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LONG-TERM TENDENCIES AND ANNUAL DISTRIBUTION OF WATER REGIME, SUSPENDED SEDIMENTS AND MINERALIZATION OF THE LOW DANUBE WITHIN THE UKRAINIAN PART

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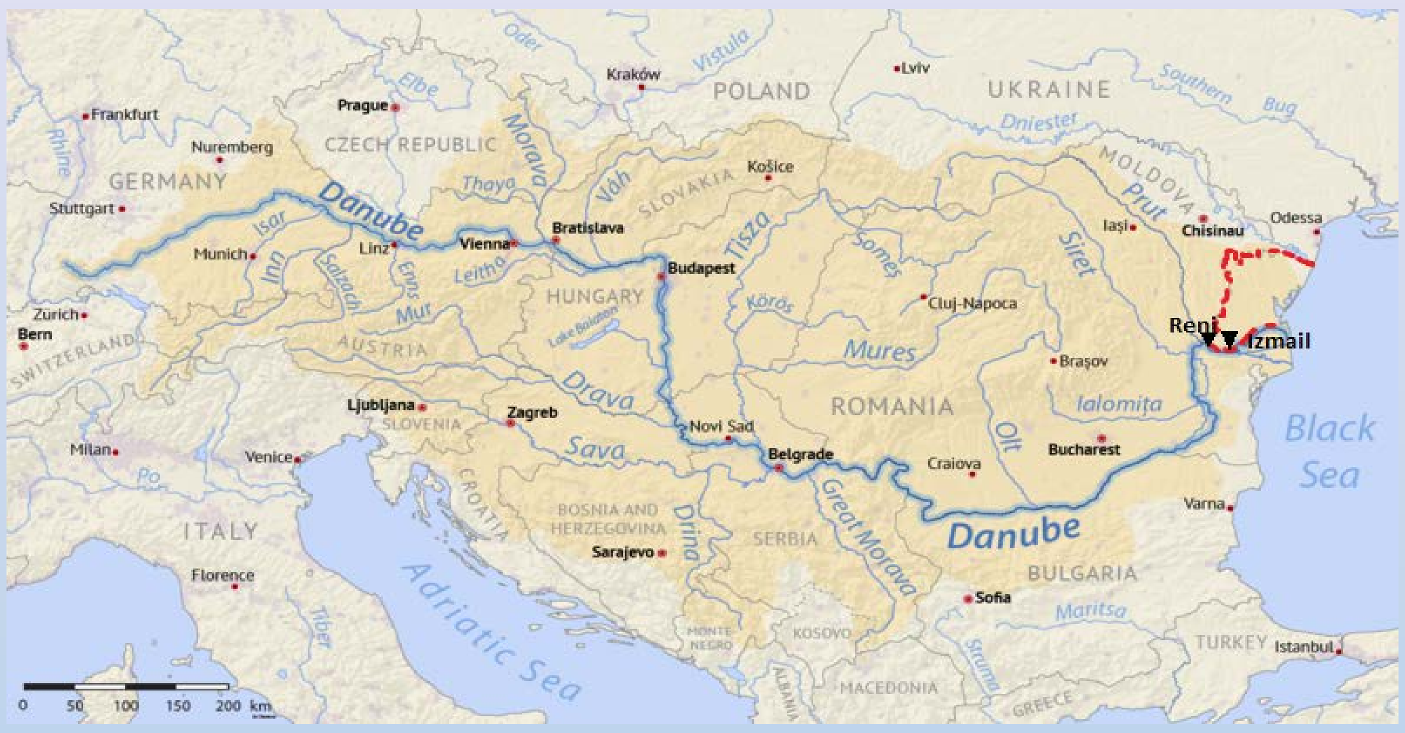
Studying the individual components of the hydrological and hydrochemical regimes of the **Low Danube River (within Ukraine)** (Fig.1) is necessary in connection with the widespread use of the river's water for water supply and irrigation in the southern region, as well as to ensure more effective regulation of water-salt regime of the Danube lakes using the Danube River as a main source for their water renewal.

The analysis of the current state of the hydrological regime in the Lower Danube shows that natural and anthropogenic changes which affecting the water discharge should be considered separately. ***Anthropogenic factors*** are mainly related to hydraulic engineering structures which have been actively implemented since the 1960s and led to the regulation of the Danube River runoff (Best, 2019).

The impact of ***climate change*** on the water regime of the rivers of the Danube Countries (especially in the territory of Ukraine) has been manifesting itself over the last thirty years of the retrospective period (Pekárová et al., 2019). The paper (Grebin, 2010) considers 1989 to be a turning point in terms of the air temperature change in Ukraine and, accordingly, the rivers' hydrological regime change. The determination of climate change impact on the Lower Danube River allowed introduction of authors of a new, present period of its hydrological regime (1990-2015) (Romanova et al., 2019).

The purpose of the work is to study long-term and current trends related to changes in hydrological (water levels and discharges, suspended sediments runoff) and hydrochemical (mineralization) regimes of the Danube River within the Ukrainian interval from Reni to Ismail, internal annual distribution of water runoff, as well as suspended sediments runoff and mineralization during the years of varying water content.



----- Study area ▼WGS

Fig. 1. Scheme of the Danube River Delta

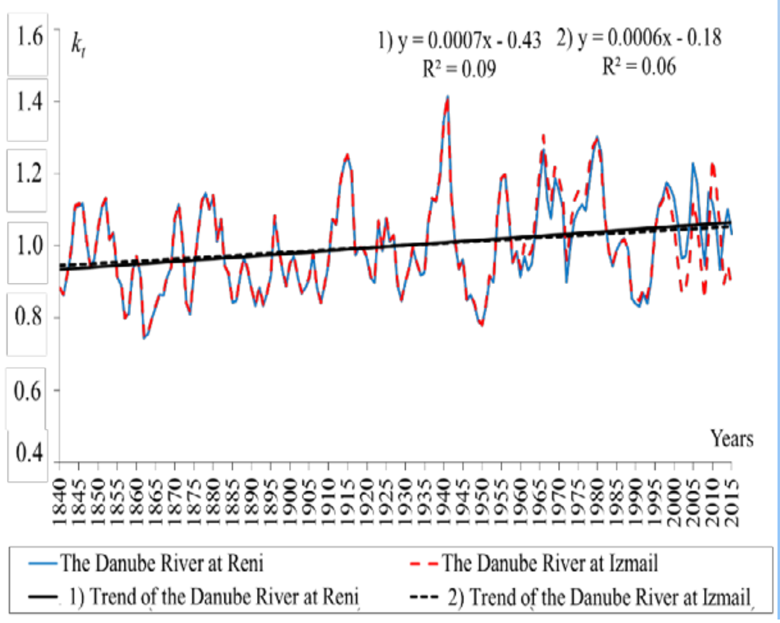


Fig. 2. Time series of modular coefficient of average annual water discharges (three-year moving averages) and their trends in the Danube River across its length from Reni to Izmail

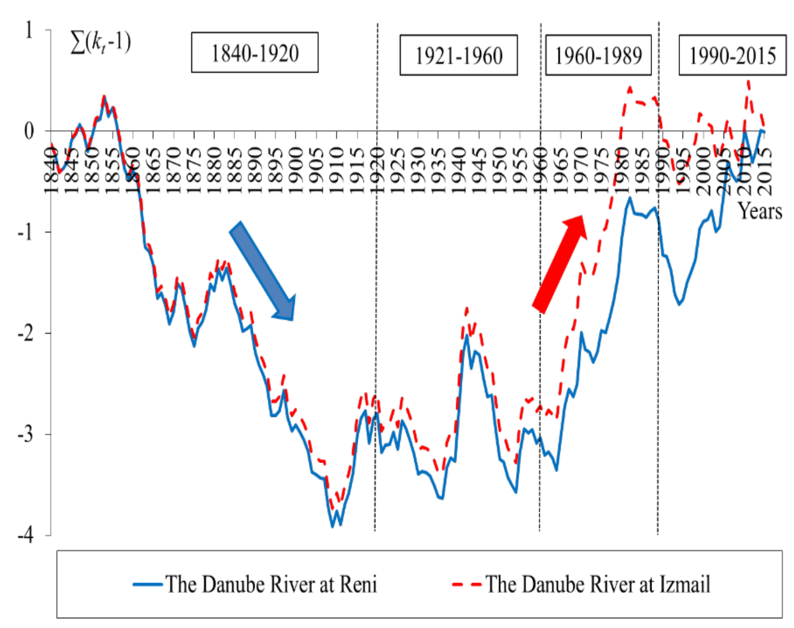


Fig. 3. Residual mass curves of the modular coefficient of average annual discharges of the Danube River across its length from Reni to Izmail

According to F-test (at the significance level of 5%) time series of average annual water discharges at Reni and Ismail water gauge station (WGS) should be considered as uniform, i.e. the influence of anthropogenic factors and climatic change did not have a major impact on the annual river runoff of the Danube Delta as a whole. However, if we consider the different phases of water content separately, there are still some changes.

The annual runoff series are determined to be homogeneous in time and the analysis of the aggregate multi-year series (1840-2015, i.e. over the period of 176 years) of the Danube River average annual water discharges across its length from Reni to Ismail indicated the presence of a weakly expressed, almost two centuries long trend towards their increase (Fig.2).

Performed the analysis of the cyclicity and uniformity of the annual water discharges in the course of time over different periods of the Lower Danube water content (Fig.3). The period after 1989 (the period of significant climatic changes) had a trend towards a certain decrease of the annual river runoff up to 1994 and a slow increase (starting from 1995) of the annual river runoff across the lower course of the Danube River.

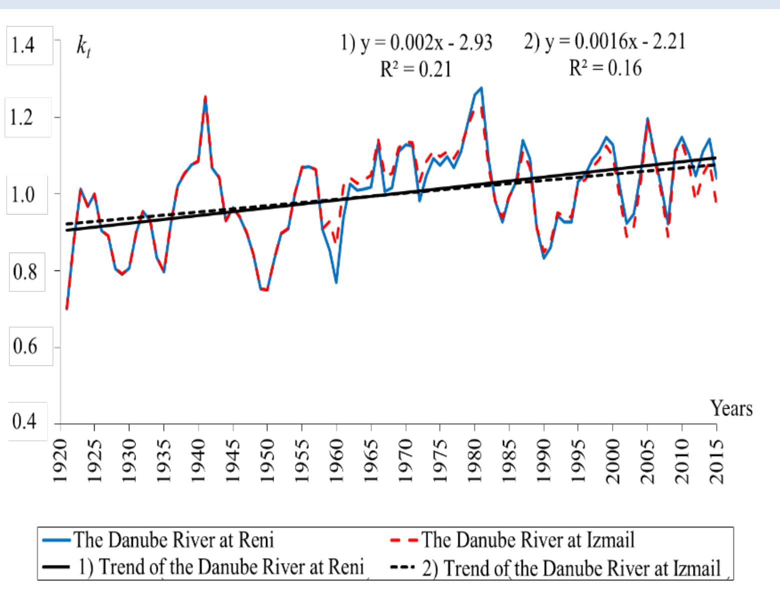


Fig. 4. Time series of modular coefficient of the maximum water discharges (three-year moving averages) and their trends in the Danube River across its length from Reni to Izmail

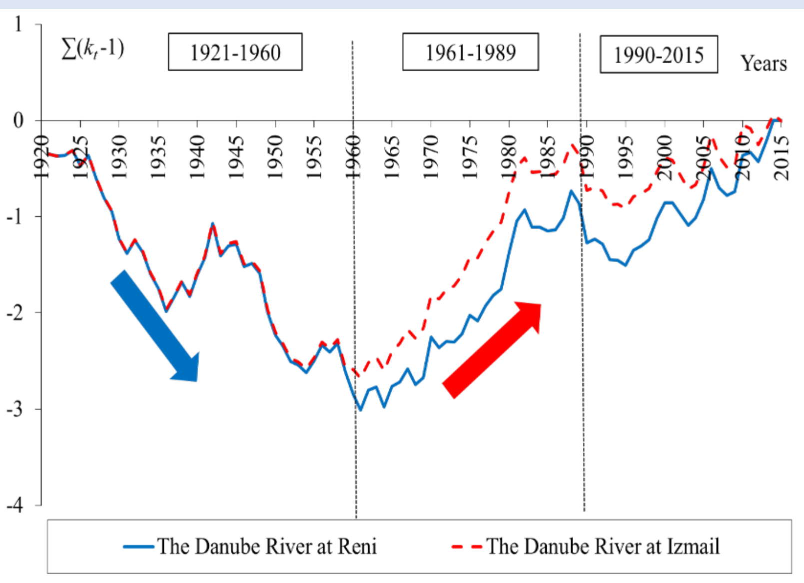


Fig. 5. Residual mass curves of modular coefficient of the maximum water discharges of the Danube River across its length from Reni to Izmail

The study of long-term variation of maximum water discharges over the period of 1921-2015 showed that the maximum water discharges featured a slight increase (Fig.4). It should be noted that the period of climatic changes (after 1989) is characterized by a less intensive growth of maximum water discharges (Fig.5).

The construction of chronological charts of the minimum water discharges across the Danube River from Reni to Ismail allowed the identification of insignificant positive trends and synchronicity of their course over the interim period for both of the WG. However, since the 2000s such synchronous trend was disrupted due to the redistribution of water discharge between the Danube Delta branches (Fig. 6).

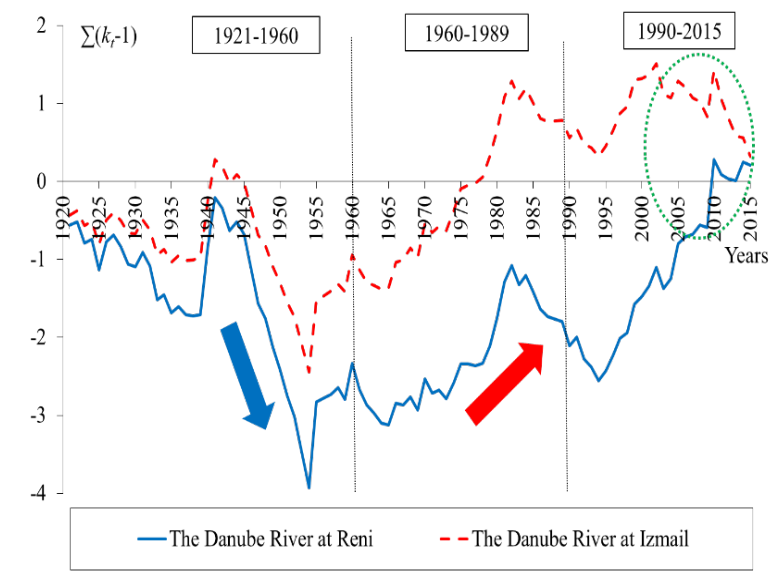


Fig. 6. Residual mass curves of modular coefficient of the minimum water discharges of the Danube River across its length from Reni to Izmail (1921-2015)

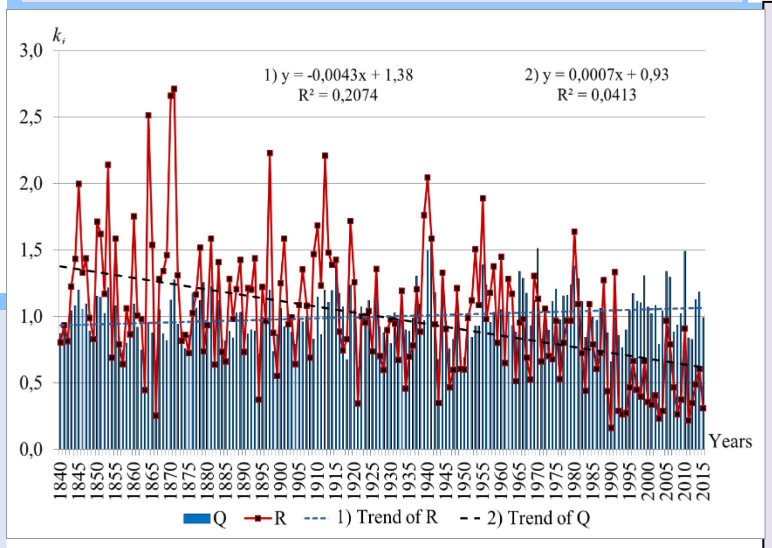


Fig. 7. Chronological graphs of the average annual of suspended sediment discharges (R) and discharges (Q) (1840-2015) of the Danube River at Reni (in modular coefficients)

The study shows the presence of a pronounced trend to reduction of suspended sediments runoff of the Danube River at Reni (for the period of 1840-2015), with their most intensive decrease over the period of 1990-2015 (Fig.7). Annual distribution of average monthly suspended sediments runoff of the Danube River for the years with typical water content (for the period of 1978-2015) showed that they have seasonal fluctuations. At the same time, there is a decrease in the suspended sediments runoff along the length of the river from Reni to Ismail.

The long-term course of average annual mineralization values of the Danube River at Ismail (1981-2015) is characterized by their decrease against the background of a small increase in average annual discharges. As per the annual distribution of mineralization values associated with all water content groups there are the periods related to the phases of the river's yearly water regime during and the economic use of water (Fig.8) (Shakirzanova et al., 2020).

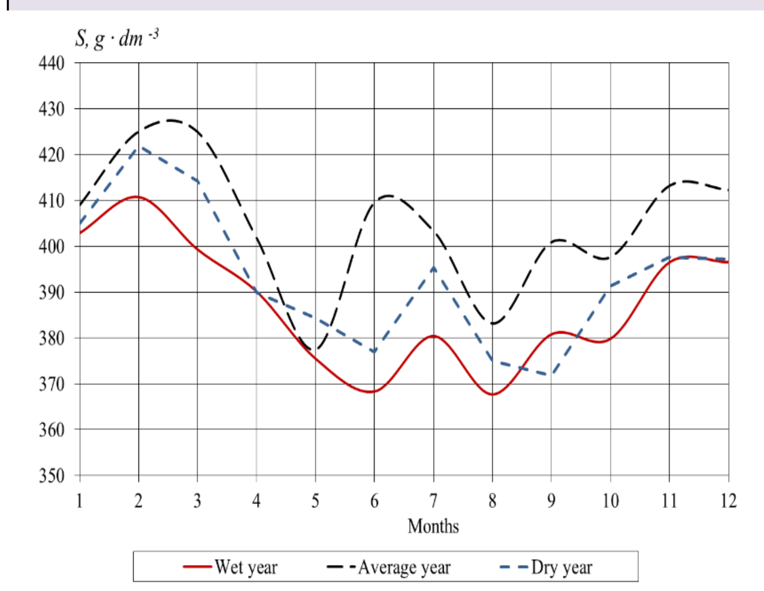


Fig. 8. Annual distribution of mineralization of the Danube River at Izmail (for the period 1981-2015)

Conclusion. **Thus, the increase in the long-term period of the Danube River runoff within the interval from Reni to Ismail will contribute to the development of the region's economy and water supply, irrigated farming, regulation of the Danube Lakes filling with weakly mineralized river water. At the same time, the reduction of the suspended sediments runoff will restrain the siltation of the inlet canals connecting the lakes with the Danube River, which will improve the water renewal of the lakes with the river's fresh waters.**

References

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