CLIMATE CHARACTERISTICS OF SPECIAL NATURE RESERVE „OBEDSKA BARA"(SERBIA)

Aleksandar Krajić[1], Dejana Jakovljević[2], Dorin Lozovanu[3]

Abstract. Special Nature Reserve Obedska Bara has moderately continental climate, characterized by slightly cold and conservative climate, which is manifested through the following physiological sensation of heat: cold, very fresh, comfortable and weakly sultry. Essential climatic characteristics exert as abiotic climatic factors on wildlife. Air temperature affects the growing season, the types of vegetation present and wetland primary productivity. Air pressure impacts on animal activity. Wind influences on subjective temperature sensation and in plants on transpiration, reproduction and distribution. High humidity impedes insects in flight, forces frogs to leave ponds, contributes propagation in some plants and asphyxiates others. High insolation causes germination and foliation and awaking from hibernation of mammals, reptiles and amphibians, while low insolation forces animals to take shelter in hiding places. Under wet – dry cycles, species are frequently annual, and are destroyed either when the wetland dries (submerged species), or when it is re – inundated (emergent species).

***Keywords**: climate, ecosystems, wetlands, Obedska Bara*

1. Introduction

Wetlands are often dynamics environments that are transitional between terrestrial and aquatic ecosystems. The essential components for wetland formation include an excess of precipitation over evapotranspiration, flat – lying terrain or depressions in the landscape and low permeability of underlying soils or bedrock (Mortch 1998). Most environmental parameters govern the maintenance and dynamics of aquatic communities (Bornette and Puijalon 2011). Wetlands are exposed to widely fluctuating environmental conditions with periodic changes in inundation, temperature, and water quality (Ramdani et al. 2001). Wetlands develop in different ways and at different speeds according to the climate and geology of the region and the concomitant geomorphological processes (Espinar and Serrano 2009).

Climate exerts direct and indirect impacts on wetlands. Solar radiation, precipitation, and other elements broadly define ecoclimatic zones and the distribution and composition of wetland regions. Indirectly, solar radiation, temperature, evaporation, precipitation, and wind influence wetlands through long – term change in the water balance (Mortsch 1998). Temperature, humidity and air movement influence transpiration rate (Xu et al. 2009).

[1] University of Belgrade, Faculty of Geography, Studentski trg 3/III, 11000 Belgrade, Serbia
[2] Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Djure Jakšića 9, 11 000 Belgrade, Serbia, e-mail: jakovljevicdejana@yahoo.com, Telephone: +381 64 208 59 86
[3] "Al.I.Cuza" University of Iasi, Faculty of Geography and Geology, POSDRU/89/1.5/S/49944, dorinlozovanu@yahoo.com

2.Material and methods

2.1. Site description

Special Nature Reserve "Obedska Bara" is located in Pannonian Serbia, in the southern Srem, along the left Sava riverside (46 – 95 river km), on alluvial plain and loess terraces. It includes areas of Ashanya, Kupinovo, Obrezh (Pechinci municipality), southeastern part of area Grabovci (Ruma municipality) and southwestern part of area Progar (Surchin municipality). It extends from 44º 38' to 44º 50' N and from 19º 47' to 20º 09' E. It consists of the following spatial units: Kupinske beams, Chenyin, Widths, Vitojevachko and Grabovachko islands, Kupinski angle, Jasenska, Matijevica, Kadionica, Bena, High Forest and Loshinci. Obedska Bara is the largest wetland in Serbia, because it is flooded nearly 12,000 ha during high water levels of Sava. Alluvial plain with the width from 1.7 to 7 km is intersected by beams and dales alternatively. Oak forests with ash and hornbeam grow on the beams, while arc ponds are located in the dales. Narrow area of the reserve is cut off meander, a fossil river bed of the River Sava, called Horseshoe, with the length of 13.5 km and average width of 750 m. The elevation ranges from 71 m in dales and ponds to 82 m on the high banks above the Horseshoe (Puzović et al. 2010). Ecotone (transitional) territory of Obedska Bara belongs to biome South - European, mostly deciduous forests and biomes of steppe and wooded steppe (Vitanović 1996). The essential natural value of Obedska Bara is ecosystem integrity of marshes, ponds, wet meadows, forest, an oxbow, stagnant tributaries and pits, with extremely rich ecosystem and species biodiversity, which is characterized by the presence of rare and endangered species of national and international significance. It contains a numerous sensitive (fragile) ecosystems, especially wetland and ancient forests of Common oak and Italian oak with associated species of ash and elm.

Obedska Bara is one of the oldest protected areas in the world. First administrative protective measures have been introduced in 1874, when the Habsburg Empire protected it as hunting ground of the royal family. Yugoslavian Government has protected this area in 1919 for the first time as king hunting ground of dynasty Karadyordyevich and in 1951 as reserve. Municipality Pechinci has protected Obedska Bara as special nature reserve in 1968. Presently, it has first-category legal protection status, denoting a natural asset of exceptional value with the total surface of 9820 ha, since 1993. There is a three level protection regime, in which scopes are defined allowed and forbidden activities. Its status has been verified by the Ramsar Convention on swamps since 1977, and it is in the List of areas of special significance for birds of Europe of Important Bird Area Project N°041 since 2000, which contains of Special Nature Reserve "Obedska Bara" (98 km^2) and its protective zone (195 km^2) It is also on the UNESCO list of world's most important wetland areas.

In March and April this territory is inhabited by migratory birds: Black–crowned Night Heron (*Nytricorax nytricorax*), White Stork (*Ciconia ciconia*), Black stork (Ciconia nigra), Little Egret (*Egretta garzetta)*, Great Bittern (*Botaurus stellaris*), Pygmy Cormorant (Phalacrocorax pygmeus), Grey Heron (*Ardea cinerea*), Little Bittern (*Ixobrichus minutes*), etc. They stay here until the end of August (Gajić and Karadžić 1991).

Figure 1: Geographical position of Obedska Bara Special Nature Reserve

2.2 Data analysis

Data includes values of the following climatic elements: air temperature, air pressure, wind direction and speed, relative humidity, insolation, cloudiness and precipitation. Climatic conditions were studied based on data recorded at weather stations in Sremska Mitrovica (elevation 81 m above the mean sea level, 44°58′ N 19°38′ E) and Surchin (elevation 96 m above the mean sea level, 44°49′N 20°17′ E).

We have used mathematical – statistical analyses from this stations and the reduction on the mean annual and monthly values for the period 1976 – 2005 and the method of interpolation.[4] Method of observation have been used for considering cause - effect relationship among climatic elements and organisms.

---

[4] Interpolation of mean annual air temperature is calculated by the form:

$$t = (t_{sm} + t_s)/2,$$

where t is the mean annual air temperature of Obedska bara, t_{sm} mean annual air temperature at the meteorological station Sremska Mitrovica and t_s mean annual air temperature at the meteorological station Surchin.
Mean daily values concerning pressure, relative humidity and water vapour saturation were calculated by the form:

$$X_{srd} = \{(X_{srm7}+X_{s7})/2+(X_{srm14}+X_{s14})/2+(X_{srm21}+X_{s21})/2\}/3,$$

where X_{srd} is mean daily value of previous mentioned climatic elements, X_{srm7} and X_{s7}; X_{srm14} and X_{s14}, X_{srm21} and X_{s21} value of climatic elements at 7 h, 14 h and 21 h at the meteorological stations Sremska Mitrovica and Surchin.
Monthly values of precipitation and solar radiation duration were presented cumulatively, while the monthly values of air temperature, air pressure and relative humidity were obtained by the following formula:

$$\alpha_m = \sum\alpha_{srd}/n,$$

where α_m is monthly interpolated value of one of given climatic element, $\sum\alpha_{srd}$ is the sum of mean daily values of that climatic elements during the month, and n is a number of days of that month.
Mean monthly values of climatic elements were calculated by the following formula:

$$Y_{msrv} = \sum Y_m/p,$$

where Y_{msrv} is mean monthly value of that element, Y_m is the sum of monthly value for the certain period and p is that period (number of years). Their mean annual values were calculated in the same way. Results of mean monthly values were presented by using diagrams. The wind rose was presented by combined polar diagram.

3. Results and discussion

Air temperature affects the growing season, the types of vegetation present, and wetland primary productivity (Mortsch 1998). During the period from 1976 to 2005 the mean annual air temperature was 11.3 ºC, the mean air temperature in the growing season 18.3 ºC, while the mean air temperature of the warmest month (July) ranged from 19.2 ºC to 23.6 ºC and the coldest (January) from – 5.0 ºC to 3.8 ºC. The variations in air temperature ambient wetlands mainly depend on radiation equilibrium, ground temperature and the intensity of turbulent exchange (Xu et al. 2009). The mean amplitude of monthly values of air temperatures is 21.3 ºC. Expressed air temperature amplitudes occur in the spring due to the penetration of cold air masses from the northwest and they are accompanied by extreme weather conditions and often hail. In terms of bioclimatic, the autumn is much more pleasant for life than spring, despite lower value of average monthly air temperature (autumn: 11.5 ºC, spring: 11.7 ºC, summer 20.9 ºC and winter: 1.1 ºC), because there are no sudden changes in weather conditions. Considering thermal coefficient according to Cerner which amounts 2.35 this area has moderately continental climate (Milosavljević 1984).

Considering that the human comfort zone is between 16 ºC and 22 ºC, it can be concluded that it usually occurs from April to October, while the weather in the rest of the year is cool and cold (Figure 1). Tropical days, with air temperatures above 30 ºC occur mainly in July and August. During these days the riparian parts of the river Sava become the favorite picnic place, because they are fresher than hinterland. In this period, biodiversity of the wetland system is threatened not only by visitors, but also from overheating of pond water and its evaporation and drying. Warmer and drier climate may alter vegetation regime. For example, a change in the species or number of trees will significantly alter evapotranspiration, the dominant control on summer wetland hydrology (Schiff et al. 1998). In terms of growth forms, enhanced growth rates resulting from increased temperature may also increase competition and give advantage to tall competitive species, and ultimatively promote phytoplankton and turbid water stages to the detriment of clear macrophyte dominated water stages (Bornette and Puijalon 2011). Water temperature influences the rate of chemical and biological reaction (Mortsch, 1998). It has long been recognized as a major controlling variable for nitrification and denitrification rates. Nitrification rates become inhibited at the

---

Mean monthly intensity and density of precipitation were calculated by using the formula:

$$I_m = \{(P_{srm}+P_s)/2\} / \{(N_{srm}+N_s)/2\},$$

where I_m is precipitation intensity (mm/day), P_{srm} and P_s precipitation at the stations Sremska Mitrovica and Surchin, and N_{srm} and N_s number of days with precipitation at the stations Sremska Mitrovica and Surchin.
Combined bioclimatic methods: equivalent air temperature and cooling power were used in analyses of perennial relation between atmosphere and organisms. Equivalent temperature was calculated by using the formula:

$$Et = t + 2e \text{ (Pecelj, 1996),}$$

where Et is equivalent air temperature, t is air temperature and e is water vapour saturation.
The cooling power was calculated using the Hill equation which is complemented by Conrad:

$$H = (0,13 + 0,47\sqrt{v})\,(36,5 - t)\,0,9 \text{ (Vujević,1962),}$$

where H is the cooling power, v is wind speed, and t is air temperature.

water temperature of about 10ºC and drop rapidly at 6ºC (Kim et al. 2010). Most aquatic plant species exhibit optimal rates of photosynthesis at relatively high temperatures (between 20 and 35ºC and between 28 and 32ºC). Several authors consider that aquatic species have a limited capacity for thermal acclimatization. However, other have demonstrated that plants are still able to grow and multiply vegetatively at cool, and even cold temperatures, suggesting that the ability of species to acclimatize could be greater than expected (Bornette and Puijalon 2011). Water temperature also affects fish distribution and success (Mortsch, 1998). Due to overheating of pond water fish take refuge deep in the mud. Some fish species have adapted to dry summer periods, so they can survive drying of pond hiding in the mud (e.g. carp *Carassius Auratus*). During the tropical temperatures, weather conditions without winds and high humidity, sultriness occurs inside of the Reserve.

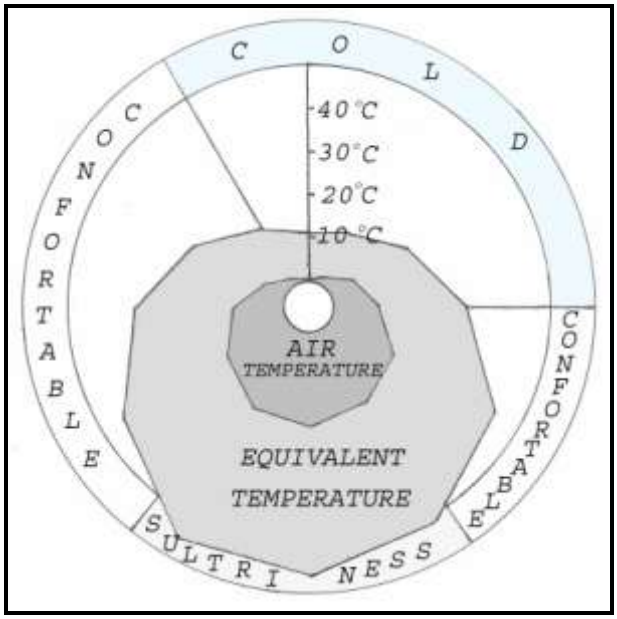

Figure 2: Polar diagram of real and equivalent temperatures with weather types in the period from 1976 to 2005 (The source: Meteorological yearbook 1 – Climatological data)

Frost days can occur in this area from October to April and then it can be kept from climate of overcooling. An extreme case occurred in 27th June 1777, when the frost destroyed crops (Dukić 1999).

Mean monthly air temperatures above 10 ºC occur during the seven months. This period begins in the late March and early April and lasts until late October, which generally coincides with the stay of migratory birds and the growing season.

Because people dissimilarly feel temperatures and wet or dry air, equivalent air temperatures are commonly used for determination of the bioclimatic benefits of the area (Pecelj 1996). According to the Krüger classification of the air equivalent temperatures (Vujević, 1962), in this area the following sensations of heat are present: *cold* (December, January and February), *very fresh* (March), *comfortable* (April, May, September, October and November) and *slightly humid* (June, July and August) (Table 1). Applying this classification it can be concluded the absence of one level of transitive sense between March and April (fresh) and two transitional levels between November and December (fresh and very fresh)

and on this basis it can be inferred that there are quite abrupt transitions between winter and summer and between autumn and winter.

Table 1: Classification of equivalent air temperatures on the area of *Obedska Bara* according to Milosavljević (in °C)

EQUIVALENT TEMPERATURES	SENSATIONS		REPRESENTATIVE MONTH
< 5	very cold	cold	–
5 – 18	cold		January, February, December
18 – 22	very fresh		March
22 – 30	fresh	comfortable	November
30 – 40	pleasant		April, October
40 – 50	warm		May, September
50 – 58	slightly humid	sultriness	June, July, August
58 – 70	humid		–
> 70	very hot		–

Source: Milosavljević, 1983.

The average annual air pressure from 1987 to 2005 amounted 1006.8 mb (1017.5 mb translated on the sea level). It ranged from 1005.9 mb (1988) to 1008.5 mb (1989).

The air pressure varies in the range from 1003 mb to 1011.6 mb during the year, while it can vary about 5 mb during the day. The air pressure during the year has three maximums (in January, June and October) and three minimums (in April, July and November). Months with a minimum air pressure are also the months with higher precipitation. Month with the highest value of air pressure is January and with the lowest is July (Figure 2).

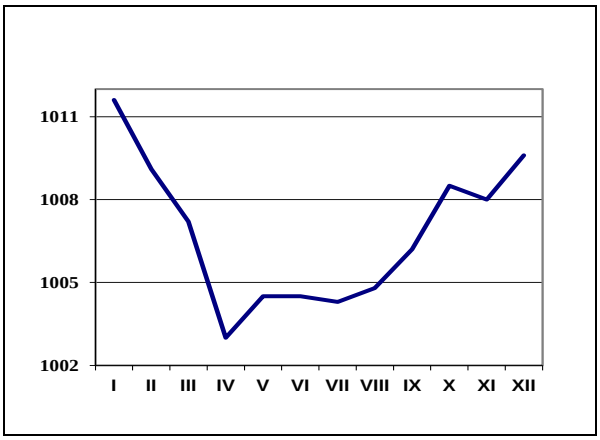

Figure 3: Mean monthly values of air pressure from 1987 to 2005 (The source: Republic Hydrometeorological Service of Serbia)

Observed by seasons, winter has the highest value of air pressure (1010.1 mb or 1021.2 mb translated on the sea level), then autumn 1007.6 mb (1018.3 mb), spring 1004.9 mb (1015.5 mb) and summer 1004.5 mb (1014.8 mb). High air pressure is characteristic of sunshiny, stable weather condition. During summer, in that condition, warblers sing all night.

For spring and early summer weather disasters are typical, accompanied, inter alia, by decline of air pressure. Such sudden changes in air pressure have negative effects on cardiovascular system, mental conditions, rheumatism and migraine in sensitive persons**,** while those in aquatic animals reflect as increased activity (at fish, it reflects in intensive nutrition).

Wind influences air humidity, subjective temperature sensation and in plants regarding transpiration, reproduction and distribution. Due to orographic conditions (hill – mountain ranges of Frushka Gora in the north and Cer, Vlashic and Avala in the south) the strongest winds over the area are from the west and east, while the most frequent winds are from the northwest and the southeast quadrants (Figure 3). Winds blow over the area 293 days in year.

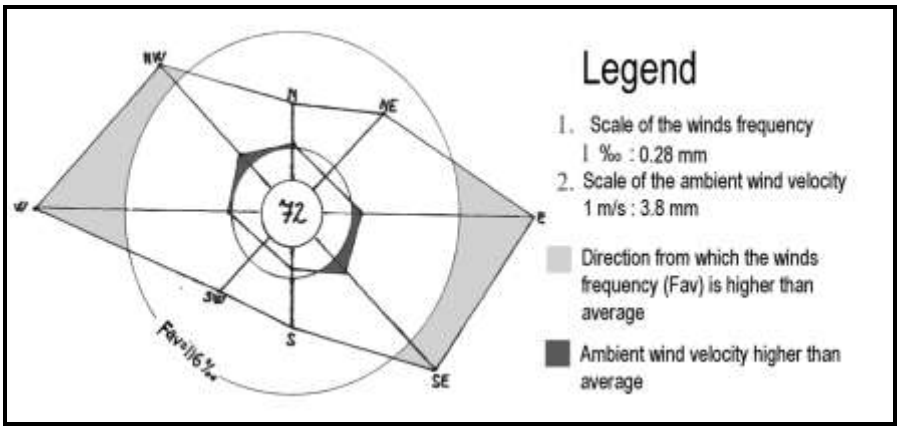

Figure 4: Mean annual wind rose for the period 1976 – 2005 (The source: Republic Hydrometeorological Service of Serbia)

Wind from the east and southeast direction, blows in gusts of 40 – 120 km/h. It occurs in all seasons, except summer and blows a few days up to a week, sometimes up to three weeks. It is especially inconvenient in winter, if there is a snowfall, because it causes snowdrifts which make problems in traffic. This wind is mainly dry, because in crossing the Carpathians it releases moisture excess and in descent it additionally increases absorbing capacity. East winds bring air masses from chilled Eurasian mainland. These are dry, continental air masses usually cold, which is characterized by clear and stable weather. In bioclimatology it is considered that these winds cause irritability in unbalanced persons (Dukić, 1999).

Winds from the west bring mostly precipitation, because they bring moist air from the big sea waters (Atlantic Ocean). In summer, this precipitation is manifested through strong showery rain, accompanied by thunder and wind storm, and in winter through calm and lasting secretions in the form of rain and snow. Storms break the branches of the trees and destroy nests during the summer and they are caused by the air mass collided with northern cold air masses and in this way cause damage to flora and fauna of Obedska Bara. From 1996 to 2005 it is recorded 36 thunder-storms. Often, during the summer, these storms are accompanied by hail. Because of that the network of hail suppression stations is created in Ashanya, Obrezh, Ogar and Grabovci.

South wind is also warm and moist, because it blows from African continent. As it crosses the Mediterranean Sea, it saturates by steam. Due to orographic condition it has small

frequency (7.3 %) and it acts as well as southeastern wind. It blows at low velocity (2.4 m/s) and it supports humidity which favours the growth of insects and lichens.

Wind from the north is always cold. Frushka Gora Mountain contributes to its small frequency (7 %). This mountain reroutes it and because of that this wind can appears as northeastern at this territory. It can cause the temperature drop about ten degrees, for the short time. In winter, it is uncomfortable for population and animals, because, when it blows, the subjective sensation of cold is more expressed.

Growing season duration depends on insolation and meridian air movement direction. Warm south air masses can extend vegetation season, in distinction to northern one, which diminishes it. In 1745, grass and full leafed forest has been recorded in March (Dukić 1999).

Migratory birds build nests on the sunny slopes or on the shady sides of trees. This indicates whether spring and summer will be hot or cold, while their early arrival suggests a warm spring and early departure suggests cold winter. The behaviour of the hooded crows before the calm weather is also interesting. Then they sit on a tree top looking at the different sides, while before the windy weather all of them look at the same direction (Dukić 1999).

Cooling power is combined bioclimatic element, as well as equivalent temperature. Mean cooling power from 1996 to 2005 was 833.17 kgJ/m²s (19.9 mg cal /cm²s). According to the Conrad typology climate is the transition between the conservative and slightly cold climate (Dukić, 1999) (Table 2). Mean monthly cooling power range between minimum in August (427.05 kgJ/m²s or 28.4 mg cal /cm²s) and maximum in January (1189.05 kgJ/m²s or 28.4 mg cal /cm²s).

Table 2: Values of cooling power in the area of *Obedska Bara* according to Conrad

Values of cooling power		**Climate types**	**Obedska bara**	
in kgJ/m²s	**in mg cal /cm²s**		**present**	**Total months**
< 418.7	< 10	overheated	-	-
418.7–837.7	10 – 20	conservative	√	7
837.7–1256.0	21 – 30	slightly cold	√	5
1256–1674.7	31 – 40	very cold	-	-
> 1674.7	> 40	overcooling	-	-

Source: Dukić, 1999.

Conservative climate is present from the mid-April to the end of October, while during the rest of the year *slightly cold climate* prevails. The period with pleasant climate coincides with the stay of migratory birds, as well as in equivalent temperatures.

Mean annual values of relative humidity from 1976 to 2005 ranged from 69% to 81%. According to the bioclimatic classification (Stanković 2000) the air of this region is *moderately humid*.

In this area two minimums and two maximums have been recorded. The primary minimum was registered in May (68.5%), which coincides with trend of air temperature growth. The primary maximum occurs in June (70.5%) and correspondents to the month with the highest precipitation (Figure 4). Although all parameters indicate that humidity is not high in May one's subjective sense is opposite because the human organism is also influenced by parameters such as temperature, radiation, cloudiness and wind. This humidity contributes the germination and growth of vegetation cover. Secondary minimum occurs in August (69%) and coincides to the secondary minimum of average values of precipitation. Secondary maximum occurs in December and does not coincide with the maximum of average monthly

air temperature, because the precipitation in the coldest month (January) excretes in the form of snow and then evaporation and air humidity saturation are lower than in the warmer December (Ćurčić 1984).

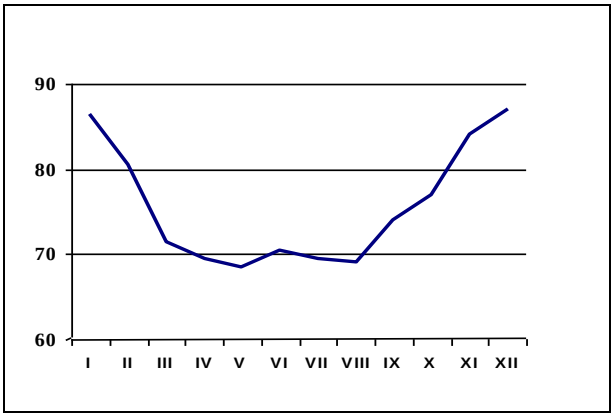

Figure 5: Mean monthly values of relative humidity from 1976 to 2005 (The source: Republic Hydrometeorological Service of Serbia)

High humidity during the summer, especially before the rain, impedes insects in flight, because their wings become wet. Then the frogs leave the pond and move freely in the surrounding areas. High humidity assorts to the growth of bacteria and the spread of viruses. In winter, penetration of warm and moist air masses from the south increases the spreading of influenza virus. Also, high humidity helps some plants in propagating, such as: lichens (*Lichenophyta*), moss (*Bryophyta*), algae (*Chlorophyta*) and ferns (*Polyphodiophyta*) at the end of the spring and in early summer after the rain and wet air. On the contrary, high humidity has negative influence on the English oak (*Quercus pedunculata*) and Turkish oak (*Quercus cerris*), because it slows transpiration of these plants and asphyxiates them.

It has been testified that the evaporation intensity of wetlands could increase the relative humidity of ambient atmosphere of wetland ecosystem, due to high transpiration of wetland plants (Xu et al. 2009).

The mean annual insolation, from 1990 to 2005 was 2039.7 hours. It ranges from 1833.4 hours to 2419.6 hours. Maximum insolation occurs in July, an average of 280.6 hours (9 h/day). It is analogical value as well as northern Adriatic coast (9.2 h/day), which is on the approximately same latitude. The lowest average monthly insolation has the foggiest and the wettest December with 52.6 hours (Figure 5). Looking at seasons, summer has the most insolation (815.3 hours), then spring (576 hours), autumn (427.5 hours) and winter (220.6 hours). Thus, during the growing season, insolation is more than enough.

Biological processes depend on insolation. Insolation higher than 5.2 h/day is enough to increase soil and air temperature above 10 ºC at the end of March and in early April which cause germination and foliation and awaking from hibernation of mammals, reptiles and amphibians. On the contrary when insolation declines under mention limit, air and soil temperatures also decline and animals take shelter in their hiding places in order to begin hibernation. Hedgehog (Ernaceus europaeus) takes shelter at first, at the temperature of 15 ºC, while the hamster takes shelter when temperature decline below 10 ºC. Fish and amphibians react on water temperature change, which is a consequence of insolation change. Thus, pikeperch (*Stizostedion lucioperca*), from the adjacent Sava river, at temperatures lower than 16 °C, stops feeding and takes shelter to the river bottom.

During the late summer, insolation is excessive and plants can no longer absorb solar radiation by photosynthesis. The optimal insolation for wildlife in this area would be from 6 to 7 hours per day. March and September have that mean insolation. When insolation is higher animals seek shade and plants have enhanced transpiration.

Cloudiness is an important abiotic factor because it affects the mood of both humans and animals. Linden (*Tilia*), dandelion (*Tarxacum officinale*), daffodil (*Hijacitus*) and tulip (*Tulipa*) close its flower as soon as a cloud hid the sun. The mean annual cloudiness from 1976 to 2005 was 5.3 tenths. It varied from 4.4 to 6.1 tenths. It is expressed as two maximums and two minimums. The first maximum occurs in January (68.5%) and the second one is in April (56.5%), while the primary minimum occurs in the August (36%) and secondary (54.5%) in the March (Figure 5).

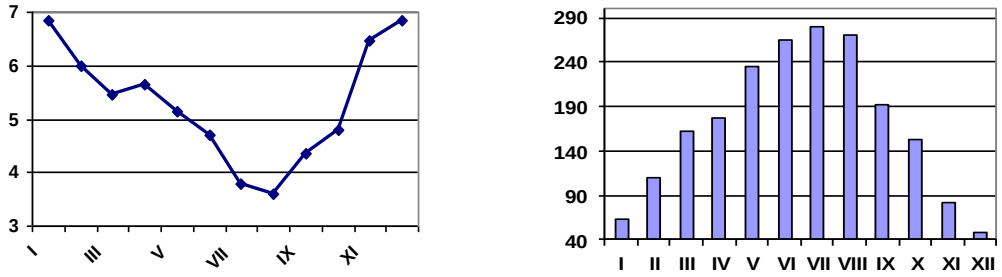

Figure 6: Mean monthly values of cloudiness from 1976 to 2005 (left) and monthly mean values of insolation from 1990 to 2005 (right) (Source: Republic Hydrometeorological Service of Serbia)

From 1996 to 2005, mean annual number of cloudy days was 87.6 (number of days with cloudiness higher than 8 tenths) and number of clear sky days was 66 (number of days with cloudiness lower than 2 tenths). December and January are the months with the most cloud days (14.9) while July and August have the least cloud days (3.3).

Fog as down-to-earth cloudiness impedes breathing in sick persons and increases the sensation of cold in winter. It is the most frequent in December (7.9 days) and the rarest in May (0.7). Looking at seasons, it occurs 18 days in autumn, 13.5 days in winter, 5.1 days in summer, and 2.7 days in spring. During the autumn, it forms mainly by evaporation, as a consequence of higher soil temperature in relation to air temperature and lack of air flow.

Wetlands are highly sensitive to the rainfall regime (García – Barón, Aguilar, Sousa, 2011). Considering that the ponds of Special Nature Reserve mainly feed with rainwater, precipitation is one of the most important abiotic factors for the biodiversity development in this area. Mean annual precipitation from 1976 to 2005 was 625.3 mm. It can range from 324.9 mm (2000) to 843 mm (2005) and it is a limiting factor in agricultural production (Figure 6). In order to mitigate it, it was built a dense network of canals. In dry years there are used as irrigation canals, and in wet years they work are used as drainage canals. The second purpose is perhaps more significant, because in this area groundwater is close to topographic surface and during abundant precipitation (especially during May and June) there is no space for water to run off and it can cause floods.

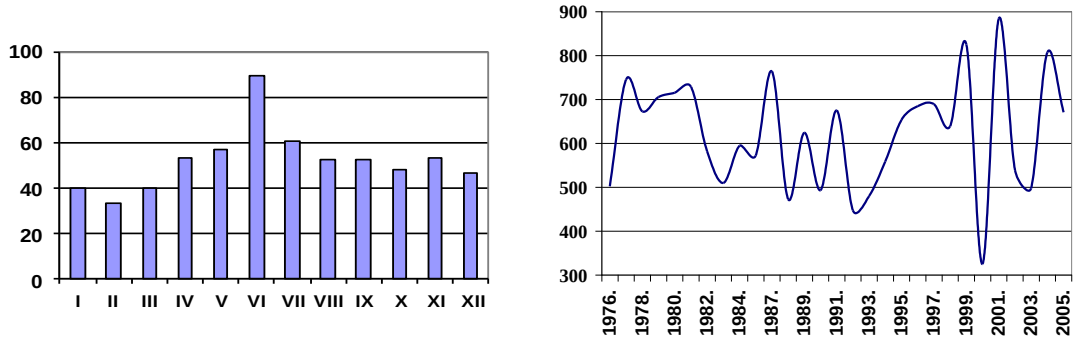

Figure 7: Mean monthly precipitation values from (left) and mean annual precipitation values (right) from 1976 to 2005 (The source: Republic Hydrometeorological Service of Serbia)

Temperate wetlands have strong seasonal hydrological cycles in which comparatively dry summers alternate with periods of flooding (Gallardo 2003). There are also recorded increased oscillations between wet and dry years in this territory. Natural multiannual dry and wet episodes affect wetlands much more than most other ecosystems because a change in the annual amount precipitation of a few decimetres often changes considerably the area covered by water, the water depth and the water balance with dramatic consequences for the organisms living there (Junk et al. 2006). Under such wet – dry cycles, species are frequently annual, and are destroyed either when the wetland dries (submerged species), or when it is reflooded (emergent species). Consequently, slow growing species that rely mainly on vegetative multiplication to maintain a presence are disfavoured. While wetland is characterized by alternating dry and wet periods, there is also seasonal succession characterized by the replacement of submerged species by floating leaf species and finally emergent or short–lived ones (Bornette and Puijalon 2011). Feeding habits vary according to food availability between low water and high water period, pointing to the importance of flood plain resources during floods (Junk et al. 2006). During wet years depressions in Obedska Bara are mostly filled with water. Because of long–term high water and significant floods of Kupinik wet habitats and meadows, numerous bird species are concentrated at the edges of valleys. Open waters are used by migratory birds for rest and food. Various species of herons, preys, ducks (*Anatydae*) and coots (*Fulica atra*) visit constantly the area of Kupinik wet habitats. Because of long–term floods in late spring the specific wet meadows and shallows with low vegetation are formed (Panjković et al, 2006). Flood scouring allows for the maintenance of a highly diverse shifting mosaic of plant species (Bornette and Puijalon 2011). This provides favourable condition for feeding of numerous marsh birds (Panjković et al. 2006). During dry years with short–term floods presence of bird species and individuals declines, especially from the family of herons and ducks, as well as individuals of amphibians (Panjković et al. 2008).

Mean monthly precipitation varies from 33.2 mm in February to 89.3 mm in June varying among three maximums and three minimums. According to Vujević this territory is classified in Danube pluviometric regime type. Distribution of precipitation by seasons is following: summer 160.4 mm, autumn 153.6 mm, spring 150.1 mm and winter 119.4 mm. For the growth of flora this distribution is relatively good, because there is enough precipitation during the growing season. Precipitation also occurs in a form of snow, which height is usually about 10 cm and number of days with the snow cover is about 20. According to Lang rain factor (55) climate of Obedska Bara is humid, wherein steppe vegetation prevails (Milosavljević 1984).

In addition to pluviometric regime important characteristics for geoecological analysis are intensity of precipitation and number of days with precipitation. The mean intensity of precipitation is the ratio of frequency and height of precipitation (Vujević 1962). From 1996 to 2005 mean annual intensity of precipitation ranged from 1.6 mm in March to 3.6 mm in July. During the same period the mean monthly number of days with precipitation ranged from 15.3 mm in March to 22.3 in December. Mean annual intensity of precipitation was 2.6 mm during the day with precipitation. Maximum of mean monthly precipitation coincides with maximum of intensity of precipitation. Mean monthly number of days with precipitation was 19.6. Number of days with precipitation has three maximums (in December 22.3, in April 21.9, and in September 19.8) and three minimums (in March 15.3, in August 16.8, and in October 18.6). Mean annual number of days with precipitation was 235.

4. Conclusions

Area of Obedska Bara is characterized by complex ecosystem of wetlands and meadows which is predominantly conditioned by climatic elements.

The steppe–continental climate is characterised by more precipitation during the warm half of year than in cold one and high daily temperature amplitudes (about 15 ºC).

The stay of migratory birds coincides with growing season and with mean monthly air temperatures above 10 ºC.

Meridian air flows affect the growing season and animal activity. Air pressure can fluctuate about 8 mb during the year, and 5 mb daily.

Position of northern and southern mountain ranges affects wind direction and speed. The air of this region is moderately humid. The optimal insolation for wildlife is from 6 to 7 hours per day, while insolation higher than 5.2 h/day increases soil and air temperature above 10 ºC.

December and January are the months with the most important number of cloudy days while July and August have the least number of cloudy days.

Pluviometric regime belongs to Danube type with feeble intensity of precipitation. Development of biodiversity depends on pluviometric regime.

Special Nature Reserve Obedska Bara is characterized by slightly cold and conservative climate.

Acknowledgments

1. Dejana Jakovljević was supported by the PhD Fellowship from the Ministry of Sciences and Technological Development, Republic of Serbia. Authors are grateful to Public Company "Vojvodina Forests" for sharing data.

2. Dorin Lozovanu was supported by the European Social Fund in Romania, Managing Authority for the Sectorial Operational Programme for Human Resources Development 2007-2013 through the post-doctoral program POSDRU/89/1.5/S/49944 *"Development of innovative capacity and increasing of research impact by post-doctoral programs".*

References

1. Barrón LG, Aguilar M, Sousa A 2011. Evolution of annual rainfall irregularity in the southwest of the Iberian Peninsula. Theor Appl Climatol 103:13 – 26. doi:10.1007/s00704-010-0280-0

2. Bornette G, Puijalon S 2011. Response of aquatic plants to abiotic factors: a review. Aquat Sci 73: 1 – 14. doi:10.1007/s00027-010-0162-7
3. Ćurčić P, Maraš Ž 2006. Prostorni plan opštine Pećinci, Strategija razvoja do 2025. Godine. JUP „Plan“ Ruma, Zavod za urbanizam Vojvodine, Novi Sad, Srbija
4. Ćurčić S 1978. Opština Pećinci. Prirodno-matematički fakultet, Institut za geografiju, Novi Sad, Srbija
5. Ćurčić S 1984. Opština Stara Pazova. Prirodno-matematički fakultet, Institut za geografiju, Novi Sad, Srbija
6. Dukić D 1999. Klimatologija. Geografski fakultet, Beograd, Srbija
7. Gajić M, Karadžić D 1991 Flora ravnog Srema sa posebnim osvrtom na Obedsku Baru. Šumarski fakultet Beograd, Šumsko gazdinstvo Sremska Mitrovica, Srbija
8. Gallardo A 2003. Spatial Variability of Soil Properties in a Floodplain Forest in Northwest Spain. Ecosystems 6:564 – 576.doi: 10.1007/s10021-003-0198-9
9. Espinar JL, Serrano L 2009. A quantitative hydrogeomorphic approach to the classification of temporary wetlands in the Donana National Park (SW Spain). Aquat Ecol 43: 323 – 334.doi: 10.1007/s10452-007-9162-7
10. Junk WJ, Cunha CN, Wantzen KM, Petermann P, Strüssmann C, Marquez MI, Adis J 2006. Biodiversity and Its Conservation in the Pantanal of Mato Grosso, Brazil. Aquat Sci 68: 278 – 309.doi:10.1007/s00027-006-0851
11. Kim DG, Park J, Lee D, Kang H 2010. Removal of Nitrogen and Phosphorus from Effluent of a Secondary Wastewater Treatment Plant Using a Pond – Marsh Wetland System. Water Air Soil Pollut.doi: 10.1007/s11270-010-0399-8
12. Meteorological yearbooks 1976-2005. Republic Hydrometeorological Service of Serbia, Serbia
13. Maćejка M (2003). Klima i njen zdravstveni značaj u banjama Srbije. Srpsko geografsko društvo, Beograd.
14. Milinčić, MA, Pecelj, MR, 2008. Prirodna osnova geoekoloških procesa Župe Aleksandrovačke. Glasnik Srpskog geografskog društva, 88(1) pp 54-68
15. Mortsch LD 1998. Assessing the impact of climate change on the Great Lake Shoreline wetlands. Climatic Change 40: 391 – 416
16. Milosavljevic R 1983. Bioklimatska rejonizacija Bosne i Hercegovine za potrebe čoveka, Zbornik radova XI Kongresa geografa SFRJ, Titograd, SFRJ pp 120-124
17. Milosavljevic M 1984 Klimatologija. Naučna knjiga, Beograd, Srbija
18. Panjković B, Kiš A, Kovačević B, Pil N, Mikeš VH, Dobretić V, Stojšić V, Sabadoš K, Stojnić N, Delić J, Igić R, Ćirović D, Savič D, Tucakov M 2008. Monitoring živog sveta vlažnih staništa u SRP „Obedska Bara“. In Monitoring osetljivih ekosistema ugroženih biljnih i životinjskih vrsta na teritoriji AP Vojvodine, Zavod za zaštitu prirode Srbije, Novi Sad, Srbija, pp 22 – 33
19. Panjković B, Kiš A, Kovačević B, Pil N, Mikeš VH, Dobretić V, Stojšić V, Sabadoš K, Stojnić N, Delić J, Igić R, Ćirović D, Savič D, Tucakov M 2006. Monitoring živog sveta vlažnih staništa u SRP „Obedska bara“. In Biomonitoring ugroženih biljnih i životinjskih vrsta i njihovih zajednica u Vojvodini, Zavod za zaštitu prirode Srbije, Novi Sad, Srbija, pp 26 – 38
20. Pecelj MR, Popara S, Jovičić J, Stevanović V, 1996. Bioklimatske karakteristike Podunavlja. Zbornik radova naučnog skupa „Podunavlje u Srbiji”, Uređenje, zaštita i razvoj, pp182 – 184
21. Pecelj MR, Milinčić MA, Pecelj M 2007. Bioklimatska i ekoklimatska istraživanja – pravci razvoja. Glasnik Srpskog geografskog društva, 87(2), pp 199-210
22. Puzović S 1995. Savremeni ekološki okvir Obedske Bare In Povratak Obedskoj Bari, Mladi istraživači Srbije, Edicija Povratak ibisa, sv. 1, Beograd, Srbija, pp IX - XIX
23. Puzović S, Stojanović T, Vig L, Marić B, Tešić OĐ, Dobretić V, Stojšić V, Lazić L, Stojanović V, Pavić D 2010. Ramsarska područja Vojvodine Obedska bara. Pokrajinski sekretarijat za zaštitu životne sredine i održivi razvoj, Novi Sad, Srbija
24. Ramdani M, Elkhiati N, Flower RJ, Birks HH, Kraïem MM, Fathi AA, Patric ST 2001. Open water zooplankton communities in North African wetland lakes: the CASSARINA Project. Aquat Ecol 35:319 – 333

25. Schiff S, Aravena R, Mewhinney E, Elgood R, Warner, B, Dillon P, Trumbore S 1998. Precambrian Shield Wetlands: Hydrologic control of the sources and export of the dissolved oxygen matter. Climatic Change.
26. Stanković S 2000. Turistička geografija. Geografski fakultet, Beograd „A.M.R.I.", Srbija
27. Vitanović MV 1996. Ekološka studija Obedske Bare. Javno preduzeće za gazdovanje šumama "Srbijašume", Beograd, Srbija
28. Vujević P 1962. Prilozi za bioklimatologiju oblasti Kopaonik. Zbornik radova Geografskog instituta „Jovan Cvijić", 18: 1-83
29. Xu H, Yin J, Deng W, Xu K, Wang Z 2009. Transpiration rates of *Carex Meyeriana* in Relation to Micrometeorological Factors in a Mountain Valley Wetland, J Mt Sci 6: 293 – 298. doi: 10-1007/s11629-009-1007-5