EVALUATION OF THE INFLUENCE OF MOUNTAIN PEAT BOGS RESTORATION MEASURES ON THE GROUNDWATER LEVEL: CASE STUDY ROKYTKA PEAT BOG, THE ŠUMAVA MTS., CZECH REPUBLIC

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ABSTRACT

The paper evaluates measures taken to restore mountain Peat Bogs and their effect on hydrological regime, with the main focus on groundwater levels. The level of groundwater is a key factor in maintaining the character of mountain Peat Bogs and the main objective of restoration is to increase and stabilize the groundwater level in disturbed Peat Bogs. At the same time, the paper provides a complex overview of the topic, which is being often discussed nowadays, mostly due to a big retention potential of mountain Peat Bogs. The paper is based on detailed measurements of groundwater levels in a selected experimental drainage ditch in the catchment of the Rokytka stream. Basic statistical characteristics, the equation of Penman-Montheit or antecedent precipitation index were used to show the dependence of groundwater level on precipitation or evapotranspiration. The results show a positive influence of the restoration measures on Peat Bogs. In this case it has been confirmed that restoration measures cause increase of groundwater level and decrease its fluctuation in the Peat Bog.

Keywords: Peat Bog, groundwater level, the Šumava Mts., Peat Bog restoration

Received 27 August 2016; Accepted 1 June 2017; Published online 19 July 2017

1. Introduction

In the context of occurrence of hydrological extremes (floods, droughts), the increase of retention ability of headwater areas has recently become a fundamental question. The headwater area of the Otava River is characterized by a great amount of Peat Bog complexes, whose hydrological regime has not been completely uncovered yet, in spite of numerous analyses (Janský and Kocum 2008). The most recent studies emphasize that the occurrence of Peat Bogs in a catchment increases the extremity of flow (Holden et al. 2011; Holden et al. 2001; Ferda et al. 1971; Čurda et al. 2011).

The increase of a discharge in streams which have been restored is particularly significant at the Šumava Mts. catchments (Čurda et al. 2011). However, Peat Bog restoration measures could also have a negative effect on runoff process during flood events (Holden et al. 2011).

Restoration measures contribute greatly to a decrease of fluctuation of drainage ditches in the cases of mean and low flow. However, in the case of a higher water content caused by intensive precipitation, the barriers, which retain water in a catchment, might have negative effects on area retention capacity. After an excess of retention capacity of these barriers, an intense and rapid increase of flow follows, reaching a higher extremity (Čurda et al. 2011). Organic soils or other waterlogged areas saturated with water can then function as an outflow accelerator. Despite the fact that organic soils have a great retention capacity for water, releasing it gradually to the streams, their retention capacity is not applied in the case of water saturation (Šefrna 2004).

The depth of groundwater in organic soils is a very important factor for Peat Bog ecosystems. In an undisturbed Peat Bog, groundwater is situated very close to surface for most of the year and water fluctuation is largely limited (Holden et al. 2001). The changes in groundwater level concern mainly Acrotelm, which is characterized by higher porosity. Lower situated Catotelm includes more decomposed organic material with smaller pores and lower hydraulic conductivity, so the water movement is extremely limited there (Rizzuti et al. 2004). The combination of the characteristics of Acrotelm and Catotelm thus makes Peat Bogs a significant water reservoir with a unique hydrological regime in the area (Holden et al. 2011). Dynamics of groundwater level is also significant during a low precipitation period. Peat Bog reacts very fast. The rate of groundwater level changes can reach several centimeters per day (Vlček et al. 2012). The main factors influencing groundwater level in Peat Bogs are precipitation, evapotranspiration, topography and, in a local scale, also peat porosity and hydraulic conductivity (Allott et al. 2009).

The main changes in the Šumava Mts. Peat Bogs have been caused by efforts of draining and drying. Peat Bogs have been traditionally drained for the purpose of peat exploitation, agricultural land cultivation, or increase in wood exploitation in waterlogged forest areas. Nevertheless, the extent of surface drains was already considerable at the turn of the 19th and the 20th century. However,

https://doi.org/10.14712/23361980.2017.11
Doležal, T. – Vlček, L. – Kocum, J. – Janský, B. (2017): Evaluation of the influence of mountain peat bogs restoration measures on the groundwater level: case study Rokytka peat bog, the Šumava Mts., Czech Republic
AUC Geographica, 52, No. 2, pp. 141–150

the major period of drainage digging was in the 70s and 80s of the 20th century. Nowaday, the drainage systems are still visible. Stocktaking researches have displayed that drainage has affected almost 70% of Peat Bogs in the Šumava Mts. (Bufková 2013). The open system of drains causes especially: fast surface flow, steeper culmination, and higher fluctuations of groundwater level (Ballard et al. 2011). Performed restorations can improve these aspects and consequently increase the groundwater level by several centimeters in a year (Worrall et al. 2007). A research from Schachtenfilz in the Bavarian Forest has confirmed that restoration measures increased groundwater level and decreased its fluctuation (Bufková 2013).

Since 1998 a complex restoration program has been implemented in the area of the National Park of Šumava (The Program of Restoration of Šumava Wetlands and Peat Bogs). The program is primarily aimed at a general improvement of disturbed water regime in the Peat Bog area (Bufková et al. 2010). A concept of so called "target water level" has been exercised during the restoration in the Šumava Mts. The method is based on determination of necessary water level, which is particular for each Peat Bog, eventually for their parts, and which is desirable to be achieved by restoration measures. The necessary water level can be described as a maximal tolerated decline of water in a ditch under the dam head, which is bearable for a given type of a Peat Bog (Bufková 2006). However, the increase of water level can be only observed few meters from a restoration because groundwater level is no longer influenced by the drainage system in a further distance from the drainage ditch (Wilson et al. 2011; Holden et al. 2011).

Peat Bogs are physically and ecologically adapted on the depth of groundwater level. The depth has a great significance for ecological niches of vegetative species and hence even for peat development (Kværner and Snilsberg 2011). The response of groundwater level on an exercised restoration is usually very fast; nevertheless, the changes in water chemism and consequent reactions of Peat Bog species are very slow. Peat Bog vegetative species are vulnerable and sudden changes of pH factor or changes in the amount of nutrients after exercising restoration can also have negative effects. Peat Bog restoration consequently includes stabilization and increase of groundwater level and a repeated habitation of the standpoint by Peat Bog species. It is thus important to limit the amount of water drain (Holden 2005).

However, there are still several problems, namely uncertain influence on water drainage ditch and water chemism, uncertain response species on water regime changes, and the price for restoration (Holden 2005).

The main aims of this paper are:

- to establish the influence of a drainage ditch on groundwater level in an experimental catchment;
- to determine dependence of groundwater level behavior on evapotranspiration and precipitation and its influence on groundwater level changes;
- to describe differences in groundwater levels near a functional drainage ditch and near a restored part of a drainage ditch (increased water level in the ditch due to a wooden dam).

2. Site description

The catchment of the Rokytka stream (Fig. 1) is located in the central part of the Šumava Mts. The whole complex of Rokytka Peat Bogs is placed on moderate slopes near the bottom of the Rokytka stream valley. The complex comprises several large and many small mountain Peat Bogs, which are surrounded by forest Peat Bogs, waterlogged pine stands, and minerotrophic sedge Peat Bogs (Bufková 2009). The total area of the Peat Bog is almost 250 ha. The depth of large Peat Bogs is about 5 m. Although in some locations, it can reach up to 7 m (Bufková and Spitzer 2008). Height relations of the catchment are consistent with the location of the central flat areas of the Šumava Mts. The altitude alters between 1089 and 1244 m a.s.l. The Rokytka catchment is rather flat in spite of its high altitude. The average gradient of slope is only 4°. Only exceptionally the gradient of slope reaches up to 10°, with the maximum of 12° (Jelínek 2009).

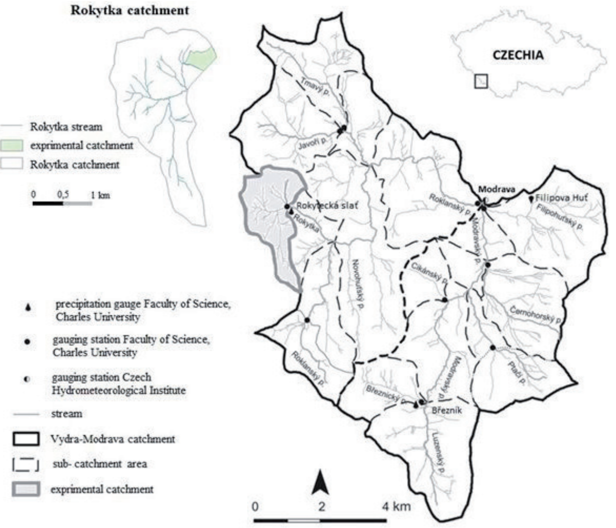

Fig. 1 The catchment of the Vydra River with the positions of gauging stations of the Czech Hydrometeorological Institute and automatic level gauges and precipitation gauges of the Faculty of Science, Charles University. The Rokytka stream catchment and the monitored experimental catchment is highlighted. Source: Kocum, Janský (2009).

The research of the Rokytka Peat Bog was focused on a selected experimental drainage ditch, which is located in the northern part of the catchment, at 1100 m a.s.l., and which drains an area of 0.14 km^2. The drainage ditch was partially dammed by small restoration dams; partially it was left functional, with a depth of 1 m.

In terms of soil cover, the soil region consists of entic Podzol, even of Rankers in steep slope areas (Šefrna 2004).

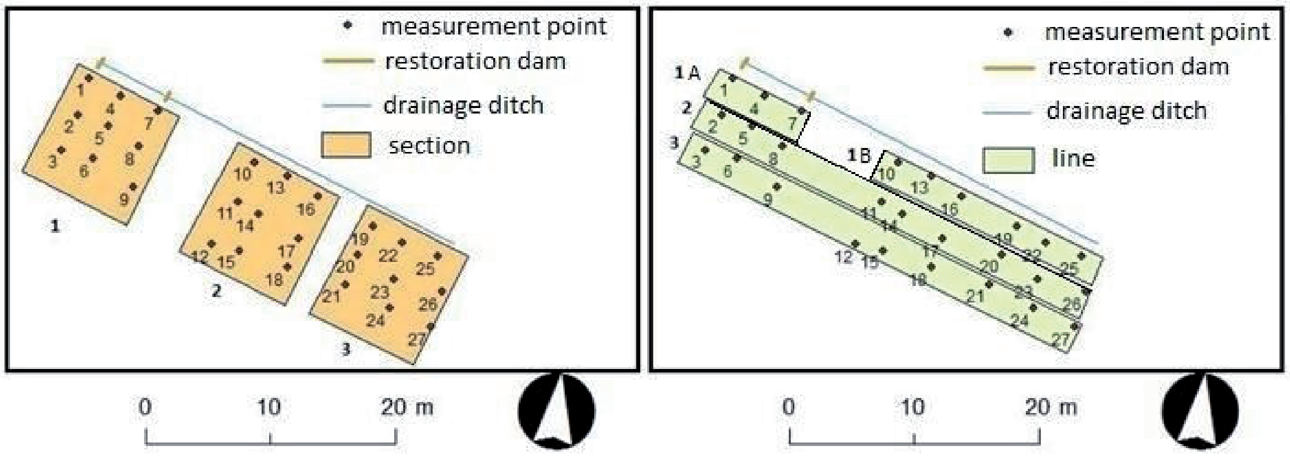

Fig. 2 The scheme of particular measurements of groundwater level and of the segments where the groundwater level was measured.

The soil of the researched catchment is a typical example of soil of the Šumava Mts., where a vertical sequence of soil is typical. Organic soil only occurs in watersheds and at the bottom of the valley. The catchment of Rokytka is mostly covered by Histosols. A peaty Gley can be found in some parts of the stream floodplains. Gleys are represented only marginally. The monitored drainage ditch is located in the part of a Peat Bog with a prevailing occurrence of fibric organic soil. The total area of organic soils in the catchment is 0.87 km^2, which stands for 23% of the whole area (Vlček et al. 2012).

In the area of interest, there are two precipitation gauges with long data series. It is Březník (1150 m a.s.l.) and Modrava (1000 m a.s.l.). The annual precipitation in Březník alters between 1100 and 1300 mm. The long term average of annual precipitation from Modrava is 1100 mm (Kocum 2012).

The annual discharge minimum can be measured at the end of February (before the snow melting) or in September (at the end of summer, a dry period). Discharge maximum is generally in spring, when the snow melts. A significant fluctuation in the outflow can also be seen in the summer period, due to a higher frequency of intensive precipitation. However, this fact does not influence the average monthly discharge variability, which might be caused by short duration of precipitation (Kocum 2012).

The vegetation in the Rokytka catchment is formed by a relict plant community. Low grass with the growth of *Trichophorum caespitosum* can be found there, predominantly. It blends in a mosaic pattern with the hydrophilic vegetation of shallow oblong depressions and the edges of lakes. It is made of a mat of *Sphagnum cuspidatum* and *Sphagnum majus* with the growth of *Carex limosa* and *Scheuchzeria palustris*. One of the constituents of *Trichophorum caespitosum* are obvious, large, and cambered bults with reddish types of peat as *Sphagnum magellanicum*, *Sphagnum russowii* or *Sphagnum rubellum* (Bufková 2009). In the surroundings of the monitored drainage ditch, the herb vegetation is formed by *Vaccinium uliginosum*, *Empetrum nigrum* or *Andromeda polifoli*a are also plentifully represented here. Nevertheless, the most dominant is vegetation primarily *Pinus mugo*.

3. Methodology

Groundwater level measurements were implemented during the period from August 14, 2014 to October 31, 2014. The groundwater level was measured manually in tubes which were inserted into the peat to a depth of 1–1.5 m. The water levels were measured in lines which were copying parts of the drainage ditch and the distance between measurement points was 3 meters. Thus, a regular net with 27 groundwater level measurement points, placed in regular distances, was created. The groundwater level was measured from the surface. For this purpose, particular segments were created from the measuring areas and the groundwater levels were then compared with each other within the scope of the individual sections and lines (see Fig. 2). The line 1 was divided into part A and part B for better accuracy. Part A is located directly to restoration dams and part B is placed in area which is not affected of restoration measures. At the same time, tubes were located by a total station, so the exact location of measurement points is known and therefore maps and interpolations could be created. At each point, 28 values of groundwater level were measured. Further, particular level changes were statistically evaluated in the scope of individual sections and lines to better demonstrate the dependence of groundwater level fluctuation on the distance from a drainage ditch, or from restoration dams. Data of groundwater level from an automatic station in Rokytka Peat Bog were also used. Additionally an interpolation method "natural neighbor" was applied to obtain range information. At first, the whole dataset was analyzed by basic statistical characteristics and data testing. For distribution of measured values of groundwater level in various intervals box plots were used. Statistical characteristics variance, correlation coefficient and directive deviance were calculated. All the statistical

Tab. 1 Statistical characteristics of groundwater level fluctuation in sections and lines.

	line 1A	line 1B	line 2	line 3	section 1	section 2	section 3
Number of measured values	84	168	252	252	252	252	252
Average groundwater level (cm)	13.04	23.04	18.13	10.49	10.95	17.93	19.37
Medium (cm)	12.90	24.70	18.90	10,80	11.20	15.85	18.90
Minimum (cm)	0.10	7.50	2.30	0.10	0.00	6.30	4.80
Maximum(cm)	28.00	50.00	42.00	30.00	28.80	50.00	50.00
Variance	28.98	69.16	53.94	30.67	46.98	63.09	52.72
Directive deviation	5.39	8.31	7.34	5.54	6.85	7.94	7.26

procedures were calculated in a statistical software StatSoft Statistica.

Groundwater level fluctuation was put into context with particular significant factors of rainfall-runoff process. One of them is potential evapotranspiration (equation 1). In this research, Penman-Monteith equation was used for the determination of daily potential evapotranspiration. In this case, the daily potential evapotranspiration is calculated according to the following equation:

$$\mathrm{PET}_0 = \frac{0.408 \cdot \Delta \cdot (Rn\text{-}G) + \gamma \cdot \dfrac{900}{T+273.16} \cdot \mathrm{u} \cdot (\mathrm{e_s}\text{-}\mathrm{e_a})}{\Delta + \gamma \cdot (1+0.34 \cdot \mathrm{u})} \quad (1)$$

where Δ represents the inclination of water vapor saturation curve in dependence on temperature [kPa °C^{-1}], *Rn* radiation balance [MJ m^{-2} day^{-1}], *G* flow of heat into soil [MJ m^{-2} day^{-1}], *ϒ* psychometric constant [kPa °C^{-1}], *u* speed of wind [m s^{-1}], $(e_s - e_a)$ saturation deficit of air in elevation z [kPa], *T* average air temperature [°C] (Penman, 1948).

The antecedent precipitation index API (equation 2) is also applied in this paper. The index is used for determination of catchment saturation and it expresses the influence of precipitation which occurred in previous days to the given date. It thus demonstrates the ability of a catchment to absorb more precipitation. For the purpose of this paper, the API index was calculated for five previous days according to the following equation:

$$\mathrm{API} = \sum 0.93^{i} \cdot P_i \; (2)$$

where "*i*" stands for the number of the day counted back from the date, which API is counted for, *P* daily amount of precipitation, [mm] in the *i*-th day before the causal precipitation (Mishra and Singh 2003).

4. Results

4.1 Statistical evaluation of groundwater level fluctuation

When basic statistical characteristics were used, significant differences between the areas lying near restoration dams and those with the absence of restoration were ascertained. At first, statistical differences were tested in sections using analysis of variance ANOVA. Significant differences on the probability level ($p < 0.05$) were proven. The resulting coefficients were significantly higher than the critical value of the distribution ($31.5 > 3$). It means that high differences between data sets were detected. However, the analysis was not able to show where exactly the differences occurred. Due to this fact, a t-Test was used on the probability level ($p < 0.05$). The only significant difference was detected between section 1 and section 3. In other cases, the differences were not prominent.

In the case of lines, a uniquely high difference can be found in the biggest proximity of the drainage ditch (line 1A and 1B), Fig. 3. The difference between average groundwater levels in these two lines during a monitored period was 10 cm. The data from a distance of 6 m from the drainage ditch are very similar to line 1A from the location with restoration measures. Consequently, it can be presumed that in the distance of 6 m from restoration measures, the behavior of the groundwater level seems natural. The amplitude in the distance of 6 m from the drainage ditch was only 29.9 cm. It is very similar to line 1A which contains data from the area with restoration measures. A similar divergence can be seen during evaluation of particular sections. In the scope of section number 1 (Fig. 3), which is the closest one to the exercised restoration, it was proven that the groundwater level is less fluctuated and that it remains near the surface. In this section, the average groundwater level was 10.95 cm and the amplitude was 8 cm. On the contrary, in the furthest section, the average groundwater level, for the monitored period of time, was 19.37 cm and the amplitude reached up to 45.2 cm. Thus, in the proximity of restoration, the level of groundwater is located 8.42 cm higher on average.

In Table 1, statistical characteristics of groundwater level fluctuation in sections and lines are shown. For example, line 1B, which is the nearest to the drainage ditch without restoration measures, expresses the highest numbers in variance and in directive deviations. On the contrary, the furthest line 3 and line 1A with restoration measures have significantly lower values. When sections were compared, it was observed that section 1, which is the closest to restoration, disposes of the lowest numbers

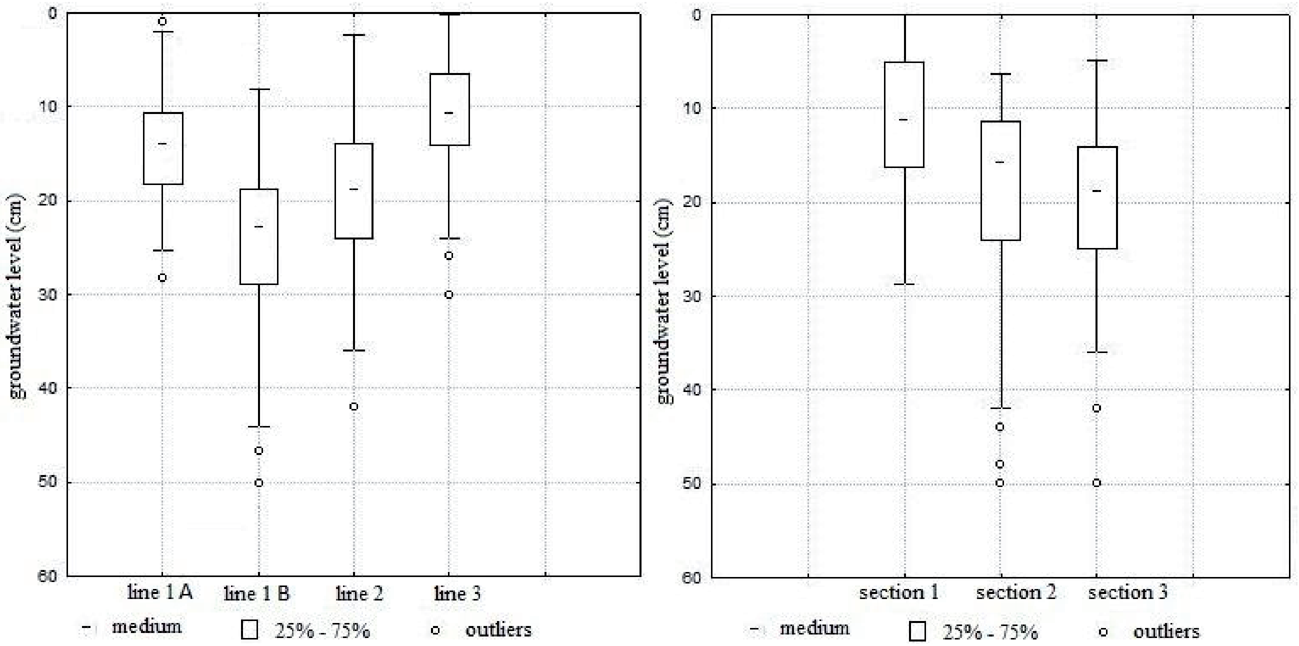

Fig. 3 Groundwater level fluctuation in the scope of particular sections and lines.

in variance and in directive deviations. Further sections show expressively higher values which point to a positive influence of restoration measures on fluctuation and on groundwater level.

The highest groundwater level can be found at measuring points in the proximity of restoration. The above mentioned statement, that the higher the distance from the drainage ditch, the higher the groundwater level, is also confirmed here. Another important finding is that in the distance of 6 m from the drainage ditch, the drainage effect can no longer be seen.

4.2 The dependance of groundwater level on meteorological factors

In particular sections, the groundwater level fluctuation was compared to the difference between precipitation and evapotranspiration between measurements.

It was found that these two factors are the most essential ones for groundwater level. A dependence was visible in Fig. 4, moreover, with quite high coefficients of determination. The dependence was proven most significantly in the section located the closest to the drainage ditch. Consequently, a daily groundwater level fluctuation can be rather accurately estimated and explained with the regard of these two factors.

A few values of decrease of groundwater level were also observed when precipitation was higher than evapotranspiration. This fact could be caused by an interception. During a lower precipitation period, rainwater is probably intercepted by trees, which growth rather densely in the experimental area.

For the quantification of the dependence, coefficients of determination and other correlation coefficients were calculated. Correlation coefficients in Table 2 reach very high values. The dependence of groundwater level on precipitation and evapotranspiration is statistically significant in sections 1 and 3.

Tab. 2 Correlation coefficients and determination coefficient in particular sections, mark * is statistical significant at probability level, $p < 0.05$.

	section 1	section 2	section 3
Coefficient of determination (level change; ET-precipitation)	0.869*	0.770	0.842*
Correlation coefficient (level change; ET-precipitation)	0.755*	0.593	0.708*
Correlation coefficient (average level; API)	−0.532*	−0.306	−0.511*

The same approach was exercised at the automatic station at Rokytka Peat Bog. The difference is in the fact that the station is in a sufficient distance from the drainage ditch and therefore it is not influenced by melioration. It was revealed that the difference of precipitation and evapotranspiration describes the actual course of groundwater level more precisely (see Fig. 5). The moving average of the difference of precipitation and evapotranspiration follows precisely the process of groundwater level changes. The changes of groundwater level in an area with no human influence in Peat Bog can be expressed more precisely and its course corresponds better to meteorological factors.

4.3 Groundwater level fluctuation during chosen episodes

The variability of groundwater level is also an important factor. Two episodes have been selected for an evaluation. The first one, an episode of intensive precipitation

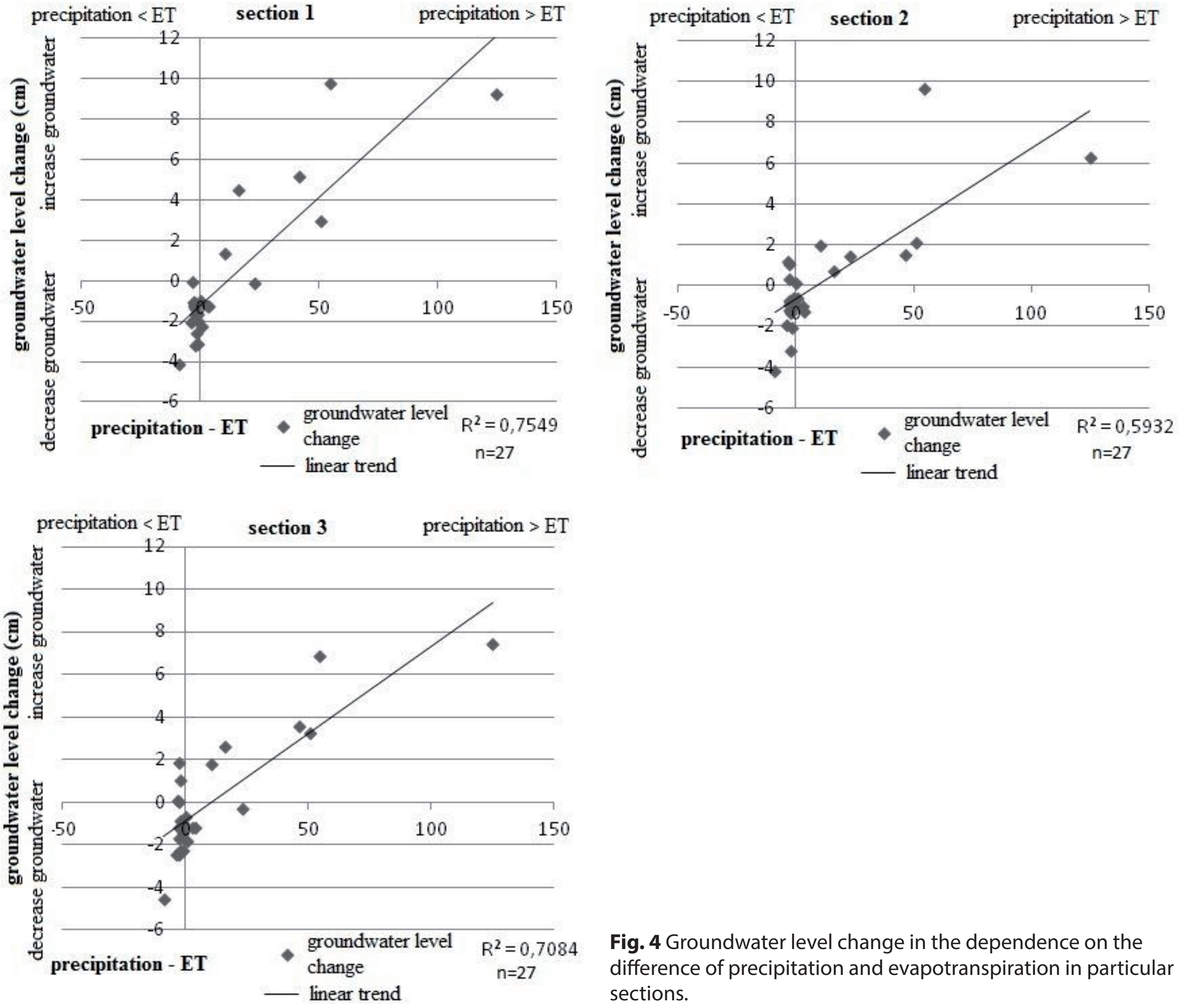

Fig. 4 Groundwater level change in the dependence on the difference of precipitation and evapotranspiration in particular sections.

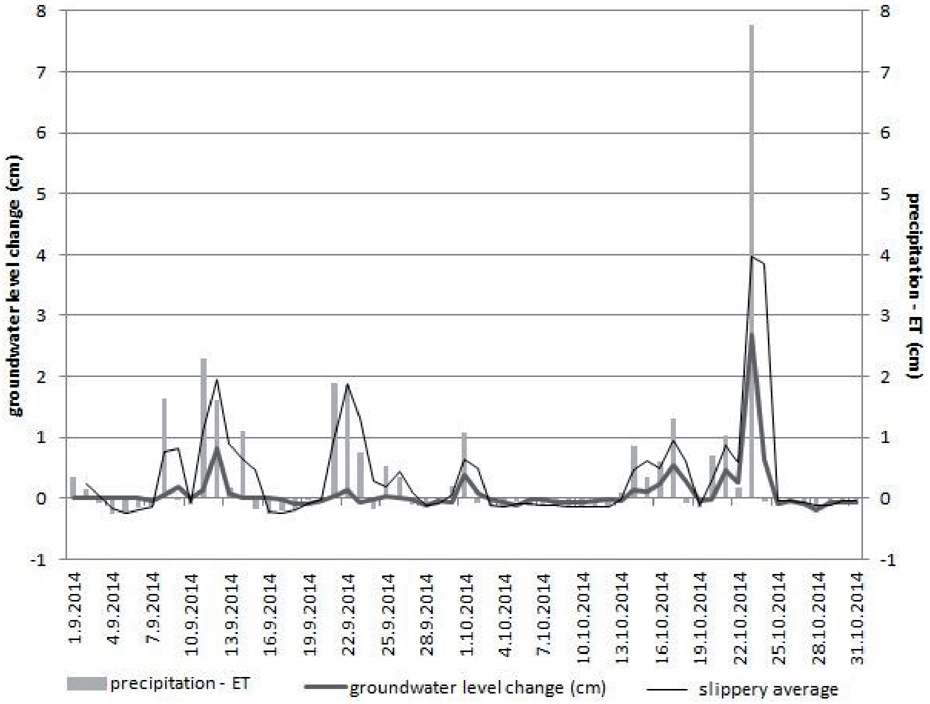

Fig. 5 The fluctuation of daily average groundwater level in dependence on the difference of precipitation and evapotranspiration in Rokytka Peat Bog, from the September 1, 2014 to October 31, 2014. Source: Data from the automatic station of Faculty of Science, Charles University.

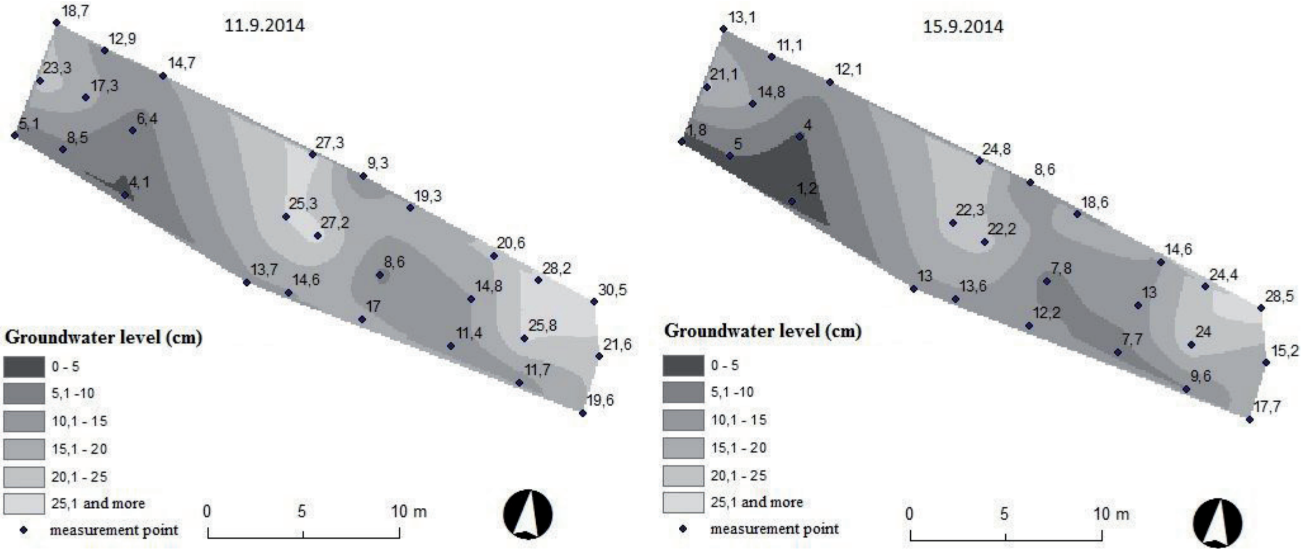

Fig. 6 Changes of groundwater level during a selected episode of intensive precipitation between the September 11, 2014 and September 15, 2014. The given numbers in the graph represent measured groundwater level in centimeters on a given day.

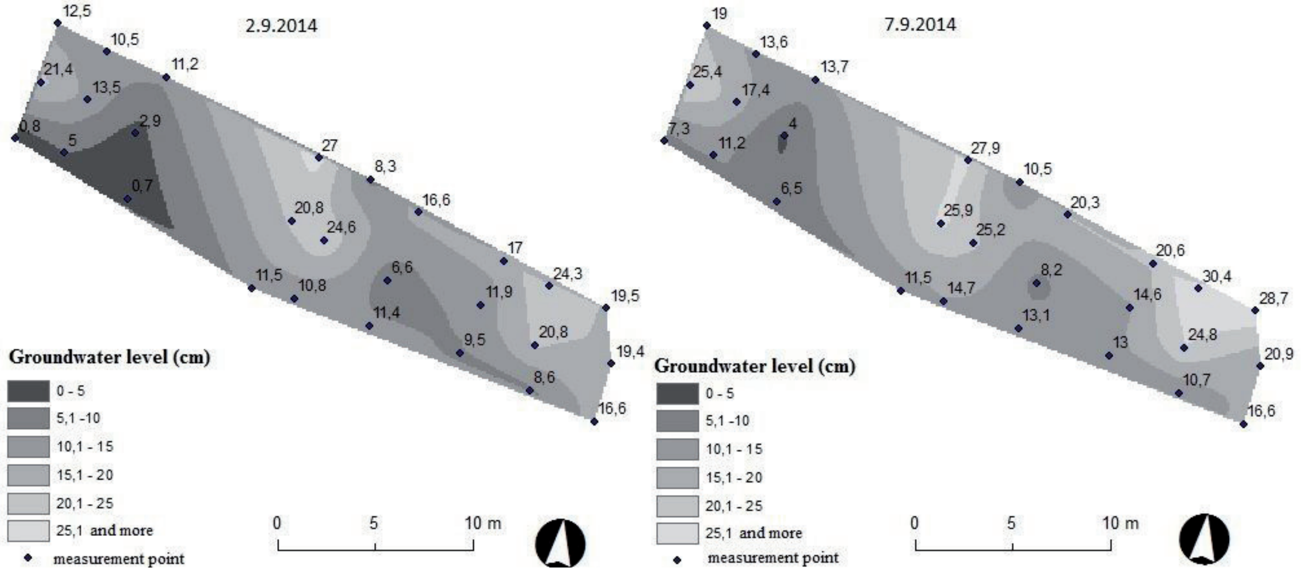

Fig. 7 Changes of groundwater level during a selected episode of drought between the September 2, 2014 and September 7, 2014. Given numbers in the graph represent measured groundwater levels in centimeters on a given day.

(55.4 mm), was analyzed between the September 11, 2014 and September 15, 2014 at the Rokytka catchment. It is obvious that groundwater level along the drainage ditch shows a high amplitude, see Fig. 6. With longer distance from the drainage ditch, the groundwater level increases and its change during an episode decreases. The level is the highest in the section close to restoration dams. Their influence is perceived as positive, as they raise groundwater level. They also have a stabilizing effect. However, the results also imply that in a certain distance from restoration dams, their effects can no longer be seen and groundwater level fluctuates naturally as in the Peat Bogs, which are not influenced by a drainage. It is also evident that the decreases or increases of water level are very variable and there are noticeable differences between individual points, in spite of the fact that it is a small homogenous area. The difference between the spot with the highest and with the lowest decrease is 6.4 cm. On the contrary, in the areas near restoration dams, the groundwater level was increasing very gradually and a similar increase was reached at all the measurement points.

Another observed episode was during a dry period, when there was only 1.4 mm of precipitation from the September 2, 2014 to September 7, 2014 (see Fig. 7). The smallest changes of groundwater level in a period with low precipitation were reached in the middle line of the observed area, precisely in the distance of 3 m from the drainage ditch. It is interesting that in this episode, rather big amplitudes can be found, even in the area of restoration. It can be caused by the fact that before the period of drought, the groundwater level was very high, precisely right under the surface; hence, following decreases could have progressed faster there. The biggest difference between water levels is significant again and it is even up to 9.2 cm during the monitored five day range. It has been confirmed repeatedly that in the areas located further from restoration, the groundwater level is distinctly lower and, moreover, there is a remarkable and fast fluctuation of groundwater, which is not beneficial for the evolution of mountain Peat Bogs.

5. Discussion

The results of the research conducted in Rokytka Peat Bog are in correspondence with other national and international researches concerned with the same subject (Bufková 2013; Vlček et al. 2012; Worrall et al. 2007; Wilson et al. 2011). The most significant finding is that restoration measures have the ability to increase groundwater level and to decrease its amplitude. In this case, it was statistically observed especially in line 1A, which contains data from restoration measures. At the point of restoration, the mean groundwater level was up to 10 cm higher than at a place with no restoration, similar to Worrall et al. (2007). Holden's research (2011) brings the difference of 4 cm. Ketcheson and Price (2011) demonstrated that the size of groundwater level change depends on many factors. Similar results in the Šumava Mts., particularly in the Schachtenfilz Peat Bog, were achieved, for example, by Bufková (2013), who declared that after three years from a restoration, the average groundwater level increased and its fluctuation was considerably reduced, especially in the most disturbed parts of the Peat Bog and in the forest cover of peat and pine grove. In our case it was also statistically significant.

The groundwater level increases more steeply perpendicularly from the drainage ditch in the area of restoration in contrast with the area without restoration. Thus, it can be presumed that restoration measures have an important role in the attenuation of negative effects of a drainage ditch. It was confirmed by a research of Haapalehto et al. (2011) who found that damming and filling of the ditches resulted in a raised groundwater level in the restored bog and fen systems by several centimeters. However, in a certain distance, these differences decrease and groundwater level behaves naturally as in a Peat Bog with no human disturbance. This statement is also confirmed by the work of Wilson et al. (2011). Although, it was revealed that particular changes of groundwater level can be rather variable, in spite of the fact that the researched area was small and very homogenous. Vlček et al. (2012) notes that daily relations of groundwater level are quite fast and they can reach several centimeters during a day. In this case, even higher values were observed in some areas, due to the fact that in the proximity of the drainage ditch, significantly higher amplitudes appeared, compared to the further located areas from it. Thus, it was proven that the influence of restoration measures on groundwater level is positive in this case.

This research has also demonstrated that the evaluation of factors of precipitation and evapotranspiration is sufficient to clarify precisely the changes of groundwater level in Peat Bogs. It is manifested predominantly by high values of correlation and determination coefficients. On the other hand, a little decrease was observed in the groundwater level, even though there was a higher precipitation than evapotranspiration. It could be caused by interception during a low intensity rain. Kellner (2003) and Allott et al. (2009) note that the size of evapotranspiration from wetlands is variable. General factors influencing the evapotranspiration are surface conditions, such as roughness, temperature, and dryness, together with the air temperature, humidity, and solar radiation. Since the climatic factors vary significantly, it is hard to generate absolute values without a great uncertainty.

The correlation of groundwater level with the index of previous precipitation manifested itself in the same manner. An important aspect of the paper was also to refer to space variability of groundwater level changes. Though the observed area is small and homogenous, a high variability in groundwater level changes appeared even during selected episodes. The difference between maximum increase and decrease reached up to 9.2 cm during five days. Ketcheson and Price (2011) reminded that topographical variability and the location of the dams can strongly influence the magnitude of the groundwater level rise at any given location. Price et al. (2003) notes that groundwater level also depends on the depth of the ditch, the distance between ditches, and the hydraulic conductivity of the peat. For example, Wilson et al. (2011) observed conflicting results in a few experimental locations, when after drain blocking, groundwater level was deeper than before blocking. It shows that in a Peat Bog, there are some places with non-standard local specific water regime.

Changes of groundwater level were especially prominent in the areas far from restoration. It was also discovered that the lowest deviations (0.48 cm) were achieved at the automatic station, which is not influenced by melioration. The moving average of the difference between precipitation and evapotranspiration at this point demonstrated that it copies the natural course of groundwater level changes very accurately. This statement is confirmed by another research (Vlček et al. 2012), which was also implemented in Rokytka Peat Bog; similar daily changes were observed, approximately 2–3 cm according to the temperature and precipitation. A rapid and sudden increase of groundwater level during intensive precipitation was also confirmed (Kučerová et al. 2009). Despite the fact that many factors are involved in groundwater level changes, the dependence can be largely explained by the difference between precipitation and evapotranspiration. It was observed also in Wilson et al. (2011).

6. Conclusion

The headwater area of the Otava River is characterized by a high portion of Peat Bogs, thus it is an area with a very specific hydrological regime. In the context of the occurrence of hydrological extremes, it is very important to pay attention to the retention potential of the areas.

The most significant outcome of the paper is the demonstration of positive effects of a restoration on groundwater level. It was proven that restoration decreases fluctuation and increases groundwater level, which is essential for a natural evolution of a mountain Peat Bog. The main factors of groundwater level fluctuation are predominantly evapotranspiration and precipitation; the explanation of this phenomenon is demonstrated by high values of determination and correlation coefficients. The paper thus contributes to the understanding of the retention potential of peat complexes, which is essential for the understanding of the hydrological regime of the Otava River. This part of the Šumava Mts. can consequently offer other valuable findings, due to its significant retention potential.

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