APPLICATION NOTE

FIELD PHOTOMETER

Water quality assessment in rivers, lakes and groundwater using Exaqua photometers

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Exaqua

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INTRODUCTION

Water quality assessment is one of the most important research issues carried out at the Department of Hydrology of the University of Warsaw. Such studies lead primarily to the exploration and better understanding of the spatial and seasonal variability of physicochemical parameters of rivers, lakes, and groundwater. However, the application aspect of research is also significant, especially during field exercises and courses held in various regions of Poland. The ecological disaster on the Oder River in the summer of 2022 caused increased interest in the subject of water quality, which is reflected in a greater number of bachelor's and master's theses, realized currently in this field. Exaqua photometers turned out to be the best solution in face of the growing interest in chemical analysis of water and this text is a short summary of our experiences and observations from the use of these devices.

EXAQUA PRO3 IN RESEARCH AND DIDACTICS

Proper preservation of water samples is a key principle in hydrochemical measurements; one of the basic requirements is to minimize the time between taking a water sample and its further analysis. This applies in particular to biogenic compounds, such as nitrate, nitrite, and ammonium ions, but also phosphates, iron, and manganese; ion interaction with oxygen and microorganisms in the sample could significantly change their concentrations over time. Therefore the best solution is to analyze the samples directly on the spot, as it eliminates the need for sample preservation and increases the reliability of the results. In the case of water analysis during field courses and exercises, taking place off-campus, there is no access to the laboratory, while the results of water analysis are needed almost immediately. The only way, practiced so far, was to use simple colorimetric test kits.

Summer field exercises with students
During summer field exercises we had the opportunity to compare the Exaqua PRO3 photometer with other devices – it did very well and was praised by students.

Unfortunately, such method did not offer satisfactory accuracy of measurements – in the case of some ions, the intervals between successive colors on the color chart were very large, while the visual color identification carried a large load of subjectivity. It was therefore necessary to find a more precise solution, guaranteeing an accurate level of measurements. In this way, we have become users of Exaqua PRO3 photometers, which we use intensively in research and didactics.

ABOUT THE DEVICE

The Exaqua PRO3 photometer has a number of features that give it a truly field and portable character. First of all, it is a handy and small device, and does not require a standard cap due to the unique Rayject technology. This makes the photometer extremely light and flat, which is of great importance when moving in difficult terrain, often with other suitcases full of equipment. Moreover, the device is solid, dust, and splash resistant. This makes Exaqua photometers accompany us practically everywhere (also as pH-meters and dissolved oxygen meters, which will be discussed later), for example to Warsaw lakes and ponds, small rivers near Biała Podlaska, Grodzisk Mazowiecki, and Ciechanów, as well as the springs of the Pilica River valley. The device is also shockproof, which – of course unintentionally – has been verified in the terrain. The Li-ion battery lasts for several hours of measurements, even at air temperature around 0°C, while the built-in guide function, praised by our students, eliminates the need to carry a paper manual. Finally, it was a good idea to put four vials and a syringe in a suitcase with a photometer, which makes the Exaqua PRO3 nearly always ready to use.

Field exercises in full sunlight
We used the Exaqua PRO3 photometer during field exercises for chemical analysis of water samples from the Krzna River. The device is doing great even in full sunlight.

ABOUT THE METHODS

The Exaqua multi-wave photometer and dedicated reagents allow the use of several implemented measurement methods. Most often, we measure the concentrations of biogenic compounds (including potassium), sulphates, and metals, such as iron and manganese ions; these parameters are considered indicators of water eutrophication or anthropogenic pollution. In this context, it is worth mentioning the photometric titration methods (Exatitr), which are made possible by the implementation of the innovative Rayject

Laboratory work with Exaqua photometers
We also use Exaqua photometers in the laboratory, where we measure several dozen of samples.

Alternative to classic oxygen meters
The ability to measure the concentration of dissolved oxygen using the Exaqua photometer is a great alternative to classic oxygen meters.

technology. There is no need to cover the vial from external light during the measurement, so it is relatively easy to determine water hardness and the concentration of calcium and magnesium by the titration. During this procedure, the photometer automatically signals a change in the colour of the sample, which suggest the end of the titration – the result of the measurement is calculated after entering the amount of reagent used in the process. The Exatitr technology proved to be very useful, eliminating the need to run separate complexometric titration tests for calcium and magnesium and improving the quality of measurements.

The accuracy of the measurements is generally consistent with the specifications of the individual methods, and the results are stable if the whole procedure is performed according to the manual or guide. This enables one measurement for a given sample, which speeds up analysis and reduces the consumption of reagents. What's more, we very positively perceive the fact that the producer listed all available methods on the website, along with precise information about their type – it is generally not obvious, while this information is crucial from the point of view of the description of the research methods. However, we have noticed that in the case of field measurements at low air temperature (below 10°C), the time duration between successive steps of the procedures should be extended, as the manual and guide in the photometer take into account laboratory conditions (20°C). This was especially important in the case of the measurements of nitrates and phos-phates ions and the con-centration of dissolved oxygen during winter.

Routine measurements from the spring
Routine measurement of nitrate ion concentration in water from the spring in the Pilica River valley.

The big advantage is the unification of the volume of the water sample used for testing. In the vast majority of cases, 5 ml of water is used for a single measurement. Similarly, a very clever and practical solution was to implement methods for different measurement ranges, based on the same reagents for a given ion. High range methods require only the appropriate dilution of samples with deionized water.
In terms of the reagents, their competitive price must also be emphasized. This is of little importance to users who take several measurements a week, but in the case of routine measurements it seems to be crucial. Research conducted for the purposes of one diploma thesis usually requires up to 50-100 measurements per month (several ions from dozens of measurement points), the same as during field courses and exercises. This way we get thousands of measurements every year, so the cost-effective Exaqua photometer is the favorable option. An important advantage of the reagents is also their relatively safe composition, enabling disposal without posing a threat to the environment. This is particularly important during field measurements.

APPLICABILITY AND FUTURE

A definitely interesting possibility of using the Exaqua photometer are the measurements of pH and concentration of dissolved oxygen. In the case of pH, the colorimetric method is used (the photometer recognizes color), while the dissolved oxygen concentration is determined with the use of the Winkler method adaptation. The biggest advantage of these methods is that there is no need to calibrate the measuring equipment; both the pH meters, equipped with standard electrodes, and the polarographic probes for measuring oxygen concentration, must be regularly calibrated and properly stored in specific solutions. By using a photometer for this type of measurements we avoid the need for regular probe calibration, which, apart from convenience, is also cost-effective. The measurement of dissolved oxygen concentration in reservoirs and lakes using the Exaqua device also has another clear advantage over classic dissolved oxygen meters – it does not require water flow, which is necessary in the case of oxygen probes (a water velocity of at least 10 cm/s is usually

recommended).

Installing the new software on the photometer is very easy and took only a few minutes; it requires uploading a file to the device's memory, connected to the com-puter via a USB cable. The dedi-cated mobile application also seems to be useful, especially for individual users, enabling communication between the smartphone and the photometer – in that way it is possible to transfer recorded results to a spread-sheet application or to generate measurement reports and graphs. Exaqua photometers are attractive devices, as new measurement methods are successively introduced (such as total and free chlorine), which expands their possibilities. We believe that the manufacturer has not said the last word on the matter.

In less than a year, Exaqua photometers have become the basic tool for field water quality testing carried out in Department of Hydrology. We hope that there are still thousands of exciting measurements of rivers, lakes, and groundwater ahead of us.

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