The characteristics of the Dzhankoy Region Rivers and Dzhankoy Town Okrug of the Republic of the Crimea

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Abstract. The article focuses on the characteristics of the rivers flowing through the territory of the Dzhankoy region and Dzhankoy town okrug in the Republic of the Crimea (Istochnaya, Tselinnaya, Vygonnaya, Sivash, Zavet-Leninskaya, Mirovka with Stepnaya, Pobednaya, Stal’naya, Zelyonaya, Gvardeiskaya, Blagodatnaya, Velikosl’skaya). In the main these rivers are temporary watercourses, filled up with water during thaw in winter and after rains. They are slightly inclined from the south to the north. Their headwaters are on the height of little more than 20-30 m, but their estuaries may have negative values of absolute heights. The most characteristic feature of the rivers studied is the fact that their watercourses were straightened and deepened in the 60s–70s of the last century and they began to be used as collectors. It was caused by putting into operation the first stage of the Severo-Krymsky canal. After that the level of ground waters rose and this resulted in water logging of the territory and flooding the settlements. Water discharge depended, in the main, upon dumping of drain water, the volume of which had sharply reduced after cutting off the Dneeper water to the Severo-Krymsky canal.

1. Introduction

The Dzhankoy region is located in the north-east of the Crimean peninsula. The administrative center is the town of Dzhankoy, which forms the town okrug of Dzhankoy, not included into the region. The area of Dzhankoy region and town okrug of Dzhankoy is approximately 2.7 thousand sq. km.

The rivers running through the territory of Dzhankoy region are referred to as rivers of the plain Crimea (the Azov sea basin). They flow into the Sivash bay of the Azov Sea and dry up in draught (parts of the land, periodically flooded in high tides from the Azov Sea in the easterly directed winds).

According to the classification of the State Water Register the territory of the Dzhankoy region and Dzhankoy town okrug includes water bodies of water economic area: 21.02.00.001 (water bodies of the Sivash bay of the Azov Sea from Russian-Ukrainian border to the Salgir river basin).

Rivers flowing here have a slight slope from the south to the north, their headwaters are a little higher than 20m. The most characteristic feature is the fact that their river beds were deepened and straightened in the 60s – 70s of the last century and they began to be used as collectors. It can be explained by rising of the ground waters which resulted in water logging and flooding several settlements after the first stage of the Severo-Krymsky canal had been put into operation. Due to this straightening the real length of the rivers decreased [1, 2]. Figure 1 shows the rivers of the studied territory.
2. Materials and methods

In comparison with large rivers of the Crimean peninsula [3-22] the rivers of the Dzhankoy region and those of Dzhankoy town okrug have not been studied yet. So, it has determined the aim of our work – to characterize the rivers of the territory studied. Its aim stipulates the task – to define hydrographical and hydrological characteristics. The methods of study are based on literary (Code of Practice: Engineering Hydrometeorological Survey for Construction СП 11-103-97; Code of Practice: Determination of Design Hydrological Performance СП 33-101-2003) and analytical, statistical, geo-information techniques, as well as on engineering hydrometeorological studies [23], including: collecting, analyzing and summarizing hydro-meteorological and cartographic data of the territory; reconnaissance studying of the region examined; office study and defining the calculated characteristics; generalizing the data received.

ArcGIS program was applied in determining the catchment basins and calculating hydrographic characteristics:

- average height of the catchment basins was computed by the following formula:
  \[ H_{cp} = (f_1*H_1 + f_2*H_2 + \ldots + f_n*H_n) / F \]
  where \( f_1, f_2, f_n \) – private areas of the catchment basin between horizontal lines, sq.km, \( H_1, H_2, H_n \) – average heights between horizontal lines, km; \( F \) – area of the catchment basin, sq.km [23];

- average slope of catchment basin was computed by a formula:
  \[ i_{av} = h*(0,5*(l_0+l_1)+0,5*(l_1+l_2) + \ldots + 0,5*(l_{n-1}+l_n)) / F \]
  where \( h \) – exceeding between horizontal lines (or relief cutting), km; \( l_0, l_1, l_2, l_{n-1}, l_n \) – the length of horizontal lines, km; \( F \) – the area of catchment basin, sq. km [23];

- average river slope was computed by the formula:
I_{av} = (H_{river\ source} - H_{river\ mouth}) / L

where $H_{river\ source}$ – altitude of river source, m; $H_{river\ mouth}$ – altitude of river mouth, m; $L$ – length of the river, km [23].

The computation of maximum water discharge by the formula of maximum intensity:

$$Q_{\%} = q_{\%} \times q_{\ run-off} \times H_{\%} \times \delta \times \lambda_{\%} \times A$$

where $Q_{\%}$ – frequent water discharge, m³/s; $H_{\%}$ – day and night layer of precipitation with probable 1% mm exceeding; $A$ – catchment basin area, sq. km; $q_{\ run-off}$ – flooding run-off factor; $q_{1\%}$ – maximum module of run-off of annual probable 1% exceeding, which is defined depending on hydrometrical characteristics of the river bed and duration of slope water travel time.

3. Results and discussion

Described rivers flow completely or almost completely on the territory of their Dzhankoy region and its town okrug (Zelenonaya, Gvardeiskaya and Velikosel’skaya – partly on the territory of Nizhnegorsky region), and Istochnaya – partly on the territory of Krasnoperepovsky region) [22, 24, 25].

The rivers catchment basins are presented on figure 1. Table 1 shows hydrographic characteristics of the rivers and their catchment basins, which accurate data, in comparison with the obsolete data given in [2].

| Table 1. Hydrographic characteristics of the rivers and their catchment basins. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| River name      | Length, km      | Calculated      | Area, sq.km     | Average slope, m/km | Average height, m |
|                 | According to [2]| Calculated average slope m/km | According to [2]| Calculated       |                  |                  |
| Istochnaya      | 10.0            | 14.6            | 1.2             | 112             | 107             | 4.0             | 18              |
| Tzelinnaya      | 10.0            | 16.3            | 1.0             | 143             | 136             | 3.3             | 21              |
| Vygonnaya       | 23.0            | 14.3            | 0.6             | 99              | 111             | 1.4             | 11              |
| Sivash          | 7.0             | 9.9             | 0.8             | 92              | 104             | 3.1             | 17              |
| Zavet-Leninskaya| 10.0            | 23.2            | 0.8             | 166             | 178             | 3.8             | 21              |
| Mirmovka        | 15.0            | 19.8            | 0.7             | 270             | 307             | 6.3             | 25              |
| Stepmayia       | 12.0            | 10.4            | 0.7             | 85              | 96              | 6.8             | 24              |
| Pobednaya       | 18.0            | 26.9            | 0.5             | 366             | 379             | 7.6             | 38              |
| Stal’naya       | 6.9             | 10.9            | 0.6             | 134             | 176             | 4.8             | 20              |
| Zelenaya        | 5.7             | 10.1            | 1.0             | 169             | 234             | 5.3             | 29              |
| Gvardeiskaya    | 7.9             | 10.0            | 0.8             | 122             | 126             | 3.3             | 19              |
| Blagodatnaya    | 5.0             | 4.8             | 1.5             | no data         | 25              | 0.2             | 7               |
| Velikosel’skaya | 19.4            | 6.4             | 1.3             | 46              | 67              | 1.7             | 12              |

The rivers of the studied territory are, in the main, watercourses filled up with water during thaw and after rains. The level begins to rise in spring at the end of February – the beginning of March. Since the end of March the rivers dry up almost in all length, the run-off occurs occasionally.

Till 2014 all rivers were filled up with drain waters, which stipulated the amount of annual run-off.

According to table 2 one can see that the water discharge in rivers has decreased 2.0-6.1 times since 2014. It is caused by cutting off the Dneper water supply to Severo-Krymsky canal and decrease of drain run-off as a result. It is clearly shown on figure 2.

Catastrophic water peaks are formed due to heavy shower precipitation. According to Dzhankoy meteostation data the maximum day and night layer of precipitation, where $P = 1\%$, is 178 mm. The calculated maximum water discharge, where $P = 1\%$, is shown on table 3.
Table 2. Annual average indices of water discharge in rivers (according to the data of Crimean hydrogeologist and land-reclamation expedition).

| River name       | 2004 - 2013 | 2014 - 2018 | Times decrease | Maximum water discharge, m$^3$/s | Year | Minimum water discharge, m$^3$/s | Year |
|------------------|-------------|-------------|----------------|----------------------------------|------|----------------------------------|------|
| Tzelinnaya       | 0.061       | 0.010       | 6.1            | 0.108                            | 2006 | 0.0                              | 2017 |
| Vygonnaya        | 0.070       | 0.016       | 4.4            | 0.092                            | 2009 | 0.005                            | 2018 |
| Sivash           | 0.062       | 0.022       | 2.8            | 0.089                            | 2006 | 0.008                            | 2017 |
| Zavet-Leninskaya| 0.136       | 0.029       | 4.7            | 0.181                            | 2010 | 0.010                            | 2017 |
| Mirmovka         | 0.434       | 0.221       | 2.0            | 0.548                            | 2006 | 0.082                            | 2018 |
| Pobednaya        | 0.576       | 0.256       | 2.2            | 0.836                            | 2012 | 0.080                            | 2018 |
| Stal’naya        | 0.124       | 0.027       | 4.6            | 0.292                            | 2004 | 0.016                            | 2014 |
| Zelenaya         | 0.115       | 0.040       | 2.9            | 0.242                            | 2004 | 0.009                            | 2014 |
| Gvardeiskaya     | 0.135       | 0.029       | 4.6            | 0.159                            | 2006 | 0.010                            | 2017 |

In summer the rivers dry up for two-four months. As it was mentioned above, their cleared watercourses began to be used as collectors (table 3) – that fact is considered to be the characteristic feature of the rivers studied.

Table 3. Maximum water discharge, P = 1%.

| River name       | Maximum momentary discharge P=1%, m$^3$/s | Collector number | Collector Length, km | Length in watercourses, km |
|------------------|------------------------------------------|------------------|----------------------|-----------------------------|
| Istochnaya       | 7.7                                      | №19              | 9.2                  | 6.7                         |
| Tzelinnaya       | 9.2                                      | №20              | 16.4                 | 10                          |
| Vygonnaya        | 7.1                                      | №1               | 14.7                 | 14.7                        |
| Sivash           | 7.8                                      | №21              | 16.5                 | 7.0                         |
| Zavet-Leninskaya| 14.1                                     | №3               | 11.0                 | 10.0                        |
| Mirmovka         | 27.5                                     | №4               | 9.8                  | 9.8                         |
| Pobednaya        | 24.2                                     | №5               | 24.5                 | 18                          |
| Stal’naya        | 19.7                                     | №6               | 14.7                 | 6.9                         |
| Zelenaya         | 16.5                                     | №7               | 25.3                 | 5.7                         |
| Gvardeiskaya     | 8.9                                      | №10              | 13.0                 | 7.9                         |
| Velikosel’skaya  | 3.7                                      | №11              | 11.5                 | 11.5                        |

Despite the cutting off the Dneper water supply to Severo-Krymsky canal and sharp decrease of the amount of drain waters, flooding of the territory in Dzhankoiisky region and in Dzhankoy town okrug takes place periodically. It can be explained not only by catastrophic floods during heavy showers, but also by the conditions of the river beds. Once cleared, straightened and deepened, they were pervious to high waters. Now they are mainly overgrown by 80 – 90%.
4. Conclusion

The rivers – Istochnaya, Tselinnaya, Vygonnaya, Sivash, Zavet-Leninskaya, Mirnovka, Stepnaya, Pobednaya, Stal’naya, Zelyonaya, Gvardeiskaya, Blagodatnaya, Velikosel’skaya – flow on the territory of Dzhankoy region and Dzhankoy town okrug. Practically all rivers originate in the territory of Dzhankoy region excluding the Istochnaya, Zelyonaya, Gvardeiskaya, Velikosel’skaya. These rivers have not been studied yet. The hydrographic and hydrological river characteristics and those of their catchment basins have been received, and they will assist us in carrying out the necessary hydrological and water economic calculations. The annual water discharges before and after cutting off the Dneiper water supply to the Severo-Krymsky canal have been analyzed. The maximum momentary discharge $P = 1\%$ has been computed.

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