

SOLAR SALTWORKS
A MULTI EXPLOITABLE - PROFITABLE WETLAND
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ABSTRACT

Salt is one of the world's best-known minerals and the chemical substance most related with the history of human civilization. Its significance for the creation of life itself on the planet and its importance as a commodity are paramount.

Man produces sea salt by solar evaporation since the dawn of human civilization. Nevertheless, recognition of the unique coastal ecosystems that developed in parallel with the Solar Saltworks production process evolution is often lacking.

The sea salt production process goes through some distinct stages [1] before getting its current configuration that is a series of interconnecting ponds covering the whole range of brine salinity from regular to hyper saline environments. The biological process that develops along with the salinity vector in the evaporating ponds and crystallizers has actually transformed Solar Saltworks into integrated saline coastal ecosystems [1].

The wetland function of Solar Saltworks, in connection with the historical value of salt, give rise to many additional to salt production ways of Solar Saltworks exploitation.

1. **Salt Museums** are created to exhibit to the general public the salt production methods and techniques along with the cultural values of the salt making sites.
2. Bird watchers organizations visit Solar Saltworks at specific seasons for avifauna observation and recording. That develops strong waves of **eco-tourism** in Solar Saltworks that furthermore affects the nearby local economy and development.
3. The high density ponds of Solar Saltworks are widely used for **therapeutic baths** and also people cover their skin with mud from the ponds bottom for therapeutic and cosmetic purposes.
4. **Products of high commercial value** can be produced in Solar Saltworks such as β -carotene, artemia and cosmetics.
5. Solar Saltworks are used for **environmental education** by Environmental Education Centers (EEC) established by Solar Saltworks Companies or by Local authorities.

Furthermore there is a large number of abandoned small Salinas in the Mediterranean basin that can serve the broader society if rehabilitated properly. They will provide enhanced nature conservation areas and become part of regional networks of ecotourism opportunities.

Keywords: solar saltworks, sea salt, solar salt, constructed ecosystems, wetlands, salt museums, ecotourism, therapeutic baths, environmental education.

INTRODUCTION

The uniqueness of current Solar Sea Saltworks, is based on the fact that in parallel with the salt production (physical process), a unique and of particular importance community of microorganisms develops in the ponds' system (biological process), consisting with organisms and microbes of all domains of life that is, Eukaryotes, Bacteria and Archaea [1].

The ecological importance of Solar Saltworks is also connected to their ornithological interest as shelters to avifauna. Basic organisms of their biological process constitute excellent food for a large number of birds living in the Saltworks for this matter. Certain species of birds, especially the Avocet, the Black-necked Grebe, the Kentish Plover etc., depend directly on the productivity of the Saltworks, since their diet is exclusively based on *Artemia salina*. *Artemia* is also part of the diet of the beautiful flamingos and it is the main reason for the orange colour of their feathers.

Precisely that wetland function gives rise to many side ways of exploitation of Solar Saltworks that in most of the cases develop spontaneously. Taking as example the Greek Saltworks we can mention that in:

- **Kalloni Saltworks**, a strong wave of eco-tourism has been developed following the reconstruction and optimization of its production area
- **Kitros Saltworks**, people use to take saline and mud baths for therapeutic and cosmetic purposes
- **Messologhi Saltworks**, is well known for its spas and mud baths. Additionally it serves as an environmental education site for a local authority.

It is obvious therefore that life shows the way how to proceed with every specific case (Saltworks) since it is not possible/proper to apply all the aforementioned side ways of Saltworks exploitation in every Solar Saltworks.

In this study we concentrate on the effectiveness of Messologhi Saltworks high salinity mud, since for many years unconfirmed information reported on the efficacy of Messologhi Saltworks mud compresses as a treatment for osteoarthritis and cellulite.

QUALITY OF CLAY SEDIMENTS

The Messologhi Lagoon Area has been formed with the sediments from the estuaries of two large rivers that define the borders of the area from east and west and also created substantial reserves of mature mud in the area of Aspri and Turlida Saltworks. The transfer of sediments from adjacent highlands coming in contact with salt water is the substrate for the creation of mud. The sediment materials are enriched with organic ingredients and microorganisms coming from the biological process of the Saltworks and transformed in mature therapeutic mud. The most important microorganisms involved in the biological process of mud maturation are species of algae or green algae. Brine and these algae species with their actions and their metabolites, alter the physiochemical characteristics of sediments, turning them in mature mud, enriched with numerous organic compounds that have therapeutic effects to humans.

The mud is black, homogeneous, with good plasticity and perfect affinity on the skin, elements that make it ready for application. The mud acts therapeutically simultaneously in three ways: thermal, mechanical and chemical. During the application - due to the heat and texture - creates local hyperemia, chemical element absorption through the skin and excellent cosmetic properties like cleanliness, firming, tender touch on the skin. The black color is due to sulfides, which are important therapeutic components and during the contact of the mud with the human skin react with skin's acidic components freeing sulfide ions. These ions are absorbed by the skin treating dermatological diseases. Thus, the chemical action is due to the abundance of metals and minerals that have identified palliative or curative properties. Two experimental clinical studies demonstrated the beneficial effect of curative mud patches to osteoarthritis and cellulite.

The quality of the clay samples from Aspri and Turlida Saltworks, the two Saltworks that operate in Messologhi Lagoon Area have been analyzed in order to identify their therapeutic peloids. Indicatively it is mentioned:

Table 1. Indicative mud sample analysis from Messologhi Saltworks

Analyte	Units	Aspri Saltworks	Tourlida Saltworks
Ag	ppm	0.03	0.05
Al	%	0.49	1.56
Ca	%	17.15	5.85
Fe	%	0.76	2.42
K	%	0.22	0.45
Mg	%	0.91	2.61
Mn	ppm	217	692
Na	%	1.93	5.33
P	ppm	220	560
S	%	>10	1.11
Sr	ppm	1320	399
Zn	ppm	21	57
C Organic	%	0.62	3.43
Sulfide	%	2.51	0.32
Br	ppm	200	340
I	ppm	13.0	29.0
pH	unity	8.1	7.5

Consecutively the heavy metals concentrations are very low:

Table 2. Indicative heavy metals content.

Analyte	Units	Aspri Saltworks	Tourlida Saltworks
As	ppm	3.0	3.8
Cd	ppm	0.07	0.17
Cu	ppm	25.8	37.9
Hg	ppm	0.02	0.06
Pb	ppm	5.9	17.7

OSTEOARTHRITIS TREATMENT

The application of mud compresses from Messologhi Saltworks is examined, as an alternative treatment for the symptoms of neck, shoulder, arm, back, hip and knee, osteoarthritis [2].

Two hundred and forty (n=240) patients were selected and agreed to participate in the research. The patients got assigned to **six different groups of forty people each** (n=40), according to their arthritic joint, i.e. the **neck** group, the **shoulder** group, the **back** group, the **arm** group, the **hip** group and the **knee** group.

All patients followed the same **treatment procedure**:

- Application of a thin layer of sea mud (≤ 3 mm) covering the joint in a uniform way.
- Exposure to sunlight for thirty (30) minutes taking care that all parts of the joint received the same amount of sunlight.
- At the end of the 30 min. period the patients washed off the mud at the sea.
- The same procedure repeated for fifteen (15) consecutive days.

An initial evaluation was performed using the appropriate questionnaires for **pain**, **functionality of the joint** and estimation of the **general health status** (clinical disability) of the patient:

- **Pain Evaluation**
The pain was measured by the eleven point Numeric Rating Scale, where the 0 represents the absence of pain and the 10 the worst pain he had ever felt.
- **Joint Functionality Evaluation**
It was measured by a special for each joint questionnaire. That is the Neck Disability Index (**NDI**), the Shoulder Function Assessment Questionnaire (**SFSAQ**), the Back Pain Functional Scale (**BPFS**), the Disability Arm Shoulder Hand (**DASH**), the Hip Rating Questionnaire (**HRQ**) and the Knee Function Questionnaire (**KFQ**).
- **General Health Status** (Clinical Disability)
The classification of the patients according to their disability level carried out as follows: 0-20% minimal disability, 21-40% average disability, 41-60% major disability and 61-80% patients are bedridden.

After the completion of treatment the patients filled the same questionnaires at the end of each subsequent month and for a period of four months.

RESULTS

The results of the research are presented in the following tables 3 and 4.

Table 3. Statistical data.

	FRIEDMAN TEST (p value)							
	OWESTRY ¹	NDI ²	SFAQ ³	BPFS ⁴	DASH ⁵	HRQ ⁶	KFQ ⁷	NRS ⁸
Neck	0,001	0,001						0,037
Shoulder	0,001		0,006					0,003
Back	0,003			0,001				0,001
Arm	0,001				0,004			0,003
Hip	0,016					0,039		0,004
Knee	0,001						0,001	0,004

- 1: **Owestry Disability Index** (Evaluation of patient's clinical disability 0-80%)
- 2: **Neck Disability Index**
- 3: **Shoulder Function Assessment Questionnaire**
- 4: **Back Pain Functional Scale**
- 5: **Disability Arm Shoulder Hand**
- 6: **Hip Rating Questionnaire**
- 7: **Knee Function Questionnaire**
- 8: **Numeric Rating Scale** (11-point scale for patient self-reporting pain)

Table 4. Aggregate data according to general health status, joint functionality and reduction of pain.

Data analysis (p values)			
Shows improvement ($p < 0,05$) of patients			
	general health status	joint functionality	reduction of pain
Neck	0,001	0,001	0,037
Shoulder	0,001	0,006	0,003
Back	0,003	0,001	0,001
Arm	0,001	0,004	0,003
Hip	0,016	0,039	0,004
Knee	0,001	0,001	0,004

Result analysis showed that there was significant reduction of pain and improvement of the general health status of the patients and of joint functionality as well ($p < 0,05$), with the exception of the hip where the observed improvement is very close to statistical error.

CELLULITE TREATMENT

Clay minerals are used in Aesthetics and in the Cosmetology to clean and moisturize the skin, to peel off the keratinocytes and to combat lipodystrophies, acne and cellulite. Cellulite is a herniation of subcutaneous fat within fibrous connective tissue that manifests topographically as skin dimpling and nodularity, most often in the pelvic region, lower limbs and abdomen.

Many therapeutic approaches have been used to confront the condition, usually with inconclusive results. We used mud from a well known for its therapeutic properties location in Messologhi - Greece and evaluated its ability to affect the condition.

A total of **30 female patients** [3] exhibiting the same degree of cellulite, lifestyle and activity level were recruited and divided randomly in two groups, A and B. The first group (A) was left untreated while the group (B) received the sea mud therapy for fifteen consecutive days. The degree of difference was determined measuring the circumference in the middle of the thigh.

The therapy consisted of a thin application of sea mud on the affected areas followed by exposure to direct sunlight for thirty (30) minutes, covering all parts of the affected areas. The 2-tailed paired t-test (SPSS v 17.0) was utilized for the statistical evaluation of the measurement.

RESULTS

The results for groups A and B are presented in Tables 5 and 6 respectively [3].

Table 5. Group A

	MEAN	Std. Deviation	Std. Error Mean	Significance	Correlation
STAGE CELLULITIS B.T.*	2,4000	0,63246	0,16330	0,000	0,802
STAGE CELLULITIS A.T.**	2,2000	0,67612	0,17457		
RIGHT THIGH B.T.	67,5000	6,49725	1,67758	0,000	0,999
RIGHT THIGH A.T.	67,3333	6,37704	1,64655		
LEFT THIGH B.T.	67,5000	6,49725	1,67758	0,000	0,999
LEFT THIGH A.T.	67,3333	6,37704	1,64655		
CIRCUMFERENCE B.T.	114,6000	9,59762	2,47809	0,000	1,000
CIRCUMFERENCE A.T.	114,5133	9,64897	2,49135		
WAIST B.T.	82,3333	7,54431	1,94793	0,000	1,000
WAIST A.T.	82,2800	7,48343	1,93221		

*B.T. = Before Treatment, **A.T. = After Treatment

Table 6. Group B

	MEAN	Std. Deviation	Std. Error Mean	Significance	Correlation
STAGE CELLULITIS B.T.*	2,4000	0,63246	0,16330	0,003	0,706
STAGE CELLULITIS A.T.**	1,9333	0,70373	0,18170		
RIGHT THIGH B.T.	66,9000	6,49725	1,67758	0,000	0,996
RIGHT THIGH A.T.	67,4000	6,33076	1,63460		
LEFT THIGH B.T.	67,1333	6,43151	1,66061	0,000	0,999
LEFT THIGH A.T.	67,3333	6,42947	1,66008		
CIRCUMFERENCE B.T.	114,6000	9,59762	2,47809	0,000	0,996
CIRCUMFERENCE A.T.	113,9333	9,50359	2,45428		
WAIST B.T.	82,3333	7,54431	1,94793	0,000	0,998
WAIST A.T.	81,8667	7,42214	1,91639		

*B.T. = Before Treatment, **A.T. = After Treatment

As it is shown in **Table 5** no significant change was observed in the stage of cellulite in the perimeter of the thighs, in the circumference or in the perimeter of waist in group A, which did not received any treatment ($p > 0,05$, in all cases). On the contrary, improvement was noticed with statistical significance ($p < 0,05$), regarding the aforementioned parameters in group B (**Table 6**).

The mean stage of cellulite was decreased from 2,4000 to 1,9333 ($p=0,004$), while the perimeter of each thigh was also diminished (right thigh $p=0,002$, left thigh $p=0,001$). Decrease was noticed in the circumference ($p= 0,007$), as well. The perimeter of waist was also improved from 82,3333 to 81,8667 ($p=0,004$) [3].

It is noteworthy that no irritating effects such as redness or itching has been reported.

CONCLUSION

Aim of the research was to verify the efficacy of Messologhi Saltworks mud as a treatment for osteoarthritis symptoms and cellulite.

The conclusions that can be drawn from the above results are that the application of Messologhi sea mud for fifteen consecutive days has been proved to be:

- quite effective in treating the symptoms of osteoarthritis in most of the major joints of the body
- a beneficial and safe method for the treatment of cellulite.

The possible mechanism of action of mud treatment remains unknown; it appears that the beneficial effect of the mud is due to a multifactorial (multi-element) mechanism.

We wish to emphasize that in a next step, the results of this study should be confirmed by clinical examinations in order to accurately visualize the extent of the disease in each patient.

Also, with further clinical studies can be shown that the mud is beneficial in cases of dermatological diseases as have occasionally noted by such references.

Lastly, the mud with proper processing can be incorporated into cosmetic formulations, or can be used as it is, on human skin (face and body).

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