sciendo Ovidius University Annals Series: Civil Engineering, Year 23, 2021
DOI: 10.2478/ouacsce-2021-0022

Assessment of Water Quality from Coastal Lakes for Use in Irrigation

Mădălina Stănescu, Constantin Buta and Geanina Mihai

***Abstract* – The assessment of water quality from coastal lakes for irrigation purposes has emerged from the practical necessity of the land improvements companies, in order to determine the irrigation class of water from coastal lakes that could represent the water source for irrigation facilities in the coastal area. These assessments are the support for the hydro-saline dynamics of the soil, so that the intervention in the environment is harmoniously assimilated to it.**

Keywords – coastal lakes, irrigation, lake, water quality

1. INTRODUCTION

Along with genetics, irrigation represents one of the great hopes of mankind for food production. With its complex organization and characteristic features, the soil behaves like a huge water reservoir continuously consumed by plant evapotranspiration, by leakage to the surface and seepage and it is continuously renewed through precipitation, a phreatic inflow, from the neighboring areas and irrigation.

Any intervention in a complex of well-defined elements and hydro-ameliorative arrangements, which mainly control the water factor, produce multiple effects in the environment.

Water quality studies used in the technological process of irrigation provide a scientific tool that can differentiate the positive effects from the negative ones as well as the size of each one.

The usefulness of these studies derives both from methodological considerations, that provide the basis for modifying some solutions in design and/or exploitation , as well as ecologically by explaining the causes that alter the environment, the magnitude of these changes, resulting in solutions which can be adopted to prevent environmental degradation or ecological restoration of some ecosystems.

It should be considered that equipping the territory with irrigation facilities had mainly a favorable ecological and social impact. Their dominant positive impact was due to the application within the complex of various categories of land improvement works, through intervention works that allowed control of the hydro-saline dynamics of the soil.

Under the current conditions of irrigated agriculture in Romania, dominated by a real crisis caused by the entry into preservation of large irrigation systems, any viable alternative to the realization of small irrigation systems is worthwhile. These systems ensure, at least locally, the prerequisites for obtaining harvested crops from the random empire of unfavorable climatic factors.

This is also the case with the local irrigation facilities in Dobrogea, which use the lakes located in the vicinity of the areas with irrigation potential as a source of water.

2. MATERIALS AND METHODS

2.1. Criteria for assessment of water quality used for irrigation

The realization of a forecasting study on the evolution of irrigated soils involves knowing the initial parameters of the quality of water used in the irrigation technological process, in correlation with the genetic types of the irrigated soils and the salt tolerance of the irrigated crops.

The main parameters for the quality assessment of the water used for irrigation, known in the specialized literature, and regulated by the standards in force are:

1. The Sodium Adsorption Ratio (S.A.R. Index)

The S.A.R. index is determined by the cations of Na+, Ca2+ and Mg2+ (miliequivalents per liter) using the relation [1]:

$$SAR=(Na^{+})/[(\sqrt{Ca^{+}+Mg^{2+}})/2] \quad (1)$$

2. The irrigation coefficient, C_i, determined according to the „Priklonski criteria"

The irrigation coefficient, C_i, is determined according to the „Priklonski criteria", depending on the content of Na^+ cations and the strong anions of Cl^- and SO_4^{2} expressed in miliequivalents:

Table 1. Irrigation coefficient, C_i[1]

Type of solution	Irrigation coefficient, C_i
Content of Na^+<Cl^-, Sodium chloride is present	$C_i=288/(5Cl^-)$
Content of Na^+>Cl^-but Na^+ <∑ (Cl^- + SO_4^{2}), Chlorides and sulphates are present	$C_i=288/(Na^+ +4Cl^-)$
Content of Na^+ >∑ (Cl^- + SO_4^{2-}), Chlorides, sulphates and carbonates are present	$C_i=288/(10Na^+ -5Cl^- -9SO_4^{2-})$

Table 2. Irrigation water classification by Ci[1] value

C_i	Classification	Terms of use
> 18	Good	It is used for irrigation without the need of special measures
18÷6	Satisfactory	Measures are needed to prevent the accumulation of salt in the soil, except light soils with good natural drainage
5,9÷1,2	Unsatisfactory	In most cases it requires artificial drainage
< 1,2	Poor	The water is not good for irrigation

3. The absolute salt content and the relative Na^+ content, established using the „Florea diagram".

The absolute salt content and the relative Na+ content are another important indicator for the assessment of the irrigation water quality using the „Florea diagram". The relative Na+ content is determined with the relation:

$$Na(\%)=[(Na+)/(Ca^{2+}+Mg^{2+}+K^{+}+Na^{+})]*100 \quad (2)$$

The irrigation water quality assessment according to the „Florea diagram" criteria are shown in Figure 1.

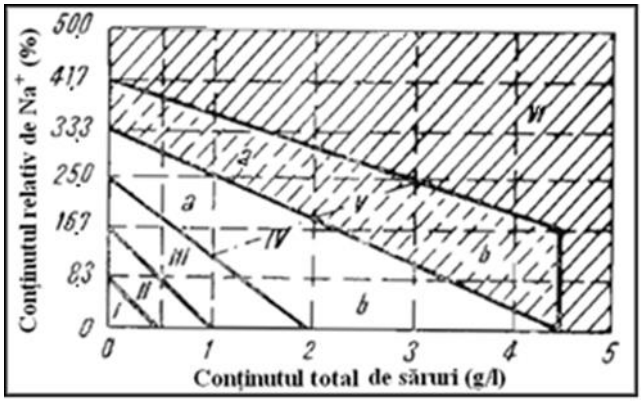


Fig. 1. „Florea diagram" for the assessment of irrigation water I – excellent waters; II – very good waters; III – good waters for most crops; IV – acceptable waters for most crops: IV a – acceptable waters for easily leached; IV b –waters that require periodic washing on heavy soils V – harmful waters for most crops VI – very harmful waters for most crops

4. The salinity class established according to STAS9450/88.

STAS 9450/88 norms the admissible values of the salt concentrations (SAL, mg/l) for different classes of water quality used for irrigation, as shown in Table 3.

Table 3. Maximum concentrations permitted by STAS 9450/88

Oxygen Regime RO, mg O_2/l	**Nutrients NUTR, mg/l**	**AICR,µg/l**
Dissolved oxygen = -	NH_4^+ = -	Phenols and anionic detergents are not normed
CBO5 = -	NO_2^- = -	
CCO-Mn = -	NO_3^- = -	
CCO-Cr = -	PO_4^{3-} = -	
Not normed	Not normed	
Metals, µg/l	**Salinity SAL, mg/l**	
Cr^{6+}= 100	Rez Fitr.= 500/C_2; 1500 /C_3	
Cu^{2+}= 200	Cl^- = 120/C_2	
Pb^6= 2000	$SO4^{2+}$ = 320/C_2	
Zn^{2+}= 100	Ca^{2+} = -	
As^{3+}= 100	Mg^{2+} = -	
Ba^{2+}= -	Na^+ = 120/C_2/S_1	
Fe^{2+3+}= 1000	- C_2, C_3:salinity class 2, respectively 3* - S_1 low alkaline subclass	

According to STAS 9450/88, the salinity classes are:

C_1 – „low" salinity class – water usable on most types of soils and crops,

C_2 – „moderate" salinity class – water usable on permeable soils and on plants with moderate salinity tolerance,

C_3 – „high" salinity class – water usable on permeable soils and salinity-tolerant plants,

S_1 – low alcalinity subclass (determined by the Sodium Adsorption Ratio – SAR and the sodium content, the former being more important) - usable water on most soils.

3. CASE STUDY - DETERMINING THE WATER QUALITY FOR IRRIGATION FROM THE MANGALIA POND (HERGHELIEI)

The Mangalia Pond (Hergheliei) is located to the north of the tourist resort Saturn and the city of Mangalia, and along with the lakes to the north - Lake Tismana, Lake Jupiter, and Lake Neptun - form a part of the hydrographic network within the Coastal hydrographic basin, located near the Black Sea (Figure 2).

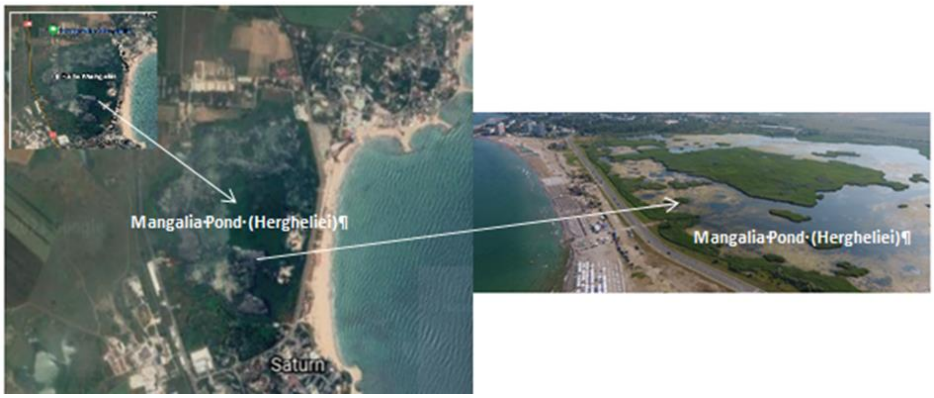


Fig. 2. Location of the Mangalia Pond (Hergheliei) - Sattelite view - (Source: Google)

The Mangalia Pond is separated from the sea through a coastline belt (Figure3), is roughly semicircular and occupies an area of 90ha [2].



Fig. 3. The superficial reception basin of the lakes North of Mangalia, including the Mangalia (Hergheliei) Pond [2]

Some of the coastal lakes were used as water sources for the irrigation of certain areas of agricultural land, as is the case of the Mangalia Pond (Hergheliei). This lake is the water source for irrigation facility served by the SP3 Venus pumping station (Figure 4).

The SP 3 Venus pumping station takes over the water from the Mangalia (Hergheliei) Pond and it delivers it to the underwater pipe network of the irrigation facility, which serves an area of 500ha (Figure 4).

In order for the beneficiary (ANIF) to analyze the possibility of re-comissioning the SP3 Venus pumping station, chemical analyses have been carried out to determine the irrigability class of the water from the Mangalia (Hergheliei) Pond.

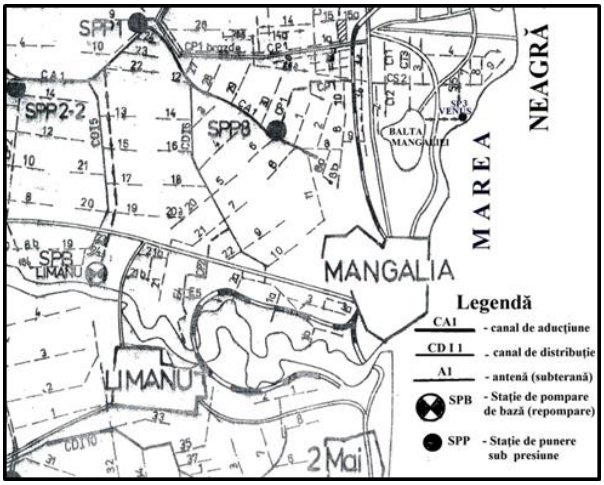


Fig. 4. Overview of the Mangalia (Hergheliei) Pond and the SP3 Venus pumping Station

The water samples were taken form 3 harvesting points (Figure 5):

1.- the suction line of the SP3 Venus Pumping Station (symbolized as SPV Point),

2.- next to the dam/pier (symbolized as STV point),

3.- at the exit to Saturn and Mangalia (symbolized as I).

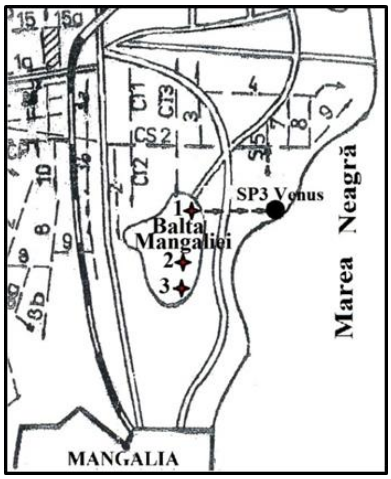


Fig. 5. Situation plan of the SP3 Venus Irrigation Facility with the location of the water sampling points (1 - SPV; 2 - STV; 3 - I) in the Mangalia Pond

In order to determine the irrigability class of the water from the Mangalia (Hergheliei) Pond, after taking water samples from the lake, chemical analyzes were carried out and the specific quality criteria for water used in irrigation were applied, according to STAS 9450/88 and of the literature in the field.

The water samples were analyzed in the Analytical Chemistry Laboratory of the Faculty of Physics, Chemistry, Electronics and Petroleum Technology at the "Ovidius" University of Constanta and at OSPA Constanta. The results of the water sample analyzes are presented in the Table 4.

Table 4. Analysis results of the water samples from the Mangalia (Hergheliei) Pond

Sample	Conductivity, µS/cm	Salinity, g/L	Ions Concentration, meq/l				
			Na^+	K^+	$Ca^{2+}+Mg^{2+}$	Cl^-	SO_4^{2-}
I	1694	0,59	0,055	0,007	3,35	8,83	0,1466
SPV	1600	0,55	0,053	0,0078	3,68	8,15	0,2303
STV	1605	0,54	0,054	0,008	3,14	8,03	0

With regard to these results, it is stated that:

- the analyzes for chlorides, sulphates, calcium and magnesium were carried out using the titrimetric method,
- the salinity was calculated using the empirical formula S = Cl^- (g/l) x 1,8 + 0,03,
- sodium and potassium were determined at OSPA Constanta,
- conductivity was measured electrometrically at OSPA Constanta.

Using the values in Table 4 the irrigation water quality assessment parameters were determined for the Mangalia Pond, as follows:

1. The S.A.R. Index:

Table 5. SAR Values of the water in Mangalia Pond

Sample / Sampling point	Ions Concentration, meq/l		SAR Index
	Na^+	$Ca^{2+}+Mg^{2+}$	
I	0,055	3,35	0,043
SPV	0,053	3,68	0,039
STV	0,054	3,14	0,044

For SAR=0,10 values , the water from the Mangalia Pond falls under the subclass S1, of low alkalinity, with reduced potential of accumulating exchangeable sodium in harmful quantities, usable on most soils.

2. The Irrigation Coefficient, Ci, "Priclonski":

Table 6. Irrigation Coefficient, Ci,, in the Mangalia Pond

Sample / Sampling point	Ions Concentration, meq/l			$C_i=288/5Cl^-$
	Na^+	Cl^-	SO_4^{2-}	
4I	0,055	8,83	0,1466	6,53
SPV	0,053	8,15	0,2303	7,06
STV	0,054	8,03	0	7,17

According to the values of the Irrigation Coefficient, Ci, the water in the Mangalia Pond is satisfactory for irrigation but it requires measures for preventing the accumulations of salt in the soil, on all soil categories, except light soils with good natural drainage.

3. The absolute salt content and the relative Na^+ content, established using the "Florea diagram"

Table 7. The values of the absolute salt content and the relative Na+ content in the Mangalia Pond

Sample / Sampling point	Conductivity, µS/cm	Salinity, g/l	Ions Concentration, meq/l				Na^+ (%)
			Na^+	K^+	$Ca^{2+}+Mg^{2+}$	∑ ioni	
I	1694	0,59	0,055	0,007	3,35	3,41	1,61
SPV	1600	0,55	0,053	0,0078	3,68	3,74	1,42
STV	1605	0,54	0,054	0,008	3,14	3,20	1,69

Using the absolute salt content and the relative Na^+ content values from Table 7 and using the diagram in figure 1, it is found that the water in the Mangalia Pond falls in the IV b category, indicating the necessity of applying periodic washes on heavy texture soils.

4. Salinity Class according to STAS 9450/88

From the conductivity analysis with values of 1694 and respectively 1600 and 1605 µS/cm, and with SAL Values from Table 3, 4, water from the Mangalia Pond falls under C_2 Class - "moderate" salinity class - water usable on permeable soils and for plants with moderate salinity tolerance, and class C_3 - "high" salinity class, water usable on permeable soils with the application of special washing and drainage works and on salinity-tolerant plants.

4. CONCLUSIONS

Under the current conditions, of the conservation of some large irrigation facilities in the country, in general and in Dobrogea, in particular, an alternative in the battle against severe droughts are the local irrigation facilities having as a source of water the lakes or the groundwater.

Such is the case with the SP3 Venus Facility, serving an area of 500 ha, which the beneficiary ANIF S.A. (National Agency for Land Improvement), Dobrogea branch - Constanta South Administration Unit - wants to restore it, not before ensuring that the water from the source - Mangalia (Hergheliei) Pond - fulfills the conditions of irrigability as provided by the standards in force.

Following the determinations made it is estimated that the water from the Mangalia Pond is good water for irrigation for all types of soils, except heavy soils for which periodic washing is recommended.

It is also recommended to periodically determine (especially during summer) the water chemistry, in order to detect any increase in the degree of water mineralization.

5. REFERENCES

[1] Lucica Roşu, *Îmbunătăţiri funciare, Vol.I*, Publisher: „Ovidius University Press, Constanţa, 1999, ISBN 973-9289-51-7
[2] Ariadna Breier, *Lacurile de pe litoralul românesc al Mării Negre*, Publisher: Editura Academiei RSR, Bucureşti, 1976
[3] Corneliu Cismaru, V.Gabor, *Irigaţii, reabilitări şi modernizări*, Publisher: Ed. Politehnium, Iaşi, 2004, ISBN 973-621-094
[4] Lucica Roşu, *Raport de expertiză tehnică* la cerinţa de calitate A - exigenţele A9, B7 şi D privind *Stabilirea calităţii apei pentru irigat din Balta Mangaliei (Hergheliei) în vederea repunerii în funcţiune a staţiei de pompare SP 3 Venus*, Constanţa, 2011

Note:

Mădălina Stănescu - Ovidius University of Constanta, Bd. Mamaia nr. 124, 900356-Constanta, Romania (corresponding author to provide e-mail: stanescu.madalina@univ-ovidius.ro)
Constantin Buta - Ovidius University of Constanta, Bd. Mamaia nr. 124, 900356-Constanta, Romania (e-mail: buta.constantin @univ-ovidius.ro)
Geanina Mihai - Ovidius University of Constanta, Bd. Mamaia nr. 124, 900356-Constanta, Romania (e-mail: mihai.geanina@univ-ovidius.ro)