THE MICROBIOLOGY OF THE DEAD SEA:
PAST, PRESENT, AND FUTURE

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Aral Sea Symposium, St. Petersburg, Russia
15 October 2009
The International Society for Salt Lake Research

Since 1979, an informal international association of salt lake researchers have sponsored a series of triennial conferences to foster scientific exchange and further our understanding of saline lakes.

In 1999, at the 7th International Conference on Salt Lake Research held in Death Valley, CA, participants voted to incorporate the International Society for Salt Lake Research (ISSLR).

ISSLR was founded to establish effective liaison between persons interested in any aspect of inland saline waters, to encourage these interests, and to educate the public in the scientific use, management, and conservation of salt lakes.

Our web site: http://isslr.org
The drainage basin of the Dead Sea
Bathymetric map of the Dead Sea

Flow through the Jordan river in the past:
around $1000 \times 10^6$ m$^3$/year

Presently:
less than $50 \times 10^6$ m$^3$/year
The Dead Sea – May 2008
Stratification ceased to exist in February 1979
The ionic composition of the Dead Sea

<table>
<thead>
<tr>
<th>Ion</th>
<th>1977 (average)</th>
<th>1996 (average)</th>
<th>2007 (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>1.73</td>
<td>1.59</td>
<td>1.54</td>
</tr>
<tr>
<td>K⁺</td>
<td>0.18</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>1.81</td>
<td>1.89</td>
<td>1.98</td>
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<tr>
<td>Ca²⁺</td>
<td>0.43</td>
<td>0.44</td>
<td>0.47</td>
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<tr>
<td>Cl⁻</td>
<td>6.34</td>
<td>6.34</td>
<td>6.48</td>
</tr>
<tr>
<td>Br⁻</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>0.005</td>
<td>0.005</td>
<td>0.004</td>
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</tbody>
</table>

Total dissolved salts: about 340 g/l

pH: about 6.0
Life in the Dead Sea

The remarkably high salt tolerance of unicellular organisms, which have been found in a saline lake of salt concentration so high as 19-28 per cent sodium chloride by Ruben Troch, T. Hof, Baas-Becking and others, caused us to doubt the accuracy of the reputation of lifelessness, which tradition imparts to the Dead Sea. Accordingly, samples of Dead Sea water were taken under sterile conditions at a distance of 3-4 km. from the mouth of the Jordan at various sea depths up to 7 metres. The total salt concentration of the water samples was 28-29 per cent. Bacterial organisms could be grown in 1 per cent peptone sample water media at temperatures of 21°-23°C. and 30°-40°C., from all the samples taken.

In addition, microscopic examination of a hanging drop of the water revealed the presence of a living phytoplankton 13μ long, which we believe is either a Chlamydomonas or a Dunaliella. Three microorganisms have so far been distinguished: a yeast-like, Gram-negative orange-pigment producer 1-6 x 1-2μ (Fig. 1a), a Gram-negative small rod-like organism 1-8 x 0-8μ, and a Gram-positive long filamentous organism (Fig. 1b) 3-3 x 9μ to 17μ x 0-8μ. The investigations are being continued.

We take this opportunity of expressing our thanks to Mr. M. A. Novomytsky, managing director of the Palestine Potash Co. Ltd., for his most kind assistance.

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Dunaliella from the Dead Sea
Halophilic Archaea from the Dead Sea

- *Halofex volcanii*
- *Haloarcula marismortui*
- *Halorubrum sodomense*
- *Halobaculum gomorrense*
$C_{50}$ carotenoids of halophilic Archaea

\[ \alpha\text{-bacterioruberin} \]

\[ \text{monoanhydrobacterioruberin} \]

\[ \text{bianhydrobacterioruberin} \]
The 1980 archaeal bloom in the Dead Sea

In the summer of 1980 the water was red!
An early record of a “red” Dead Sea?

And when they rose early in the morning, and the sun shone upon the water, the Moabites saw the water opposite them as red as blood. And they said: “This is blood ...”

(2 Kings 3: 22-23)
The 1980 *Dunaliella* bloom in the Dead Sea
Phosphate is the limiting inorganic nutrient in the Dead Sea

Nitrogen ($\text{NH}_4^+$) is abundantly available in the Dead Sea
Comparison of the 1980 and 1992 microbial blooms in the Dead Sea
Metagenomics efforts:

1. The current (2007) microbial community in the Dead Sea

2. Preserved material from the 1992 microbial bloom
Aharon Oren, Idan Bodaker, Itai Sharon, Oded Béjà, Mira Rosenberg, Moshe Rhodes, Christopher House

The Hebrew University of Jerusalem
Technion – Israel Institute of Technology, Haifa
Penn State University, University Park, PA, USA
The polar lipid pattern was consistent with the genera *Halobaculum* and/or *Haloferax*.
GC% distribution of Dead Sea 1992 bloom and the 2007 residual community fosmid-ends. Data for selected haloarchaeal and halobacterial genomes as well as a Spanish saltern crystallizer pond fosmid-ends are shown for reference.
% identity of recruited reads as a function of recruited segment length

- Spanish Saltern
- Dead Sea
Taxon distribution of top BLASTn High Score Pairs

Top pies represent unassigned (white), bacterial (black) or archaeal (red for 1992 and blue for 2007) gene assignments.

Columns represent archaeal assigned genes at the species level.
The shrinking Dead Sea
Photographs: courtesy of the Tamar Regional Council
The history of the “Med-Dead” and “Red-Dead” canal plans
The first record of a planned connection between the Red Sea and the Dead Sea (1855)
The canals proposed by Capt. William Allen in 1855

(“a new route to India”)

Sketch for a “Med-Dead” canal with hydroelectric power plant

Max Burchart, 1899
Proposed Med-Dead canal alignments

Filling stage:
1.6 x 10^9 m^3/year

Afterwards:
0.95 x 10^9 m^3/year

Compare: National Water Carrier:
0.4 x 10^9 m^3/year
Cross-section through the proposed southern alignment

Power plant: 600-800 MW
The Johannesburg Summit – September 2002

Israel, Jordan announce joint Dead Sea plan
September 1, 2002 Posted: 4:04 PM EDT (2004 GMT)

JOHANNESBURG, South Africa (AP) -- Israel and Jordan announced their largest-ever joint project at the World Summit on Sunday, a $800 million pipeline intended to save the shrinking Dead Sea from environmental devastation.

The level of the sea, shared between the two countries that signed a peace agreement in 1994, is sinking at the rate of nearly a meter (3.3 feet) a year and could disappear in a few decades, damaging tourism in both countries and indirectly draining scarce water supplies in the region, Cabinet ministers from both countries said.

"It's a catastrophe underway and it might be apocalyptic if we don't challenge it as fast as we can," Israeli Environment Minister Tzahi Hanegbi said.

The two governments said Sunday they hoped to work together to build a 300-kilometer (190-mile)-long pipeline from the Red Sea through both countries to halt the decrease in water level in the Dead Sea.

Israel and Jordan Agree Plan to Save Dead Sea
Reuters

JOHANNESBURG - Israel and Jordan agreed a plan on Sunday to lay an $800 million pipeline to rescue the shrinking Dead Sea.

The two countries, meeting at the Earth Summit, said they would study ways to pipe water north from the Red Sea to the Dead Sea, which they share, in their biggest cooperation deal since a 1994 peace accord.

The pipeline would stretch about 200 miles and aim to help refill the sea, which is falling by about three feet a year.
The proposed “Peace Conduit”

Flow: between 1.2 and $2.5 \times 10^9$ m$^3$/year
What will be the effect on the ecosystem?
Simulation experiments in experimental ponds, in a project undertaken by the Geological Survey of Israel and The Dead Sea Works Ltd.
These and other simulation experiments are being continued to obtain information on the possible biological effects of the “Peace Conduit”

How much “alive” will the Dead Sea eventually become?
לא כל האנשים אינדריולים הם יהודים. וראשה של העברית, הם עיקריים על בכל האנשים הם נחלים. והנה כל אחד ואחד נושאים ירח של שמים נחלים זה הזד blev ירח שמים נחלים הוא. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. ולפי שלושה ירח של שמים נחלים הוא. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. ולפי שלושה ירח של שמים נחלים הוא. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נחלים וראתו בבל שמה בצלאל נחלים. והנה דבורת אשתו פִּי כְּלָל שמה בצלאל נח
И сказал мне: эта вода течет в восточную сторону земли, сойдет на равнину и войдет в море; и воды его делаются здоровыми. И всякое живущее существо, пресмыкающееся там, где войдут две струи, будет жило; и рыбы будет весьма много, потому что войдет туда эта вода, и воды [в море] делаются здоровыми, и, куда войдет этот поток, все будет живо там. И будут стоять подле него рыболовы от Ен-Гадди до Эглаима, будут закидывать сети. Рыба будет в своем виде и, как в большом море, рыбы будет весьма много. Болота его и лужи его, которые не делаются здоровыми, будут оставлены для соли.

(Иеекииль 47:8-11)
And he said to me, “This water flows toward the eastern region and goes down into the Arabah; and when it enters the stagnant waters of the sea, the water will become fresh. And wherever the river goes every living creature which swarms will live, and there will be very many fish, for this water goes there, that the waters of the sea may become fresh; so everything will live where the water goes. Fishermen will stand beside the sea; from Ein-ge’di to En-egla’im it will be a place for spreading of nets; its fish will be of very many kinds, like the fish of the Great Sea. …. But its swamps and marshes will not become fresh; they are to be left for salt.