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MODERN TENDENCIES OF CLIMATE, WATER RESOURCES AND ECOSYSTEMS CHANGES IN THE MIDDLE-LOWER PART OF SOUTHERN BUG RIVER, UKRAINE

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Abstract

Purpose: *Analyze the features of climate and water regime change in the northwestern part of the Southern Bug River basin in second half of the 20th century and at the beginning of the XXI century in the region of the South-Ukrainian Nuclear Power Plant (SUNPP). Assess the impact of the SUNPP on the microclimatic conditions and identify possible threats to the biotic diversity of natural ecosystems which are associated with environmental changes.* ***Methods:*** *The main results of work are obtained on the basis of empirical materials by statistical analysis and analytical review of published materials.* ***Results:*** *The energy production at the SUNPP requires significant amount of water from Southern Bug River for cooling. Due to the climatic changes, namely, with the increase of the average annual air temperature and the decrease the amount of precipitation (in the upper and middle part of the river), the operations of the connected with cooling became complicated.* ***Discussion:*** *The SUNPP activity in the modern limits already have a negative impact on the environment, but the concern of ecologists is exacerbated by the possible increase of the Oleksandrivske reservoir to a mark of +20 m, which will increase the load on natural ecosystems and the society, and will violate the number of international and national legal acts, while not taking into account current trends of climate change.*

Key words: climate change; correlated dynamics of temperature and precipitation; ecological and social consequences; technogenic influences; trends of ecosystem changes; water ecosystems and water resources.

1. Introduction

Due to the climate change, which is especially evident in recent decades [1, 2], in particular, in reducing of the water content of the Southern Bug River basin, that's why the South-Ukrainian Nuclear Power Plant c feels a sharp shortage of water that limits its activity.

The energy production at the South-Ukrainian NPP requires significant amounts of water for cooling from the Southern Bug River. Due to climatic changes, namely, with the increase of the average annual air temperature and the decrease of the amount of precipitation (in the upper and middle part of the river), the exploitations of the SUNPP connected with cooling became complicated. In order to ensure the operations of Tashlytska Storage Plant (Tashlytska SP) and the SUNPP, it is planned to increase the level of the Oleksandrivske Reservoir from +16.9 to+20 m.

With this aim, a catchment from the river is expected and an additional $51.65 \cdot 10^6$ m^3 of surface water in the reservoir will be accumulated (according the plans, not adopted yet), which will be accompanied by an increase in water losses from Oleksandrivske reservoir at 1.5 10^6 m^3 / year [3, 4].

Activity of the SUNPP in the modern limits already has a negative impact on the environment, but the concerns of ecologists are exacerbated by an increase in the level of reservoirs to mark +20 m, which will increase the load on natural ecosystems and the society, and will violate the number of international and national legal acts, while not taking into account the current trends in climate change.

2. Analysis of last researches and publication, problem statement

The main negative impacts on the environment from the South-Ukrainian Nuclear Power Plant. The SUNPP is located in the southern part of Dnipro upland, on the left bank of the middle reaches of the Southern Bug River.

The purpose of the SUNPP is the generation of electricity for the supply of consumers in the southern regions of Ukraine (with a population more than 5 million people) in Mykolaiv, Odesa, Kherson oblasts. The SUNPP provides more than 10% of the total electricity production in Ukraine.

Because of the Oleksandrivske and Tashlytske Reservoirs filling there was: seizure of lands of various purposes (natural and economic lands), the transformation of landscapes, the formation of a specific microclimate, changes in surface runoff conditions; violation of the conditions for the existence of natural biodiversity and the forced migration of wild fauna.

As a result, of the SUNPP operations, the environment was affected mainly by the following impacts, which are listed below.

Thermal influence. The thermal factor of the SUNPP is the most influential on the environment. About 65–70% of the heat generated in the reactors is dumped through cooling systems of the water reservoirs and discharged into the atmosphere. In comparison with the air temperature, the water temperature in the cooling water reservoir is increased and this leads to intense evaporation from the water surface, which increases the frequency of the evaporation fogs formation.

The evaporation of water during cooling is about $(40–45) \cdot 10^6$ m^3 per year [3,4].

According to the data presented in [5, 6], the thermal flux into the atmosphere equal to: during the operation of one power unit $(1.7–2.6) \cdot 10^9$ W, and from three power units – $(3.4–5.3) \cdot 10^9$ W.

Radiation influence. In the normal mode, during operation of the SUNPP, localization of radioactive products in the reactor plant is provided by special water and gas purification systems.

In the monitoring zone of the SUNPP, ground air pollution by radioactive substances due mainly to the presence of artificial radionuclide ^{137}Cs.

Radionuclides ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{134}Cs are registered in 75±25 % of selected samples [5, 6]. Radionuclides ^{51}Cr, ^{131}I, ^{110}mAg, ^{95}Nb, ^{103}Ru episodically present in air, mainly in period of planned production repairs.

In unusual situation probable contamination of environment by products from separation of radioisotopes, radioactive substances, in the form of products of neutron activation at corrosion of structural materials (tritium (^3H), gaseous radioactive particles, including evaporation of tritium water and inert gases, aerosols, gaseous particles, etc.).

Also as potential sources of radioactive contamination of the Tashlyk Reservoir can be discharges through the drainage and sewage system from the control tanks of drainage water purification systems, and waters from specialized laundries.

In the zone of the SUNPP influence, state of radioactive contamination of the water catchment area is estimated as "satisfactorily" (radiation levels of cesium–137, strontium–90 and plutonium–239 within acceptable levels) [5, 6].

Chemical influence. Sources of chemical impact on the environment are periodic non-radioactive emissions and discharges that occur in the facilities of the SUNPP and contain chemical elements and substances, allowable content of which is regulated by sanitary norms and regulations.

In the atmosphere released gas-aerosol non-radioactive emissions from auxiliary structures and industrial premises: about 30% consists of sulfur dioxide, 20% – from solid particles (soot, dust), 20% are non-methane volatile organic compounds (NMVOC), and rest are nitrogen dioxide, oxide and carbon dioxide, hydrocarbons, metal compounds, hydrogen sulfide, ammonia, chlorine, etc. [5, 6].

Stationary and mobile sources on territory of the SUNPP emits into atmosphere approximately 6 tons of pollutants per year [5, 6].

2. The problem statement

The purpose of this work is to analyze the peculiarities of climate and water change in the lower part of the Southern Bug River basin of the second half of the 20th century and at the beginning of the XXI century in the region of the SUNPP. Assess the impact of the SUNPP on the microclimatic conditions and identify possible threats to the biotic diversity of natural ecosystems associated with environmental changes.

3. Materials and methods of research

The main results of work are obtained based on empirical materials by statistical analysis and analytical review of published materials.

In this study, empirical data were obtained from the meteorological stations Pervomaysk, Voznesensk and Yuzhnoukrayinsk for the period 1945-2015 and Yuzhnoukrayinsk for the period of 2005-2014 (average annual and average values of temperature and precipitation). Meteorological data are also used in the Ukrainian Cadastre of Climate for the period 1961–1990 (norms of the main parameters, including data about wind speed, relative humidity, total evaporation and repeatability of fogs) [7].

For the estimation of water content in the lower part of the Southern Bug River there are used data from the average annual and average monthly water consumption at the water depots (stations) of Pervomaysk city and Oleksandrivka town for the period of 1914–2014.

In the research, there were used materials of section "Environmental Impact Assessment (EIA)" of the working project "Increasing the level of the Oleksandrivske reservoir to the project mark of 16.9 m" [5] and “Estimates of the environmental impact of elevating the Oleksandrivsk reservoir to the project mark of 20.7 m” [6].

The monitoring research data on fauna and flora of the Tashlytska SP zone of impact for the period 2006–2009 and 2014 were used in the current research [8–10].

4. Results of the research

Analysis of influence from SUNPP on water regime of the lower part of the Southern Bug River. The Southern Bug River is the main waterway in the region (total length – 792 km, area of water catchment $63.7 \cdot 10^3$ km^2, depth 1.5–8.0 m, width of channel 50–200 m, speed of water flow 0.1–0.3 m/s, volume of average perennial runoff – 2.9 km^3) [4, 11].

For water regime of South Bug River is typical some uneven distribution of drainage by the territory of the basin, and during the year (prevailing snow and rain nutrition, and underground runoff).

The annual runoff of the Southern Bug River is formed in the upper reaches of the forest-steppe part of the basin – 56%, and the flow of steppe part of the basin (mainly in the lower part of the basin) is only 17.5% from annual flow of whole river. In the spring, observed peak of flood on the river, and the rest of the year is a stable low flow with a slight increasing of water content in the autumn and in separate winter thaws.

The Southern Bug River is overregulated (~200 reservoirs and $6.9 \cdot 10^3$ of ponds with total volume of 1.5 km^3) and has a widespread using it is of water resources for economic needs. The average annual water losses of Southern Bug River in the mouth of the river in the first half of the XX century amounted to 87 m^3/s. After the creation of reservoirs and ponds, the average water losses increased to 93 m^3/s, and the construction of the cooling water reservoir of the SUNPP almost do not change the losses in 1981-1999 ~92 m^3/s [3, 4, 12].

The water intake for reversible water supply of the SUNPP is carried out from the Southern Bug River through the Tashlyk SP cooling pond (in 2010–2014 volume of reversible water supply was 3.38–350 10^9 m^3, and the expenses for household needs are fluctuating significantly, from $0.60 \cdot 10^6$ to $1.43 \cdot 10^6$ m^3) [5, 6]. After elevating of Oleksandrivske reservoir to 14.7 m, the area of the water aquatopia increased from 770 hectares to 1025 hectares, compared to area at level 8.0 m, which was 255 hectares [3–6, 13].

The age course of average annual water consumption from the Southern Bug River – in urban settlement Oleksandrivka for the period 1914–2014 is presented on Fig.1 (the annual average water consumption is ~ 90 ± 30 m^3/s). Increasing the water content in the Southern Bug River at 7–10 m^3/s for 100 years over the period in 1914–2014 years is negligible, but traced periods with significant variations in water content (30–200 m^3/s). From the 70-s of the last century and until now, the period of reduction of water content is continuing [4].

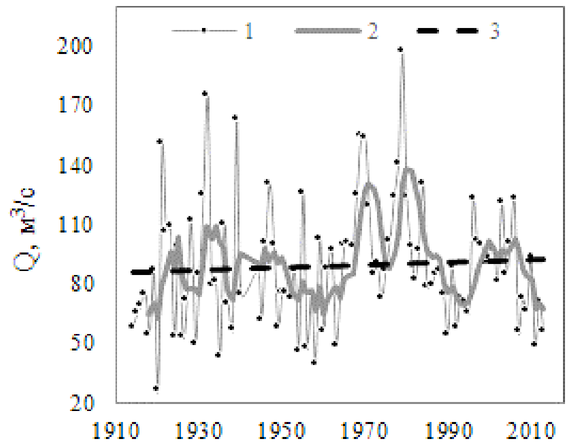

Fig. 1. Age course of average annual water consumption (1 – Q, m^3/s) the Southern Bug River – urban settlement Oleksandrivka by period of 1914-2014 (2 – current averaging, 3 – linear trend)

Comparison of the seasonal course of the average monthly water losses in South Bug river on water post of Pervomaisk city and urban settlement Oleksandrivka in the period after construction of cooling water reservoir of the SUNPP, and filling of the Oleksandrivskyi reservoir to the level of 16,9 m, and for the long-term period (respectively) are shown in Fig.2. As you can see, activity of the SUNPP (water intake) in whole has led to significant reduction in water consumption of South Bug River, in spring months (March-April) almost in two times.

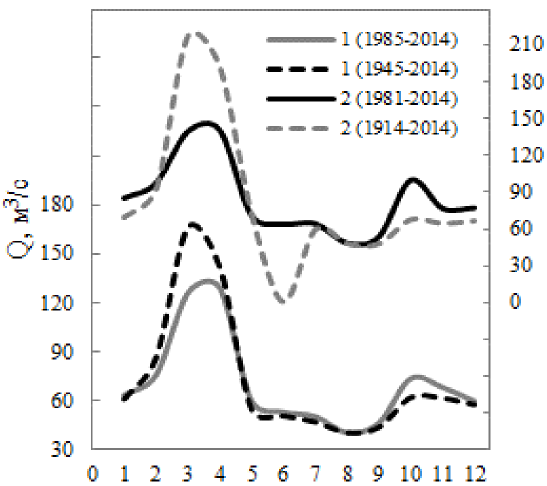

Fig.2. Comparison of the seasonal course of the average monthly water losses in South Bug River on water post of Pervomaisk city (1 – left scale) and urban settlement Oleksandrivka (2 – right scale) in the period after construction of cooling water reservoir of South Ukraine NPP, and filling of the Oleksandrivske reservoir to the level of 16,9 m, and for the long-term period (respectively)

In the last decade observed a tendency to some increased of oxygen content in water. In the warm period of year, sometimes observed situation with an oxygen concentration of ~4 mg/dm^3 (limit of concentration). However, should take into account the relationship between increasing of oxygen content and increasing of average water temperature (this was probably due to the intensification of phytoplankton development [4].

According to data [4], mineralization of water in the urban settlement Oleksandrivka (in the region of the SUNPP location) is: in the spring flood – 600 mg/dm?; summer-autumn low water periods – 674 mg/dm?; in winter low water periods – 701 mg/dm?.

During last decade, pH level of surface water of the Southern Bug River basin fluctuated within the range of 7.71–7.94. Fixed increasing of pH for the city of Pervomaisk, which correlates with the decreasing of CO_2 content in water and pH increasing in the lower part of the river (urban village Oleksandrivka) of is explained by the influence of the sedition phenomena [4].

The unfavorable situation also occurred in the delta of the South-Bug River. The main factors that cause disastrous condition of the waters of the Bug Liman are: increasing of water salinity, decreasing of depths (due to silting), increasing of water temperature, reducing of volume of fresh water flow from the Southern Bug River and intensification of seawater outcrops from the Black Sea (through raising sea level at 18–20 cm during last 100 years), periodic traces of the hydrogen sulfide from Black Sea in water, high content of nutrients (ammonia and nitrate nitrogen, mineral phosphorus, etc.) [8, 14, 15]. All this has led to the degradation of inherent biodiversity in the estuary and cause the increasing the number of marine species.

The climatic conditions in the region of the location of the SUNPP. The climatic conditions in the region of the location of the SUNPP are temperate continental, with insufficient humidification regime, which is characteristic of the steppe zone (arid summer, warm and a little snowy winter, and in the frequent occurrence of arid phenomena) [16].

The average annual air temperature in the lower part of the basin of the Southern Bug River ranges from 8 to 10 ^{o}C. So, at meteorological stations located in this region Pervomaysk and Voznesensk, the meteorological norm of temperature for the period 1961-1990 is 8.8 ± 0.9 and 9.6 ± 1.0 °C, and the annual amount of precipitation is 553 ± 113 and

517 ± 109 mm. (in separate years the minimum amount of precipitation is ~285 mm, and the maximum is ~800 mm per year [7].

The seasonal course of surface temperature of air has a characteristic maximum in July 19–22 ° C and a minimum in January at an average of –2 ? –7 °C), and in other seasonal periods, the average temperature is –1 ? 17 ° C in the spring and –3 ? 16 °C in the autumn (Fig. 3) [7].

The maximum precipitation is in the warm period of the year 330-350 mm, and in the cold period of the year 185–200 mm (Fig. 4). In separate months, in separate years, almost complete absence of atmospheric precipitation (for example, April 1948 and September 1944) and excess of meteorological norm in 3–4 times (for example, June 1958 and August 1947) can be observed [7, 17].

Winter in this region is relatively warm (average temperature is –3.1? –2.1 ° C) and a little snowy (the height of the snow cover is ~5–11 cm with an average duration of 45–65 days, and the depth of freezing of the soil to 30±15 cm) [7].

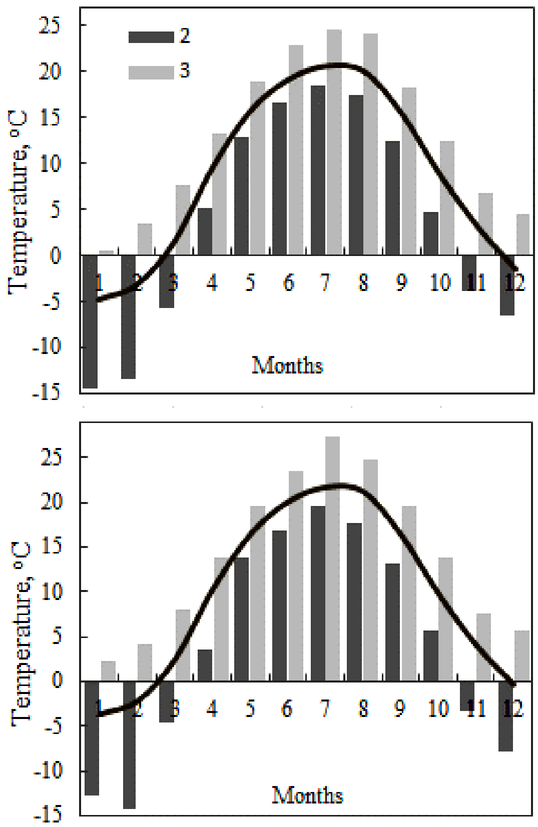

Fig.3 The seasonal course of the meteorological norm of the average monthly air temperature in the period 1961-1990 for the meteorological stations Pervomaysk (A) and Voznesensk (B): 1 – the average monthly value, 2 – the minimum, 3 – the maximum.

The total evaporation in the lower part of the basin of the Southern Bug River is seasonal: in the winter, it is about 30–40 mm, in the summer to 200–300 mm, in the spring to 125-160 mm and in the autumn to 80-95 mm [16, 17].

Fogs show most often in the cold period of the year, in the lower reaches of the Southern Bug River, the average number of days with fog during the year is about 30-39 days [7].

The vegetative period, in the lower part of the Southern Bug River basin lasts an average of 225 ± 4 days [16].

The average annual air humidity in the region is 70–75%, in the cold period of the year its value reaches 84 ± 3, and in the summer – 62 ± 2% [7, 16].

The average wind speed in this region is 2.6 ± 0.3 m/s (in the winter to 3-4 m/s and in the summer to 2 m/s. With strong winds at a speed of ≥15 m/s on average is 30–35 days, and in separate years to 65 days per year is observed, and the repetition of hurricane winds at a speed of ≥30 m / s is fixed once every 25 years [7, 16].

It should be noted, that the meteorological parameters might vary somewhat depending on the chosen period, due to the presence of quasiperiodic oscillations and under the influence of modern climate change [2, 18].

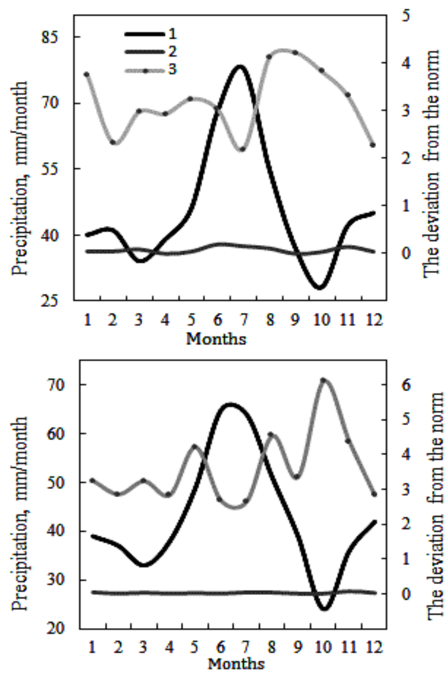

Fig.4 The seasonal course of the meteorological norm of the monthly amount of precipitation (1) and the deviation from the norm (2 – minimum, 3 – maximum) for the meteorological stations Pervomaysk (A) and Voznesensk (B) in the period 1961-1990.

Features of climate change in the region of the location of the South-Ukraine NPP. On the territory of Ukraine in the 20th century, due to global processes, certain climate changes took place (temperature increase was 0.6 ± 0.1 °C for 100 years), and over the past several decades, warming has become more intense with the increase a frequency of climate anomalies in different seasons [2, 18, 19].

In the conditions of the current regional peculiarities of climate change and taking into account long-term prospects, the ecologically unfavorable situation in the basin of the Southern Bug River is even more complicated, in the context of increased anthropogenic pressure on the environment [20].

Analysis of meteorological observations data in the south-western regions of Ukraine (in the location of the SUNPP) in the XX century, showed that the following climate changes occurred, namely [18-20]:

•an increase in the average annual surface temperature (in the lower part of the basin) only at 0.4±0.1 °C/100 years;

•a general increase in the amount of precipitation by 5–10%;

•aridization of climatic conditions, during the warm period of the year (reduction of atmospheric precipitation, especially in May and August-September);

•decrease in the amplitude of the seasonal temperature variation: significant warming in the winter and spring months up to ~0.4±0.1 °C/100 years, and in the summer months the warming is insignificant.

However, more significant global warming is characteristic in the second half of the XX century and in the beginning of the XXI century [1].

On the Fig. 5 shown, the temporal course of temperature air for the period 1945-2015 at the meteorological stations Pervomaysk and Voznesensk: the values of the coefficients of linear trends are, respectively, 2.26 and 2.07 °C/100 years (at average temperature of 9.1 ± 1.0 and 9.8 ± 1.0 °C, respectively).

It should be noted, that for the last several decades, the rates of warming, both in the whole territory of Ukraine and in the southwest of the country became very significant [19–20].

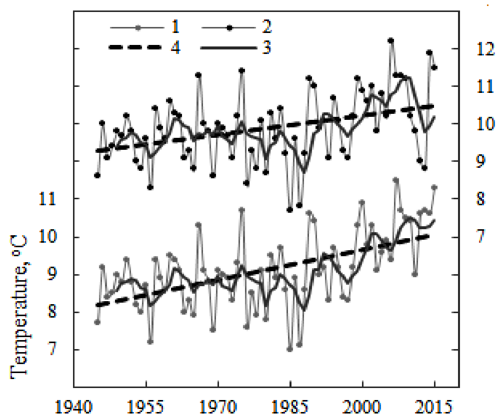

Fig.5. Temporal course of temperature at the meteorological stations Pervomaysk (1 – left scale) and Voznesensk (2 – right scale) for the period 1945-2015 (3 – sliding averaging, 4 – linear trend).

According to meteorological observations at weather stations Pervomaysk and Voznesensk for the period 1945–2015, the annual amount of atmospheric precipitation is 538 ± 107 and 566 ± 131 mm, respectively, and the values of linear trend coefficients are 21.6 and 18.5 mm/100 years, respectively (Fig. 6). Thus, over the past 70 years in this region, the annual amount of precipitation has increased by –5±2%.

Such regional climate change can lead, to a certain extent, to the decreasing of water content of the reservoirs, due to increased evaporation with increasing temperatures and decreasing precipitations, especially in the upper and middle parts of the basin. Slight precipitations increasing in the lower part of the basin do not compensate such negative tendency (the drain in this part of the basin is only 16-18% of the annual flow of the entire river).

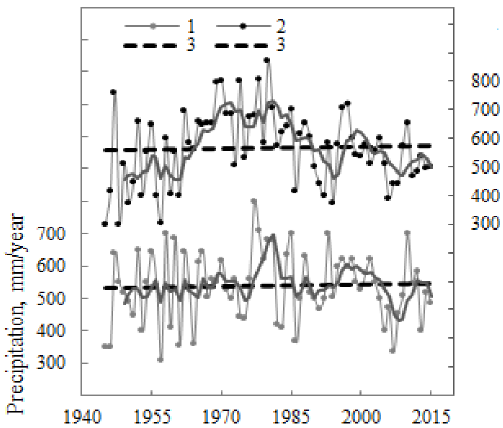

Fig.6. Temporal course of the annual amount of atmospheric precipitation at the meteorological stations Pervomaysk (1 – left scale) and Voznesensk (2 – right scale) for the period 1945-2015 (3 – sliding averaging, 4 – linear trend).

For example, in 2015-2017, the general hydrological situation in the basins of many rivers and reservoirs of Ukraine was rather complicated and dangerous, due to the lowest water content during the entire period of operation of reservoirs and due to the difficult weather conditions (aridization of climatic conditions) in conditions of increased water consumption [17]. The water of the Southern Bug in August-September was 12–15% less than the monthly norm.

Taking into account possible scenarios of global climate change by the end of the XXI century [1], for the territory of Ukraine, the following regional scenarios are proposed [2, 18-20]:

1) optimistic (forecast) on the basis of trends detected in the XX century): an increase in the average annual temperature by 2,0 ± 0,5 ^{o}C and a general increase in the annual amount of atmospheric precipitation by 15 ±5%;

2) pessimistic (scenario), which is based on various model interpretations and takes into account paleo-climatic reconstruction of the warmer epochs of the past: temperature increase by 3.5 ± 0.5 ^{o}C and differentiated by the territory of the distribution of annual amount of precipitation, namely increasing precipitation in the north northern - the western and northeastern regions and decrease in the southern, southeast and southwest regions by 15±5%. At such a level of warming in the northern regions, a display of the effect of excessive moisture is possible, and in the south, on the contrary, aridization of the climate with the display of the effect of desertification is possible.

Microclimatic features in the region of the location of the South-Ukraine NPP. The influence on the microclimatic conditions of the area can be caused by intensive evaporation of water in the cooling systems of the SUNPP, which is about (40-45)·10^6 m^3 per year [5,6].

An analysis of the changes in the microclimatic conditions in the 30 km zone of the impact of the SUNPP was conducted by comparing the thermal regime and the humidification regime at the weather stations of Pervomaysk, Voznesensk and Yuzhnoukrainsk for the period 2005-2015. The coefficient correlation for these stations for the temperature is 0.91–0.96%, and for atmospheric precipitation, it is a little less 0.75–0.6%.

The main statistical characteristics of the meteorological parameters (surface temperature and amount of atmospheric precipitation) at the meteorological stations located in the 30–km zone of influence of the SUNPP Pervomaysk (P), Voznesensk (B) and Yuzhnoukrainsk (Yu) during the period 2006-2015 are given in Table. 1.

Table 1

The main statistical characteristics of meteorological parameters at the meteorological stations Pervomaisk (P), Voznesensk (B) and Yuzhnoukrainsk (Yu) for the 2006-2015 period.

Statistical characteristics	Meteorological stations		
	P	V	Yu
Average annual value	10,4* 511,4**	11,2 483,6	11,2 454,0
Root-mean-square deviation	0,7 140,0	0,6 93,1	0,6 81,9
Trend (normalized to 10)	0,3 61,1	0,3 75,0	0,5 10,5

* temperature of air, oC

** amount of precipitation, mm/year

As we see from Tabl.1, certain minor differences exist: the characteristic tendency of temperature increase at the Yuzhnoukrainsk station is more intense than 0.5 ^{o}C/10 years, than at other stations 0.3 ^{o}C/10 years, with the slight increase the amount of precipitation.

The difference in temperature between reservoirs and the Southern Bug River leads to significant evaporation from the surface of water and the formation of evaporation fogs.

During the year, the water temperature is several degrees higher on the surface of the Tashlyk Reservoir (an area of 1.2 km^2); in winter, in the cooling-reservoir the temperature water is constantly within the range of 5–9 ° C [3, 4, 8].

During the year, the number of days with fog is observed on average at stations Pervomaysk – 38,8 ± 10,7 days, Voznesensk – 30,4 ± 8,6 days, and days with fog are more often observed in October-March, 25–34 days, and in April – only 4–5 days [7, 16].

The analysis of the possible influence of SUNPP on microclimatic conditions (temperature regime, intensity of evaporation and repetition of fogs) has been shown, and it has been shown that in the conditions of modern climate changes it is necessary to take into account during the operation of the South-Ukraine NPP in the future.

On the possible impact of the operation of the South-Ukraine NPP on natural ecosystems.

Flora. South-Ukraine electric power producing complex (EPPC), which includes the South-Ukraine NPP, Olexandrivska Hydroelectric Power Plant and

Tashlytska SP is located in the northwestern part of the Mykolaiv region within the natural region, which is called the Granite-Steppe Pobuzhzhya [11]. This region is unique, unparalleled and one of the key European territories for the conservation of biodiversity. However, in the area of the immediate impact of the EPPS (30-km zone) there are both natural ecosystems of the protected areas and the human population of the Yuzhnoukrainsk, Voznesensk cities and other settlements of the Arbuzynsk, Domanivka and Voznesensk districts of the region.

According to the physico-geographical zoning of Ukraine, 30-km zone of EPPC is located in the North-Steppe subzone of the Steppe zone [21]. There are 30 protected territories of national and local significance are located inside 30-km zone of the EPPC (national nature park (NNP), different types of zakazniks (habitat/species management areas: botanical, forest, hydrological, landscape, ichthyological and ornithological, "sanctuaries"), natural monuments, "zapovidni urochyshcha" (local wilderness areas - "protected tracts"), parks-monuments of landscape architecture) and all of them are under the impact of EPPC.

The most vulnerable to the impact of the EPPC is the NNP "Buzkyj Gard" which was created in 2009. The NNP is located on the southern outskirts of the Ukrainian Crystal Shield within the spurs of the Podolska and Prydniprovska Uplands [11]. The "Buzki Broyaky" wetland is located within the NNP and it is perspective for inclusion to the list of Ramsar Wetland Sites [22]. In addition, the NNP "Buzkyj Gard" together with other areas of Mykolayiv and surrounding regions (NNP "Biloberezhzhya Sviatoslava" Dnipro-Bug estuary, Tylihul Estuary, Nature Reserve "Yelanetsky Step") are included in the list of the Emerald Network of Ukraine as the territories of high natural value [23].

According to the floristic zoning [24], the region of the Granite-Steppe Pobuzhzhya belongs to the Holarctic Kingdom, the North Palearctic Sub-kingdom and 2 districts: the Right-Dnipro-bank (Eastern European Province of the European Region) and the Western Prychornomorsko-Plain-Crimea (Prychornomorsko-Don province of the Pannonsky-Prychornomorsko-Caspian region). Its flora genesis is closely linked to the endemic and relict species of the granitopetrophyton: *Silene sytnikii, Dianthus hypanicus, Stachys angustifolia, Onosma graniticola, Seseli pallasii, Silene hypanica, Stipa graniticola, Moehringia hypanica, Aurinia saxatilis, Cerasus klokovii* etc [25].

The flora of vascular plants of the NNP "Buzkyj Gard" consists of 1,103 species, 867 of which are belonging to aboriginal fraction and 236 - to the alien one [25]. The species of the aboriginal fraction of the flora of the park are associated with the plant communities of the true, shrub and rocky steppes, meadow-steppe areas, granite outcrops, shrub areas, fragments of forest vegetation, meadow, floodplain-meadow, riverain areas and aquatic communities [14, 26, 27]. The vegetation of NNP "Buzky Gard" has 11 plant communities, which are listed in the Green Book of Ukraine [9]: Querceta (roboris) cotinosa (coggygriae), Stipeta graniticolae, Stipeta tirsae, Stipeta pulcherrimae, Stipeta pennatae, Stipeta dasyphyllae, Stipeta ucrainicae, Amygdaleta nanae, Stipeta capillatae, Stipeta lessingianae, Nuphareta luteae [26].

The fraction of aboriginal flora of the NNP has: endemic species of granite outcrops (*Silene hypanica, Dianthus hypanicus, Cerasus klokovii, Sedum borissovae, Seseli pallasii, Moehringia hypanica, Onosma graniticola* etc.), species, which are listed in the Red book of Ukraine [10] (*Astragalus odessanus, A. ponticus, A. dasyanthus, Stipa lessingiana, S. pulcherrima, S. pennata, S. dasyphylla, S. asperella, S. ucrainica, S Disjuncta, S. capilla It has been shown that S. tyros, S. graniticola, Moehringia hypanica, Elytrigia stipifolia, Iris pontica, Thalictrum foetidum, Fritillaria ruthenica, Ornithogalum boucheanum, Silene hypanica, Silene sytnikii, Pulsatilla pratensis, Alyssum savranicum, Cerasus klokovii, Dianthus hypanicus, Gymnospermium odessanum, Adonis vernalis, A. wolgensis, Onosma graniticola, Delphinium sergii, Tulipa hypanica, T. quercetorum, Stachys angustifolia, Crocus reticulatus*), Appendix I of the Bern Convention [28] (*Dianthus hypanicus, Moehringia hypanica*), European Red list of Vascular Plants [23] (*Dianthus hypanicus, Moehringia hypanica*) and the IUCN Red List [27] (*Dianthus hypanicus, Moehringia hypanica*). Moreover, 6 species of Red book of Ukraine and international red lists occur in the wild only at one territory of the world (*Moehringia hypanica, Silene hypanica* and *Dianthus hypanicus* only at Granite-Steppe Pobuzhya region, *Stipa graniticola, Onosma graniticola* and *Sedum borissovae* - only at the southern part of the Southern Bug River basin) [25, 27, 29].

Along with the protection of rare and endangered plant species *in situ*, it is important to grow and preserve them *ex situ* and use the technique of reintroduction. With the help of reintroduction, some of protected species from the influencing area of the Tashlyk Storage Plant were returned into the natural ecophytons of the Southern Bug Valley, so their local lost and transformed populations may become partially restored and, under favorable conditions, return to normal conditions [5, 6].

Fauna. According to zoogeographical zoning, the territory of the SUNPP belongs to the western steppe zone of the North-Black Sea region [8, 30]. Within the 30-km zone of EPPC there are 31 species of land insects, 3 species of fish, 3 species of reptiles, 19 species of birds, and 7 species of mammals, which are listed in the Red Data Book of Ukraine, may occur in the area of immediate influence of the EPPC [5, 6]. The monitoring of wildlife in the Tashlyk Storage Plant influencing area in 2006-2009 and in 2014 showed that there are no significant changes in the species communities and number of vertebrate animals [5, 6]. However, due to the increasing of shallow water areas after raising the water level of the Oleksandrivsky reservoir to 16.9 m, the increasing of waterbirds (*Ardea cinerea, Anas platyrhynchos, Fulica atra* etc.) relative number was observed [5, 8].

Much of the biodiversity, communities and species populations are vulnerable due to both natural circumstances and the influence of anthropogenic factors, have very weak anthropotolerance and can be significantly affected by flooding of Oleksandrivske reservoir under water level raising. From the official documents and research data [5] we can know that the Oleksandrivske reservoir level raising will damage the genotypic diversity of some particularly valuable species of plants and animals and will certainly lead to the significant loss of the biodiversity and proper functioning of existing protected areas in the region.

Discussion of the results

The discussion is based on a balanced compromise between the economic and stratigraphic needs of the state and the preservation of the environment in conditions of modern climate change. In addition to hydropower, there are other alternative sources of energy (wind, solar, etc.), but changes in the environment, in this case, are irreversible.

Summary and Conclusions

Feature of climate, water regime and biodiversity changes in the northwestern part of the Southern Bug River (in location of the South-Ukrainian Nuclear Power Plant) of the second half of the 20th century and at the beginning of the XXI century are analyzed. The negative influence of the SUNPP on microclimatic conditions water regime and natural ecosystems, which is associated with environmental changes, have been identified.

Due to registered regional climatic changes, further exploitation of South-Ukrainian NPP and whole EPPC is complicated. Further development of EPPC, in the case of more significant water consumption from the Southern Bug River, will be accompanied by essential negative environmental impacts, which should be avoided.

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Сучасні тенденції зміни клімату, водних ресурсів та екосистем у середньо-нижній частині річки південний буг, україна

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Статтю присвячено аналізу особливостей змін клімату та водності в нижній частині басейну Південного Бугу, в регіоні розташування ЮУАЕС, в другій половині ХХ ст. та на початку ХХІ ст., оцінці впливів від діяльності ЮУАЕС на мікрокліматичні умови, а також визначенню можливих загроз для біотичного різноманіття природних екосистем, які пов’язані зі змінами довкілля.

Ключові слова: водні екосистеми та водні ресурси; екологічні та соціальні наслідки; зміна клімату; корельована динаміка температури та опадів; тенденції зміни екосистеми; техногенні впливи.

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Современные тенденции изменения климата, водных ресурсов и экосистем в средне-нижней части реки южный буг, украина

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Данная статья посвящена анализу особенностей изменений климата и водности в нижней части бассейна Южного Буга, в регионе расположения ЮУАЭС, во второй половине ХХ в. и в начале ХХІ в., оценке воздействий от деятельности ЮУАЭС на микроклиматические условия, а также определению возможных угроз для биотического разнообразия природных экосистем, связанные с изменениями окружающей среды.

Ключевые слова: водные экосистемы и водные ресурсы; изменение климата; коррелированая динамика температуры и осадков; тенденции изменения экосистемы; техногенные воздействия; экологические и социальные последствия.

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