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Considerations on the lake morphometry changes occurred in Lacul Ştiucii (Cluj County, Romania) and safeguard measures proposed

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Abstract. In order to quantify as accurately as possible recent transformations of Lacul Ştiucii (Pike Lake) reservation in the Transylvanian Plain, this work has been aimed at portraying the lake's morphometric evolution throughout the last fifty years and at finding the most effective methods to stop or reduce the siltation phenomena which threaten this priceless heritage. To the end, a set of corrective measures meant to slow down the fast-paced silting up process affecting this lake has been envisaged. The human impact on the natural environment dates back to immemorial time, being apparent ever since the onset of the human civilization. However, anthropic transformations became more and more prevalent as the human species evolved and as it evolutionary features became more diversified. Humans have been exerting an ever-increasing impact on the nature, as a result of the synergistic influence of several aggravating factors, as follows: occupation of all biotopes deemed to provide favorable conditions for human life and human activities; continuous improvement and breakthroughs in the field of natural resource extraction/exploitation (both underground and aboveground); dramatic increase in human population growth rates (Giurcăneanu 1982). The situation was made worse by the increasingly irresponsible behavior of humans and by their selfish belief that they have the right to treat and exploit nature as they see fit, as long as this generates lucrative results (Soran & Borcea 1985). The brief review of all the factors mentioned above provides an accurate representation of the continuous degradation of our natural environment, including the natural reservation Lacul Ştiucii, on which the current study focuses.
Key Words: Lake morphometry, Lacul Ştiucii, safeguard measures.

Lacul Ştiucii. Lacul Ştiucii (Pike Lake) is the deepest freshwater lake lying on the northwest side of the Transylvanian Plain at an altitude of 247.5 meters, being surrounded by hills not exceeding 500 meters in height and is deemed to be a genuine continental mini-delta. The lake is located on Bontului Valley, which is a tributary of Fizeş River, at approximately seven kilometers distance for the town of Gherla (Cluj County) (Battes 2006).

Declared a natural reservation of national interest ever since 1966, Lacul Ştiucii is listed among the most outstanding natural reservations in our country (from the both point of view, natural beauty and variety), displaying a highly diversified aquatic flora and fauna and an extraordinary avifauna (Şerban & Sorocovschi 2003).

The lake has formed naturally, as a result of dissolution, subsidence and collapse of the salt ceiling along the salt mine sites lying on the axis linking Dej to Ocna Mures, in a period of time which remains debatable, seeing that the experts have never been able to reach an agreement on this matter.

As a result of high quantities of silt being washed away from the adjacent slopes into the lake, the salt was eventually separated from water by a watertight layer of mud, which caused the process of salt dissolution to stop, hence triggering a gradual sweetening process. Therefore, the water in this lake nowadays provides optimum conditions for the development of a rich and diversified flora and fauna.

The lake surface area, volume and water levels are highly influenced by the water supply/water loss ratio. In addition to surface sources, the lake is also supplied with

water coming from several underground springs having relatively steady flows. The volume of the lake is constant, in general, except for short periods when water levels are at their highest share (i.e. during snowmelt, rainfalls) (Burian 2002).

The highly steep adjacent slopes previously covered by oak and durmast woods have been completely deforested and are now in agricultural use, which generated the steady escalation of sedimentation issues, as a result of ever increasing quantities of sediments being washed away into the water, thus causing eventually the silting up of this lake.

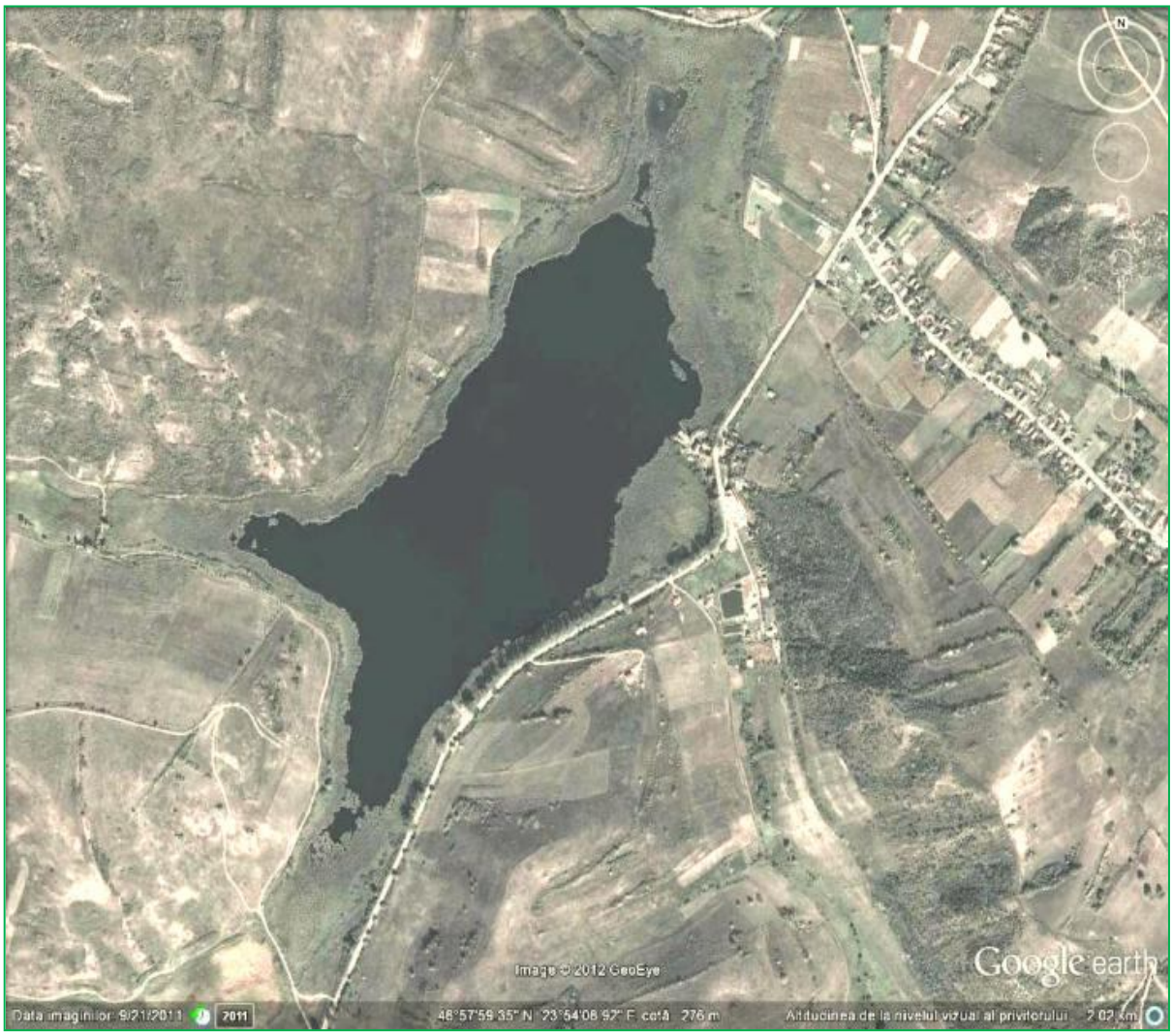

Figure 1. Lacul Ştiucii - Satellite image (Google Earth 2011).

Physicochemical characteristics of the lake. From the point of view of chemical properties of the water in Lacul Ştiucii, it should be noted that its pH is moderately alkaline, ranging from 7.3 to 8.56 in different periods of the year, which means that Lacul Ştiucii falls in the category of carbonated lakes.

Values recorded for water temperatures feature similar variations to other lakes in the temperate regions of the world, with mixing and stratification periods which exert significant impacts on the vertical distribution of aquatic organisms. Multi-annual average temperatures of water recorded in July, the warmest month of the year, reach over 20 degrees Celsius, whilst in January water temperatures are around 2–3 degrees. The first frost event typically occurs sometimes in the second half of November, with the last frost occurring in the second half of April. There are approximately 160-180 frost–free days in a year.

Rainfall amounts vary greatly from one year to another and from one season to another, the average annual rainfalls being 700-800 mm. During the summer, precipitations fall quite frequently in the form of showers, sometimes exceeding 100–200 mm in 24 hours.

Having completed this brief excursion into the main characteristics of Lacul Ştiucii and giving due consideration to all the peculiarities of this natural reservation, it was our goal to look into the ways in which the lake basin has transformed during the last 50 years, as well as to analyze the main reasons behind these developments.

Lacul Ştiucii - transformation patterns. Using the unquestionable information available on the dramatic shrinking of the lake surface area, we have endeavored to determine the extent of this reduction and to identify the steps to be taken in order to stop this phenomenon or at least to mitigate its effects.

The relevant investigations were conducted during 2000–2010 and they are part of a more extensive study that has been thoroughly looked into as part of the thesis preparation process. However, this paper only aims to sum up issues related to the recent shrinking of the lake surface area.

According to the data presented by Săndulache (1963), the lake surface area was 68.70 hectares in 1957, but this diminished alarmingly to the point where, 43 years later, the lake surface area had already shrunk by 17.71 hectares (the equivalent of a 19.79% drop rate), the lake surface area in 2000 having reached 57.35 hectares.

A quick comparison between our own findings and data presented by other researchers having studied this phenomenon reveals that significant changes have, in fact, occurred, as detailed in Table 1.

The biggest differences noted concern the lake surface area, water depth, lake bottom slope and total volume, all these changes being determined by high siltation rates and extensive growth of macrophyte vegetation, large quantities of suspensions being present both in the lake water and in the storm water runoffs reaching the lake. As a result of erosion of the adjacent slopes and of basin characteristics, the sources supplying water to the lake carry along large quantities of organic and alluvial sediments, further aggravating the siltation process.

Along with water chemism changes, a rapid proliferation of phytoplankton occurred, which was followed by a significant drop in the oxygen concentrations and an increased tendency for pronounced eutrophization.

The abundant growth of floating, emerged and submerged species and their decomposition by bacteria generated large amounts of sapropelic sludge, sometimes releasing excessive quantities of hydrogen sulphide, which is an extremely hazardous gas, being highly toxic for all living organisms. Therefore, whenever the quantity of hydrogen sulphide exceeds the admissible levels, large numbers of fish are found dead. High concentrations of hydrogen sulphide are also the consequence of a poor dynamics of the water, especially in the deeper layers of the lake, which create favorable conditions for the formation of hydrogen sulphide.

Table 1

Transformation of morphometric features of Lacul Ştiucii during 1957 - 2010

Description	*M.U.*	*Period*					
		Săndulache (1963)	*Şerban & Sorocovschi (2000)*	*Difference (1957 – 2000)*	*Our results (2010)*	*Difference (2000 – 2010)*	*Difference (1957 – 2010)*
Lake surface area	ha	68.700	57.350	11.350	51.629	5.721	17.071
Length	km	1.720	1.555	0.165	1.343	0.212	0.377
Average width	km	0.399	0.369	0.030	0.322	0.047	0.077
Maximum width	km	0.816	0.662	0.154	0.538	0.124	0.278
Average depth	m	5.468	3.123	2.345	2.950	0.173	2.518
Maximum depth	m	12.700	6.800	5.900	6.530	0.270	6.170
Long axis	km	1.720	1.545	0.175	1.350	0.195	0.370
Short axis	km	0.520	0.525	0.005	0.515	0.010	0.005
Lake perimeter	km	4.261	4.263	0.002	4.251	0.012	0.010
Lake bottom slope	m/km	40.210	31.840	8.370	29.850	1.990	10.360
Total volume	mcm	3.757	1.780	1.977	1.380	0.400	2.377

M.U. – measurement unit; ha – hectare; km – kilometers; m – meters; mcm – million cubic meters.

Conclusions and recommendations. To sum up the findings of the investigations carried out, the following final considerations can be drawn and the following measures can be suggested. In order to prevent further siltation of the lake, we have identified a number of practical, concrete methods, requiring financial efforts, but producing effective and tangible results.

One of the mitigation measures that could be taken immediately involves creating riparian buffer zones in the form of forest belts to be planted along the perimeter, on a 30–50 meters width and consisting of different trees, which should serve to retain part of the silt which is normally washed away into the lake basin during heavy rainfalls.

Another method that would bring the most beneficial results consists of executing a simple dam upstream the inlet point of the water sources supplying the lake, in order to retain silt and sediments and of regular cleaning in order to prevent build-up.

The hydrogen sulphide emissions, which are highly toxic for the fish and other living organisms in the lake, could be reduced by minimizing biogenic compounds which generate, by decomposing, the sapropelic sludge giving off hydrogen sulphide. In this context, fighting off excessive submerged vegetation and especially rigid hornwort is of the utmost importance.

Further to the research activities conducted, we believe that another measure to be taken consists in the execution of spill wears downstream, to facilitate drainage and discharge of suspended sediments during flooding periods or high water conditions, in order to prevent their build-up at the bottom of the lake. Furthermore, such spill weirs should serve to ensure a much better water dynamics both horizontally and in deeper layers, which will reduce siltation phenomena and thus contribute to improving water quality and providing a better living environment for the flora and fauna of this lake.

Another measure to be taken in order keep or maintain in unaltered condition the fish fauna involves setting drastic limits on recreational fishing, shortening the open season as much as possible and enforcing drastic bans on the capture of large, breeding size fish, of predatory fish and of threatened or declining fish species.

All efforts should be undertaken in controlling the spread of invasive species, such as the pumpkinseed sunfish (*Lepomis gibbosus*), whose presence poses a significant threat to local fish populations, impacting detrimentally on the living conditions, ecological balance and diversity of species in this reservation, altering the food chain of this ecosystem, competing with the native species for food, eating their spawn, larvae and preying on their young.

Other measures to be adopted refer to reducing stress on the fish fauna and avifauna in this reservation, by limiting boat traffic on the lake, which also impacts detrimentally on bird mating and nesting. This should be easily achieved by enforcing strict bans on the boat traffic during some periods of the year.

Permanent monitoring and following up closely on the evolution of phenomena which are likely to engender detrimental effects on the preservation and maintenance of this unique and priceless natural heritage are also a must.

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