Qualitative Studies
ISSN: 1308 724X (NWSAQS)
ID: 2018.13.3.E0036

Status : Original Study
Received: April 2018
Accepted: July 2018

Edis Koru
Fatih Perçin
Ege University, İzmir-Turkey
edis.koru@ege.edu.tr; fatihpercin@gmail.com

DOI	http://dx.doi.org/10.12739/NWSA.2018.13.3.E0036	
ORCID ID	0000-0003-2862-247x	0000-0002-5118-8061
CORRESPONDING AUTHOR	Edis Koru	

CHARACTERISTICS OF BIOLOGICAL SYSTEMS IN ÇAMALTI SOLAR SALTWORKS (İZMİR/TURKEY)

ABSTRACT

The multi-pond coastal solar salterns consist of a series of conjunctive saltponds, with a gradient of salinities ranging from seawater to NaCl precipitation. This region is anthropogenic supralittoral zones exploited for sea salt, which becomes progressively concentrated by evaporation. In this study, some biological characteristics of Çamaltı saltern was investigated, whic is the biggest marine coastal solar saltworks in Turkey. The Çamaltı saltern is a variable and dynamic ecosystem where 30-35 tons of water of water per minute are constantly circulating. Çamaltı saltworks was opened in 1863 and located the north of İzmir. It is 28km away from the city center. Generally, the saltworks contains of four divisions, namely the first and second saltworks, water ponds, and cristalisation ponds. Anually, the saltworks give 600000 tons of salt, which makes 35-40% of the salt produced in Turkey. Solar saltworks activities are normally ordinarily in wetlands, more specifically in salt swamps rich in biodiversity and represent distingtive biological systems which make them environmentally relevant. Many species live, feed and reproduce in a salt marsh and in a solar saltworks area. It provides biological diversity, including bacteria, macro and microalgae, Artemia, plants, birds, reptiles, fish and invertebrates and contribute to flood prevention and improved water management.

Keywords: İzmir, Saltworks, Biological Characteristics, Algae, Çamaltı

1. INTRODUCTION

Solar saltworks (marais salants, salterns, saltfields, salinas, solnitzi) use energy from wind and sun to evaporate seawater, inland brines, or subterranean saline water in outdoor ponds and manufacture salt (sodium chloride) or other valuable products (Davis, 2000) .The solar evaporation of sea water to produce especially salt and other components of sea water is not only a physical process but there is also an organic contribution from the biological communities with in the saltern ecosystem. Çamaltı saltworks is the biggest coastal solar saltern located on the Aegean coast of Turkey (Koru, 2004; Tıraş, 2011). The saltern of Çamaltı is man-made systems for the extraction of salt from seawater, by means of solar and wind evaporation (Figure 1). The Çamaltı saltpans manufacture sodium chloride continuously throughout the year, but others lie fallow during winters and produce salt only during the summer seasons. Continuously operated saltworks maintain a salinity gradient throughout their ponds during the entire year; they produce salt uninterruptedly (although decreased amounts

How to Cite:
Koru, E. and Perçin, F., (2018). Characteristics of Biological Systems in Çamaltı Solar Saltworks (İzmir/Turkey), **Qualitative Studies (NWSAQS)**, 13(3):15-25, DOI: 10.12739/NWSA.2018.13.3.E0036.

may be harvested in the autumn and winter); and their crystallizers maintain a layer of salt (the salt floor) above which the harvestible crop is deposited. These installations are found in dry climates with low annual rainfall. The saltworks of Çamaltı is also coastal aquatic ecosystem of great ecological importance, as they are characterized by considerable habitat heterogeneity. It combines a spectrum of aquatic environmental types along a long salinity gradient (seawater salinity-280 ppt). It is a multipond system that consists of 176-180 ponds covering approximately 58-60km². Seawater from the Aegean Sea flows into these shallow ponds (Figure 1 and Figure 2).

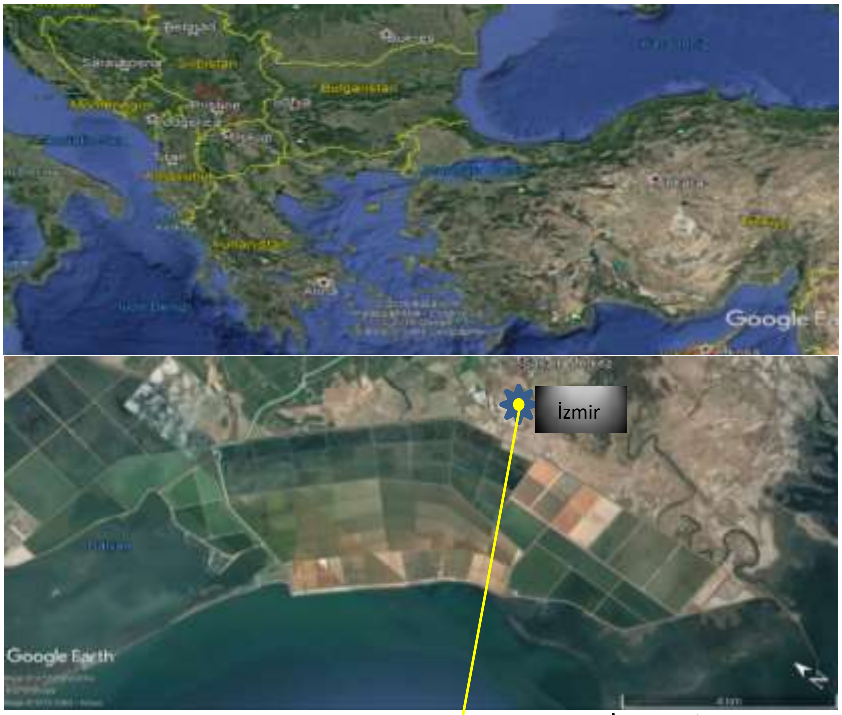


Figure 1. Çamaltı Saltworks (Sasalı-İzmir/Turkey)

Figure 2. Çamaltı saltern ponds

As the wind and sun evaporate the brine, it flows through a sequence of ponds of increasing salinity. In this discontinuous salinity gradient, the salt concentration in each pond is approximately constant over time. When the saturation is reached, at approximately 8-9 times the salt content of the original seawater, crystallization begins. Therefore, multipond solar salterns have a range of salinities, from seawater to saturation, that are model habitats for studying biological communities in hypersaline environments (*Silinabacter* sp, *Hallobacillus* sp, *Dunaliella* sp, *Artemia* sp, *Chironomus* sp, *Phoenicopterus* sp, various water birds, etc) (Figure 3).

Figure 3. Silinabacter sp, Hallobacillus sp, Dunaliella sp, Artemia sp, Chironomus sp, Phoenicopterus sp, various water birds

2. RESEARCH SIGNIFICANCE

Çamaltı solar saltworks is a coastal water ecosystem with great ecological importance, characterized by important habitat heterogeneousness. Combines a number of aquatic environment types along a long salinity (sea water salinity -280 ppt). Çamaltı is a plural ecosystem consisting of 176-180 ponds covering approximately 58-60 km². Sea water from the Aegean Sea flows into these shallow pools. In this way, Izmir also makes the Bird Paradise. Because of the sea water drawn from the sea in the dry summer season and pumped to the Bird Paradise ecosystem. Çamaltı Saltern's obligation to pump water has compose a habitat for many organism with birds. Çamaltı salt water is an important natural habitat owing to its wetland capacity.

For this reason, it is the most important area of biodiversity. At the same time it's an important natural habitat through its wetland characteristics. For this reason, Çamaltı saltern ecosystem is the most important area of biodiversity to Gediz Delta.

3. MATERIAL AND METHODS

The samples for this study were collected in situ of Çamaltı saltworks and investigated as per conventional methods in laboratory. The production monthly time from typical saltworks of season in Çamaltı salterns is from April to November. The active salt production operation in the saltworks is seasonal; the production period is from April to November. The water samples were taken from the evaporators of the saltworks, hydrographical factors such as studies samples were taken with the help of a 38-40°C temperature, salinity, dissolved oxygen, pH, and total mesh plankton net. All samples were preserved total 5% formalin and the organisms were identified by solids, nutrients (nitrite, nitrate, phosphate, ammonia using published papers and monographs.) and primary productivity, were studied along with plankton communities. Water temperature was recorded with a digital thermometer, salinity by using a salinometer and pH with a pH meter. Standard methods of seawater parameters at analysis were followed for the estimation of other parameters. Samples for phytoplankton analysis were collected by filtering 5 liter of water through plankton net having a mesh size of 40µm.

3.1. The Brine Biological System

In an aquatic ecosystem, related algae (seaweeds and phytoplankton), small animals, and microscopic organisms naturally develop a biological system composed of planktonic and benthic communities in the ponds of every solar saltworks. The plants, algae, and bacteria with photosynthetic pigments use sunlight energy and inorganic nutrients (e.g., sectional nitrogen and phosphate) to output organic matter, but the total group of organisms consumes and oxidizes these matters.). Continuously operated Çamaltı saltern maintain flows of water (20-25tons/min) and desired salinity gradients throughout the circuit of ponds, harvest one times in a 12-month period, and maintain salt floors in their crystallizers. The salt floor a 10 to 15cm layer of NaCl above which the crop is deposited is not harvested; it enables crops nearly free of insoluble substances and supports grading, harvest, and hauling vehicles. The Çamaltı saltern production system in the salt fields consists of 6 main parts (Figure 4).

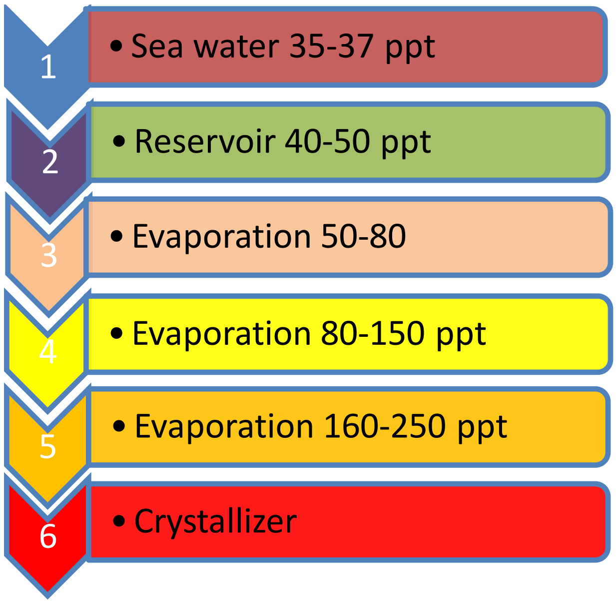


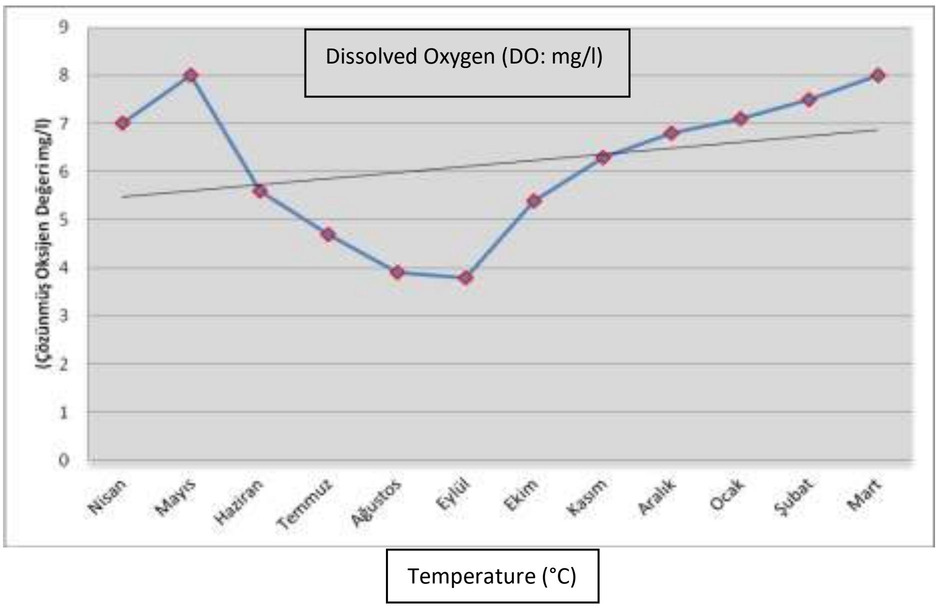
Figure 4. The common salt production system on salt fields

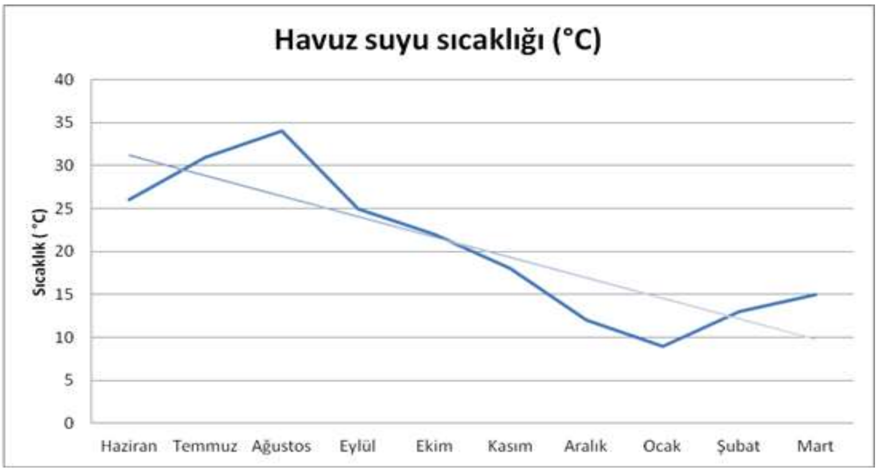
4. RESULTS

4.1. Physico-chemical Parameters

Table 1. The Meteorological data of Çamaltı saltworks ecosystem

İzmir/Time (Monthly)	January	February	March	April	May	June	July	August	September	October	November	December
Time	Average Values in Years (1950 - 2017)											
Average Temperature (°C)	8.9	9.5	11.7	15.9	20.8	25.6	28.0	27.7	23.7	18.8	14.0	10.6
Average Max. Temperature (°C)	12.5	13.5	16.3	20.9	26.0	30.7	33.2	32.9	29.1	23.9	18.5	14.1
Average Min. Temperature (°C)	5.9	6.2	7.8	11.3	15.5	20.0	22.6	22.5	18.7	14.7	10.7	7.7
Average sunny Time (hours)	4.2	5.1	6.2	7.5	9.5	11.3	12.1	11.5	10.1	7.3	5.3	4.1
Average Number of Rainy Days	11.9	10.8	9.2	8.2	5.4	2.1	0.5	0.5	2.0	5.6	8.9	12.5
Monthly Total Rainfall Average (kg/m²)	125.1	101.9	75.6	46.4	30.9	9.8	1.8	2.6	15.0	45.3	94.8	141.1





Time (month) April-May-June-July-Agus.-Sept.-Oct.-Nov.-December

Figure 5. Some chemical, physical and biological data of earth ponds

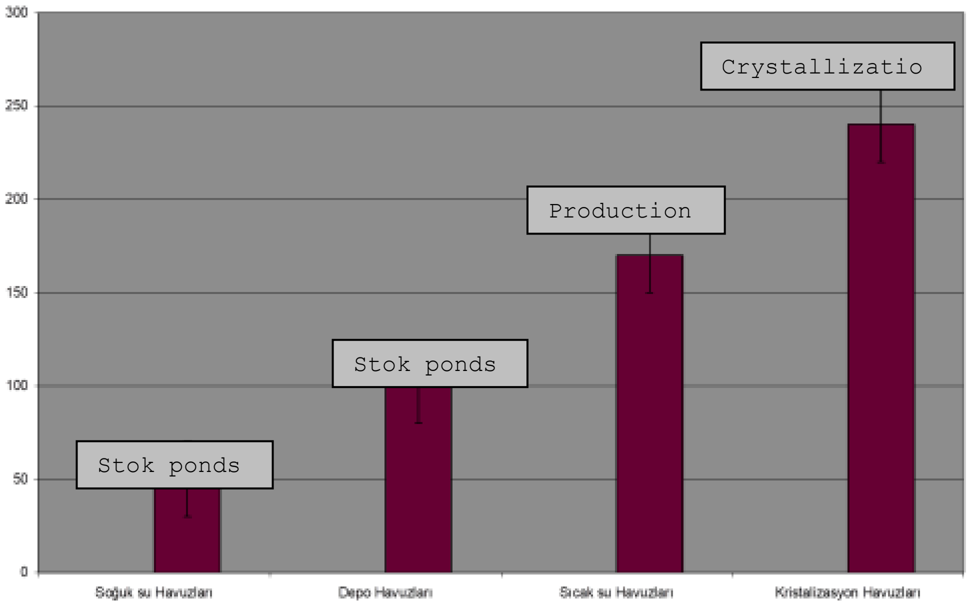


Figure 6. The general salinities of the Çamaltı Saltern pans (%S ppt)

4.2. Biological Data

4.2.1. Halophilic archaea

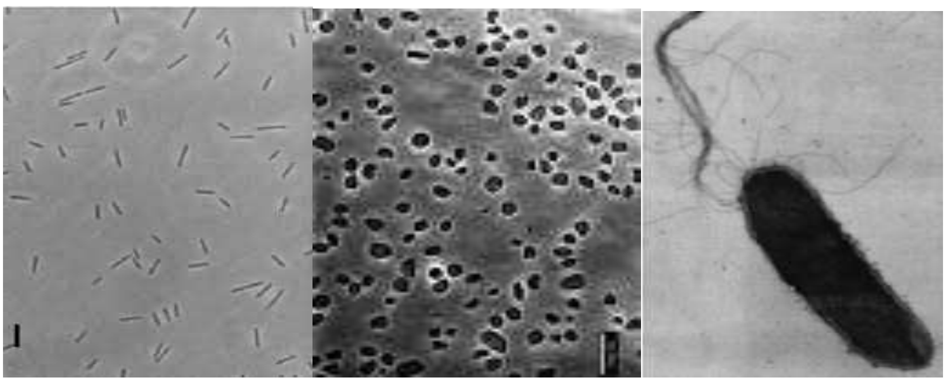


Figure 6. Salinabacter sp., Haloferax alexandrines, Halobacterium salinarum

4.2.2. General species of algae

Table 2. Some algae data on Çamaltı saltern ecosystem

Taxon	March/April/May	June/July/August	Sept./October/November	December/January/February
CYANOPHYTA				
Anabaena spp	– + +	+ – –	– + –	– – –
Arthrospira spp.	– + +	+ + +	+ + –	– – –
Spirulina subsalsa Oersted	– + +	+ + +	+ + –	– – –
Spirulina sp.(Setchell & N.L.Gardner) Geitler 1932	– + +	+ + +	+ + –	– – –
Lyngbya birgei G.M.Smith	– + +	+ – –	– – –	– – –
Microcystis aeruginosa (Kutzing)Lemmermann	– + +	+ + +	+ + +	– – –
Coccochloris elabens Brebisson	– + +	+ + +	+ + +	– – –
Oscillatoria tenuis Agardh	+ + +	+ – –	– + –	– – –
CHLOROPHYTA				
Ankistrodesmus acicularis (Braun)Korshikov	+ + +	– – –	– – –	– – –
Chlamydomonas sp	+ + +	+ – –	– – +	+ – –
Dunaliella salina Teodoresco	+ + +	+ + +	+ + +	– – –
Dunaliella viridis Teodoresco	+ + +	+ + +	+ + +	+ + +
Pediastrum integrum Ehrenberg	– + –	– – –	– – –	– – –
Micractinium pusillum Fresenius	– + –	– – –	– + –	– – –
Haematococcus sp. Flotow, 1844	– – –	+ + +	– + –	– – –
Chlorella sp. Beijerinck,1890	+ + +	+ + +	+ + +	– – –
Tetraselmis sp.	– – –	+ + +	+ – +	– – –
Nannochloris sp. Naumann, 1921	– – +	+ + +	+ + –	– – –
Ulva lactuca Linnaeus, 1753	– – +	+ + +	+ + +	– – –
DINOFLAGELLATE				
Gyrodinium sp. Stein, 1878	– + +	– – –	+ – –	– – –
Oxyrrhis marina Dujardin, 1841	– + +	+ – –	– – –	– – –
BACILLARIOPHYTA				
Amphora coffeaeformis (Agardh) Kutzing	+ + +	– – –	– – –	– – –
A. ovalis Kutzing	+ + +	– – –	– – –	– – –
Cocconeis pediculus Ehrenberg	+ + +	+ + +	+ + +	+ + +
Cymbella pusilla Grunow	+ + +	– – –	+ + –	– – –
Entomoneis paludosa (Smith) Reimer	+ + +	– – –	– – –	– – –
Navicula halophila (Grunow) Cleve	+ + +	+ – –	– + +	– – –
Navicula clamans Hustedt	+ + +	+ – –	– + +	– – –
Navicula *salinarum* Grunow	+ + +	+ + +	– + +	– – –
Navicula sp.	+ + +	+ + +	– + +	– – –
Nitzschia sigma Kutzing	+ + +	+ – –	– + +	– – –
Nitzschia ovalis Arnott ex Grunow in Cleve & Grunow, 1880	+ + +	+ – –	– + +	– – –
Nitzschia sp.	+ + +	+ – –	– + +	– – –
HAPTOPHYTA				
Isochrysis galbana Parke	– + +	+ – –	– + –	– – –
RHODOPHYTA				
Gracilaria sp. Greville,1830.	+ + +	– – –	– – –	+ + +
Porphyridium sp.	+ + +	– – –	– + –	– – –

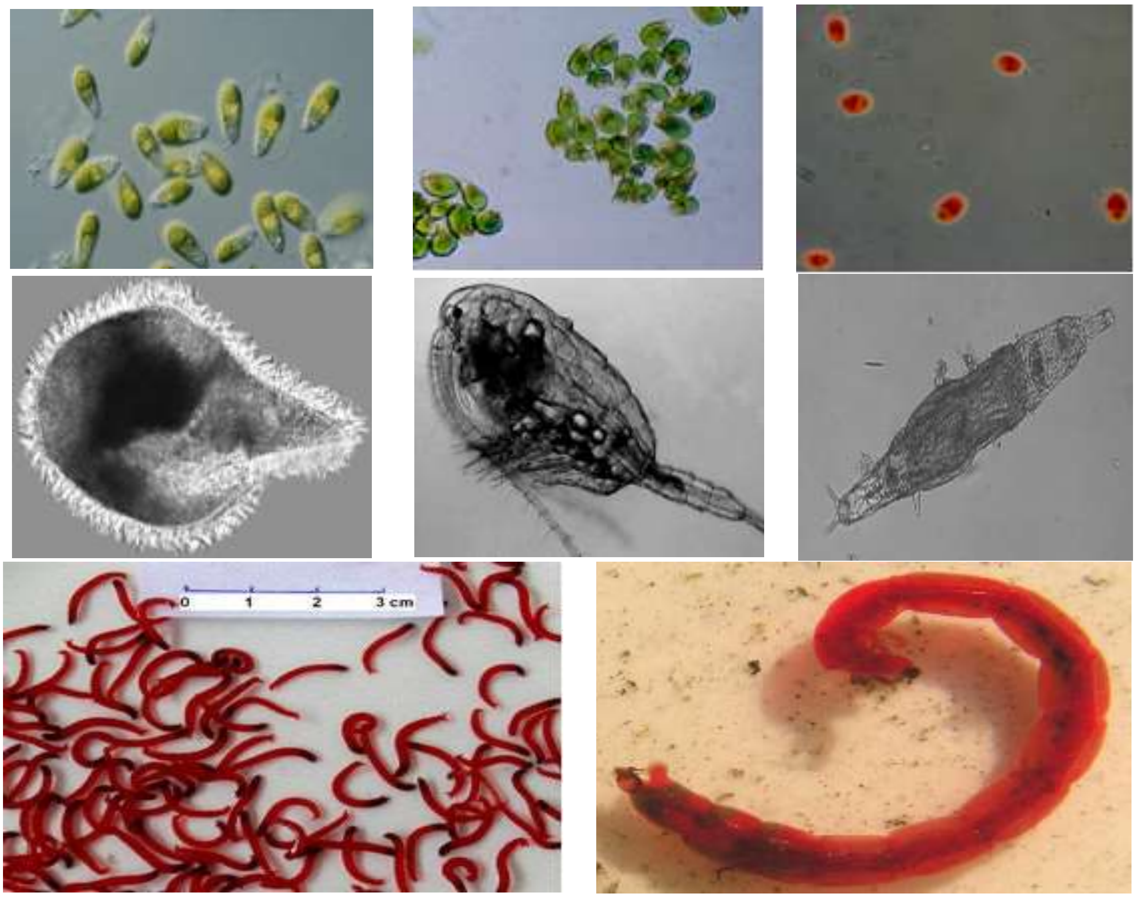


Figure 7. Some microbiological biota: Dunaliella viridis, D. salina, Fabrea salina, Copepods, Rotifer, Chironomus salinarius

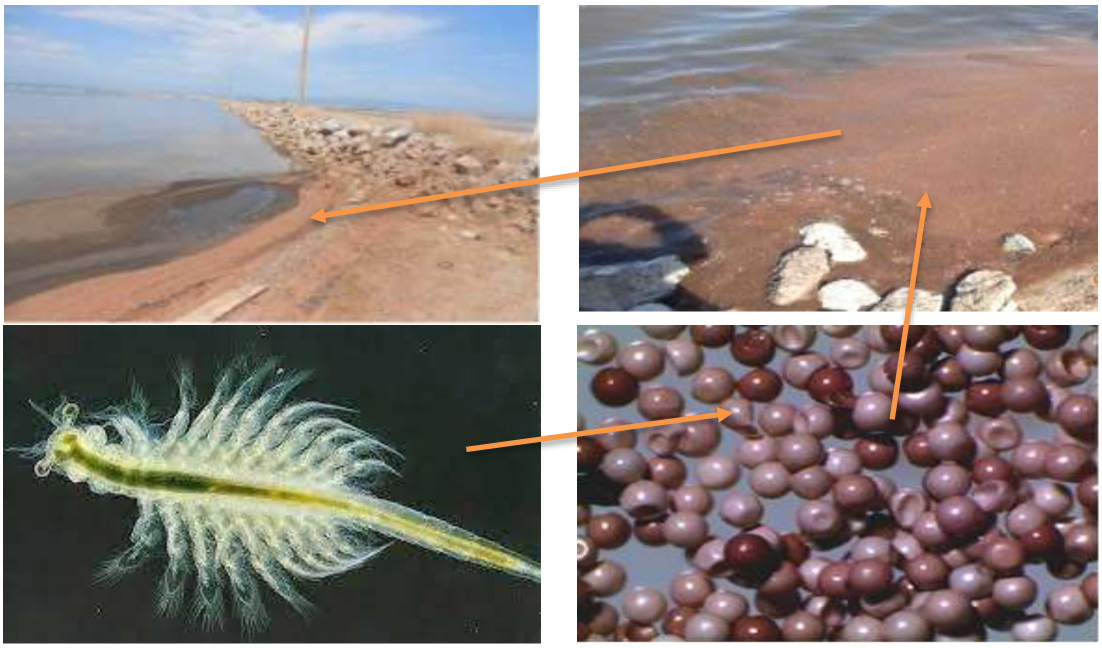


Figure 8. *Artemia parthenogenetica* adult and cysts and their habitats

Within the boundaries of Çamaltı Salt Lake, Bird Sanctuary and Gediz Delta with a surface area of 40 thousand hectares, 289 birds with present-day flowers are present, and in the winter months, they are hosting hundreds of water birds. One of the two areas where urea flamingos in Turkey, İzmir Bird Paradise there are 30 thousand flamingos. The crested pelican, which is endangered on a prolific global scale, is also in the same field. With the ecological side of Gediz Delta, where wild cats, pigs and foxes live their lives, The Ramsar Site has multiple national and international protection statuses such as First-Degree Natural Sites and Wildlife Protection (Anonim, 2007; Karataş, et.al, 2017).

Figure 7. *Phoenicopterus* sp., *Pelecanus* sp

Figure 8. *Aphanius fasciatus*

5. DISCUSSION

Saltworks are artificial ecosystems that are exploited for salt production. These extreme environments create particular habitats for a diversity of species. In "extreme" environments organisms must adapt to stressful environmental conditions. Saltworks are particularly influenced by biotic factors, such as biodiversity. This ecosystem interspecific interactions, which are linked to abiotic factors. The large variation of abiotic factors in extreme ecosystems helps explain the causal relationships between them, as well as the structure of the communities that inhabit them. Species that live in these habitats develop adaption strategies in order to survive and reproduce. Despite the important role of saltwork communities, especially regarding the ecological aspects of the biota of high saline environments that remain poorly understood, few studies have been carried out in these ecosystems. In this context saltworks are a particularly interesting type of study given that they contain a large diversity of species and environments. Hypersaline environments can be classified as thalassohaline and athalassohaline. Thalassohaline waters are "concentrated seawaters with NaCl as the major salt," while athalassohaline waters are "saline waters that are rich in anions other than chloride and/or cations other than sodium". Therefore, on the basis of their salt compositions, Çamaltı salterns are thalassohaline hypersaline environments. This study is the report on the general biota of marine origin at such a saltern ecosystem. Toward a global scale, solar salterns are not a major ecosystem that contributes much to primary production. Whereas, the highly diverse biological system of the salterns, with evaporation and crystallizer ponds of different salinities, and with frequently high densities of planktonic as well as benthic phototrophic microorganisms, makes salterns excellent model systems for the study of primary production under a diversity of conditions. Furthermore, their generally good accessibility and the relatively constant conditions maintained in each pond system make the salterns a suitable environment for the study of basic questions about the activities of phototrophic microbial communities and the way these communities answer to their environment.

Çamaltı saltworks are similar to other hypersaline environments, such as crystallizer earth ponds in coastal solar salterns, in several respects: their microbial diversity is low such as overall, two groups of Archaea and one group of Bacteria, they are dominated by Archaea, although Bacteria account for around ≥10% of the community, and they hausing a very large population of square haloarchaea. On the other hand, there are also some features unique to this system. Thus, even for such low-diversity and extreme systems, studies of new environments can supply unexpected findings. As anticipated by Oren and Rodri´guez-Valera (Oren et. al., 2001; Maturrano et. al., 2006), crystallizer ponds at different geographical locations may indeed harbor microbial communities with different structures. There is an immediate need to establish a strategy that promotes the containment of the Çamaltı solar saltworks as conservation zones, in whose frontier only can be developed activities that do not damage the ecological stability of these important and unique ecosystems. These environments have an ecological dynamic in field and time, where the existing knowledge about the diversity and potential use of natural resources found are still incipient. For this reason, the integrated management of solar saltwork ponds has implied the need for ongoing monitoring and conducting further studies on the feasibility of these other potential uses in Çamaltı saltern earth ponds.

REFERENCES

- Anonim, (2007). Gediz Delta Management Plan [Gediz Deltası Yönetim Planı] Technical Report, T.C. Çevre Ve Orman Bakanlığı Doğa Koruma ve Milli Parklar Genel Müdürlüğü. Sulak Alanlar Şubesi Müdürlüğü.
- Davis, J.S., (2000). Structure, function, and management of the biological system for seasonal solar saltworks, Global Nest: The International Journal, 2, 217-226.
- Koru, E., (2004). Artemia and its importance in Çamaltı Saltworks (İzmir, Turkey) ecosystem. E.U. Journal of Fisheries & Aquatic Sciences 2004 Cilt/Volume 21, Sayı/Issue (1-2):187–189, ISSN 1300–1590, http://jfas.ege.edu.tr/.
- Koru, E. and Deniz, M., (2017). Çamaltı Tuzlasının (Sasalı/İzmir) alg florası ve mevsimsel değişimleri, Su Ürünleri Dergisi, Cilt.34, ss.431-442, DOI: 10.12714/egejfas.2017.34.4.10.
- Karataş, A., Kesici, E. ve Erkol, L., (2017). İzmir Gediz Deltası'nın UNESCO Doğa Mirası Kriterlerine Göre Değerlendirilmesi. Doğa Derneği, İzmir.
- Maturrano, L., Santos, F., Rossello´-Mora, R., and Anto´n, J., (2006). Microbial Diversity in Maras Salterns, a Hypersaline Environment in the Peruvian Andes, Applied and Environmental Microbiology, June 2006, p:3887–3895 Vol:72, No:6, 0099-2240/06/$08.000 doi:10.1128/AEM.02214-05.
- Oren, A. and Rodrı´guez-Valera, F., (2001). The contribution of Halophilic bacteria to the red coloration of saltern crystallizer ponds. FEMS Microbiol. Ecol. 36.123–130.

- Rodrigues de Melo Soares, H.R., Anizio de Assunção, C., Felipe de Oliveira, F., and Marinho-Soriano, E., (2018). Identification and analysis of ecosystem services associated with biodiversity of saltworks, Ocean & Coastal Management 163:278-284. DOI:10.1016/j.ocecoaman.2018.07.007.
- Tıraş, M. (2011). Çamaltı Tuzlası. Doğu Coğrafya Dergisi, 12 (18)291-300, http://dergipark.gov.tr/ataunidcd/issue/2443/31171.