Earth Observation

How satellites can help us clean up our rivers

Arthur

Mullion School

Summary

Water quality monitoring can be labor-intensive and time consuming. However, using satellite images, water quality can be observed in real time. Using the Ulyssys water quality viewer in the EO browser, it is possible to observe levels of chlorophyll in water. High chlorophyll levels have been linked to high levels of untreated sewage in water. Chlorophyll levels in the Thames and Severn Rivers were examined using the browser. There appears to be a significant increase in chlorophyll levels downstream of large sewage works.

Background

In 2022 there were over 389,000 discharges of untreated sewage into UK rivers. The Water Framework Directive shows that only 14% of UK rivers meet good ecological status, and none meet good chemical status.

The situation in the UK is not improving. Sixty-two serious pollution incidents were reported by sewage and water companies in 2021, the highest number since 2013 (1), and the environmental performance of these companies fell to the lowest level on record in 2021 (2).

Untreated sewage leads to a lack of dissolved oxygen in the water. When dissolved oxygen levels become too low, aquatic organisms cannot survive, and water quality is affected.

Currently, water companies have to report “incidents”(raw sewage discharges into rivers) but are not obliged to disclose the volume of these discharges. This means, while we can see the number and area of discharges, it is difficult to analyse the impact without expensive testing equipment. This method allows for approximate analysis of the extent of sewage discharges in rivers, and could provide a useful guideline to show the overall health of the river.

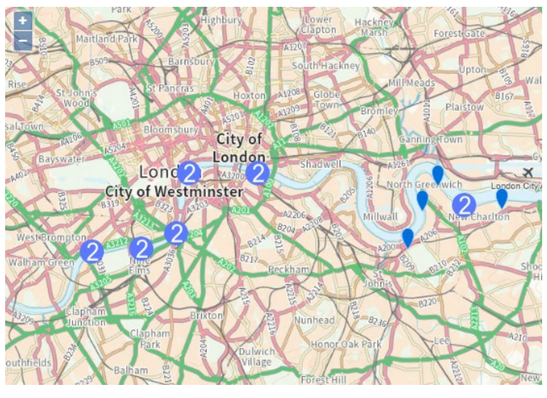
We can observe the impacts of these discharges using this method because chlorophyll levels in rivers can be used as a biological indicator in monitoring and assessing levels of organic pollution in water (3), and pollution levels have been linked to high BOD (Biochemical Oxygen Demand) in water. BOD is an important parameter for assessing water quality, as it measures the amount of oxygen consumption by biological organisms to oxidise organic compounds. If the BOD of water is too high, it leads to a decrease in dissolved oxygen levels in the water, meaning many organisms cannot survive. Low levels of dissolved oxygen are a sign of contamination, and are an important factor in determining water quality, pollution control and treatment processes (4).

This research aims to show that high chlorophyll levels are associated with sewage plants, to determine the extent of the pollution, to suggest ways in which this methodology could be used to decrease levels of pollution in areas without the infrastructure required to test water quality using more sophisticated methods, and to suggest ways in which regulators could use this program to advise their decisions on whether or not to allow water and sewage companies to discharge raw sewage into rivers.

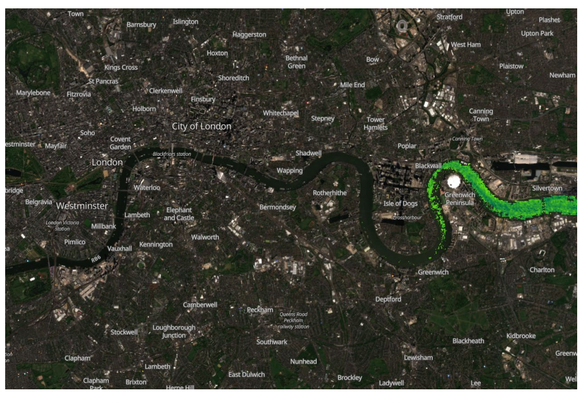
Experimental method

The Ulyssys water quality viewer was used to observe the chlorophyll-a concentrations and corelate these to the location of known sewage pumping stations. In many cases, raised levels of chlorophyll-a could be detected on the browser and this was found downstream of the pumping station. In the example below, the sewage pumping stations are marked with blue markers, and the chlorophyll-a concentrations can be seen increasing as the water passes these stations.

Examples are shown below.



Manual water quality sampling
An area of the Thames River showing the Environment Agency water sampling points (from www.environment.data.gov.uk)



Using satellite imagery to view water quality
This method of using satellite images allows us to visualise water quality along stretches of the river without the need for costly sampling.

Satellite image of chlorophyll-a concentrations in the Severn River downstream of Bristol. A number of large sewage stations discharge into this section of the river. Green and yellow colours denote raised chlorophyll-a levels.

Analysis & conclusions

This work has identified interesting patterns in the chlorophyll-a concentrations in rivers downstream of sewage pumping stations. Using satellite imagery, the water quality along large sections of river can be visualised. This detailed and regularly updated data allows for a good indication of the health of the river without the need for costly sampling.

Suggestions For Future Work

Currently, this system has some flaws. Namely, the satellites that are able to monitor using this filter only pass over specific areas once every 2-3 days, and there is no guarantee that their images will be usable. Clouds can obscure the river, meaning the satellite is unable to effectively capture the chlorophyll levels in the water on certain days.

With all this taken in to account, for practical use (i.e. advising water boards on whether or not to allow companies to discharge sewage into the river), a script (computer programme) that finds an average chlorophyll level for a period of time may be more effective (this could also be repurposed as a tool to show whether an incident is a one-off, or a regular occurrence), as this reduces the impact of one-off events, such as periods of heavy rainfall, which induce higher levels of sewage discharge into the river.

If the browser shows high mean chlorophyll levels in the river already, sewage companies should not discharge untreated material unless absolutely necessary, as doing so would worsen the impact of these events.

Acknowledgements

Many thanks to Dr. Royle from Mullion School for support with this piece of research. Thanks to IRIS for the opportunity to carry out this research and for access to the EO Browser.

References

(1) Environment Agency Performance Assessment, 2021

(2) Environment Agency Performance Assessment, 2021

(3) Phu, S.T.P. (2014). Research on the Correlation Between Chlorophyll-a and Organic Matter BOD, COD, Phosphorus, and Total Nitrogen in Stagnant Lake Basins. In: Kaneko, N., Yoshiura, S., Kobayashi, M. (eds) Sustainable Living with Environmental Risks. Springer, Tokyo. https://doi.org/10.1007/978-4-431-54804-1_15

(4) Omid Bozorg-Haddad, Mohammad Delpasand, Hugo A. Loáiciga, 10 - Water quality, hygiene, and health, Editor: Omid Bozorg-Haddad, Economical, Political, and Social Issues in Water Resources, Elsevier, 2021, Pages 217-257, ISBN 9780323905671

Mullion School

E003

The Institute for Research in Schools

sentinelhub