegean Sea

Abstract

Saronikos Gulf (South Aegean Sea) ecosystem is affected by the sewage effluents of Athens metropolitan area. A monitoring study of the area has been performed by HCMR during the last 20 years by monthly or seasonal sampling of abiotic and biotic parameters. Spatial distribution patterns clearly depend on the distance from the sewage outfalls and the dominant circulation. Application of primary (after 1994) and secondary/tertiary (after 2004) treatment on sewage resulted in significant changes of the area trophic and ecological quality status.

Résumé

L'écosystème du golfe Saronikos (Mer Egée sud) est influencé par les effluents domestiques de l'agglomération d'Athènes. Durant les 20 dernières années, le HCMR a mis en œuvre un programme de surveillance du golfe basé sur une observation saisonnière ou mensuelle des paramètres abiotiques et biotiques. L'application du traitement primaire (après 1994) puis secondaire/tertiaire (à partir de 2004) sur les eaux usées a provoqué des changements considérables de l'état trophique et de la qualité écologique de la région.

INTRODUCTION

Discharges of domestic sewage « produced » by large cities are among the major pollution problems in the Mediterranean Sea, since they affect considerably the marine ecosystems stability. Effects depend on the sewage characteristics (volume and treatment level, organic load), the basin topography and water circulation, the position of outfalls, the bottom substrate (for benthic communities) and the dominant trophic webs (plankton and benthos). Saronikos Gulf, located in the oligotrophic South Aegean Sea, receives the sewage effluents of Athens metropolitan area (about 4 million inhabitants). Waste waters are primarily treated since 1994 and secondary-tertiary treated since 2005. Effluents were discharged in the surface close to station S3 (Figure 1) before 1994 and at 60 m depth close to station 7 afterwards.

Figure 1. Sampling stations in Saronikos Gulf in the period 1987-2004

METHODS

The monitoring study of Saronikos Gulf has been performed by HCMR during the last 20 years. Sampling was done monthly (in 1987, 1989, 1998, and from 2000-2007) or seasonally. Spatial (7 to 13 stations, see Figure 1) and temporal (seasonal and inter-annual) variability of the following parameters were studied: temperature, salinity, turbidity, currents, dissolved oxygen, nutrients, particulate organic carbon, chlorophyll-a, phytoplankton species composition, mesozooplankton biomass and species composition, phytobenthic communities of the upper infralittoral zone and soft bottom macrozoobenthic communities. In addition, dissolved organic carbon, bacterial production and microzooplankton abundance were studied in 2003-2006.

RESULTS AND DISCUSSION

Water circulation was revealed to be quite complex in Saronikos Gulf, changing from cyclonic to anticyclonic according to the dominant winds and including several small gyres in the area close to the sewage outfalls (Kontoyiannis, accepted). As a result, dissolved oxygen, nutrients and particular organic carbon spatial distribution varied among months, but the general pattern was consistent with higher values of the two later parameters close to the outfalls, decreasing with increasing distance from the pollution source (Figure 2). Chlorophyll-*a* followed a similar (more or less) spatial pattern and similarly did the overall trophic status of the area.

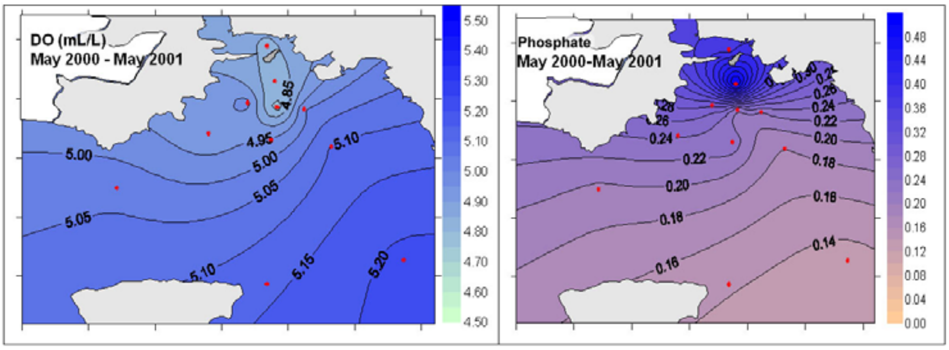


Figure 2. Horizontal distribution of annual mean values of dissolved oxygen (μM/L) (left) and phosphates (μM/L) (right) in the water column of Saronikos Gulf during the period May 2000 – May 2001

Nutrient values had an increasing trend in the period 1987-2004, due to the increment of the effluents volume. Chlorophyll-a values decreased in parallel, accompanied by an increment of mesozooplankton biomass (Figure 3), whereas autotrophic biomass did not vary considerably after 2000. The range of nutrients and chl-*a* values was smaller after 2000 than previously, except very close to the outfalls. Inter-annual variability of the aforementioned parameters has resulted in changes of the area trophic status. High availability of dissolved organic carbon and nutrients close to the sewage outfalls seems to favour bacterial production rather than primary production as well as the abundance of ciliates preying upon bacteria (Saridou et al., 2009; Zeri et al, 2009). Given the preference of copepods for ciliates versus phytoplankters as food items, it is probable that the microbial food web dominates in this area affected by the effluents, especially during the stratification period (may-november). Dominance of the microbial food web is very common in the Eastern Mediterranean Sea, both in coastal and offshore waters (Christaki et al., 2003, Siokou-Frangou et al., 2002), and this seems to hold true also in the study area close to the sewage outfalls. Therefore the microbial component should be also considered in ecosystem quality monitoring studies performed in the Mediterranean Sea.

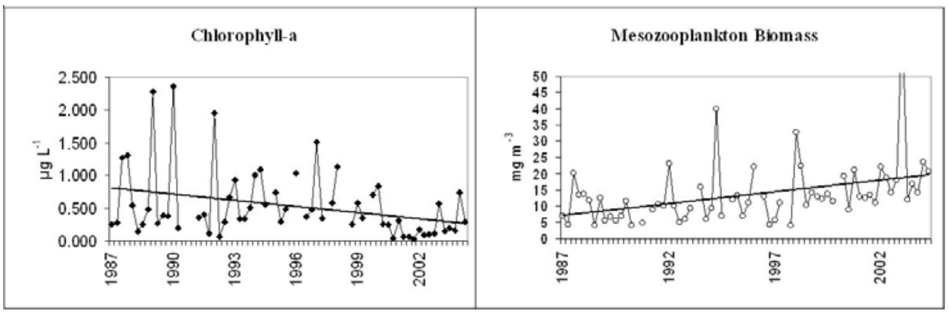


Figure. 3 Interannual variability of chlorophyll-a (mean integrated values over the water column) and mesozooplankton biomass at station S11 in the period 1987-2004

The spatial variability of nutrients and particulate organic carbon values has affected also phytobenthic and macrozoobenthic communities. The ecological quality status (according to the classification suggested by the EU Water Framework Directive, 2000) of both parameters improves with increasing distance from the sewage outfalls, varying from poor to high (Figures 4 and 5). In addition the inter-annual evolution of the ecological quality revealed significant changes. It was observed that sewage treatment, deep outflow of the sewage field and its entrapment below 50 m during the warm season, do not favour the development of nitrophilous phytobenthic Chlorophycae in the upper infralittoral zone. As a result the ecological quality of the phytobenthic communities improved since 1994 (primary treatment) and even more after 2004 (secondary-tertiary treatment). After 1994, soft bottom macro-invertebrates communities living at 70-90 m depth, showed a deterioration very close to the outfalls and an improvement with the distance from the discharge point increases. Elimination of organic load after 2004 by the secondary treatment resulted in the amelioration of the entire area planktonic and benthic communities.

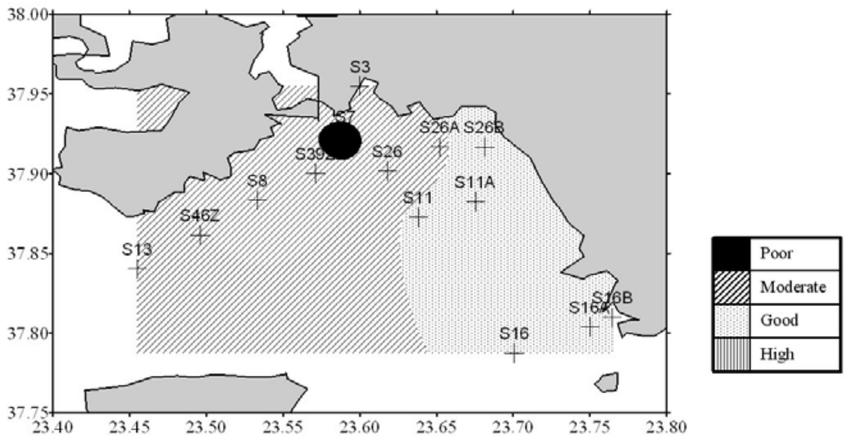


Figure 4. Ecological Quality Status (EcoQ) of macro-invertebrate communities in Saronikos Gulf according to the classification suggested in the WFD (from Simboura et al. 2005)

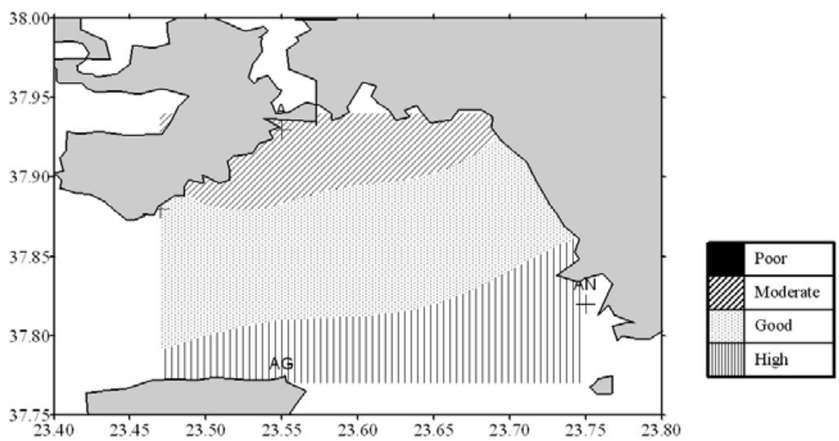


Figure 5. Ecological Quality Status (EcoQ) of macrophyte communities in Saronikos Gulf according to the classification suggested in the WFD

REFERENCES

Christaki O., Kormas K.A., Giannakourou A., Asimakopoulou G., Gotsi-Skreta O., 2003. The structure and function of the planktonic microbial food web during different trophic status in an Aegean Sea coastal system (Pagasitikos gulf, Aegean Sea). *7th Hell. Symp. Ocean. Fish.,* Chersonissos, Greece, 6-9 May 2003 pp. 254-255.

EC, 2003. Guidance on typology, reference conditions and classification systems for transitional and coastal waters. Produced by: CIS Working Group 2.4. (Coast), Common Implementation Strategy of the Water Framework Directive, European Commission, p. 116.

Kontoyiannis H. (accepted) Observations on the circulation of Saronikos Gulf : a Mediterranean embayment sea-border of Athens, Greece. *J.Geophys. Res*.

Saridou M., Verriopoulos G., Siokou-Frangou I., Giannakourou A., 2009. Microbial food web in the Saronikos Gulr marine area affected by the Psittalia sewage outfalls. 9th *Hell. Symp. Ocean. Fish., Book of abstracts.*

Simboura N., Panayotidis P., Papathanassiou E., 2005. A synthesis of the biological quality elements for the implementation of the European Framework Directive in the Mediterranean Ecoregion: The case of Saronikos Gulf . *Ecological Indicators* 5, 253–266

Siokou-Frangou I., Bianchi M., Christaki U., Christou E.D., Giannakourou A., Gotsis O., Ignatiades L., Pagou K., Pitta P., Psarra S., Souvermezoglou E., Van Wambeke F., Zervakis V., 2002. Organic carbon partitioning and carbon flow along a gradient of oligotrophy in the Aegean Sea (Mediterranean Sea). *J.Mar.Syst*. 33/34, 325-353.

Zeri C., Kontoyiannis H., Giannakourou A., 2009. Distribution, fluxes and bacterial consumption of total organic carbon in a populated Mediterranean Gulf. *Cont.Shelf Res., 29,* 886–895.

Pressures associated with large coastal cities in the Black Sea

Violeta Velikova

Black Sea Commission[1] PS Dolma Bahce Sarayi, Hareket Kosku II, Besiktas Istanbul, Turkey

Keywords: urban pressures, Black Sea, pollution, marine litter, biodiversity

Abstract

Large cities along the Black Sea coast are 20 and most of them are highly developed touristic areas, industrial centers and ports. More than 26 000 ships call annually at these ports, and at least 150 million tons of dangerous goods are transported to and from them. Influence of municipal and industrial discharges (including atmospheric pollution), litter, ballast waters and oil pollution are associated with these cities, where the population varies between 50 thousand (Poti, Georgia) and more than 12 million in Istanbul (Turkey). Waste Water Treatment Plants (WWTP) basically lack tertiary treatment. The trends for all the pressures are, however, generally decreasing during the last years, especially for municipal discharges (volume of untreated waters) and atmospheric pollution, whereas industrial discharges, ballast waters and oil pollution still pose a serious threat to the Black Sea sensitive coastal environment.

Résumé

Les grandes villes de la côte de la Mer Noire sont au nombre de 20 et la plupart d'entre elles sont très développées en tant que sites touristiques, centres industriels et ports où chaque année plus de 26 000 navires font escale avec un minimum de 150 millions de tonnes de marchandises dangereuses transportées. Les rejets municipaux et industriels (y compris la pollution atmosphérique), les déchets, les vidanges d'eaux de ballast et les pollutions par les hydrocarbures sont des conséquences de l'activité de ces villes, où la population varie de 50.000 habitants (Poti, Géorgie) à plus de 12 millions (Istanbul, Turkey). Les stations de traitement des eaux usées n'ont pas de traitement tertiaire. Cependant, les tendances sont en général à la baisse ces dernières années, notamment pour les rejets municipaux et la pollution atmosphérique. Les rejets industriels, les eaux de ballast et la pollution par les hydrocarbures continuent toutefois de faire peser une menace sérieuse sur l'environnement côtier sensible de la Mer Noire.

[1] http://www.blacksea-commission.org/main.htm

INTRODUCTION

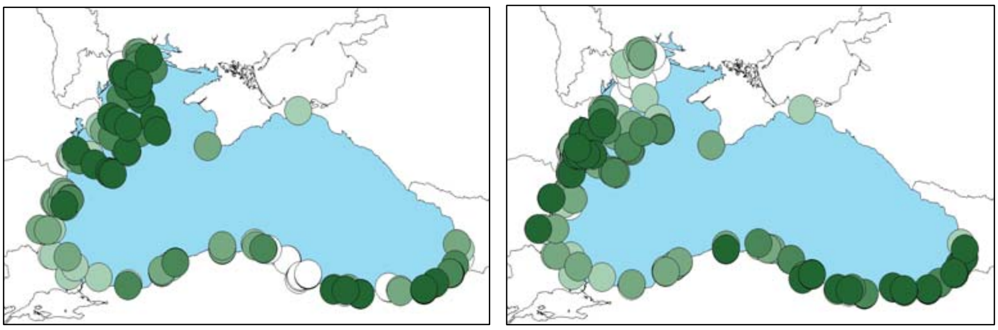
The Black Sea State of the Environment Report (BSC (SOE), 2008) indicates that, presently the major environmental problems in the Black Sea area involve the decline of commercial fish stocks, loss of habitats and species, replacement of indigenous species with exotic ones, and undesirable changes caused by eutrophication and chemical pollution. The primary sources of environmental degradation for the Black Sea associated with large cities (Fig. 1) include industrial discharges, domestic sewage, operational/illegal or accidental oil pollution, mismanagement of wastes, lack of integrated coastal zone management, and introduction of exotic species from ship ballast waters.

Figure 1. Large cities in the Black Sea region (the names are given around the Black Sea)

INDUSTRIAL AND MUNICIPAL DISCHARGES

Presently, there is a regional acknowledgement that the Black Sea marine and coastal ecosystems, while offering a certain amount of natural resilience (positive signs since 1995), are still fragile and require robust national and international protection. Eutrophication and chemical pollution are even now recognized as two of the most serious causes of environmental degradation in the Black Sea.

The industrial discharges are reported as significant source of trace metals, which are later accumulated in sediments and biota. The concentrations of metals in the water column are found relatively low in 2001-2007 (Korshenko, 2008). On the contrary, in bottom sediments around large cities, such as Odessa, Sevastopol, Constanta, Bourgas, Samsun, etc., this type of contamination is quite substantial. During the last ten years Copper, Zinc, Arsenic, Chromium (Fig. 2A) and Nickel exceeded the permissible levels (PL) concentrations, sometimes more than 10-fold, in the sediments of Ukrainian, Turkish, Bulgarian and Romanian coastal waters (the latter basically related to the Danube river influence). Mercury content, known to be the most toxic metal, never exceeded the PL in the Black Sea, however, it significantly increases close to the Odessa port, and the Crimean cities of Sevastopol and Alushta (Korshenko, 2008). Along the Russian coast there are no industrial sources of pollution and the concentrations of trace metals are rather low both in water and sediments. Copper levels along the South Georgian and East Turkish coasts are likely to be naturally high, since a copper ore mine is situated close to the Sea near the Georgian/Turkish border (Fig. 2B).



Colour	Chromium (mg/kg)	Copper (mg/kg)
	<40.00	<21.21
	40.00-64.00	21.21-32.00
	>64.00-89.00	>32.00-43.00
	>89.00-112.00	>43.00-68.50
	>112.001	>68.501

Figure 2. Mean concentrations of chromium (A) and copper (B) in sediments of the Black Sea, 1996-2006 (No dots – no data) (redrawn from TDA2007, www.blacksea-commission.org)

Since the early 1990s nitrogen and phosphorus discharges show decreasing trends, but their 2000-2005 average values are still 1.5 times higher than their pristine levels at 1955-1965. However, main sources of elevated nutrients are the Black Sea rivers (Danube, Dniestr, Dniepr and others), and around large cities the BOD5 values do not exceed the critical loads of 10-30 tons per day (Fig. 3 A-C), when major to sever impacts on the coastal environment could be expected (MED POL).

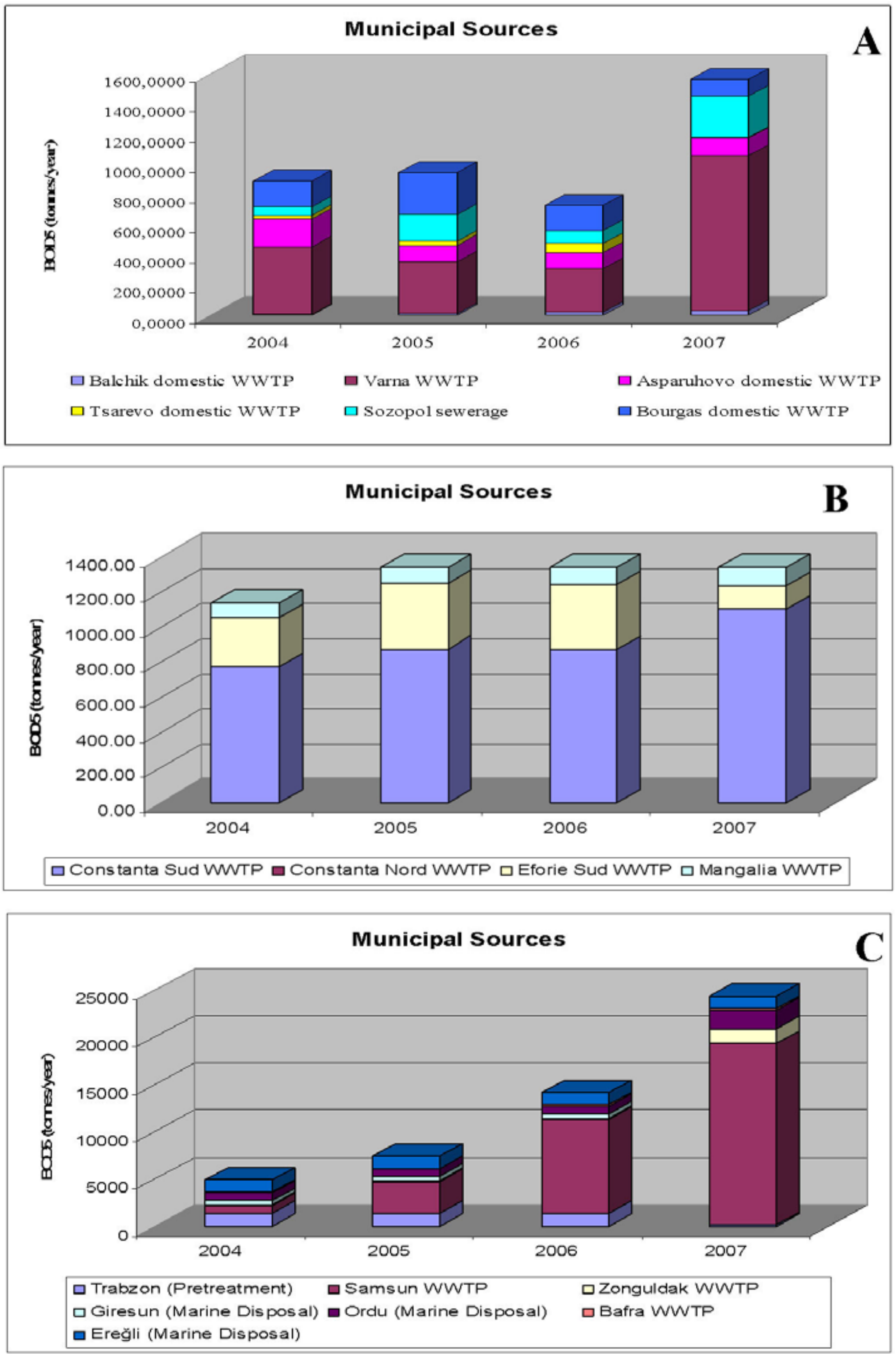


Figure 3A-C. BOD5 (tons per year) Discharged from Municipal Sources defined as HOTSPOTS: A – Bulgaria; B – Romania; C – Turkey (no data for Istanbul), (redrawn from unpublished Land Based Sources of Pollution Report of the BSC, 2008)

Additionally, the amount of insufficiently treated or untreated waters decreases during the last years, as shown on the example of Ukraine (Fig. 3D). In the Black Sea region, rural population not connected to WWTP varies in the range of 42-95%

for different states whereas it is 0.3-34% for the urban population concentrated in large cities.

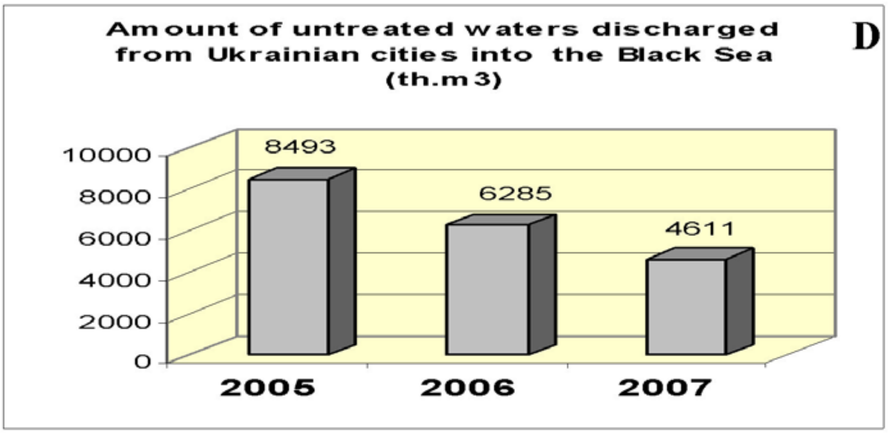


Figure 3D. Amount of untreated waters discharged from Ukrainian cities into the Black Sea (th.m3), (reported by Ukraine, E. Patlayuk, figure redrawn from unpublished Land Based Sources of Pollution Report of the BSC, 2008)

AIRBORNE POLLUTION

Though decreasing trends in emissions and atmospheric deposition of pollutants have been observed in the Black Sea region since the early 1990s, available information specifically suggests that the deposition of nitrogen to the Sea may be of similar order of magnitude to river loads and that there is no pronounced change in these N-emissions in the region since 2002 (Fig. 4A, example from Romania). Risk of damage from ozone and particulate matter is high in all Black Sea states (EMEP data). Since 1995, due to less extensive use of coal, the average daily concentrations of CO, NO_2 and SO_2 (Fig. 4B) dropped down significantly in densely populated areas along the Black Sea. However acid rains and smog are still frequent phenomena in the region.

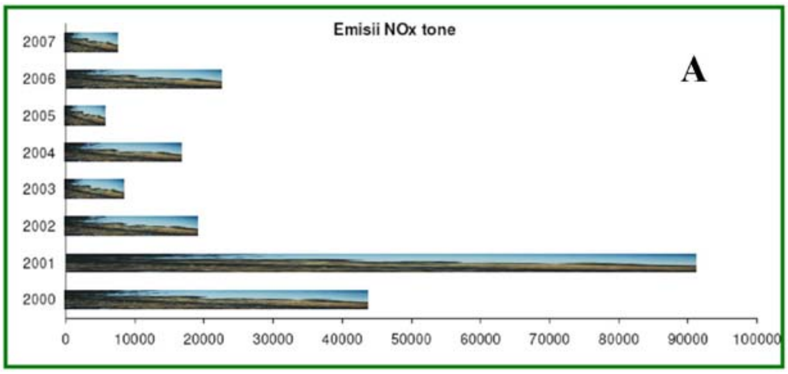


Figure 4A. Inter-annual variability of NO_x emissions (tons per year) in 2001-2008 nearby Constanta (EPA Constanta data, reported by Romania, Andra Oros), (redrawn from unpublished Land Based Sources of Pollution Report of the BSC, 2008)

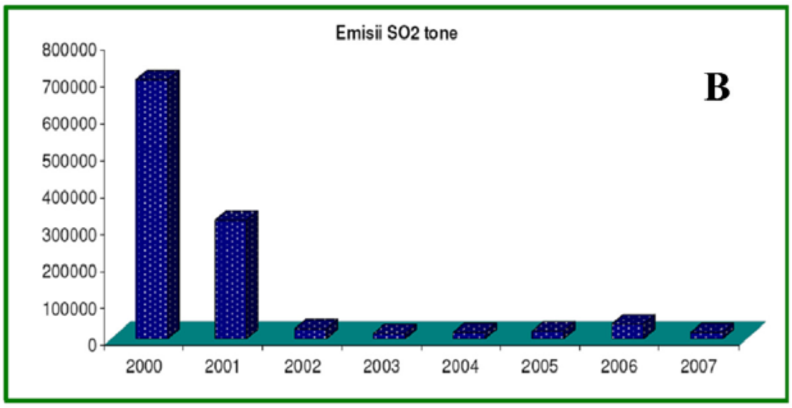


Figure 4B. Inter-annual variability of SO_2 emissions (tons per year) in 2001-2008 nearby Constanta (EPA Constanta data, reported by Romania, Andra Oros), (redrawn from unpublished Land Based Sources of Pollution Report of the BSC, 2008)

OIL POLLUTION

The environmental impact of oil pollution around large cities was found to be relatively less adverse than the influence of eutrophication and other chemical pollution. However, certain issues, including future energy projects, ask for attention and more detailed investigations on oil pollution effects. More than 26 000 ships call annually at Black Sea ports, and minimum 150 million tons of dangerous goods are transported to and from these ports. The main large cities-ports in the Black Sea for the export of oil are Novorossiysk, Tuapse, Odessa, Supsa, and Batumi. The Black Sea port of Novorossiysk, one of the ten largest in Europe, has seen a steady increase in exports of oil and oil products: from approximately 40 million tons annually (mta) in 2000 to approximately 52 mta in 2007. Nevertheless, the volume of accidentally spilled oil there and the number of accidents are not high (Fig. 5).

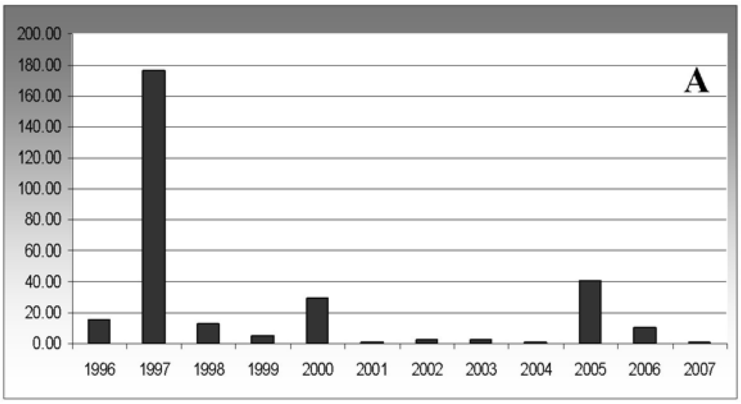


Figure 5A. Volume of oil spilled during accidents (metric tons per year) during the bunkering operation in the port of Novorossiysk, 1996 – 2007 (reported by Russian Federation, Natalia Kutaeva), (redrawn from unpublished Environmental Safety Aspects of Shipping Report of the BSC, 2008)

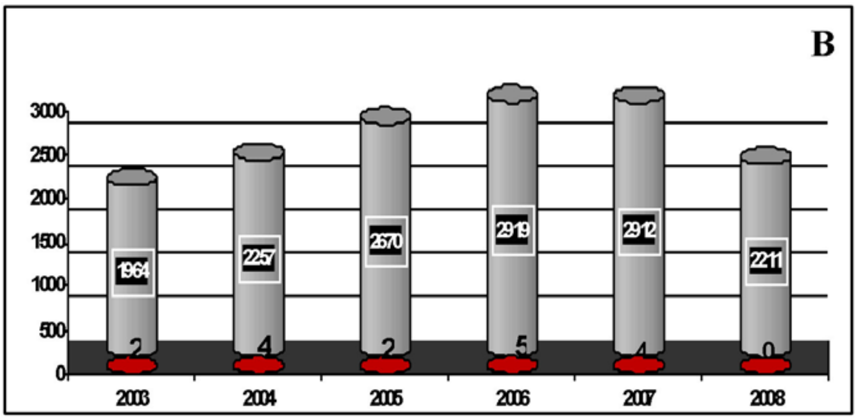


Figure 5B. Number of bunkering operations (blue columns) and number of incidents (oil spills, numbers at the bottom of the blue columns) during the bunkering operation in the port of Novorossiysk, 2003 – 2008 (reported by Russian Federation, Natalia Kutaeva), (redrawn from unpublished Environmental Safety Aspects of Shipping Report of the BSC, 2008)

Quite the opposite, the illegal discharges (Fig. 6) still pose serious threat and according to investigations of JRC in the Black Sea, 1227 likely oil spills were detected in 2000-2004 based on satellite imagery investigations (BSC (SAP IR), 2009). Ports like Odessa, Constanta, Novorossiysk, Istanbul, etc. are under the pressure of high values of petroleum hydrocarbons (TPH), usually exceeding many times the threshold of PL, and reaching up to 25 $mg.l^{-1}$ in the water column. In bottom sediments high TPH values of up to 12 $mg.g^{-1}$ were recently recorded in Turkish, Romanian and Russian waters around large cities (Korshenko, 2008).

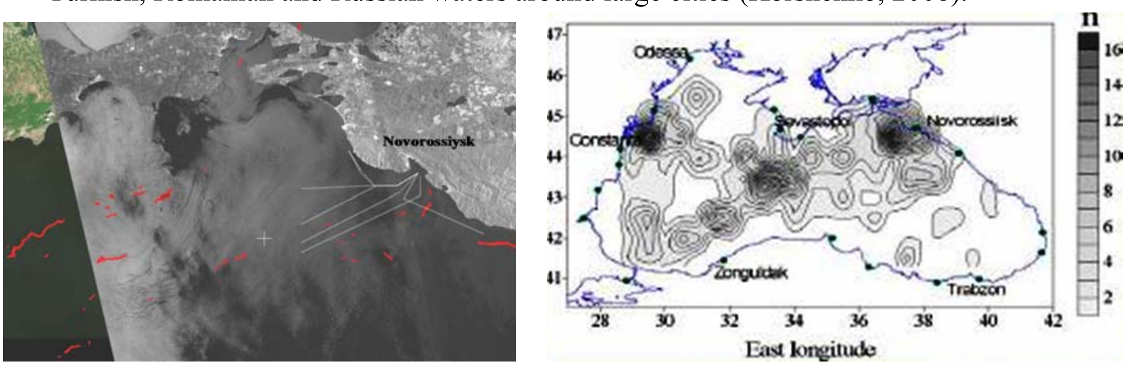


Figure 6. (A) Potential oil spills due to illegal discharges (40 found out as a result of 4 RADARSAT photos 19/08/08 – 11/09/08, SCANEX, www.blacksea.kosmosnimki.ru). (B) Statistics on detection of oil pollution in the Black Sea in 2001-2004 (68 photos - 428 oily shots), (Russian National Report, 2008, www.blacksea-commission.org)

MANAGEMENT OF WASTE

By rough estimate, over 100 landfills exist on the Black sea coast (mostly around large cities), of which - 66% are authorized, 12% receive hazardous waste, only 22% were constructed with a liner and even fewer (8%) have a leachate treatment system, albeit that 18% have stormwater diversion systems (BS TDA2007). Some of them are situated in the immediate proximity to the sea (Fig. 7A) and serve as significant source of nutrients, hazardous substances and marine litter. If the specific solid waste production rate comes to 0.64 kg per capita per day (TUGAL, 2002), then the large cities load is 32 ton per day at the average for a population of only 50 000 people (which is the smallest large city around the Black Sea, out of a total of 20 with a population more than 12 million in Istanbul, for example). Therefore, the solid waste production in the Black Sea coastal zone could be considered as one of the significant environmental pressures; however, the management of solid waste still leaves space for a lot of improvements.

The beaches of the large cities get cleaned during the touristic season, otherwise they are covered with various items of marine litter (Fig. 7B), which often end in the sea.

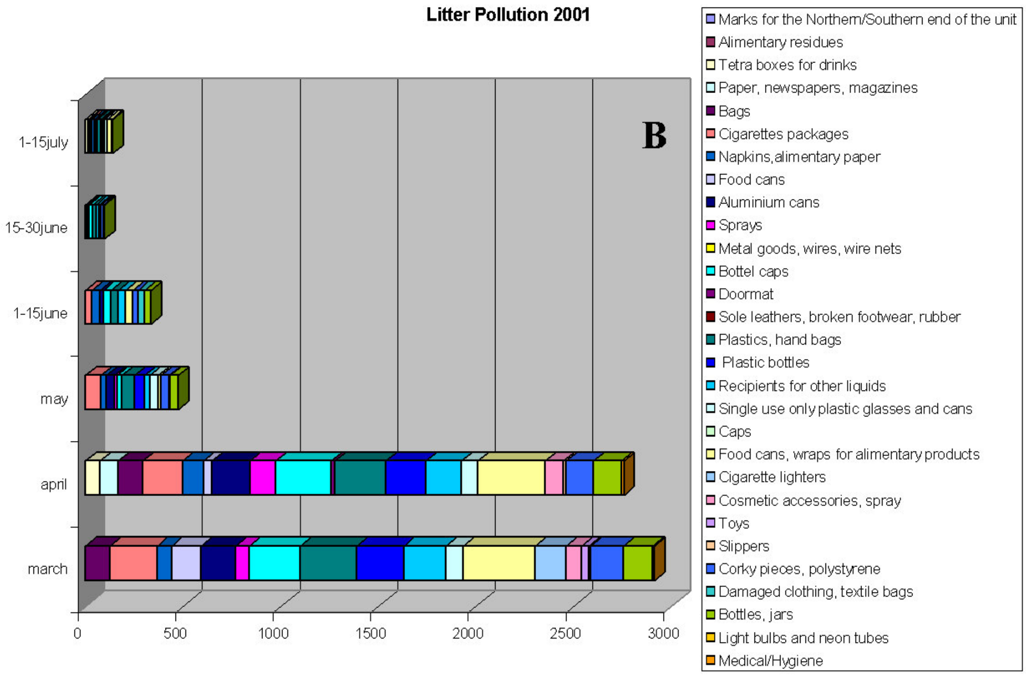


Figure 7. (A) Enormous deposit of marine litter (ML) represented by the landfill near Zonguldak (Turkey). The height of the waste dump is not less than 20 m (upper photo). Waves demolish it shifting ML staff into the sea (redrawn from Yildirim et al., 2004). (B) Number of ML items and their category on the beach of the city of Sozopol (Bulgaria) in March-July 2001 (redrawn from Birkun, 2007)

According to recent investigations the ML weighting indices varied from 333 to 6 250 kg.km^{-2} (plastics) and from 222 to 1 455 kg.km^{-2} (glass) in Ukraine coasts. Floating marine litter (plastics) in the coastal zone of the Black Sea was found in average 7 pieces per km2 and the aggregate mass of plastic ML floated upon the entire surface of the Ukrainian Black Sea was estimated at 18 559 kg. 11 diving surveys have been realized in 2005 in the Bosporus and around the Prence Islands in Turkey - 1606 ML pieces under 224 different titles were recorded on the sea bottom. The situation around large cities in other states is not different and the implications of this serious problem are still to be evaluated from biodiversity change point of view (Birkun, 2007, BSC Marine Litter Report 2007).

INTEGRATED COASTAL ZONE MANAGEMENT

None of the Black Sea countries have shown constant and really effective political support for the ICZM[2] process during the last years. Coastal planning and management aspects seem to be mostly in place in Bulgaria, Romania and Ukraine whereas less developed in other countries. Coastal erosion and deforestation have been dealt in national policies, plans and projects. However, a regional survey for the Black Sea has not been undertaken so far. Large cities are basically associated with uncontrolled construction, weak protection against erosion and, correspondingly, destruction of habitats, silting of bottom (Fig. 8) and loss of biodiversity.

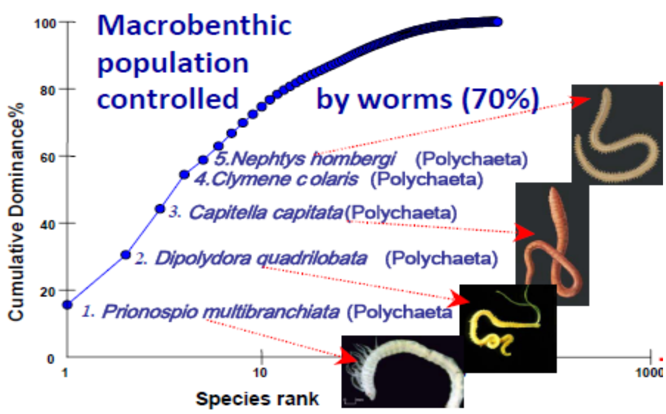


Figure 8. Species rank of macrozoobenthic population indicating its overwhelming domination by worms in northwestern coastal waters of the Black Sea (after Friedrich et al., 2008) – indicator of silting of bottom

BALLAST WATER AND SPECIES INTRODUCTION

One of the worst Black Sea environmental crises resulted from the introduction of the jellyfish *Mnemiopsis leidyi* through ship ballast water in the 1980s. Yet, ballast

[2] Integrated Coastal Zone Management

waters control is not well developed in the Black Sea region. The sea in the vicinity of large cities-ports becomes the nursery for invasive species and the trend in the number of these species is positive (Fig. 9).

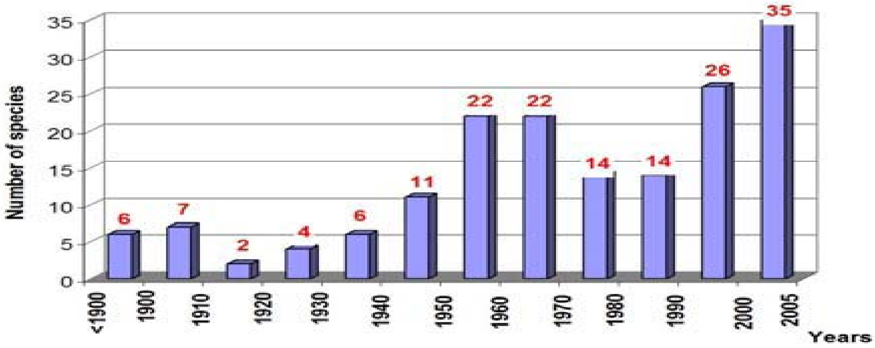


Figure 9. Long-term changes in distant alien species introduction in Ukrainian waters, Odessa Bay (redrawn from Aleksandrov et al. 2007)

References

Aleksandrov B., Boltachev A., Kharchenko T., Liashenko A., Son M., Tsarenko P., Zhukinsky V., 2007. Trends of aquatic alien species invasion in Ukraine. Aquatic Invasions. // Aquat. Invasions, Vol. 2(3) : 215–242.

Birkun A. 2007. Marine litter in the Black Sea Region: A review of the problem. Black Sea Commission Publications 2007-1, Istanbul, Turkey, 148 pp.

BSC (SAP IR), 2009. Implementation of the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea (2002-2007). Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2009-1, Istanbul, Turkey, 252 pp;

BSC (SOE), 2008. State of the Environment of the Black Sea (2001-2006/7). Edited by Temel Oguz. Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2008-3, Istanbul, Turkey, 448 pp.

BSC SAP IR, 2009. http://blacksea-commission.org/main.htm

BSC SOE, 2008. http://blacksea-commission.org/main.htm

EMEP data, www.emep.int

Friedrich J. et al., 2008. State of the benthic ecosystem on western Black Sea shelf in early spring 2008. In: 2nd Biannual and Black Sea Scene EC project joint conference on climate change in the Black Sea – hypothesis, observations, trends, scenarios and mitigation strategy for the ecosystem. 6-9 October 2008, Sofia, Bulgaria.

Korshenko A., 2008. The state of chemical pollution. In: State of the Environment of the Black Sea (2001-2006/7). Edited by Temel Oguz, Black Sea Commission Publications 2008-3, Istanbul, Turkey, 419 pp.

MED POL, http://195.97.36.231/acrobatfiles/MTSAcrobatfiles/mts124Eng.pdf

TUGAL, 2002. Municipal solid waste treatment plant feasibility report: Province of Zonguldak. Technical Report, Zonguldak.

Yildirim Y., Özölçer İ.H., Çapar Ö.F., 2004. A case study of rehabilitation of uncontrolled municipal solid waste landfill site in the province of Zonguldak. In: 6th International Congress on Advances in Civil Engineering (Istanbul, Turkey, 6-8 October 2004), 10 pp.

List of Participants

Maged Al-Sherbiny	Ministry for Scientific Research, Egypt 101 Kasr Al-Ainy St. 2nd Floor 11516 Cairo-Egypt
Michael Angelidis	UNEP/MAP – MED POL 48 Vas. Konstantinou Avenue 11634 Athens - Greece angelidis@unepmap.gr
Carlo Avanzini	Marine Waste Water Discharges Organization (MWWD) Cemiltopuzlu Cad. Bal Apt. 26-1 Kat:5 Daire:6 TR-34726 Çiftehavuzlar Istanbul - Turkey carlo.avanzini@mwwd.org
Aly Il Beltagy	National Institute for Oceanography and Fisheries (NIOF) Kayetbay, Al Anfoshy Alexandria - Egypt tsm@idsc.net.eg ebt007@gmail.com
Julian Blasco	Spanish National Research Council Departamento Ecología y Gestión Costera Institute of Marine Sciences of Andalusia (CSIC/ICMA) 11510 Puerto Real (Cadiz) - Spain julian.blasco@icman.csic.es
Françoise Breton	Autonomous University of Barcelona (UAB) European Topic Centre on Land Use and Spatial Information Universitat Autònoma de Barcelona Facultat de Ciències, Edifici C, Torre C5-S, 4ª Planta E-08193 BELLATERRA Barcelona - Spain Francoise.Breton@uab.cat
Jean François Cadiou	Ifremer French Research Institute for Exploitation of the Sea BP 330 83507 La Seyne sur Mer - France Jean.Francois.Cadiou@ifremer.fr
Giuseppe Di Luca	Genoa Port Authority Environment Department Maritime Station - Ponte dei Mille 16126 Genova - Italy g.diluca@porto.genova.it

Mamdouh Fahmy	National Institute for Oceanography and Fisheries (NIOF) Kayetbay, Al Anfosy Alexandria - Egypt
Hedi Haddada	Centre Français de Culture et de Coopération 1 rue Madrasset Al Huquq Al Frinseya, Mounira Cairo - Egypt hedi.haddada@cfcc-eg.org
Tarek Hussein	Academy of Scientific Research and Technology (ASRT) 101 Kasr Al-Ainy St. 6th Floor 11516 Cairo-Egypt
Amir Ibrahim	High Institute of Marine Research (HIMR) Tishreen University Lattakia - Syria a.ibrahim@aloola.sy
Mohamed Ibrahim	Community Development & Environment Affairs Faculty of Science Alexandria University P.O. Box 21511 Moharam Bay Alexandria - Egypt mibrah@gmail.com
Oliver Keserue	UNEP/MAP – Blue Plan Sophia Antipolis 06560 Valbonne - France okeserue@planbleu.org
Gaby Khalaf	Lebanese National Council for Scientific Research Marine Research Center Batroun - Lebanon bihar@cnrs.edu.lb
Suzan Kholeif	National Institute for Oceanography and Fisheries (NIOF) Kayetbay, Al Anfoshy Alexandria - Egypt suzan_kholeif@yahoo.com
Filiz Kucuksezgin	Dokuz Eylul University Institute of Marine Sciences and Technology Inciralti 35340 Izmir-Turkey filiz.ksezgin@deu.edu.tr
Alain Lagrange	Ifremer French Research Institute for Exploitation of the Sea Direction for European and International Affairs 155, rue Jean-Jacques Rousseau 92138 Issy-les-Moulineaux Cedex - France Alain.Lagrange@ifremer.fr

Jean-Charles Lardic	City of Marseille Department of sustainable development 27 bd Joseph Vernet 13008 Marseille - France jclardic@mairie-marseille.fr
Jae Oh	International Atomic Energy Agency Marine Environment Laboratory 4 Quai Antoine 1er MC-98000 - Monaco J.Oh@iaea.org
Giovanni Pagano	Federico II University Dept Biological Sciences Hygiene Section I-80134 Naples - Italy gbpagano@tin.it
Albert Palanques	Spanish National Research Council Institute of Marine Sciences - CSIC/ICM Passeig Maritim de la Barceloneta 37-49 Barcelona 08003 - Spain albertp@icm.csic.es
Nicola Pirrone	CNR-Institute of Atmospheric Pollution Research Via Salaria Km 29.300-CP10 00015 Monterotondo St. Rome - Italy pirrone@iia.cnr.it
Çolpan Polat-Beken	TÜBİTAK- Marmara Resarch Center Institute of Environment Gebze-Kocaeli - Turkey Colpan.Beken@mam.gov.tr
Abou Bakr Ramadan	Atomic Energy Authority National Center for Nuclear Safety 3 Ahmed El Zomor St. Nasr City 11672 P.O. Box 7551 Cairo - Egypt ramadan85@yahoo.com
Chafika Rebzani Zahaf	Université des Sciences et de la Technologie Houari Boumédienne - Faculté des Sciences Biologiques/USTHB BP 32 16111 Bab Ezzouar Alger - Algeria chafikarebzanizahaf@gmail.com

Nafaa Reguigui	National Center of Nuclear Science and Technology Technopole Sidi Thabet 2020 Sid Thabet - Tunisia n.reguigui@cnstn.rnrt.tn
Alessia Rodriguez Y Baena	Mediterranean Science Commission - CIESM 16, Bld de Suisse, MC-98000 Principality of Monaco arodriguez@ciesm.org
Louis Alexandre Romaña	Ifremer French Research Institute for Exploitation of the Sea Centre Ifremer de Toulon-La Seyne BP 330 83507 La Seyne-Sur-Mer Cedex - France Axel.Romana@ifremer.fr
Mohamed Said	National Institute for Oceanography and Fisheries (NIOF) Kayetbay, Al Anfoshy Alexandria - Egypt mamsaid2@hotmail.com
Cherif Sammari	National Institute of Marine Sciences and Technologies INSTM 28 rue 2 mars 1034 2025 Salammbô Tunis - Tunisia cherif.sammari@instm.rnrt.tn
Didier Sauzade	Ifremer French Research Institute for Exploitation of the Sea BP 330 83507 La Seyne-Sur-Mer Cedex - France Didier.Sauzade@ifremer.fr
Michael Scoullos	University of Athens Laboratory of Environmental Chemistry Athens - Greece secretariat@gwpmed.org
Mohamed Sheredah	National Institute for Oceanography and Fisheries (NIOF) 101 Kasr Al-Ainy St. 14th Floor 11516 Cairo, Egypt NIOF@hotmail.com
Ioanna Siokou-Frangou	Hellenic Centre for Marine Research 46.7 km Athens-Sounio avenue 19013 Anavyssos - Greece isiokou@ath.hcmr.gr

Apologies

Bruno Andral	Ifremer French Research Institute for Exploitation of the Sea BP 330 83507 La Seyne-Sur-Mer Cedex - France bandral@ifremer.fr
Pierre Boissery	Agence de l'Eau Rhône Méditerranée & Corse 62, immeuble le Noailles 13001 Marseille - France Pierre.Boissery@eaurmc.fr
Frédéric Briand	Mediterranean Science Commission - CIESM 16, Bld de Suisse, MC-98000 Principality of Monaco fbriand@ciesm.org
Nureddin Esarbout	Marine Biology Research Center - Libya P.O.B 30830 Tajura - Libya esarbout@mbrc.org.ly
Jean-Yves Guivarch	Marseille Urban Community Direction de l'Eau et de l'Assainissement 27, Bd Joseph Vernet 13008 Marseille - France Jean-Yves.GUIVARCH@marseille-provence.fr
Grozdan Kušpilić	Laboratory of Chemical Oceanography and Sedimentology of the Sea Institute of Oceanography and Fisheries Šet. I. Meštrovica 63 HR-21000 Split - Croatia kuspe@izor.hr
Violeta Velikova	Black Sea Commission – BSC PS Dolma Bahce Sarayi Hareket Kosku II Besiktas Istanbul - Turkey violeta.velikova@blacksea-commission.org

IMPRIM'VERT®

Imprimerie MARIM – 83000 Toulon (France)

Achevé d'imprimer février 2010

Dépôt légal : 1er trimestre 2010

ISBN : 978-2-84433-160-1

"Integrated approaches and methodologies
should be developed to evaluate the impact
and the relative contribution of anthropogenic activities
carried out in large urban areas
on the marine environment and ecosystems"

*****

*"Des approches et des méthodes intégrées
doivent être développées pour évaluer la contribution
relative des activités anthropiques exercées
dans les grandes zones urbaines et leur impact
sur l'environnement et les écosystèmes marins"*

Bibliotheca Alexandrina