AGROLOGY

ISSN 2617-6106 (print)
ISSN 2617-6114 (online)
Agrology, 2(3), 161–169
doi: 10.32819/019024

Original researches

Albedo of the Soil Cover as a Factor of the Temporal Dynamics of Readily Available Soil Moisture in the Technosols of the Nikopol Manganese ore Basin

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Received: 26 July 2019
Revised: 30 July 2019
Accepted: 31 July 2019

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Cite this article: Gritsan, Y. I., Kunah, O. M., Fedushko, M. P., Babchenko, A. V., Sirovatko, V. O., Zhukov O. V., & Kotsun, V. I. (2019). Albedo of the soil cover as a factor of the temporal dynamics of readily available soil moisture in the technosols of the Nikopol manganese ore basin. *Agrology*, 2(3), 161–169. doi: 10.32819/019024

Abstract. The simulation of moisture content in Nikopol manganese ore basin technosols was performed using the Penman-Monteith approach and evaluate the role of the dependence of soils surface albedo from the humidity in the intensity of evapotranspiration. The sod lithogenic soils on loess-like loam and pedozem were chosen as the objects of the investigation. The research was conducted during 2012–2014 years at the investigation station of the remediation within Nikopol manganese ore basin (city Pokrov, Ukraine). The evapotranspiration from the soil surface was calculated by means of Penman-Monteith equation. Root zone moisture depletion is evaluated as the difference between soil water content at field capacity (pF = 2.3) and actual soil water content. The Ks value which is a water stress factor equals 1.0 as long as soil water content is higher than readily available water. If soil water content is lower than readily available water, Ks decreases linearly from one to zero according to total available soil water consumed. The soil water balance is performed in ISAREG with a daily time. The evaluation of readily available water content was carried out based on Penman-Monteith model taking into account meteorological data, technosols water-physical properties and the dependence of soil surface albedo on soil humidity. The color of the surface of the sod-lithogenic soil on the loess-like loam varies from yellow (2.5Y 4/2) in wet condition to yellow-red (10YR 6/5) in the dry condition. Albedo of this soil depended on the humidity varies in the range 0.17–0.31. The surface color of the pedozem varies from very dark gray (10YR 3/1) in wet condition to light-gray (2.5YR 6/2) in the dry condition. Albedo of this soil depended on the humidity varies in the range 0.10–0.31. There is a linear relationship between the moisture content in the soil and albedo of the soil surface. Albedo changes along with the humidity are most significant in the sod-lithogenic soils on loess-like loams. This is confirmed by the greatest regression coefficient. Albedo changes along with the moisture content are least significant in the pedozem. The distributioni of this index for different technosols are characterized by a high level of similarity of shape due to the fact that the overall climate factors are crucial in shaping the dynamics of moisture. The distributions can be most good represented as a complex mixture of normal distributions. It was found that water supplies monitoring before the start of the growing season can provide valuable information necessary for the selection of crops for cultivation in the current year. The results indicate the urgency of measures to save the winter rainfall on the fields.

Keywords: reclamation; water regime; technosols; evapotranspiration; Penman-Monteith equitation.

Introduction

The hydrological budget is driven principally by precipitation and evapotranspiration (Rahgozar et al., 2012). These two climate elements largely determine the amount of moisture available for plant use or, in arid and semiarid regions, the magnitude of water deficiency (Toy, 1979). The difference in transpiration water rate of soil may be induced by the ground biomass and vegetation coverage which are different in soils with different organic layer thickness (Tromp-van Meerveld & McDonnell, 2006). Evapotranspiration is the key element of land water balance structure (Hlaváčiková & Novák, 2013). The transpiration water rate variation considerably effects on the spatial distribution of soil moisture (Detto et al., 2006). In semiarid regions evapotranspiration is the leading loss term of the root zone water budget (Reynolds et al., 2000; Williams & Albertson, 2004). Mining and open-cast mining cause drastic disturbances to the natural environment (Frouz, 2018). Reclamation can restore soil quality after mining over time aiming at the restoration of a stable and productive ecosystem (Shrestha & Lal, 2011). The development of a water regime of the post-mining sites can be divided into two parts: the development of soil, which stores water in the ecosystem, and the development of vegetation, which is an important consumer of water (Frouz, 2018). The land surface albedo, evapotranspiration, and surface roughness are the key factors of physical land-atmosphere interaction (Bonan, 2008).

Various modelling approaches were used for estimation of evapotranspiration at regional scales (Ray & Dadhwal, 2001; Consoli et al., 2006; Tasumi & Allen, 2007). There are direct and indirect methods for evapotranspiration estimation (Chanasyk et al., 2006). Indirect methods include those based on the concept of actual evapotranspiration versus potential evapotranspiration and utilize meteorological data (Sharma, 1985). At the field scale a model for determining wheat basal crop coefficients from observations of the normalized difference vegetation index (NDVI) were developed (Hunsaker et al., 2005). The daily evapotranspiration was computed from instantaneous latent heat flux estimates derived from digital airborne multispectral remote sensing imagery (Chavez et al., 2008). The FAO Penman-Monteith reference evapotranspiration equation is basic tools to calculate evapotranspiration from meteorological data (Penman, 1948; Allen et al., 1998). The Penman-Monteith equation has been revealed to be reliable in a wide range of environments (Hess, 1996). Its computation requires weather data on maximum and minimum temperature, solar radiation, relative humidity and wind speed at 2 m height. This approach was tested and validated (Pereira et al., 2003; Popova et al., 2006; Jabloun & Sahli, 2008). The first step of actual evapotranspiration estimation includes the calculating potential evapotranspiration from meteorological data using equations based on the aerodynamic theory and energy balance (Penman, 1948; Monteith, 1965). The potential evapotranspiration is then used to estimate actual evapotranspiration after application a soil water reduction factor, which is based on available or extractable soil water (Slabbers, 1980). Reference crop evapotranspiration is the evapotranspiration from a crop with specific characteristics. FAO-56 method sets the specific characteristics of a reference crop with certain height (0.12 m), surface resistance (70 s m^{-1}) and albedo (0.23) and then determines the reference evapotranspiration using the Penman-Monteith Equation (Allen et al., 1998). The albedo was shown to be able to considerably effect on the evapotranspiration rate (Seginer, 1969). Albedo is a leading factor in terms of climate impact (Zeng & Yoon, 2009). The effect of albedo on potential evapotranspiration varies with the season. Albedo having its greatest influence in the summer month (Jackson, 1967). Soil colour was detected to change after reclamation (Singh et al., 2015).

Artificial soils formed in the process of reclamation are classified as technosols. These manufactured soils have specific physical and chemical characteristics along with potential toxicity problems (Leguédois et al., 2016). Technosols were shown to perform ecosystem services such as water regulation (Huot et al., 2015). The research on physical properties of soil plays a significant role for the evaluation of reclamation success (Dexter, 2004). Soil thickness, texture, bulk density, porosity, pH (Klimkina et al., 2018), soil mass water content, soil mechanical impedance (Zhukov, 2015; Zhukov & Zadorozhnaya, 2016), soil gravel content, and soil electrical conductivity (Zhukov et al., 2016b) are the important indicators for assessing the physical properties of reconstructed soils (Arshad & Martin, 2002; Maslikova et al., 2016; Zhukov et al., 2016a; Zhukov & Zadorozhnaya, 2016). Reclamation enhances soil quality by improving physical and chemical properties, which helps in restoration of mine soils (Shrestha & Lal, 2008; Zhukov et al., 2016c). The considerable changes of the soil bulk density, soil porosity, and soil mass water content were revealed to be changed after a long time of vegetation restoration (Cao et al., 2015; Maltsev et al., 2017; Zhukov et al., 2019). After rehabilitation period the content of water available for plants was found to be favourable in reclaimed soils but less beneficial conditions of the soil were associated with air and water permeability (Kofodziej et al., 2016; Shcherbyna et al., 2017; Zhukov & Maslikova, 2018). Saturated hydraulic conductivity was found to increase in agricultural reclamation as a result tillage and alfalfa growing (Krümmelbein et al., 2010; Krümmelbein & Raab, 2012). Water holding capacity was near to the reference sites after 25 years of reclamation (Scherbina et al., 2014; Singh et al., 2015; Potapenko et al., 2019).

The aim of the study is to perform a simulation of moisture content in Nikopol manganese ore basin technosols using the Penman-Monteith approach and evaluate the role of the dependence of soils surface albedo from the humidity in the intensity of evapotranspiration.

Materials and methods

The research was conducted during 2012–2014 years at the investigation station of the remediation within Nikopol manganese ore basin (city Pokrov, Ukraine). The experimental area for the study of optimal modes of agricultural reclamation was created 1968–1970 years. The sod lithogenic soils on loess-like loam and pedozem were chosen as the objects of the investigation. Technosols are characterized by the following water-physical properties (the amount of moisture in the soil layer thickness of 1 m). Sod-lithogenic soils on the loess-like loam: field capacity – 320.55 mm, available soil moisture – 190.15 mm, maximum hygroscopic moisture – 97.33 mm, permanent wilting point – 130.40 mm. Pedozems: field capacity – 311.35 mm, available soil moisture – 196.36 mm, maximum hygroscopic moisture – 85.86 mm, permanent wilting point – 114.99 mm (Zhukov et al., 2017a, 2017b). The presented hydrological constants were used in further calculations.

The evapotranspiration from the soil surface was calculated by means of Penman-Monteith equation (Monteith, 1965):

$$E_{ref} = \frac{0.408\,\Delta(R_n - G_0) + \gamma\frac{900}{T_d + 273}u_2(e_d - e_a)}{\Delta + \gamma(1 + 0.34u_2)}, \quad (1)$$

where E_{ref} is reference evapotranspiration rate, mm d^{-1}; R_n – net radiation flux (MJ $m^{-2}d^{-1}$); G_0 –sensible heat flux into the soil (MJ $m^{-2}d^{-1}$); T_d – mean air temperature, °C; u_2 – wind speed (m s^{-1}) at 2 m above the ground; e_d is saturated vapour pressure at temperature T_d, ºC:

$$e = 0.611\exp\left(\frac{17.27T}{T + 237.3}\right), \quad (2)$$

Δ is the slope of the vapour pressure curve; γ is the psychrometric constant (kPa °C^{-1}); e_d–e_a – is saturated vapour pressure deficit.

Actual evapotranspiration may be calculated as follows:

$$E_{act} = K_s\,E_{ref}, \quad (3)$$

where K_s – water stress factor.

Root zone moisture depletion is evaluated as the difference between soil water content at field capacity (pF = 2.3) and actual soil water content. The K_s value which is a water stress factor equals 1.0 as long as soil water content is higher than readily available water (a fraction of the total available water). If soil water content is lower than readily available water (RAW), K_s decreases linearly from one to zero according to total available soil water consumed.

The following equation for calculating the daily net radiation was applied (Allen et al., 1994a, 1994b):

$$R_n = (1 - \alpha)R_{si} - [a_c(\frac{R_{si}}{R_{so}}) + b_c](a_1 + b_1 e_d^{0.5})\sigma(\frac{T_m^4 + T_n^4}{2}), \quad (4)$$

where σ is the Stefan-Boltzmann constant (σ = 4.903×10–9MJ $K^{-4}m^{-2}$); T_m and T_n represent the maximum and minimum air temperatures (ºC) in one day, respectively; a_c and b_c are the cloud factors, equal to 1.35 and –0.35, respectively; a_1 and b_1 are the emissivity factors, equal to 0.35 and –0.14, respectively (Evett et al., 2011); α is the soil surface albedo depending on the soil water content, color and texture as well as the organic matter content and surface roughness. R_{si}/R_{so} is the relative short-wave radiation, which is used to express the cloudiness of the atmosphere. When the sky is cloudier, its value is smaller. It varies in the range from 0.33 (dense cloud cover) to 1 (clear sky) (Allen et al., 1998).

The solar radiation in case of clear sky, R_{so}, is expressed as:

$$R_{so} = (0.75+0.00002EL_{msl})\, R_{sa}, \quad (5)$$

where EL_{msl} is the elevation (m) above the mean sea level; R_{so} and R_{sa} is the extraterrestrial solar radiation, which can be calculated by (Evett et al., 2011):

$$R_{sa} = [\frac{24(60)}{\pi}]\, G_{sc} d_r(\cos\theta\cos\delta\sin\omega_s + \omega_s\sin\theta\sin\delta), \quad (6)$$

where:

$$d_r = 1 + 0.33\cos(\frac{2\pi J}{365}), \quad (7)$$

and

$$\omega_s = \cos^{-1}(-\tan\theta\tan\delta), \quad (8)$$

where the term $24(60)/\pi$ is the inverse angle of rotation in daily; G_{sc} is the solar constant (–0.08202 MJ $m^{-2}min^{-1}$); d_r is the relative distance between the Earth and the sun, m; J is the day of year; ω_s is the sunset time angle (rad), the angle from solar noon to sunset; θ is the latitude; and δ is the solar declination.

The relationship between the 0.3–2.8 mm soil albedo and the Munsell color value component has the form (Post et al., 2000):

$$Y = -0.11 + 0.07\, X, \quad (9)$$

where Y – albedo; X – Munsell color value component.

The soil water balance is performed in ISAREG (Teixeira & Pereira, 1992) with a daily time step as:

$$SW_i = SW_{i-1} + P_i + I_i + G_i - E_i - D_i, \quad (10)$$

where SW_i and SW_{i-1} are respectively the soil water storage (mm) in the soil layer zone at the end of day i and of the previous day, i−1; P_i is the precipitation; I_i is the net irrigation depth; G_i is the capillary rise; E_i is the actual evapotranspiration, and D_i is the deep percolation out of the root zone, all referring to day i. All units but for SW are in mm d^{-1}. I_i, G_i, and D_i were neglected in this application.

Readily available water was found as:

$$RAW_i = SW_i - PWP, \quad (11)$$

where RAW – readily available water, mm; SW_i is the soil water storage, mm; PWP – permanent wilting point, mm.

Statistical calculation were made using software Statistica (version 8, StatSoft, USA).

Results

Precipitation falls very unevenly in time on the investigated area. In 2013, the duration of rainless period was 259 days in 2014 – 264 days, in 2015 – 261 days. The maximum daily rainfall varies within 18–49 mm. The highest amount of precipitation fell in the year 2015 (506.8 mm), and the lowest – in 2014 (328.9 mm). In 2013 fell to 345.6 mm. The intensity of the rainfall varies throughout the year. The highest rainfall usually occurs in June and the lowest – in August (Fig. 1). There are significant interannual differences in the intensity of rainfall. Minimum total annual precipitation in 2014 was due to a decrease in atypical rainfall in late winter and early winter. Maximum annual rainfall in 2015 was caused by intense rainfall both in the spring and in mid-summer and late autumn.

The average annual temperature is 11.14 ± 0.30 ºC and is not statistically significant different between years during the study period (F = 0.19; p = 0.82). The temperature range is from –23.4 to +37.8 ºC during the study period (Fig. 2). Minimum temperatures occur in January or February, and the maximum temperatures – in July or August. The largest temperature fluctuations occur in the winter or spring. Autumn period is usually marked by the sharp fall of temperatures.

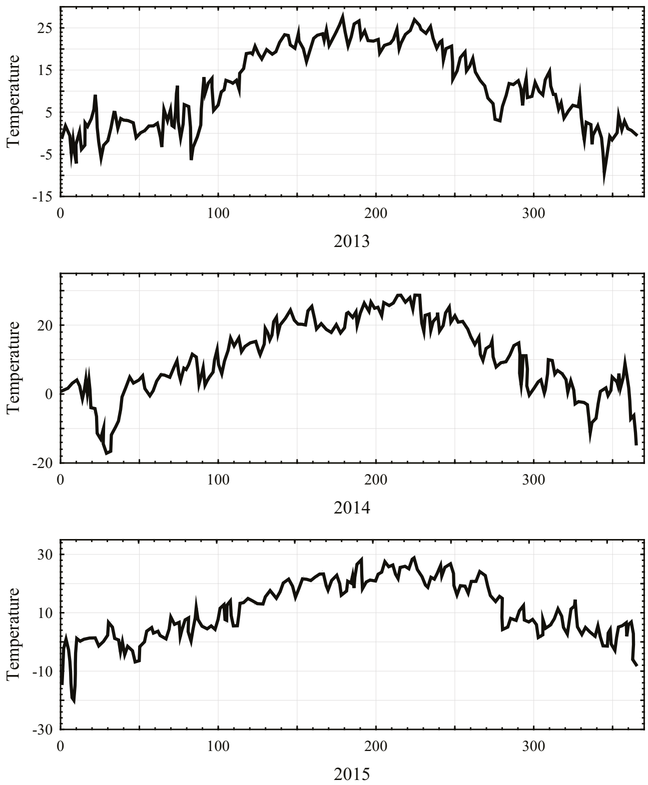

Fig. 2. Dynamics of daily mean temperature.
The abscissa axis is the order of the day this year,
the ordinate axis is daily mean temperature, °C

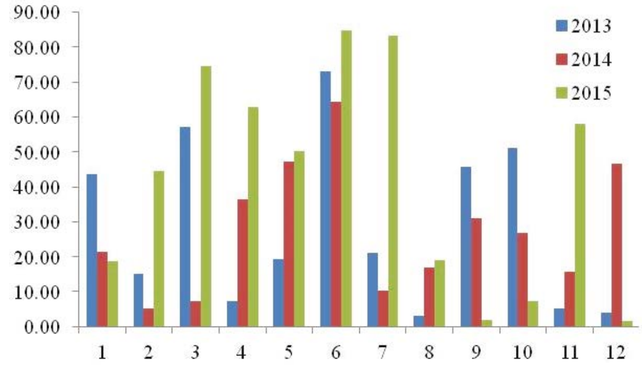

Fig. 1. Total monthly precipitation during 2013–2015.
The abscissa axis is the order of months, the ordinate axis is a monthly precipitation, mm

The winds blow predominantly from the east and north direction (in 2013), from the east and northeast direction (in 2014) or from the north and northeast direction (in 2015) (Fig. 3). The average wind speed is statistically significantly different from year to year (F = 8.72; p <0.001). The highest wind speed was observed in 2013, and the lowest – in the 2015 (Fig. 4). The wind speed local maximum was observed in March and autumn. The wind speed local minimum occurs in late summer. From the patterns indicated there are significant deviations from year to year. Thus, in 2014 the maximum wind speed was observed in January. In 2013 there was a minimum wind speed in June, after which there was a monotonic trend of increasing wind speed.

The average atmospheric humidity is statistically significantly varies from year to year (F = 7.67; p <0.001). The highest humidity was found in 2013, differences in the level of humidity in 2014 and 2015 were not significant (Fig. 5). From the beginning of year, there was a monotonic decrease in humidity until August, when there was a minimum of this indicator. The growth of humidity was de-

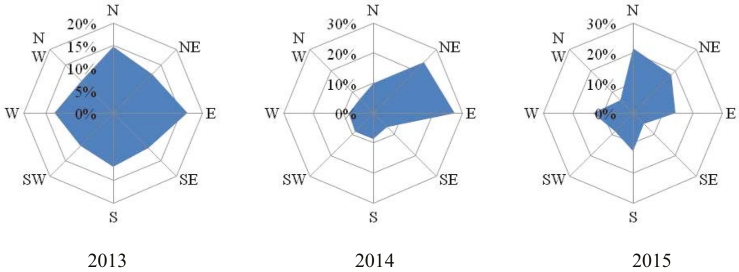

Fig. 3. Windrose

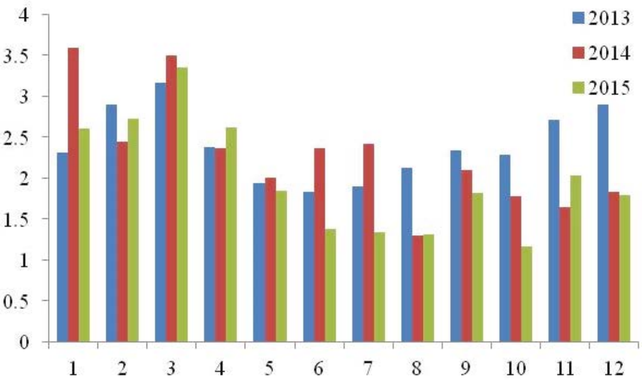

Fig. 4. The distribution of monthly average wind speed during 2013–2015. The abscissa axis is the order of months, the ordinate axis is a monthly average wind speed, m/s

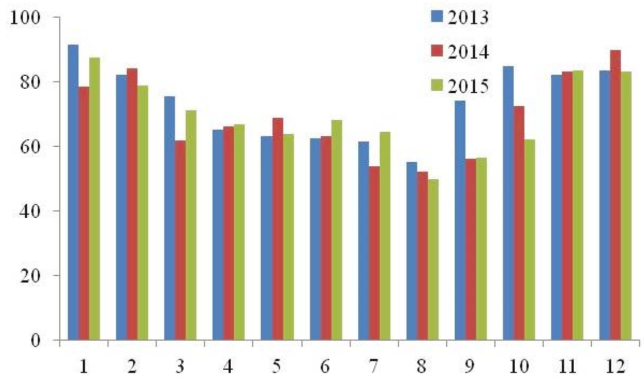

Fig. 5. The distribution of monthly average atmospheric humidity during 2013–2015. The abscissa axis is the order of months, the ordinate axis is a monthly average atmospheric humidity, %

tected in autumn, sometimes very quickly to the maximum values in winter. The atmospheric humidity is depended on the other climatic indicators that can be described using regression dependence, which is able to explain 46% of the variability in this parameter (F = 233.6; p <0.001, all predictors in model are statistically significant at p <0.001):

$$Y = 529.8 \pm 51.1 + 1.04 \pm 0.11 R - 1.16 \pm 0.04 Temp - 2.51 \pm 0.28 W - 0.43 \pm 0.05\, Pr,$$

where Y – atmospheric humidity; R – precipitation; $Temp$ – temperature; W – wind speed; Pr – atmospheric pressure.

The mean atmospheric pressure is statistically significantly varies from year to year (F = 60.22; p <0.001). The lowest atmospheric pressure was observed in 2015 (Fig. 6). The difference between 2013 and 2014 was not statistically significant. The most value of the atmospheric pressure is typical of early winter, and then in spring pressure was quite sharply reduced. In May, there was usually minimum of the atmospheric pressure, followed by a gradual increase it, which takes a sharp character from the middle of autumn.

The technosols color properties and its surface albedo vary depending on the moisture content. The surface color of the pedozem varies from very dark gray (10YR 3/1) in wet condition to light-gray (2.5YR 6/2) in the dry condition (Table 1). Albedo of this soil depended on the humidity varies in the range 0.10–0.31.

The color of the surface of the sod-lithogenic soil on the loess-like loam varies from yellow (2.5Y 4/2) in wet condition to yellow-red (10YR 6/5) in the dry condition. Albedo of this soil depended on the humidity varies in the range 0.17–0.31.

There is a linear relationship between the moisture content in the soil and albedo of the soil surface (Fig. 7). Albedo changes along with the humidity are most significant in the sod-lithogenic soils on loess-like loams. This is confirmed by the greatest regression coefficient. Accordingly, albedo changes along with the moisture content are least significant in the pedozem.

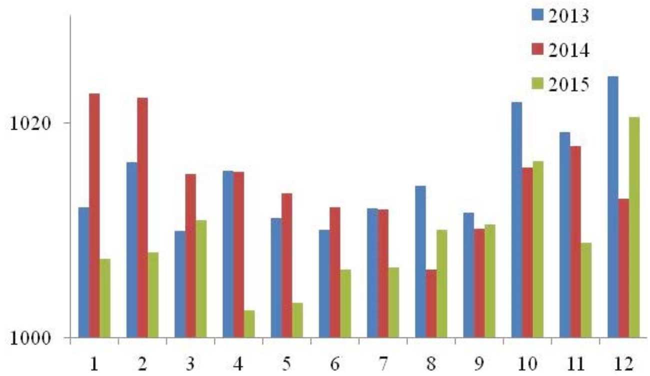

Fig. 6. The distribution of monthly average atmospheric presure during 2013–2015. The abscissa axis is the order of months, the ordinate axis is a monthly average atmospheric pressure, gPa

The evaluation of readily available water content was carried out based on Penman-Monteith model taking into account meteorological data, technosols water-physical properties and the dependence of soil surface albedo on soil humidity. The distributioni of this index for different technosols are characterized by a high level of similarity of shape due to the fact that the overall climate factors are crucial in shaping the dynamics of moisture (Fig. 8).

The distributions are asymmetric, which is also confirmed by the skewness coefficients that are statistically significantly diffe-

Table 1. The variability of the albedo and surface color characteristics of the technosols depending on water content

Water content, mm in 1 meter soil layer	Mansell color properties			Albedo*
	Hue	Value	Chroma	
		Pedozem		
85.9	2.5YR	6.00	2	0.31
111.9	2.5YR	5.80	2	0.30
137.9	2.5YR	5.40	2	0.27
163.9	2.5YR	5.00	2	0.24
189.9	2.5YR	4.80	2	0.23
207.3	5YR	4.40	2	0.20
233.3	5YR	4.00	2	0.17
259.3	5YR	3.50	1	0.14
285.3	10YR	3.20	1	0.11
311.4	10YR	3.00	1	0.10
		Sod-lithogenic soil on the loess-like loam		
97.0	10YR	6.00	5	0.31
122.8	10YR	5.80	5	0.30
148.7	10YR	5.40	5	0.27
174.5	10YR	5.20	4	0.25
200.4	2.5Y	5.00	4	0.24
217.6	2.5Y	4.80	4	0.23
243.5	2.5Y	4.50	3	0.21
269.3	2.5Y	4.30	3	0.19
295.2	2.5Y	4.10	3	0.18
321.0	2.5Y	4.00	2	0.17

Note: * – estimation on the basis of the equitation $Y = -0.11 + 0.07\,X$, where Y – albedo; X – Munsell color value component (Post et al., 2000).

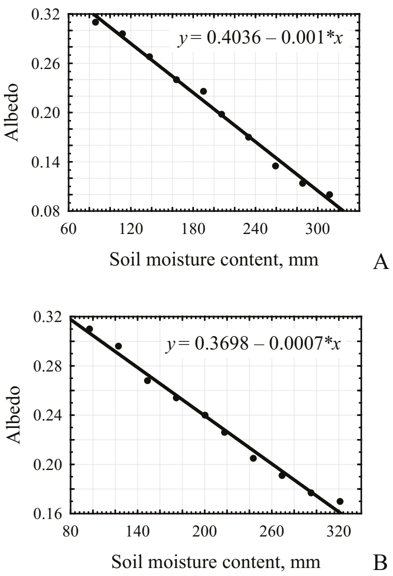

Fig. 7. The dependence of soil surface albedo on soil water content:
A – pedozems; B – sod-lithogenic soils on loess-like loams

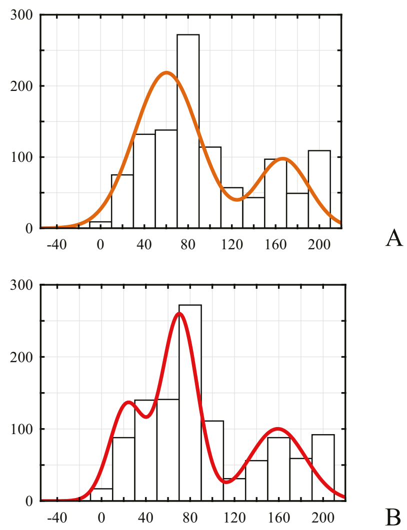

Fig. 8. Histograms of the readily available water distributions.
Axis abscissa – the moisture content, mm:
A – pedozems; B – sod-lithogenic soils on loess-like loams

rent from zero (Table 2). The distributions can be most good represented as a complex mixture of normal distributions. A mixture of three normal distribution is the best model for the distribution of readily available water in sod-lithogenic soils on the loess-like loam (Kolmogorov-Smirnov statistic d = 0.03; p = 0.25). The first mixture component holds 0.24 of the total variation (mean = 23.0; σ = 15.6), the second component – 0. 47 of the total variation (mean = 70.4; σ = 16.0), the third – 0.29 of the total variation

Table 2. Descriptive statistics of the readily available water content

Soil*	Mean±st.error, mm	Minimum, mm	Maximum, mm	Skewness±st.error	Kurtosis±st.error
			2013		
LL	99.44±3.30	1.31	191.12	0.30±0.13	–1.29±0.25
PZ	103.37±3.33	5.08	196.47	0.31±0.13	–1.29±0.25
			2014		
LL	49.14±1.34	–7.48	94.27	–0.60±0.13	–0.77±0.25
PZ	52.96±1.33	–3.47	98.26	–0.60±0.13	–0.77±0.25
			2015		
LL	105.14±2.53	22.11	191.12	–0.25±0.13	–1.21±0.25
PZ	108.03±2.55	24.98	196.47	–0.24±0.13	–1.20±0.25
			Total		
LL	84.57±1.64	–7.48	191.12	0.53±0.07	–0.74±0.15
PZ	88.12±1.65	–3.47	196.47	0.55±0.07	–0.71±0.15

(mean = 159.1; σ = 25.1). Thus, readily available water in sod-lithogenic soils on the loess-like loam is on three levels and most often this level is 70.4 mm (Fig. 9). High levels of moisture occurs in the winter-spring period, when the rate of precipitation generally prevailing rate of evaporation of water in the summer or during intensive downpours. In 2014 water supplies were on average and very low level due to the fact that in winter, water supplies were not renewed due to low rainfall. Also this year there was intensive rainfall in early summer, which tends to compensate intense evaporation

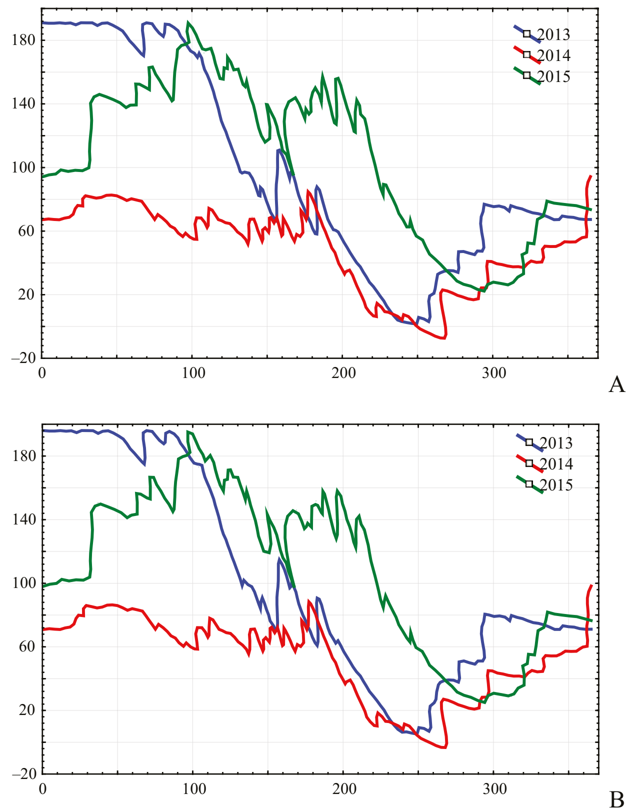

Fig. 9. The dynamics of readily available soil moisture:
A – in the sod-lithogenic soils on loess-like loam; B – in pedozem.
The horizontal axis is the order of the days of the year,
the vertical axis is readily available soil moisture, mm

during this period. The readily available water content decreased below a critical level (permanent wilting point) only in 2014.

For pedozems the available for plants moisture distribution is best can be presented as a mixture of two normal distributions (Kolmogorov-Smirnov statistics d = 0.045; p = 0.15). The first part embraces 0.73 of the total variations (mean = 60.3; σ = 29.5), the second – 0.27 of the total variations (mean = 166.6; σ = 24.5). The relatively high levels of water reserves is characteristic for winter and spring periods. They tend to expand as a result of the high rainfall in early summer. The recharge was sufficient in 2013 and 2015, respectively, whereas in 2014 in the summer there was a drought. The drought lasted 9 days.

Discussion

Obviously, the meteorological conditions are most important factors that determine the dynamics of moisture content in all soil, including artificial. The water regime features of technosems depend on their water-physical properties and characteristics of the soil contact surface with the environment. Vegetation, color and character of the soil surface greatly affect the intensity of energy and material exchange with the soil environment. The technosems are young soils, which have a large variability in surface color. This feature leads to a significant variation of technosols surface albedo. The relationship between albedo and moisture creates the preconditions for the formation of the negative feedback mechanism of communication between the humidity and the evapotranspiration intensity. Reducing the water content in the soil leads to reduction of evaporation due to increased albedo. It should be noted that over the soil forming process the color differences between technosols will decrease due to the accumulation of organic matter that provides soils black or gray. But the accumulation of organic matter improves the technosols water-physical properties enabling better use of the climate potential.

The dynamics of the soil moisture content can be modeled by the balance of precipitation and evapotranspiration intensity in condition of the non-washing water regime of soil. The routine meteorological data can be used to simulate the balance of water and evapotranspiration (Allen et al., 1998). Besides climatic regimes the water-physical properties of the particular soil type play a key role in water dynamics. Albedo of a soil surface is particularly important. In this regard the technosols as young soil-like bodies are characterized by considerable color diversity. Albedo essentially depends on the color of the soil surface (Post et al., 2000). The color of the upper soil layers is depended on organic matter content which gives it colors from gray to black. The technosols organic matter content is low in the early stages of development (Zhukov et al., 2017a; Komlyk & Brygadyrenko, 2019), so technosols encompass a diverse range of colors. The pedozem is most similar to natural analogues in structure and color of the surface and is characterized by the lowest albedo. The technosols that manufactured on the gray-green clay have the highest albedo value. It should be noted albedo is depended on the moisture content: wet soils are characterized by a lower albedo. Also, the higher organic matter content decreases albedo. Thus, the evapotranspiration rate decreases due to increased albedo with the decrease of water content in soil.

The general trend of the readily available soil moisture variation is very similar for all studied technosols. The differences relate to quantitative characteristics, which are caused by the water-physical properties. The field capacity is attributable mainly to the soil aggregation structure (Frouz, 2018). The investigated soils are clay or loam, which have a high ability to aggregate formation. The low humus content makes aggregates to be water unstable (Frouz & Kuráž, 2014). Organic matter can improve bulk density of the technosols, its aeration and water retention/infiltration (Sanborn et al., 2004), aggregation and structure (Larney & Angers, 2012). In loess used for reclamation CaCO3 as cementing agent dominates soil aggregation (Pihlap et al., 2019). Also salinity processes in technosols do not contribute to the formation water stable aggregate structure (Klimkina et al., 2018). However, all technosols studied have the high rates of field capacity, which determines the range of available soil moisture. The permanent wilting point is a function of soil granulometric composition (Bradshaw, 1997) and, in condition of salinity, this parameter is affected on the content of soluble salts (Shrestha & Lal, 2011). Clay and loamy particle size generates high values of permanent wilting point.

This study examined the year with relatively high precipitation (2015), during which rain fell almost a half times more than in the rest of the studied years. The years 2013 and 2014 are characterized by similar precipitation values. But the peculiarities of the readily available soil moisture dynamics in the years are significantly different, due to the different patterns of rainfall during the year. In 2015 the duration of summer, when precipitation falls was significantly extended, resulting generated optimal conditions for the plants growing. In the 2013 summer peak rainfall was not long, but it was enough to compensate for the intense summer evaporation. The rainfall deficit in the winter 2013–2014 years do not made it possible to create the necessary supply of moisture before the growing season. Almost until the middle of summer moisture level in the soil was constant, but in late summer fell sharply. This is even despite the fact that during April–June precipitation in 2014 was at even slightly higher than in 2013.

The specify of albedo dynamics depending on moisture content and technosols water-physical properties create the preconditions for the formation of water regime stability. The stability of the water regime allows for sufficient available for plants moisture within a significant range of vegetation. Even crops most sensitive to water shortages with long vegetation period can finish life cycle on technosols under conditions of heavy rainfall at the beginning of the summer. But unfortunately, the considerable supplies of moisture in spring do not guarantee this. Initial indicators of moisture content in 2013 and 2015 were almost the same, but no significant rainfall in early summer 2013 led dynamics of moisture content to the level of 2014, when the starting conditions were much worse.

A common feature of global warming is the increase in precipitation and change it time patterns. As shown by the results of our research, reducing the norms of precipitation in winter period significantly affects the mode of moisture during the growing season. On the other hand, favorable moisture reserves in the Spring does not guarantee an optimal water regime during growing season, which is possible only in conditions of high levels of rainfall in early summer, but the latter is a random event and cannot be accurately estimated. With this in mind, the following practical recommendations can be made. First, water supplies monitoring before the start of the growing season can provide valuable information necessary for the selection of crops for cultivation in the current year. Secondly, the results indicate the urgency of measures to save the winter rainfall on the fields. Thirdly, it is the use of mulch to conserve moisture, including by increasing the albedo of the surface soil.

Conclusion

The natural soils tend to have varying degrees humus top layer. Organic matter provides soils gray or black. The technosols are characterized by a much greater variety of surface colors. This diversity is increased in the moisture gradient conditions. Changing moisture content significantly affects the technosols color properties. A color affects the albedo. In the arid conditions the moisture acts as a strong limiting factor, because the slightest differences in the moisture content dynamics are reflected in the significant environmental impacts. The simulation showed that the overall trend variability of moisture content in technosols is determined by weather conditions flow. Technosols features are depended on water-physical properties and albedo connection with soil moisture content.

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