Formation mechanism

By clicking here you can see a short outreach video that well describes the eutrophication process. Eutrophication is characterised by a significant increase of algae (microscopic organisms similar to plants) due to the greater availability of one or more growth factors necessary for photosynthesis, such as sunlight, carbon dioxide and nutrients (nitrogen and phosphorus). When algae start to grow in an uncontrolled manner, an increasingly large biomass is formed which is destined to degrade. In deep water, a large amount of organic substance accumulates, represented by the algae having reached the end of their life cycle. To destroy all the dead algae, an excessive consumption of oxygen is required, in some cases almost total, by microorganisms. An anoxic (oxygen-free) environment is thus created on the lake bottom, with the growth of organisms capable of living in the absence of oxygen (anaerobic), responsible for the degradation of the biomass. The microorganisms, decomposing the organic substance in the absence of oxygen, free compounds that are toxic, such as ammonia and hydrogen sulphide (H_2S). The absence of oxygen reduces biodiversity causing, in certain cases, even the death of animal and plant species. All this happens when the rate of degradation of the algae by microorganisms is greater than that of oxygen regeneration, which in summer is already present in low concentrations.

Effects

The disturbance of aquatic equilibria may be more or less evident according to the enrichment of water by nutrients (phosphorus and nitrogen). An aquatic environment with a limited availability of phosphorus and nitrogen is described as “oligotrophic” while one with high availability of these elements is called “eutrophic”; a lake with intermediate availability is called “mesotrophic”.When the eutrophication phenomenon becomes particularly intense, undesirable effects and environmental imbalances are generated. The two most acute phenomena of eutrophication are hypoxia in the deep part of the lake (or lack of oxygen) and algal blooms that produce harmful toxins, processes that can destroy aquatic life in the affected areas (www.unep.or.jp).

The main effects caused by eutrophication can be summarised as follows (N. Sechi, 1986):

- abundance of particulate substances (phytoplankton, zooplankton, bacteria, fungi and debris) that determine the turbidity and colouration of the water;
- abundance of inorganic chemicals such ammonia, nitrites, hydrogen sulphide etc. that in the drinking water treatment plants induce the formation of harmful substances such as nitrosamines suspected of mutagenicity;

- abundance of organic substances that give the water disagreeable odours or tastes, barely masked by chlorination in the case of drinking water. These substances, moreover, form complex chemical compounds that prevent normal purification processes and are deposited on the walls of the water purifier inlet tubes, accelerating corrosion and limiting the flow rate;

- the water acquires disagreeable odours or tastes (of earth, of rotten fish, of cloves, of watermelon, etc.) due to the presence of particular algae;
- disappearance or significant reduction of quality fish with very negative effects on fishing (instead of quality species such as trout undesirable ones such as carp become established);

possible affirmation of toxic algae with potential damage to the population and animals drinking the affected water;

- prohibition of touristic use of the lake and bathing, due to both the foul odour on the shores caused by the presence of certain algae, as well as the turbidity and anything but clean and attractive appearance of the water; bathing is dangerous because certain algae cause skin irritation;
- reduction of oxygen concentration, especially in the deeper layers of the lake at the end of summer and in autumn.

In the light of these significant repercussions and serious consequent economic and naturalistic damage, there is a clear need to curb the progress of eutrophication, avoiding the collapse of the affected ecosystems.

Control

In the past, the traditional eutrophication reduction strategies, including the alteration of excess nutrients, physical mixing of the water, application of powerful herbicides and algaecides, have proven ineffective, expensive and impractical for large ecosystems (Michael F.

Chislock, 2013). Today, the main control mechanism of the eutrophic process is based on prevention techniques, namely removal of the nutrients that are introduced into water bodies from the water.It would be sufficient to reduce the concentrations of one of the two main nutrients (nitrogen and phosphorus), in particular phosphorus which is considered to be the limiting factor for the growth of algae, acting on localised loads (loads associated with waste water) and widespread loads (phosphorus loads determined by diffuse sources such as land and rain). The load is the quantity (milligrams, kilograms, tons, etc.) of nutrients introduced into the environment due to human activity.
The possible activities to be undertaken to prevent the introduction of nutrients and to limit phosphorus loads can be summarised as follows (www3.uninsubria.it):

- improvement of the purifying performance of waste water treatment plants, installing tertiary treatment systems to reduce nutrient concentrations;
- implementation of effective filter ecosystems to remove nitrogen and phosphorus present in the run-off water (such as phyto-purification plants);
- reduction of phosphorous in detergents;
- rationalisation of agricultural techniques through proper planning of fertilisation and use of slow release fertilisers;
- use of alternative practices in animal husbandry to limit the production of waste water.

In cases where water quality is already so compromised as to render any preventive initiative ineffective, “curative” procedures can be implemented, such as:

- removal and treatment of hypolimnetic water (deep water in contact with the sediments) rich in nutrients since in direct contact with the release source;
- drainage of the first 10-20 cm of sediment subject to biological reactions and with high phosphorus concentrations;
- oxygenation of water for restore the ecological conditions, reducing the negative effects of the eutrophic process, such as scarcity of oxygen and formation of toxic compounds deriving from the anaerobic metabolism;
- chemical precipitation of phosphorous by the addition of iron or aluminium salts or calcium carbonate to the water, which give rise to the precipitation of the respective iron, aluminium or calcium orthophosphates, thereby reducing the negative effects related to the excessive presence of phosphorus in the sediments.

Conclusions

Water is not a commercial product like any other but rather a heritage which must be defended and protected, especially in the presence of a global decline in the availability of drinking water and increase in its demand.

Despite the considerable efforts made to improve the water quality by limiting nutrient enrichment, cultural eutrophication and the resulting algal blooms continue to be the main cause of water pollution. The prevention and protection action that countries must adopt to safeguard the quality of surface water as requested not only by the scientific community and other experts, but to an increasing extent also by citizens and environmental organisations, is therefore increasingly important (ec.europa.eu).

Management of the eutrophic process is a complex issue that will require the collective efforts of scientists, policy makers and citizens.