THE ECOLOGICAL RISK PROVOKED BY THE INVADING ICHTHYOLOGIC SPECIES IN THE RED-LAKE

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Abstract: The present study tries to outline a series of risks that are generated through the introduction of some non-native ichthyologic species in the aquatic biotope of the Red-Lake. The study briefly presents the short history of this unique lake formed behind a natural barrier, respectively some critical risks concerning the possible evolution of this lake due to sedimentation factors which can be: natural sedimentation; anthropically-induced accelerated silting; sedimentation triggered by logs fallen into the lake; influences brought about by chemical residues thrown away by the big number of visitors and which come from illegal waste water dumping directly into the lake or into its tributaries. Then the study focuses on the risks induced to the ecologic balance of the lake. Firstly, we presented the native fish species, with rare elements that became endangered in the biotope and the introduced fish species (predatory species) which resulted in the significant reduction of the number of native species. Furthermore, we wish to show in which way the ecologic balance of this aquatic micro-environment has changed during the last 20 years. In the final part of the study, we draw some conclusions and formulated some suggestions regarding the possible solutions and steps to be taken in order to redress the current aspect of the environment, which already seems to be out of control.

Keywords: *biodiversity, ecological balance, native fauna, introduced ichthyologic species.*

1. Introduction

The first official information on the formation of the lake is registered by the ethnographer Balazs Orban in 1864 in his work: "*Monografia Tinutului Secuiesc*". Balazs Orban was a great observer and a pioneer in using photography as an official document and useful tool for research. We need to mention that the 19th century photographic equipment weighed around 30 kg and carrying it was a challenge itself. He approximates the origin date of the lake as being the year 1837 based on the stories of the locals. In his writing, he mentions the lake under the name of the Killer Lake. The other hypothesis is based on the 1838 earthquake that shook the Eastern Carpathians and was said to have triggered the massive landslide that led to the formation of the Red Lake.

After 176 years from the formation of the lake, researches and observations tend to bring arguments to the debates around the origin date of the lake. After the observations following the 1977 earthquake, because there was no change either in the scenery or in the landscape, some scientists concluded that the lake could not have formed after the 1838 earthquake. The origin of the lake is mainly associated with the heavy precipitation period in June 1837, when the humidification and saturation of the clay-layer (which resulted from the decomposition of the carbonate deposited materials) led to the massive piedmont landslides from the base of the Ucigas Massif, which blocked the valley and formed the lake behind the natural barrier.

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In 1859 Hebrich, while conducting a series of researches in the Haghimas Mountains, describes some instable parts of the natural barrier. In 1914, the geologist Janos Banyai draws attention upon some unstable parts of the piedmont over which some villas were constructed. His predictions proved to have been correct, because some villas needed to be pulled down due to their cracked and deteriorated foundations.

In his work *The history of Borsec*, Ferenc Puskas from Ditrau parish mentions a torrential downpour which totally flooded and plugged the main mineral water spring, more times repeating that from his point of view this is the triggering element that led to the formation of the Red Lake.

The surface of the lake can be monitored and analyzed by means of all the geologic clues left behind by specialists and researchers such as: E. Balogh (1940), J. Ujvari and J. Grigercsik (1950), Pisota and Nastase (1955), Csiki (1987), G. Pandi (2002). Based on the topographic measurement, we can identify two stages in the expansion of the shores: between 1995 – 1987 and between 1987 – 2001 (according to G. Pandi and Zs.Magyari-Saska).

2. The evolution of the lake

The situation of this emblematic lake had been presented in several studies but without any practical results until the moment of writing this paper, which would or could solve at least a few of the aroused problems concerning the life expectancy of this phenomenon.

So far, several natural factors and factors of anthropogenic origin have been discussed; among them, we can mention:

- natural silting – well known from the genesis and filling up of all natural lakes;
- natural sedimentation – caused by the logs and branches that fall into the lake and lead to an accelerated sedimentation, afterwards invaded by water plants which later on contribute to the expansion of the shores;
- anthropogenic silting and accelerated sedimentation due to human activities repeatedly done in the Natural Park Bicaz-Gorge and Haghimas Mountains (huge deforestations, not repairing the damaged and fractured collector dams raised in the valleys of the main tributaries and the lack of collector dams on temporary riverbeds);
- the influence of the chemical residues that reach the lake, which are the result of all tourism activities and of the fairly high number of tourists that visit the Lake and its surroundings. The lack of supervising personnel of funds for a better waste management majorly influences the quality of the water and environment;
- not respecting the laws and regulations regarding environmental protection;
- ill managed waste water management, which infiltrates or is directly dumped into the tributaries of the lake;
- disturbing the ecological balance of the lake by introducing new fish species that endanger the existence of the native fish species in the lake. The indigenous fish species are the brown trout, rainbow trout, common rudd, common minnow and the European crayfish, which have been seriously decimated in the last twenty years by the newly introduced pike, European perch and Prussian carp.

The vegetation along the shallow watered shores contributes to the decrease of the water quality, which favours the introduced species, which hunt and feed only in these areas, and can ford almost delta like alluvium depositing at the confluence points of the tributaries. These deposits can measure up to 4 meters in thickness.

2.1. Silting and ecological degradation of the lake

Since the lake was formed 176 years ago, its size has reduced by 60%. This is due to its clogging with sediments carried by the tributaries of the lake and completed by biological causes (logs, driftwood, branches or any other organic material that get into the water of the lake or logs that get to surface from the bottom of the lake); they all contribute to the silting of the lake in a constant rhythm.

The major factor for the degradation of the eco-balance of the whole landscape is the anthropogenic influence. In its early years, the lake was used only for fishing and hunting but, step by step, together with the development of the economy, forest exploitations developed. These activities caused the valleys of the tributaries to get deforested. In 1895 on the banks of the lake people set up saw-mills and additional buildings around them (such as barracks for workers and a pub).

The deforestation continued until 1921 and all the residues produced by the pre-processing of the resulted lumber was dumped into the lake or deposited on its banks. Eyewitnesses signalled the existence of those sawdust deposits even twenty years after the mills stopped functioning. The proof of the existence of these activities is provided by the geological samples analyzed by G.Pandi (2001), the sawdust layer appearing between 273 and 284 cm in depth, measuring 11 cm in thickness.

The construction of the forest road along the Suhard Valley in 1964 reduced the surface of the lake significantly, all the debris and rocks resulted from the explosions being dumped into the lake. In order to reduce the impact of these road construction works on the environment and on the image of the landscape, a group of environmental enthusiasts intervened and, as a result of their protests, we can see the remnants of a limestone cliff as a reminder of those works called Poarta de Piatra, meaning The Stone Gate (see figure 1).

Figure 1: The Stone Gate (photograph from personal sources)

In 1913 a dam was constructed in the valley of the Ucigas brook in order to protect the national road that was under construction between Gheorgheni and Bicaz and not to protect the lake from deposits or silting! In 1938, another dam was built, this time on the valley of the Licas brook, with the purpose of protecting the trout fishery. But during heavy downpours it failed several times. The dams on the Oii and Rosu brooks were constructed in the 1950s. The dam on the Oii brook got fractured at its base in 1975 due to some severe meteorological phenomena and, until the present day, it hasn't been repaired yet. This dam is fully filled up with deposits and it does not serve almost any good. The area behind the dam

built on the Rosu brook is almost totally filled up, fulfilling its purpose in a percentage of about 5-10% (see figure 2 and 3).

The conservation management of the lake is performed totally inappropriately, the logs detached from the bottom of the lake and the trees knocked down by winds or any other natural causes being not disposed of, thus favouring the rooting of aquatic plants and hydrophilic vegetation, leading to an accelerated rate of expansion of the banks (see figure 4 and 5).

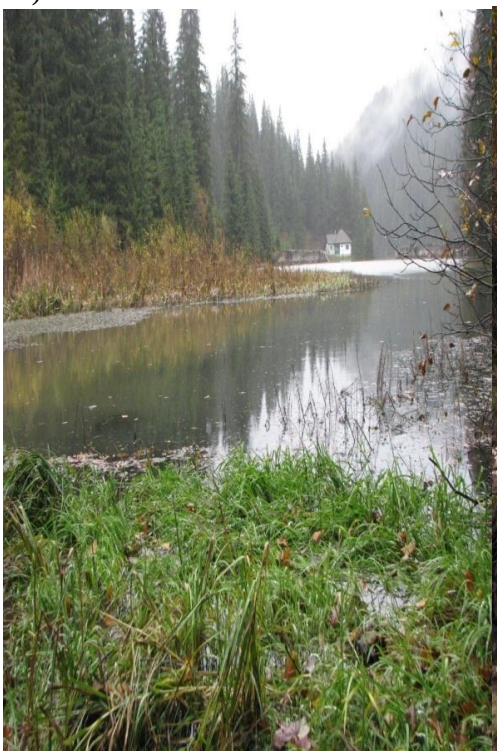

Figure 2. Silting behind the dam on the Rosu Brook (Source: personal archive)

Figure 3. Deteriorated dam on the Oii Brook

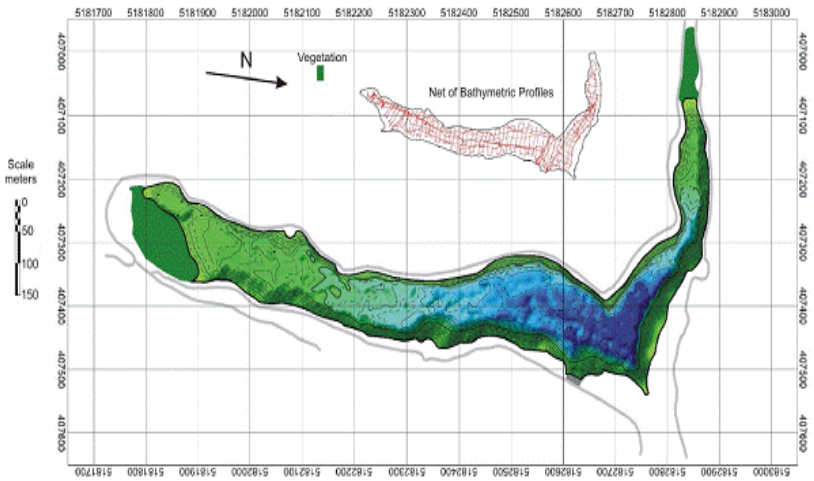

Figure 4. Bathymetric map of the Red Lake (according to Briceag et. al, 2010)

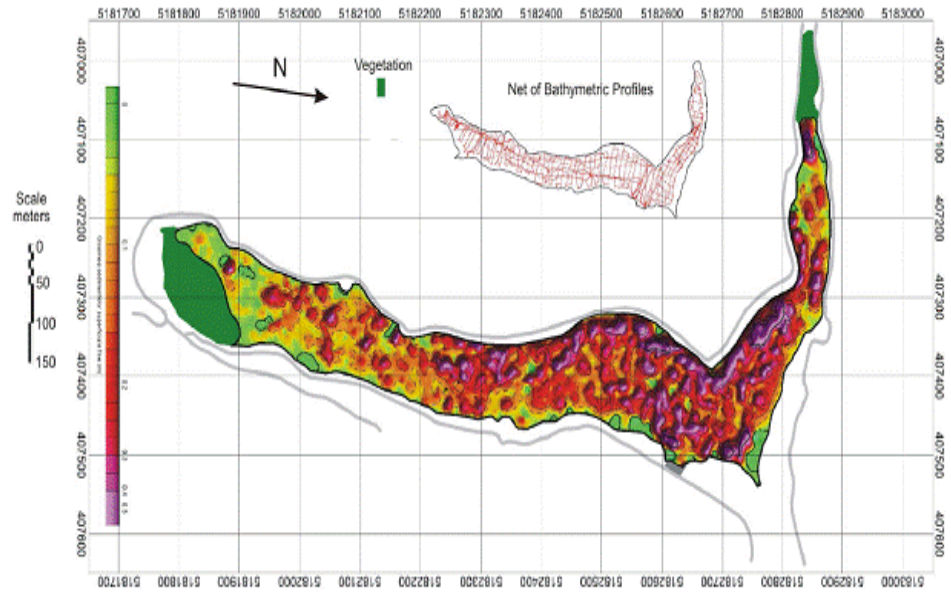

Figure 5. Distridution of sediments in the Red Lake (according to Briceag et. al, 2010)

3. Information on the fish species living in the Red Lake

Having a major impact on tourism since its existence, the lake has been the home of some spectacular native fish species that have attracted many fishing enthusiasts for two centuries. In the following, we will present some of the characteristics of these species.

The main attractions of the lake were the **native brown trout** (*Salmo trutta fario*), **the lake trout** (*Salvelinus namaycush*) and the **rainbow trout** (*Salmo trutta iridius*). The fish lives in waters with an average temperature of 12°Celsius, with an oxygen level between 7 and 9 cm^3/liter and they are highly sensitive to pollution. In the mating season, they choose their partners and, during the ritual, they lay around 1,500 to 2000 eggs, with the diameter of 4-5 millimetres for the brown trout, measuring about one kilogram (see table 1). All trout species thrived here and they represented the top of the food chain in this ecosystem.

Another fish species that we included among the native fish species of the lake is the **common rudd** (*Scardinius erythrophthalmus)*. This fish species was probably introduced into the lake accidentally, as it was used as a bait for trout fishing. It adapted well to the environment of the lake, which brought about slight physiological changes to it. Its body became more robust, its scales got a darker colour, showing much more vivid colours, its back turning into dark grey to black, but its fins remained deeply red. The shape of its head became more robust due to the lack of fighting against strong currents. This fish species can be found in almost all the freshwaters in Europe, from an altitude of 800 meters down to the Danube Delta. Due to the given conditions, it developed into a very interesting subspecies, being mentioned in several studies. Depending on the water temperature, its spawning season is between late May and the middle of June. It can grow up to 1 kg and it can lay between 80,000 and 100,000 eggs. It lays its eggs on the pine tree branches in great numbers, and this ritual is visible in places where we see the water as if "boiling".

The common whitefish (*Coregonus lavantus amarus)* and the common minnow (*Phoxinus phoxinus)* also live in the Red Lake. This fish species became protected by law in several European countries. This is a very lively coloured little fish, a very important member of this environment situated at 981 meters above the sea level. It can grow as long as 12 cm

and it can live up to 5 years. Together with the European crayfish, they are the water quality indicators; their presence ensures clean water.

One more species that we wish to mention is the European crayfish (*Astacus astacus*), which became endangered due to the predatory behaviour of the pike and of European perch. In one of his studies done on the Red Lake, the biologist Nagy Hunor studied crayfish. The mentioned study was based on direct observation and research carried out between the 11th of July and 19th of October 2003 and was published in 2005. The samples were collected in six stages from four locations. Three circular baskets were used in order to catch the 409 crayfish. The study showed an abundance of crayfish, but more recent studies show a significant reduction. This is due to the pollution of the water of the lake and to the presence of the pike and perch, which have settled at the top of the food chain within this ecosystem.

Table 1. Reproduction rates of the native and introduced fish species within the Red Lake (Kaszoni, 1981).

Pike	European Perch	Prussian Carp	Common Rudd	Trout
100,000 - 350,000	300,000 -500,000	150,000 - 400,000	80,000 - 150,000	1,500 - 2,000

Artificially introduced fish species include the following:

The pike (*Esox lucios*) is a widely spread fish species that can be found in all lowland watercourses all around Europe except for the Iberian Peninsula, Greece and Albania. In Romania, it is found in all midland and lowland waters, rivers and lakes and it has recently reached mountain lakes as well. For its ferocious feeding behaviour it was called "the fresh-water-wolf". This fish has cannibalistic tendencies; it feeds not just for hunger but for the pleasure of hunting as well. This is one of the facts that represent one of the major biological risks to the eco-balance of the Red Lake. The accidental and naïve introduction of this fish species in this remote location severely affected the ecological balance of the Lake in only twenty years. Its presence dramatically reduced the number of all trout species and the population of common rudd in the lake. It is also important to mention that the number of native wild trout species dramatically decreased in the past three decades, not just in the lake but throughout Romania as well.

The local population of the resort and the fishermen in the region let us know that, since sport-fishing was prohibited in the lake, the dominant fish species became the pike, the trout population being almost totally exterminated. The introduction of the pike nearly 20 years ago has caused a severe disturbance in the lake, the only thing that could control this event being a well managed sport-fishing program. Today in these waters there lurk monsters aged over 15 years, which exceed ten kilograms; there were caught fish of 4 to 6 kilograms in significant numbers, including one documented specimen of 8.5 kg. These figures do not even cover all the specimens caught, because publishing data like this would interfere with the fishing prohibition policies applied. As a curiosity, we need to mention the situation in which, in the stomach of a one-kilogram pike they found a native trout of 0.5 kg.

In the following, we will present a couple of aspects regarding the growth and feeding habit of the pike. As a very greedy fish, it shows a very quick growth rate, as at the age of one it reaches a length of 25 to 30 cm and a weight of 0.250 kg. The average size in Romania would be a length of 40 to 50 cm and a weight of 1.8 kg, the biggest captures recorded measuring 1.5 to 1.8 meters in length and weighing between 20 and 25 kilograms. It is a stealthy hunter, with a torpedo shaped muscular and streamlines body, using a very effective camouflage to hide between the branches and vegetation of the lake. The victim is

immobilized between its needle-like, long and sharp teeth. It is known for its hunger and ferocity, being the most aggressive fish in our fresh waters, attacking not only its pray, but anything that comes into its territory: fish, crayfish, amphibians, small birds etc. It feeds the whole year and has a very strong organism (in its stomach there were found metallic objects, lures, hooks, with which they had perfectly survived). It has a slightly inefficient digestive system that forces it to consume ten kilograms of food in order to gain one kilogram in weight. In our unfortunate case, its food includes the very valuable and now rare trout species, common rudd population, crayfish etc.

According to Mihalti, in our country the pike has its reproductive cycle between February and the end of March, when the water temperature is between 4 and 10°C. Depending on weight, one female can produce between 100,000 to 350,000 yellowish eggs, measuring 2.5 to 3mm in diameter (see table 1). At any moment of its life, it doesn't have a competitor for food. A newborn pike of 2-3 month can easily reach 15cm in length, and at the age of 3 months stars hunting for food.

Another greedy hunter introduced in these waters is the **European Perch** (*Perca fluviatilis*), which reached this place through unknown sources, but has a significant negative effect on the ecological balance of this system.

It can be found in any freshwater stream from midlands to lowlands, in both still and running water, just like the pike. It can be found all over Europe, except for the United Kingdom, the Iberian Peninsula, central and south Italy and the Balkan Peninsula.

The fish has a robust body, packed with muscles, with a nice vivid colour, with very tiny and rough scales and barbed studs near its dorsal fin and two barbs ahead of its pectoral fins.

The perch is a very greedy fish but it has a slow growth rate and this is the reason why it does not have any economical value, although its meat is very tasty, with white flesh. In the Romanian waters, specimens measuring 35cm in length and up to 0.5 kg are considered trophies, although they could reach 60cm in length and a stunning weight of 5kg. In the Red Lake it reproduces quickly and, apart from the pike, it does not have any competitors because no trout species that live in the lake can eat the perch because of its sharp barbs.

The juvenile perch lives in banks, but elder specimens have a solitaire life. This fish brings serious prejudices to the native fish population of the lake. It has a big appetite, attacks crayfish, smaller fish, amphibians, ducklings etc and has a very developed taste for fish-eggs. Where the perch appears and starts to strive, other species slowly disappear! Is represents a serious threat to all native species in the lake! At the reproduction level, it is a prolific fish; it reaches its sexual maturity at the age of three and lays its eggs in chainlike laces; one female can lay between 300,000 and 500,000 eggs, measuring 2-2.5mm in diameter (see table 1). According to the botanist Zoltan Kaszoni, it is a negative player in any ecosystem, not having any economical value, devouring the eggs and juveniles of other fish species, many ecosystems doing better without it than with it.

The Prussian Carp (*Carassius auratus gibellis*) was brought to Europe in the 16th or 17th century by the Spanish and Portuguese fleet. This species is found in almost all rivers in Eastern Asia, in China and Japan. In Romania it first appeared in Oltenia, Muntenia and Moldova, and now being found in great numbers in the Danube Delta and all midland and lowland rivers and ponds. Unfortunately, it settled in most ponds and lakes; it has an average size of 10-30cm and average weight of 100-350 grams, but it can reach 50cm in length and 3kg in weight in the Danube and Danube Delta. The Prussian carp has a very bad food processing and assimilation. This species can live in waters with a low level of oxygen and it stays alive for up to 4-5 hours if pulled out of water. It is an omnivorous species, very greedy, a big fish-egg consumer and a juvenile fish eater. It is a serious contender to the native fish

species, especially the common rudd, which is accepted as a native fish species in the Red Lake. It reproduces easily, more times a year, from May to August, one individual being able to lay from 150,00 to 400,000 eggs, measuring 0.5mm in diameter (see table 1).

The Red Lake used to be home for some very valuable and nowadays rare fish species like the native brown trout, rainbow trout, the introduced lake-trout, common rudd or European minnow. The salmonid family representatives formed the top of the food-chain in the lake, but after the arrival of the pike and perch their number was seriously reduced. The native fish species require clean and oxygenated waters, the human presence and activity largely influencing their existence. All trout species once populated all mountain streams, rarely reaching waters under 400 meters in altitude. The trout's hunting habit of praying in open streams became its death, because the pike and the perch hunt from hideouts, thus the once undisputed hunter became the hunted. Human activities facilitating the spreading of the vegetation and the carelessness for fallen trees and branches into the waters offer more hunting ground for the pike, perch and Prussian carp. The salmonid species travel to the springs on the brooks to spawn, but damming these brooks and performing huge forest exploitations affect the water quality, the breeding ground of the trout and furthermore expose them to poachers.

4. Exploitation of the natural resources of the Red Lake

After the lake was formed, the trout species found here a perfect place to thrive and reproduce. As their number increased, the locals started fishing and hunting them for food and later on for pleasure. The caught fish was used as food; in order to preserve it during the winter, they smoked the meat (Orban Balazs, 1869). Another delicacy was and still is the crayfish, culinary delights being made and served in the local restaurants to both tourists and locals. In 1937, Csaki Mihaly mentioned the visit of two groups of tourists who came from the U.K. and Germany to catch some giant trout. In 1943, he mentioned captures of trout weighing 7-8 kg.

4.1. The history of fishing in the Red Lake

The first photographs of the lake include local fishermen and their captures. We can also see their tackle and tools for catching fish. Today, those tools would be prohibited: nets weaved baskets etc. In 1885 laws were brought to define the fishing and hunting methods in the region, but it took about twenty years to have a visible effect on the environment. In 1907 the Fishing Association of the Upper Mures Valley was founded in Gheorgheni, which introduced and developed the sport fishing in the region; they built a small cabin and hired a permanent guardian. The lake received a dock, several boats and rafts for modern fishing. The biggest catch of lake trout ever recorded measured 85cm in length and 7.8 kg in weight; the biggest native brown trout was a 55-cm long specimen, weighing 1.76 kg (see figure 6).

After WWII, the trout population almost totally disappeared from the lake, but with the help of the Red Lake fisheries, it was repopulated. During the next years the lake was nationalized and its management was taken over by the Forest District of Gheorgheni. Today fishing is prohibited by law, which favours the introduced ichtiological fish species to reproduce uncontrollably. By prohibiting the repopulation of the lake with trout species, the top of the food chain was taken over by the pike and the perch and, due to the existence of the dams on the tributaries, the trout can only escape by leaving the lake downstream and thus the lake and the region loses of its former attraction and rare value.

5. Conclusions and suggestions to preserve the Red Lake and its values

In order to be able to protect the biodiversity, to nurture its rare species and ecological associations, we need to mention a couple of human errors that have occurred and the appearance of the introduced fish species that have radically changed the bio-balance of the Red Lake (pike, perch and Prussian carp). The invading fish species have decreased the number of native species due to the sport fishing interdiction.

- introduced fish species are net superior to the native ones in respect of the number of laid eggs;
- their reproducing rate is much higher and thus they are much more prolific than native species.
- the ideal solution would be allowing sport fishing with no restrictions regarding introduced fish species but very attentively handled in respect of native species.
- this activity should be implemented in association with nongovernmental organizations and the Bicaz-Gorge – Hasmasul Mare N.P. administration;
- these activities should attract material income from fishermen and it should implement a partnership between protectors and fishermen in order to be able to analyze the caught pikes and the content of their stomach for further research and monitoring;
- earned funds should serve the involved parties in modernizing their equipments and better managing the lake and its surroundings in order to restore the ecological balance of the lake and to offer qualitative experiences for those who pay to fish here;
- educating and informing fishermen on a more ecologic behaviour regarding the cleanness of the shores and water and handling the trout or any other native species;
- implementing methods of eco-friendly behaviour to all visiting tourists concerning the value of the natural environment;
- revenues resulting from the visiting and fishing should be oriented towards reducing the negative natural and anthropic factors that influence the Red Lake and its surrounds.

If there are no immediate actions, all these proposals will be in vain, because the Red Lake will slowly become clogged up and we will lose a unique ecological association and a spatially attractive unique biodiversity.

By means of this study we wish to draw the attention on the bio-ecological disaster that is affecting the Red Lake, the disappearance of such a tourist attraction (landscape and biodiversity) causing us to become poorer.

We need to see the positive side of the tourism activity that can be generated if fishing is allowed. The local pensions, villas, guesthouses, in one word the local population will benefit greatly and the number of overnight stays will surely increase significantly. This would become one important eco-touristic alternative which will have medium and long term development effects (see figure 6).

The restrictive sport fishing towards the native fish species would be the ideal solution in the regeneration of the native ichthyologic fauna of the lake. If no measurements are applied or no action is taken, we will witness the disappearance of all trout species along with the common rudd, minnow and crayfish population.

This area should be treated as a site for community interest, which, with a future oriented management for the following generations may offer a valuable heritage in the heart of the Haghimas Mountains. Human activity needs to be more carefully monitored, because illegal fishing can't be stopped or monitored and thus the native fish species that are captured contribute to the decrease of their population.

Sport fishing is not only a simple and fun activity; it can be considered a segment of eco-tourism, significantly contributing to a sustainable strategy and development. By the

generated revenue, it can significantly contribute to the rehabilitation process of the natural environment and to the bio-diversity of the Red Lake.

According to the Ecotourism Society, ecotourism can be considered as a form of activity in a natural environment, in such a way that it doesn't change or influence the parameters of the protected biodiversity of the ecosystem and the protection of this area should be financially possible, viable and acceptable to the local population.

Figure 6: 8.5-kg pike caught by a local fisherman! (Source: private archive)

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