# The Perseus Ambassadors Competition: Eutrophication

The term *eutrophication* describes the ecosystem's response to the addition of artificial substances through human activity. Eutrophication has become a serious problem worldwide because the recent development of humanity brought changes that the environment simply could not adapt to quickly enough. Now it is our responsibility to help the environment to recover from what could become a catastrophe.

A strong, sound action plan should ask and then answer these questions:

1. What are the mechanisms behind eutrophication?
2. Is it possible to recover from big ecological disasters?
3. What actions can help prevent such events from happening in the future?

The mechanism behind eutrophication is fairly complex, but its simplified version starts with the cause – an oversupply of nutrients. These nutrients usually reach aquatic systems through detergents, fertilizers or sewage (Schindler et al., 2004). This in turn induces an explosive algae growth. When these algae die and decompose, their organic matter is converted into an inorganic form by microorganisms, a process which consumes oxygen. The reduced concentration means that all of the oxygen-dependent organisms in the sea will begin to die. The result of the algal blooms is the disruption of the ecosystem's normal food chains and functioning. The water becomes cloudy with a shade of greenish-brown. The important part of this mechanism is that nutrients, which we typically associate with growth and prosperity, can in fact be too much of a good thing. They start a chain reaction that so far has been difficult to stop.

A historical perspective on the Black Sea is helpful in order to better understand the problem of eutrophication in this area. Oceans and seas may seem eternal, but in fact they have appeared and disappeared throughout our planet's history. Our Black Sea is very young, just seven or eight thousand years old; it form as a result of Mediterranean water flowing through the Bosphorus Strait. The salty water filled the bottom, while freshwater remained at the top. This natural density barrier (pycnocline) settled to a depth of about 200 meters. The water below became depleted of oxygen, therefore the photosynthetic population evolved in order to use hydrogen sulfide to make oxygen. The resulting water body is now the largest volume of anoxic water on our planet (Cociaşu et al., 1999).

In the North-Western shelf of the Black Sea there has been little to no evidence of human impact for a long time. Therefore, the area has experienced a remarkable development, since its shallow waters were very well oxygenated, being above the pycnocline. Some changes were noticed in the first half of the 20$^{th}$ century, and they were precursors of much more events to come. (Cociaşu et al., 1999).

The North-Western Black Sea area is where the Danube, Dnieper and Don, three of the four largest river basins of Europe, discharge their nutrients. However, the effects of eutrophication are felt all over the Black Sea. It is estimated that almost 70 percent of dissolved nutrients come from the Danube alone, no country is completely innocent, because eutrophication is observed far away from the influence of the Danube. The Black Sea basin spans over 17 countries and includes 160 million people. A study by the Black Sea Environmental Program suggests that, in 1992, 70% of the nutrients were coming from the six Black Sea countries (three of which – Romania, Bulgaria and Ukraine – discharge much of their nutrient load through the Danube) and the remaining 30% comes from the non-coastal countries, mostly of the upper Danube. For total nitrogen nutrients, values from a 1995 study were: Bulgaria 14%, Romania 27%, Ukraine 12%, Russian Federation 10%, Georgia 1%, Turkey 6% and non-coastal countries 30%. The same study estimates the following figures for phosphorus nutrients: Bulgaria 5%, Romania 23%, Ukraine 20%, Russian Federation 13%, Georgia 1%, Turkey 12% and 26% for the remaining countries. This goes to show that the effects of eutrophication are encountered at a great distance from their cause.

In the late 1960's, the increase in nutrient flux led to what can now be considered an environmental catastrophe. The chain of events leading to the decline of the Black Sea ecosystem started with the so called "Green Revolution" (Cociaşu et al., 1999). The increase in agriculture production necessitated an intensive use of fertilizers and pesticides. What farmers did not take into account was that these dangerous chemicals infiltrated in the soil, reached the waters of adjacent rivers, then the Danube and ultimately the Black Sea. However, crop growth was not the only cause, as there were multiple issues arising at the same time. Meat production became highly industrialized and turned large-scale, therefore it became more difficult to re-use animal manure as a natural fertilizer for crops. Also, urban construction in the rapidly developing cities of that time was unplanned and hazardous. Cities were not equipped with proper sewage systems, so nutrients were not removed and they contaminated the water in which they were discharged. Furthermore, polyphosphates were introduced into detergents, which led to an increase of phosphorus, a main nutrient which causes eutrophication, reaching water bodies. The Black Sea became an increasingly popular attraction for people from Eastern and Central European countries. This, together with demands for space for shipping, harbors and industry continued to place increasing demands on the coastal environment. An estimate of the Danube Basin Environmental Program suggests that about half the nutrients discharged in the sea is from agriculture, one quarter from industry and a similar proportion from domestic sources. In other words, there is not just one cause behind the degradation of the coastal landscape. Instead, a combination of factors causes the problem at hand.

When discussing the ecosystem's recovery from eutrophication, it should be underlined that in the past eutrophication was more difficult to solve. There was not enough knowledge on the topic to allow scientists to tackle the subject accordingly. And that is why it has kept growing up to its current state. But now we are fully prepared to solve the problem of eutrophication. There is evidence of some recovery in the ecosystem but it remains limited. There is still a possibility that nutrient discharges will rise again, with consequent damage to the Black Sea.

One simple way to track the long-term evolution of eutrophication is by measuring water transparency. This is done with the help of the Sechi disk, a white disk which is gradually lowered until it disappears from sight when observed from above. The deeper the disk goes, the more transparent the water. Changes in transparency are usually due to phytoplankton present in the water. Prior to 1970, scientists recorded a Sechi Depth of over 20 meters. However, the 1970's and 1980's were a period of major ecological disturbance for the Black Sea ecosystem. In 1991, the Sechi Depth reached a minimum of only 6 meters due to phytoplankton booms. Since that time, values have slowly started to improve.

The economic collapse of the surrounding socialist republics in the early 1990s was a first step in the decrease in nutrient loading, which has allowed the Black Sea ecosystem to begin to recover (Cociasu et al., 2009; Gomoiu et al., 1992). Added to these were the extensive efforts of the Black Sea riparian countries to permanently adopt legislation and measures to prevent the eutrophication of the area. One of the most important actions was the Convention on the Protection of the Black Sea against Pollution, Bucharest, 1992. An important follow-up of that convention was the Protocol on the Protection of the Marine Environment of the Black Sea from Land-Based Sources and Activities (revised in 2009). Another important step to reduce eutrophication was the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea (revised in 2009) in which reducing eutrophication is one of the Ecosystem Quality Objectives (EcoQOs3), to reduce eutrophication (Lazar et al., 2013).

In 2007, Romania and Bulgaria joined the European Union and together with them, part of the Black Sea became, legally, a European Sea. Thus, the protection of the Black Sea, relevant to eutrophication, was enhanced by the new legislations like: Urban

Wastewater Treatment Directive (1991), Nitrates Directive (1991), Habitats Directive (1992), Water Framework Directive (2000) and the Marine Strategy Framework Directive (2008). Their objectives consist of the protection, preservation and, where practicable, restoration of the marine environment

The next logical step after recovery is prevention. The first measures should be practical and short-term; in other words, they should be easy to implement. They should include but not be limited to:

- Reform agricultural practices: crop rotation to improve soil structure and fertility
- Create “buffer strips” near streams and rivers
- Restrict the use of artificial fertilizers; ensure manure provisions and encourage the use of natural fertilizers
- Improve waste and water treatment

An important long-term follow-up in the coastal region should be the restoration of natural wetlands which bring many benefits. They are efficient at removing nutrients, provide a habitat for wildlife and also protect against floods.

To summarize, eutrophication has many causes and involves complex mechanisms. Nutrients should be kept “on land”, where they are needed, and out of water basins. The future of the sea is looking a little muddy because of eutrophication. But if enough awareness is raised among all citizens and if policy makers get involved, eutrophication will be one more problem solved.

References:

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