Some Considerations about the Economic Problems Generated by Hypertrophication in the Romanian Shore Area of the Black Sea

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Abstract: The hypertrophication phenomenon (excessive eutrophication, induced by human activities) affects more and more the waters in the western area of the Black Sea, including the Romanian sector. This phenomenon is generated by the accumulation, in large volumes, in the sea waters, of some compounds, especially phosphorus, nitrous and nitrates, which mainly originate in the agriculture made in the river basin of the Black Sea, and from certain industrial activities, as well as from the household waters reaching the flowing waters that are tributary to the Danube. Romanian sea waters are affected by the transport of these compounds mainly by the Danube, but also by the ones coming from the Dniester and the Dnieper. There is a common responsibility for the fact that these phosphorus and nitrous compounds, which generate the hypertrophication in the waters of the Black Sea, belonging to all the states from the river basin of the three large flowing waters, to a larger or smaller extent, which is frequently hard to quantify. The negative economic impact consists of the more and more frequent pollution with algae of the sea water and beaches in the Romanian area, disturbing phenomenon which even banishes tourists. Then, the changes in the biocoenosis structure also lead to loses in aquaculture and fishing. It is necessary to implement a system to identify polluters, to quantify the amount of pollution of each involved part to share the costs between them.

Keywords: excessive eutrophication; hypertrophication; pollution cost sharing; Black Sea

Introduction

Quite frequently lately, during the summer season, we have been warned by the mass media, assaulted by information regarding the algal blooming phenomenon on the Romanian shore of the Black Sea. These phenomena coincide with the touristic

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season and, thus, the impact of this information about the large scale development of the algae deposits brought by the sea tides towards the shore or the images with the sea water full of algae get to shock us. As for the present article, we aim at opening a discussion on the causes of this phenomenon, on who is guilty about it and who should support the economic or environmental costs of this anthropic originating phenomenon, according to the principle claiming that "the polluter pays", to point out the fact that one should think about, to implement a system that would measure the ratio between the anthropic and the natural regarding the causes of the excessive algal blooming.

The Definition of Certain Terms; the Eco-Geographic Context of the Black Sea

First of all, we should start from the fact that, through *eutrophication*, one understands an enrichment of the water with organic and inorganic nutrients (Török, 2006). This eutrophication practically influences the whole aquatic ecosystem, all trophic chains, with multiple implications from the biological perspective. Eutrophication represents a phenomenon which, up to a certain limit, is normal, met within the nature, with no human influence and which is practically influenced by the physiology of the algae; sometimes, due to natural reasons, there is an explosive algae bloom, favored by higher temperatures or rich volumes of precipitations, which is a part of the breeding cycle of algae; this phenomenon is also known as (improperly) as algal blooming, in spite of the fact that algae do not have flowers, do not really bloom.

Nevertheless we are interested in the eutrophication excess generated by the inclusion in the aquatic ecosystem of the nutrients resulted from human activities (especially from agriculture), thus the eutrophication as an anthropogenic effect. In order to make a clear delimitation between the natural and the anthropogenic eutrophication, some authors worldwide use the *hypertrophication* concept for the human eutrophication (Mahoney & McLaughlin, 1977; Lavery et *al*., 1991; Crossetti et al, 2008; Petre & Teodorescu, 2009; Mahmood et *al.,* 2019, etc). This is an ecological phenomenon generated by human activities, consisting of the rapid growth, overpassing the optimal level of nutrients, especially of the nitrous and phosphorus compounds, leading to massive ecologic imbalances. In order to be more clear, we will further use the *hypertrophication* concept, regarding this excessive eutrophication, which is more and more present, caused by the accumulation of nutritive human compounds for the algae.

Hypertrophication can be observed in many lakes, gulfs, estuaries on the Globe, but it also frequently affects some sea shore areas where the circulation of the water, both on vertical and on the surface is lower (https://oceanservice.noaa.gov), such as the Black Sea case, a sea that is a marginal sea, semi-enclosed sea (http://blacksea-education.ru/e2.shtml) it is almost a lake, which communicates very difficult with the Planetary Ocean. Sometimes, this phenomenon of hypertrophy can be caught even in some rivers, in areas where the flow speed is slow (Müller D., Kirchesch, 1980; Vlăduțu, 2005), or where on the course of the rivers accumulation lakes were arranged, water stagnating (Conete, 2011; Conete, 2014).

Several unique particularities of the Black Sea make it even more vulnerable against this hypertrophication phenomenon.

First, the Black Sea, with a surface of 432.000 km^2 (www.blacksea-commission.org), is geographically a quasi-closed sea; it hardly communicates with the Atlantic Ocean, by a pathway crossing the Bosphorus Strait, Marmara Sea, the Dardanelles, the Aegean Sea and the Mediterranean Sea and the Gibraltar (Fig. 1). The depth of the Bosphorus varies between 36 and 124 meters, and the width between 700 and 3600 meters (www.istanbultrails.com), which makes it impossible for a profound change of the water volumes, a whitewashing of the Black Sea waters at significant depths.

Second, the Black Sea is an atypical sea, namely its waters are stratified, with just the surface water layer reaching approx. 180-200 meters depth has an lower average saltiness and is oxygenated, then comes an aphotic layer, with an increased salinity and, which is more important, anoxic, an acidic environment, reaching the bottom of the sea. Such an anoxic environment is also called “euxinic”, originating in the old name of the Black Sea, namely Pontus Euxinus. Hence, from a general perspective of things, we can now better understand that the life in the Black Sea (excepting the anaerobic microorganisms) is only possible within that layer of water between the surface of the water until approximately 180 meters depths (Dorobăț, 2012a; b). The maximum depth of the Black Sea is 2212 m (www.blacksea-commission.org).

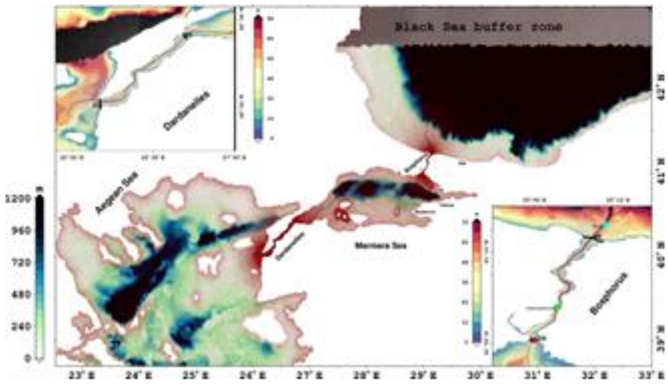

Figure 1. Communication between the Black Sea and the Aegean Sea through Bosphorus Strait, Marmara Sea and Dardanele Strait
Source: Aydoğdu et al., 2018

To the above mentioned information, we can add the fact that the geomorphology of the Black Sea basin has developed so that in the north-western area of the sea, hence in the Romanian shores area, the depth of the sea is under 50 meters (Fig. 2). Practically, the risk for the sea animals' species in this area is even higher, as they do not have the chance of taking shelter in deeper waters, given the hypertrophication of the surface waters and the decrease of the oxygen volume.

If we take a look over the map in Fig. 3, we can also notice another aspect: the Danube, but also the Dniester and the Dnieper feed the sea in low-depth areas.

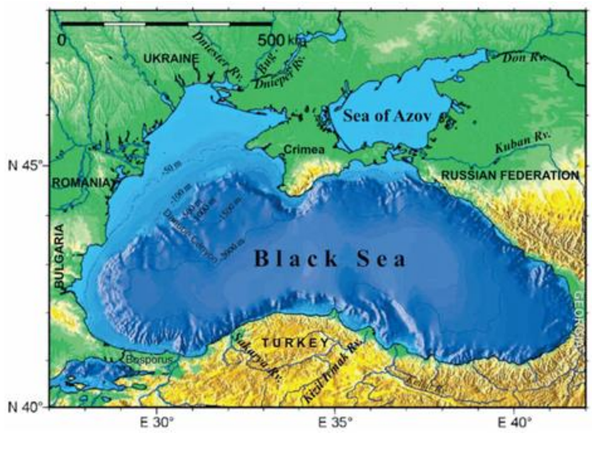

Figure 2. Black Sea Morfology; Detailed View of the NW Black Sea Sector.
Source: Popescu et al, 2015

Moreover, figure 3 proves that, on the surface, in the Romanian seashore area also, there are surface sea currents (in red arrows) that are parallel to the shore, which have a trigonometric direction, from the NE towards SW, thus transporting pollutants from the Danube, even from the Dnieper and the Dniester.

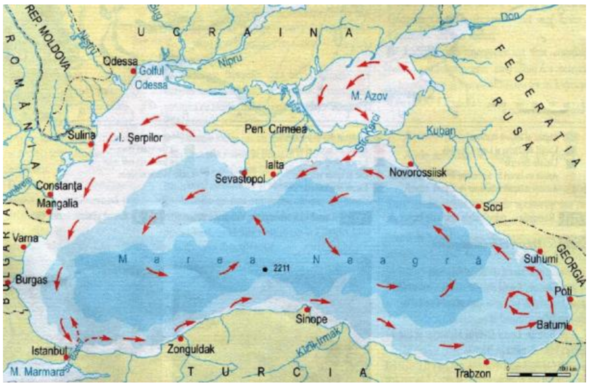

Figure 3. Black Sea Marine Currents (in Red Arrows)
Source: Budea et al., 2016

Considering that these three large flows drain a significant part of Europe (Fig. 4), transporting industrial and household residual waters and also waters full of chemical nutrients from the agricultural industry, the conclusion is that the north-western and the western area of the Black Sea has significant chances of containing an increased content of phosphorus and nitrous compounds, which have been dumped in the sea through the flowing waters, thus leading to hypertrophication.

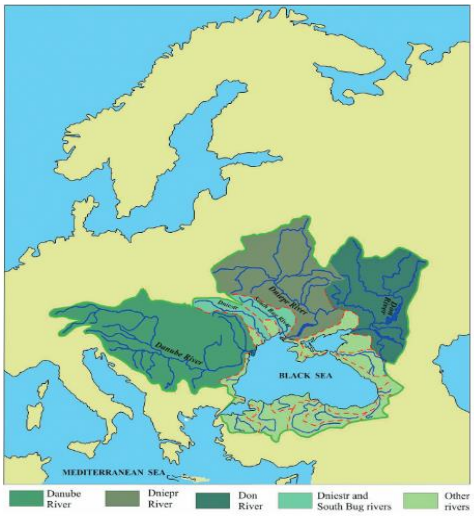

Figure 4. Drainage Basin of the Black Sea
Source: Popescu, 2002, from Popescu et al. 2015)

Direct Economic Implications

In the beginning, we should have asked ourselves which would have been the effects of this hypertrophication phenomenon generated by the human factor. Are they significant? When it comes for the ecological effects, we do not deepen the debate, as it does not represent the scope of the present paper, but the researchers' conclusion is that a spill in the sea of nitrous and phosphorus compounds through flowing rivers that drain the river basins, leads to significant disturbances in the less depth seashore areas, as it is the case of the Romanian shore. We only mention the fact that the hypertrophication is seen as a major issue around the Globe, and the hypoxic or even the anaerobic areas are met in many areas of the Planetary Ocean, in gulfs, deltas, some coast areas, as well as in the continental waters, in many lakes. The hypertrophication phenomenon does not simply regard the hypoxia of certain marine areas, but it also has another side: the changing of the phytoplankton species in an aquatic environment (as a result of the excessive nutrients), will determine major changes within the whole food chain, as it will also change the zooplankton species, which eat phytoplankton, then it will also determine the changes in the fish species which eat that zooplankton. We can rather notice a reverse effect, the disappearance of some nutrients due to anthropogenic causes, which leads to the changes in the phytoplankton structure and it produces timely changes in the ecosystem. Such an example is represented, in the case of the Black Sea, the fact that, subsequently to the constructions of the Portile de Fier (Iron Gates) I and II dams, as well as of other dams on the Danube tributaries, the silicone dioxide volume from the sediments carried by the water to the sea has decreased in an extreme manner, which lead to the drastic decrease of the diatoms (microalgae), which effects regarding the structure of the biocoenosis in this areas of the Black Sea (http://old.lefo.ro/iwlearn/eutrofizarea.html).

When approaching the immediate economic effects generated by hypertrophication, we can provide certain examples in order to understand that this phenomenon is just a theoretical issues, far from the economic life. We can start with what we have already reminded in the introduction of this article, the fact that this hypertrophication is spectacular, as this huge volume development of this algae in the seashore area, filling the beaches and the water right next to the shore. The phenomenon is also accompanied by smell and is disgraceful for tourists, making them want to leave or never come back in such places. Nevertheless the duration of the touristic season on the Romanian seashore is lower than in other southern states, leading to the problem of the profitableness and the recovery of the investments by the owners of touristic complexes (resorts). If we also add the periods when the water and the beaches are full of alga on a large scale, things become more complicated. These images are presented in the mass media or through the social media networks and determine many tourists to give up on buying a vacation in such places, which has also been noticed by the touristic patronage. One can find several images below (Fig. 5).

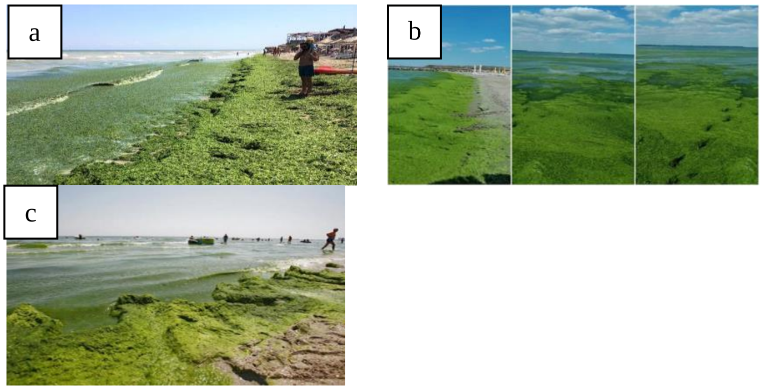

Figure 5. Algae on the Beach and in the Water
Source: a. https://evz.ro; b. https://observatornews.ro; screen capture; c. http://www.horeca.ro)

In order to show that it is not a specific phenomenon of Romanian beaches, we also provide an image from France from 2011, when six beaches were closed in Bretaigne (Fig. 6).

Figure 6. Bretaigne, France. Algae on the beaches
Source: http://epochtimes-romania.com

The cause in this area in France is also external, as specialists claim, over the English Channel, in the SW side of Great Britain. Moreover, loses were not in this country, from the touristic perspective.

Epoch Time – Romania magazine mentions, citing various sources:

“For decades, potentially lethal green algae have gathered in the gulfs on the north-western coast of Great Britain, according to The Guardian.”

“During the discomposure, algae become dangerous, being able to induce fainting moods or even kill a person in a relatively short time.”

“Generating unusual large volumes of green algae is related to the nitrites from the fertilizers and the wastes resulted from the pigs, poultry and the dairy farms in the region. These are drained in the pluvial system and finally get in the sea, providing an excellent fertilizer for the marine algae. When algae decompose themselves, they create poisoning gas bulbs of hydrogen sulfide, which makes the algae potentially fatal for humans. In order to get the things more complicated, in time, toxic mud gathered on the shore, which can lead to fainting and cardiac arrest, and ecologists claim that the effect got worse this summer due to the exceptionally warm weather, according to France 24.”

“At least two persons and tens of animals have died during the inhalation of toxic gases in the area, in spite of the fact that some individuals warn that the two separate incidents do not reveal the scale of the phenomenon. Around 20 people die on the coast each year, frequently taken by the waves or streams, but the question is: how many of those individuals have fainted due to the toxic gas in the algae before being taken by waves? The state has not provide a certain answer to all these issues”, claimed for the Guardian Inès Léraud, one of those who constantly warn about the phenomenon…”

Such news really has a devastating emotional impact on the potential tourists which clearly decide to avoid such areas, especially if their lives are threatened.

We have mentioned the case in France in order to show that the hypertrophication phenomenon must not be underestimated, how some tend to, as it can also lead to human deaths. Fortunately, no such cases were signaled in Romania.

Another example of economic implications with significant impact is the one regarding fishing, fish farming/aquaculture and fish manufacturing. To provide devastating effects of the coast water hypertrophication, we should move over the Atlantic Ocean, in the USA. Thus, in 1997, 16.000 km^2 of the USA territorial waters in the north of Mexico Gulf, turned into a dead area as a result of nutrients spilling through Mississippi River, a phenomenon which caused major losses to the fishers, evaluated at more than 3 billion USD, as the nutrients came from the farmers in the river basin (http://old.lefo.ro/iwlearn/eutrofizarea.html).

Raising the Problem

Considering all of the above, we might raise a problem: what could be done in order to diminish this hypertrophication and how could we establish who and how much is polluting and then provide them with sanctions.

Practically, human nutrients sources are the unpurged industrial and household waters spilled in the areas in the river basin of the Danube and other rivers which are tributary to the Black Sea. Though, the largest “provider” of such substances which cause the hypertrophication of algae is the agriculture, by spilling animal wastes in rivers and especially by using agricultural fertilizers. A part of these fertilizers does not reach the plants, it is washed by precipitations and it ends in rivers. If rivers have a faster flow, then these substances cannot accumulate, but in the areas with slow flowing of the water, on the lower courses, we can notice algae hypertrophication. As a large volume of fertilizers reach the waters of the rivers and seas, it causes economical loses to the farmers, since these substances, rather than being used by plants, they are practically thrown, also causing damages in ecosystems.

Once these are accepted, we should see if we could implement a monitoring and evaluation system of pollution caused by hypertrophication compounds, and, then, identify the polluters.

We believe that there might be technical solutions. One could install evaluating stationaries of the water quality on the Danube course, for example (we took the Danube as an example, as it is the most “international” river in the world, flowing through most countries and draining a large part of the water catchment of the Black Sea).

To quantify the contribution of each country to the nutrients’ spill, we can install, at the entrance and leave of each country of some measuring/analysis stations of the chemical composition of the water. Things would be useless on the areas where the Danube represents the interstate border. In these sectors, one could install stations at the spilling of all Danube tributaries, on both shores in both countries. Moreover, on the Danube tributaries which flow through more countries (for ex., the Tisza, the Siret, the Proute), the procedure could be repeated, on their tributaries also. In fact, although it might look expensive, there would not be high costs and one could really monitor are research what happens with the pollution on the whole river basin of the Danube and one could also avoid/prevent ecologic problems which might become economic problems. Such, one could calculate each country's pollution intake, a more accurate quantification. If one wants to deepen the issue, each country can individually identify its pollutants and their intake.

By doing so, a pollution tax might be imposed, which would discourage the inefficient use of chemical fertilizers or the polluted water spilling in rivers. These amounts might be used to compensate the loses, for example the loses of the ones that own touristic complexes on the seashore and whose activity is damaged by hypertrophication.

Things are though complicated at the political level and probably this is why the implementation of such and system is not desired.

The Black Sea does not have to become a latrine of Europe and Asia Minor, where various pollutant substances gather and it does not mean that only its coastal states should support it and pay the costs.

The catchment of the Black Sea covers an area of 1,874,904 km^2; the Danube basin represents 43.57% of the total area of Black Sea basin, approx. 817,000 km2 (Vespremeanu & Golumbeanu, 2018)

19 states (20 if we include Kosovo) are part of the river basin of the Danube and, thus, of the Black Sea (www.unece.org/).

It is obvious that the heterogeneity of these countries, their different interests, make it difficult to implement such a system and accept the common sharing of the costs generated by the damages caused by the spilling of the compounds that generate the hypertrophication.

Maybe this implementation might also lead to a higher interest of the water pollutants in finding and using less polluting technologies. Ultimately, used substances should exclusively reach the plants and not get spread in the environment.

Long time ago a functional organism was created, ***The Commission on the Protection of the Black Sea Against Pollution,*** under whose umbrella the problems generated by the pollution of the Black Sea are monitored and researched and maybe that under the same umbrella the above discussed measures might be implemented.

Conclusions

The scope of the present paper was to warn about and approach a problem, the one of supporting the costs generated by the hypertrophication phenomenon.

From our perspective, the conclusion is that we first need to accurately identify the scientific causes of the excessive algae blooming, to see if these causes are anthropogenic or natural, which is the human intake, if the causes are various. This is difficult, very difficult, it requires years of observations and sometimes leads to specialists' contradictions.

For the cases when we can certainly identify the cause is represented by nutrients of anthropogenic origin, we then need to realize a complex system which should involve all the countries that are part of the river basin of the Danube (on the west-north-western part of the Black Sea), system which is to monitor and quantify as accurate as possible, from the scientific perspective, the intake of each country.

It would then approach the political aspect, very complicated and difficult, the creation of political-economic mechanism who should identify the economic loses and the participation of the polluting states in these loses, to sharing the guilt between polluters according to the principle claiming that "the polluter supports the pollution". Practically, the pollution generated losses and the environmental costs could be distributed between the guilty ones.

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