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Management of cane overgrowth to dampen Caspian Sea-lake level and regional climate warming

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Abstract. Historical fluctuations in the level of the Caspian Sea are not yet amenable to reliable forecasting. The riches of the sea and changes in its level do not leave the administration alone, in sometimes paradoxical, ways of regulating the forces of nature. Recent decades have been characterized by significant shallowing of the sea-lake (≈1 m). This is mainly due to the frequent Volga low water, whose runoff accounts for > 70% of all river waters (instead of the characteristic values of the annual Volga runoff of 230-330km^3, less than 215km^3 often come). To dampen the level, it is possible to either direct water from other river basins into the sea, which has been proposed repeatedly before, or reduce losses on streams. In this work, the latter is proposed - to regulate the evaporation of water from the Volga delta, which has grown by almost an order of magnitude. Of the ≈9 thousand km^2 of the delta area, > 70% is covered with reed reeds. In summer floods, reeds evaporate 5-9 times more intensively than the water surface. The reduction of even half of the thickets will "save" billions of tons of Volga runoff from premature evaporation, dampens the level of the Caspian Sea. Another problem in the south of Russia is massive fires, both natural and anthropogenic genesis. In the spring, last year's dried reeds burn massively, raising the temperature of the environment, contributing to the growth of evaporation in the region. When damping the area of reeds for 15-25 years, an additional 100km^3 would flow into the sea, which would compensate for the shortage of Volga runoff. The previously stated approach was not so effective due to the smaller size of the delta, although, implicitly, it was used, however, regardless of the course of sea level - in the USSR, 5 reeds were harvested in the Volga delta for the needs of a cell-cardboard plant (which contributed to minimizing the number of fires in the delta). A reduction in reeds at times in the floodplains and deltas of the Volga, Don, Kuban and Terek rivers (an area of up to 100 thousand km^2) would give additional water for irrigation, reduce the number of fires in the Southern Federal District at times, which regionally minimized the current global warming.

Keywords. Cane, Volga runoff, delta, sea level, evaporation, fires.

1. Introduction. History

The importance of predicting the level of the Caspian Sea and its regulation is due to economically significant historical changes in the level by tens of meters. However, "no one can yet guarantee that a decrease in the level will not be replaced by an increase in it" [1]. When the level drops, tens of kilometers of littoral are exposed, new islands appear, the former become peninsulas (Figure 1.a). During regression, everything is again hidden under water, including the historical coastal caravanserai in Baku Bay, Derbent quarries, the fortress of Terki, laid by Ivan the Terrible at the mouth of the Terek. These fluctuations are mainly caused by changes in the values of river flow, 70-80% of which is provided by the Volga catchment, whose annual flow is ≈150÷350km^3. In the industrial era, technical possibilities for regulating the forces of nature appeared (Figure 1.b), but administrators cannot decide on the base sea level.

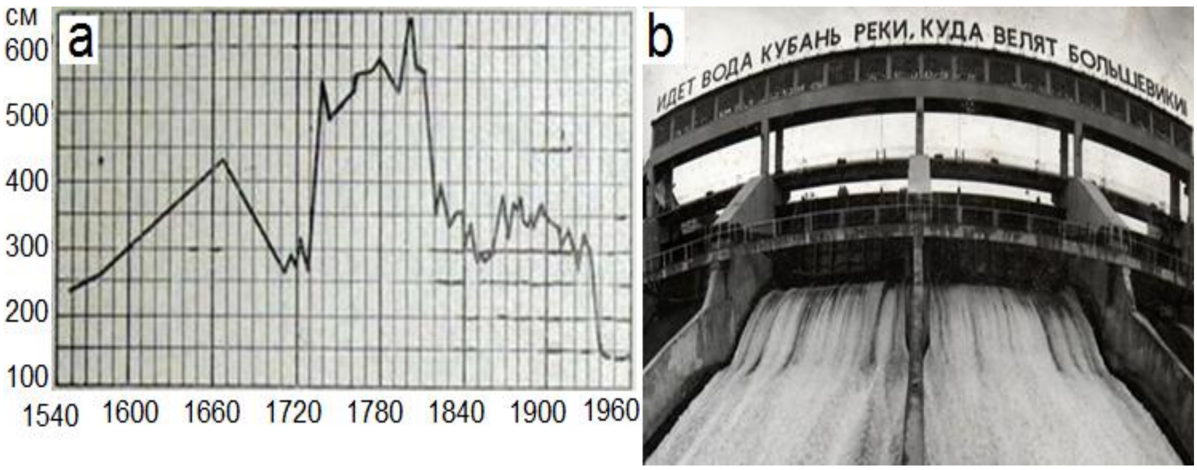

Figure 1. a - the century-long course of the Caspian level near Baku [1]; b- photo of a dam on the Kuban river. Slogan over the dam "The waters of the Kuban River go, where the Bolsheviks command" [2].

At the beginning of the 20th century, for the convenience of oil production, they began to fill up the bay and build a dam near Baku. In 1952, the possibility of drying the entire sea was considered for the same purpose. Only the water of Aragvi and Kura stopped these plans, which would then flood the fertile lands of Georgia [3]. In 60-80, the next decrease in sea level by 2÷3 m to -29 m seemed catastrophic (due to shallowing, it became problematic to approach port facilities, etc.). The possibility of transferring the waters of the Don and Dnieper to the Caspian, as well as the waters of the northern rivers (despite the gigantic work and costs of building 4 thousand km of water pipelines) began to be considered. In 1980, they temporarily stopped at cutting off the dam from the sea of Kara-Bogoz-Gol Bay, evaporating up to 10km^3 of water per year. Soon, sea level suddenly began to rise, flooding the built objects in the drying zone. In 1984, the dam was first partially, and in 1992 it was completely blown up [4].

2. Caspian Sea level, annual Volga runoff, evaporation

These works were preceded by calculations of the water balance of the sea-lake, in which the parish part is river flow and precipitation, and the consumption part is evaporation. Since estimates of the circulation of water withdrawn from rivers for industrial and economic needs, filtration and ground feeding, as well as geological deformations of the sea bowl are considered not reliable, balance gaps are attributed to incorrect evaporation [5-7]. For example, the decline in sea level in 2001-2010 relative to the last decade by 16 cm (Makhachkala settlement) against the background of a decrease in the average annual flow of the Volga by 19km^3 (Verkhnyaya Lebyazhye settlement) was taken for granted, the evaporation of water from the Caspian Sea mirror was not discussed (Figure 2) [8]. The subsequent shallowing in 2011-2020 by ≈77 cm with a reduction in the average annual runoff by another 11km^3 without evidence was attributed to an unprecedented increase in evaporation. Which is doubtful, since the area of the North Caspian has decreased by ≈10%, and the total sea by ≈10÷15 thousand km^2. There was also no concomitant favorable thermal trend for evaporation growth - the tendency to change the average values of air temperatures in Volgograd for 2005-2015 was even negative ≈ -0.1°C [12]. In general, for the North Caspian region, the average annual air temperature in 2009-2020 was 1,8°C lower than in 1996-2008 [13].

The reason for the "discrepancies" is the dynamics of runoff and the level in the accumulation of a shortage of Volga runoff relative to the level below 215km^3. The trend of the development of the "drying" of the sea in the 21st century worsened after 2010, burdened by massive fires and drought in the Volga basin. Previously, there were also sharp declines in runoff, but isolated. For example, with an average flow of > 265km^3 in 1990-1999, extreme low water 1996 (176km^3) did not lead to a significant decline in the level. Similarly, there was no jump-like shallowing of the reservoir in the period 2000-2009 with an average runoff of >245km^3 from a single low water 2006 (202km^3). In 2010-2019, low water was 2010 (196km^3), 2011 (189km^3), 2014 (212km^3), 2015 (182km^3) and 2019 (205km^3), the average flow decreased to ≈225km^3. Thus, in the last two decades, each km^3 of the accumulated deficit of Volga runoff relative to 215km^3 led to a decrease in sea level by ≈1 cm (for 2000-2009, the deficit of runoff ≈13km^3/16 cm - a decrease in level in 2001-2010; for 2010-2019, the deficit of runoff ≈78km^3/77 cm - a decline in the level in 2011-2020). In general, the trends in the dynamics of runoff and level in the 30 and 80 years of the 20st century were similar. It should be noted that the difficulties of formalizing the response of sea level to the dynamics of Volga runoff are due to the peculiarities of stabilizing the sea mirror at low surface slopes, filtration, ground feeding and evaporation in the areas of drying and regression of water when changing surface soils due to river sediments, dredging, ice exaration and bottom biota.

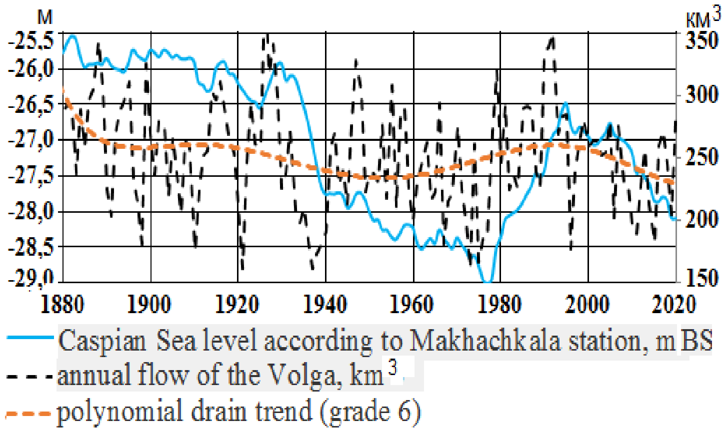

Figure 2. The course of sea level according to Art. Makhachkala, the annual flow of the river. Volga and its trend [9-11]

3. Reed

In this work, attention is paid to the peculiarities of estimates of evaporation in the delta and lower floodplain of the Volga. Of the annual volume of Volga waters, up to 4.5km^3 is irrevocably lost in the section from Volgograd to the beginning of the delta near the village of Verkhnyaya Lebyazhye. In 1939, evaporation costs from Volgograd to the sea were estimated at ≈5÷10km^3. Moreover, it was believed that evaporation from a dry delta in the low water was much lower than from open water. In 1880, the area of the delta was ≈3 thousand km^2, later, due to the fall in sea level, the area of the delta began to grow. By 2013, it reached ≈19 thousand km^2, currently ≈27 thousand km^2. According to the increase in delta area, evaporation costs increased to 20km^3 in high-water years [4, 14, 15].

Reeds are the first to settle on the entire growing part of the delta. The density of stems in thickets reaches 100 pcs/1 m^2, height up to 6 m, growth rate up to 16 cm/day (Figure 3). With the continuation of the soil formation process, reeds in some places give way to thickets of other types of reeds [1, 17-19].

In the USSR, in the surface delta and on the islands, reed was harvested as fuel (at times it was more profitable for them to heat than with oil products), for construction needs, in animal husbandry, and most importantly, 5 reed farms harvested up to 180 thousand t of cane for the Astrakhan cellulose-cardboard plant. Due to the gradual degradation of reed plantations, due to the negative impact on reed tubers of heavy equipment and the mowing of reeds in green form by agricultural enterprises, harvesters had to move from the middle of the delta to the lower. Over 30-40 years of operation, the reserves of reeds decreased by 3 times, in areas freed from reeds, up to 60 thousand t of hay were mowed per year [20, 21].

Figure 3. a- a photo of reeds in the Volga delta, b, c- harvesting reeds in the Volga delta [16]: d- a burned-out area (photo by P.I. Bukharitsin)

Here we approached the unification of the stability of the Caspian Sea level and air-water plants with surface stems and leaves (reeds - reeds, cattails and papyrus), which increase evaporation due to the surface area of the leaves. "Experimental limnological studies in the Berlin area have shown that evapotranspiration (i.e. evaporation from water + transpiration of macrophytes) in August reaches 18 mm of water layer per day in reed thickets, "while physical evaporation from the water surface reaches ≈2÷3 mm (Figure 4).

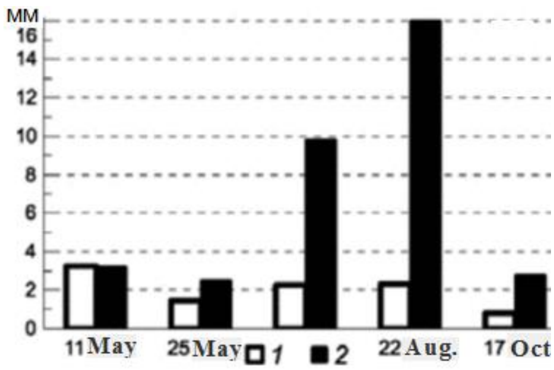

Figure 4. Rates of evaporation from water (1) and transpiration (2) in reed thickets during the growing season (according to: Wetzel, R. G. Limnology. 2001) [22]

In the summer months, 5÷7 thousand km^2 (which is up to ≈1,5% of the sea mirror area) of swamp cane lands of the delta evaporate 5÷9 times more than open water, i.e. from May to September, an additional ≈1÷2 m layer of water evaporates, which is especially detrimental to the survival rate of young fish - fry do not have time to develop and roll out of the drying delta. Replacement of reeds with grass, sand or clay deposits, which do not evaporate water so intensively, will cause billions of tons of water that has not evaporated in the delta to enter the sea. If we "fight" the growth of reeds in the floodplain of the Lower Volga, then the savings on evaporation will increase by another 10÷30%.

With the hypothetical harvesting of half of the reed thickets from 2000, leaving the places of mass reproduction of birds and fish untouched, there would be no current meter lowering of the level. In the years 50-80, when the area of the delta was several times smaller and catastrophically low sea level, harvesting of reeds unexpectedly saved up to ≈0,5 m of the level, otherwise gigantic work could begin on the transfer of the waters of the northern rivers to the Caspian Sea-Lake, and in the 80s, on the contrary, the rise in level, including those associated with the mowing of the reed, contributed to the demolition of the recently built dam, which cut off the Kara-Bogaz-Gol evaporator bay from the sea.

Efforts to limit reed thickets to reduce moisture losses are similar to the dressing of shafts and dams around drying ilmen lakes, which are flooded in floods for only weeks per decimeter. These efforts will complement the clearing of fish canals from excess wetland vegetation. Tractor-ramming reeds will reduce evaporation from the soil, leave biogenic elements in place. Non-beveled reeds will remain in shallow water, islets and in a 50-100 m strip along the intergrade edge of the shore. In any case, there is an Astrakhan reserve for biota within the framework of the Ramsar Convention, whose area has increased almost 2.5 times since 1919 [23]. From the fact that in 30-60 years there were more fish in the Lower Volga and the North Caspian than today, although the delta area was several times smaller, it follows that the area of wetland vegetation is not determining for fish, the reason is not the ecological mode of operation of the cascade of Volga hydroelectric power plants [24, 25].

There is an alternative Australian-American way to prevent lakes from drying out. They are coated with a solid film of hexadecanol, which reduces evaporation by 60-90% [26].

In addition to the direct effect on evaporation, reeds also have an indirect effect on the regional climate. Namely, in reed thickets, an increased concentration of biogas - methane is characteristic, which contributes to the instant growth of any fires. The food for fire is last year's dry reeds, which burn with a terrible, multi-meter flame that instantly spreads over long distances. Every year, about 200 thousand hectares burn out in the Volga Delta, and in some years - up to 500 thousand hectares (this is the easiest way to clear the land of last year's dry vegetation in order to graze cattle [27]). Spring fires increase the surrounding temperature of the environment by 3÷5°C or more, massively occur in the reed thickets of the deltas and floodplains of the Volga, Terek and Don (Figure 5.a-c). The black color of burning also contributes to the increase in the temperature of the soil-medium (Figure 3.g, Figure 5.g). Note that until the 90s of the 20st century there were almost no mass fires in the Volga delta - the reed was mowed.

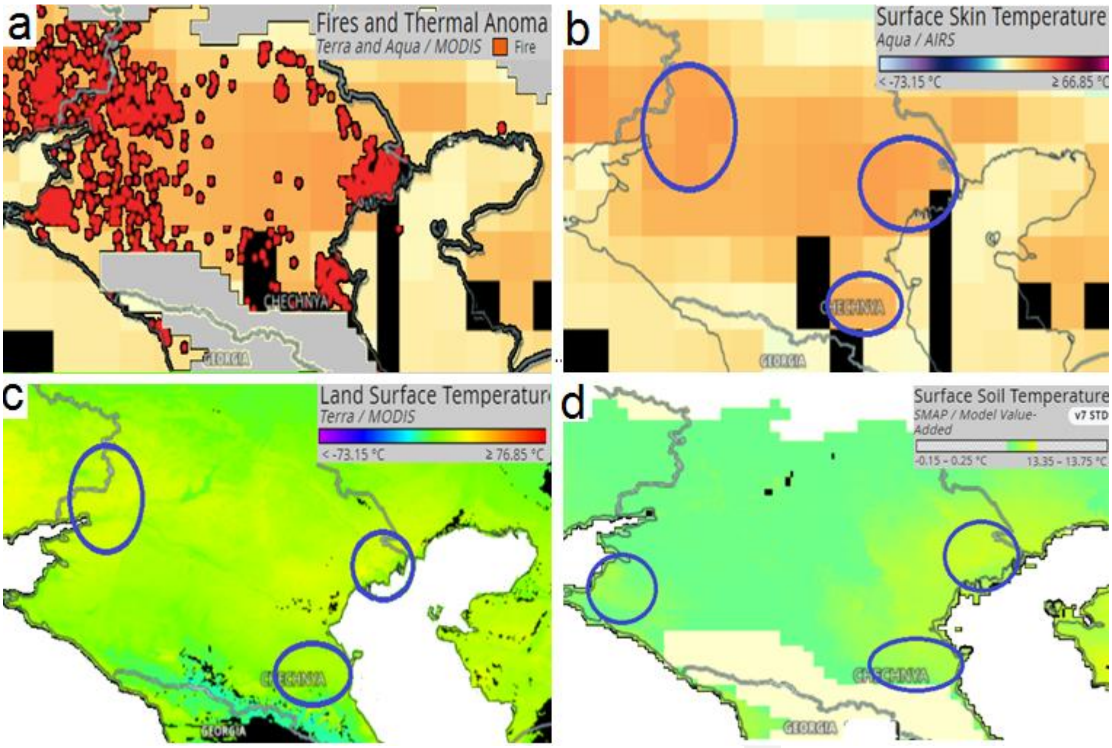

Figure 5. a, b - fragments of temperature maps of the skin layer on May 23, 2022 (*a*, *b*), with superimposition on **Figure.***a* fire centers, *c* - surface temperature, *d* - soil temperature (ellipses contoured areas of mass fires heated above the background) [28]

The presented approach to damping the level of the Caspian Sea through the regulation of the area of reed thickets in the lower floodplain and the Volga delta is "pioneer." When using it earlier, it would not have to either build or soon blow up the dam near the Kara-Bogaz-Gol evaporator bay, deliberately carry out construction in the coastal zone. We express our gratitude to S.I. Shaporenko and P.I. Bukharitsin for the information provided.

4. Conclusions

To dampen the level of the Caspian Sea by meters and prevent massive fires in the Volga delta and floodplain, it is necessary to limit the growth of reed thickets in the spaces drying up in the low water (similar to what was done in the

USSR) without relatively to evaporation and sea level. Due to the slow restoration of reed thickets after its mowing and ramming, it will have to be cleaned again in 3÷5 years. If such actions are extended to the catchments of the Don, Kuban, Terek and Samur (which, together with the lower floodplain and the Volga delta, will amount to over 100 thousand km^2), it will be possible to increase the supply of water for irrigation, reduce the number of fires several times, and regionally reduce the current climate warming in the Southern Federal District.

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