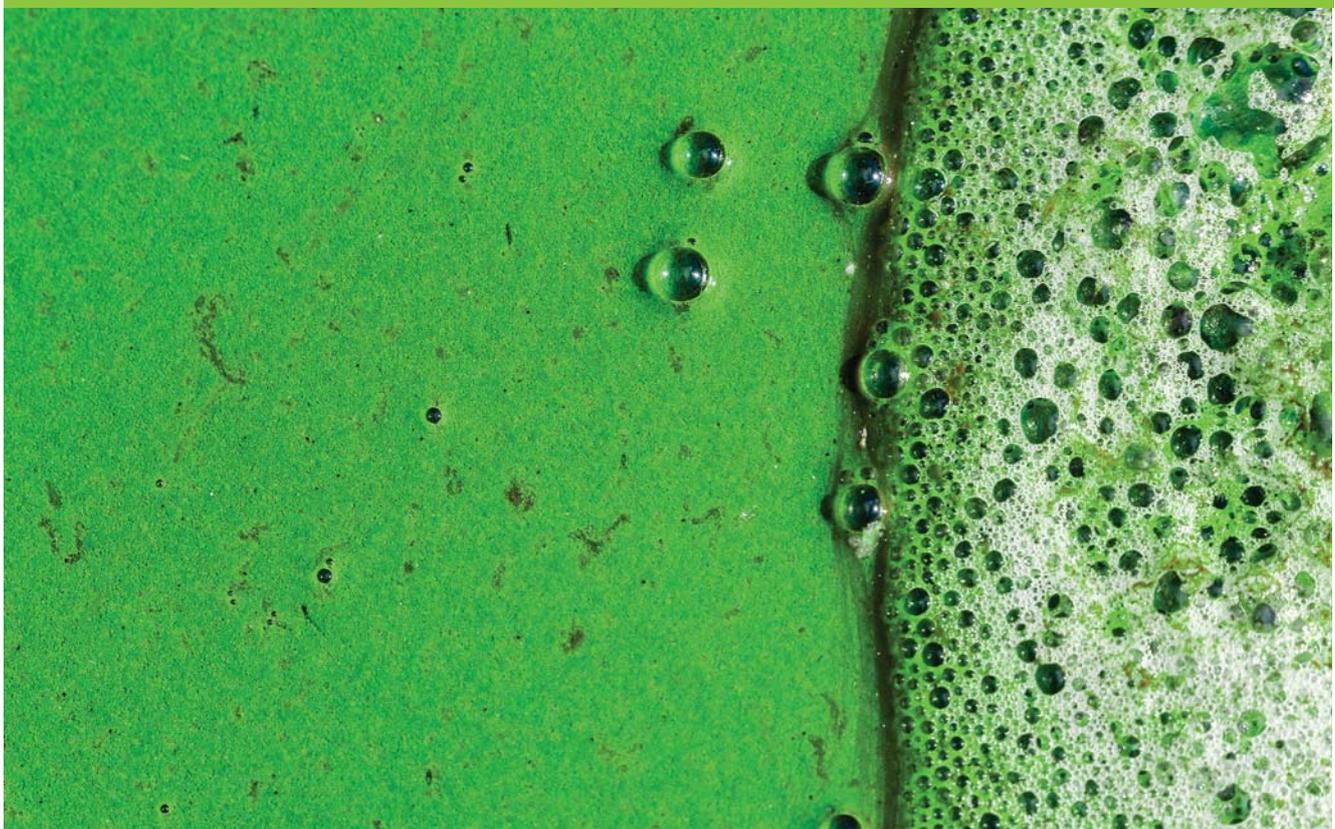


EUTROPHICATION

The CyanoLakes mobile app: Weather-like information for lakes from satellite imagery

Remote sensing scientist and founder and CEO of CyanoLakes, Dr Mark Matthews, reports on a new tool available for the monitoring of eutrophication in lakes and dams.



Cyanobacteria blooms and associated eutrophication in the world's lakes represent an increasing threat to safe water supply, recreational water users and ecosystems, and are worsening with climate warming. Cyanobacteria produce harmful toxins (cyanotoxins) associated with chronic diseases such as liver cancer, and acute poisonings of animals and rarely humans. Cyanobacteria are often the primary cause of nuisance taste and odor problems in drinking water. There is an immediate need for up-to-date information to protect public health and enable water companies, lake user associations and water professionals to respond to problem blooms in a timely manner with necessary interventions.

The CyanoLakes mobile app ('Your Weather App for Lakes') provides up-to-date weather-like information on cyanobacteria and algal blooms in the world's lakes from satellite imagery. The technology was funded by the South African Water Research Commission (**WRC Project No. 2019-2020-00198**), which has been funding research and development projects on satellite detection of water quality since 2015. The most recent project funded the development of the CyanoLakes mobile app (the app) to complement the CyanoLakes web app, a commercial product that is aimed at the public utility sector. The app, designed to make user-friendly information available to professional and novice users around the world, was released

in November 2020 on both the App (iOS) and Google Play (Android) Stores.

Description

The app presents potentially complex information related to water quality in an intuitive easy-to-understand format similar to the way in which information is presented in weather apps (see Table 1 for an explanation as to what information it provides). The app features a dynamic graphic background corresponding to the most recent satellite measurements of chlorophyll-a and cyanobacteria presence giving the user an immediate sense of the likely water colour and clarity.

A user must add lakes to their app by selecting an existing lake from a map, or by dropping a pin to add a new lake.

The app currently handles lakes larger than 600 m². The user is able to add or remove lakes as needed, with a limit of four lakes that can be added at any one time for free users. By upgrading to a premium monthly or annual subscription, the limit on the number of lakes falls away, and the user is then able to access high-resolution satellite imagery (from Sentinel-2 satellites) and set notifications for updates and alerts for various bloom risk-level thresholds.

Table 1. Summary of information provided by the app

Parameter	Explanation
Chlorophyll-a concentration	The green pigment found in all plants and a robust proxy for algae and cyanobacteria abundance
Cyanobacteria cell count	The estimated cyanobacteria cell count derived from chlorophyll-a (2000 cells per 1 ug/L chlorophyll-a)
Potential <i>microcystin</i> concentration	The potential concentration of <i>microcystin</i> toxin (the most commonly occurring cyanotoxin) converted from chlorophyll-a (0.4 ug/L <i>microcystin</i> per 1 ug/L chlorophyll-a)
Cyanobacteria risk level	The risk level to human health from cyanobacteria based on World Health Organization guidelines
Pollution level	The trophic state or level of nutrient enrichment based on chlorophyll-a which is a robust proxy for pollution from human sources
Recreational advisory	An advisory for both full and partial-contact recreational water use
Area coverage for cyanobacteria, scum and vegetation	The overall area in percent of the lake affected by cyanobacteria presence, cyanobacteria scum or floating aquatic vegetation

The app uses the World Health Organization guideline (2003) values to derive health risk levels for recreational users determined by the concentration of chlorophyll-a from cyanobacteria (see Table 2 for how these risk levels are defined and Table 3 what they mean for recreational users). The cyanobacteria cell count and potential *microcystin* toxin concentrations are determined using conversion factors from the WHO guidelines, although these are not directly estimated from satellite. Similarly, the pollution levels are also derived from chlorophyll-a concentration using accepted OECD guidelines for lakes.

The recreational advisory is determined with reference to both the cyanobacteria risk level and pollution level to provide an advisory for both full-contact water use (e.g., swimming) and partial-contact water use (e.g., fishing). It is important to always follow advisories issued by your local authority, as guideline values differ between countries, states and territories. The information should also be used in conjunction with additional water quality information before determining safety for any use. More details regarding the thresholds used by the app and the information it provides can be found in the app's Frequently Asked Questions (FAQs) page.

Table 2. Cyanobacteria health risk levels presented by the app

Risk Level	Low	Medium	High	Very High
Chlorophyll-a (ug/L)	< 10	10 – 50	50 – 100	> 100
Cyanobacteria count (cells/L)	< 20 000	20 000 – 100 000	100 000 – 200 000	> 200 000
Potential <i>microcystin</i> toxin (ug/L)	< 4	4 – 20	20 – 40	> 40
Partial-contact recreation*	YES	YES	NO	NO
Full-contact recreation*	YES	NO	NO	NO

* US EPA guidelines recommend value of < 8 ug/L microcystin for recreational use

Table 3. Explanation of cyanobacteria health risk levels

Low	No cyanobacteria have been detected from satellite. There is a low risk of adverse health effects from cyanobacteria. But since cyanobacteria can exist below the detection limit of the satellite, cyanobacteria may still be present. Recreational activities may be safe, provided that additional water quality information is first consulted and that any advisories issued by local authorities are followed. Routine sampling should be performed to determine if cyanobacteria are present.
Medium	Cyanobacteria have been detected from satellite at medium concentration. There is a small risk of adverse health effects, however high-risk individuals should avoid recreational activities. The water should be observed carefully for any areas of high concentrations that may form as a result of wind. Recreational activities may be safe for uncompromised persons, although full contact recreational activities such as swimming should be avoided. Additional water quality information should first be consulted, and any advisories issued by local authorities must be followed. Sampling frequency should be increased to monitor for the development of any accumulations.
High	Cyanobacteria have been detected from satellite at high concentrations. There is a chance you may experience adverse health effects from cyanobacteria. It is recommended that all recreational activities be suspended . Satellite imagery may be used to determine whether recreational activities can be continued in medium or low risk areas. Depending on the prevailing wind, dangerously high concentrations of cyanobacteria could form within minutes to hours. Frequent sampling should be implemented to monitor the situation.
Very High	Cyanobacteria have been detected from satellite at very high concentrations. There is an increased probability you may experience adverse health effects from cyanobacteria. It is recommended that all recreational activities be suspended . Satellite imagery may be used to determine whether recreational activities can be continued in medium or low risk areas. Cyanobacteria scums are likely to be present which may contain high concentrations of cyanotoxins that could cause acute poisonings of animals. Frequent sampling should be implemented to monitor the situation.

The app's information is derived from multiple satellite sensors, including the Sentinel-3 Ocean and Land Color Instrument and Sentinel-2 Multi-Spectral Imager of the European Space Agency Copernicus Mission. The information is updated daily, however, seasonal changes in cloud, ice or snow cover may reduce the number of updates. Information is typically available within three hours after the satellite image is acquired on the same day. The app is similar to the US Environmental Protection Agency's CyAN App (available on Android and web) but differs in the design, functionality and information it provides, its daily update frequency (as opposed to weekly updates), the availability of high spatial resolution imagery for subscribers, and in being available for lakes worldwide and not only in the United States.

Use and availability

The app, which already has 1 000+ downloads across iOS on Android, is being used by both recreational water users (sailors, fisherman, boaters), lake user associations and water utility companies to improve their knowledge of prevailing conditions in lakes. It is helping recreational water users to steer clear of potentially dangerous blooms and pollution problems, whilst also helping utilities improve decision making for water treatment and ecological management. The app can be downloaded free from the Apple App Store and Google Play Stores.

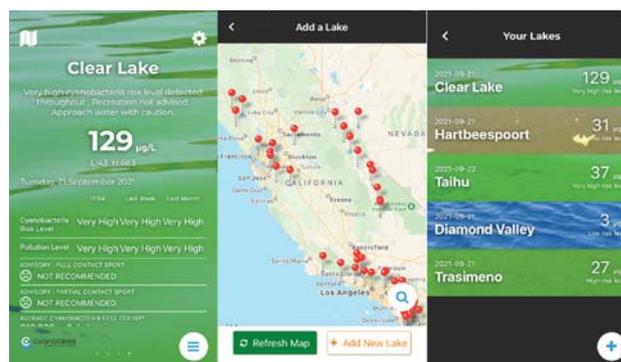
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Screenshots from the app showing (from left) the home page, add a lakes page and the list view.

References and further reading

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