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Changes in the basic ionic composition and other parameters of the Aral and Dead Sea waters during their drying.

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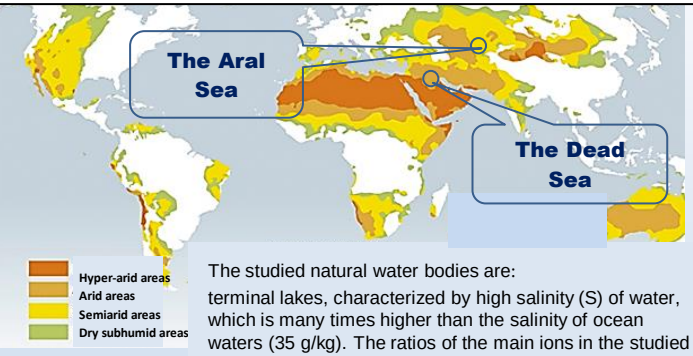
THE MAIN AIMS of THE INVESTIGATION

- To obtain of the main ionic composition, salinity, density and other parameters of the waters of the Aral Sea (2014 – 2019) and Dead Seas (2017 – 2019).
- To compare obtained data of the samples under study with the previously published data.
- To compare the hydrochemical characteristics of these waters and their changes with historical data and with each other.

The location of investigated water bodies on the arid areas map

Figure 1

Drylands Vulnerable to Desertification and Their Categories



The studied natural water bodies are:
terminal lakes, characterized by high salinity (S) of water, which is many times higher than the salinity of ocean waters (35 g/kg). The ratios of the main ions in the studied sources differ significantly between water bodies, as well as from similar ratios in the oceans

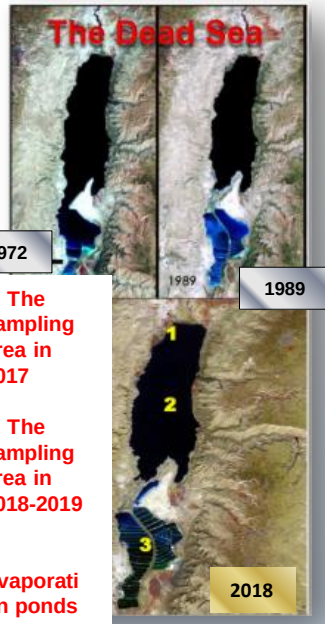
$S_{\text{Dead Sea 2019}}$ = 300 g/kg, $S_{\text{Aral Sea 2019}}$ = 10-240 g/kg

Hyperhaline Lakes before and today

Figure 2

1. The western basin of the Large Aral Sea
2. The estern basin of the Large Aral Sea
3. Tshebas Lake
4. Tshebas Lake
5. The Smal Aral Sea

1. The sampling area in 2017
2. The sampling area in 2018-2019
3. Evaporation ponds



At the same time The lakes have different depths and areas and are located at different heights relative to sea level. Until 1960s the Aral Sea level fluctuated at an altitude of about 53.5 m above sea level at a depth of 66 m ; in 2019, the sea level dropped to 30 m. The Dead Sea is more than 400 m below sea level, and its depth is today more 300 m .

https://earthshots.usgs.gov/earthshots/node/91#ad-image-0-0

https://ankushtiwari.wordpress.com/tag/dead-sea-ocean/

Investigated water bodies are closed inland lakes. They are located in an arid climate zone. Their level is decreasing from year to year as a result of global warming on the planet and anthropogenic pressure.

Ion content determination: methods and equipment

Automatic titrator Metrohm 905 Titrando

Figure 3

The titrator can carry out any kind of potentiometric titration, it is possible to measure the pH, the potential and temperature of the sample and to determine the concentrations using ion-selective electrodes.

Identified ions	Methods	Electrodes
Cl^{-}*	Precipitation titration of AgNO3	The combined Ag Titrode Metrohm (glass indicator / silver chloride)
$SO4^{2-}$	Precipitation titration of BaCl2	The ion-selective polymembrane Ba^{2+} (Ecom-Ba) and reference electrode chlorine silver
$HCO3^{-}$	Acid-base pH titration with HCl	combined pH-electrode Metrohm (measuring glass electrode / silver chloride electrode)
Ca^{2+}	Complexometric titration EDTA	The Combined Ca^{+} Metrohm polymembrane and reference electrode silver chloride
Mg^{2+}	Complexometric titration EDTA	The combined Ca^{+} Metrohm polymembrane and reference electrode silver chloride
K^{+}	Gravimetric by adding sodium tetraphenylboron	
Na^{+}	Determination of the difference between anions and cations*	

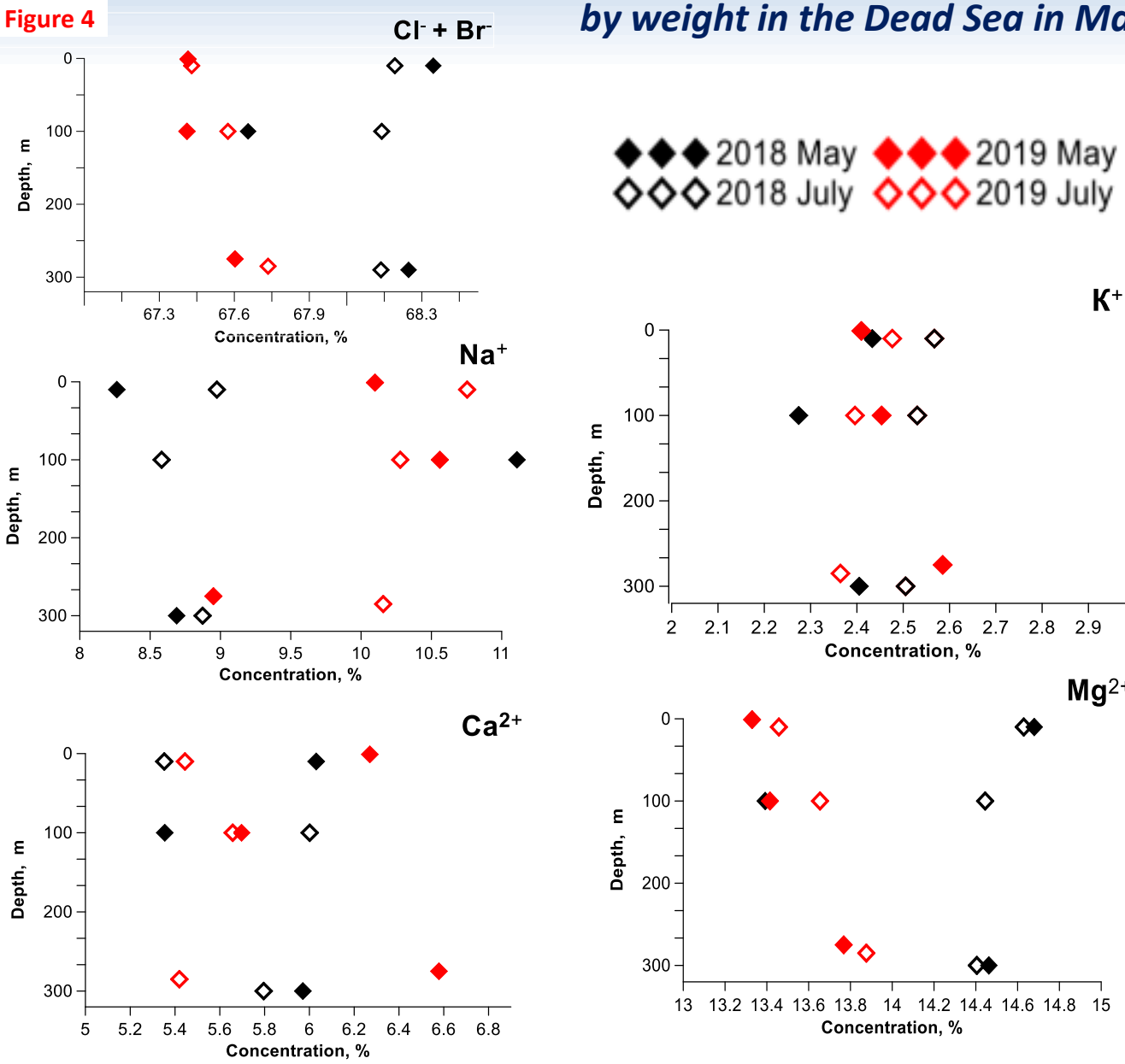
Laboratory density meter Anton Paar DMA 5000M

The method is based on measurement of vibrations of a U-tube which contains the analyzed water. Resonant frequency of the oscillation tube, measured by optical sensors, depends only on fluid density.

RESULTS

The depth distribution of the relative content of basic ions by weight in the Dead Sea in May and July in 2018 and 2019

Figure 4



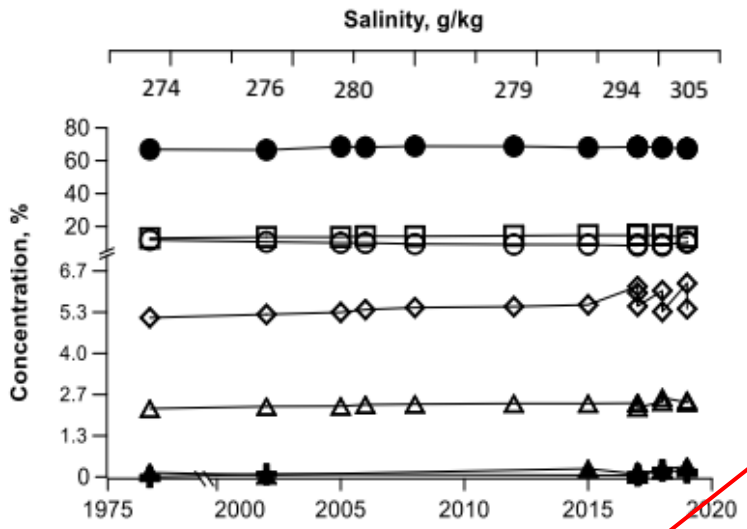
The chemical composition Dead Sea waters subject to seasonal fluctuations and anthropogenic impact.

The bottom layer at this point EG 320 is characterized by the presence of water coming from the evaporation basins (End Brine) and changing the ratio of the main ions (Na/Cl, Mg/K). The supply of the End Brine is accompanied by an increase in temperature in the bottom layer

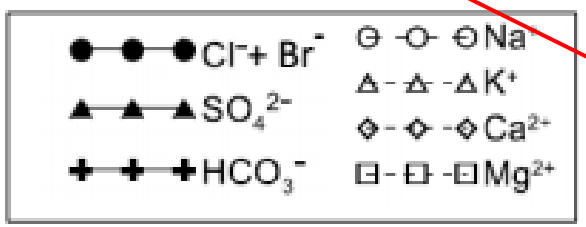
Figure 5

Transformation of the basic chemical composition as a result of lowering the levels of the studied water bodies, expressed as a percentage of the total salinity of the sample water

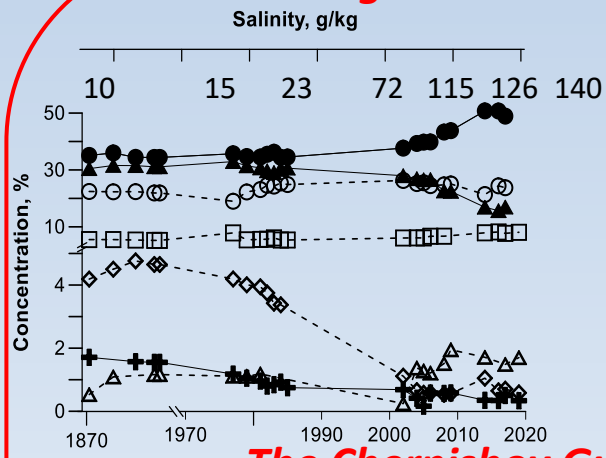
The Dead Sea 1977-2019



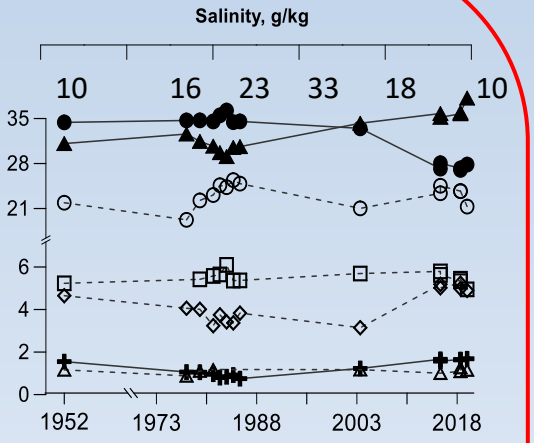
The Aral Sea 1870-2019



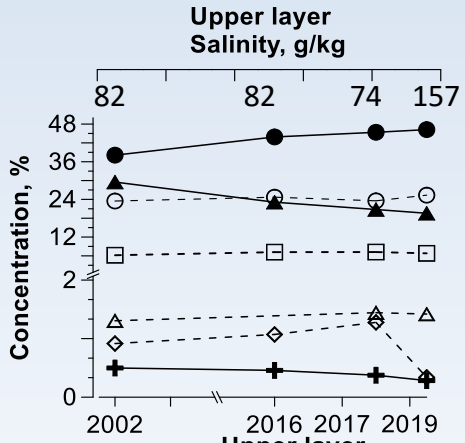
The Large Aral Sea

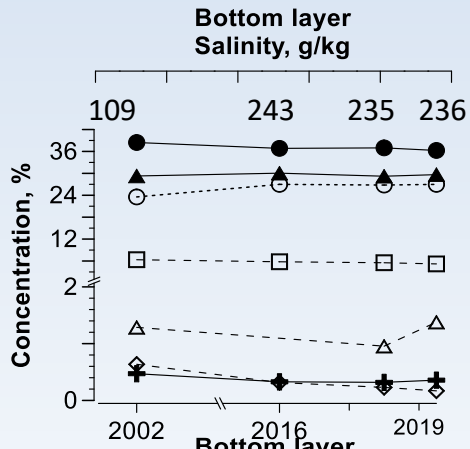


The Small Aral Sea

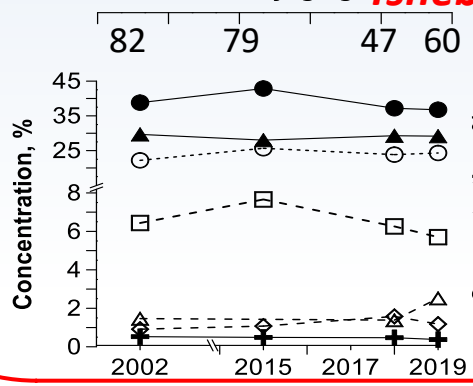


The Chernishov Gulf of the Large Aral Sea





Tshebas Lake



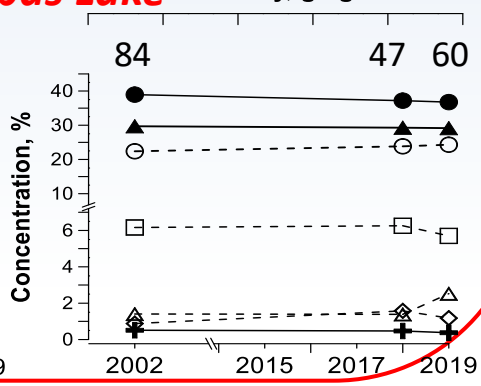
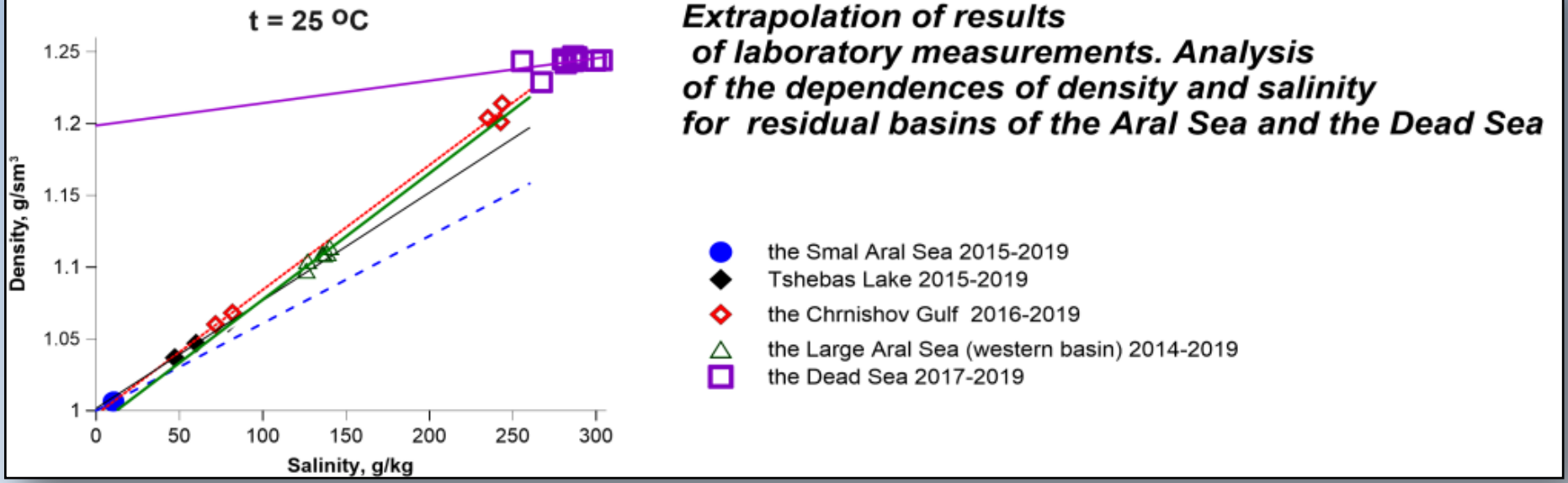


Figure 6



C O N C L U S I O N S

1. The ratios of main ions of composition of hyperhaline water bodies under study has significant difference between each other. Each basin of the Aral Sea have unique chemical composition which differ from each other and from the sea until its degradation.
2. Changes in the basic ionic composition of the Dead Sea are not so pronounced, despite an annual in sea level decrease of 1 m. There are seasonal and anthropogenic variations in individual ions.
3. Na/Cl and Mg/K interactions along with temperature data are indicators of the End Brine waters in the Dead Sea
4. Analysis of the dependences and density on salinity for three hyperhaline and one slightly saline reservoirs of the Aral Sea revealed differences in these dependences for waters of different ionic composition. If Lake Tschebas reached the maximum salinity of Chernyshev Bay (about 242 g / kg), the deviation between the density values would be 30 kg / m3, and in the case of the Small Aral, 70 kg / m3.
5. Dead Sea water samples obtained in July and October in the northernmost part of the sea in 2017 from the surface (sampling area 1 Fig.2) differed from samples obtained in July 2018 in the central part of the sea (sampling area 2 Fig.2) with a high content of chlorine ions, calcium and magnesium with coefficients 1.003, 1.113 and 1.006, respectively. They contained less sulfates, bicarbonates, sodium, and potassium with coefficients of 0.447, 0.265, 0.937, and 0.918, respectively.

Acknowledgement

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