ENVIRONMENTAL SCIENCE JOURNAL FOR KIDS

JUNE 2023

How do estuaries improve water quality?

Authors:
Dunia Rios-Yunes, Justin Tiano, Dick van Oevelen and others

Associate Editors:
Elitsa Panayotova and Alexandra Appleton

Abstract

Estuaries are very special. They act like a natural filter that helps clean the water before it enters the ocean. But we don't fully understand how this works and how the processes change throughout the year. So, for a whole year we took samples from various sites along the Western Scheldt estuary. It's a restored estuary that used to be very polluted. The samples were taken from freshwater, marine water, and brackish water. We analyzed them for several nutrients. We wanted to check how the concentration of nutrients changes in different seasons. Thankfully, our results show that the Western Scheldt estuary is healthy! We discovered that each section of water works differently as a filter. We also found out that temperature is a very important factor in how they work.

Introduction

Do you know what an estuary is? It's where the river meets the ocean. It's very special because fresh water mixes with salty marine water. This creates a unique environment where many different organisms can live. A lot of estuaries help clean the water by trapping **pollutants** and excess **nutrients**. Just like natural filters! This is why it's very important to protect them.

But many estuaries are in danger. We change their habitats when building dams. We also pollute the land and the water we use. When we grow crops, we increase the amounts of nutrients that go into estuaries. This may sound good, but it actually leads to **eutrophication**. Small plants called algae thrive when there are too many nutrients. They grow very quickly and cover the surface of the water. When they die, they fall to the bottom and start to decompose. This takes a lot of oxygen! But when this happens there is not enough oxygen for other plants and animals, so they get sick or die. And climate change affects these ecosystems, too.

Many countries have started to restore estuaries. This may include controlling the nutrients from farms, creating new habitats, or removing dams. We wanted to see if these measures helped to improve the water quality. We also wanted to find out how a restored estuary works. What processes occur there? Do they change in different seasons? How does the salt in the water impact them?

The Western Scheldt estuary in the Netherlands.

Photo: Dunia Rios-Yunes

Methods

To answer these questions, we took samples from the Western Scheldt estuary (Fig. 1). It used to be very polluted, but several countries have worked to restore it. The river starts in France, flows through Belgium and the Netherlands, and finally meets the North Sea. The estuary is like a funnel: narrow at the beginning and wider at the end. We took samples for a whole year from different sites:

- where the water is fresh,
- where the water is mostly saltwater (marine), and
- where the water is a mix of fresh and saltwater. This is called **brackish water**.

We took samples from the water and also from the **sediment** on the estuary shore. We **incubated** part of the samples to simulate real-life conditions. We looked for various chemical compounds like **ammonium**, **nitrates**, **nitrites**, and **phosphates**. These nutrients are vital for many plants and animals. We wanted to know what amount of nutrients the sediment exchanges (takes in or releases).

We tested the water's **salinity** (how salty it was) at each site during each month of the year. We also measured the temperature and oxygen levels each month.

Figure 1: Taking sediment samples from the brackish site of the estuary's shore.
Photo: Pieter van Rijswijk

Results

The salinity of the water stayed the same throughout the year at all sites. But the temperature changed with the seasons. The concentration of most of the nutrients depended on these temperature changes. The salinity also affected the nutrients' concentrations. For example, ammonium in the freshwater was high in the winter. But in the marine water, it was high during the summer. Oxygen **exchange rates** were highest in the summer, especially at the marine site. Overall, the concentration of nutrients was much higher in the freshwater. Then it started to decrease towards the ocean.

So how do sediments exchange various nutrients at these different sites? On average each year:

- the freshwater site took in more nitrogen and phosphorus than it released;
- the brackish site took in more nitrogen but released more phosphorus;
- the marine site released more nitrogen and phosphorus than it took in (Fig. 2).

The sediments at the marine and brackish sites were great at **remineralizing** carbon! Plus, sediments removed 11% of the total nitrogen that had entered the estuary. They also removed 15% of the phosphorus.

Where are the highest oxygen exchange rates?

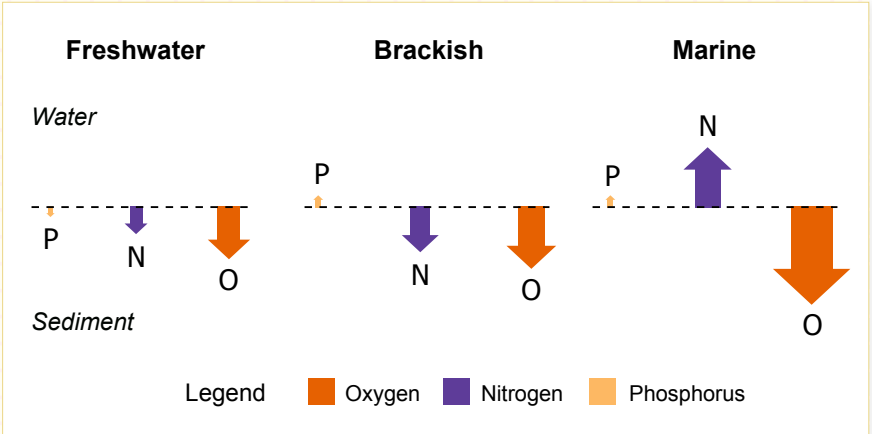

Figure 2:
Exchange rates of oxygen, nitrogen, and phosphorus in the marine, brackish, and freshwater sites. Upward-pointed arrows indicate the nutrients released by the sediment, while downward-pointed arrows indicate the nutrients taken in by the sediment.

Discussion

The estuary restoration efforts have been worth it! The estuary used to be very polluted, but now there is no eutrophication. The oxygen levels are not low, either. But what happens at each site of the estuary?

The river washes down water rich in pollutants, nutrients, and **organic matter**. Then comes the estuary. The first part of the estuary – the freshwater – traps a lot of nitrogen and phosphorus. The brackish and marine sites also trap many nutrients, since they cover a larger area. And they are great at breaking down organic matter! The high oxygen exchange rates there show levels of high **microbial activity**. The warmer it gets, the quicker they break the organic matter down. This is important, as climate change warms the Earth. We can use this information to better predict what could happen in these unique environments in the future.

Conclusion

You can see now that estuaries are very special. There may not be one where you live, but research some estuaries in nearby regions. What is their condition? How can we help? Remember that it is humans who pollute estuaries! Here are a few ideas:

- Dispose of household (e.g. cooking oil, soaps) and yard chemicals (e.g. fertilizers, pesticides) properly.
- Avoid using toxic pesticides in your garden. Try using natural treatments instead!
- Reduce your waste by using reusable water bottles and food containers. This reduces the amount of trash going to landfills, as well as the amount of litter in natural areas.

Glossary of Key Terms

Ammonium - a form of nitrogen. When animals and plants die in the water, they fall to the bottom and microorganisms start to decompose them. Ammonium is a byproduct of that process (ammonification). Next, other microorganisms turn that into nitrites and then nitrates (nitrification).

Brackish water - a mix of freshwater and saltwater, found in estuaries.

Eutrophication - when lakes and rivers receive too many nutrients (e.g. nitrogen and phosphorus) due to human activities such as agriculture and sewage discharge. Algae use these excess nutrients and grow rapidly. But when they die, microbes use a lot of oxygen to decompose them.

Exchange rates - the rate at which nutrients or oxygen move between two environments; for example, between the water and the sediment.

Incubation - maintain something in conditions that allow it to grow or develop. In our case, we put the water samples in the lab under similar conditions to the natural ones.

Microbial activity - when microorganisms eat, breathe, and grow, they break down organic matter to nutrients. They need a lot of oxygen for that – just like we need oxygen to live and function.

Nitrates and nitrites - forms of nitrogen. They are useful for plant growth (there are nitrates in fertilizers), but when their levels are too high, they lead to harmful overgrowths of algae.

Nutrients - chemical substances that plants and animals need to grow.

Organic matter - matter that comes from organisms; waste from living things and parts of plants and animals that used to be alive. When microorganisms decompose organic matter, they use oxygen and release nutrients.

Phosphates - a form of phosphorus; also important for plant growth and commonly used in fertilizers.

Pollutant - a substance that has negative effects on the water, soil, or air.

Remineralization - the breakdown of organic matter to inorganic forms and nutrients.

Salinity - the saltiness of the water.

Sediment - the bottom of the river, lake, estuary, etc. It consists of rocks, sand, minerals, and organic matter.

Check your understanding

1. How does the estuary water change from upstream to downstream?

---

2. What happens to organic matter in the estuary?

---

3. How does eutrophication happen in estuaries and what are the consequences?

---

4. We mentioned some of the ways humans affect estuaries. Can you think of any other human impacts?

---

5. Estuaries act like filters and stop harmful compounds from entering the ocean. With a partner, look up other ways that estuaries are helpful to animals or humans.

REFERENCES

Dunia Rios-Yunes, Justin C. Tiano, Dick van Oevelen, Jeroen van Dalen, and Karline Soetaert (2023) *Annual biogeochemical cycling in intertidal sediments of a restored estuary reveals dependence of N, P, C and Si cycles to temperature and water column properties.* Estuarine, Coastal and Shelf Science.
https://www.sciencedirect.com/science/article/pii/S0272771423000173

NOAA: What is an estuary?
https://oceanservice.noaa.gov/facts/estuary.html

Kiddle: Estuary facts for kids
https://kids.kiddle.co/Estuary

Acknowledgment:
This article's adaptation was supported by the Royal Netherlands Academy of Arts and Sciences (KNAW).