How dead zones form due to nutrient pollution

Water contamination is caused not only by plastic, but also by other substances like pesticides, herbicides and fertilizers used in intensive agriculture which seep into the environment, polluting aquifers and waterways that end in the sea. There are many other contaminants such as slurry from farms, dyes used in the textile industry, heavy metals, radioactive materials and certain household products which end in the water and are even found inside the bodies of marine animals. The area on which this research has been focused was the anthropogenic impact of the use of nitrogen and phosphorus chemicals in the ocean, called nutrient pollution. Sources of nutrient pollution released to freshwater and coastal areas are diverse, and include agriculture, aquaculture, and fossil fuel combustion, among others. These nutrients enter aquatic ecosystems via the air, surface water, or groundwater (Selman, 2010). Specifically, it will be analysed how the nutrient pollutants contribute to the eutrophication process, which is one of the most common causes of water quality impairment of inland and marine waters (Le Moal et al., 2019). Furthermore, linkages are drawn with the Sustainable Development Goal (SDG) 14 (Life below water) and the other SDGs.

Sources

The main source is the agricultural source. Farmers apply nutrients on their fields in the form of chemical fertilizers and animal manure, which provide crops with the nitrogen and phosphorus necessary to grow and produce the food we eat. However, when nitrogen and phosphorus are not fully utilized by the growing plants, they can be lost from the farm fields and negatively impact air and downstream water quality (US EPA, 2020). These nitrogen and phosphorous compounds end up in the ocean through different ways: 20% of nitrogen used is lost through surface runoff or leaching into groundwater and 60% of the nitrogen suffer atmospheric volatilization, getting deposited in waterways through atmospheric deposition. The phosphorus binds to the soil and ends in the water through soil erosion from agricultural lands. Another important source of nitrogen and phosphorus that has a role as well is the industrial pollution. Fossil fuels remain the dominant fuel source in our century, and through its burning, it releases nitrogen oxides into the atmosphere ending in the water through the rain (Spokes, 2005). There is a third main source, the aquaculture source which contributes for example with the excess feed, which causes elevated levels of organic water and nutrients and it leads to phytoplankton blooms and untreated wastes (Alexander, 2017).

Effects on the marine environment

When the dissolved oxygen drops below 2 ml O_2/L a marine system is often called hypoxic (Diaz & Rosenberg, 2008). This leads to conditions in which most marine organisms cannot survive. These regions are then known as dead zones. In most cases, hypoxia is promoted by natural conditions such as semi-enclosed geomorphology that, combined with water-column stratification, restricts water exchange (Diaz & Rosenberg, 2008). In addition to the seasonal process in some estuaries, fjords, and along open coasts due to upwelling, the above-mentioned anthropogenic sources are becoming more and more significant (Levin et al., 2009).

The urgency of the problem is also reflected in SDG 14, so target one is by 2025, to “prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution” (United Nations, 2021). Target two is also important for this topic, as it has set itself the task of “a sustainable management and protection of marine and coastal ecosystems to avoid significant adverse impacts in order to achieve healthy and productive oceans” (United Nations, 2021).

The nutrient runoff from anthropogenic sources encourages the massive growth of algae through the process of eutrophication. A 'Nature' article states that in 80% of cases runoff stimulated a bloom within days of fertilisation and irrigation (Beman et al., 2005). The phytoplankton is increasing the dissolved oxygen in the water due to photosynthesis but also decreases it at night by respiration and even more when the algae die. This biomass is then decomposed in the lower water column and in the sediments which reduces the oxygen concentration in the water (Rabalais et al., 1999).

This has a crucial effect on the living organisms in the region. Researches showed an impact on the faunal communities and impairing fish habitat (Conley et al., 2011). Not only flee mobile species the area once the oxygen concentration decreases to a critical level, furthermore sessile organisms die when exposed to hypoxic conditions over time (Vaquer-Sunyer & Duarte, 2008). Benthic fauna also shows aberrant behavior like Diaz and Rosenberg (2008) claim. For example, they abandon burrows for exposure at the sediment-water interface, culminating in mass mortality when dissolved oxygen declines below around 0.5 ml O_2/L (Diaz & Rosenberg, 2008).

Unfortunately, the problem is growing as hypoxic areas in the nearshore oceans have expanded exponentially since the 1960s, as reported by Diaz and Rosenberg in their 2008 article. Dead zones have now been reported in more than 400 systems, corresponding to a total area of more than 245,000 square kilometres. This makes them a key stressor for marine ecosystems (Diaz & Rosenberg, 2008).

Effects on humans and links to other SDGs

Agriculture-related water contamination has also direct harmful impacts on human health, such as the well-known blue baby syndrome caused by elevated levels of nitrates in water. The topic is therefore highly relevant for other SDGs like SDG 3 (Ensure healthy lives and promote well-being for all at all ages) and SDG 6 (Ensure availability and sustainable management of water and sanitation for all). Pesticide accumulation in water and the food chain, with documented adverse effects on humans, led to the universal prohibition of many broad-spectrum and permanent pesticides such as DDT and certain organophosphates. Nevertheless, some of these pesticides are still used in developing countries, causing acute and perhaps chronic health effects (Merrington et al., 2002).

Dead zones have direct and indirect impacts on SDG 2 (Zero hunger). Hypoxia leads to a vanishing of fish populations in the area. Number of catches decreases, influencing not only the market but also the quantity of delivered food. The development of this problem can have serious effects on poor communities and the ones which rely their economy on fishery. It is therefore linked with SDG8 (Decent work and economic growth). Indirect influence emerges during a fight against dead zones. One of the basic steps is a reduction of using fertilizers in agriculture placed on the whole river catchment system. Riversides have great potential for farming and cover huge areas. As a result, abandoning fertilizers there can cause a decrease in food production (Lee & Jones, 1991).

Although the focus of this research is on marine ecosystems, eutrophication is also a problem on land. The same challenges of oxygen deficiency can occur in lakes and wetlands. Therefore, the topic is also strongly linked to SDG 5 (life on land), especially target one, “conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services” (United Nations, 2021).

Dead zones recovery

It is important to understand that dead zones are hard to recovery, and lowering the amounts of plant nutrients reaching rivers will be not enough. Three reasons can be distinguished. First of all, rivers and their catchments are storing nutrients. Either in groundwater or absorbed on the soil. Stored compounds of nitrogen and phosphorus leak to the river over years or even decades passing to the sea.

Secondly, dead zones can remain, when nearby there are no healthy populations of fish and plants. After the extinction of organisms, the new ones are necessary to act as a germ of a new population.

Finally, as nutrient concentrations begin to increase early on, some species decline, but ecosystems as a whole may remain strong for a long while if the natural populations can withstand a relatively high amount of phytoplankton growth and the like. At some point, however, a threshold is reached at which the loss of key species yields an abrupt collapse to a new degraded state. The new equilibrium consists of the species tolerant to eutrophication's effects. What is more, this effect can speed up by overfishing in this area (Mee, 2006).

To fix dead zones, cooperation between countries is necessary. The nitrogen and phosphorus have to be kept on the land and out of the water. For example, in a specially designed place. This has to be performed on an entire river catchment system. Another step is to allow fishes to recover. The stocks in and nearby dead zones are depleted, and reducing commercial fishery is crucial to achieving the goal (Mee, 2006).

Conclusion

To conclude, eutrophication is a worldwide problem, which affects both inland and marine aquatic ecosystems having biological and economic repercussions. Therefore, it affects the sustainable development goals in many ways and it's in need of a change in the use of fertilizers or other sources such as the fossil fuels burning. There is already a great knowledge of the sources and impacts but for the future we need more research and new technologies on how to recover dead zones.

The problem can become even more serious with the global population growth. The more people, the more food, and more fuel will be needed. But if we want to conserve our marine life, biodiversity and a long-lasting coastal fishery we need to decrease the amount of nutrients with which we are polluting the water.

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