Hydrometric and Water Quality Properties of the Medulin Pond (Republic of Croatia)

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V Ecohydrology and Water Body Protections

HYDROMETRIC AND WATER QUALITY PROPERTIES OF THE MEDULIN POND (REPUBLIC OF CROATIA)

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Abstract

The objective of this paper is to present the first hydrometric and water quality properties research data of the naturally formed small lake called Medulin pond (*cro, Medulinska lokva*) in order to provide methodology foundations for the development of the procedure aimed toward water quality and ecological potential evaluation of small urban water resources. Medulin pond is placed in an urban area of the Medulin municipality in Istria County (Republic of Croatia), and is considered a public water resource under the jurisdiction of the Croatian waters, and is not characterized as a highly protected, vulnerable, or landscape significant area according to any Croatian or European Union laws and directives or local authority urban plans. In this paper, first preliminary hydrometric and water quality data in order to assess the current condition of the pound including the bathymetry of the pond, temperature stratification, and standard water quality parameters will be presented.

Keywords: Medulin pond, hydrometric, water quality, small urban water resorce, evaluation.

1. Introduction

The Republic of Croatia can be considered rich in natural beauty, especially in the area of water resources. Water resources in urban and non-urban areas are under the jurisdiction of Croatian waters and are declared as protected, vulnerable, or landscape significant areas according to which local municipalities have to plan the development of their space. The Beforementioned is mostly aimed toward specific water resources that are also protected by Natura 2000. But there are a lot of urban waters, for example, small rivers, lakes, or ponds, that are on the list of the Croatian waters resources but they are not recognized as significant or special in any way. Usually, they are not considered to have any harmful water effect on the surrounding urban area. Reasons for that can maybe be found in their size or anthropological impact on some of them. Because of that, some of these "water pearls" are sometimes forgotten or not recognized as valuable which can cause many problems in the urban planning process. If some water resource is not recognized, by excessive urban planning in that area, water resource can be irretrievably destroyed. Also, if the water resource is not used for the drinking purpose (water protection zones), usually Croatian waters have jurisdiction only on the area of water resource by itself and not on the catchment area.

Because of the beforementioned problems, it would be purposive to have some kind of procedure aimed toward the evaluation of small urban water resources in order to provide guidelines for the urban planning process. By simple hydrometric, water quality, ecological potential evaluation, and hydrological analyses, the catchment area of water resource can be easily protected and a small ecological system can be set in the balance. For example, if the water resource catchment system depends mainly on surface runoff, the overall percentage area of construction on the lot can be lower to provide better soil permeability. Also, if the water resource receives water from underground, by urban planning restriction considering underground floors can be provided. Besides these two examples, there is a long list of additional simple measures by which small urban water resources can be preserved.

This whole idea of analysis and evaluation of small urban water resources became interesting in a moment when we discover that in the middle of the Medulin municipality urban area, a small natural pond is placed, and its lacks any hydrometric, hydrological, or water quality measurements.

2. Methods

In this section, the location of the research area, as well as hydrological characteristics, biodiversity, and urban significance of the Medulin pond, are going to be described. In continuation, the hydrometric, and water quality measurement procedure is going to be presented.

2.1. Location of the research

Medulin pond is placed in an urban area of the Medulin municipality in Istria County (Republic of Croatia) as is shown in Figure 1.

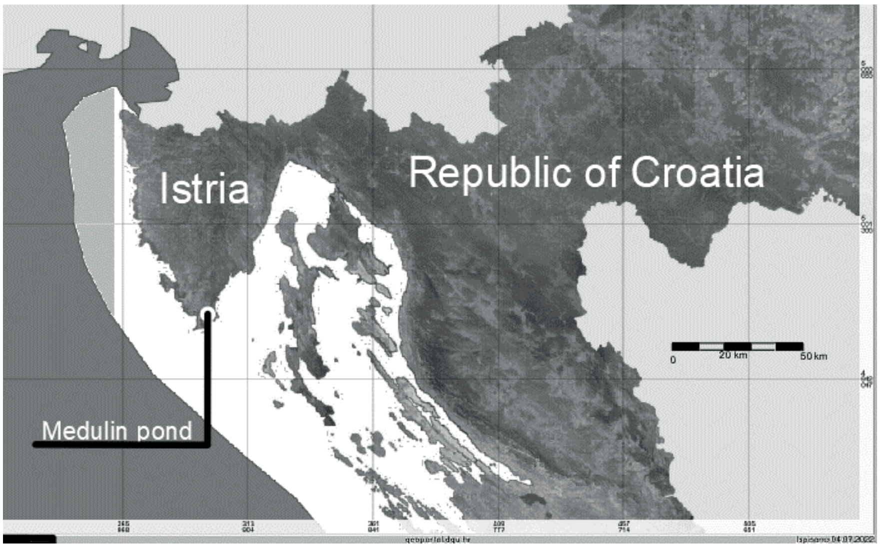

Figure 1. Location of the Medulin pond in Istria County (Republic of Croatia) [1]

On the north, west, and south side the pond is surrounded by buildings, and on the east side agricultural area is located. According to the areal map, the size of the pond in the condition of the maximum water level is approximately around 80 m wide and 100 m long and takes over the area of around 7000 m^2 as is shown in Figure 2. The pond contains fresh water and is placed around 650 meters from the Sea coastal line.

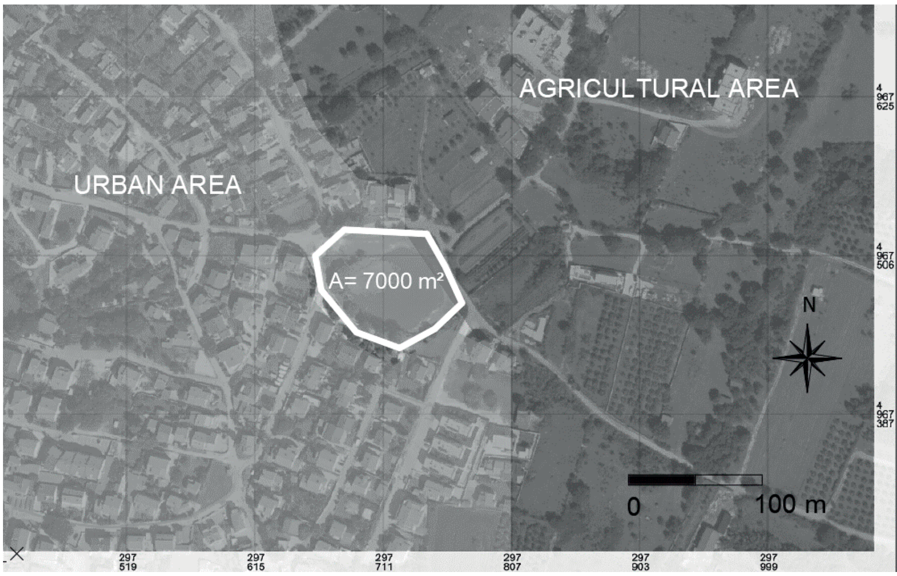

Figure 2. The Medulin pond on the areal map [1]

2.2. Hydrological characteristics

The Medulin pond topographical catchment has an area of approximately 3,08 km^2, and encompasses parts of the Medulin and Ližnjan municipalities as shown in Figure 3. The runoff characteristics are not yet explored, but it is visible that they are subjected to changes due to spreading of the urbanization. The water level in the pond is at the moment around 12,80 m.a.s.l. and the maximum elevation on the catchment is around 68 m.a.s.l.

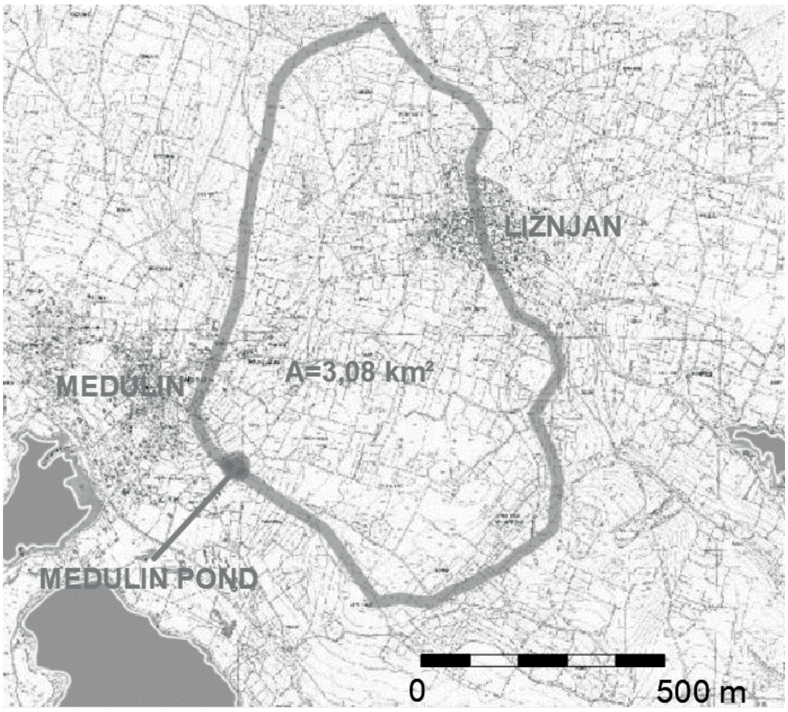

Figure 3. The Medulin pond topographical catchment [1]

According to local news, there were two rain events that caused an overflow of the pond. The first one happened on the 8. January 2010. year when rainfall over several days caused the overflow [2], and the second one is recorded in the night on 29. May 2019. year induced by the 45 mm of rainfall with big rainfall intensity [3]. There is an overflow object placed in the pond but considering problems with overflow it has apparently too small a flow capacity.

The pond is under a significant anthropological impact considering not only the pond by itself but also the catchment area. Since the anthropological impact on the catchment area is constant and constantly changing by urbanisation it can be considered a reason for overflow occurrence.

According to local people, there is always some water in the pond and it has never dried up, although they emphasize that the water levels are constantly dropping down in the last two decades.

According to all abovementioned, it can be concluded that the Medulin pond is filled with water booths from underground water aquifer and surface runoff.

2.3. Biodiversity and urban significance of the Medulin pond

Historically, there is only a little information about the Medulin pond past. The first records are from 1563 year, mentioning that this pond was connected with the Sea by the canal and was used for eel fishing [4]. Nowadays, the pond is not visibly connected to the Sea and is naturally filled with fresh water. Also, the area is recognized as a small oasis in the urban area that attracts both a local and tourist recreational population.

Since the pond is not characterized as a highly protected, vulnerable, or landscape significant area according to any Croatian or European Union laws and directives or local authority urban plans, the local people started to take care of the pond. Those nature enthusiasts artificially inhabited the pond with fish species, plants, and birds. Although their interference in natural water resources cannot be considered the right way to preserve and save the Medulin pond, it looks like they managed to establish one very stable ecosystem. One could expect that anthropological impact will have a negative impact on that small water resource as the Medulin pond, but in this case, it seems that people developed a biodiverse ecosystem as is shown in Figure 4. By artificial inhabitation of flora and fauna in the pond, they developed a place that attracts more wildlife because of which today the area of the pond can be seen more than 50 different bird species throughout the whole year as well as a lot of insects and amphibians [5].

Figure 4. The Medulin pond biodeversity

Urban significance of the Medulin pond is apparent from the fact that local people and nature enthusiast are taking care about the pond [6]. Also, it is place where both local people and tourist love to spend time.

2.5. Hydrometric and water quality measurement

The aim of this paper is to conduct the first preliminary hydrometric and water quality measurements on the Medulin pond, and the overall objective, in the future of this research, is to provide methodology foundations for the development of the procedure aimed toward the evaluation of small urban water resources. It is important to provide preliminary hydrometric and water quality data in order to assess the current condition of the pound.

Hydrometric measurement under this research encompasses bathymetry and temperature stratification in the Medulin pond. Bathymetry is provided by usage of the CTD – diver (Van Essen Instruments B.V., Nederland), Topcon positioning system HiPer V for geodetic surveying, and a small inflatable boat. With an inflatable boat is possible to navigate on the surface of the pond, and with geodetic surveying equipment is possible to take precise georeferenced points on which the depth of the water is measured by the CTD-diver [7]. CTD-diver also provides information about the temperature of the water and its conductivity. Used equipment in hydrometric measurement is shown in Figure 5.

Figure 5. Equipement used for the bathimetry measurement (from left to right): Inflatable boat, Topcon positioning system HiPer V and CTD – diver [7]

Water quality measurements are carried out by water sampling and water analyses in Hydrotechnical Laboratory at the Faculty of Civil Engineering in Rijeka. The water quality parameters are measured by the Spectrophotometer – Hach DR 3900 as shown in the Figure 6 [7].

Figure 6. Equipement used for water quality measurement: Spectrophotometer – HACH DR 3900 [7]

In this paper physical and chemical properties are provided as follows: pH, Total dissolved solids [ppm], Conductivity [μS/cm], Nitrates [mg/L; NO_3 –N], Ammonium [mg/L; NH_4^+ – N], Chloride [mg/L; Cl^-], Nitrites [mg/L; NO_2^- – N], Total nitrogen [mg/L; TNb], Orthophosphate [mg/L; PO_4^{3-} – P], Total phosphorus TP [mg/L; PO_4^{3-} – P], and Chemical oxygen demand COD [mg/L; O_2], in order to asess overall quality and ecological potential of the water. All of these water quality parameters have quality ranges, and scales by which the natural water resources can be evaluated. Evaluation is going to be conducted according to the Regulation on the water quality standard (NN 96/2019) [8] issued by Republic of Croatia goverment.

3. Results and discussion

The bathymetry data was recorded on the 20 June 2022, on the same day when water quality sampling is done. The bathymetry was measured by usage of the small inflatable boat on which the Topcon positioning system HiPer V for geodetic surveying was attached. Also, the CTD diver was attached to the aggravator and rope, and the depth measuring was conducted by constantly immersing the CTD diver in the water. Since the CTD diver is equipped with a temperature sensor, by moving all around the pond it was possible to take 122 depth and temperature points. In the area where water lilies have grown very densely, conduction of the measurement was not possible. The route of depth measurement points is shown in Figure 7.

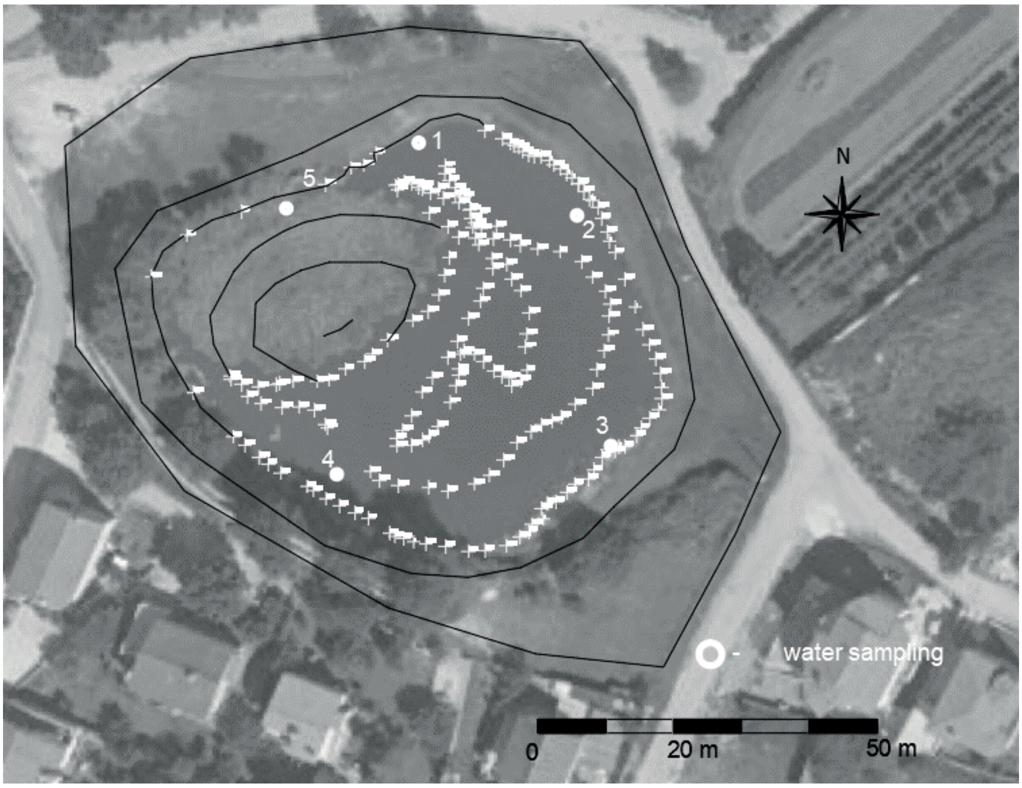

Figure 7. The route of the water depth and temperature measurements and water sampling points

Since on the north-west part of the pond was not possible to measure depth because of water lilies, the collected data was processed with help of the software Matlab 7.11.0 (R210b) from MathWorks in order to approximate the depths in that area. In the same software 2D visualization of the bathymetry is prepared and shown in Figure 8.

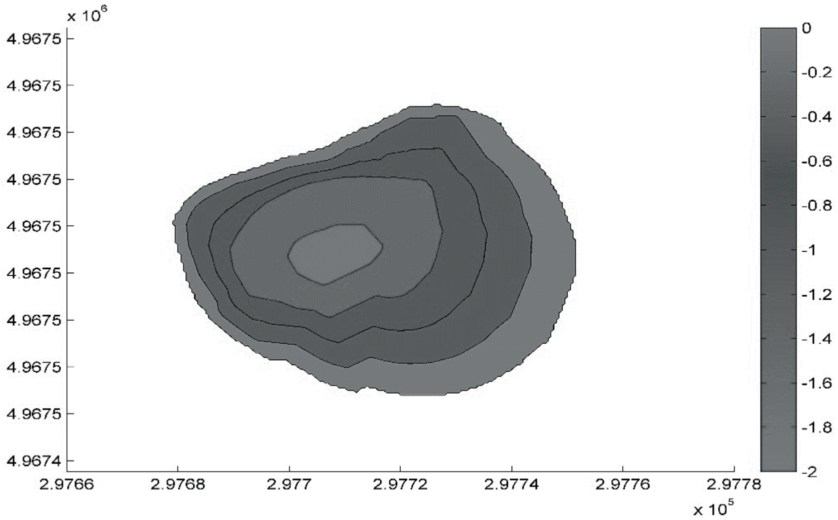

Figure 8. The 2D representation of the Medulin pond bathymetry

Also, by usage of the same recorded and processed depth and location data, the 3D visualization is done and shown in Figure 9.

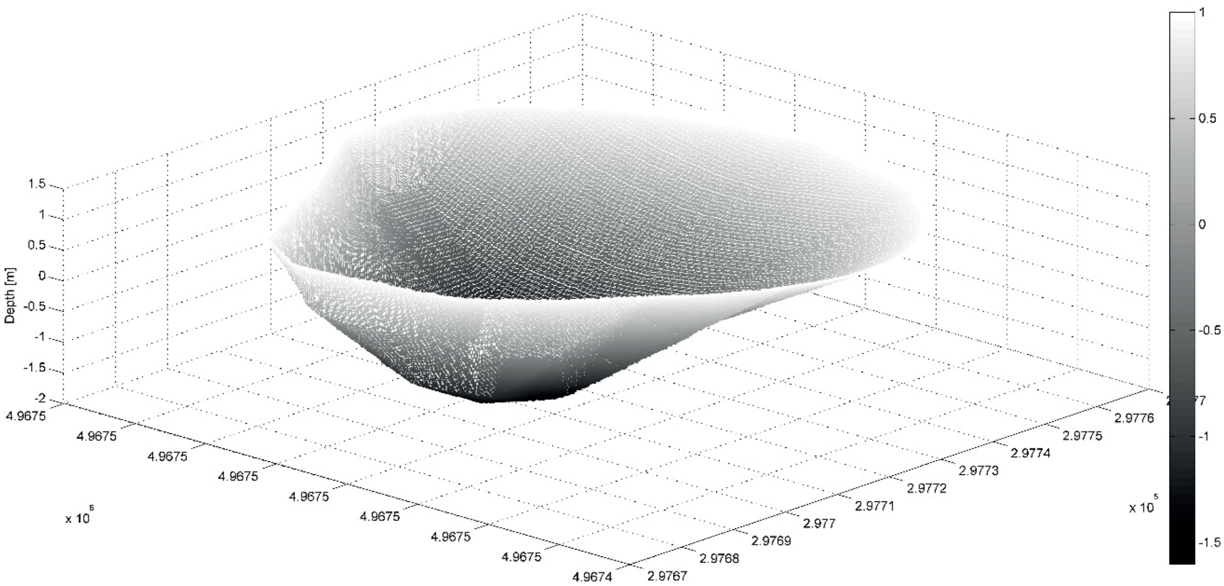

Figure 9. The 3D representation of the Medulin pond bathymetry

The collected depth and geodetic data points have shown that the water surface area at the time of measurement was 3237,8 m^2 and the water level is placed at 12.80 m.a.s.l. The maximum measured depth is 1,57 m and placed around the middle of the pond. The pond is very shallow, and there is no vertical temperature stratification. The measured temperature of water at the surface and bottom of the pond was 27°C while the air temperature was at the time of measurement 33°C.

According to the Regulation on the water quality standard (NN 96/2019) [8] water samples should be taken four times per year, one for every season of the year. The first preliminary water quality measurement was conducted on 20. June 2022. (summer measurement) at the same time when the bathymetry data was collected, and five surface water samples were taken. The next water sampling should be done in autumn, and then in winter and springtime. At the time of water sampling, significant turbidity is noticed. Also, the surface pollution, and not pleasant smell are noted. Water samples were taken to the laboratory at the Faculty of Civil engineering in Rijeka, and water quality parameters were measured by usage of the Spectrophotometer – Hach DR 3900. The results of laboratory water quality parameters tests are shown in Table 1.

The results of the analysis are compared with threshold values in order to evaluate the ecological potential that is specified in the Regulation on the water quality standard (NN 96/2019) [8], and shown in Table 1. According to mentioned regulation, the Medulin pond is a part of the Dinard ecoregion (coastal sub-region) and belongs to a group of very shallow reservoirs, and a group of lowland, medium-deep, small lakes (Crypto depressions on the carbonate substrate).

The results of the water quality parameters are quite surprising. According to the results, Medulin pond is evaluated with good ecological potential. The only parameter that is characterized as marginally acceptable is total dissolved solids (TDS), and this result was expected since the noticeable turbidity is observed at the time of water sampling. Also, the temperature of the water, as mentioned above, is considerably high because of ponds' shallowness, and can affect the water ecosystem. For the natural water resource with a high anthropological impact, it is great to see the positive ecological impact. It is unknown if the purpose of local people was to preserve or to improve the ecological system, but as is beforementioned, the pond has good water quality and potential for biodiversity enrichment and seems that it is in ecological balance.

Table 1. Results of the water quality parametrs laboratory analisis and ecological potential evaluation

Water quality parameter	**Label/Unit**	**Water sample**					**AVERAGE:**	**Evaluation of ecological potential [8, 9]**
		1	**2**	**3**	**4**	**5**		
pH	[–]	7,2	7,2	7,2	7,3	7,3	**7,24**	Good: 7<pH<7,4
Total dissolved solids (TDS)	[ppm]	265	263	262	262	263	**263**	Marginally acceptable: 200 <TDS<300

Conductivity (C)	[µS/cm]	466	461	457	457	462	**460,6**	Fresh water
Nitrates	NO_3 –N / [mg/L]	0,344	0,311	0,388	0,327	0,3	**0,334**	Good
Ammonium	NH_4^+ –N / [mg/L]	0,228	0,165	0,126	0,153	0,33	**0,2004**	Good: Cyprinid water <1)
Chloride	Cl^- / [mg/L]	0	0	0	0	0	**0**	Good: <0,005
Nitrites	NO_2^- –N / [mg/L]	0,026	0,022	0,024	0,022	0,026	**0,024**	Good for water life: < 0,03
Total nitrogen	TNb / [mg/L]	2,52	1,77	2	1,71	1,85	**1,97**	Good: > 1,24
Orthophosphate	PO^{3-}_4–P / [mg/L]	0	0,021	0,019	0,005	0,046	**0,0182**	Good: <0,1
Total phosphorus (TP)	PO^{3-}_4–P / [mg/L]	0	0,08	0,123	0,063	0,141	**0,0814**	Good: <0,3
Chemical oxygen demand (COD)	O_2 / [mg/L]	40,6	48,2	49,9	33,6	45,3	**43,52**	Good: 20<COD<200

4. Conclusion

Medulin pond is placed in an urban area of the Medulin municipality and is considered a public water resource under the jurisdiction of the Croatian water. It is not characterized as a highly protected, vulnerable, or landscape significant area according to any Croatian or European Union laws and directives or local authority urban plans. The pond is under a significant anthropological impact considering not only the pond by itself but also the catchment area. Since the impact on the catchment area is constant and constantly changing by urbanisation the change in hydrological function can be expected in the future and is already noticed by the lowering of water level in the pond through the years according to local people.

Hydrometric or water quality measurements for the pond do not exist, and therefore first preliminary hydrometric and water quality measurements data for the Medulin pond (Istria) are introduced within this paper in order to evaluate the condition of the pond. Research has included measurement of bathymetry, water temperature, and water quality sampling. Analyses of collected data have shown that Medulin pond is a small shallow natural lake with a maximum depth of 1,57 m in present condition, and because of its shallowness, vertical temperature stratification does not exist. Also, the temperature of the water is quite high (27°C on 20 June 2022) and can have a negative impact on the water quality and biodiversity.

The water quality analyses encompassed pH, Total dissolved solids [ppm], Conductivity [µS/cm], Nitrates [mg/L; NO_3 –N], Ammonium [mg/L; NH_4^+ –N], Chloride [mg/L; Cl^-], Nitrites [mg/L; NO_2^- –N], Total nitrogen [mg/L; TNb], Orthophosphate [mg/L; PO^{3-}_4–P], Total phosphorus TP [mg/L; PO^{3-}_4–P], and Chemical oxygen demand COD [mg/L; O_2]. For the purpose of preliminary analyses 5 water samples were analysed. According to the results, the Medulin pond is evaluated as having good water quality, and good ecological potential. The only parameter that is characterized as marginally acceptable is total dissolved solids (TDS).

For the natural water resource with high anthropological impact on the catchment area with urbanization, and direct impact on the pond by artificial inhabitation of fish species, plants, and birds done by local people it is quite surprising to see good water quality results. Medulin pond is a balanced ecological system, with potential for biodiversity enrichment.

Regardless of good evaluation results in water quality, Medulin pond can be considered as vulnerable considering water levels and inflow water quantities, caused by a significant impact on the Medulin pond catchment area. Already, urbanization disturbs a natural function of the pond water inflow and causes an overflow of the pond after two significant rainfall events.

The overall conclusion is that the Medulin pond can be considered a small "water pearl" and it has to be protected in some kind of way. Since the pond itself has a good balanced ecological system, in order to preserve this pond, better urbanization management in the catchment area is required. This means that one part of the responsibility in the preservation of the pond should be placed on the local municipality authority by providing guidelines for the urban planning process.

Because of all the beforementioned, future research plans will go in two directions. One is to provide more relevant measurement data for all year seasons, and the other is to develop a methodology for the small urban water resources evaluation in order to prepare guidelines for the preservation or revitalization of the water resources. It is clear that every single water resource can not be protected, but if its ecological or cultural significance can be proven then we all have obligation to save it.

Acknowledgements

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References:

[1] Digital map: https://geoportal.dgu.hr/ 29.06.2022.

[2] Rain event: https://www.vecernji.hr/vijesti/lokva-poplavila-medulinske-podrume-i-setnice-76655 29.06.2022.

[3] Rain event: https://www.glasistre.hr/istra/video-obilna-kisa-naglo-se-srucila-na-rovinj-i-medulin-gdje-je-palo-cak-45-mm-589573 29.06.2022.

[4] Medulin pond: https://www.istriago.net/hr/medulinska-lokva/ 29.06.2022.

[5] Medulin pond: https://m.facebook.com/groups/4333729936653118/ 29.06.2022.

[6] Medulin pond: https://mapio.net/images-p/11548548.jpg 29.06.2022.

[7] LABORATORY EQUIPMENT CATALOGUE OF THE FACULTY OF CIVIL ENGINEERING: https://www.gradri.uniri.hr/files/Katalog_laboratorijske_i_terenske_opreme_GF_Rijeka.pdf 29.06.2022.

[8] Republic of Croatia Government: The Regulation on the water quality standard (NN 96/2019), https://narodne-novine.nn.hr/clanci/sluzbeni/2019_10_96_1879.html, 2019.

[9] Chapman, D. (1992). Water quality assessment. In D. Chapman (Ed.), (p. 585). London: Chapman & Hall (on behalf of UNESCO, WHO and UNEP).