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Volumetric and landscape-ecological diachronic analysis of a historical artificial water reservoir Evička in Slovakia

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Abstract

The present study focuses on the analysis and evaluation of the changes in the retention volume of the water reservoir Evička, the ecosystems of littoral, sublittoral and profundal zone as well as the changes in the land cover of the riparian zone and reservoir basin. The changes in reservoir volume were determined on the basis of a comparison of the actual bottom's topography, acquired through field surveying with the bottom's topography from the maps for a 40-year period (1971-2011). The volume of the sediments deposited in the water reservoir Evička for given period is 10917 m^3. The changes in the landscape structures of riparian zone and reservoir basin, identified on the basis of the analysis of aerial measurement pictures, orthophotomap and field survey, were evaluated for the period of 1949-2012, i.e., 63 year. It is evident from the analysis of the landscape structure changes in the whole reservoir basin that the area of developed surfaces increased by 11.2% and the surface area of water reservoir Evička decreased by 1165 m^2 during that period. We interpret these facts as the result of a negative anthropogenic effect, mainly by building activity within the reservoir basin and near the water reservoir. At the same time, the contribution presents possible measures for the management of water reservoir Evička and its surroundings.

Keywords: bottom bathymetry, lake ecosystems, riparian zone changes, reservoir basin development, siltation

1. Introduction

The erosion and sedimentation processes occurring in the reservoir basin cause the silting of water reservoirs, resulting in the spatial change in the morphology of their bottom's topography and thus changes in their thermal stratification and zonation. They cause a range of negative consequences, the most serious of which are the loss of usable volume, the gradual silting and the damage to manipulation devices of reservoir, causing changes in the biological and ecological quality of water and leading to the a gradual perishing of water reservoirs (Ahmed & Sanchez, 2011; Pradhan et al., 2011). They also significantly affect many organisms living in the water environments and cause the changes in their biotopes. The issue of sedimentation is current in many countries worldwide (Childs et al., 2003; Boddy & Ganske, 2005; Jordan et al., 2005; Kress et al., 2005; Ceylan et al., 2011). In the Slovak Republic, the Water Research Institute has been concerned with this issue for many years. Riparian zone as a three-dimensional entity of the interaction of aquatic and terrestrial natural systems is a specific part of water reservoirs (Gregory et al., 1991; Cebecauerová and Lehotský, 2002). It is often referred to as shore or near-river buffer zone (Malanson, 1993; Hupp and Osterkamp, 1996). The riparian zone has numerous functions (Hansen et al., 2010) that are important with regards to the sustainable development of water bodies and that need to be studied and monitored. This zone participates in improving the quality of water, i.e., it reduces the excessive supply of nutrients and contaminants from the surroundings (slopes, roads, fields, etc.), it reduces the erosion of shores and the supply of sediments, it increases the biodiversity, auto-regulates and optimises the structure and composition of its floral and faunal societies in an ecologically natural way. The present contribution's objective is the comparison and evaluation of spatial changes in the ecosystems of littoral, sublittoral and profundal zone as well as changes in the riparian zone and the morphometry of the topography of water reservoir Evička's bottom.

2. Site of the study

The water reservoir Evička is located in the cadastral area of Štiavnické Bane municipality near Banská Štiavnica (Fig. 1) and together with other water reservoirs around Banská Štiavnica is on the UNESCO World Heritage list. The water reservoir's origin dates before 1683 (Hydroconsult, 1991). The water reservoir's basin with the catchment boundary of 5.169 m has the total surface area of 1.370 km^2. Evička is the last stage of the cascade of water reservoirs Bakomi, Vindšachta, Evička. The smaller water reservoir Krechsengrund is part of

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the reservoir basin as well, but it is not hydrologically bound with the higher lying water reservoirs.

Figure 1. Location of the water reservoir Evička within the Slovak Republic

3. Materials and methods

3.1. Assessment of storage capacity changes

When comparing the changes in the relief of Evička's bottom we proceeded with the analysis methodology of water reservoir Ružín (Pauk et al., 1997) and water reservoir Klenovec (Kočický et al., 2002) in Slovakia. This methodology was selected also for other water reservoirs in the Banská Štiavnica, Soovakia surroundings, e.g., in the research of Halčiansky tajch (Kubinský and Weis, 2011), Belianskeho (Kubinský and Weis, 2012), and Bakomi (Kubinský and Weis, 2013). The field research was executed on October 14, 2011. For an accurate depth measurement, the echosoundingdevice Humminbird 717 with a GPS device was used. The sonar uses a dual-beam probe 20° or 60° with the frequency of 200 & 83 kHz. The accuracy of sonar depth measurement, declared by the manufacturer, is ±10 cm, the declared accuracy of location measurement with the external 50-channel GPS antenna is ±100 cm. The device was placed on a boat, GPS recorded the location of every measured point, sonar measured the depth of bottom.

To eliminate the systematic error, control reference measurements with levelling staff, with flat base, were done during the measurement. The depth measurement only with the levelling staff without the use of sonar is difficult to implement into practice, mainly in depths over 5 meters, due to the stabilisation of the vessel on the surface and maintaining the vertical position of the levelling staff. Some of the already analysed water reservoirs were draw-down after the measurement due to the reconstruction of the dam by the Slovak Water Management Enterprise. The accuracy of the measurement of selected points was re-verified with the method of geometric levelling in the measurement accuracy level AL (Accurate levelling). The accuracy of results from the sonar device was determined by this verification to ± 3 cm.

The measured depths were converted to the absolute height above mean sea level of the bottom. The conversion was set on the basis of the difference of the known height of water level on the day of measurement. The absolute height above mean sea level of the water surface was set by the difference against the spot height of the safety spillway edge. At the time of measurement, the absolute height of the water reservoir's surface was 664.41 m a. m. s. l. The necessary data were provided by the office of Slovak Water Management Enterprise. The absolute height above mean sea level of the measurement point was derived after the subtraction of the measured depth from the height above mean sea level of the water surface. The position of measured points was converted to coordinates of the JTSK (Unified trigonometric cadastral network), Křovák's projection. In this way we acquired the first set of input data for modelling the actual topography of the water reservoir's bottom.

The input data sets for the elevation model 1971 were created as the vectorisation of contour lines of the historical map called "Evička Rybník - Štiavnické Bane" in the 1:10000 scale. The contour map was scanned in 300 DPI resolution and converted into digital TIFF format. The vectorisation of contour lines was done in the R2V software environment. Each contour line was assigned an information on height above mean sea level (Z coordinate) and the data were subsequently exported into a*.shp file. This file was later georeferenced into JTSK, Křovák›s projection. The georeferencing was done in the ArcGis software with the Spatial Adjustment module. As graphic data with known coordinate system were used the aerial images (Eurosence, 2006) and also several control points acquired by the field measurement with manual GPS. Easy to identify items, such as the location of service building on the dam, plotted buildings, edges of the dam, etc. were selected and used on both sources. The second input set of data for modelling the contemporary topographyof the water reservoir Evička›s bottom, i.e., the model representing the state from 1971, was acquired in this way. 3D models, describing the situation for both timelines, were generated and visualized for the years 1971 and 2011 (Figs. 2 and 3) in the Surfer 8 software environment (Golden Software, Colorado, USA). We used the Kriging interpolation method with the 2×2 m raster unit size for the generation of models. The changes in the bottom›s topography provided an information basis for the identification of ecologically interpretable changes in the upper layer of littoral, sublittoral zone and the deepest profundal zone of the water reservoir›s bottom (Hartman et al., 2005).

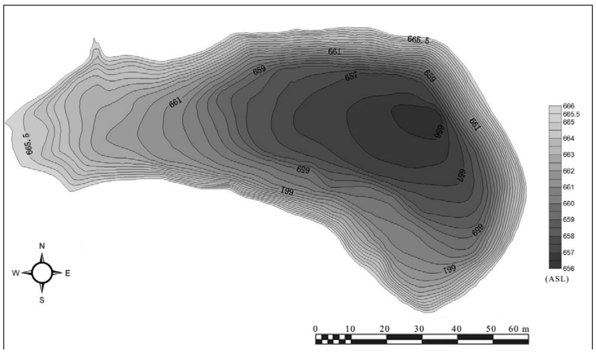

Figure 2. The detail of the topography of water reservoir Evička's bottom (condition in 1971)

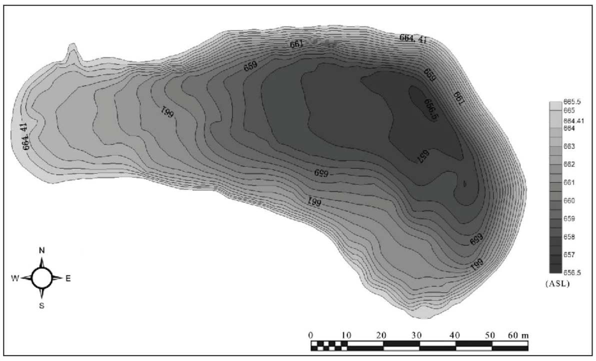

Figure 3. The detail of the topography of water reservoir Evička's bottom (condition in 2011)

3.2. Assessment of the reservoir basin and ecosystems changes

The changes in the affected ecosystems in the water reservoir and landscape structures in the riparian zone were processed in the ArcGis software environment. The riparian zone was defined as 20-meter wide surroundings or buffer from the shoreline. Through the interpretation of orthophotographfrom 2006 with subsequent completion of data by field inspection as the actual status (2012) and the regressive interpretation of aerial black and white pictures from 1949, we created a map of the land cover of the area for both timelines (1949 and 2012). The evaluation of the riparian zone structure was done for 1949 (Fig. 4) and for 2012 (Fig. 5). Through analysis and synthesis of supporting results (changes in bottom's topography and riparian zone), we proceeded to the selection of the changes in ecosystems in the water reservoir Evička (Fig. 6).

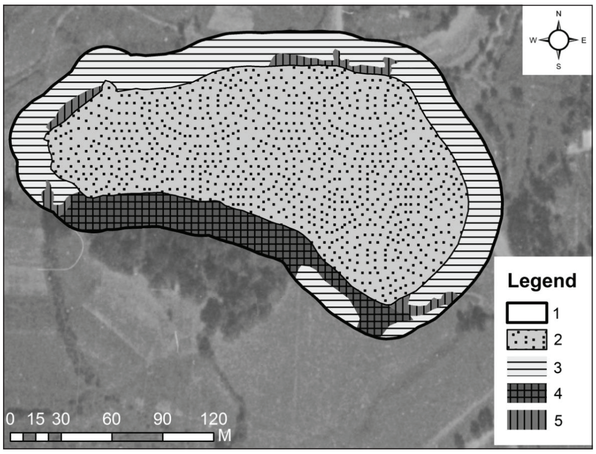

Figure 4. The situation of the riparian zone in 1949 (© Copyright Topografický ústav Banská Bystrica)
Legend: 1) the boundary of the riparian zone, 2) water surface, 3) stable grassy vegetation, 4) tree vegetation, 5) bushes

Table 1. Calculation of the volume of sediments deposited in the water reservoir Evička

Interpolation method	Area [m^2]
Trapezoidal Rule	10,921
Simpson's Rule	10,916
Simpson's 3/8 Rule	10,913

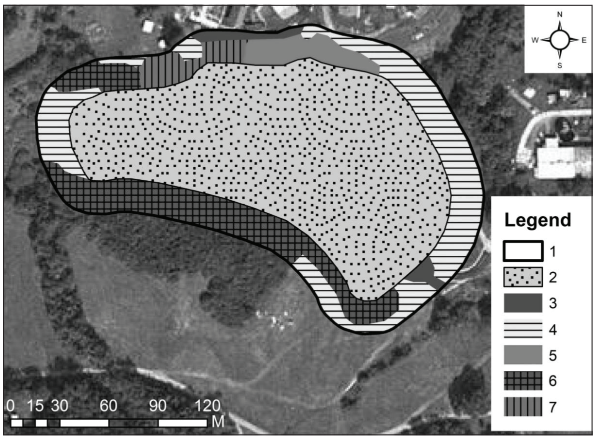

Figure 5. The situation of the riparian zone in 2013 (© Eurosence, 2006)
Legend: 1) the boundary of the riparian zone, 2) water surface, 3) developed areas, 4) stable grassy vegetation, 5) scattered trees, 6) tree vegetation, 7) bushes

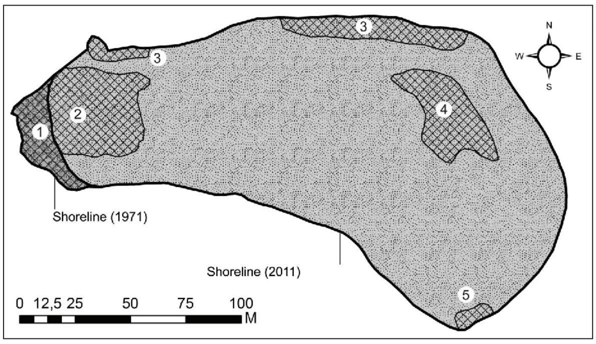

Figure 6. Changes in the water reservoir Evička's ecosystems

The landscape structures of the reservoir basin were mapped in the ArcGis software environment. Through the interpretation of orthophotograph from 2006 with subsequent completion of data by field inspection as the actual status (2013) and the regressive interpretation of aerial black and white pictures from 1949, we created a map of the land cover of the area for both timelines (1949 and 2013). Given the fact that the water reservoir Evička was reconstructed in 2013/2014 to secure and increase the safety of the dam, this water reservoir was drained at the time of writing of this contribution and therefore the accurate geodetic measurement of sediment distribution was possible. On the basis of field inspection, the boundaries of accumulated sediments were visually determined; their exact location was determined by a total station placed on the dam's crest.

4. Results

4.1. Changes in Volume and Bottom's Topography

We acquired the following models with computer visualisation of the bottom's topography. The greatest change in the topography occurred in the area of the greatest depth (Fig. 3). The course of contour lines with the height above mean sea level of 657 m a. m. s. l. and 657.5 m a. m. s. l. is significantly modified and their outlines prove the shallowing of the water reservoir's central part by at least 60 to 80 cm. It proves that the significant part of deposited material is accumulated right in these parts. This happened despite that during the first reconstruction of the water reservoir Evička in 1993 the bottom sediments were partially removed to enable access and safe manipulation with the outlet device. Signs of sediment accumulation can be seen also in the western part of the water reservoir, in the direction towards the feeder from the higher located water reservoir Veľká Vindšachtská, where the S-shaped bend of a series of contour lines suggests the forming of double-sided symmetric benches with central, slightly meandering gully. In this space, the trough (erosive) bedding is dominant. This gully is functioning at the time of the long-term summer decrease of water level after the previous deficit of rainfall during subsequent episodic torrential rains. The second period, when this feeder gully is functioning, is spring, when after the winter decrease of the operating water level come either floods of water with higher energy during a sudden rise of temperature and a fast melting of ice and the strong flow erodes in this gully even under the ice or during the first strong spring showers, when the water reservoir's surfaces is not covered with ice.

Table 2. Surfaces of riparian zone's category

Surface category	Surface area [m^2]		Change of area [%]
	1949	2012	
Water surface	20,413	19,248	-5.7
Stable grassy vegetation	11,770	5,946	-49.48
Scattered trees	-	1,136	+100
Bushes	3,299	986	-70.11
Forest-like vegetation	11,770	4,873	-58.59
Developed areas	-	586	+100
Total	47,252	31,639	-33.04

The contour lines in south-southeast and mainly in the most eastern part of the water reservoir show the same nature, just with different origin of accumulations. Despite the sporadic but too poor water source existing in this part (probably a descending contact or talus spring), the fine-grain material is in the water reservoir distributed mainly through movements of the water mass in the prevailing direction of rippling. Also, a mild directional sorting out of grain fractions and the creation of slanting bedding, in places with the characteristics of ripples, corresponds with this.

The calculated differences in volume from the comparison of the condition of bottom's topography in the past and present, executed in the Surfer 8 environment with the use of three computational methods, are as follows:

- Given the standard deviation of all values is minimal (σ = 4.04), the resulting value was determined as an arithmetic average of all three calculations, i.e., 10917 m^3. This value represents the volume of sediments deposited in the water reservoir Evička's space for the time period of 40 years and represents a decrement in the water reservoir's overall storage volume by the given value (Fig. 13).
- To determine the changes in the water reservoir's bottom due to sedimentation, cross-sections were constructed every 32 meters; 7 profiles in total, A – G and one longitudal section, H, across the water reservoir in the east-west direction (Fig. 12) and maximum and average thickness of sediments and the standard deviation were evaluated (Table 5).

4.2. Changes in Reservoir Basin

In accordance with the analysis of landscape structure changes in the whole reservoir basin (Fig. 7 and Table 3), the amount of developed surfaces increased significantly by as much as 11.2%. The development conditioned by the adjustment of slopes and roads mainly on meadow and pasture surfaces has probably the greatest influence on the amount of sediments deposited in the water reservoir. The trend of gradual development and the change of the surroundings to urban area will probably continue also in future. Therefore, it is necessary to look for such water management measures that will focus more on capturing the sediments already before the entry into the water reservoir than on the reduction of their creation. It should be noted that there is no longer a water reservoir below the water reservoir Evička today. In the past, there was a water reservoir bottom Vindšachta approximately 500 m below in the direction of valley, but today it is completely filled up. The possible decrease in the amount of sediments with flushing the water reservoir could be considered, it would not mean the sediment transfer from the upper to the lower water reservoir. We assess the increase in afforestation in the reservoir basin by 14.5% positively. It concerns mainly fast-growing tree species. In the reservoir basin has occurred a significant reduction in the surface area of meadow vegetation from the original 66.5% of the overall surface area to 41.8%, whereas 13.17% of meadow vegetation was built up and changed to municipality's urban area and 20.85% of the surfaces were forested.

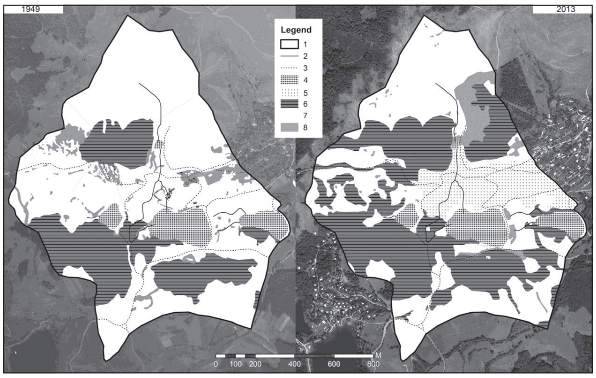

Figure 7. Changes in the water reservoir Evička's reservoir basin
Legend: 1) the boundary of reservoir basin, 2) roads, 3) streams, 4) water surface, 5) developed area, 6) forest vegetation, 7) meadows and pastures, 8) bushes

4.3. Changes in Riparian Zone and Ecosystems

By comparing the changes in the topography of water reservoir's bottom for the period of 1971-2012 (Figs. 4 and 5) and changes in the riparian zone for the period of 1949-2012 (2) as the element, development of which directly affects the water level, we selected the following parts within the water reservoir's area that were affected or modified during given time periods (Fig. 6):

1. The water surface from 1971 was transformed to a terrestrial ecosystem fully filled with soil, located

behind the shore line, due to sedimentation processes. Its land cover is represented by bushy vegetation, the substrate consists of fine sandy sediment but also spreading gravel for the winter maintenance of roads. Thus, the water ecosystem became a terrestrial one during the monitored period. Today, this part is overgrown with common reed (Phragmites communis) and fast-growing natural seeding tree species.

2. The area of significant shallowing, acquired through the comparison of 3D elevation models of the bottom. We expect the presence of fine mud sediments and due to a more significant decrease in depth also change in temperature and light regime.
3. The increase in the presence of the wood vegetation and the possibility of the organic mass falling into the water reservoir. The detritus can cause local short-term changes in the water's pH. The increase in shading did not occur due to the shore oriented to the north.
4. The deepest part of the water reservoir shrank and became shallower due to the silting and deposition of sediments. The deepest parts of the water reservoir are the environment for the wintering of cyprinids and therefore their changes and the gradual decrease of depth will affect mainly these species.
5. The area near the adjusted outlet gully of safety spillway. Because the outlet gully is the only outlet, we can expect the sedimentation of the finest material in its close surroundings due to the flow of water.

4.4. Changes in Thermal Stratification

Due to the erosion and sedimentation processes, the accumulation of material and the anthropogenic effect, changes also in the water reservoir's stratification occurred in the area of the water reservoir Evička. The stratification of the water reservoir Evička in 1971 and in 2011 and the surface areas of individual zones were evaluated (Figs. 8 and 9, Table 3).

Table 3. Changes in landscape structures in the reservoir basin (1949 – 2013)

Landscape structure category	Surface area [km²]		Proportion [%]		Change of area [%]
	1949	2013	1949	2013	
Meadows	0.911	0.574	66.5	41.8	-24.7
Forest	0.312	0.512	22.9	37.4	+14.5
Non-forest vegetation	0.071	0.057	5.2	4.1	-1.1
Developed area	0.003	0.156	0.2	11.4	+11.2
Water surface	0.073	0.071	5.3	5.2	-0.1
Total	1.370	1.370	100	100	0.00

The distribution of the sediments in the area of the water reservoir and the expected direction of their supply and subsequent accumulation was visualised (Fig. 10). Two sources of sediments can be observed, one in the western part of the water reservoir in the places of the feeder gully from upper water reservoirs and one in the southern side, where the transfer of sediments from surrounding slopes occur. The distribution of sediments is unequal due to a slight inclination in the bottom's topography. The sediments deposited from the western part do not have enough kinetic energy capable of their transfer over the bottom of this inclination and they are transported further towards the deepest parts of the water reservoir. The field survey at the drained water reservoir Evička's bottom has shown the occurrence of spreading material in the most western part. The sediments deposited from the southern part are re-deposited in the deepest parts and only a small part of it accumulates at the inclination's dam crest in the bottom's topography.

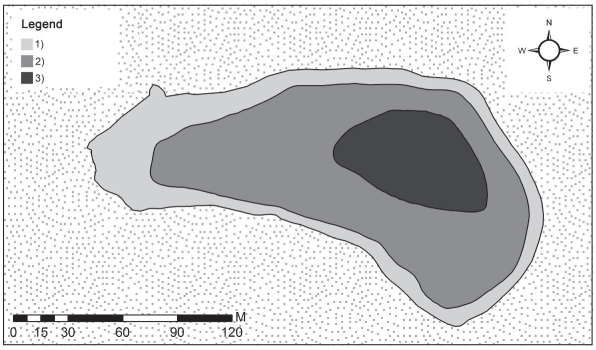

Figure 8. The stratification of the water reservoir Evička in 1971
Legend: 1) littoral zone, 2) sublittoral zone, 3) profundal zone

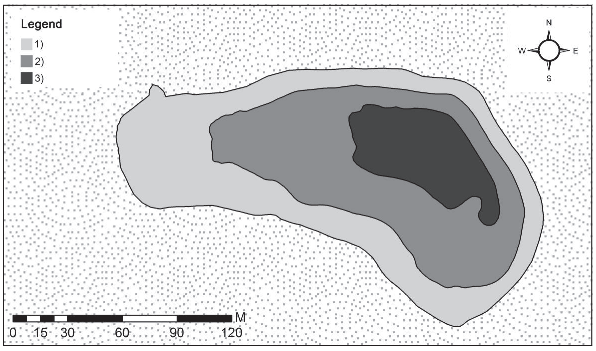

Figure 9. The stratification of the water reservoir Evička in 2011
Legend: 1) littoral zone, 2) sublittoral zone, 3) profundal zone

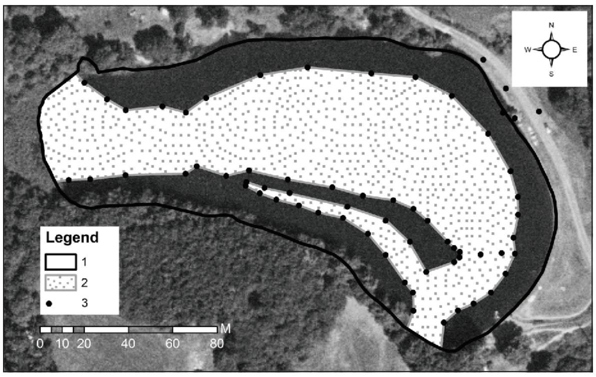

Figure 10. Distribution of sediments in the water reservoir's area
Legend: 1) Shore line in 2013, 2) the boundary of accumulated sediments, 3) topographical points

Table 4. The calculated surface areas of the water reservoir Evička's zones

Surface category	Surface area [m²]		Change of area [%]
	1971	2011	
Littoral	4,830	7,384	52.87
Sublittoral	12,264	9,065	-26.08
Profundal	3,065	2,797	-8.74
Total	20,160	19,248	-4.52

Figure 11. View on the Evička water reservoir's bottom during reconstruction

Table 5. Sediment thickness and Sample standard deviation of cross sections

Section	Sediment thickness [m]		
	Max	Average	Standard sample deviation
A	1.17	0.75	0.44
B	1.09	0.64	0.95
C	1.27	0.56	0.90
D	1.31	1.1	0.87
E	1.42	1.5	0.89
F	1.21	0,57	0.85
G	1,40	1.2	0.40
H	1.31	0.59	0.32

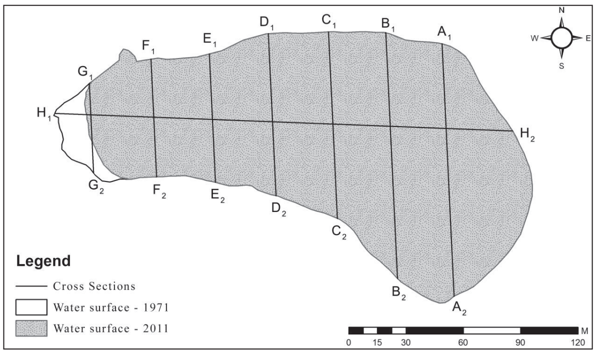

Figure 12. Location of selected cross section lines of water reservoir Evička

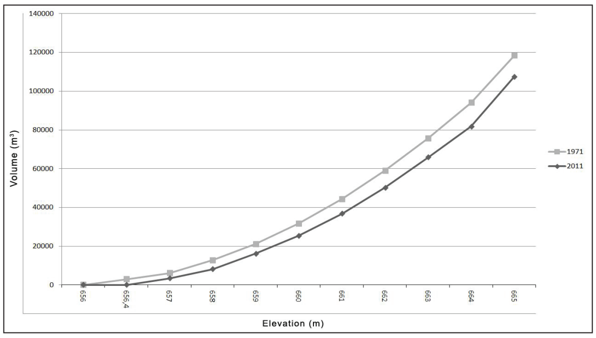

Figure 13. Figure 13. Volumes of water reservoir Evička

5. Discussion

The methodology of data collection using the ultrasound device and sonar proved to be sufficiently accurate, fast and economical. This procedure, with slight modifications, is also commonly used in studies at other locations (Dost and Mannaerts, 2008; Choiński and Ptak, 2009; Elçi et al., 2009; Hollister and Milstead, 2010).

In the results, we can see a negative effect of erosion and sedimentation processes on the changes in bottom's topography and the overall morphology of the water reservoir Evička's bottom, but also the changes in the landscape structure and ecosystems in the shore zone. The volume of sediments deposited in the water reservoir Evička for 40 years is 10917 m³. Even despite the short time horizon we are not talking about extreme silting. For example, the water reservoir Alitnapa in Turkey was decreased by 33.4% for the period of 1967-2009 (Ceylan et al., 2011). The negative situation of silting of lakes and water reservoirs was described also in the neighbouring Poland, where 25 lakes in total has lost 9.9% of accumulation capacity over 50 years (Choiński and Ptak, 2009). The concentration of sediments at bottom outlet, frequently reaching the height of several meters (Kubinský and Weis, 2012), it can often lead to the loss of the device's function. The negative phenomenon is common also at other water reservoirs, e.g., the Dąbie lake in Polland, where over 2 meters of sediments were deposited over the years 1962-1996 (Wiśniewski and Wolski, 2005).

For the period of 22 years (1949-1971), the water surface area shrunk by 252 m² in total, the overall decrement of water surface area for the period of 40 years (1971-2011) is 912 m². That means that the water surface area of the water reservoir Evička has shrunk by 1.165 m² for the period of 63 years (1949-2012). This indicates the fact of a negative, mainly anthropogenic effect. The increased construction and building activity is typical mainly for past twenty years, whereas the construction adjustment and the construction itself are continuously nearing the water surface itself. As we can see by the comparison of landscape structures in the reservoir basin for the period of 1949-2013, the fact of increased development due to gradual expansion of the Štiavnické Bane municipality is obvious. At locations with predominantly meadow and pasture surfaces, new buildings gradually emerged, this factor is also conditioned by the adjustment of slopes and construction of access roads. The importance of the analysis of changes in land cover in relation to the silting of water reservoirs was described also in other locations (Newman et al., 2009). It is evident from the results of these works that the changes in the use of land and land cover lead to the understanding of the sedimentation mechanisms throughout the whole reservoir basin.

As it is noted on the geological map (SGÚDŠ, 2013), the majority of the reservoir basin's surface lies on predominantly loam-stony (inferiorly sand-stony), deluvim and detritus deluvial sediments. It is a subsoil that is unstable to water erosion, it is eroding very quick when uncovered and the material of sand-loam nature is subsequently transported with surface flow. The Evička's reservoir basin includes 3 other water reservoirs capable of accumulation of the sediments (Bakomi, Vindšachta, Krechsengrund), but the micro-reservoir basin belonging only to the water reservoir Evička lies in a significant part on the mentioned subsoil of deluvial sediments.

The accumulation of sediments is a serious problem not only in Slovakia. Over 45 years (1966-2011), the artificial lake Velika Dicina in Serbia accumulated 18.750 m^3 of sediments (Ristic et al., 2013). The authors see as the main cause of the adverse condition the anthropogenic effect in the reservoir basin.

The negative trend of building and development near the water surface itself is not exceptional. We can encounter it at other water reservoirs in the vicinity of Banská Štiavnica (Kubinský et al., 2014). The analysis of the development of erosion and sedimentation processes is key in designing of the management procedures in the whole interest reservoir basin (Ambers, 2011; McAlister et al., 2013), it enables to predict the future development (Wiśniewski and Wolski, 2005). Abroad, we can encounter also the division of reservoir basins into zones with different management approach (Lin et al., 2000). Given the relatively small reservoir basin with two other water reservoirs, we did not divide the reservoir basin any further.

The results of stratification show that the changes occurred also in individual zones, in their surface areas. These are characterised by variable ecological conditions (water temperature, lighting, water density, the circulation of oxygen, CO_2, ...) and subsequently by species variability. The erosion of water reservoir's uncovered shores and the subsequent flush of terrigenous material into the littoral environment, together with the annually accumulated layer of decomposing organogenous detritus (the cast of leaves and needles, organic remains of water organisms and plants), contribute to a significant degree to slow and gradual eutrophication.

We can encounter this type of native biotope devastation mainly in smaller and more shallow water reservoirs (for example, in Bakomi, Klinger, Belianska reservoirs), but even the larger water reservoirs, where the regular removal of deposited sediments ceased over the years (for example, in the mouth of the Halčianska water reservoir feeder) or where the fixation of ecologically adverse condition occurs through gradual decrease in flow rates in feeders, are not an exception. For these water reservoirs only minimal exchange of water in the water column (often made impossible also by the non-functioning of bottom outlet) is typical, thus gradual eutrophication and the silting of the water reservoir with fine-grain sediments occurs (for example, in Ottergrund, Krechsengrund, Brenneštôlnianska, Červená studňa or Komorovské ponds). This fact also refers to actuality and the importance of systematic research also on other water reservoirs and it also proves the fact that adverse development occurs in water reservoir. In general, we summarised the causes to the devastated system of trenches, the decrease in the flow rate of feeders with excessive consumption and deflection already before the inflow to the water reservoir, the non-functioning of bottom outlet devices, the absence of sump caissons for sediments in feeders' mouthings. Last but not least, it concerns also the uncovered shores of the water reservoir, the flushing of the eroded, medium to fine-grain material (soil, sand, loam, clay) with the surface rainwash, the decomposition and accumulation of organogenous detritus, the insufficient prevention of enormous macrophyte development, mainly the submersive vegetation, the gradual overheating of the water reservoir due to draining the heated layer through the surface spillway instead of draining the colder "bottom" water. The water reservoir Evička is undergoing the second repeated phase of general repair in 2013-2014. The process of the reconstruction of water reservoirs in Banská Štiavnica area is executed by SVP, š.p., which is responding to the fact that even though the water reservoir Evička was among the the first reconstructed water reservoirs after 1989, the non-functioning of the bottom outlet device in the third, last stage of the Bakomi – Veľká Vindšachtská – Evička cascade was a serious issue. The water reservoir Bakomi, as the first stage of the mentioned cascade, shows only slight supply of sediments for the same period of 41 years (Kubinský and Weis, 2013). We assume that several of the described adverse effects will be gradually eliminated after the successful completion of the reconstruction of outlet device, the dam and the handover of this water reservoir into use.

Conclusion

The present work points out the changes in the water reservoir Evička's ecosystems, using diachronic analysis of its bottom's topography and the riparian zone. The changes in bottom's topography are conditioned mainly by erosion and sedimentation processes and the subsequent accumulation of sediments in the water reservoir. The changes in riparian zone have direct effect on multiple factors that condition the temperature and light regime. We have selected several changed ecosystems in the area of the water reservoir through the synthesis of both main factors, i.e. the changes in topography and in the landscape structure of the riparian zone. Evička is not only a technical monument, recorded on the UNESCO list, but it is important to see it as an ecosystem as well that contains in a relatively small space a confined population of organisms and in which relatively important changes occur over the course of time, as the results of the contribution indicated.

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