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POSSIBILITIES TO RESTORE NATURAL WATER REGIME IN THE ŽUVINTAS LAKE AND SURROUNDING WETLANDS – MODELLING ANALYSIS APPROACH

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Abstract. The Žuvintas Lake, located in southern Lithuania in the basin of the Dovinė River is one of the biggest lakes and the oldest natural reserves of the country. However, the changes in the hydrology of the Dovinė River basin, caused by large-scale melioration and water management works carried out in the 20th century, have resulted in significant alteration of hydrological regime and decrease in biodiversity of the Žuvintas Lake and surrounding wetlands. In order to prevent the ongoing deterioration of the Lake and wetlands solutions have to be found. Therefore, various scenarios have been analysed to evaluate the impact of water management alternatives. For these scenarios the physically-based distributed parameter model SIMGRO was used. The results have shown that natural water regime in the Žuvintas Lake is hardly reversible. However, the replacement of sluice-gates implemented at the outlet of the Žuvintas Lake by overflow weir as well as the blocking of drainage ditches and the removal of scrubs and trees in the wetlands surrounding the Lake can be highly successful measures to improve hydrological conditions.

Keywords: the Žuvintas Lake, wetlands, the Dovinė River, water regime, SIMGRO, Lithuania.

1. Introduction

The objectives of the EU Water Policy as described in the Water Framework Directive (2000/60/EC) identify a need for greater integration between factors such as water quantity, quality, water use and environmental protection. The Directive is to be implemented focusing on the river basin scale. Furthermore it aims to protect and enhance the status of aquatic ecosystems. One implication with respect to water management is that there should be an objective to maintain flow regimes as close to natural ones as feasible. The flow regime is generally considered the primary driving process in the river ecosystem (Rhoads *et al.* 1999; Richter *et al.* 2003; Jacobson and Galat 2006). Wetlands, due to their influence on controlling peak flows and droughts as well as on removing pollutants and recycling nutrients and accumulating sediment, can play an important role in governing processes between terrestrial and aquatic environments (Bragg *et al.* 2003). The significance of wetlands in landscape ecology is crucial concerning biodiversity (Andel and Aronson 2006). Therefore, naturalization of the flow regime as well as restoration of wetlands have received increased attention in river basin management during recent years (Dunn and Ferrier 1999; Mitsch *et al.* 2002; White and Fennessy 2005; Zalidis *et al.* 2004; Zhang and Mitsch 2005; Abad and Garsia 2006; Mitsch and Day 2006).

During the second half of the twentieth century, large-scale agricultural expansion has posed a threat on natural water conditions in river basins, like in the Dovinė River basin, Lithuania. The water regime of the River was significantly altered, sluice-gates were built at the outlets of some lakes and natural wetlands were changed into agricultural land. The land reclamation and associated drainage works caused peat land to subside. As a result the neighboring wetlands suffer too dry conditions and as a consequence a rapid encroachment by scrubs (Zingstra *et al.* 2006). Therefore, the changes in hydrology have caused biodiversity to decline.

Spatially distributed hydrological models have become useful tools to support the design and evaluation of river basin management. The dynamics of flow between aquifer systems and interconnected streams are explored using coupled stream–aquifer interaction models that are capable of accounting for the interdependence of groundwater and surface water functioning (Bradley 2002; Thompson *et al.* 2004; Adrian *et al.* 2006). Using a hydrological model covering the Dovinė basin can give a proper basis for decision-making on feasible measures. Analysis of the complex Dovinė basin with its wetlands and lakes requires the use of a combined groundwater and surface water model and prediction of the effect of measures on a regional scale. Therefore, the regional hydrological model SIMGRO was used. The model simulates the flow of water in a saturated zone, unsaturated zone and surface water. The model is physically-based and therefore suitable to be used in situations with changing hydrological conditions.

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This paper discusses the measures to improve the hydrological conditions in the Žuvintas Lake and the adjacent wetlands, using the model SIMGRO. Measures were judged on their merits to improve the outflow and water level conditions in the Lake. Further improvements of the groundwater conditions in the wetlands were also considered.

2. Site description

The Dovinė River basin covers an area of 588 km² and is located in the southern part of Lithuania (Fig. 1). The basin is the right tributary of the Šešupė River consisting of a network of streams and a number of through-flowing lakes (Dusia 23 km^2, Žuvintas 9 km^2, Simnas 2.4 km^2, and Amalvas 2 km^2). The Dovinė River basin holds one of the most important and meanwhile most threatened lakes of Lithuania, the Žuvintas. In the past the Lake was a good example of a mezotrophic lake but in the current situation only small parts of the Lake qualify to be designated under the EU Habitats Directive, and its conservation status is far from favourable.

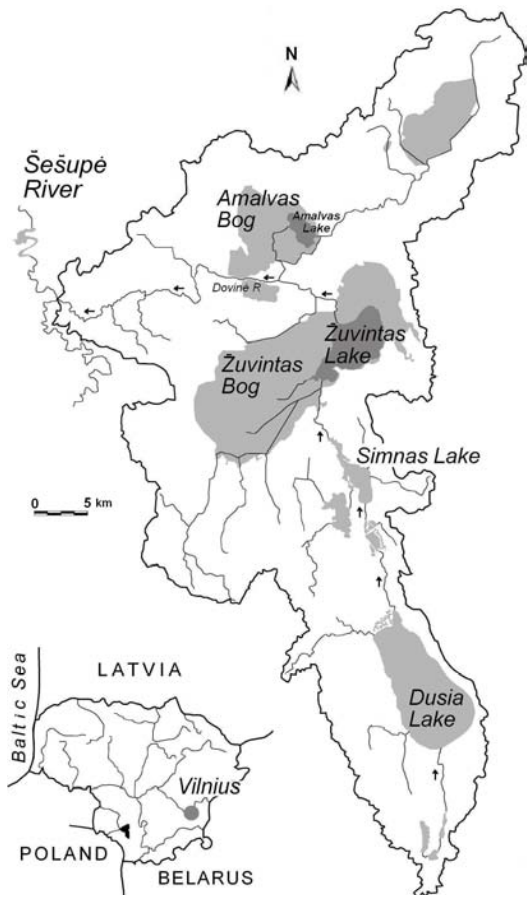

Fig. 1. Location of the Dovinė River basin

Adjacent to the Žuvintas Lake are extensive bog and fen areas of the Amalvas wetland complex. Both the Žuvintas and Amalvas wetlands make up the Žuvintas Biosphere Reserve (BR). The Amalvas wetland is influenced by human activities to an even higher extent. Draining ditches cover almost half of the original wetland complex, excavated in the late 80-ties of the last century, when the area was transformed from a bog area into pastures and hay-producing meadows. On the northern side of the wetland a small polder was created and was used to grow agricultural crops. During the last decade parts of the polder and meadows were abandoned, resulting in the encroachment of scrubs. These again use more water and result in dryer conditions, stimulating again the growth of more scrubs. Unless management is taken up again this process will cause the loss of valuable areas in the near future.

Land use in the basin is predominantly agricultural, about 46% is arable land, 16% is pasture and meadows, 14% is natural wetlands (including wet forest), 12% are lakes, 9% is forested and 3% is urbanized. The dominant soils are Haplic Luvisols covering one third of the basin while Gleyic Luvisols cover more than 20% of the territory. Sandy loam soils prevail in hilly southern part of the basin, light clay loam and peat soils dominate within the Žuvintas Biosphere Reserve.

The predominantly fertile soils in the Dovinė River basin stimulated the extension of agriculture. In 1980's the water regime of the River and its basin was significantly altered. Due to intensified drainage activity about 36% of the Žuvintas Lake basin area was ameliorated. Sluice-gates were built at the outlets of the Žuvintas and other lakes. After the arrangement of sluices average water level in the Žuvintas Lake has increased by 0.31 m, while the water level fluctuation has decreased from 1.2 to only 0.70 m (Gulbinas *et al.* 2007). The damming has prolonged water residence time and increased sediment retention capacity. Nowadays the Žuvintas Lake, being quite shallow, is rapidly shrinking in size due to massive overgrowth by water plants. High nutrient concentration in sediments is the main reason for the massive growth of plants.

It is evident that the change of hydrological regime has had a negative impact on the Žuvintas Lake and surrounding wetlands. Further demand for damming is irrelevant. Therefore, natural water regime is aimed to be restored.

3. Methods and data

SIMGRO (SIMulation of GROundwater and surface water levels) is a distributed parameter model that simulates regional transient saturated groundwater flow, unsaturated flow, actual evapotranspiration, sprinkler irrigation, stream flow, groundwater and surface water levels as a response to rainfall, reference evapotranspiration, and groundwater abstraction (Fig. 2). To model regional groundwater flow, as in SIMGRO, the system has to be schematized geographically, both horizontally and vertically. The horizontal schematization allows different land uses and soils to be input per node, to make it possible to model spatial differences in evapotranspiration and moisture content in the unsaturated zone. For the saturated zone, various subsurface layers are considered. For a comprehensive description of SIMGRO, including all the model parameters, readers are referred to Van Walsum *et al.* (2004) or Querner (1997).

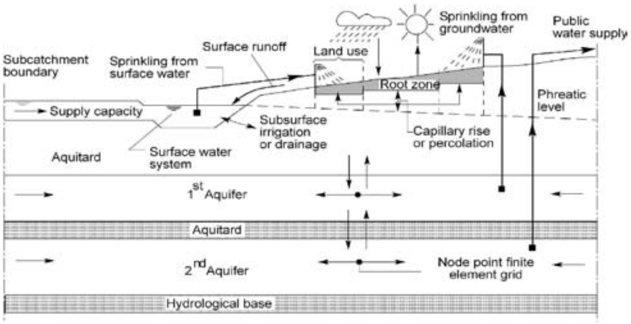

Fig. 2. Schematization of water flow in SIMGRO model

The SIMGRO model is used within the GIS environment. Via the user interface AlterrAqua, digital geographical information (soil map, land use, watercourses, etc.) can be input into the model. The results of the modelling are analysed together with specific input parameters.

In SIMGRO the finite element procedure is applied to approach the flow equation which describes transient groundwater flow in the saturated zone. A transmissivity is allocated to each node to account for the regional hydrogeology. A number of nodes make up a subcatchment. Evapotranspiration is a function of the crop and moisture content in the root zone. To calculate the actual evapotranspiration, it is necessary to input the measured values for net precipitation, and the potential evapotranspiration for a reference crop (grass) and woodland. The model derives the potential evapotranspiration for other crops or vegetation types from the values for the reference crop, by converting with known crop factors.

Snow accumulation has been accounted for in the model: it is assumed that snow accumulation and melting is related to the daily average temperature. When the temperature is below 0 °C, precipitation falls as snow and accumulates. At temperatures between 0 °C and 1 °C, both precipitation and snow melt occur: it is assumed that during daylight hours the precipitation falls as rain, whereas precipitation falling during the night accumulates as snow (and the melt rate is 1.5 mm water per day). When the temperature is above 1 °C, the snow melts at a rate of 3 $\text{mm}\cdot\text{day}^{-1}$ per degree Celsius.

A surface water system usually consists of a natural river and a network of small watercourses, lakes and pools. It is not feasible to explicitly account for all these watercourses in a regional simulation model, yet the water levels in smaller watercourses are important for estimating the amount of drainage or subsurface irrigation, and the water flow in major watercourses is important for the flow routing. The solution is to model a surface water system as a network of reservoirs. The inflow into one reservoir may be the discharge from various watercourses, ditches and runoff. The outflow from one reservoir is the inflow to the next reservoir. For the interaction between surface water and groundwater, there are four different categories of ditches (related to its size) to simulate the drainage. It is assumed that three of the subsystems – ditches, tertiary watercourses and secondary watercourses – are primarily involved in the interaction between surface water and groundwater. The fourth system includes surface drainage to local depressions.

3.1. Input data and schematization

The SIMGRO model application has been built for the entire Dovinė River basin with a size of approx. 600 km^2. The finite element network covering the basin comprised of 4370 nodes spaced about 400 m apart. The peat layer of the Amalvas and Žuvintas bog was considered as an aquitard ranging in thickness of 2–4 m. The resistance of this peat layer is in the order of 400 days. The aquifer below covers the whole basin and has a thickness of 40–80 m and a transmissivity of about 20–65 $\text{m}^2\cdot\text{day}^{-1}$. For the modelling of the surface water, the basin was subdivided into 460 sub-basins, and the schematization further included the sluice-gates.

For the modelling of spatially distributed features in the Dovinė River basin, the available digital data were used. This included topography (scale 1:10000) along with the boundaries of the River basin and sub-basins, together with land use; soil type; geological layers and hydro-geological parameters; hydrographic network and positions of hydraulic structures. Meteorological data was taken from the Žuvintas BR station. No other station in the basin was available and the data was assumed to be applicable for the whole basin. The approximate size of the basin, north to south of about 50 km and east to west of about 26 km is not too large that a differentiation in meteorological conditions over the basin would be needed.

3.2. Model calibration and verification

The SIMGRO model was calibrated with the available meteorological information and water levels measured in the Žuvintas and the Dusia Lakes for the period 1996–2002. Analysis of residual errors was used to evaluate the model performance by characterizing systematic under and over-predictions.

Model verification was performed using information collected for the period 2003 to 2005. The groundwater levels as well as surface water level dynamics in the lakes during the period was statistically analysed afterwards. Verification also included analysis on simulated and measured daily discharge patterns in the Bambena River (The Dovinė River strip in between the Žuvintas and Simnas Lakes) for the year 2005.

The comparison of measured and simulated discharges, groundwater levels and lake water levels revealed that there were differences. A problem faced by the comparison is that the observed groundwater level is for a certain location, whereas the calculated level is an average for the area associated with a nodal point.

However, in spite of some inaccuracies that could be also related to the errors in the measured data, SIMGRO model appeared to be a useful tool to predict groundwater movement and its interactions with surface water in the Dovinė River basin. More detailed results on evaluation of model performance under calibration and verification procedures are given by Povilaitis and Querner (2006).

3.3. Mitigation measures

The water management measures are focused on the entire Dovinė basin, with particular attention for the Žuvintas Lake and its wetland complex. Given the aim of making the Dovinė River runoff regime more natural, different scenarios were analysed to ascertain the impact of changes on the River regime and on the water levels in the Žuvintas Lake and adjacent wetlands. Therefore, three scenarios (Table) have been analysed to get insight in the impact of the measures. Simulations with the model were carried out using a daily time step and meteorological conditions of the period 1994–2005.

Management scenarios

Scenario	Description (main features)
0	Present situation used as reference
1	Replacement of sluice-gates by weir
2	Removal of scrubs and trees in Žuvintas and Amalvas wetlands
3	Blocking drainage ditches around Žuvintas and Almalvas wetlands

Scenario 0 reflects the present water management situation in the Dovinė Basin and was used as reference for the other scenarios. It gave possibility to judge the impact of different water management practices on water regime. In scenario 1 the sluice gates were replaced by weirs. This was done due to the fact that previous studies revealed impossibility to restore the water regime in the Žuvintas and other lakes entirely by removing the sluice-gates downstream (Povilaitis and Querner 2007). Such a measure would lower the water level in the Žuvintas Lake by more than 1.0 m and consequently destroy it. Therefore, to improve the hydrological situation, the scenario analysed involved replacing the sluice gates by overflow weirs designed so as to release environmental flow during dry periods whilst ensuring that the water level does not fall so low that large shallow areas near the shore appear. In scenario 2 the effect of the encroachment of scrubs and trees on the bog area was analysed. Higher groundwater levels are needed, and the loss of water to adjacent reclaimed land should be reduced as much as possible. In scenario 3 the blocking of drainage ditches, implemented on the outskirts of wetlands, was considered.

4. Results

4.1. Present situation (scenario 0)

Simulation results have shown that under the present conditions the average groundwater level during summer season in the Dovinė River basin occurs from 0.10 up to more than 10.0 m below the ground surface. In the winter period the highest average water level at different sites within the basin fluctuates from 0 to more than 7.0 m. The groundwater level in the complex of the Žuvintas and Amalvas wetlands is much higher than in the surrounding areas.

4.2. Replacement of sluice-gates by weir (scenario 1)

This scenario involves replacing the sluice-gates by overflow weirs. In the model the situation was reached by adjusting the stage-discharge (Q-h) relationship of the Lake outlet. For the case of the Žuvintas Lake, this was considered to be an effective measure for achieving partial naturalization of hydrological regime and for minimizing the impact of human interventions. The simulations showed that the specially designed overflow weir along with fish ladder (Zingstra *et al.* 2006) would raise the water level in the Žuvintas Lake by 0.05 m on average. During dry periods the rise is expected to be in the order of 0.1 m compared to the reference scenario. The groundwater level in the Žuvintas wetlands would also marginally rise. The changes in water levels would affect outflow as well.

Though the average daily outflow from the Lake would remain about the same (Fig. 3), the average outflow during the driest 30-day period would increase by 45%. Maximum peak outflows are expected to decrease by 10% on average. Seasonal outflow conditions would also be affected: in winter and during spring floods, the outflows would be by 6% and 10% smaller, respectively. However, in summer and autumn the outflows would increase by 17 and 11%, respectively.

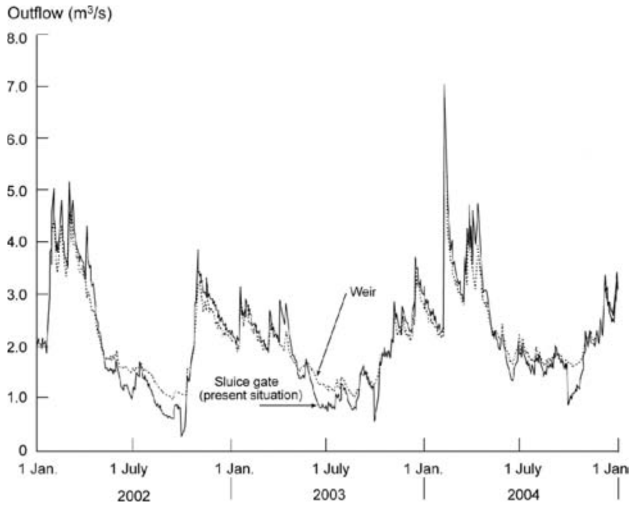

Fig. 3. Impact of the replacement of sluice-gates by weir on the outflow conditions from the Žuvintas Lake

4.3. Removal of scrubs and trees in the Žuvintas and Amalvas wetlands (scenario 2)

The complex of wetlands around the Amalvas Lake covers an area of 1826 ha, the largest part of which is covered by raised bogs (1506 ha) situated on both banks of the Dovinė River. A large area (94%) of the bogs is overgrown with forest. Wetlands around the Žuvintas Lake cover an area of 5790 ha, 80% of which is covered by forest (Fig. 4). Possible influence of the changed land use cover in the wetlands upon their groundwater levels was evaluated under this scenario.

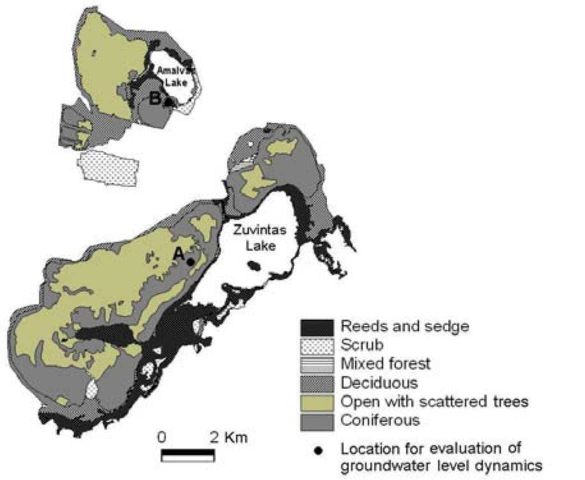

Fig. 4. Land cover in the Žuvintas and Amalvas wetlands

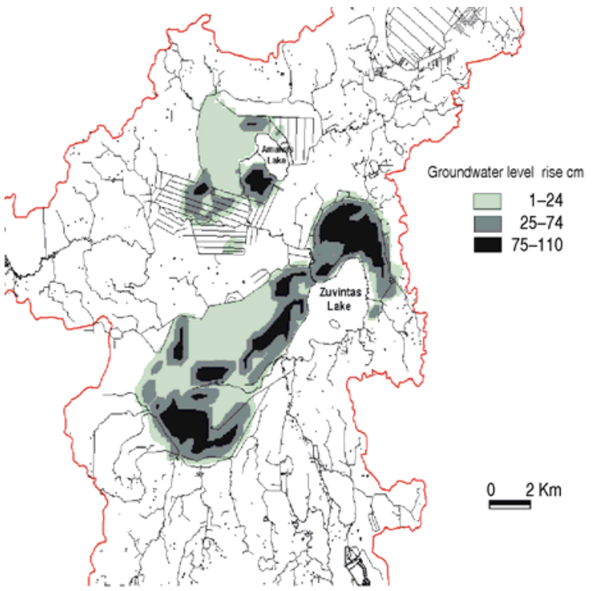

Fig. 5. Impact of the removal of scrubs and trees on groundwater level changes in the Žuvintas and Amalvas wetlands

The results have shown that summer season is the most susceptible to those changes. It conditions "the rise" of the groundwater level from 0.01 up to 1.10 m (Fig. 5). In a large part of the area the rise makes up to 0.30 m. The most vivid changes can be expected in the northern and eastern wetlands of the Žuvintas Lake, where dense forest, mainly pine trees, is situated. The largest changes in the wetlands around the Amalvas Lake would be observed in the drained raised-bog (on the right bank of the Dovinė River) and in the southern strand of the Lake. There the groundwater level would rise by 0.20–0.90 m. During winter the rise in groundwater levels in both wetlands is expected to be less than in summer.

For the accentuation of the above-mentioned consistent patterns, analysis of the groundwater level change at different sites of the wetlands was carried out. The groundwater dynamics above the mean sea level (MSL) at two points of the Žuvintas and Amalvas wetlands (in simulation nodes following the SIMGRO schematization) is shown in Figs 6, 7. Location A is situated in the Žuvintas raised bog, and location B characterizes the intermediate stage between the Amalvas raised bog and fen (Fig. 4). The nodal point in the Žuvintas raised bog reflects conditions with the covering of coniferous trees and the point in the Amalvas wetland – with the covering of deciduous trees.

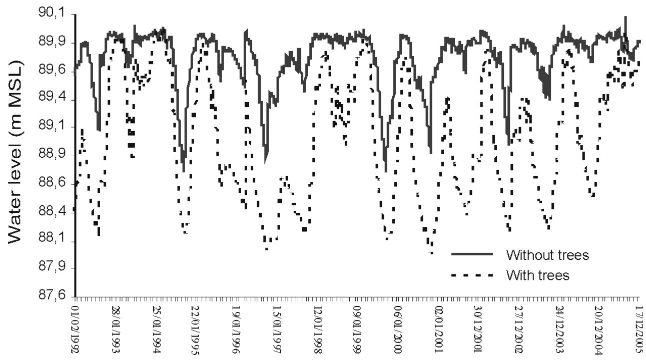

Fig. 6. Impact of coniferous upon the groundwater level dynamics in the Žuvintas raised bog for location A

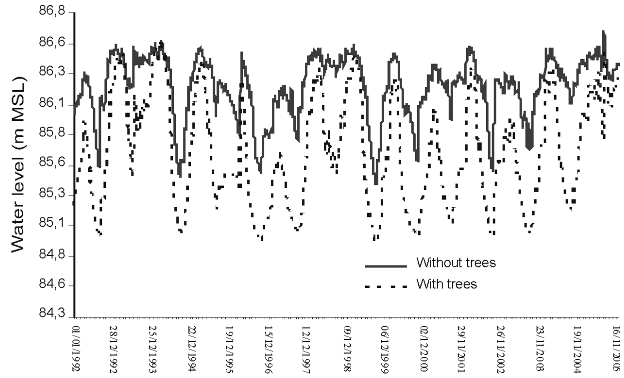

Fig. 7. Impact of deciduous upon the groundwater level dynamics in the Amalvas wetland for location B

The impact of the removal of deciduous trees in the Amalvas transitional mire (location B) manifests in the rise of the groundwater level by 0.55 m on average. During dry season the difference between the rise of the groundwater level with wood vegetation and without it can reach up to 0.65 m. During wet periods it decreases up to 0.17–0.30 m. In the Žuvintas raised bog (location A) the impact of the removal of coniferous forest manifests in the rise of the groundwater level by 0.70 m on average. During dry periods this impact can reach 0.90 m.

4.4. Blocking drainage ditches around the Žuvintas and Amalvas wetlands (scenario 3)

The rise of the groundwater level at the outskirts of the Žuvintas and Amalvas wetlands can be achieved by raising the water levels in the draining ditches by means of small dams or bars at 23 locations.

The height of a dam corresponds to the water level in the ditches according to the 10% probability discharge (10-year return period). The damming is considered only in those ditches, which are given in the Žuvintas Biosphere Reserve management plan.

The results revealed that on the northern, north-western and north-eastern outskirts of wetlands surrounding the Žuvintas Lake the damming of water in the ditches would raise the groundwater level by 0.60–0.70 m on average (Fig. 8). A cascade of small dams of various heights can affect the areas situated at a distance from 100 to 1000 m. The small dams in the ditches would affect the area of the drained Amalvas raised bog (to the south-west from the Amalvas Lake) in particular. There the groundwater level would rise by 0.60 m on average.

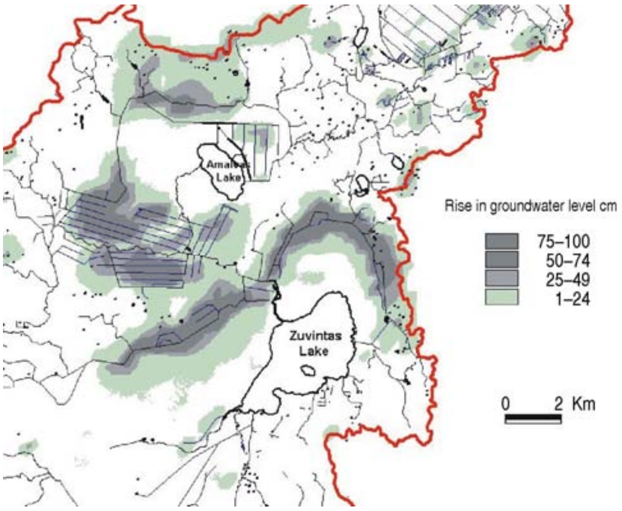

Fig. 8. Average annual rise of groundwater level around wetlands after blocking of drainage ditches

5. Discussion

Dams have major impacts on river hydrology, primarily through changes in the timing, magnitude, and frequency of low and high flows, ultimately producing a hydrologic regime differing from the pre-impoundment natural flow regime (Magilligan and Nislow 2005). Restoration of an unregulated flow regime has been cited as a necessary, and often sufficient, condition for restoration of the ecosystem (Bednarek 2001). However, many of the physical changes are irreversible and have to be taken for granted when assessing the quality status of the river (Doyle *et al.* 2005). This necessitates the use of combined groundwater and surface water models to evaluate the effect of the changes. The SIMGRO model applied in this study showed to be a useful tool to predict the hydrological effect of different water management practices.

Previous studies revealed (Povilaitis and Querner 2007) that removal of sluice-gates at the outlet of the Žuvintas Lake would, benefit to higher fluctuations of the water level in the Lake in comparison with dammed conditions. However, the deepening and widening of pre-damming outlet while installing sluice-gates created new outflow conditions. The restoring would result in undesirable water level decrease. Therefore, the entire naturalization of the hydrological regime in the Žuvintas Lake is impossible. Such a measure would destroy the Lake. The necessity of the damming in the Lake remains in order to prevent drying out of the Lake and to prevent undesirable lowering of the groundwater table in adjacent wetlands. When striving for at least a partial flow naturalization, reconstruction of the sluice-gates into an overflow weir along with a fish ladder is necessary. This would raise the water level in the Žuvintas Lake and make outflow conditions more natural. The impact of the human factor upon water resources management would be diminished and the pathways for aquatic fauna would be released. In order to reduce the inflow of sediment and nutrient in the Lake, additionally, three blocking walls are planned to be arranged in the riverbed of the Bambena before it enters the Žuvintas Lake (Zingstra *et al.* 2006). This measure is expected to be effective during all seasons – the water would overflow into the floodplain and retain sediments in upstream wetlands.

Measures to improve the hydrological situation in the wetlands are also possible. It is well recognized that land cover and land use change have significant effects on hydrological processes such as evapotranspiration, soil moisture and groundwater recharge (Zhang and Schilling 2006). Forest cover leads to higher transpiration rates and interception of rainfall (Pizzaro *et al.* 2006), therefore, clear cutting on wetlands can result in a rise of the groundwater table (Pothier *et al.* 2003; Roy *et al.* 2000; Laiho 2006). These findings have been proved out under the clear cutting scenario in the Žuvintas and Amalvas wetlands. It shows that when the prevailing grassy peat-moss (*Oxycocco Sphagnetea*) cover is reinstated, significant changes in the groundwater level in the bogs can occur. Scrubs and trees lower the groundwater level and therefore the peat layer can dry up leading to intensified mineralization of organic matter and subsequent degrading of wetlands. Therefore, the highest impact is estimated in the areas of coniferous wood during summer season. The groundwater level after clear cutting can rise from 0.03 up to 1.10 m there. During the cold period the water levels in the raised bogs would rise from 0.01 to 0.90 m. This "post-harvest" water table rise would be caused by a drop in evapotranspiration, which itself is due to decreases in rainfall interception and leaf transpiration. Based on this knowledge it is recommended to remove trees and scrubs in the wetlands. The removal of woody vegetation would not have a significant impact on the water level dynamics in the Žuvintas and Amalvas lakes.

A significant threat to peatland sustainability in the Žuvintas and Amalvas wetlands has been the installation of artificial drainage ditches. However, recent restoration schemes have pursued drain blocking as a possible strategy for reducing degradation. Many studies have demonstrated that drain blocking can be a highly successful technique in reducing the oxidation of peat layer and CO_2 emissions and to return the hydrological conditions necessary for *Sphagnum* moss regeneration (Macdonald *et al.* 1998; Shantz and Price 2006; Tiemeyer *et al.* 2006; Wallage *et al.* 2006). The results from simulation scenario have shown that the rise of the groundwater level at the outskirts of the Žuvintas and Amalvas wetlands can be achieved by raising the water levels in the draining ditches by means of small dams and bars. Such small dams in the ditches would raise the groundwater level by 0.6–0.7 m on average on the northern, north-western and the north-eastern edges surrounding the Žuvintas wetland. The dams in the ditches would affect the area of the drained Amalvas raised bog in particular. It is expected that small dams in the ditches on the outskirts of wetlands would have a positive impact on bird habitats as well.

6. Conclusion

The replacement of sluice-gates implemented at the outlet of the Žuvintas Lake by an overflow weir along with a fish ladder as well as the blocking of drainage ditches and removal of scrubs and trees in the wetlands surrounding the Lake can be highly successful measures to improve hydrological conditions and prevent the ongoing deterioration of the Lake and wetlands.

Acknowledgement

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NATŪRALAUS VANDENS REŽIMO ŽUVINTO EŽERE IR APLINKINĖSE PELKĖSE ATKŪRIMO ANALIZĖ TAIKANT MATEMATINĮ MODELIAVIMĄ

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Santrauka

Dovinės upės (dešinysis Šešupės upės intakas) baseine yra seniausias Lietuvoje Žuvinto biosferos rezervatas ir kitos europinės svarbos saugomos teritorijos. Tose vietose hidrologinis režimas tiesiogiai reguliuojamas šešiose vietose pastatytais reguliavimo šliuzais. Šiuo metu poreikio reguliuoti nėra, todėl darbe analizuojamos natūralaus vandens režimo atkūrimo galimybės Žuvinto ežere ir aplinkinėse pelkėse. Tam buvo taikytas matematinio modeliavimo metodas naudojant pasiskirsčiusių parametrų *SIMGRO* modelį.

Ankstesni tyrimai parodė, kad atkurti natūralų hidrologinį režimą vien panaikinus reguliavimo šliuzą žemiau Žuvinto ežero, negalima. Tai sunaikintų ežerą ir neigiamai paveiktų požeminio vandens režimą Žuvinto ir Amalvos pelkių komplekse.

Siekiant bent dalinio vandens režimo natūralizavimo reguliavimo šliuzą siūloma rekonstruoti į slenkstinę nuopylą įrengiant žuvitakį. Žuvinto ir Amalvos pelkių masyve požeminio vandens režimui pagerinti rekomenduojama pašalinti ten augančią sumedėjusią augaliją ir apypelkio teritorijose patvenkti melioracijos griovius. Pateikiamas tokių priemonių galimas poveikis Žuvinto ežero ir aplinkinių pelkių hidrologiniam režimui.

Reikšminiai žodžiai: Žuvinto ežeras, pelkės, Dovinės upė, hidrologinis režimas, *SIMGRO* modelis, Lietuva.

АНАЛИЗ ВОССТАНОВЛЕНИЯ ВОДНОГО РЕЖИМА В ОЗЕРЕ ЖУВИНТАС И ОКРУЖАЮЩИХ БОЛОТАХ С ПОМОЩЬЮ МЕТОДА МАТЕМАТИЧЕСКОГО МОДЕЛИРОВАНИЯ

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Резюме

Водный режим бассейна реки Довине в южной части Литвы в прошлом столетии был подвержен важным изменениям. Там находится старый заповедник Литвы – озеро Жувинтас с близлежащими болотами. В статье представлен сценарий по восстановлению водного режима в озере Жувинтас и окружающих болотах. Для исследования была применена математическая модель SIMGRO. Результаты показали, что полное восстановление гидрологического режима в озере невозможно. Для улучшения водного режима предложен ряд мер.

Ключевые слова: озеро Жувинтас, болота, река Довине, водный режим, модель SIMGRO, Литва.

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