

Considerations on the Main Confrontations of Pollution by the Black Sea Ecosystem

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Authors' contributions

This work was carried out in collaboration between both authors. Author BVC designed the study, performed the literature searches and wrote the first draft of the manuscript. Author MC managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Until the beginning of the 21st century, concerns related to environmental management have been reduced only to voluntary initiatives of nature lovers, rarely materializing in specific protection and conservation measures carried out by the authorities or administrators of those areas. As the concern for the management of protected areas, in general, of marine areas of community interest, in particular, is relatively new in Romania, and the information related to this subject is relatively little, especially those regarding marine ecosystems. We considered this study as useful to those with concerns in the field. The Black Sea ecosystem, following the analyzes carried out on the basis data from the media and the literature consulted, as well as following other observations, we

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concluded that it has a significant pollution with plastic waste, and less with petroleum products resulting from accidents and spills. At the same time, the protected areas associated with the Black Sea, as well as the marine ecosystem itself, are far from being affected by such incidents. Through this paper, we aim to review some general aspects of the main problems facing the Black Sea ecosystem, an ecosystem that has great potential to become a sustainable model of community development, promoting in them, more than in other areas, sustainable resource management. We also aim to highlight the evolution of pollution of the ecosystem considered, the study itself relating to the principles of management of protected areas of community interest and good practice policies specific to environmental management.

Keywords: Coastal pollution; conservation; dangerous substances; ecological consequences.

1. INTRODUCTION

Marine pollution is defined as the presence, in excess, in the marine environment of organic and inorganic compounds (often of anthropogenic origin), which leads to the alteration of ecosystem characteristics [1]. The first signs of deterioration of the Black Sea ecosystem appeared in the 60s-70s. In the following years, the ecological situation in the region worsened [2]. The gradual reduction of the pressure and stress exerted on the ecosystem by anthropogenic activities, as well as the improvements observed today in the marine ecosystem, even if they are minor, are reasons for hope.

In the Black Sea, in addition to small-scale navigation, fishing and aquaculture, mining, tourism, recreation, and military operations are also practiced [2]. The continental shelf and the Black Sea basin are also under strong pressure due to intensive human activities, including urban development, industry, hydroelectric and nuclear energy use, agriculture, and land artificialisation [2]. The main factors threatening the Black Sea ecosystem are the pollution of the sea (with solid and liquid waste), the physical changes of the seabed, coasts, and tributaries, the depletion of natural resources caused by the overexploitation of marine species with high economic value, and the list goes on.

Man-made pollution is the main threat to the Black Sea region and is the most serious environmental problem [2,3]. The main causes of Black Sea pollution are land-based waste, air pollutants, waste intentionally or accidentally discharged from ships, and pollutants brought into the sea by rivers. In addition to the factors mentioned, the main types of pollution observed in the Black Sea ecosystem are the chemical pollution (nutrients from agriculture, crude oil and petroleum products, persistent synthetic

pollutants and trace elements), radioactive pollution, solid waste pollution and biological pollution caused by living invasive marine organisms.

Through this paper, we set out to show what are the main problems (at least some of them) facing the Black Sea ecosystem, which have made their presence felt more and more recently. In addition to pollution with petroleum products, pollution with waste and substances used in intensive agriculture, are also addressed issues related to fishing (in most cases illegal) and the introduction of non-native species.

2. METHODOLOGY

The documentation for this paper started, as was probably the case, from the authors' concerns for ecology, for the management of protected areas and, last but not least, because they love marine ecosystems. Having at hand a series of extremely relevant studies at the international level, as well as a series of articles published in the media, regarding both the management of protected areas and pollution with petroleum products. The authors extrapolated those approaches to the relatively limited space of the Black Sea ecosystem.

This is how the subject of pollution of the marine environment with various products (plastic products, petroleum products, etc.) reaches the lands of our country, where there are few studies that make direct reference to the management of marine or even coastal areas. Through this paper, we want to actively contribute to stimulating a process of biodiversity restoration. Although it does not have a true methodology, in the sense of conducting field research, is only a review of the literature and publications in the media, the paper is based on interesting documentation to follow, the bibliographic

sources being mainly in the range reference 2014-2020.

3. RESULTS AND DISCUSSION

The Romanian coast, located exclusively in the Pontic biogeographical region, has a length of 244 km, to which is added the actual marine part, included in the Black Sea bioregion composed of associations of marine, coastal and dune ecosystems [4,5]. The marine park covers an area of approximately 5,400 km², if we take into account only the territorial waters. Currently 24.5% of this area has the status of protected natural area. In the coastal area, out of the total length of 244 km of the Romanian coast, approx. 68% are in protected areas [6].

The Black Sea is a semi-enclosed sea in the Atlantic Basin, part of the Mediterranean Sea, to which it is connected by the Marmara and Aegean seas through the Bosphorus and Dardanelles straits. Geographically, the Black Sea is located between Europe and Asia (40°55' and 46°32' lat. N and 27°27' and 41°42' long. E), in a region where ancient stable platforms come into contact with young mountains generated by alpine orogeny [7,8]. The border established by geographers between the two continents, the Caucasus and the Bosphorus Strait, cuts this sea into two unequal parts, most of which are European. The states bordering the Black Sea are: Romania, Ukraine, the Russian Federation, Georgia, Turkey and Bulgaria (see Fig. 1) [7,8].

The Black Sea river basin (see Fig. 2) has an asymmetrical position: 82% occupies central and southeastern Europe, the remaining 18% includes the northern Anatolian peninsula and the western Caucasian and Transcaucasian regions [7,8]; the numerous watercourses that flow into the Black Sea have a radial arrangement and varying lengths, and their hydrological regime differs according to the regions they cross. Most rivers flow on the northwest coast: the Dniester (1,411 km), the Dnieper (2,285 km), the Bugul (857 km), whose mouths have been transformed into estuaries, further south, the Danube river (2,860 km), Provadiyska (119 km) and Kamchya (244 km) [7].

Important water supply is received by the Black Sea from the Don (1,950 km) and the Kuban (870 km), through the Sea of Azov. On the southern coast, in Turkey, the rivers Sakarya (824 km), Kızılırmak (1,350 km) and Yeşilirmak (418 km) flow into the sea [7]. Other waters flowing into the Black Sea are Çoruh (438 km) in Turkish Armenia, Rioni (327 km), and Inguri (213 km) in Georgia. The hydrographic network thus drains a basin area of 2,402,119 km², of which the Danube basin has 805,000 km² [7,8]. Due to the isolation of the ocean, inland waters significantly influence the hydrological elements of the sea.

The Black Sea is connected to land by the Danube River which is considered the main



Fig. 1. Black Sea Basin and its connection with other seas [7]

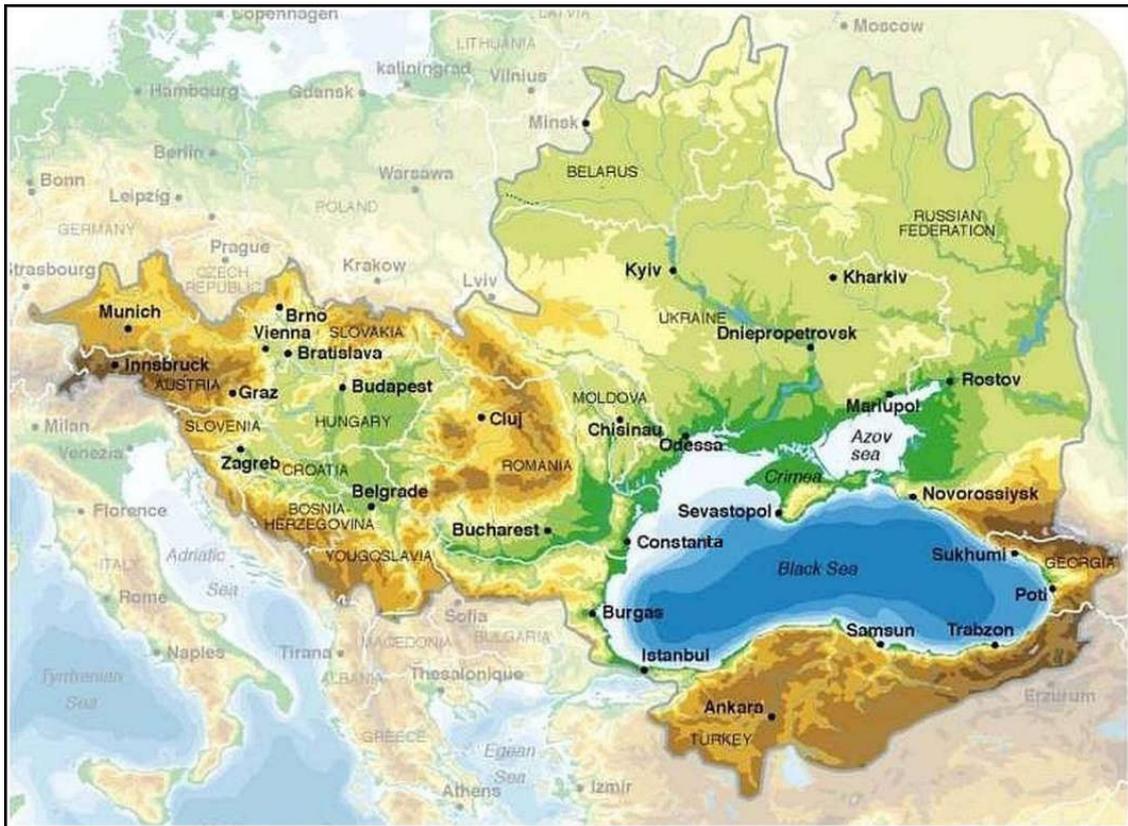


Fig. 2. Black Sea Basin and watercourses that flow into [7]

transmitter of pollutants. The chemicals seep through the ground into the river water and are thus carried to the Danube and from there to the sea. Chemicals such as oil, fertilizers, insecticides and herbicides that do not decompose in contact with the soil eventually enter the Black Sea. The sea thus becomes a huge repository for these mixed collections of fertilizers and waste [9-11]. Crude oil and other petrochemicals are the main pollutants in the Black Sea, along with wastewater, household waste and air pollution. Crude oil is always involved in major pollution incidents. Common practice of washing oil tanks spills a lot of crude oil, along with significant amounts of heavy metals such as cadmium, nickel, arsenic, copper, lead, zinc or chromium, which unbalance the balance of the entire ecosystem.

3.1 Pollution of the Black Sea Ecosystem with Dangerous Substances

Persistent organic pollutants are toxic chemicals that adversely affect human health and the environment worldwide. Many of these substances were widely used during the development of industrial production after World

War II, when thousands of synthetic chemicals were introduced into the commercial circuit. These chemicals have proven beneficial in pest and disease control, in the development of agricultural production, but also in industry. On the other hand, those substances had unintended effects on human health and the environment. Although in Romania the production and use of these substances has been banned or restricted since the '70s and' 80s of the last century, these compounds are still present in the marine environment.

The most likely sources of contamination for the Black Sea are the Danube River and air transport. Because persistent organic pollutants can be transported by wind and water, most of these substances affect the population and the environment away from where they are used and released (see Fig. 3). The transport of persistent organic pollutants depend on the temperature, they tend to pass into the gaseous phase at ambient temperature.

And so, these compounds can volatilize from soils, vegetation and water bodies in the atmosphere and, due to their resistance to



Fig. 3. Pollution associated with the persistent organic pollutants, near Danube [2]

degradation reactions, are transported long distances before being deposited again. The cycle of volatilization and deposition can be repeated several times: in the process known as the "cricket effect", these chemicals circulate on the entire surface of our planet, evaporating in warm regions, then being carried by the wind with dust particles, it settles in the cold regions of the Earth, then evaporates again and circulates further.

Persistent organic pollutants (POPs) monitored on the Romanian Black Sea coast are composed of the range of organochlorine pesticides (DDT and its metabolites, cyclodan insecticides, heptachlor, lindane, hexachlorobenzene) and polychlorinated biphenyls (PCBs). POPs present or arrived in the marine environment accumulate in sediments, where they can remain for long periods.

Through complex interactions, they can be immobilized, resuspended in water or taken over by marine organisms and pass from one species to another through the food chain. Those pollutants persist for long periods of time in the environment and even in the situation of reduced anthropogenic contributions, the sedimentary reserves accumulated over time continues to threaten the health of the marine ecosystem. Of particular interest is the presence of contaminants in fish and other marine organisms intended for human consumption. By contaminants we mean, according to European

legislation, dangerous substances present in fish, as a result of environmental contamination, for which limits have been set for human consumption or whose presence in fish is relevant".

Persistent organic pollutants have been associated with a significant impact on the environment in terms of a wide variety of species and virtually all trophic levels. Many persistent organic pollutants have been implicated in a wide variety of adverse effects on the environment and human health, including impaired reproduction, endocrine disorders, reduced immunity, and cancer. In addition, exposure to persistent organic pollutants has been correlated with population decline in several marine mammals. But, as with other environmental pollutants, it is difficult to establish a condition or disease that can be directly attributed to a persistent organic pollutant. Adverse effects associated with chronic exposure to low levels of environmental contamination are of particular interest because they may affect the stability of the entire ecosystem.

3.2 Pollution of the Black Sea Ecosystem with Other Substances

3.2.1 Agricultural waste and eutrophication

The Black Sea is polluted with agricultural waste (different types of fertilizers) of animal, household, and industrial origin, as well as with

organic and inorganic nutrients from various sources. Most of the nutrients are brought into the sea by rivers. An increase in the concentration of nutrients leads to the excessive development of the phytoplankton population, a phenomenon called "eutrophication".

Due to the nutrients, the life cycle of a unicellular alga becomes very short, it develops very quickly and then dies just as quickly. The decomposition of dead organic matter decreases the amount of oxygen in the marine environment. In ecosystems where the phenomenon of eutrophication is observed [12], the water becomes dark due to the excessive growth of plankton [13], and living organisms die en masse due to lack of oxygen. This phenomenon leads to a decrease in biodiversity.

The increase in the number of nutrients (eutrophication) [13-15], respectively significant amounts of nitrates and phosphates reach the seawater due to the extensive use of fertilizers in agriculture and the discharge of untreated domestic water, leads to the explosive multiplication of algae at certain times of the year (April-July), having as an effect:

- massive consumption of oxygen in the water (in some areas it leads to suffocation and mass death of organisms living on the seabed);
- the appearance of seaweed waves on the shore (see an example in Fig. 4);
- changes in the qualitative and quantitative structure of benthic associations (almost continuous impoverishment of plant structure and animal populations, resulting in reduced biofilter power and increased biocenosis uniformity);
- changes in the structure of marine animal populations (decrease in the number of zooplankton species, almost total extinction, etc).

3.2.2 Discharges of wastewater and petroleum products

In the Black Sea, oil pollution is concentrated in coastal areas. It comes from permanent sources such as estuaries, wastewater discharges, ports, and industrial areas. The discharge of oil and petroleum products into the sea from ships triggered either accidentally or by operational causes, leads to pollution of the coasts or off the Black Sea (see Fig. 5).

Almost 110,000 tons of oil are dumped annually in the Black Sea. According to official data, most of these spills occur due to accidental causes [17]. Oil pollution unbalances the coastal ecosystem by destroying fish eggs and larvae and also affecting seabirds. Moreover, crude oil sticks to birds' feathers and destroys their vulnerable feathers. Thus, birds lose their ability to maintain body temperature, fly, and sink, as well as the impermeable nature of feathers, which leads to disease and death.

Oil negatively influences, on the one hand, the transfers of matter within biogeochemical circuits, and on the other hand, the flows of caloric energy at the interface between the two environments. It has been estimated that one tonne of oil can cover 12 km² of ocean, which means that at the annual number of millions of tons spilled across the planetary ocean, the sea surface contaminated by this form of pollution would be tens, maybe even hundreds of millions km² (in the case of the Black Sea). Due to the current concentration of pollutants on the surface, the ocean - which plays an important role in the exchange of gases with the atmosphere, absorbing some of them - takes up decreasing amounts of atmospheric CO₂, so that excess CO₂ of anthropogenic origin contributes to amplifying the effect greenhouse.

3.2.3 Heavy metals, plastic waste and radioactive pollution

Heavy metal pollution is not considered a problem affecting the entire Black Sea basin. However, in some coastal areas where industrial structures are found, the surface of the sediments contains high amounts of chromium, lead, copper, zinc, cobalt, nickel, arsenic, mercury, and iron. This pollution can end up being toxic levels for consumers in trophy chains such as humans, seabirds, and marine mammals. Heavy metals tend to reach the upper links of the food chain. For example, mussels that live on the seabed can accumulate large amounts of heavy metals in their bodies. Consumption of these mussels can lead to food poisoning. The intake of toxic elements through food can lead to various pathological disorders (chronic poisoning) of different systems, organs, and tissues.

On the Black Sea coast, there is a large amount of solid waste containing plastic (Fig. 6). Plastic waste and lost fishing nets pose a serious threat to marine mammals that swallow them. For



Fig. 4. Pollution associated with the eutrophication phenomenon [16]



Fig. 5. Pollution associated with the discharges of petroleum products [18-21]

example, foreign objects were found in the stomachs of some common porpoises and failed dolphins.

Another type of pollution in the Black Sea is caused by radioactive substances from human activities. In 1986, the Chernobyl disaster took place in the USSR. The radioactive pollution caused by it was carried into the sea by rivers and rainfall. This has led to the death of many marine organisms and the surface of ships. Untreated ballast water also transports such organisms into the Black Sea. Currently, the Black Sea is invaded by some

loss of the reproductive capacity of several fish species.

3.3 Introduction of Non-native Species and Fishing

Accidental introduction into the Black Sea of non-native (or invasive) plant and animal species poses a threat to the ecosystem and is difficult to control. Marine organisms that cause this type of pollution are usually transported to the outer exotic species of crab, jellyfish, ringworm, mollusks and algae. Another factor that has determined the penetration of non-native species



Fig. 6. Pollution associated with the plastic warehouses, Black Sea coastal area [2]



Fig. 7. Group of fishermen from the Russian Black Sea coast

in the Black Sea is the dolphins or large aquariums on the coasts. Exotic marine mammals from these places are kept in outdoor shelters near the shore, and from here, sometimes escape into the sea.

Fishing in the Black Sea dates back thousands of years, with Herodotus being the first to mention the presence of large shoals of anchovies, sardines and trout in the Black Sea basin. Preserving its wealth of living organisms with economic value until the 1970s, the Black Sea became the host of a growing number of fishing boats over time. Until the 1990s, fishermen used traditional fishing methods (see Fig. 7) and located their shoals of fish.

With technological progress, fishermen began using sonar to find fish, while wooden boats were replaced with boats with metal hulls. These developments, which left no chance of fish escape, led to the massive exploitation of fish

stocks, which was exacerbated by the increase in the number of fishing boats. Recent studies indicate that some fish species have become endangered due to overfishing. Accidents with dolphins caught in fishermen's nets are another problem related to fishing. Especially turbot-prepared nets pose a serious threat to dolphin species swimming in coastal areas.

4. CONCLUSION

Reducing poverty and improving livelihoods, society and the economy are not possible without the conservation and protection of the environment, including the marine environment. But people still ignore and do not understand that nature, all the species of plants and animals that populate it (biodiversity), are the ones who provide us with new material goods and services. The whole community needs to understand this, and more than that, they need to start taking a stand on what is happening.

Oil pollution in the world's seas and oceans has reached such a magnitude in the last forty years that, according to many experts, marine ecosystems should take years to fully recover, both in terms of the health of biotopes and in terms of rehabilitating all species of flora and fauna that have suffered as a result of pollution. As shown in recent studies, the analysis of the hydrocarbon content present in ocean waters showed that in offshore waters, the concentration is less than 1 ppb, and in coastal waters, it is about 1-10 ppb; a higher concentration was highlighted near the oil rigs, where values of 2-20 ppb were recorded.

Unlike the oceans, in the waters of the seas, it has been estimated that, in general, the concentration of hydrocarbons is about 3 ppb offshore, 20-50 ppb in territorial waters and can reach values of 100-1000 ppb in areas polluted with petroleum products. These values are average and differ from one sea to another, depending on several factors: the volume of oil spills from various sources, the intensity of maritime traffic, sea characteristics (surface, water volume, degree of opening, the concentration of biodegradable factors, etc.)., the intensity of the effects of hydrometeorological phenomena, etc.

At the same time, ocean surfaces polluted with hydrocarbons, but also with other categories of pollutants (detergents, pesticides, PCBs, etc.), reduce the processes of photosynthesis, evaporation, and formation of oxygen and marine aerosols, whose role in atmospheric circulation and in supporting some hydrometeorological phenomena is decisive. Through this paper, we wanted to show that without oil we can not live, at least in terms of the transport system of today's society, but we can carefully ensure the necessary harmony between specific technologies and our living environment, of which they are part until followed by both terrestrial and marine ecosystems. In this context, the ecological management of protected areas, whether they are part of the marine ecosystem can be a good starting point for achieving a human-nature balance. Moreover, only in this way, by respecting the legislation and by adopting an active and pro-environmental behavior, it is possible for the Black Sea ecosystem to be conserved, protected and reintegrated in a tourist circuit according to sustainable principles. Only in this way the main problems facing the Black Sea can be solved and pollution be kept under control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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