THE WATER BALANCE'S IMPACT OF THE DEAD SEA'S TRIBUTARIES ON THE DEVELOPMENT OF ITS PORT WATERS

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Abstract. The tendency of change of the hydrological parameters of the Dead Sea is increasingly evident in recent decades, both as a consequence of high evapo-transpiration and as a reduction in volume of Jordan's waters and of other tributaries. Basically, this is manifested by the lower sea level, which may result even in its death in a near future. Intense evapo-transpiration (average 1500 mm / year) leaded in time to lower water level, which changed the aspect of port waters as well as the emergence of underground cavities as a result of salt dissolution. The same effect it has the excessive use of Jordan for potable water for the growing population, as well as for industrial water or irrigation, by Israel and Jordan. The reduction of water balance of the sea is reflected in increased regressive erosion on tributaries, with effect on disposition of watershed around the sea, but in the Jordan basin, as well. As a result, the target of our study was focused on the revaluation of the rate of decline in volume and sea water level by extending the range of hydrological observations. The current quantifying is an alarm on the decreasing flow of Jordan river, the negative balance of the level of port waters of Dead Sea, with immediate consequences on the region's sustainable development.

Introduction

The Dead Sea is located between parallels 310 29' and 350 28' 47" north latitude. It was known in Antiquity as the Great Desert and was named Asfalticum Sea by the Romans when reached, after the bitumen coming out of the depths to the surface under form of pebbles (asphalticum). The Dead Sea is named in Hebrew Sea Salt (Iam Hamelah), due to higher salinity. In fact, it is an endoreical sea (Lake Terminal) with a salt concentration of 33 %o and it is, in this regard, number 2 in the world after Lake Asal in Africa, which has a concentration of about 35%o. The only water sources are precipitation in the hydrographic basin area of the sea and the river Jordan from which Israel and Jordan are consuming a lot. Even small direct tributaries with intermittent flows have decreasing values which result in negative fluid balance of the Dead Sea, respectively the lowering port waters. If in

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Fig. 1 - The Dead Sea seen from outer space. We can distinguish the two existing basins: the northern one with port waters and higher depths and the southern, smaller and clogged

the 80s of last century the lake impoundment was still appreciable in size (76 km length and 18 km width, maximum depth 320 m), which gave the name of "sea", the water mirror reached -408 m below the Mediterranean Sea, in 2009 and it dropped to -422 m and the size of its port waters were reduced to 67 km in length and 15 km width, so the maximum depth has decreased to about -310 m. To all these it also contributed, besides natural factors that have driven all the time (low rainfall and an exceptional evapo-transpiration), the increased water consumption of Jordan by the two bordering countries Israel and Jordan, both for population, for industry of chlorine-sodium products and for spa tourism activities. After 1997, until 2007 the descent rate reached an annual rate of 1.2 m / year rate that has increased since 2008, a dry year, reaching 1.38 m / year. This reduced the port waters area of the Dead Sea in just 13 years, with about 25% and it also had consequences on hydro-geomorphologic processes around sea. The withdrawal of water also had an impact on the process of dissolving salts in the geological substrate of recess. Therefore, both factors contributed to increased linear erosion and displacements of material on slopes. Moreover, in the opinion of geologists (Garfunkel et al, 1981, Ashbel Dov, 1965) in the geological time when it was formed, the depression was much larger, but the strong evapo-transpiration and the absence of powerful tributaries to bring in compensation water from around; this made the water level drop permanently, so that today the water mirror is located at 420 meters below the Mediterranean Sea. In the modern period, when water use of Jordan has diversified and its consumption increased, water intake fell significantly worse and this resulted in the reduction of water volume of the Dead Sea. Besides lowering the level, side effects also occurred in the semi-arid and arid conditions from here: the change of its contour, volume reduction and increasing salinity, as well as the increased erosion accompanied by a massive transport of materials coming from disruption and deposited in the sea. Practically, today the Dead Sea is divided into two parts, by the Lisan Peninsula (from deposits in Lisan hydro-geological period): a larger and deeper part in north with spa usage and a southern, which is smaller, used as evaporation ponds for salt extraction, that supplies the chemical factories of chlorine-sodium products belonging to the two neighboring countries (fig. 1).

1. Geology of the region

The Dead Sea's Graben represents a district in the north part of the huge African-Syrian rift which extends here along the Red Sea through the Gulf of Eilat (Aqaba) and it prolongs itself through Kineret Graben and Lebanon Graben through the Taurus Mountains, until south-eastern Turkey (Figure 2). The specifics of this part is a sequence of rhombus shape sector Graben (*rhomb shepe graben*) with thresholds of horst type which separate them (in comparison, but at other scale and other terms of evolution, such a series of graben and horst is Rucar-Bran Corridor in the Southern Carpathians). Among the Rift's grabens, the largest is that of the Dead Sea, and among the thresholds, Mount Hermon is the highest. The graben's walls are cut into old semi-horizontal structures, having at the base of slopes chaotic accumulations with large granulometry. The eastern slope has older structure (at its base magmatic formations and pre-cambrian conglomerate appear at surface) while the western, sandstone and carbonate structures at the base (Upper Cretaceous limestone).

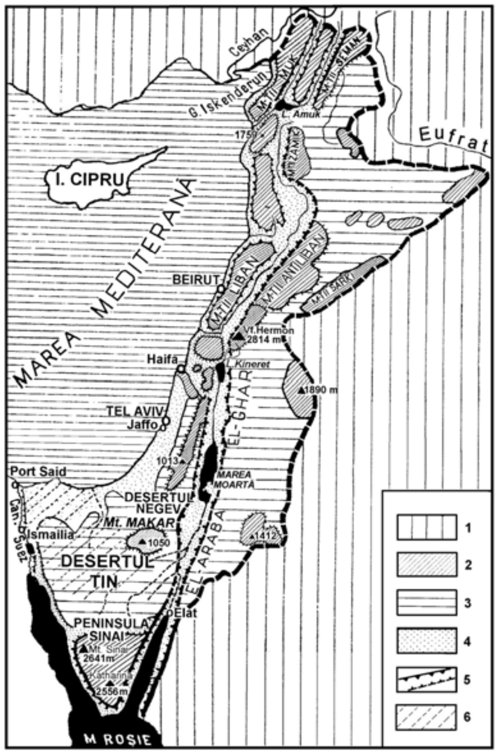

Fig. 2 - The huge African-Syrian rift. 1. Neighboring regions; 2. The mountains along the marginal faults; 3.structural plateaus; 4. Plains; 5.succession of grabens; 6. dunes (processing after Levant map, in volume Europe and Asia, Petre Cotet, 1970)

Basically, the graben separates two tectonic plates: the Arabian Plate to the east and African plate to the west. These plates are moving horizontally in opposite directions: the African north to south, while the Arabic from south to north, which from the initial formation until today has exceeded 105 km (*Garfunkel, 1997*), starting with the upper Miocene. The eastern flank of graben is similar in the southern part of the Dead Sea with the structures from Timna region (near Eilat), while the western, present in the north of the Dead Sea, are similar to those of Makhtesh Ramon anticline buttonhole. In a straight line with the Dead Sea, these movements suffer a diversion to the northeast, allowing fragmentation of rifts and formation of rhombic grabens; among them that of the Dead Sea. The rhombus shape of grabens is the result of the angle under which rupture occurred, according to movement direction and friction surface of the moving plates. Recent sediment structure and geophysical data attest the string of geological events that generated the Dead Sea. It is about continuity of water in the Graben, even if their areas vary. From the geochemical studies of Levi (1987) has resulted the continuity of sedimentation since the Upper Miocene till Pliocene, proving stagnant water environment in this area. Moreover, in the Pleistocene (1.5 million years before) Sedom and Amora southern regions were covered by the Dead Sea waters.

Due to tectonic movements that have operated along fault lines, the sea's configuration has changed, and its waters have receded. In terms of stratigraphy, there are sufficient arguments to show that the lake, which existed before the Dead Sea, was much larger. From these data, it follows that the lake began in the north in the recess from southern Lake Kinneret until Hatzeva region, and it had a level of only 180 m above Mediterranean's level (Fig. 2). This lake has decreased from 18 000 years ago, keeping the chemical properties and salts that exist today in the Dead Sea. Originally, it consisted of a single wider port water May, but since Lissan period (the evolution of the graben), today it came to be divided into two parts by the strip of sediments of Lissan age with peninsular character, called by the locals "Language" of the Dead Sea. Also in the study of Levi (1987), it is also mentioned Geo-Archaeological evidence: after the withdrawal of the sea, the gravel that covered the ancient cities such as Sedom (Avportit) and Amora appeared to date. In the eastern and western part, the banks are steep, while in the north and especially in the south the banks have moderate slopes to nonexistent, even though they are part of the graben.

2. Geomorfology of the region

The Dead Sea's area with its both parts was approximately 1600 km2 (after Topographic Map during the British mandate) and in 1930 it dropped to 1038 km2 area (length 77 km, width 17.5 km). The north Lake, larger and deeper, is marked by a series of poles, certifying active seismicity due to the contact between the two tectonic plates. The south Lake, before being clogged and dried, had a depth of 5 m, while the north one has now 230 m.

Its surface is 810 km2, being in one of the elongated grabens of the huge African -Lebanon Rift, called the Dead Sea. Initially it was a single oblong basin, but the dropping of the water level and clogging processes separated it. In the northern part of the Dead Sea's hydrographical basin, this extends with Jordan's basin. In this way, it captures the entire river basin which collects the rain water that reaches an area of 41,000 square kilometers (more than two times the Israel's area). From this basin, Jordan brings the waters of several tributaries to the Dead Sea: Nahal Eitan, Iabuh and Iarmih in the east.

We must also mention the waters from precipitation falling in Judea and arrived in the Dead Sea through a series of valleys and canyons (Ahziv, Muav), as well as those from the Transjordan Mountain: Argon, Nahal and Zrar. Due to the rapid deepening required by the decreasing of the level base represented by the Dead Sea, the short valleys with high energy of relief have shaped their slopes like vertical walls and with stepped longitudinal profile, of typical canyons aspect. In the south, between the Dead Sea and Eilat Gulf, the rift continues through Nahal Ha Arava, which has no water course, on its entire length of 170 km.

Tab. 1 **-** Chronology and pace of the relief's evolution in Israel.

Nr.	Events	The average pace of movements (m/10 000 yrs)	Field data	Nr of Obs.
1	The lift of earth's crust	0.7	4.0 - 0.3	19
2	Erosion	0.2	0.6 - 0.1	6
3	Formation of plains and Dead Sea graben within 6 million years. All lacustrine basins.	10.3	54.5 - 1.5	31
4	Hahula lake	8.2	49.2 - 2.1	13
5	Kinneret lake	3.4	24.0 - 2.1	6
6	Dead Sea	19.3	54.5 - 6.3	7
7	South Arava	2.3	3.3 - 1.5	5
8	Formation of plains outside Dead Sea's graben	1.1	5.0 - 0.3	19
9	The advancing and deepening of the canon valleys in hard rocks	1.0	3.3 - 0.3	21

(after *Gerson, Amit* ,1987, completed by *Begin. Zilberman,* 1993)

Judea Desert is one of the most beautiful and impressive arid region of the area. One can appreciate that in this area, there are reliefs of all ages: narrow or canyon valleys, isolated rocks, arches, fragments of Lissan levels of erosion as well as Mountains of East Israel, bordered by the Dead Sea's slopes. This whole ensemble stretches from Beer Sheva valley and Tel (Colina) Arad in south to Ugea valley in north on a distance of 90 km. From the Jordan Valley and Dead Sea on east, to the slopes of Judea Mountains on west, there lies a piedmont of accumulation with coarse materials, from torrential transport through canyons or subsidence and collapse of slopes, with a variable width, of 10 - 20 km (Fig. 3). On the other shore, the Transjordan Mountains were built in the last 5 million years as a system of parallel folds, on the direction of the graben’s axis. Judea Mountains are divided into three massifs: Jerusalem Mountains, Mount Hebron and Beit-El Massif.

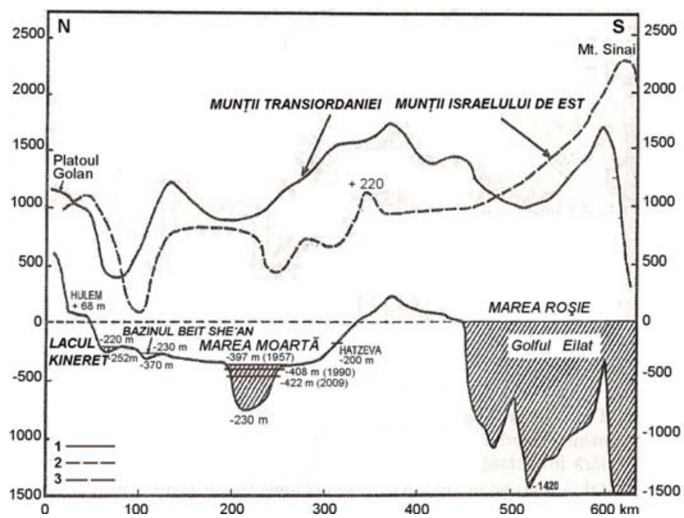

Fig.3 - Longitudinal sections through the Dead Sea’s Graben: 1. The profile line through the bottom of the graben; 2. The profile line of the water sweep on the western flank of the graben(The mountains of western Israel); 3. The profile line of the water sweep on the eastern flank of the graben (Transiordaia mountains). Processing and updating of the author, after Shick, 1990, quote by Garfunkel & Ben Avraham ,1997

Among the peaks of the Jerusalem Mountains there are: Navi (prophet), Samuiel (895 m), Mount of Olives (816 m), Hertzel Mount (830m) north of Jerusalem, Mount Scopus (821 m) in front of the southern wall of the Jerusalem Citadel, Mount Zion (778 m) etc. Mount Hebron is also divided into two chains by Hebron Valley: the eastern chain that follows the Dead Sea parallel and the western chain parallel to the Mediterranean. The area of mount Hebron is over 2500 km2, and its height varies between 850 and 900 m: Mesada Mountain (462 m) Adoraim - mountain valley with many hills, Mount Herodion (758 m) 11 km from Beit Lehem, Zif (889 m). Beit El Massif is also crossed by valleys which separated him into mountain massifs: Ramala (872 m), Ramataim Tzofim (872 m), Baal Hatzor (1

017 m) m), being the highest peak of Beit El. The massif includes also the Iudeean dessert, which unlike other desserts, is quite fragmented.

3. Formation stages of the Dead Sea's Graben

Dead Sea's Graben is located in the north of the Syrian - East African Great Rift (the lowest depression of the globe) and includes:

• Jordan Valley, carved by Jordan river, whose name comes from the Hebrew word IARAD meaning GO Down, springs from Hermon Mountain in Hermon (or Banias), Dan (of Dan Mountain) and Shnir (at the foot of Mt. Hermon in Lebanon). It descends to the south, passing through Galilee, where it crosses a region of tropical vegetation and reaches the Sea of Galilee (as it is called Kineret Lake) and then, it heads to the Dead Sea, having a total length of about 300 km;

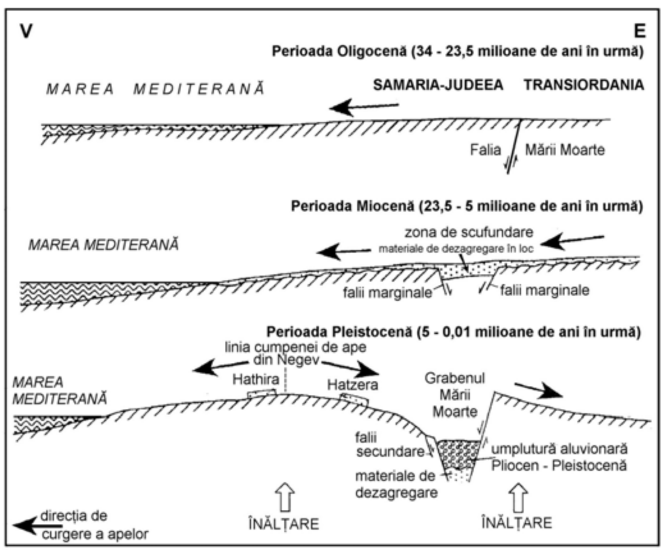

Fig. 4 - Formation and evolution of water sweep on the line of Samariei- Judeei- Negev Mountains (processing after the sketch of evolution of the rift which allowed formation of the Dead Sea's graben, Garfunkel,1988)

• Galilee Sea (Kineret Lake), 212 m under the sea level, fed by numerous springs both with freshwater and salt water from all around;

• Dead Sea, located at - 422 m (the lowest level in the world), with a higher saline, so the evaporation generated salt concretions on the shores and in caverns in salt, even stalactites;

• Gulf of Eilat at the northern tip of the Red Sea between Africa and Sinai Peninsula. Today the relief of Israel started to form from the withdrawal of sea water in Eocene (Fig. 4). Until then, the sediment cycles of the Eocene and Oligocene that covered the crystalline base, did not allow the development of sculptural processes. This is because there has been a continuity of sedimentation which began 55-34 million years ago (Eocene), when the sea covered all the Middle East. In this interval, limestone sediments, thicker in the concavity of the seabed of anticline vaulting, were deposited.

In the following period, the Oligocene (34 to 23.5 million years ago), water remained only in those mentioned depressions, so the erosion began to emerge more vigorously, cutting the marginal mountainous projections. Thus, gradually, as the waters receded in the last depression, the mountainous space was flattened.

In the Miocene (from 23.5 million years ago), the sea level was 100 m above its current level. The lifting of the chain of mountains and the formation of the initial plain on the current site of the Dead Sea’s Graben, began 20 million years ago, by cracking the African plate, of which Israel was part. 15 million years ago, it began to sketch the northern segment of the Afro-Syrian Rift, of the Gulf of Aqaba (Eilat), through the Dead Sea’s Graben, of Kinneret Lake, then through Lebanese Graben, reaching in the north, in Turkey. This rift separates two tectonic plates: the Arabian Plate to the east and the African plate (Israel -Sinai) in the west, moving horizontally in opposite directions. Thus, the Arabian plate is moving south to north, while the African plate, which includes Israel-Sinai plateau, from north to south (Garfunkel and Ben-Avraham, 1997). In addition to these major movements between the two plates, along the rift, there also took place deviation movements to the northeast, allowing the formation of the Dead Sea’sGraben. Along the rift, at the beginning a shallow valley was installed, barely outlined. In time, with the opening of the graben, it expanded toward the center of the country, changing all the original river systems. On the eastern part of the graben, on the edge of the Arabian plate, it remained a system of folds parallel with each other, as well as with the shaft of the Dead Sea, built in the last million years, forming the Transjordan Mountains. In the west, between the Galilee and Negev, on a wide strip of 50-100 km, parallel to the Dead Sea Graben , the chain of mountains from the western Israel was formed. Mountainous movements that have created this orographic axis occurred in the last 5 million years (Wdowinski, Zilberman, 1996). There is evidence that the tectonic movements responsible for the uplifting of these mountains occurred even before the drafting of the Dead Sea’s Graben, when there was a flat plain, which was vaulted. Somron and Cârmei massifs, as well as the heights of Galilee, were shaped by external agents which posted from consolidated sediments secondary peaks with hilly appearance, as well as river deposits that formed coastal plains.

In the Quaternary, in the southern of Negev at Eilat, the two flanks of the Graben were raised by several hundred meters requiring a deviation to the northwest of Arava desert to the southern (Gaifimkel, 1970). Therefore, there can be distinguished one subunit with a unique landscape, between the peaks of the Central Negev and the graben occupied by Arava and Zin valleys, in comparison with the central and northern portion of the Negev, where anticlines buttonholes, known in British literature of specialty as "craters" and in the Israeli as makhtesh, were sketched and built. In the last part of the Quaternary, more precisely in the last hundred thousand years, volcanic eruptions took place in the Golan Heights, the formation of the piedmont glacis at the foothills of Transjordan Mountains and through deflation and compaction of the river sediments of the coastal plain, the forming of eolianit deposits.

This evolution of landforms, according to major structures and their neotectonics has defined four longitudinal morphogenetic strips, a few tens of kilometers wide and hundreds of kilometers long as follows:

Coastal plain of the Mediterranean, which begins from the west line of submerged coast consisted of: continental slope and continental shelf;

Israel's eastern mountains, including Negev mountains and Eilat plateau;

3. Dead Sea’s Graben, fragmented by several cross faults;

4. Transjordan Mountains.

The evolution of watershed around the Dead Sea

The watersheds, although they depend on the law of level of erosion, refer to the general trend of achieving balance surfaces in the ocean of the world, because below this level, the erosion and transport cease. Regional or local (lakes, inland seas), there are formed regional or local base levels. For this reason, in the evolution of watersheds near the Dead Sea and of a good part of the Jordan River, there are taken into account moments of the formation of the base levels and the impact these may have on the lowering of these erosion bases, located in mentioned grabens. To this classical application, in the study of fluvial erosion and in the transport of their products, the latest technical means can be installed on slopes or in valleys. Such an example is the experimental fields of the river basins with episodic drainage in the Negev (Mishmar and Mor basins under the guidance of Prof. Dan Bowman and Yattir basin, of Professor Jonathan Larrone). These researches (1992-1993) were extended later to the high area of Iehuda desert. In this way, observations could be made at the origin of canyons that are directed towards the Dead Sea, implicitly on the movement to west of the watershed. Corroborated with the quantitative data of exceptional rains in the region and those referring to the pace of decline of the Dead Sea port water level of Ein Ghedi, there were outlined those areas from the springs that tend to withdraw to west. Elementary processes of erosion are leading to the assessment of impact on the withdrawal of the spring line, and thus to the movement of the watershed. If processes came from intervention of atmospheric agents dominate, the pace is fast and attacks the rock, adding more or less biological and human agents.

In terms of the Dead Sea Graben, however, the agent action that is shaping the slopes from here, we should also include the transport processes. There is a consequence of the fact that the cracking and disintegration, for playing an important role in preparing the rocks that form the plateaus, are manifested in discontinuous rate. In this way, the processes of digging from the springs of the torrential valleys and canyons also have discontinuous nature and the change of the disposition of the watershed is rhythmic, especially during exceptional rainfalls. It is possible however, that the power of dissociation of the created minimum tensions by the expansion of water that fill, to grow with this opportunity. But perhaps the most important in the withdrawal of springs, due to exploitation of the Dead Sea's tributary waters, is the high density of microscopic voids of grained rocks, as some geomorphologists explain the granular disintegration of weakly cemented sandy sandstone here. In addition, the presence of dissolved salts in the infiltration water (which here has a surplus value) seems necessary to trigger this phenomenon even at the base of the slopes. In this case it is about that haloclastie (halos = salt klastos = break), due to developed pressure in less open pores of the grainy rocks accompanied by rapid growth of crystals fueled by an active evaporative of salt solutions which were infiltrated (e.g. along the coasts of warm seas – the Red Sea - and in closed depressions – the case of the graben which houses the Dead Sea - filled with layers of salt dust, gypsum and various chlorides).

4. The region's climate and waters

Israel, due to its latitudinal position on the eastern shore of the Mediterranean Sea, has a climate characterized by long, hot and dry (between June and September rainfall do not fall, except on the coast) summers (April-October) and short winters (November to March), but cool and rainy. These characteristics differ from shore to the heights of the mountains and from north of Kinneret Lake to the Gulf of Eilat. For example, the average temperature of the air in January, the coldest in Israel increases from 60 C in the north, to 150C at Eilat and in summer, the average of July, or August, the hottest in Israel increases from 220C in north, to 330C in south. Here, in Eilat, heat registers absolute maximum values between 44 and 460C. Another aspect of the Israeli climate, this time due to its longitudinal position, is the transition between the subtropical humidity of the Levant, subtropical aridity of the Sahara and Arabian deserts, felt especially in the Dead Sea region. On the Mediterranean coast, summers are wet and increasingly dry, as we move east to the mountains of central Judea, reaching maximum values along the rift and in the Negev desert. Rainfalls fall at a rate of over 70% during winter (November-March). They decrease suddenly to south and they are rare in the Judea desert, but the amount increases in the mountains of Jerusalem and Hebron, where the annual average precipitation reaches between 600 and 800mm. A characteristic of these is the relatively high frequency of exceptionally heavy rain, when in just a few hours in one rain, tens of mm falls. In Judea desert there is almost no rain, so the precipitations can reach at most 20 mm per year. However, there is water in the desert all year, because of the west winds that push Mediterranean moist air to the east to the contact with the mountains of the desert, where either short, orographic rains or diurnal processes of morning condensation (dew) occur. The largest variations of these are registered in the Negev desert, where they can focus on exceptional, violent thunderstorm (as it was the tornado of April 4, 2006), when due to large amounts of water from exceptional rainfall, the erosion processes have intensified and caused flooding. Precipitation in the form of snow are very rare, usually concentrated in the central mountains around Jerusalem, or in the north, on the slopes of Hermon mountains, snow can persist here even over three months.

The desert land due to impermeable geological substrate can not absorb water from exceptional rainfall, so most of them are draining through “ueduri”, comparable in form with canyons. At the beginning of the rain, the drainage of water has the character of canvas, derived from water dispersal on the desert surface. Then, when the rain intensity increases, the water concentrates in small, torrential valleys in the form of small streams and, as they flow in the existing “ueduri”, they gather, forming real huge rivers. The central orographic axis along the rift forms the watershed, which gives the main direction to tributaries of the Dead Sea from west to east. In the main valleys, waters seem insignificant, like springs, but as we approach the giants’ rock, this is changing. Here the water has carved deep canyons with waterfall of few tens of meters high. All water streams gather together in about 15 large valleys that dig their river beds in hard rocks of Mount of the giants’ rock and descend to the Dead Sea. Of these, the largest is Nahal Tzeilim which flows in the Dead Sea between Ein Ghedi and Mezada. The walls of the valley are steep and reach a height of 400 m. The narrow canyon is Nahal Drtaga which flows into the Dead Sea near Mizpe - Shalem.

East of central, orographic axis, along the rift, joining a series of grabens, there are Jordan river and Kinneret Lake. The Jordan Valley, 322 km long, starts with some springs: Dan, Baniyas, and then under Hermon, Hasbani. Of Anti-Lebanon Mountains Lake Kinneret receives Hula, with a large contribution of freshwater. Kinneret Lake (Tiberias) has an area of 165 square kilometers (which usually grows in the wet season) and the water mirror is located at 213 meters below the Mediterranean Sea. The water volume is estimated of 3 kmc, making this lake the main source of water of Israel where it reaches the consumers through

Kinneret-Negev pipeline, called the National Channel. Jordan continues its course between Kinneret Lake and the Dead Sea, its port water being located at 422 meters below the Mediterranean Sea.

5. The evolution of the Dead Sea level

In the last three years (2007-2009) the Dead Sea level dropped by 2.5 m, so that, at present the annual rate of decline is of 1.1 m. It is known that hydrological deficit is due to the difference between the water flow that enters the lake and the evaporation. The Dead Sea has a hydrologic deficiency between 600-700000000 cubic m per year. The level's descent continues today and the experts, by actual research, deduced that in the not too distant future, the level will stabilize itself somewhere at the rate of - 550 m. From the made measurements (Israeli Authority for Water protection) our assessment for 2009 (in Israel it is considered hydrological year the period until September, between October and December there is the rainy season) indicate a succession of variations as follows:

- January marks a reduction of sea level drop, only 0.08 m, compared with data from the same month in 2007 and 2008 (0.12 m), reaching -422.17 m (annual decrease was 1.23 m compared to the same month of the previous year and 1.35 m compared to 2007);
- February shows a rate of decline of level at the same parameters (0.08 m), due to richer upstream rainfall (the level of Kineret lake rose with 0.42 meters), such as the sea level reached -422, 25 m, 1; 22 m compared to the level in February last year, 2008;
- March is the month when the abundant precipitation made the level stagnate (- 422.22 m), the lowering of the level to 0.03 m is not significant, and the decrease compared to March 2008 was of only 1.19m;
- April recorded the same level as in March (- 422.22 m) but with 1.11 m lower than in April 2008;
- May marks the first significant decline of 0.08 m, compared to the previous month (-422.30 m), 1.03 m lower than in May 2008;
- June is the month when the descent is increasing, compared to the previous month to 0.16 m, reaching -422.46 m, 1.08 m lower than in June 2008;
- July achieves annual paroxysm of the level decrease, compared to the previous month, 0.19 m, so that the sea level is -422.65 m, 1.08 m lower than in July 2008;
- August keeps the same pace of decline in (0.18 m) and the Dead Sea's level is of -422.83 m (annual decrease was 1.16 m, compared to the same month of the previous year and 1.29 m compared to 2007)
- September, the closing month of the hydrological year here, the decrease is reduced, compared to August to only 0.06 m (3 times less than the decrease in

August) so as the sea level reaches -422.89 m, with 1.19 below, compared to last year.

Comparing these data with those recorded a decade ago, we found that at the end of September 1999, the level was -411.68 m, 11.21 m higher than today and every month the values of the monthly decrease more. (tab. 2).

Tab. 2 - The monthly evolution of the Dead Sea levels(m) in 2009 compared to 1999

month	Jan.	Febr.	March	April	May	June	July	August	Sept.
1999	1.09	1.14	1.16	1.01	1.026	1.11	1.16	1.16	1.145
2009	1.13	1.23	1.22	1.11	1.21	1.17	1.18	1.19	1.29

To confirm the secular decline in the level of the Dead Sea in conditions of close values of evapo-transpiration in this area, but of the increase in geometric progression of water consumption in Jordan and Hula, direct tributary to Kineret Lake, we present (tab. 3) Compared situation of Dead Sea water

Tab. 3 - Dead Sea evolution in the last decades

Level	Area	Volume	Debit entry	Debit exit
At the beggining of the 20th centry				
- 390 m	950 km^2	156 km^3	1500 mil. m^3	1500 mil. m^3
At the beggining of the 21st centry				
- 415 m	650 km^2	135 km^3	450 mil. m^3	1060 mil. m^3

In the area of arid and semi-arid climates, lands characterized by general lack of water and vegetation because of low rainfall, there are instead large diurnal oscillations of temperature. Here morphogenesis is driven by natural weathering, wind and episodic ally, by external torrential water, just as presented above. Therefore, the geomorphological landscape of the Dead Sea is dominated by rocks exposed at surface, unrolled coarse materials or accumulation of sands and alternating with clays and gravels. Because of this, both on the western shore of the Dead Sea, as on the east and even on the slopes of Jordan, the steep cut in the rock are overcome by the springs of torrential valleys and canyons tributary to this river system. As the liquid flow is reduced considerably (intermittent, flow in canvas) or disappears totally, because extreme evapo-transpiration and the decrease of the amount of precipitation, there prevails mechanical and chemical weathering agents. Thus, delineation of water sweep is difficult because meteorization in arid and semi-arid regions is not accompanied by coarse material removal caused.. Meteorization products contribute to the covering of the slopes and even interfluves with coarse materials produced by weathering, which may form crusts or blankets that reduce or even prevent further disaggregation. Only when these materials come to very small dimensions (of millimeters or microns), the wind takes them instead of water courses and transports them and then creates a special morphology, of dunes in depression areas.

Between 1920 and 1930, the first measurements were made on fixed hydro-meteorological stations on western and northern shores of the Dead Sea. Based on this series of observations, the corroboration of the climatic and the hydrological data was possible, namely those which have registered the evolution of the level of the Dead Sea and its tributaries' flows. Thus, the British researchers from Israeli Research Foundation evaluated the lowering of sea level with 5 m from the beginning of the century until 1930. (Dov Ashbel, 1965). Dov Ashbel retrieved these data and continued climatic and hydrological observations, extending the range of observations, renewing measurements of the Dead Sea levels started by British scientists and extending them to the surface of the water port. Between 1930 and 1997 the level decreased other 21 m, respectively 0.5 meters per year, rate doubled afterwards with approximately 1 m per year. After 1997, until 2007, the descent of the level reached an annual rate of 1.2 m / year, rate that has increased since 2008, a dry year, reaching 1.38 m / year. In 2009 (the last series of observations that we analyzed), the dry nature of climate made the mirror water decrease till September (from January to September) to 1.13 m. These data were published by the Israeli Authority for water protection, both in magazines and online. This significant decrease was caused by evaporation, the lack of rainfall and use of freshwater resources that supply the Dead Sea basin.

Current development of the Dead Sea level, compared with a decade ago (Fig. 5) during 1998-2007, was about 100 cm / year. Since 2008, a dry year, the annual rate of decline in the level reached 1.38 m / year and in 2009, it maintained the dry character of the climate, the water mirror decreased so far (January to September) to almost 1 .13 m. These data were published by "The Israeli Authority for water protection" in magazines. This significant decrease was caused by high evaporation, simultaneous with the lack of rainfall, but especially by the great increase of freshwater consumption by the growing population by over 3.7% a year in Israel (Statistical Abstract of Israel, Jerusalem) and focus, by 24.6% in Jordan (Bulletin of Statistics, Amman), in both countries, the urban population is exceeding 73.5% of the total. Agricultural and economic growth was also accompanied by increased use of water resources that supply the Dead Sea basin, in industry and agriculture.

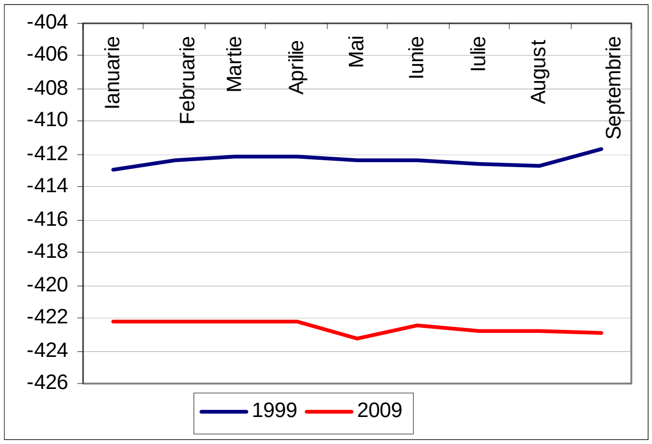

Fig. 5 - Comparison of monthly oscillations in the hydrological years 1999 and 2009

At the exit of Kineret Lake average flow of Jordan is 550 million cubic meters per year. Of this flow, 50 mil cbm / year are given to Jordan, based on the peace agreement signed by Prime Minister Ariel Sharon. In 1964 National Canal was built in Israel and in parallel, Howrah channel dug along the Jordan Valley in Jordan, capturing Iarmuh waters, a tributary of Jordan River on its way to the Dead Sea. Today, Jordan's water resources provide one third of Israel's water consumption and only a very small amount of recycled water reaches the Dead Sea. Water from rainfall and from deep drilling, captured and routed to Jordan, as well as the salty water from springs around Kineret Lake, captured by the channel designated for that purpose, although they reach the Dead Sea, fails to compensate its water balance. This still affects the Dead Sea, leading to its drying in the future. No less important is the fact that reducing the amount of water had a disastrous impact on the flora and fauna along river. We recall that if upstream of Galilee, around the valley, there is a forest vegetation storey in the mountainous space and below, subtropical and even tropical vegetation, specific to this latitudinal area, and downstream the vegetation disappears, so around the Dead Sea and in Negev, we speak of semi-arid and arid areas.

6. Management of water resources

In Israel, water is a very precious natural element (so precisely that it is the reason you say "water is more precious than gold") and for this reason, a special attention was paid to the recovery and efficient use of available funds, as well as for the discovery of new fresh water sources needed in different sectors. Annual sources of water renewal amounted to 1.8 billion m3, of which 71% are for agriculture.

The main water resources are: the Jordan River, Kineret Lake, some smaller rivers from the north and Jarcou -Rosh Ha'ayin groundwater in the central part. In the '60s these water sources were combined into one national network, whose main artery - the National Canal opened in 1964 - leads the water through a system of pumping stations, reservoirs, canals and pipelines from the north to arid south. Due to the use of this system, the area under agriculture increased from 30,000 ha in 1948 to 300,000 hectares at present. Almost half of it is cultivated in irrigated system. In addition to the sprinkler method, there were introduced advanced techniques of water use, including drop irrigation that leads the water directly to plant’s root. Using computerized irrigation system, it is allowed the save 50% of the used water. A crucial element in automatic control of irrigation is represented by the electronic sensors that determine when water reserves decrease to values close to critical thresholds of plants and they act by additional watering. All these investments are part of the application project of environmental policies, compatible with the principles of sustainable development. Automation increases efficiency of water use, reduces labor and saves by recycling the water flow. These great advantages fully justify the investment value in this field, in which the role of a clearly defined management preserves and reinforces for future generations both economic resources and environmental factors.

Conclusions

As the natural conditions regard, especially soil and water, Israel’s agriculture has been favored. Most part of the country is unsuitable for crops. For these reasons, Israel's current agriculture is the result of a long and heavy fight against adverse natural conditions. Her secret of success is the close interaction between farmers and researchers, who cooperate in the development and introduction of sophisticated methods in all agricultural branches, advanced irrigation techniques and new, mechanized equipment. Israel now produces more than consumes. History of the development of this advanced agriculture shows that natural potential in general and climate in particular is not absolute, it can be modified and improved continuously.

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