Prokaryotic diversity in the extreme lakes of Turkey, SW Anatolia, Turkey

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INTRODUCTION

The Lake District, located in the SW Anatolia region of Turkey, hosts a number of lakes with unique water chemistry. Among them, Lake Acigol, Lake Salda and Lake Yarisli display extreme biogeochemical conditions. In terms of their water chemistry and diverse prokaryotic community, each lake sets a great example for microbially mediated reactions (e.g carbonate precipitation).

Fig. 1 Location of the extreme lakes (Google Earth, Landsat 2013 image)

MATERIALS AND METHODS

In scope of elucidating complex bio/geochemical reactions that regulate C, S and O cycles in these lakes, water, surface sediment and shallow core samples were collected and farther analyzed at ITU Geomicrobiology and Biogeochemistry Laboratory. For the first time, prokaryotic diversity of Lake Acigol, Salda and Yarisli were determined by Next-Generation Sequencing (NGS) during this study (Balci et al., 2013).

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Lake Acigol

Lake Acigol (average pH around 8.6) is known for commercial thenardite production, provided by its hypersaline and alkaline water chemistry.

Fig. 2 Lake Acigol: (A) General view (B) fresh-water spring input (C) salt precipitation as a rim (D) salt marsh environment

Table 1 Dominant bacterial and archaeal classes determined in Lake Acigol with their abundances (total number of 22 and 8, respectively)

Bacteria	%	Archaea	%
Alphaproteobacteria	68.2	Methanobacteria	51.7
Cyanobacteria	10.2	Halobacteria	48
Bacilli	9.6	Thaumarchaeota	0.002
Gammaproteobacteria	6.1	Thermoplasmata	0.1
Actinobacteria	2.7	Methanomicrobia	0.1

Lake Salda

Lake Salda (average pH around 9.1) is known for its hydromagnesite beaches, clayey-hydromagnesite shoreline and ancient-modern stromatolite formations as well as being a model for Mars via *Carnobacterium viridians* (Nicholson et al., 2013).

Fig. 3 Lake Salda: (A) General view with stromatolite formations (B) Stromatolite (C) Modern stromatolite formation with microbially formed crustations (D) Shoreline with hydromagnesite sand and stromatolite formation

Table 2 Dominant bacterial and archaeal classes determined in Lake Salda with their abundances (total number of 19 and 7, respectively)

Bacteria	%	Archaea	%
Alphaproteobacteria	25.6	Methanobacteria	76.1
Cyanobacteria	5.3	Halobacteria	21.4
Bacilli	23.7	Thaumarchaeota	1.4
Gammaproteobacteria	39.6	Thermoplasmata	0.8
Actinobacteria	1.8	Methanomicrobia	0.06

Lake Yarisli

For the first time, Lake Yarisli having alkaline conditions with an average pH value of 9.5 is investigated for its geochemistry and geobiology during this study. Algal bloom and well developed cyanobacterial mats are visible on shallow waters along the Eastern shoreline of the lake.

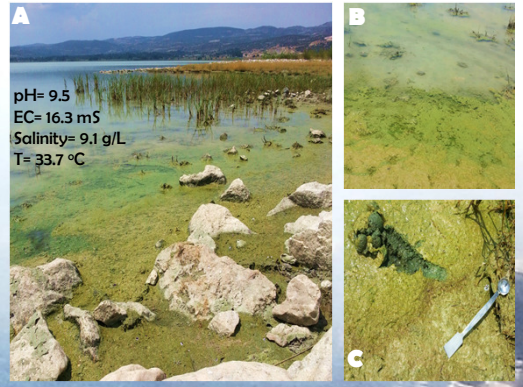

Fig. 4 Lake Yarisli: (A) General view from the Eastern shoreline with algal bloom and carbonate coated rocks (B) Algal bloom (C) Microbial mat formation

Table 3 Dominant bacterial and archaeal classes determined in Lake Yarisli with their abundances (total number of 19 and 6, respectively)

Bacteria	%	Archaea	%
Alphaproteobacteria	1.9	Methanobacteria	61.2
Cyanobacteria	92.9	Halobacteria	38.5
Bacilli	0.45	Thaumarchaeota	0.02
Gammaproteobacteria	4.3	Thermoplasmata	0.1
Actinobacteria	0.06	Methanomicrobia	0.2

Table 4 Extreme lake water chemistry

Lake	pH	EC (mS)	Salinity (g/L)	T (°C)	Alkalinity (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)
Acigol	8.67	35.25	21.4	38.8	284	419.6	987.6	10321.3	915.8	28365	12046	6.8
Salda	9.12	1.82	0.91	26.8	1685	72.8	325.3	372.5	37.8	586.8	472.7	28.9
Yarisli	9.49	16.26	9.09	33.7	3501.7	102.9	86	4607.5	61.2	102.9	3891.2	250.2

CONCLUSIONS

Numerous numbers of bacterial and archaeal classes determined in the lakes are indicators of diverse biogeochemical cycles in such extreme conditions. Elucidating survival strategies of microorganisms in such extreme conditions may provide valuable information about extraterrestrial life. In our laboratory, we continue to study the effect of such microbial diversity on C and S cycles via isotopes, mineralogy and biogeochemistry.