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UrbanBlueHealth

Solutions on improving urban bathing sites – Prague

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1. Introduction

With an increasing number of summer and tropical days, bathing and other surface water-related activities have become more popular, particularly in urban environments. A healthy lifestyle has also sparked interest in bathing, even outside of the bathing season (including the winter months). Stagnant waters such as ponds and reservoirs are often negatively affected by eutrophication, which is characterised by the mass growth of planktonic cyanobacteria and algae.

Current monitoring of cyanobacteria and algae in bathing waters in the Czech Republic is based on the visual assessment of water blooms and laboratory analysis of chlorophyll-a and phytoplankton (counting in light microscope). The main problems of this monitoring approach are

1) low frequency (not more than once a week) due to high cost of analysis and also due to limited capacity laboratories and
2) limitation results to sampling point and its close surroundings which could not cover spatial heterogeneity of phytoplankton distribution.

These problems can be overcome by data of Sentinel 2 satellites which have sufficient overflown, coverage frequency (up to 15 days per month with the data from satellite). Furthermore, the sensors of the Sentinel 2 satellite provide images in sufficient and good for spatial phytoplankton distribution assessment which is the core element of the solution.

The tested solution and actions were listed in the action plan address the site-specific water quality stressors and potential health risk issues at the designated bathing site in and near Prague, as follows:

- Improve monitoring scope and reliability through satellite imaginary combining additional microbiological and chemical parameters for better understanding of health and environmental risks.
- Support the designation of new bathing sites on surface waters following a remoted (satellite) monitoring protocol.
- Improve monitoring and management of bathing waters with respect of climatic change in space and time in and near Prague
- Enhance cooperation and communication among institutions, stakeholders, decision-makers and the public.

- Increase the knowledge and skills of bathing water related professionals.
- Monitor and support activities leading to improvements in the water quality of bathing sites (measures on a combined sewer network).

2. Solution implemented in Prague

2.1. Technical description of Sentinel 2

The Sentinel 2 mission is a part of the Copernicus program managed by the European Commission. Data from three satellites are freely available for everyone and can be used for various purposes. One of them is water quality assessment in freshwater localities.

The Sentinel 2 includes three satellites: Sentinel 2A (released in 2015), Sentinel 2B (released in 2017) and Sentinel 2C (released in 2024). The data are collected in 13 spectral bands (table 1): 443 nm– 2190 nm including 3 bands for atmospheric corrections. Spatial resolution of sensors is 10 m, 20 m and 60 m. Data can be gained in several levels of processing (e.g. after atmospheric correction).

The frequency of available of images is approximately 15 per month (Figure 1). However, only part of them is suitable for water quality assessment, due to cloud cover in most cases. An example of this discrepancy can be seen in the figure below. There were 75 available images in the period May – September, but only 18 can be used for water quality assessment.

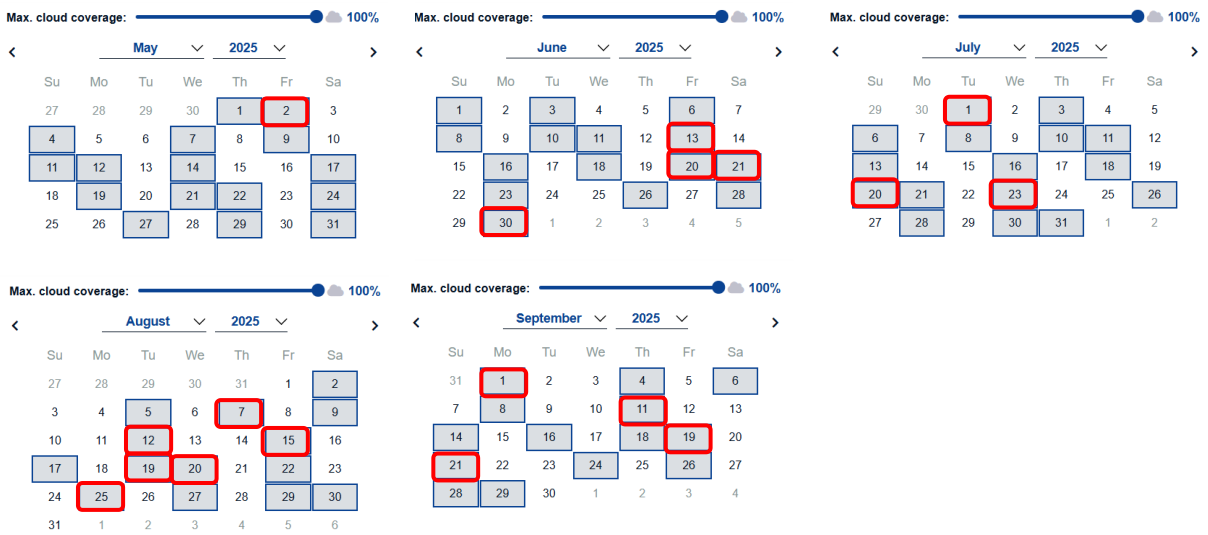

Figure 1. Calendar from May 2025 to September 2025 (extended bathing season 2025) shows available images from Sentinel 2 satellites for Prague area (grey background). Images with sufficient quality have red frame (source Copernicus Browser, 2026, adapted)

Band Number	Sentinel-2A		Sentinel-2B		Spatial resolution (m)
	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	
1	442.7	20	442.3	20	60
2	492.7	65	492.3	65	10
3	559.8	35	558.9	35	10
4	664.6	30	664.9	31	10
5	704.1	14	703.8	15	20
6	740.5	14	739.1	13	20
7	782.8	19	779.7	19	20
8	832.8	105	832.9	104	10
8a	864.7	21	864.0	21	20
9	945.1	19	943.2	20	60
10	1373.5	29	1376.9	29	60
11	1613.7	90	1610.4	94	20
12	2202.4	174	2185.7	184	20

Table 1. Sensors in Sentinel 2A a 2B [4]

Two system of phytoplankton assessment have been tested within the frame of the UrbanBlueHealth project pilot activity. The first one is available via the Copernicus Browser[1]. It is a customised user script as *The Aquatic Plants and Algae Custom Script Detector* (APA Script) [1], the second one is on-line application of RQWForecast [2].

Both tools provide an accurate estimation and detection of bathing water quality in space and time.

[1] https://browser.dataspace.copernicus.eu

2.1.1. Aquatic Plants and Algae Custom Script Detector

The Aquatic Plants and Algae Custom Script Detector seems to be very useful for estimation of Cyanobacteria and Algae in bathing waters. It is a user-coded script available through the Copernicus Browser application. The APA script is a quick method for estimating phytoplankton revitalization. As the name suggests, if there are "higher" plants in the surface water, it displays them in the same way as phytoplankton. The APA script does not provide any scale for estimating the chlorophyll-a concentration. Revitalization is estimated by feeling according to colors. The APA script shows weakly revitalized tanks as blue, more revitalized as turquoise, and very revitalized as green. If a strong cyanobacterial bloom forms somewhere near the surface, it is displayed in yellow; if there is strong turbidity in the water that is not caused by photosynthetic organisms, it is displayed in red (see Figure 2). The first signs of turquoise begin to appear at chlorophyll-a concentrations of approximately 10–20 µg/l chlorophyll-a. Concentrations above 100 µg/l are already intensely green and can be considered the upper range of the method. By customizing the coefficients in the script, the intensity of the colors can be changed, and thus the range in which differences in concentration can be perceived (even if this does not correspond to the original setting).

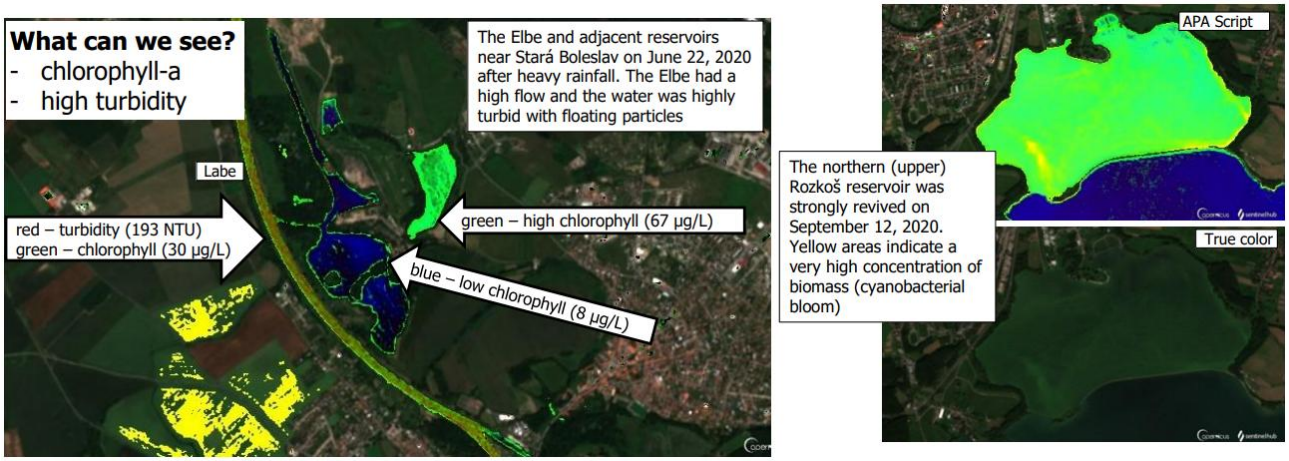

Figure 2. Interpretation of colours in the Aquatic Plants and Algae Custom Script Detector (source Copernicus Browser adapted with own data)

2.1.2. RWQForecast

RWQForecast is a web application for forecasting water quality in freshwater reservoirs using Sentinel 2 satellite data and machine learning models. It was developed as an output of research project by the team from the University of South Bohemia in České Budějovice. The application

allows users to visualize historical and forecasted water quality parameters, such as chlorophyll-a, phycocyanin, total suspended solids concentration for selected reservoirs.

2.2. Bathing water quality information obtained from Sentinel 2

2.2.1. Spatial heterogenity of phytoplankton occurrence

The main strength of the satellite and remote sensed data is the opportunity to observe spatial heterogeneity of phytoplankton occurrence which could not be obtained by the field sampling on the spot. Thus, the two tested systems is applied because of this advantage. The APA Script is more intuitively coloured (more green intensity means more phytoplankton) but it doesn't provide any exact numeric concentration. The RWQForecast application include scale with intervals of concentration (Figure 3).

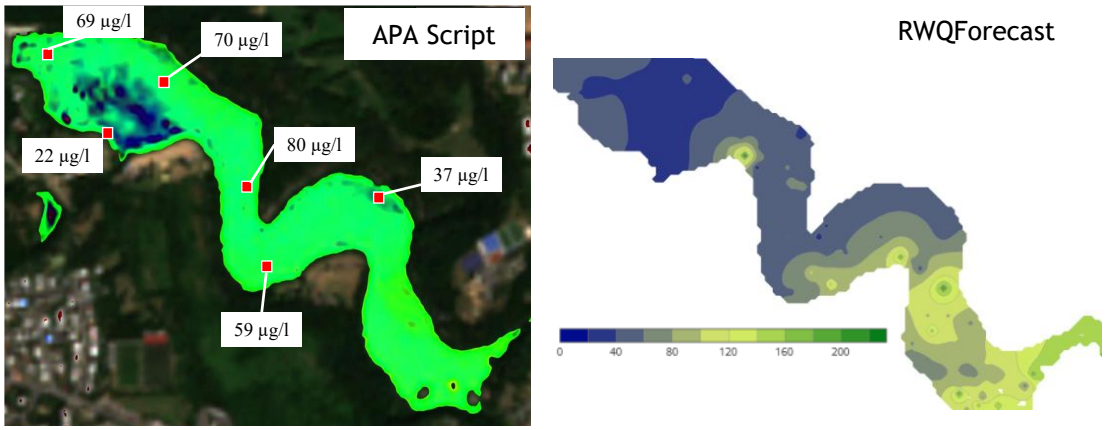

Figure 3. The Hostivař reservoir on 1st July 2025 when significant spatial heterogeneity of phytoplankton occurred. APA Script in the left (results of laboratory fluorometric analyses of chlorophyll-a were added for better understanding), RWQForecast results in the right comprise scale generated by application automatically

2.2.2. Time series and historical data

Available satellite data show accurate and verifiable view to the past (up to 2015) and support verification and comparison of existing data from visual site assessment and laboratory analysis. This information is very useful for non-designated bathing waters where data from standard monitoring is limited or completely missing. Both systems used in the UrbanBlueHealth project as pilot activity and are fully capable to calculate concentration of *chlorophyll-a*.

In Copernicus Browser the APA Script is used for visualisation (Figure 4) and MAGO-5 [3] for calculating concentrations (Figure 5). Moreover, in RWQForecast it is possible to calculate also *phycocyanin* (Figure 6) and *turbidity*.

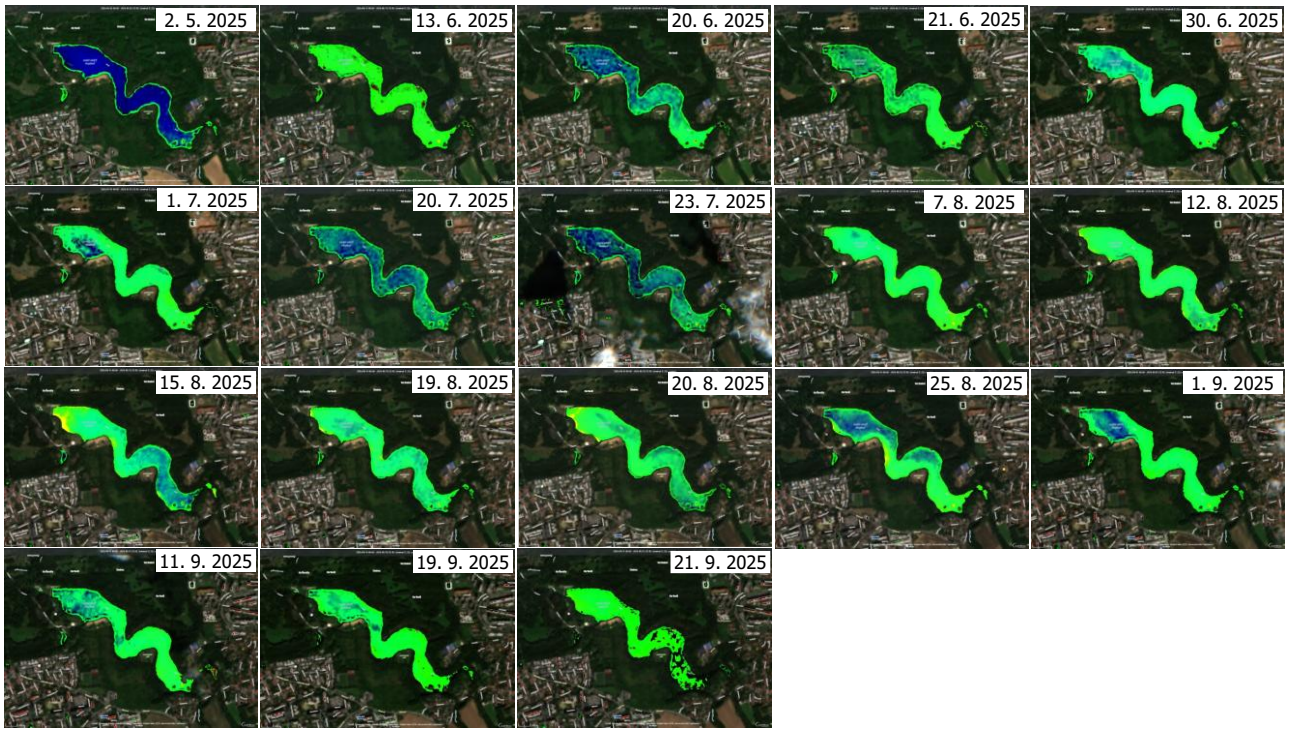

Figure 4. Extended bathing season 2025 (May - September) in the Hostivař reservoir with colour after the Aquatic Plant and Algae Custom Script Detector (source Copernicus Browser, 2026, adapted)

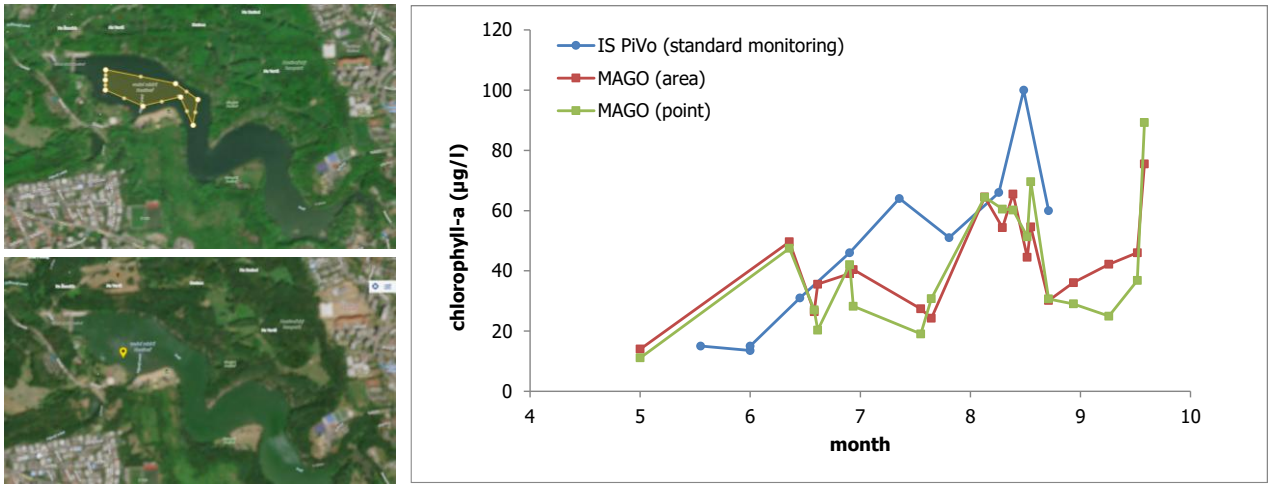

Figure 5. Comparison of chlorophyll-a concentration in the Hostivař reservoir (May - September 2025) from standard procedure according to the method ISO 10260 and from Sentinel 2 data (MAGO5 method [3]) - data from area (upper left image) and point in the place of standard monitoring point (lower left image), (source Copernicus Browser, 2026, adapted; IS PiVo database)

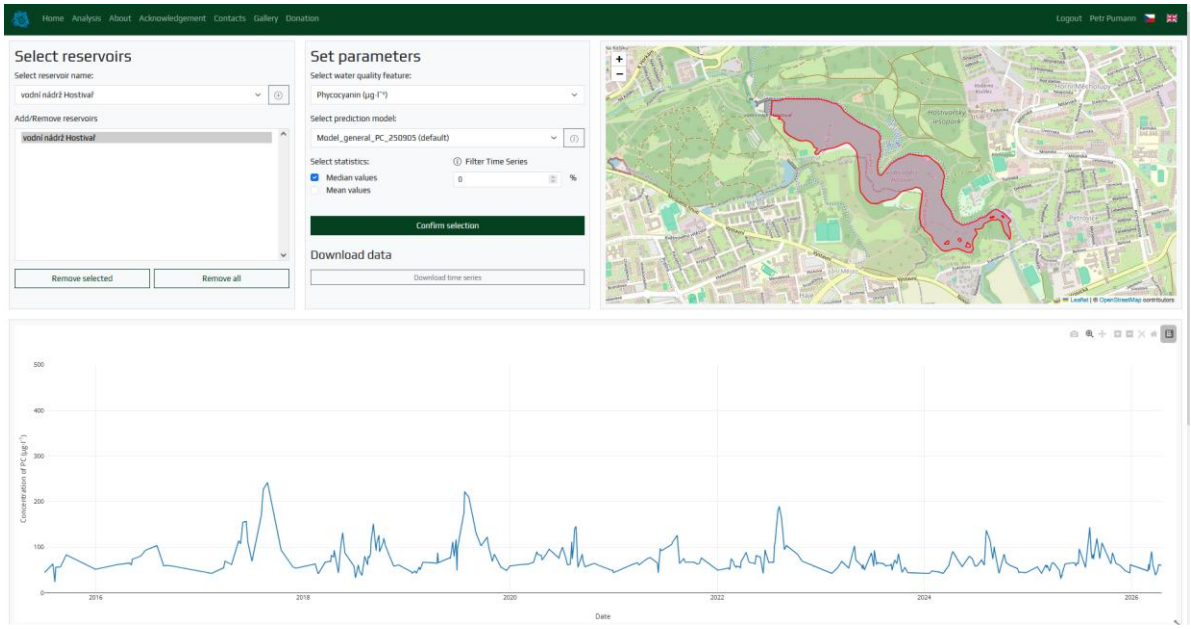

Figure 6. Phycocyanin concentration in the Hostivař reservoir in the period 2016 - 2026 calculated by the RWQForecast application

2.3. Validation

The data from the pilot monitoring between 2024 and 2026 (pilot action - D.2.2.1) were used for validation: specifically, the frequently monitored Hostivař Reservoir, regularly monitored profiles in the Vltava River, and other both designated and non-designated bathing waters (Figure 7). Samples from Hostivař were taken from boat to assess spatial distribution. In other sites, sampling after entering to water or from pears was done. Chlorophyll-a was determined according to the ISO 10260 standard protocol (ethanol extraction and spectrofotometry) and also by fluorometric method (AquaPen, Photon System Instruments; AlgaeTorch and AlgaeLabAnalyser, bbe Moldaenke) and microscopy. Data from Sentinel 2 were accessed mainly via Copernicus Browser. The data from regular monitoring of designated bathing waters (national database IS PiVo) were also used for validation.

This validation procedure demonstrated the practical utility of both the Aquatic Plant and Algae Custom Script Detector and RWQForecast for determining chlorophyll-a levels. RWQForecast shows higher values, especially for larger reservoirs than standard monitoring. This could be due to the calculation relies on satellite data covering not only designated bathing areas but also localities closer to the reservoir river inflow, where phytoplankton concentrations are usually significantly higher. The RWQForecast results for phycocyanin (an indicator of cyanobacteria presence) should be interpreted with caution.

2.4. Benefit of satellite data for bathing water quality assessment in Prague

The six designated bathing waters and sites in Prague are under the risk of excessive cyanobacterial and algal growth. The regular monitoring which has been done during the bathing seasons necessary in maximum frequency once a week from one sampling point. The Sentinel 2 images provide reliable and accurate information on the spatial distribution of the bathing water quality change and trigger targeted field sampling and complex risk assessment in a rapid alga-boom. Pilot action proves that in some cases the remote sensing methodology was able to show water-quality decline earlier than the laboratory (in-situ) analysis. An excellent example such a situation can be seen in Figure 3, where concentration of *chlorophyll-a* in the field sample was only 22 µg/l. However, this number represented minor part of the surface layer of the reservoir. Other parts which are also used for recreation had up to five times higher concentration. Moreover, distribution of phytoplankton can change rapidly.

The second advantage of the satellite data, the higher frequency of results, is clearly visible in Figure 4 and 5. There were nine samples in bathing season Hostivař reservoir taken by field sampling and 18 samples in extended bathing season (up to end of September).

Beyond "true" natural waters, two public small man-made bathing ponds were built in Prague the last decade (2014 and 2018) and there is also one non-disinfected swimming pool. However, these bathing sites are not good for applying satellite data due their small dimensions.

There are also several of non-designated bathing waters on small reservoirs, ponds, sand pits and the Vltava or the Berounka River inside the area of Prague where no or only very limited data on water quality from field sampling and lab analyses are available. The data from the Sentinel 2 satellites serve as the main source of results about cyanobacteria and algae occurrence. Fifteen non-designated bathing sites suitable for satellite data application were identified in Prague. Majority of them can be seen in the Figure 7. Unfortunately, some of non-designated bathing waters are too small for application of the Sentinel 2 data.

2.5. Communication

2.5.1. Stakeholder and institutional co-operation

The members of the national bathing water group were actively contributed finalisation of the action plan and the related solution setting the technical and methodological frames of use

satellite data to bathing water quality assessment. Discussion within the group included not only the key advantages of satellite data but also their drawbacks. The group members agreed to use satellite data in their work from the 2026 bathing season.

Figure 7. Satellite figure of Prague with designated standing bathing water (red circles), regularly monitored beaches near the Vltava River (yellow circles) and non-designated standing bathing water

occasionally monitored UrbanBlueHealth project (blue circles). In the lower part of the picture details of the position of sampling points and the APA script (source Copernicus Browser, 2026; adapted)

2.5.2. Digital implementation and public communication

The Prague Regional Public Health Authority (Hygienická stanice hlavního města Prahy, or HSHMP) which is the responsible body for water quality assessment of designated bathing water in Prague uses the Sentinel 2 data as support of the via Copernicus Browser mainly in cases of suspicious results from the field monitoring. Vlatave River Board (Povodí Vltavy) and the Ministry of Environment (Ministerstvo životního prostředí České republiky) also apply the Sentinel 2 data for information about current and also retrospective water quality challenges.

In cooperation with the state bodies mentioned above integrated bathing water quality web site[2] was develped for easy access to the APA script images of the particular bathing waters in Prague (both designated and non-designated – see chapter 2.4) via Copernicus Browser. It serves to everyone who interested in bathing water quality in Prague. The simple instructions for use are published there including information about the risk of misinterpretation. The link for this page is

The results from the Sentinel 2 analysis were also used for updating information in the map viewer[3] prepared by Water Research Institute in.

3. Transferability

Due to the potential for errors in results interpretation, satellite data analyses should be conducted by trained personnel who are aware of the associated risks. Automated calculations can sometimes count misleading results (e.g., if the system fails to detect cloud cover, especially tiny clouds or in cloud shadows). Users of the data should also possess a basic understanding of phytoplankton distribution in reservoirs (such as seasonal dynamics and vertical and horizontal distribution).

Results obtained via the Copernicus Browser and RWQForecast application could serve mainly as a supporting tool for other regional public health authorities in case of designated bathing waters where standard monitoring data are available and for everyone who will interested in

[2] szu.gov.cz/odborna-centra-a-pracoviste/centrum-zdravi-a-zivotniho-prostredi/ohv/projekty-oddeleni-hygieny-vody/urbanbluehealth-joint-central-european-actions-for-improving-quality-of-urban-bathing-waters/kvalita-koupacich-vod-v-praze-pomoci-druzic-sentinel-2/

[3] dibavod.cz/vodni-rekreace-praha

water quality in non-designated waters. On-line courses will be used for know-how transfer. The course will deal with basic information about Sentinel 2, practical examples of water quality assessment and information on risk of misinterpretation. It will be also recorded in uploaded to the internet. It could serve as a manual for both the course participants and new users.

The experience gained during the testing and verification satellite data for bathing water quality in Prague pilot can be used in other of the Czech Republic (as mentioned above) and also in other Central European countries. All UrbanBlueHealth project partners were informed during the UrbanBlueHealth transnational workshops and they are invited to the on-line workshop where skills needed for correct Sentinel 2 data interpretation will be trained.

4. Summary

The pilot activities implemented for the urban bating sites along the Vltava and the Berounka rivers proved the Sentinel 2 satellite data (satellite imagery) are reliable and accurate sources of remoted phytoplankton assessment [5]. Two systems were used in the pilot phase of the UrbanBlueHealth project:

1) the Copernicus Browser and custom script (the Aquatic Plant and Algae Custom Script Detector) and downloading data for the calculating of chlorophyll-a and
2) the RWQForecast application.

Both methodology on satellite image processing contribute to the implementation of the action plan approved and presented. The applied tools are supporting:

- Improved monitoring scope and better understanding of health and environmental risks and diseases.
- Modern hi-tech methodology which able to corelate with laboratory microbiological chemical analysis.
- Provide easy-to-use platform for the municipal decision-makers to designate new bathing sites.
- As Sentinel 2 is a widely use data source, cooperation and communication amongst the municipal and state institutions is sustained.

- Due to the geographical interpretation of the water quality of the popular bathing sites in and near to Prague, the publicity, the bathers can get proper and in-time information on the water quality and potential health risks.
- The methodology is flexible enough to improve and development the data processing and interpretation, thus it has a great potential for further, more problem-oriented improvement.

5. Literature

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