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Impact of Anthropogenic Factors on Runoff Formation in the Southern Urals

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Abstract: A runoff is a multi-factor phenomenon being of great importance in the life of humans, animals and plants. Rivers are known to meet the needs of biota and economic activity in fresh water. A channel runoff represents constantly replenished resources of self-purification capacity. This makes it almost the only source that provides the needs of industry, agriculture as well as housing and public utility sector in water of the required quality. The ecological situation of the territory and the extent to which natural complexes are changed due to the increased technogenic processes resulting in the depletion of the channel runoff and transformation of its regime, depend on the state of water bodies.

This paper presents the study of the runoff formation factors and the role of economic activities in changing the water volume of rivers. Statistical methods and data on human activities within river basins were used in establishing the starting point of changes in the hydrological characteristics and determining the degree of the runoff change. Rivers with disrupted runoff regime were identified; changes in annual and seasonal runoff were assessed. The role of hydraulic engineering construction and irrigation reclamation facilities in the dynamics of hydrologic processes as the main factors of changes in the water volume of river systems was grounded. The study results can be used in water management calculations to restore runoff values, in construction of economic facilities in catchments and riverbeds, as well as in adjustment of water management circuits for industrial enterprises and settlements.

Key words: Runoff, economic activity, spring flooding, summer low-water period, winter low-water period, disrupted homogeneity of runoff series.

Introduction

Runoff characteristics directly depend on the physical and geographical features of watersheds and are the result of the interaction of many environmental factors, meteorological conditions in particular. Meteorological conditions determine the sequence of high-water and low-water years associated with the prevailing atmospheric circulation type in catchments at various time intervals. However, since the middle of the 20th

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century the channel runoff formation has been greatly influenced by human economic activity resulting from increased scientific and technological advancement. As a result, runoff signatures, water regime as well as feeding characteristics of hydrographical grid elements have been changing. Hydraulic engineering structures built for water reservoirs cause changes both in the river water volume during the year and in the channel runoff patterns. Economic activities carried out in watersheds tend to change the ratio between the surface and ground runoff components and hydrologic characteristics of waterflows. Against the backdrop of global warming these changes may cause Wilcoxon signed rank problems associated with water supply of settlements and enterprises and bring about water shortages in numerous regions of the world.

A lot of researchers focus on assessing the impact of anthropogenic factors on runoff formation. Teufel (2019) explains the catastrophic Montreal flood of 2017 in Canada by the increase in winter precipitation, which was, in turn, a result of anthropogenic emissions. Thanathanphon (2018) believes that floods and droughts occurring in Thailand require developing new approaches to water management based on real cases. Floods in Africa and South America can be successfully predicted using large-scale models covering all of the river channels (Revilla-Romero et al., 2016). The case of the Platte river basin, Nebraska, USA, was used to study accelerated changes in the environment components, water volume of rivers in particular (Birge et al., 2018). The study focused on depletion of natural resources resulted from anthropogenic factors.

Changes in low water runoff observed in the late 20th century and early 21st century in the south of Province of Ontario, Canada should be accounted for by both climatic features and human economic activity (Buttle et al., 2015). Orth (2015) comes up with a hydrological model for Europe; the model would address both natural and anthropogenic factors of runoff formation. Issues of climate change, water volume of rivers and their rational use are considered in the case study of Wisconsin, USA with regard to fish farming (Selbig, 2015). Zhang analyzed the relationship between hydrologic characteristics and forest cover and identified the intensity of runoff changes in small and large catchments depending on forestry activities (Zhang et al., 2017). Praskievicz (2019) underlines the need for a new classification of river systems with consideration to anthropogenic transformations. Based on the case study of rivers in Alabama, USA, the author suggests classifying rivers characterized by relatively natural runoff (ungaged streams). The results of the study could meet the objectives of conservation and restoration of ecosystems.

Promakhova presented interesting findings on the impact of the meteorological factors and economic activity on the runoff formation for the Kondurcha and Baitugan rivers of the Lower Volga basin in the low-water 2010 (Promakhova et al., 2017). The study of anthropogenic changes in the runoff of the Moscow river revealed a two-fold increase in winter low water runoff, and a 1.3-fold increase in the summer-autumn low water runoff compared to a 1.5-fold decrease in the spring flooding (Koronkevich and Melnik, 2017). Recently, a tendency has been observed for annual runoff to decrease. The paper emphasizes the need to assess the role of anthropogenic factors in hydrology, the role being one of the most urgent objectives of the advanced science. The final point discussed in the paper is found relevant by all researchers involved in the study of conditions for runoff and hydrologic regime.

The aim of the study is to assess the role of anthropogenic factors in the formation of runoff in the southern Urals.

To determine the presence and extent of changes in runoff as a result of economic activity in catchments, it is necessary to assess homogeneity of runoff series, as disruption of the homogeneity indicates significant changes. Linear trend estimation should be used to identify insignificant changes, as the method helps to assess their tendency.

Object and Methods of the Study

The object of the study is the rivers of the southern Urals. The region boasts of highly developed national economy and intensive use of runoff. Graphic and mathematical-statistical methods, as well as data on economic activities within the river basins were used for the study. To determine the impact of anthropogenic factors on the runoff signatures we analysed all of the gaged rivers of the southern Urals. The study was divided into several stages, each stage employed different methods. The first stage involved analysis of the runoff dependence on meteorological factors, the dependence was presented in joint graphs of 5-year moving averages of water discharge, precipitation and air temperature. Then, to establish the starting point of changes in the water regime a method of double integrated lines was used combined with the data on the time when hydraulic engineering structures were launched and activities affecting the water volume of rivers were started.

$$\Sigma Q_{\text{year}} = f(t),$$

$$\Sigma Q_{\text{season}} = f(\Sigma\, Q_{\text{year}}) \quad (1)$$

$$\Sigma Q_{\text{season}} = f(t),$$

$$\Sigma Q_{\text{season}} = f(\Sigma\, X) \quad (2)$$

where ΣQ_{year} is integrated total of annual water discharge; ΣQ_{season}– integrated total of water discharge for a definite season (summer low water, winter low water, spring flood periods); ΣX – integrated total of precipitation per season; and T is the number of years observed.

The relationships may be used to determine the starting point of changes in runoff characteristics and assess the tendency of the observed changes. The integral line shows random fluctuations of the variables on both sides of the straight line. The straight line determines the general direction given there is a close link between the two time series. If the link is disrupted the integral line shows systemic deviation of points from the original direction, starting from the time when anthropogenic impact was strengthened. At the same time the economic activity carried out within the watersheds was analysed (Nesterenko and Bakirov, 2017; Mustafin et al., 2018; Nesterenko and Solomatin, 2018; Rakhimov et al., 2018; Minigazimov et al., 2019). The analysis revealed the most significant anthropogenic factors, that is building of reservoirs of various volume ad water intake structures for irrigation. The next stage revealed significant changes in the runoff using the Wilcoxon signed rank criterion, which identified rivers with disrupted hydrologic regime. The linear trend method was used for rivers with insignificant changes in water volume, the method indicated the upward/downward trend.

Results of the Study and Discussion

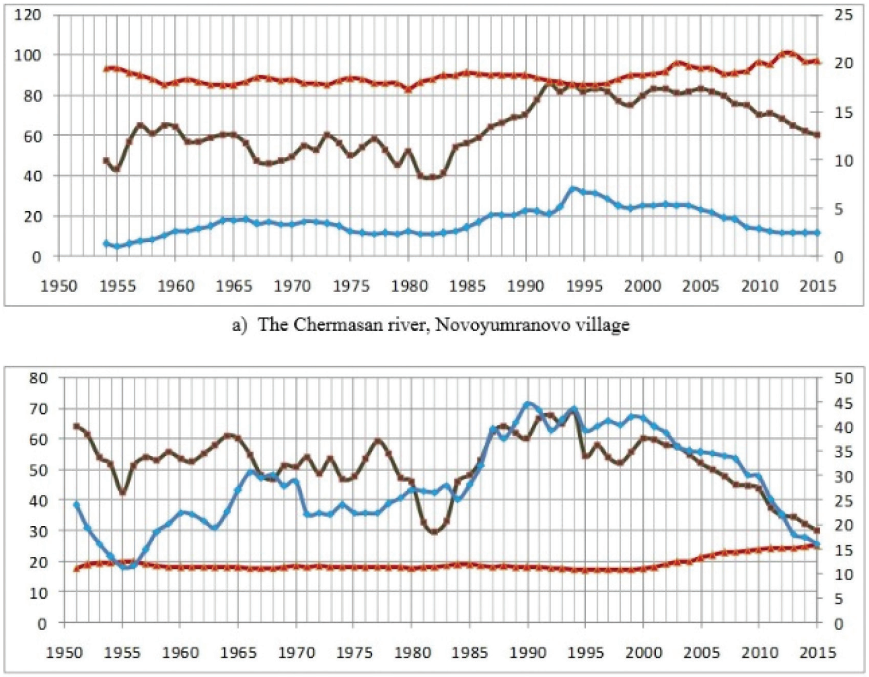
Meteorological conditions play an important role in the runoff formation in the southern Urals. The joint graphs of 5-year moving averages of runoff, precipitation and air temperature are consistent with the statement. The analysis revealed the following pattern: annual runoff decreases as air temperature values rise during the warm period and annual precipitation values decline, and the reverse is true when air temperature values fall and annual precipitation figures rise, annual runoff increases. Runoff values are a little behind the precipitation values as hydrologic characteristics depend on the precipitation not only of a given year but also of the previous period. A similar pattern is observed when comparing the spring flood water discharge with the winter precipitation and the spring air temperature. The summer low water period is characterized by a direct dependence on summer precipitation and an inverse dependence on air temperature (Figure 1).

The dependence of runoff on meteorological factors outlines a general picture but cannot reveal the role of economic activity in the changes of hydrologic characteristics in case the changes are not fundamental (Georgiadi et al., 2017; Gorshkova et al., 2017; Khafizov et al., 2019).

The study showed that changes in runoff characteristics caused by human economic activity differ depending on the territory. This is due to the location of the region at the junction of the following physical and geographical areas: The pre-Urals, the central Urals and the trans-Urals. The latitudinal zonation also influenced the study results: there are differences among forest, forest-steppe and steppe natural zones. The method of double integrated lines revealed a slight decrease in the annual runoff of the pre-Ural rivers since the late 60s of the 20th century. These are the Strelya, Urshak, Dema, Chermasan, Syun' rivers, their basins are used for agricultural production. The study area saw intensive use of irrigation reclamation practices at the specified period; the practices involved building of small reservoirs-ponds that became the main moisture evaporation sources.

Lower annual runoff values were recorded in the area of the central Urals rivers dammed by reservoirs. Generally, the reservoirs meet the needs of industrial enterprises and housing and public utility sector: they are Nugushskoe, Nyazepetrovskoe and Yumaguzinskoe reservoirs. The trans-Urals region featuring the most arid climate has large reservoirs: Verkhneuralskoe (Upper-Ural), Iriklinskoe and Yuzhnouralskoe (Southern Ural) reservoirs used for the needs of industrial towns. The reservoirs have been the cause of lower annual runoff values for the period of their existence. Ponds formed on small rivers of the steppe zone of the study region also contributed to lowering annual water discharge values due to increased evaporating surface area.

The method of double integral lines could not reveal any changes during spring flooding, the exception were the rivers where the runoff was regulated by large reservoirs. The changes were found on the following rivers: the Nugush river, Nugushskoe reservoir was



a) The Chermasan river, Novoyumranovo village

b) The Dema river, Bochkarevo village

Figure 1: Dynamics of summer low water runoff, precipitation and air temperature on the rivers of the southern Urals for the period from the beginning of observations to 2015.
The legend reads: –■– ∑X/5 – 5-year moving averages of precipitation, mm; –▲–∑t^0/5 – 5-summer moving averages of air temperature, °C; and –◆–∑Q/5 – 5-year moving averages of water discharge, m^3.

constructed on the river in 1967; the Belaya river dammed by Yumaguzinskoe reservoir in 2004; the Ural river, Iriklinskoe reservoir was built on the river in 1966.

Distinct deviations from the original direction of the double integral lines were found in analysing the runoff series of summer low water on the pre-Ural rivers: the Urshak, Dema, Chermasan, Syun' rivers. The following relationships:

$$\Sigma Q_{summer} = f(t),$$
$$\Sigma Q_{summer} = f(\Sigma Q_{year}),$$
$$\Sigma Q_{summer} = f(\Sigma X_{summer}) \qquad (3)$$

for the specified rivers demonstrate increased summer runoff since the mid-60s of the 20th century (ΣX_{summer} is consequently aggregated values of summer precipitation). This is due to the regulatory role of ponds built on small and medium-sized rivers to improve the efficiency of farming. A significant increase in summer low water runoff was also found on the following rivers of the trans-Urals and steppe zone: the Malyi Kizil, Bolshoy Kizil, Tanalyk, Urlyada, Urtazymka and Salmysh rivers. The rivers feature low water volume, and sometimes freeze and dry up. Almost 80% of annual runoff flows down with spring flooding (Pavleichik and Sivokhip, 2018). Ponds were formed on the watercourses filled in spring and used in summer for sanitary water use in the low water period and for farming purposes.

Anthropogenic factors affecting changes in runoff were analysed for winter low water period. The study found that the following relationships

$$\Sigma Q_{winter} = f(Q_{year})$$
$$\Sigma Q_{winter} = f(t) \qquad (4)$$

demonstrated increased water discharge in winter months on the Sterlya, Urshak, Chermasan, Syun' (the pre-Urals), Bolshoy Kizil, Tanalyk and Urtazymka rivers (the trans-Urals and steppe zone). The deviation of the points from the original direction had been observed since the late 60s-early 70s of the 20th century. This is due to the intensive development of irrigated land under the food programme. Irrigation reclamation practices are known to have an impact on the annual distribution of runoff. Water taken from the channel during growing period enters the hydrographic grid in autumn and winter, so the runoff increases during winter low water period.

The next stage establishes essential changes revealed in the study. The procedure implies analysis of homogeneity of hydrologic series combined with statistical data. The study used the Wilcoxon signed rank criterion as it belongs to non-parametric criteria; the latter allow abstraction from the distribution type of the studied values.

In terms of annual averages of water discharge the method revealed no disruptions of series homogeneity on any of the study rivers. The findings show that the changes are insignificant. Therefore, to describe the dynamics of this process, the main trend should be assessed using the linear trend method, as the direction of changes can be expressed mathematically. Assessment of the trend in annual river runoff in the study area is shown in Table 1:

Table 1 shows that in all of the study catchments annual runoff tends to fall systematically though to varying degrees.

No changes of annual runoff are revealed on other rivers of the region, as evidenced by the coefficient standing before parameter *t*, almost equal to 0. Deviations of the points from the trend line do not exceed the fluctuation amplitude of the hydrologic variables around their average value.

The Wilcoxon signed rank criterion used to analyse homogeneity of summer low water runoff series found that the Urshak, Chermasan, Syun', Bolshoy Kizil, Tanalyk, Urlyada and Urtazymka rivers feature disrupted runoff series homogeneity.

Increased summer low water discharge values confirm the first stage study results obtained with the help of the double integral lines method. Statistical methods found no changes in summer low water values, so the changes may be considered insignificant. The dynamics of the process is directed upwards, as evidenced by the sign "+" before the coefficient of the *t* parameter.

Disrupted homogeneity of winter low water runoff series was found on the Urshak, Dema, Chermasan, Syun' (the pre-Urals), Nugush, Belaya (the central Urals), Ural, Tanalyk, Urlyada and Urtazymka (the tras-Urals and steppe zone) rivers. Increased winter water volume was observed in the mentioned catchments, the tendency is accounted for by the return flow of irrigation water to the drainage network (the pre-Urals, the trans-Urals and steppe zone) and by reservoir operation (the central Urals).

Increased hydrological variables were found on the Sterlya and Bolshoy Kizil rivers based on the method of double integral lines. So to analyse winter low water variables of the rivers the linear trend method was applied. The method proved the upward trend in runoff variables.

Quantitative assessment is the next stage of the study focused on identifying the impact of anthropogenic factors on runoff formation. The study of the Southern Urals rivers showed that changes in summer and winter low water runoff due to anthropogenic factors may be revealed based on the formula

$$K = tg(\alpha)/tg(\alpha_1) \quad (5)$$

where α_1 and α are slope angles of the double integral curve for periods before (α_1) and after (α) change in the hydrologic regime. The assessment results are shown in Table 2.

Table 1: Trend in annual runoff of rivers in the southern Urals

River – point	*The equation of the linear trend*
The Sterlya river, Otradovka village	Y = 1.57 – 0.002 t*
The Urshak river, Lyakhovo village	Y = 8.62 – 0,006 t
The Dema river, Bochkarevo village	Y = 42.27 – 0.02 t
The Chermasan river, Novoymranovo village	Y = 6.41 – 0.09 t
The Syun' river, Min'yarovo village	Y = 15.80 – 0.15 t
The Nugush river, Andreevskiy farm	Y = 19.61 – 0.87 t
The Belaya river, the town of Ishimbay	Y = 44.39 – 0.37 t
The Ural river, the town of Orsk	Y = 21.27 – 0.24 t
The Malyi Kizil, Murakaevo village	Y = 7.82 – 0.03 t
The Bolshoy Kizil, Verkhne-Abdryashevo village	Y = 8.19 – 0.06t
The Tanalyk river, Mambetovo village	Y = 6.41 – 0.63t
The Urlyada river, Novo-Akhunovo village	Y = 4.72 – 0.009t
The Urtazymka river, Sosnovka village	Y = 5.08 – 0.07t
The Salmysh river, Bulanovo village	Y = 9.35 – 0.004t

Note: t* the number of years observed

Table 2: Increased low-water runoff on the Southern Urals rivers

River – point	*Starting point of the increase, year*	*Increase, %*	
		summer	*winter*
The Urshak river, Lyakhovo village	1972	45	36
The Dema river, Bochkarevo village	1969	55	39
The Chermasan river, Novoymranovo village	1971	60	52
The Syun' river, Min'yarovo village	1970	59	55
The Nugush river - Andreevsky farm	1968	–	37
The Belaya river, the town of Ishimbay	2005	–	43
The Ural river, the town of Orsk	1967	–	29
The Bolshoy Kizil, Verkhne-Abdryashevo village	1968	35	21
The Tanalyk river, Mambetovo village	1968	54	48
The Urlyada river, Novo-Akhunovo village	1966	34	31
The Urtazymka river, Sosnovka village	1966	31	28

Table 3: Decreased spring flood runoff on the southern Urals rivers

River – point	*Starting point of the decrease, year*	*Decrease, %*
The Nugush river - Andreevsky farm	1968	42
The Belaya river, the town of Ishimbay	2005	24
The Ural river, the town of Orsk	1967	27

Table 2 demonstrates that human economic activity increased low water runoff by within 31-60% in summer and 21-55% in winter in the watersheds of the southern Urals.

The method calculated the decrease in spring flood runoff caused by reservoirs on the Nugush, Belaya and Ural rivers (Table 3).

Table 3 shows that spring runoff of the study rivers is collected in large reservoirs, thus reducing the water discharge on the reservoir sites during spring flood.

Increased summer low water volume revealed in the study resulted from ponds. The fact is confirmed by the dynamics of the annual regulated runoff coefficient (φ). The coefficient describes the ratio of the base runoff to the annual value. The φ has been steadily increasing since the late 60s of the 20th century in catchments with intensive farming (Figure 2).

We often need to restore the changed runoff values in hydrological studies, so the original direction of the double integral line is extrapolated. The restored values are the runoff values recorded from the line. Comparing the restored runoff values with values obtained by the water balance method is of great interest. Ponds and water intakes for irrigation are the main types of economic activities on the southern Urals watersheds. The following equation can be used for the purpose:

$$W_{\text{restored}} = W_{\text{observed}} - (W_{\text{pond}} - W_1) + W_2 \qquad (6)$$

where $W_{restored}$ is the volume of runoff restored, $W_{observed}$ – volume of runoff observed, W_{pond} – total effective capacity of ponds, W_1 – water intakes from ponds and W_2 – water intakes from the channel runoff.

Based on the calculations we found that the Urshak, Dema, Chermasan, Syun', Bolshoy Kizil, Tanalyk, Urlyada and Urtazymka rivers have summer water discharge values, restored using the water balance method, a little different from the values obtained by the statistical methods. Still, the values demonstrate increased runoff values. The statistical method proves to be efficient in restoring hydrologic characteristics and the water balance method appears efficient in confirming the study findings.

The watersheds of the forest and steppe zone of the pre-Urals and the trans-Urals as well as the steppe zone of the southern Urals experience the impact of anthropogenic factors on runoff in the opposite processes. Water withdrawn from the channel runoff

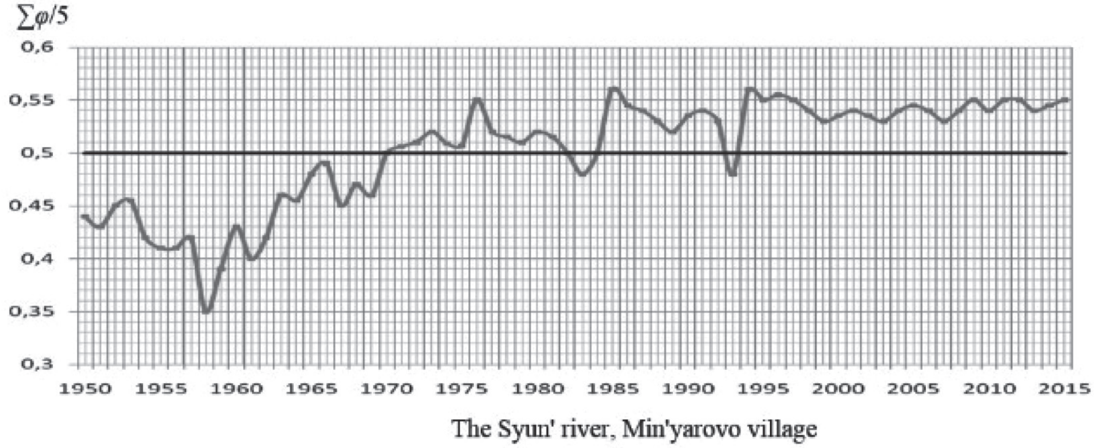


Figure 2: Coefficient dynamics of annual regulated runoff for the period from the observations start to 2015.

for irrigation purposes results in decreased summer runoff values while construction of ponds brings about a rise in summer runoff values. The upward trend in water volume means that ponds have a more significant effect on summer low water runoff than irrigation. The period of intensive construction of ponds (the 60s of the 20th century) is the starting point of the upward trend, revealed on the study rivers.

Increased winter water discharge was observed across the 60-70s of the 20th century when the region intensified the development of irrigated lands. Irrigation reclamation practices have an impact on the annual runoff distribution, as water withdrawn from the channel during the growing season, enters the hydrographic network in the autumn and winter, resulting in an increase in winter low water discharge. Large reservoirs built on the Nugush, Belaya and Ural rivers play an important role in changing water discharge; in fact they tend to increase winter low water volume downstream. These reservoirs accumulate spring flood runoff, reducing its values significantly. The annual channel runoff of the study area remained virtually unchanged, though a downward trend in the runoff was observed. The changes did not affect the river basins of the forest zone of the pre-Urals and the trans-Urals, which underwent no significant changes.

The revealed increase in water discharge improves the ecological situation in the watersheds, making the annual runoff distribution more uniform. This eliminates river shallowing, drying up and freezing and has a positive effect on conservation and development of aquatic ecosystems.

The study findings are consistent with the previous studies on the Belaya and Ural rivers. The results confirm the direction of changes in seasonal and annual runoff under the influence of anthropogenic factors (Zagitova, 2015; Nesterenko and Solomatin, 2018; Pavleichik and Sivokhip, 2018).

The studies of rivers of North America (Buttle et al., 2015; Birgé et al., 2018) and Europe (Orth and Seneviratne, 2015) resulted in similar conclusions. All of the researchers believe that economic activity is increasingly important in runoff formation; the process includes redistribution of runoff during the year.

Conclusions

The rivers of the southern Urals experience a large anthropogenic impact on the territory of the forest-steppe and steppe zones of the pre-Urals and the trans-Urals as farming is highly developed in the area.

The average annual runoff of the study area has not changed under the influence of anthropogenic factors and tends to decrease. The downward trend is a result of the increased non-recoverable water losses mainly due to evaporation from irrigated areas and the pond surfaces.

Significant changes in spring flood runoff were found on the Nugush river. In fact, the start of the Nugushevskoe reservoir in 1967 resulted in runoff redistribution within the year and a decrease of 42% in spring flood runoff. The construction of Yumaguziskoe reservoir on the Belaya river in 2004 and Iriklinskoe reservoir on the Ural river in 1966 resulted in significant reductions in spring water discharge values by 24% and 27%, respectively.

Decreased spring flood volume plays an important role in improving the environmental situation in the watersheds, as the process prevents emergency situations associated with catastrophic floods, in turn, affecting numerous biota.

The watersheds where ponds have been constructed and land irrigation has been practised since the late 60s of the 20th century see a significant rise of 31-60% in summer low water runoff and of 21-55% in winter low water runoff (the Urshak, Dema, Chermasan, Syun', Bolshoy Kizil, Tanalyk, Urlyda and Urtazymka rivers). Large reservoirs tend to increase winter low water runoff of the following rivers: by 37% – the Nugush river, by 43% – the Belaya river and by 29% – the Ural river.

Increased water volume of rivers during low water periods is an important incentive for the sustainable development of both water and coastal biocenoses, thus improving the ecological situation in catchments of the study territory.

As a result the impact of anthropogenic factors on both annual and seasonal runoff in the southern Urals could be assessed. The findings could be used in hydrological and water management calculations.

References

Birgé, H.E., Allen, C.R., Craig, R.K. and D. Twidwell (2018). Resilience and law in the platte river basin social-ecological system: Past, present, and future. *In:* Practical Panarchy for Adaptive Water Governance: Linking Law to Social-Ecological Resilience, 115-130.

Buttle, J.M., Greenwood, W.J. and R.E. Gerber (2015). Spatiotemporal patterns of baseflow metrics for basins draining the Oak Ridges Moraine, southern Ontario, Canada. *Canadian Water Resources Journal*, **40(1):** 3-22.

Georgiadi, A.G., Koronkevich, N.I., Barabanova, E.A., Zaytseva, I.S., Kashutina, E.A., Milyukova, I.P. and S.I. Shaporenko (2017). Changes in runoff in large river basins of European and Asian parts of Russia. Water resources: new challenges and solutions. *In:* Collection of scientific papers dedicated to the Year of Ecology in Russia and the 50th anniversary of the Institute of Water Problems of the Russian Academy of Sciences. Institute of Water Problems of the Russian Academy of Sciences, Russian Informational Analytical and Research Water Management Center, 155-160.

Gorshkova, A.T., Urbanova, O.N., Bortnikova, N.V., Pavlova, O.V. and A.R. Valetdinov (2017). Dynamics of changes in the nature of the formation of surface runoff in the region of the western Predkamye of the Republic of Tatarstan. *International Journal of Research*, **1-2(55):** 29-37.

Khafizov, A., Khazipova, A., Kutliyarov, D., Mustafin, R., Kamaletdinova, L., Nedoseko, I., Galeev, E., Kutliyarov, A. and R. Zubairov (2019). Justification of reclamative watershed regimes of the forest-steppe zone of the western part of the Republic of Bashkortostan with regard to their provision with heat and moisture. *Asian Journal of Water, Environment and Pollution*, **16(2):** 101-108.

Koronkevich, N.I. and K.S. Melnik (2017). Changes in the flow of the Moscow River as a result of anthropogenic impacts. *Water Resources*, **44(1):** 3-14.

Minigazimov, N., Khaidarshina, E., Abdrahmanov, R., Safarova, V., Shaidullina, G., Khasanova, L., Mustafin, R., Zagitova, L., Kutliyarov, D. and A. Kutliyarov (2019). City Snow Dumps of a Large Industrial Centre as a Source of Surface Water Pollution (on the Example of Ufa City). *Asian Journal of Water, Environment and Pollution*, **16(2):** 51-58.

Mustafin, R., Ryzhkov, I., Sultanova, R., Khabirov, I., Khasanova, L., Zagitova, L., Asylbaev, I., Kutliyarov, D., Zubairov, R. and A. Rajanova (2018). Assessment of Slope Stability in Coastal Water Protection Zones. *Journal of Engineering and Applied Sciences*, **13:** 8331-8337.

Nesterenko, Y.M. and N.V. Solomatin (2018). Formation of runoff in watersheds of the rivers of the Southern Urals in natural and anthropogenically modified conditions. *Bulletin of the Orenburg Scientific Center UB RAS*, **4:** 1-14.

Nesterenko, Yu.M. and F.G., Bakiro (2017). Impact of agricultural land use on the water balance of river catchments and atmospheric precipitation in the Southern Urals. *Proceedings of the Orenburg State Agrarian University,* **3(65):** 172-174.

Orth, R. and S.I. Seneviratne (2015). Introduction of a simple-model-based land surface dataset for Europe. *Environmental Research Letters*, **10(4)**.

Pavleichik, V.M. and Zh. T. Sivokhip (2018). Features of the long-term and seasonal river flow in the basin of the r. Ural (on the example of the rivers Salmysh and Bolshoi Ik). *News of the Irkutsk State University. Earth Science Series*, **24:** 70-80.

Praskievicz, S. and C. Luo (2019). Unsupervised hydrologic classification of rivers: Watershed controls on natural and anthropogenic flow regimes, Alabama, USA. *Hydrological Processes*, **33(8):** 1231-1244.

Promakhova, E.V., Zinchenko, T.D., Golovatyuk, L.V., Abrosimova, E.V. and E.V. Belozerov (2017). Hydrological conditions of rivers in the forest-steppe zone of the lower volga area during the extreme water shortage (case study of the Kondurcha and Baytugan rivers). *Vestnik Moskovskogo Universiteta, Seriya 5: Geografiya*, **5:** 81-89.

Rakhimov, Z., Mudarisov, S., Gabitov, I., Rakhimov, R., Rakhimov, I., Alyabiev, V., Tarkhova, L., Farkhutdinov, I., Mukhametdinov, A. and R. Gareev (2018). Reasoning a Construction Diagram and Parameters of Tillers for

Primary Cultivation. *Journal of Engineering and Applied Sciences*, **13:** 8812-8818.

Revilla-Romero, B., Wanders, N., Burek, P., Salamon, P. and A.de Roo(2016). Integrating remotely sensed surface water extent into continental scale hydrology. *Journal of Hydrology*, **543:** 659-670.

Selbig, W.R. (2015). Simulating the effect of climate change on stream temperature in the Trout Lake Watershed, Wisconsin. *Science of the Total Environment*, **521-522:** 11-18.

Teufel, B., Sushama, L., Huziy, O., Diro, G.T., Jeong, D.I., Winger, K., Garnaud, C., de Elia, R., Zwiers, F.W., Matthews, H.D. and V.-T.-V. Nguyen (2019). Investigation of the mechanisms leading to the 2017 Montreal flood. *Climate Dynamics*, **52(7-8):** 4193-4206.

Thanathanphon, W., Chantip, S., Mooktaree, A., Charoensuk, T., Luangdilok, N., Lolupiman, T. and P. Sisomphon (2018). 21st Congress of International Association for Hydro-Environment Engineering and Research-Asia Pacific Division: Multi-Perspective Water for Sustainable Development, Yogyakarta; Indonesia.

Zagitova, L.R. (2015). Evaluation of anthropogenic impact on the annual and seasonal runoff in the White River Basin. *Bulletin of the Educational and Methodological Association for Education in the Field of Environmental Engineering and Water Use*, **8(8):** 70-74.

Zhang, M., Liu, N., Harper, R., Li, Q., Liu, K., Wei, X., Ning, D., Hou, Y. and S. Liu (2017). A global review on hydrological responses to forest change across multiple spatial scales: Importance of scale, climate, forest type and hydrological regime (Review). *Journal of Hydrology*, **546:** 44-59.