

Impact of the Caspian Sea Level Fluctuation on Ground Water Regime and Functioning of the Hydro-Reclamation Network on the Caspian Side Zones

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Abstract— An aim of the research is to investigate an impact of the Caspian Sea level fluctuations on the ground water regime and functioning of the hydro-meliorative network on the Caspian side zone, including Mugan-Salyan region. On the basis of the long-term data of Baku meteorological station during 1830-2014, the water level changes in the Caspian Sea was analyzed, calculations on ground water level fluctuations on the sea influence zone with the application of the selected calculation method were performed. It was determined that due to the changes in the Caspian Sea level between -28,9 m (minimum) and -26,13 m (maximum) interval, the ground water tables at the 25 km influence coastal zone, changes between 0,5- 1,93 m. These values are less than an accepted for the zone value of $h_{esk}=2,2$ m.

An analysis of the data shows that due to the fluctuations, especially rising of the Caspian sea water level, the normal working regime of the hydro-reclamation network (collector and drainage system, different type of the irrigation canals and rivers) under operation have been disturbed in the side zones, including in Mugan-Salyan massive. Consequently, this creates risks for formation of secondary salinization, water logging and desertification in the Caspian Sea influence zone.

Keywords— The Caspian Sea, ground water, the Kur river, Head (Bash) Mil-Mugan collector, secondary salinisation, water logging, desertification, depression curve.

I. INTRODUCTION

The Caspian Sea is a closed water basin, therefore a climate with the global character, tectonic, technogen modifications in the earth disturb its level stability. When the changeability amplitude of the level gets high values, this process forms large-scale, major problems for the

seaside zones and states. But a solution of these problems requires significant finance and cost expenditures $\square 10 \square$.

An influence of the Caspian Sea level fluctuations on the country's economic development in the republic shows itself vividly. Approximately, at a length of 750 km, from northern- east to southern- east the Caspian coast falls to a share of the Azerbaijan zone $\square 1 \square$. For a ratio coefficient of the coast linear length to the zone area is the first among the Caspian side countries. And it shows an effectiveness of the level modification problems for our republic. Ten administrative districts and approximately 13 % of the zone are situated on the Caspian coast. Lately, the farms in the seaside zones of the republic have been damaged in a great amount as a result of the Caspian level rising.

The sowing areas, living and industrial objects, transport and communication lines exposed to the destructive effects by the level rising in the seaside zones which are distinguished with the high development level of the high settlement density, industrial and agrarian area. The level rising shows itself not only in the seaside zone, but also in the depths of the region. So, the level rising affects the hydrological regime of the rivers and large collectors running into the sea, and changes the course processes dynamics at the large lengths. An influence of the level modification on the ground waters level and mineralizing rate shows itself in the depths of the zone. The regular observations on the sea level of Azerbaijan were begun in the first half of the XIX century (Baku point -1930), at present 13 hydro meteorological observation stations of the National Hydro meteorological Department at the Ministry of Ecology and Natural Resources in the Caspian Sea part belonging to the Azerbaijan Republic (on the coast, open sea, islands and piers), the observations are performed on the sea level in seven of them. The

information about the Caspian level ranges for 1830-2014 on table 1.

Table.1: Mean annual absolute value of the Caspian Sea level (by the negative sign), m
 Baku meteorological station 2

Decimal years	Odd years									
	0	1	2	3	4	5	6	7	8	9
1830	25,06	25,08	25,21	25,32	25,38	25,41	25,51	25,54	25,55	25,57
1840	25,75	25,95	26,11	26,23	26,16	26,18	25,77	25,63	25,73	25,92
1850	25,94	25,99	26,11	26,37	26,25	26,28	28,21	26,33	26,34	26,25
1860	26,28	26,29	26,21	26,16	26,17	26,21	26,25	26,04	25,66	25,61
1870	25,91	26,03	26,05	26,02	25,85	25,81	25,81	25,70	25,71	25,72
1890	25,81	25,96	26,01	26,03	26,06	25,96	25,74	25,78	25,87	25,89
1900	25,91	25,95	26,05	25,93	25,96	26,03	25,98	26,03	26,03	25,99
1910	26,17	26,40	26,39	26,44	26,36	26,15	26,05	26,08	26,18	26,02
1920	26,33	26,46	26,57	26,63	26,63	26,75	26,65	26,46	26,28	26,11
1930	26,22	26,36	26,27	26,38	26,52	26,71	26,92	27,14	27,45	27,75
1940	27,91	27,95	27,86	27,83	27,86	28,04	27,97	27,83	27,86	27,89
1950	28,07	28,19	28,24	28,28	28,29	28,35	28,39	28,31	28,17	28,13
1960	28,19	28,37	28,45	28,36	28,39	28,33	28,17	28,29	28,37	28,42
1970	28,27	28,32	28,41	28,47	28,48	28,58	28,83	28,92	28,87	28,57
1980	28,43	28,17	28,08	28,01	27,98	27,91	27,84	27,73	27,54	27,54
1990	27,44	27,10	26,91	26,82	26,65	26,54	26,55	26,25	26,18	26,13
2000	26,90	27,00	27,85	26,90	26,85	26,74	26,81	26,85	26,83	26,88
2010	27,00	27,20	27,25	27,30	27,43	-	-	-	-	-

The rising and falling state of the Caspian level was available in all the geological developed period □4, 9, 5□. The sea level diminished till the least limit -28,92 m in 1977 of the XX century, then the water level in the sea reached -26,13 m for a short historical period (1977-1999). Since 1999 decrease of the sea level has been observed again. In 1999-2014 the Caspian level diminished 1,30 m and a mean annual value of the sea level was - 27,43 □ 2, 9 □ in 2014.

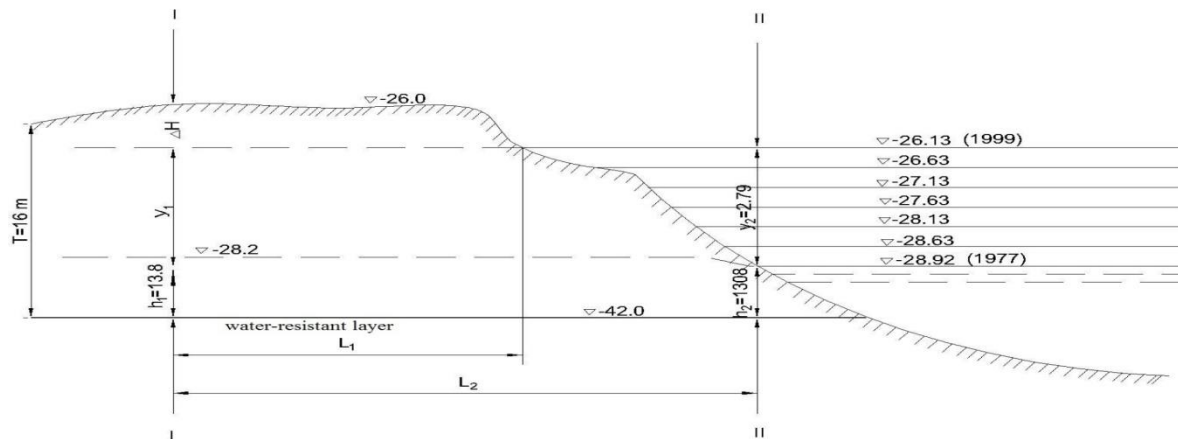
II. RESULTS AND DISCUSSION

An analysis of the different depression curves in the ground waters shows that the sea level rising, i.e. flood effect zone encircles 20-30 km of the distance.

The mineralization degree of the ground waters from the seaside areas changes to 13,5 g/l and its chemical composition is chloride-magnesium-sodium 1.

But a rate of the mineralization at 20-30 km from the sea is 78-113 g/l. The chlorine ion quantity rose till 683,0 mg.ekv., but sodium reached 816 mg.ekv. in the same zone in 2000 in comparison with 1980. This happened as a result of the sea water and ground waters mixing. A quantity of sulphate (232 mg.ekv.) and magnesium (79 mg.ekv.) ions rose in this zone. Here an amount of sulphate, chlorine, magnesium and sodium ions corresponds to the quantity before flood and chemical composition. Regarding it we can note that

$$R=25 \text{ km } \left\{ \frac{20 + 30}{2} = 25 \right\}$$
 may be called an effect interval of the flood, an impact of the Caspian Sea level modification on ground waters regime in the seaside zone has been studied according to the situation in picture 1.



Picture.1: Study scheme of the sea water level modification effect on ground waters regime

The expenses equality equation will be as the following according to the current infertility law for the I and II sections □ 12 □.

$$K \frac{h_1^2 - h_2^2}{2l_1} = K \frac{(h_1 + y_1)^2 - (h_2 + y_2)^2}{2l_2} \quad (1)$$

here: K -is a filtering coefficient of the ground water layer; K=2 m/day was received;

h_1 and h_2 -intervals to the water-resistant layer under sea and in the effect distance of the ground water layer in the I and II section before flood creation, m;

y_1 and y_2 -an absolute height of the sea water stratum and in the effect distance after flood formation, m;

l_1 and l_2 -intervals to the I section before and after the flood creation, m.

We received $l_1 = l_2$ for the account scheme: Then

$$K \cdot (h_1^2 - h_2^2) = K \cdot ((h_1 + y_1)^2 - (h_2 + y_2)^2) \quad (2)$$

after the simple overturns performance

$$y_1 = \sqrt{(h_1^2 - h_2^2) + (h_2 + y_2)^2} - h_1 \quad (3)$$

The sea water level was in the lowest value.

In 1977, (V -28,92 m), the highest level in the sea was (V-26,13 m) observed in 1999.

An interval till the water-resistant layer with the water level in the influence radius distance (L=25 km) of

the ground water depression curves in the lowest value of the sea water level will be $h_1=13,8$ m. The same level is received as a level corresponding to crisis depth. A crisis depth of the ground waters for the Mugan-Salyan zone is received as $h_{cris}=2,2$ m.

We find $h_2=13,08$ m; $y_2=2,79$ m in the II cut a difference of the maximum and minimum water levels in the sea is equal to $|-26,13 - (-28,92)|=2,79$ m.

The levels due to II-3, II-4, II-5, II-6 and II-7 sections with the 0,5 m modification of the level determine y_2 heights corresponding to them in the II cut and y_1 heights are calculated by using of formula 3. The calculation consequences have been given on table 3.

We use from this formula

$$\Delta H = T - (h_1 + y_1) \quad (4)$$

To find distances (ΔH) of the ground waters from the surface (L=25 km) at the end of the effect zone.

If the known values are written:

$$\Delta H = 16 - 13,8 - y_1 = 2,2 - y_1$$

$$\Delta H = 2,2 - y_1$$

ΔH values are found for each section according to the known values of y_1 .

As it is shown on table 2 ΔH values change from -0,5 m to 1,93 m in the different levels between -28,9 m (minimum level) and -26,13 m (maximum level) of the sea water level. These values are less than $h_{cris}=2,2$ m received for the massive.

Table.2: Ground waters level modifications in the various values of the sea water level

Section s	Minimum level of the sea water, m	Various water levels, m	L, km	h ₂ , m	y ₂ , m	h ₁ , m	y ₁ , m	ΔH, m
II-1	- 28,92	- 26,13	25	13,08	2,79	13,8	2,72	- 0,5
II-3	- 28,92	- 26,63	25	13,08	2,29	13,8	2,28	- 0,08
II-4	- 28,92	- 27,13	25	13,08	1,79	13,8	1,75	0,45
II-5	- 28,92	- 27,63	25	13,08	1,29	13,8	1,22	0,98
II-6	- 28,92	- 28,13	25	13,08	0,79	13,8	0,75	1,45
II-7	- 28,92	- 28,63	25	13,08	0,29	13,8	0,27	1,93

If we take into account that an effect distance of the flood created as a result of the Caspian Sea level raising, it affects the ground waters level in the Mugan-Salyan massive. A change dynamics of the ground waters over a massive was reflected on table 3. During the table

composition H.Y.Israfilov's materials and information of the meliorative state cadastre of the irrigated waters about a date of January 1, 2015 in the Azerbaijan Republic [11, 8] have been used.

Table.3: Distribution dynamics of the ground water table in the Mugan-Salyan irrigation massive in 1930-2015

Name of the plains	1930					1962					2015				
	0-1	1-2	2-3	3-5	> 5	0-1	1-2	2-3	3-5	> 5	0-1	1-2	2-3	3-5	> 5
	m														
Mugan	56,2		13,1	30,1	0,6	16,6	62,4	20,4	0,6	-	0,69	43,42	49,2	6,69	-
Salyan	4,8	39,3	24,8	22,6	8,5	56,4	14,5	16,6	12,5	-					

The Caspian Sea water level was -26,22 m in 1930; -28,45 m in 1962; -27,43 m in 2015.

As it is seen from the table a slope depth of the ground waters which is more than 5 m in the research zone were observed in 1930. In the following years a mitigation in the slope depth of the ground waters was observed and the areas where the ground waters spread at the slope depth more than 5 m did not participate. The zones where a slope depth of the ground waters is 1-3 m prevail. If we analyze a modification dynamics of the ground waters slope depth depending on time, we can see that on the one hand process approaching of the ground waters the land surface happened, on the other hand an amount of the areas where the ground waters with the different depth spread increased-decreased in different years.

The reason is connected with the collector-drainage and irrigation systems work on the one hand, on the other hand it is related to rising or falling of the Caspian Sea level.

The analyses show that the hesitations occurring in the Caspian Sea level disturbed a normal work regime of the hydromeliorative net which is in action in the Mugan-Salyan massive (collector-drainage systems, different fixing canals, rivers).

An analysis of the available materials shows that a flow rate of the ground waters into the sea diminishes as a result of the sea water level rising. This was a reason for decrease of the affective impression in the inter drains distance and decline of the flow rate in the collector-drainage net.

The largest collector operated in the research object is a Head Mil-Mugan collector. Building of the Head Mil-Mugan collector was started in 1984. In the same year the Caspian Sea level was -27,98 m. The Caspian Sea level vibrated in different values in 1984-2014.

The observations show that the 40-50 km of the mouth part in the collector works in a flood regime as a result of the sea water level rising. The water level of the

collector is at 1,5-2,0 m distance from the surface. That affects the water rate and expense in the collector. A comparison of the project and factual values of the water rate and expense in the collector at 110 km distance between the Araz river and Caspian Sea shows that there is an enough difference between these values. If an object expense of the water flowing into the Caspian Sea should be 107 m³/sec., this value is 30 % less than a project value by being equal to 74,0 m³/sec.

The project rate of the water in collector is 0,52 m³/sec. in the same part, but a factual value is 0,41 m³/sec.

The factual rate is 21,0 % less than the project rate. Six collectors join the Head Mil-Mugan collector at 110 km interval.

The right coast collector, K-1-1 collector, Mugan-Salyan water-throwing, North Akusha collector, the Kurside collector, South-Eastern collector.

This situation in BMMK affects the same collectors and initial drains. The normal work regimes of the collector-drainage net which is consequently in action in the massive disturbed, the nearness of the ground waters level to the surface in the effect zone of the net creates a condition for the secondary salinization in the same soils.

If we take into account that the soils possessing a different salinization degree in the soils from Salyan and Neftchala occupy large zones, then we can come to such a conclusion that the situation is rather serious □ 6, 7 □.

The second larger collector in the irrigation massive is Mugan-Salyan water-thrower. A length of this collector in the available state is 87,5 km (from the Caspian Sea to the pump station). It was put into operation in 1953. The collector water transmissivity ability of the collector on the project is before 21 m³/sec. and 36 m³/sec. at the mouth. A reason of the work regime disorder in this collector is stable and regular uselessness of the pump-station serving the same collector.

The fundamental factor affecting the regular uselessness in the pump station is water level raising in the water-thrower as a result of the Caspian water level raising. It is such a situation that the collector parameters don't answer the power, of the pump station.

Majority of the rivers including the largest river Kur flows into the Caspian Sea. Rising of the Caspian Sea level has affected and is affecting the dynamic processes in the rivers' mouth coasts and a hydrological regime of the rivers □ 3 □.

III. CONCLUSIONS

Summarizing of the research materials allows to come such a conclusion that it is important to solve the problems created by the Caspian Sea level rising, to provide the future development of the coastal farming; including an abolishment of the flood by the mechanical

means, building of the drainage systems which are basically managed on all the zones; establishment of the stable observation nets; consolidating of the coastal zone; the appropriate measures fulfilment for an improvement of the ecological-ameliorative situation; regarding of the level fluctuations in the Caspian Sea as an important factor while accommodating the new dwelling settlements and objects.

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