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REVIEW

Black Sea current environmental problems*

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Abstract.
The environmental degradation and various related sufferings of the Black Sea are more and more detailedly known.
They are connected to its natural handicaps as well as anthropogenic activities with severe impact on the Black Sea such as transport (Danube, Danube-Danube-Black Sea canal, Dnepr, Don, fluvial and maritime harbours, free economic zones), industry (fertilizers, herbicides, pesticides), fishing (and overfishing), tourism.
The evolution of the former more diversified Black Sea coastal and pelagic ecosystems has changed dramatically and got depleted, both qualitatively and quantitatively, over the years. The most significant contemporary issues affecting the natural equilibrium state concern coastal erosion, water quality and eutrophication, extension of hypo- and/or anoxic zones, possible rise of hydrogen sulfide in euphotic layers, accumulation of different fall-out and terrestrial pollutants, decrease of water self-purification capacity in coastal areas towards chemical and microbiological contaminants, significant decline of biodiversity. Following main issues and concerns in above respect are synthetically resumed: international framework, pollution, and environmental quality monitoring and sea water quality control in Romania, eutrophication, biodiversity, and urban sewage treatment.

Key words: The Black Sea, monitoring, water quality, pollution, eutrophication, biodiversity, sewage treatment

Introduction

The greatest threats to the oceans consist in pollution, the overexploitation of marine resources and the destruction of marine environments. About 80% of all pollution entering the oceans comes from land-based sources / river drainage

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basins (including both discharges through the atmosphere and land-based discharges; the rest is due to maritime transportation, dumping and offshore production. To address problems caused by pollution from land-based activities, the "Washington Declaration on the Protection of the Marine Environment from Land-based Activities", and the "Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA)" have been adopted by more than 100 countries in 1995. The latter addresses the impacts of land-based activities on the marine and coastal environment (the physical alteration of these environments, contaminants, sources of pollution, the protection of habitats critical for endangered species, and the protection of ecosystems such as breeding and feeding grounds). In addition, the World Bank, through the Global Environment Facility (GEF), has in place programmes to reduce pollution due to non- treated sewage, as well as initiatives to reduce nitrogen pollution.

For various natural and anthropogenic reasons, the Black Sea is particularly sensitive to land-based pollution (Gable, 2000; Bologa, 2001; Meinier, 2002). The Black Sea receives about 350 cubic kilometers of river water every year of Europe's second, third, and fourth largest river basins, respectively the Danube, Dniepr, and Don. Half of the Black Sea catchment area is covered by the Danube River basin (Figure 1). Nearly a thousand kilotons of nitrogen and a hundred kilotons of phosphorus are discharged in the Black Sea every year. Out of this, the total load of pollutants in the Danube and its tributaries is substantial: in addition to inorganic nutrients (N, P, Si), heavy metals, petroleum compounds, and chlorinated hydrocarbons enter the Black Sea.

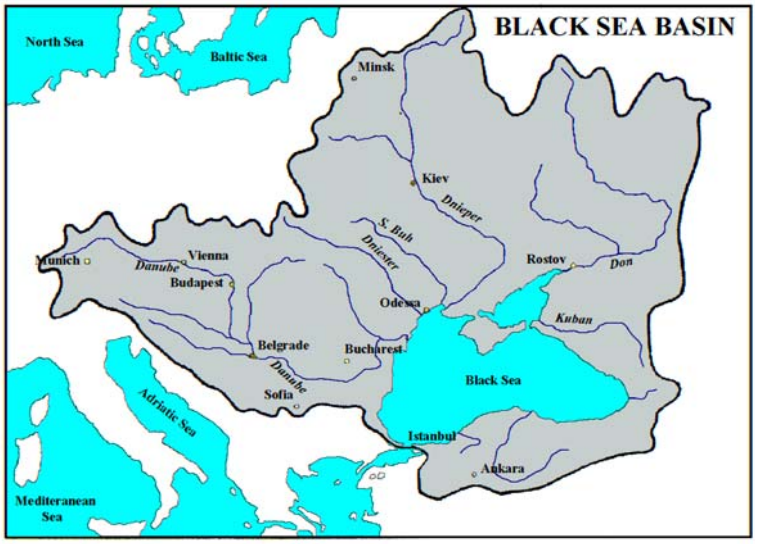

Figure 1. The Danube / Black Sea hydrographic basin

Responsibilities for the protection and rehabilitation of the Danube and Black Sea have been divided among four types of actors: states, international commissions, international organizations, and nongovernmental organizations (Meinier, 2002). Among them, the International Commission of the Protection of the Danube River, and the International Commission for the Protection of the Black Sea deserve a special consideration. Emphasis is obviously put on organizations operating under the auspices of the European Union, United Nations, and World Bank. Worth mentioning are also NGOs such as the Regional Environmental Centre, the Danube Environmental Forum, and the Black Sea NGO Network.

Contemporary experts consider that "the state of the Black Sea continues to be a matter of concern due to the ongoing degradation of its ecosystem and the unsustainable use of its natural resources" (Strategic Action Plan for the Rehabilitation and Protection of the Black Sea, (SAP-BS), Istanbul, Turkey, 31 October 1996). Similar problems occur in the semi-enclosed seas such as the Mediterranean Sea and the Baltic Sea. But the most serious contemporary events in the Black Sea have caused experts to consider it the most seriously degraded sea on our planet" (GEF, 1992).

The general characterization of the Black Sea (Figure 2) and related environmental degradation have been constantly updated (e.g. Antipa, 1941; Bologa, 1998; Mee and Toping, 1998; Besiktepe *et al*., 1999; Sorokin, 2002; Zatsepin and Flint, 2002; Vespremeanu, 2004) as well as its fascinating history (e.g. Bratianu, 1998; King, 2005).

Figure 2. The Black Sea and its coastal states

International framework

As a consequence of the severe environmental problems, the unique Black Sea (Figure 3) has been defined as one of the most critical marine areas in the world, where it may even be too late for joint action aiming at the recovery of the ecosystem. The characteristics of the Black Sea, its long overturning period, the large amount of the annual discharge from its tributaries, and the habits of the population living in its drainage basin, formed the basis of the arguments on the impossibility for remediation and the irreversibility of the environmental situation. The Black Sea states finally met in 1985 in an attempt to negotiate a legal convention to protect the sea, modeled along the lines of the Barcelona Convention, forerunner of the Mediterranean Action Plan. All six Black Sea states signed the Convention on the Protection of the Black Sea against Pollution, known as the Bucharest Convention, in April 1992. The aim of this convention was the protection of the marine environment against pollution.

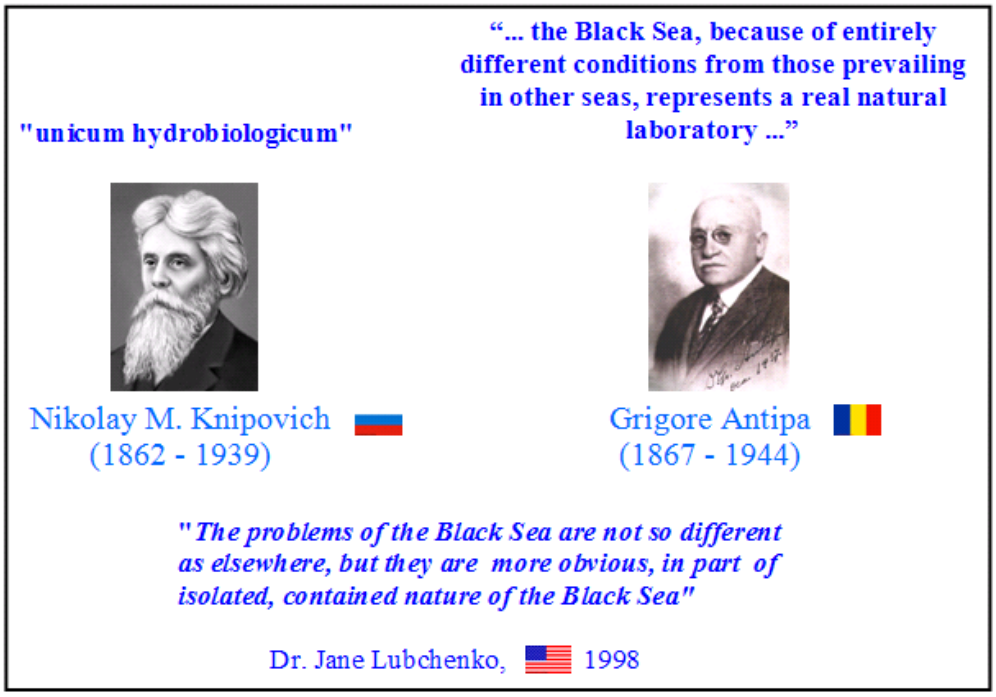

Figure 3. The unique Black Sea

Two months after the Bucharest Convention, the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brasil, on 3-14 June 1992 developed a breakthrough for the future orientation of

environmental policy at global, regional and national levels. The major output of the Conference, Agenda 21, describes actions covering a series of new approaches as the integrated ecosystem approach. In this way the protection area was extended to the coast resulting in the Integrated Coastal Zone Management (ICZM) principle. The first legal document that fit in the Rio principles and ICZM was the Odessa Declaration signed in April 1993 by the six coastal countries. According to this Declaration the countries committed themselves to work consistently towards the rehabilitation of the Black Sea ecosystem. The six states immediately requested help from UNEP in designing an action plan and made a formal request to GEF, which established ecosystem-based priorities for cross-border issues, to support the process both technically and financially, under the "Black Sea Environmental Programme" (BSEP).

Increasing and more integrated attention has been paid at national, regional and international level to environmental issues of the Black Sea since 1990; this has been particularly so in ecosystem research, development of integrated quality monitoring, and strengthening of regional cooperation.

The Black Sea has been connected several decades ago to the North Sea by the Rhine–Main–Danube channel (Figure 4) with no negative effects on its ecosystem up to now.

Less environmentally harmless seems to be the construction of the Danube - Black Sea Chilia – Bystroe shipping channel (Figure 5).

Figure 4 The Rhine – Main – Danube channel

Figure 5. The Danube – Black Sea Chilia – Bystroe shipping channel

Pollution

For the purposes of the *Bucharest Convention* **pollution** of the marine environment means "the introduction by man, directly or indirectly of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazard to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities" (Bologa, 2005).

The Bucharest Convention (Art. XV Scientific and technical co-operation and monitoring) forsees:

> 1. "The Contracting Parties shall co-operate in conducting scientific research aimed at protecting and preserving the marine environment of the Black Sea and shall undertake, where appropriate joint programs of scientific research and exchange relevant scientific data and information".
>
> 4. "The Contracting Parties shall, *inter alia*, establish through the Commission and, where appropriate, in co-operation with international organizations they consider to be competent, complementary or joint research programs covering all sources of pollution and shall establish a pollution monitoring for the Black Sea including, as appropriate, programs at bilateral or multilateral level, for observing, measuring, evaluating and analyzing the risks or effects of pollution of the marine environment of the Black Sea".
>
> 7. "Each Contracting Parties shall designate the competent national authority responsible for scientific activities and monitoring".

Also, the *Odessa Declaration* (Assessment and monitoring) emphasizes:

13. "To establish before 1997, a trend monitoring system for substances which have been identified as threatening or likely to threaten the sustainable development of the Black Sea environment" ;

14. "In order to facilitate the implementation of the provisions on assessment and monitoring":

b."The capacity of at least one institution in each coastal state to participate in Common assessment and monitoring programs will be enhanced".

Offering food and sustaining commerce and recreation for centuries, the Black Sea is severely threatened today by ecological degradation, including **pollution**, from activities within the region as well as its vast catchment area. Therefore "this sea is especially vulnerable because – of all inland seas – it is perhaps the most isolated, the least able to dilute or eliminate toxins once introduced" (Earle, 1997). Above stressed pollution considerably concern *chemical, oil* and *bacterial* pollution, as well as *biological* pollution through accidental introduction of (harmful) exotic species (Zaitsev, 1997).

The generally accepted ecological term of reference to the significant transformations in the Black Sea is the period 1950-1960.

Due to the present situation, the Bucharest Convention was signed by all coastal states (Bulgaria, Georgia, Romania, Russian Federation, the Ukraine and Turkey) in 1992. It was followed by the Odessa Declaration (1993), the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea (Istanbul, 1996), and the Ministerial Declaration (Monaco, 1998). An International Convention for the Protection of the Danube River was also signed by the thirteen Danube riparian countries in 1994.

The Black Sea and Danube conventions were assisted by GEF projects, whose main tasks consisted in:

- to increase the countries capacity of monitoring the specific ecosystems and to assess the effects of pollution;
- to identify and assess the main land based (point and non-point) pollution sources;
- to develop Transboundary Diagnostic Analyses;
- to develop and approve Strategic Action Plans (Black Sea and Danube);
- to identify and develop investment portfolios.

Among the first results were the compilation of an inventory and assessment of land based pollution sources (1996), the publication of *Black Sea Transboundary Diagnostic Analysis* (1997) as a scientific explanation of the root causes of environmental degradation of the Black Sea, and of *Black Sea Pollution Assessment* (Mee and Topping, 1998).

In 1997 a Joint Technical Working group was established by the Black Sea and Danube Commissions. Its task was to identify the existing correlation between the increase in the nutrient load in the Danube and correspondingly in the Black Sea, and the response in the ecosystem. The main conclusions were:

-"The **long-term objective** is for all Black Sea basin countries to take measure to reduce nutrient levels and other hazardous substances to such levels necessary to permit Black Sea ecosystems to recover to similar conditions as those observed in the 1960s";

-"As an **intermediate objective**, urgent control measures should be taken by all countries in the Black Sea basin, in order to avoid that discharges of nitrogen and phosphorus to the Black Sea exceed those levels observed in 1997. This will require countries to adopt and declare strategies that permit economic development whilst ensuring appropriate practices and measures to limit nutrient discharge, and to rehabilitate ecosystems which assimilate nitrogen and phosphorus. This target monitored and reported annually, shall be received in 2007 with a view to considering further measures which may be required for meeting the long-term objective".

Environmental quality monitoring

The environmental quality of the Black Sea has to be assessed through an integrated **monitoring**, by a macrosystemic understanding (Danube–Danube Delta–Black Sea), continuously developed at national and regional level, up to its recognised EU dimension (Water Framework Directive, Bathing Waters Directive, Habitats Directive, Shellfish Directive, etc.). This approach is consistently supported by UNCLOS + Agenda 21, UN Framework Convention on Climate Change, Convention on Biological Diversity, FAO Code of Conduct for Responsible Fisheries, Straddling Stocks Agreement, GPA for the Protection of Marine Environment from Land-based Activities, Integrated Maritime Enforcement and National Integrated Maritime Enforcement.

Permanently monitored parameters around the Black Sea refer to climate change, global warming and sea level rise, coastal erosion, pollution originating from the atmosphere and land-based sources, and biodiversity / living resources; usually, nutrients, heavy metals, radionuclides, petroleum hydrocarbons, persistent organic substances, litter and sewage are monitored basin–wide.

According to SAP-BS “the state of the Black Sea environment continues to be a matter of concern due to the ongoing degradation of its ecosystem and the non-sustainable use of its natural resources”; this consideration referred to levels / loads of chemical, oil, micro-(bacterial) and biological pollution.

Both GEF / Black Sea and Danube conventions increase the countries capacity of *monitoring* specific ecosystems and assess effects of pollution, identify and assess main land-based (point and non-point) pollution sources,

develop Transboundary Diagnostic Analysis (TDA), develop and approve Strategic Action Plans (for the Black Sea and Danube), and identify and develop investment portfolios.

Successful improvement of environmental quality monitoring can be achieved by taking into consideration various present Black Sea related conventions, declarations and agreements which sustain the progressive strengthening of regional co-operation between Black Sea coastal states, other countries and international organizations.

Black Sea water quality monitoring in Romania

Based on above considerations, Romania is represented in the Black Sea scientific community by the Ministry of Environment and the National Institute for Marine Research and Development (NIMRD) "Grigore Antipa" (former Romanian Marine Research Institute/RMRI) in Constantza; the institute is "the technical operator of the national network of physical, chemical, biological monitoring of coastal marine waters and of the survey of coastal erosion". Since 1974, RMRI/NIMRD is performing the marine water quality monitoring with respect to environmental protection for decision making at central and local authority levels.

As requested by Black Sea countries including Romania as active Part, and according to Resolution no. 3 of the Diplomatic Conference, GEF approved and launched BSEP in 1993. One of its major tasks consisted in elaborating SAP-BS; this one specifies at chapter Assessment and Monitoring of Pollutants:

> 54. "A **Black Sea Monitoring System** based upon biological effects measurements and measurements of key contaminants will be established in compliance with the Bucharest Convention. It will consist of the integration of obligatory national monitoring programs, to be included in the National Strategic Action Plans, and an independent quality assurance system. It is advised that the Istanbul Commission develops such a quality assurance system through its Advisory Group on Pollution Monitoring and Assessment, by 1998".

Eutrophication

The Black Sea receives a large volume of freshwater containing considerable amounts of inorganic nutrients. Owing to strong thermohaline stratification and to long residence time of water mass, the Black Sea ecosystem is highly sensitive to increased production of organic matter. The last 30 years represent a period of intensification of the anthropogenic pressure on the coastal environment and high **eutrophication**, with negative effects on the whole ecosystem. Important nutrient and organic inputs from rivers and industrial and domestic drainage resulted in the

increase of the magnitude and frequency of algal blooms followed by hypoxia and anoxia, benthic mortalities, and a remarkable decrease of biodiversity.

Anthropogenic activities having a severe impact on the Black Sea originate in a drainage system of over five times the area of the sea surface itself (Bologa, 2003). The large territories of the Danubian and riparian countries that constitute this area include over 165 million people from 17 countries (81 million in the Danube Basin alone). The activities are basically marine transportation (e.g., in the Danube, Danube-Black Sea canal and harbors), industry (e.g., cement, super-phosphates, petrochemistry, and nuclear energy), agriculture (e.g., fertilizers, herbicides, and pesticides), fishing (i.e., overfishing), and tourism (e.g., recreation, aquatic sports, and health). As a result of these activities, there has been an evolutionary trend in the Black Sea from an initially diverse ecosystem supporting highly productive fisheries to a highly eutrophic plankton culture dominated by the ctenophore *Mnemiposis leidyi*, with environmental conditions unsuitable for higher biota.

Thus, the major environmental concerns for the Black Sea today consist of the following:

- continuous degradation of seawater quality due to increasing eutrophication (e.g., the Danube input: 340,000 t of total inorganic nitrogen/year and 60,000 t of total phosphorus/year, translating into 2.5 times and 3.8 times more, respectively, compared to 1970-1990; for the Romanian littoral zone 4 to 8 times more nitrogen and 13 to 21 times more phosphorus compared to 1960-1970;
- extension of hypoxia and/or anoxia;
- possible increasing hydrogen sulphide (H_2S) concentrations in the eutrophic layers;
- continuous accumulation of atmospheric and land-based pollutants (e.g., heavy metals, radionuclides, oil, herbicides, pesticides, and detergents);
- decreasing capacity of coastal areas for self-purification from chemical and microbiological contaminants.

Biodiversity

Black Sea **biodiversity** studies have shown that since 1950-1960 there have been significant changes in the ecosystem as a whole regarding populations, species composition and biocenoses. These changes put an end to centuries of relatively stable ecological balances and marked the beginning of a new era in Black Sea biodiversity, affecting plants, animals, benthic and pelagic inhabitants, mass and rare species, and commercially exploited organisms.

The different taxa in the Black Sea have not been studied to the same extent in each of the littoral states, However, reliable data exist already sufficient to reach conclusions about the present state of Black Sea biota, including the main reasons for the changes that have occurred, the regions of the sea that have been subject to varying degrees of anthropogenic transformation, endangered species, populations and communities, and major gaps in our knowledge of biological diversity. The major biological long-term changes during the last 30 year could be summarized as follows:

- dramatic changes in the structure and functioning of coastal (benthic) and pelagic ecosystems;
- changes in both quantitative and qualitative state of phytoplankton and zooplankton communities;
- increase of phytoplankton and zooplankton blooms;
- massive reduction of both floral and faunal biomass;
- permanent decrease of biodiversity and living resources (starting from a less varied flora and fauna compared to the Mediterranean);
- frequent simplification of the trophic food chains (often eliminating species of economic value to man);
- occasional mortalities of organisms amounting up to 100-200 t km^2/year along the Ukrainian and Romanian coasts (i.e., commercially valuable fish stocks and shellfish); and
- decrease of bioproductivity (e.g., benthos, flatfish, sturgeons).

The obvious decrease of the ecological health of the Black Sea induced pronounced alterations, especially in the structure of littoral ecosystems and generated a major decrease of biodiversity.

Urban sewage treatment

As already mentioned marine water quality is one of the priorities among contemporary Black Sea environmental issues (Bologa and Costache, 2005).

Its major importance and complex implications are evinced by international and national concerted concern and actions, such as the control of eutrophication and the financing of nutrient reduction supported by GEF, the continued European Union (EU) commitment to the Black Sea, the Strategic Action Plan for the Rehabilitation and Protection of the Black Sea with related National Action Plans for the entire region.

Coastal water quality along the Romanian Black Sea coast will be considerably improved by the full operation of four modern wastewater treatment

plants at Constantza Nord, Constantza Sud, Eforie Sud and Mangalia: following main achievements are expected from the modernization of mentioned facilities:

- conformity of wastewater quality parameters with European Economic Community (now EU) Directives,
- improvement of quality control and ecological protection of coastal waters,
- fulfillment of Romania's EU obligations.

Conclusions

1. The Black Sea ecosystem is still in an advanced state of ecological disequilibrium.
2. There is a strong need for developing and enforcing adequate policies regarding environmental monitoring and protection in accordance with sustainable development.
3. National monitoring programs concerning the Black Sea should be harmonized by the coastal states at regional level following the programs, projects and co-operations.
4. The Romanian marine monitoring programs includes a complete network of transects and stations along the entire coast (from shore to offshore control sampling points), to evince all pollution sources.
5. Physical, chemical, biological, and microbiological pollutants are monitored daily, monthly, quarterly, annually and/or multiannually.
6. Annual reports on the state of the environment, including the marine one, should be (in Romania are) issued and forwarded to concerned central and local authorities.
7. Marine environmental data and databases can and should be used for development of national, regional and international research and management programs and projects.

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