TEMPORAL MONITORING OF THE FOURTH SECTOR OF LAKE PALIC

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UDK: 543.3(285)
DOI: 10.14415/konferencijaGFS2021.45

Summary: *This paper present an overview of a measuring campaign implemented on Lake Palic. The measurements aimed to provide a more comprehensive understanding of both spatial and temporal changes in water quality. A month-long measuring campaign consisting of daily sampling of water at four selected locations was conducted to attain this goal. Five parameters were monitored each day and each location, water temperature, electric conductivity, dissolved oxygen, pH value, and suspended sediments. The analysis of the extracted results provided guidance for future research.*

Keywords: *water quality assessment, measurements, data analysis, Lake Palic*

1. INTRODUCTION

The sensitive water quality of Lake Palic has caused numerous task groups to implement different investigations to determine the causes of poor water quality and provide suggestions for its enhancement [1,2,3]. One major issue is the restricted spatial and temporal water quality data [2,3]. Although there are monthly water quality measurements implemented throughout the lake, not all of the parameters are evaluated each month [1]. Much of the parameters are determined only four times a year. An additional problem with the existing measurements is their spatial distribution. These data cover only a couple of locations, significantly limiting the much-needed research of the lake. The proper understanding of the examined water body can be achieved by implementing detailed measurements (e.g., described in [4]).
As a result of the Author's previous efforts to implement continuous measurements of any kind within this area, conjoined with the analysis of the existing water quality measurements, the Authors concluded it would be reasonable to implement a localized measuring campaign within a selected segment of Lake Palic to determine potential water quality tendencies [1,2,3]. Consequently, we implemented a measuring campaign lasting one month. During this time, the chosen water quality parameters were evaluated on a

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daily basis within four locations. This paper describes a summary of our findings from the implemented investigation.

2. MEASUREMENTS

After implementing an exhaustive analysis of the existing water quality data of Lake Palic, we concluded that it would be beneficial to conduct a short-term measuring campaign focusing on increased sampling frequency. Namely, regular samplings are performed monthly, suggesting there are 12 data sets each year for the selected locations [1,2,3]. As our previous research determined [1,2,3], this is not the case since, during the years, the monitored water quality parameters were known to be replaced. Furthermore, we identified missing data sets for numerous parameters [1]. Some of the data are absent due to reduced sampling frequency for the particular parameter, while there were numerous situations where the complete data set is omitted by mistake. All these issues resulted in a significantly reduced frequency of the existing data, providing 4 sets of measurements in each year instead of the initial 12.

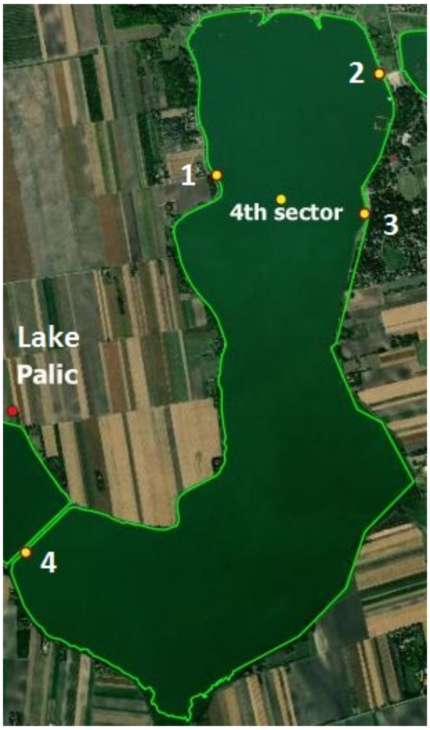


Figure 1. Lake Palic – Sampling locations

Hoping to discover if a significantly increased sampling frequency would provide some additional information regarding the monitored location's water quality alterations, we implemented a month-long measuring campaign. The experimental site was the fourth sector of Lake Palic, Fig. 1, within which we selected four points as the representative

sampling locations for the measuring campaign. The sampling locations are marked with numbers from 1 to 4. The first location presents a part of the lake in a small bay and is covered with vegetation, mostly reed, guarding against strong weather influences such as water mixing caused by wind. The second location is the outflow from the lake. As a result, this area is expected to endure continuous mixing since it is subject to regular water flow. Another essential characteristic of the second location is the absence of vegetation. The bank of this site is a concrete wall, and there is no reed or trees in the proximity to protect the water from weather influences. Therefore, it is expected that the mixing of the water is much more pronounced compared to the first location. The water quality at this location may also be affected by debris accumulated at the outflow due to the flow pattern. The third location is quite similar to the second site, regarding the concrete walls surrounding the water and the absence of vegetation that could provide cover. As a result, the third location is also subject to strong winds and insolation. However, considering this is not an outflow location, there is no additional mixing caused by the water's flow. The fourth location is an area covered with vegetation (reed) relatively close to the inflow into the lake (roughly 30 meters). It is not clear how the proximity of the influx influences the water quality since the heavy vegetation in this area could act as a barrier, consequently reducing the mixing of the water.
The implemented measurements took place from June 22nd, 2020, to July 18th, 2020. During this time, the Authors conducted daily measurements of the five selected water quality parameters. The chosen parameters were limited to temperature (measured and presented in ˚C), dissolved oxygen (in %), electric conductivity (measured and presented in μS/cm), pH (-) value, and suspended sediments (in mg/l). Considering the increased frequency of the measurements and 4 measuring sites, this resulted in 540 measured values.

3. RESULTS

By implementing this high-frequency measuring campaign, the Authors were hoping to answer the following questions: Is the existing measuring frequency dense enough to provide the necessary information regarding the water quality of Lake Palic? Could the scarce measurements covering a wide range of monitored parameters be replaced with more frequent measurements covering a significantly reduced number of parameters? Does sampling within the fourth sector of Lake Palic at four different locations provide any additional information compared to sampling at one or two locations? To try and answer these questions, we provided a comprehensive analysis of the acquired data.
Figure 2. shows the temporal changes of the measurements for each of the four locations. By evaluating the represented data, there are a few essential conclusions we can make. The general tendencies seem to coincide regardless of the sampling location for all of the evaluated parameters. For example, although there is a notable differentiation between the measured temperatures at locations 1 and 4, both locations displayed an increasing tendency in the first two weeks and an average decrease in the assessment's remaining time. A similar conclusion can be made for all of the represented data. Another observation that can be made is the similar results regarding all of the considered parameters at locations 2 and 3. As expected, due to the comparable external conditions, the water quality parameters also display matching values.

A more comprehensive evaluation shows a notable difference between measurements at the fourth location. As an example, the electric conductivity (EC) and suspended sediments (SS) were similar within the first three locations but seemed to have a more distinguished variance at the fourth location.

Figure 2. Temporal changes of the measurements

By examining the radar chart for the dissolved oxygen, Fig. 3, we can notice that the dominant oscillations are the temporal oscillations. A general tendency that can be identified is a decrease in dissolved oxygen over time. This is represented by the bulge that can be noticed on the diagram. Although all four locations follow similar behavior patterns, there is a small lag between the values from the first sampling location in comparison to the remaining locations. The reduced dissolved oxygen on this location is probably the result of this site being the least exposed location, guarded against wind's influence. Compared to this site, the second location is the most visited part of the lake, surrounded by a concrete wall. It is also the outflow location, consequently subject to various influences aiding the mixing process and causing higher dissolved oxygen values.

Location three is also on the windy side, without vegetation protection, where we noticed waves during the sampling.

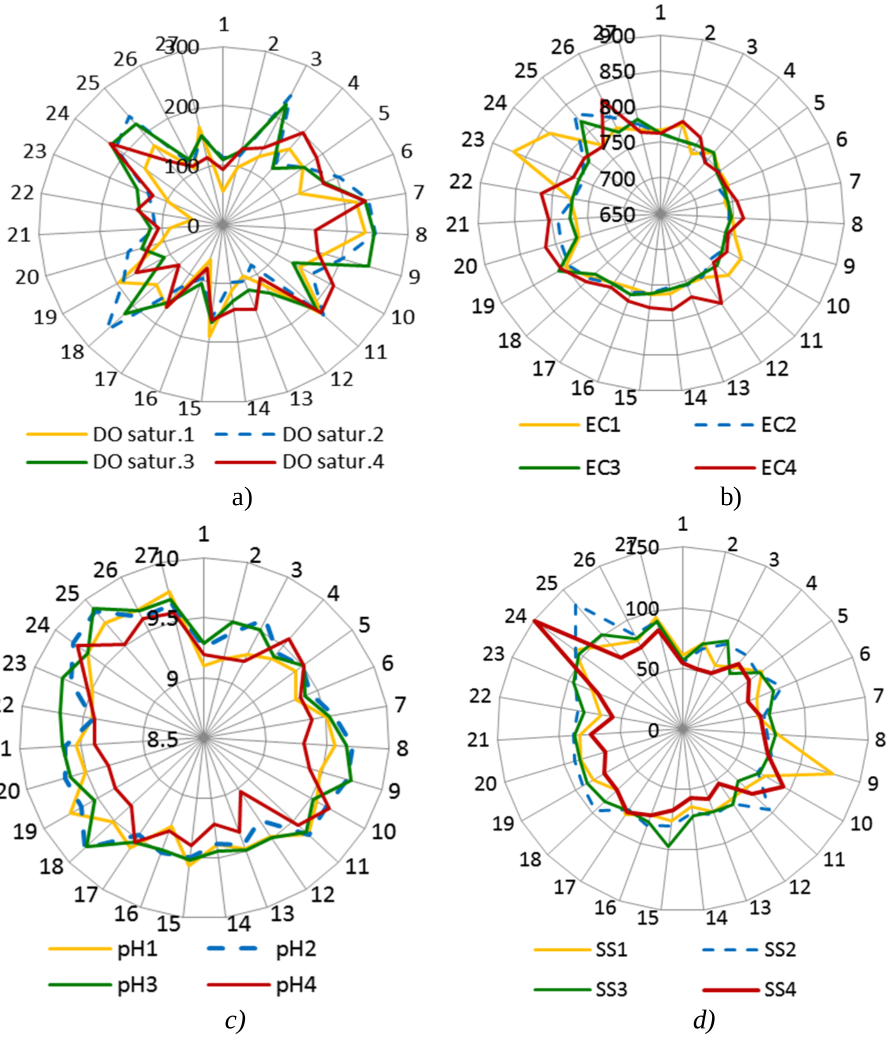
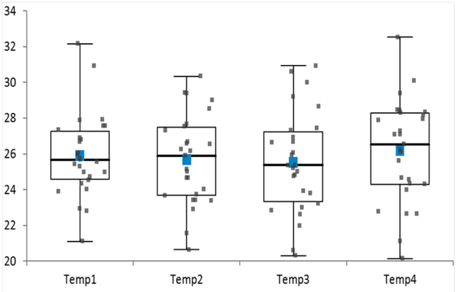


Figure 3. Temporal changes of the measurements

The fourth location is near the inflow into the fourth segment of the lake, but it is covered in vegetation. Therefore it is expected the results would be between the two aforementioned categories.

By reviewing the electric conductivity values, one can notice they seem relatively uniform with some deviations during the last week. The second and third locations' data seem to coincide quite well, while the first and last locations show minor variations. Nevertheless, the data's overall circular shape indicates a relatively uniform value of the electric conductivity, Fig. 3.



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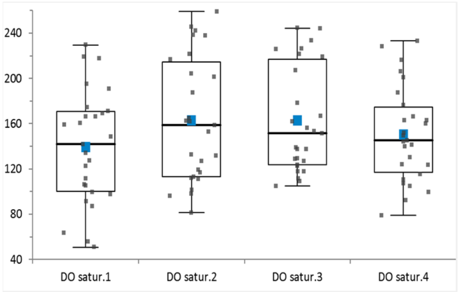

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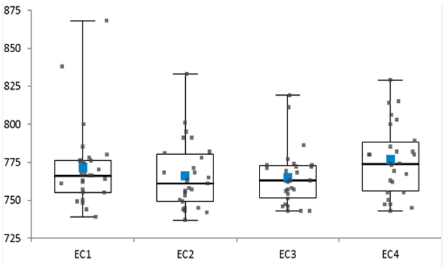

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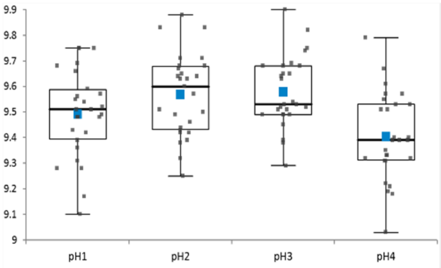

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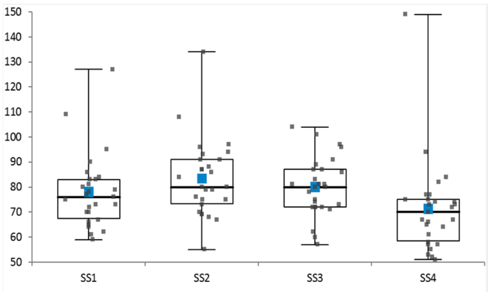

e)

Figure 4.Scatter plot of measured data for different locations

The pH values start as smaller but reach approximately 9.5 within a couple of days and remain on that value for most of the considered time interval. Further evaluation shows that the fourth location seems to be the most diverse.

The suspended sediment also follows a nearly circular graph suggesting uniform data values. There are three notable deviations of measurements, represented as three peaks. For the first location, this extreme occurred on the 9^{th} day of the measurements, on the second location, it was on day 25, and for the last location, it was on day 24. Considering the isolated values of increased suspended sediment, it is reasonable to assume these as accidental. On the other hand, by pairing this diagram with the diagram for the dissolved oxygen, one could also imagine the identified bulges are caused by strong winds. Still, extracting such a conclusion would require additional information, e.g., wind measurements.

Figure 4 shows the skeletal box plot for the sampled data, where the dots represent the measurements, the square in the middle of the box marks the mean value, whereas the horizontal line presents the median. The lines ranging up and down from the box (whiskers) mark the maximal and minimal values. Through careful examination of the results, it becomes evident that the second and third locations' values show a similarity for all of the considered parameters. As already explained, this is due to the similar conditions of these two locations, the concrete walls making the water more exposed to weather conditions, such as wind, insolation, and others.

Furthermore, these two locations are very close to each other, which also influences the sampled data's similarity. As a result, we can see that although there is a notable change of dissolved oxygen, suspended sediment, electric conductivity, or pH value measured at the four locations, the values attained at these two sites remained similar.

Another noteworthy occurrence is that data gathered at the first and fourth locations also seem to have similar tendencies. As an example, we can examine the dissolved oxygen results presented in Fig. 4.b) and see that the measured values seem to increase from location 1 towards location 2, stay uniform up to location 3, and decrease towards location 4. A corresponding trend is identified in the case of electric conductivity, pH, and suspended sediments. Although these two locations display similar behavior, they should both be included in future investigations considering the distance between them. The matching characteristics of the monitored parameters can partially be attributed to the fact that both locations represent areas covered with vegetation, in contrast to sites 2 and 3, undoubtedly influencing the quality of the surrounding water. The opposite is the case for sites 2 and 3 that most probably show equivalent values due to their proximity. Consequently, one of these two locations can be omitted from future analysis.

Considering the presented results, there are a few general conclusions that can be made. The first is that although daily measurements can give a better understanding of day-to-day changes, they are much too difficult to maintain in the long run unless an alternative, possibly long-distance measurement methodology is employed. Therefore, at this point, one can conclude the additional information attained by these more frequent data is not significant enough to be implemented relying on laboratory measurements. Nevertheless, other statistical investigations can be implemented to analyze the gathered data and compare it to the existing monthly measurements to understand them better.

Regarding the spatial distribution of the sampling locations, it is indisputable that more sampling locations are better than one. On the other hand, considering the proximity of the two selected locations, the presented investigation suggests that one of them could be omitted. To ensure more reliable conclusions, there is additional analysis to be implemented. Furthermore, conducting another measuring campaign focused on the spatial distribution of the considered parameters would provide a more in-depth insight into the lake's water quality changes.

4. CONCLUSION

The presented paper describes a measuring campaign conducted to gain a more in-depth insight into the temporal changes of water quality parameters in Lake Palic. To do so, the authors implemented a month-long, daily sampling routine. Each day the sampling was done at four sites around the lake. The goal of sampling on these locations was to determine if there is a need for a more detailed spatial evaluation of the water quality parameters.

Using various approaches for the data evaluation, it was deduced that only three are reasonable for future monitoring from the four selected locations. Namely, the attained results suggest that locations 2 and 3 are too close and may be unnecessary to monitor the water quality at both of them.

Furthermore, the evaluation of daily water quality parameters showed high oscillations of the measured data, suggesting such frequent sampling is unnecessary. Future research should focus on two potential approaches. One is implementing continuous measurements that could provide a more comprehensive understanding of the results. Such frequent measurements would allow identifying various external influences such as rain, strong wind, or others, making it possible to monitor the lake's response to the external influences. Another occurrence that needs to be additionally examined is the spatial behavior of the water quality parameters. Considering the implemented study focused on four locations, where it was determined that the presence or absence of vegetation might significantly influence the observed water quality, it could prove beneficial to widen this research by conducting a thorough spatial evaluation of the water quality parameters.

REFERENCES

[1] Horvat, M., Horvat, Z.: Implementation of a monitoring approach: the Palic-Ludas lake system in the Republic of Serbia. *Environmental Monitoring and Assessment*, **2020.**, vol. 192, № 2.

[2] Horvat, M., Horvat, Z.: Analiza kvaliteta vode jezera Palić postupkom analize glavnih komponenti. Zbornik Radova Građewvinskog Fakulteta 37, **2020.**, str. 67-78.

[3] Horvat, M., Horvat, Z.: Primena multivarijabilne analize za ocenu kvaliteta vode jezera. Zbornik Radova Građewvinskog Fakulteta 37, **2020.**, str. 31-42.

[4] Horvat, Z., Horvat, M., Koch, D., Fruzsina, M.: Environmental Monitoring and Assessment Field measurements on alluvial watercourses in light of numerical modeling: case studies on the Danube River *Environmental Monitoring and Assessment,* **2021.**, vol. 193, № 1.

ВРЕМЕНСКИ МОНИТОРИНГ ЧЕТВРТОГ СЕКТОРА ЈЕЗЕРА ПАЛИЋ

Резиме: *У раду је представљена мерна кампања језера Палић. Сврха организованих мерења је била да се обезбеди боље разумевање просторних и временских промена квалитета воде. Са тим циљем су спроведена мерења у трајању од месец дана. Током ових мерења су вршења дневна узорковања воде језера на четири локације. У оквиру сваког дана и сваке локације је праћено пет параметара квалитета, температура воде, електро проводљивост, растворен кисеоник, суспендоване материје и pH вредност. Анализа сакупљених података је омогућила дефинисање правца даљих истраживања.*

Кључне речи: *анализа квалитета воде, мерења, анализа података, језеро Палић*