


Biogeochemistry analysis to assess water quality and the aquatic ecosystem in rivers using drones and sensors

Análisis biogeoquímico para evaluar la calidad del agua y ecosistema acuático en ríos mediante sensores

Daniel Barrantes-Esquivel¹

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¹ Instituto Tecnológico de Costa Rica. Costa Rica.
 dbesquivel12@gmail.com

Keywords

Biogeochemistry; biodiversity; human activities effects; water quality; water pollution.

Abstract

River pollution is a common problem in many countries, and its analysis from a biogeochemical perspective allows us to understand the full impact on aquatic ecosystems. By examining nutrient cycles, chemical processes in living organisms, and interactions between biological and chemical factors, we can gain a deeper understanding of river pollution. Through the use of technology such as drones and specialized sensors, we can collect essential data to assess key biogeochemical parameters, such as nutrient concentration, oxygen levels, and the presence of contaminants. These analyses provide a comprehensive view of river health, enabling us to take appropriate measures for their protection and restoration, with the aim of preserving the overall health of aquatic ecosystems. The availability of nutrients in the water is crucial for the survival of aquatic organisms. These organisms rely on a variety of essential nutrients to maintain their health and balance in the ecosystem. Biogeochemistry allows us to understand how nutrient cycles and chemical processes in the water influence the availability of these vital elements. When certain nutrients are lacking or present in low concentrations, we can predict the impact on the ecosystem's health based on the organisms or living beings that depend on those specific nutrients to survive. By analyzing biogeochemical processes, we can gain a more comprehensive understanding of how the health of the aquatic ecosystem is related to nutrient availability. This approach helps us comprehend how changes in nutrient cycles and chemical interactions affect the composition and dynamics of aquatic communities. Additionally, it enables us to take appropriate measures to maintain a healthy balance in the ecosystem and ensure the survival of aquatic beings that depend on these vital nutrients.

Palabras clave

Biogeoquímica; biodiversidad; efectos de las actividades humanas; calidad del agua; contaminación del agua.

Resumen

La contaminación de los ríos es un problema común en muchos países y su análisis desde una perspectiva biogeoquímica nos permite comprender el impacto completo en los ecosistemas acuáticos. Al examinar los ciclos de nutrientes, los procesos químicos en los organismos vivos y las interacciones entre factores biológicos y químicos, podemos obtener una comprensión más profunda de la contaminación de los ríos. Mediante el uso de tecnología como drones y sensores especializados, podemos recopilar datos esenciales para evaluar parámetros biogeoquímicos clave, como la concentración de nutrientes, los niveles de oxígeno y la presencia de contaminantes. Estos análisis nos proporcionan una visión integral del estado de los ríos, permitiéndonos tomar medidas adecuadas para su protección y restauración, con el objetivo de preservar la salud de los ecosistemas acuáticos en su conjunto. La disponibilidad de nutrientes en el agua es crucial para la supervivencia de los seres acuáticos. Estos organismos dependen de una variedad de nutrientes esenciales para mantener su salud y equilibrio en el ecosistema. La biogeoquímica nos permite comprender cómo los ciclos de nutrientes y los procesos químicos en el agua influyen en la disponibilidad de estos elementos vitales. Cuando falta o hay una baja concentración de ciertos nutrientes, podemos predecir el impacto en la salud del ecosistema basándonos en los organismos o seres vivos que dependen de esos nutrientes específicos para sobrevivir. Al analizar los procesos biogeoquímicos, podemos

obtener una visión más completa de cómo la salud del ecosistema acuático está relacionada con la disponibilidad de nutrientes. Este enfoque nos ayuda a comprender cómo los cambios en los ciclos de nutrientes y las interacciones químicas afectan la composición y la dinámica de las comunidades acuáticas. Asimismo, nos permite tomar medidas adecuadas para mantener un equilibrio saludable en el ecosistema y garantizar la supervivencia de los seres acuáticos que dependen de estos nutrientes vitales.

Introduction

Drones are currently a very useful tool for monitoring different scenarios and collecting data for subsequent analysis. Therefore, this tool will be one of the foundations of this research with a focus on biogeochemistry. One of the main problems in many regions is the high pollution and poor water quality in numerous rivers. This situation affects many countries in Latin America and other regions, largely resulting from human activity and a lack of awareness about natural resources, as well as other environmental factors present in some areas.

The objective of this research is to study rivers and collect data through sensors to determine the level of pollution and water quality of a particular river from a biogeochemical perspective. In this regard, the aim is not only to analyze pollution itself but also to understand how the biogeochemistry of the river is affected by different processes and how this influences the health of the aquatic ecosystem and its interaction with humans. By focusing on biogeochemistry, we will be exploring aspects such as:

- Water quality
- How this pollution affects the aquatic food chain
- Diversity of species
- Impacts on human health
- Regional or global effects of rivers since they are interconnected with oceans



Figure 1. The most polluted rivers in the world.

This research focuses on evaluating five key aspects related to water quality and the health of the aquatic ecosystem. Through the analysis of specific nutrients and proteins collected by sensors, we can evaluate each aspect. The first aspect we analyze is water quality, which serves as the basis for the analysis of the other four.

The difference between analyzing river pollution in a general way and focusing on biogeochemistry lies in the fact that, by focusing on biogeochemistry, we take into account not only the presence of pollutants in the water, but also how these pollutants affect the biogeochemical processes in the river's aquatic ecosystem, which results in a more in-depth analysis of what we want to evaluate, given the information that can be collected by focusing on biogeochemistry.

When analyzing river pollution in a general manner, the levels of different pollutants present in the water, such as heavy metals, toxic chemicals, or excessive nutrients, can be measured. However, when analyzing pollution from a biogeochemical perspective, consideration is given to how these contaminants affect key biogeochemical processes occurring in the river's ecosystem. These processes include photosynthesis, respiration, decomposition of organic matter, and nutrient cycling. By focusing on biogeochemistry, it is also possible to assess how pollution impacts the aquatic organisms that rely on these processes and how it can alter water quality and the ecological balance of the river. This approach provides us with a more comprehensive understanding of the effects of pollution on the biogeochemical functioning of the river and its impact on the health of the aquatic ecosystem.

Components

To carry out this project, the main approach will be to utilize a drone as the primary tool for data extraction in river environments. Emphasis will be placed on the application of biogeochemistry to gather valuable information about the composition and chemical processes in rivers.

There are many drones that can be used to perform this task. For example, one option could be a drone like this: DJI M30T.



Figure. 2. DJI M30T

The drone will be equipped with specialized sensors that allow for the detection and measurement of relevant parameters for the biogeochemical study of water bodies. Some of the sensors that could be incorporated include:

Water temperature sensor

To obtain precise measurements of the temperature at different points in the river. This is crucial as temperature directly affects biogeochemical processes such as the rate of organic matter decomposition and nutrient availability.

Dissolved oxygen sensor

To assess the concentration of oxygen dissolved in the water. This provides information about water quality and the health of aquatic ecosystems, as certain species rely on appropriate oxygen levels for survival.

pH sensor

To measure the acidity or alkalinity level of water. pH influences nutrient exchange processes and the availability of metals and other chemical compounds in the aquatic environment.

Electrical conductivity sensor

To determine the amount of salts and minerals dissolved in water. Electrical conductivity is a useful indicator for evaluating salinity and pollution in bodies of water.

Chlorophyll-a sensor

To estimate the amount of chlorophyll present in water, which indicates the presence of algae and primary productivity in the aquatic ecosystem.

In addition to the sensors mentioned earlier, heavy metal sensors could also be added to the drone. These sensors would allow for the detection and quantification of the presence of toxic elements such as mercury, lead, cadmium, arsenic, among others, in river water.

The presence of heavy metals in bodies of water can result from industrial, agricultural, or mining activities, and can pose a significant risk to human health and aquatic ecosystems. Therefore, it is crucial to monitor and assess the concentration of these contaminants.

Similarly, new technologies can revolutionize related areas. For example, scientists from the School of Chemistry at the Costa Rica Institute of Technology (TEC) have patented a chemical analysis device with a unique design in the world. This innovative device aims to expand the capabilities of assessing water quality, both in terms of human health and ecosystem health. MSc. Laura Hernández Alpízar and MGA Ricardo Coy Herrera led this project.

Indeed, integrating such new technologies into a drone can help reduce costs and minimize the weight of the equipment.

By reducing the weight of the drone, it achieves greater efficiency in its performance and optimizes its flight capacity. This translates into increased autonomy and improved stability during data collection operations.

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Daniel Alejandro Barrantes Esquivel

Escuela de Ingeniería en Computación
Instituto Tecnológico de Costa Rica
dbesquivel12@gmail.com

Introduction

The preservation of aquatic resources has become a global concern due to the increasing impact of pollution on river ecosystems.



The biogeochemical analysis of pollution in rivers encompasses a wide range of factors, such as

- Presence of nutrients
- Toxic chemicals
- Heavy metals
- Organic contaminants

This study allows us not only to quantify pollutant levels but also to understand how they affect the following:

- Aquatic ecosystems
- Natural biogeochemical cycles

Materials and Methods

The study is based on the use of drones equipped with specialized cameras and sensors, complemented by other equipment.



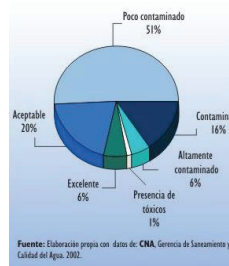
Examples of sensors

- Electric conductivity sensors
- pH sensors
- Temperature sensors
- Contaminant sensors such as heavy metal sensors

The analysis begins with:

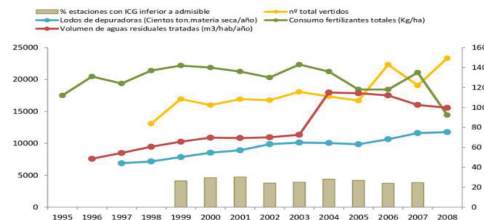
- Flight route planning that covers the target areas of the river.
- During the flight, high-resolution aerial images are captured for subsequent analysis.
- Specific data collection is carried out using sensors.
- The collected data is subsequently processed using specialized software that allows for obtaining precise and detailed information.

Environment problem



There have been numerous studies conducted in different countries addressing the issues related to rivers, the various contaminants present in them, water quality, and more. For example, one study is the "Distribución de la Calidad de Agua (ICA) en Cuerpos de Agua Superficiales, 2001" conducted by SEMARNAT (Secretary of Environment and Natural Resources) in Mexico.

The ICG (Índice de Calidad General) is a classification system that ranks the 2,415 monitoring points of the water quality control network in Spanish rivers.



Research Objective

- Analyzing river pollution from a biogeochemical perspective and its impact on aquatic ecosystems.
- Studying the dynamics of biogeochemical cycles, such as the transfer and accumulation of nutrients and contaminants.
- Gaining a better understanding of the interactions between chemical and biological processes in aquatic ecosystems.
- Understanding the potential impact on humans or the region it could generate.
- Contributing to scientific knowledge on river pollution.
- Developing strategies for the mitigation and restoration of affected aquatic ecosystems.



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