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**TECHNOLOGICAL MODEL TO COLLECT AND PARTIALLY
DRY THE ACTIVE SLUDGE FROM NATURAL LAKES USING
SOLAR PANELS**

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Abstract

In Natural Reservation is very important to maintain the environmental, the equilibrium for the protected species, flora, and fauna. The paper presents a technological model perfect adapted to these conditions as not disturb the local equilibrium. In the first part are mentioned the topic importance and the new problems appeared into last decades, related to the environmental problems in Natural Reservation Lake Techirghiol. This new solution placed on a mobile pontoon uses renewable resources as to collect and partially dry the collected sludge from the lake. Some experimental measurements were done in 2015, as to determine the quality of water, the main parameters, and the conditions responsible for disturbing the ecosystem. The technological model intends to solve the local problem, to collect, compact and partially dry the active sludge. The extracted sludge can be in short time integrally consumed for agricultural purpose, as ecologic and nutritive fertilizer for the adjacent area, known as the Plover, with low potential for agriculture. The sludge, well known in the past for its human therapeutic utilization, more, then one hundred ago, nowadays-due ecological and biological changes lost his efficiency. The reconstruction of the local ecologic balance and for the sludge to recover its therapeutic properties, using renewable resources, without disturbing the environment are the main objectives of this research. Some conclusions, the acknowledgements, and references are also presented.

Keywords: *environmental engineering, environmental monitoring, prototype, renewable energy sources, water conservation*

Introduction

Techirghiol lake, a Natural Reservation, is the biggest lake with salt water in Romania, provided by the Decision 1266/2000. Techirghiol Lake is RAMSAR site since 2006, with the number 1610, included in Nature 2000 on the base of the EU Birds Directive, having the RoSPA0061 code. Here, more than 150 bird species are permanent present in transit or in wintering, because the water never freezes, even in cold winters. There are also fish and specific salt water vegetation.

In the last decades, earthquakes with small magnitude occurred in the Black Sea, in the south part of Romania, near the Bulgarian border. This is exactly the place where the lake is situated. Some tectonic plates have been shifted and allowed freshwater to infiltrate the edge of the continental part. As consequence, the local salinity of the water decreased. The local shores restoration works that were carried out in 1980-1983 let also supplementary clean water to enter into the lake, this being another source changing the water salinity. Shortly perturbations of the environmental

conditions were observed. Some species aquatic vegetation specific to fresh water, rapidly grew and invertebrates have appeared and developed. That was the reason that made monitoring of the water parameters in different points of the lake necessary. The lake's water surface has an altitude between 0-80m, being near the vicinity of the Black Sea.

During the bird passage, in the lake are presently more than 20,000 birds, of different species. Many of them are protected by law and are into a permanent surveillance.

Other solutions known until now can't be applied in this case. Chemical solutions can't be used, due to the fact that that would change the chemical composition of the water, affecting the entire ecosystem. The biological solutions with the freshwater fish cannot be applied. They already began to emerge, develop, and grow without any intervention. The conventional, mechanical, harvester solutions use gasoline or diesel fuel with an unpleasant smell and produce noise, which disturbs the birds. Moreover, they would immediately destroy the bird nests and the rearing areas.

At present, due to eutrophication, many lakes have a diminished capacity. Massive sludge deposition was registered, favorable for the aquatic vegetation development. In short time the development being the following: massive amounts of invertebrates, interference scallops, and predator fish, followed by a decline of the specific fishes.

The proposed solution is ecological without disturbing the local environment. Its primary objective is to rebuild the local, natural, biological balance. In order to solve the problem an experimental model was realized, an autonomous pilot station placed on a mobile pontoon, powered in co-generation with PV panels, to collect, compact and partially dry the sludge.

The sludge, due to its structure full of nutrients and nitrates is perfectly ecologic to be used as a biologic fertilizer to restore the soils affected by demineralization. By repeated applications, the lands are restored and playback for agriculture; the yields were higher on the tested land.

The solution has a double benefit: restoring the ecologic equilibrium and assuring a proper and efficient consumption of the extracted sludge, as organic fertilizer on affected soils. By partially drying the sludge, the time until the economic use becomes possible is shortened and also insects' development is restricted, and the putrefaction of parasitic is reduced. Renewable energy resources are used in order to collect, compact and partially dry the sludge.

Materials and Methods

Mangalia Lake is the largest salted water lake in Romania, with a water body of 1226.97 hectares. It is located in the immediate vicinity of the coastline, approximately 15 km south of Constanta city. Its name means Lake of mullets (*Mullus barbatus*).

Sludge and lake waters are used for their health benefits since the 19th century. In 1924, at the Universal Exposition from Paris, the Techirghiol mud received the gold medal. The quality appears as result of the bacterial decomposition of the aquatic organisms after their natural cycle, especially by *Artemia salina* shellfish and the marine algae that live in the lakes' water. The sapropelic mud of Techirghiol is used warm for different kind of procedures as cataplasm, massage, skin elasticity, hydration for cell strengthening, skin healing in cases of psoriasis and eczema, improvement of pain from anterior accidents, rheumatism, and muscular immobility.

The mud from Lake Techirghiol is shiny, unctuous as black oil and has a characteristic odor (Shumway 1990).

Water salinity variation directly affects marine algae life, followed by the disappearance of the specific aquatic organisms. That's why the sludge's properties are affected, as well as the water chemical composition.

The lake's Techirghiol salinity measured in 1936 was 99.6 g/l, in 1996-81.485 g/l, 2004– 65.1 g/l, and in 2010 was below 60 g/l, which proves the cumulative effects of the natural fluctuations, but also, the environmental problems. Due to the almost permanent wind, which constantly mixes the lake's waters, the lake rarely freezes (especially in the middle area). This water characteristic, remaining unfrozen even if the air temperature gets to -2⁰C or -3⁰C during winter, makes this place so attractive to numerous wintering waders (Figure 1).



Figure 1. Images with the Techirghiol Lake

During 2014-2016 measurements of the water quality were made. Currently, the lake water chemistry is influenced by the great extension of human activities. The results are presented below, with some secondary environmental indicators in Lakes Techirghiol, Costinesti I and Costinesti II. Techirghiol Lake suffered the most important changes of level and in salinity. The water sweetening can be, in this case, harmful. In these circumstances, the therapeutic mud is recovering with difficulty.

Table 1. The main measured water parameters

Lake	Chemistry g/l	TDS mg/l	EC mS/cm	pH	U mV	Dissolved oxygen		
						mg/l	%	mbar
Techirghiol	59.7	92	91	8.4 alkaline	77.7	0.63	8.1	16.4
	Hyper-alkaline							
Costinesti I	10.7	205	17.96	9.99 alkaline	170.9	7.45	96.2	193.4
	Mezzohalin							
Costinesti II	0.3	1050	1046	9.1	118.2	3.16	37.3	76.6
	Fresh							

TDS - the total dissolved salted, EC - Electric conductivity, U - Tension

The calcareous deposits under the loess allow an important throughput quantity of groundwater. Unfortunately, the lake is poorly maintained and there are highly eutrophic waters. It comprises a system of more or less of three lakes, the upstream main water body being isolated. The upstream lake clogging is strong and entirely covered with floating plants, reeds, and bulrush at edges. Near Techirghiol Lake, two other lakes are found: Lake Costinesti I and upstream, the Lake Costinești II. Here the

salinity also varies, with a considerable difference in time: in 1963 was 1927 g/l; 1969 to 17.1 g/l and in 2004 to 10.7 g/l. The fresh water contribution is due to the underground waters flows, which greatly varies depending on the season (Radulescu 2004).

Currently, Techirghiol Lake waters are divided into three separate entities. That is a consequence of the dams constructed in 1983 and 1989 and due to the infiltrations that appeared after more than 82 small earthquakes, registered in the last 30 years. There is a salt water area (52-55 grams of salt per liter) located near the sea, a brackish area (6 -8 g/l), intermediate and freshwater area (1 to 2.3 g/l), located at the "end of the lake". This part has nowadays areas filled with marsh vegetation characteristic for freshwater (Radulescu & Nistoreanu 2004).

According to the standard registration, Techirghiol is important for the wintering of many bird species. Part of them: 7,000 red-breasted geese, one of the rarest species of geese in the world, 40 copies of whooper swan (*Cygnus cygnus*), 34 large egrets (*Egretta alba*), winter hawk (*Falco columbarius*), Falcon (*Falco peregrinus*), polar (*Gavia arctica*), 1,800 (Mergus albellus), 800 White-headed ducks (*Oxyura leucocephala*), and small cormorants 800 (*Phalacrocorax pygmeus*). Among the species that nest here, worth to be mentioned are also: 30 pairs of stilt (*Himantopus himantopus*) and 12 pairs of Little Bittern (*Ixobrychus minutus*). During the passage, the site is used inter alia for 20 pairs of Kentish Plover (*Charadrius alexandrinus*), 1,300 white storks (*Ciconia ciconia*), 600 black head seagulls (*Larus melanocephalus*), 5,200 small gull (*Larus minutus*), 100-120 pelican (*Pelecanus onocrotalus*), 100 thugs (*Philomachus pugnax*), 20 copies of the small tern (*Sterna albifrons*). In the migration periods, the site waters are used for more than 20,000 waders. For all the birds, the marine algae, marine shellfish, and marine species of fish, small frogs, or snakes represent the main food.

Dense algae growth (over 25% of the surface area) and other water plants can seriously interfere with normal aquatic life and definitely affect the life of birds, producing discrepancies for the normal environment (Caraco 2005).

During the nighttime, the oxygen depletion has supplementary biological effects; the green plants produce oxygen in sunlight, but they consume oxygen during the night. They further reduce the water of the dissolved oxygen.

Modification of water chemistry can deplete the oxygen supply, resulting in fish death by suffocation. Prolonged exposure to low oxygen concentrations can weaken the fish, making them susceptible to diseases and toxicants.

The key factors contributing to the biological process forming the therapeutic mud in Techirghiol are (Smith et al. 1999):

- *Artemia salina*, which is a crustacean philopodia, with a role in the peloidogenesis. It is the main filter and has three generations in Techirghiol lake: from April to May, June and August-September depending on weather conditions.
- Cladophora is a crystalline, reticular, filamentous alga known as "bad weed" consumed as a delicacy. It plays an important role in increasing phosphorus levels. The organic oxidized substances coming from lake inhabitants marks an increase from the surface to depth, i.e. from area trofolitica to area trofogenă. Dissolved oxygen varies in different regions of the lake, but in all cases there is a decrease with the depth. On the surface, in the trofogenă, oxygen consumption is high and less oxygen is consumed in the trofolitica.
- The sludge is, however, the factor that brought the lake fame.

It is part of a therapeutic underwater sediments organogenesis being characterized as a shore mud. Such sludge is the product of the chemical and biochemical processes that are extremely complex and lengthy, altering the minerals and organic substances from the lake (Sharpley et al. 1998).

Results and Discussion

The further solution is a prototype tested for the first time in Techirghiol Lake. It represents an autonomous innovative solution (under license), perfect ecological, and partially energetic independent. Realized on a mobile pontoon, it may be commanded from distance, and powered by co-generation, with two photovoltaic (PV) panels. They assure the pontoon movement. Sludge drying is realized in a fiberglass tank, located under the PV. The dried sludge represents a natural fertilizer that can be used for de-mineralized lands, to restore their biochemical potential.

The solution has a double benefit: restoring ecologic equilibrium of the implementation areas and to assure an efficient consumption of the extracted sludge. By additional drying, the time until economic use is shortened and insects development is restricted. Only the sludge obtained as results of the lake's eutrophication is collected, generated by the putrefaction of the aquatic, newly developed vegetation, by fresh water supplying. Taking only the sludge without any therapeutic effects, the prototype assures that the active sludge maintains its parameters and needed concentrations.

The experimental solution is efficient, using renewable resources and participates at environment and agricultural lands restoration. It can be moved in different areas, the natural reservation being completely unaffected. In Figure 2 the installation and structure are schematically presented. The setup consists of three functional blocks of the collecting system, coupled to Photo-voltaic-PV panels, the system for compacting, and the system for partial drying.

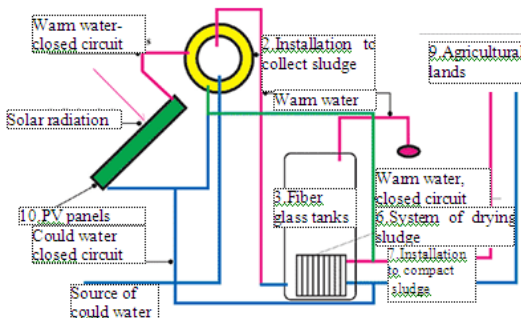


Figure 2. The prototype structure

Separately, the lakeshore commanded movement system was designed and executed, as well as the automation system to stop the pontoon when the fiber glass tank is filled with sludge, the automation system to coordinate one cycle, and finally the alimentation system from the PV panels. Between all blocks a permanently adapted to the meteorological conditions system of interconnection is realized.

The main steps in a functioning cycle are described as it follows. The prototype, placed on a mobile pontoon can advance by propulsion, commanded from the lakeshore (1). During the advance, the pump aspirates sludge and sediments. The sludge is conducted directly into a compacting system (7). At a time interval, the compacting system starts and releases the sludge into a fiberglass tank (3) to be partially dried. When the tank is filled, the automation system interrupts the alimentation (2) and the pontoon stops (5). The collected and compacted sludge starts to be dried (6), due to a system of pipes, which assures warm water circulation. After being partially dried, sediments are evacuated and used as fertilizer. The fiberglass tank is placed on the pontoon, under the PV panels (10). The prototype is automatic and autonomic. After evacuation, the pontoon movement is commanded and the cycle repeats. The main prototype components:

1. PV with a storage system (Figure 3-a)

The main advantage of this system is its small weight. The system components are an Off-Grid of 1 kW with energy storage in batteries. The package contains two 500 W panels, an inverter 24V/UPS system 1000 with Controller 60 A 12-24V EP Solar, plus accessories. The modules are reliable photovoltaic panels, with great efficiency and high yield. Even with a reduced incidence of light, the module achieves a good performance and yield. Before and after lamination, each module undergoes an electroluminescence test.



Figure 3. Prototype components

Performance guarantee: Up to 10 years: 90% of nominal output; Efficiency to 25 years: 80% of nominal power; the product warranty is 11 years for the photovoltaic panel. The Off-Grid inverter is a professional device, designed for harsh conditions. The inverter consumes firstly the battery power, until it reaches the minimum voltage consumption. Only then, it inverter automatically switches to the power supply. The inverter's power saving function has automatic detection of the battery options. This method saves battery capacity and consumption in standby mode. The inverter is in standby power mode, and its consumption is < 2W. Overcharging batteries is prevented because the controller will stop the charging when the full capacity is reached. The solar controller is compatible with all brands of solar modules. The controller 12V-24V 60A is suitable for gel and acid batteries. The integrated microprocessor controls the charging switching thresholds of the precise and stable temperature. The controller keeps the battery fully charged.

2. The sludge collecting system of the (Figure 3-b)

The collector is represented by a Screw Pump, with electric alimentation, an aspiration pipe of 55 mm diameter, and a flowrate of $Q=25$ l/min, the voltage can be of 110V or

220V. The pump can be used for pumping dirty water with sediments or sludge, Power $P=0.75$ kW, $H_{max}=40$ m, being made of stainless steel. It is specially designed to aspire sediments or sludge from reservoirs, lakes, or channels bottom.

3. The Fiberglass tank (Figure 4-a)

On the deck, the sludge is deposited in a fiberglass tank, with a capacity of around 5 m^3 , placed under the PV-s, realized with holes on both sides, of $2540 \times 1960 \times 980$ mm as to assure a good deposition of the collected sludge.

4. Sludge compacting system (Figure 4-b, 4-c)

It refers to a small compression of sludge directly after it's extraction from the lake, before depositing it into the fiberglass tank. It is formed by a screw system (augers), moving through a conic portion, assuring sludge compacting.

When the tank is full, filled with partially compacted sludge the pontoon stops. At pre-selected time interval, in conformity with the atmospheric parameters and the local conditions, the compacted sludge is dried due to warm water circulation through a system of small pipelines.

A silent and environmentally friendly engine, adapted to the specific area of the Natural reservation drives the hydraulic system of the collector. The propellers for the pontoon movement prove to be durable to ensure the maximum maneuverability of the prototype, back and forth, even in shallow water.

The solar modules are directly connected to the heating element with an electrical efficiency of 99%. There is no need to use here for an inverter. The system just consists of a heating element and a control system. This saves initial costs and maintenance.

After being partially dried, the sludge is evacuated and deposited into a special sector until it will be transported to lands as fertilizer.

Besides the mentioned parts of the prototype, there are some other components which have been realized or bought. As examples the interconnections, the pontoon's distance command, fill-up sensor for the fiber glass tank, automation of the pontoon's start and stop of the, and sensors for detecting the corresponding the sludge water contents, in accordance with the atmospheric parameters (temperature, humidity).

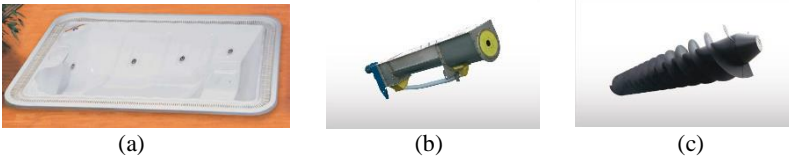


Figure 4. Components of the prototype

Conclusions

The paper presents an innovative solution to collect and use the inactive sludge from the deposits from a Natural Reservation, Lake Techirghiol. The excess aquatic plants putrefaction that appeared, the developed vegetation, lead to this sludge amounts. It affects the active sludge, existing for hundreds of years, and famous for its effectiveness in treating many diseases. The sludge with health benefits is a result of bacterial decomposition of the aquatic organisms, which have completed their

existence, especially of *Artemia salina* crustaceans and the algae living in salted water. The prototype represents a technical challenge concerning design, execution, automation, and control, in accordance with environmental conditions imposed for Natural Reservations. It represents a solution that uses renewable sources, being perfectly ecologically, without disturbing the local conditions. The solution eliminates the nutrient base that helps excess vegetation development and ensures the effective sludge use lands, as a fertilizer. The region where the lake is located is well known with less fertile soils. This sludge assures an ecologic and biologic supplement to increase the soil productivity. The elaborated database will allow further studies and research. The study aims to improve the environmental conditions, in accordance with the appropriate European standards referring to protected areas. By its functionality, the salted water quality was improved and restored the local environment. The prototype has an actual character and contains some new developed mathematical and numerical models in the realization of the technical referential. The numerical model refers to the interconnection of the formative modules. The reconstruction of the local ecological balance without using conventional fuels as not disturb the ecologic equilibrium of the reservation represents the main objective of this research (O.U.G.57). During migration, in the mentioned lake area, more than 20.000 birds of different species are present, many of them being legally protected. This solution is in accord to the Romanian reply for EU Council Directives, UE-EUCO 75/13 CO EUR 7 signed in Brussels at 22/05/2013, referring to the promotion of new solutions based on renewable technology use in the ecologic environment.

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