Ministry of Education and Science of Ukraine

# ODESSA NATIONAL ACADEMY OF FOOD TECHNOLOGIES

International Competition of Student Scientific Works

# BLACK SEA SCIENCE 2021

# PROCEEDINGS

Black Sea Science International Competition of Student Scientific Works by Odessa National Academy of Food Technologies

ODESSA, ONAFT 2021

Ministry of Education and Science of Ukraine

Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

# BLACK SEA SCIENCE 2021

## Proceedings



Odessa, ONAFT 2021

**UDC 001.8(063)**

Recommended for print by the Academic Council of
Odessa National Academy of Food Technologies
on April 6, 2021, Protocol No. 13



**Black Sea Science 2021**: Proceedings of the International Competition of Student Scientific Works / Odessa National Academy of Food Technologies; B. Iegorov, M. Mardar (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2021. – 731 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2021» contain the works of winners of the competition.

The author of the work is responsible for the accuracy of the information.

## Organizing committee:

**Prof. Bogdan Iegorov,** D.Sc., Rector of Odessa National Academy of Food Technologies, Head of the Committee

**Prof. Maryna Mardar,** D.Sc., Vice-Rector for Scientific and Pedagogical Work and International Relations of Odessa National Academy of Food Technologies, Deputy Head of the Committee

**Prof. Stefan Dragoev,** D.Sc., Vice-Rector for Scientific Work and Business Partnerships of University of Food Technologies (Bulgaria)

**Prof. Baurzhan Nurakhmetov,** D.Sc., First Vice-Rector of Almaty Technological University (Kazakhstan)

**Prof. Mircea Bernic,** Dr. habil., Vice-Rector for Scientific Work of Technical University of Moldova (Moldova)

**Prof. Jacek Wrobel,** Dr. habil., Rector of West Pomeranian University of Technology (Poland)

**Prof. Michael Zinigrad,** D.Sc., Rector of Ariel University (Israel)

**Dr. Mei Lehe,** Ph.D., Vice-President of Ningbo Institute of Technology, Zhejiang University (China)

**Prof. Plamen Kangalov,** Ph.D., Vice-Rector for Academic Affairs of "Angel Kanchev" University of Ruse (Bulgaria)

**Dr. Alexander Sychev,** Ph.D., Assoc. Professor of Sukhoi State Technical University of Gomel (Belarus)

**Dr. Hanna Lilishentseva**, Ph.D., Assoc. Professor, Head of the Department of Merchandise of Foodstuff of Belarus State Economic University (Belarus)

**Prof. Heinz Leuenberger**, Ph.D., Professor of the Institute of Ecopreneurship of University of Applied Sciences and Arts (Switzerland)

**Prof. Edward Pospiech**, Dr. habil., Professor of the Institute of Meat Technology of Poznan University of Life Sciences (Poland)

**Prof. Lali Elanidze,** Ph.D., Professor of the Faculty of Agrarian Sciences of Iakob Gogebashvili Telavi State University (Georgia)

**Dr. V. Kozhevnikova**, Ph.D., Senior Lecturer of the Department of Hotel and Catering Business of Odessa National Academy of Food Technologies, Secretary of the Committee

# 5. ECOLOGY AND ENVIRONMENTAL PROTECTION

# CHANGES IN THE CHEMICAL COMPOSITION OF SOIL UNDER THE INFLUENCE OF IRRIGATION BY MINERALIZED WATERS OF THE SOUTH-BUG IRRIGATION SYSTEM

**Author:** Yaroslava Vozihnuieva
**Advisor:** Yana Diorditsa[1], Labartkava Andrei[2]
[1]Mykolayiv National Agrarian University (Ukraine)
[2]Tbilisi Hightway (Georgia)

***Abstract.*** *The influence of irrigated water from the South-Bug irrigation system (Mykolayiv district, Mykolayiv region) on chemical indicators of soil quality is investigated in the paper. The study revealed a significant deterioration of agrochemical characteristics of the soil, in particular: a significant accumulation in the soil profile of sodium and magnesium ions and a significant decrease in calcium, which indicates about its leaching; significant growth of chloride and bicarbonate ions. A change in the chemical parameters of the soil indicates at a change in the chemistry of soil salinization from sulfate-calcium to bicarbonate-sodium and intensification of the salinization process under the influence of mineralized waters from the South Bug irrigation system. It was found the increased of toxic salts and the total content of toxic salts 2.5 times under irrigation conditions.*

***Keywords:*** *mineralized water, soils, soil salinization, irrigation, South Bug irrigation system.*

## I. INTRODUCTION

**Actuality of theme:** Recently, the problem of climate change has become more acute, due to the increasing greenhouse effect according to human activity. The consequence of global climate change is an increase in air temperature, reduced rainfalls and disruption of their uniformity, increased drought, growing shortage of quality irrigation water, which in turn negatively affects the yield and quality of agricultural crops.

According to the Institute of Water Problems and Land Reclamation, today about 60% (18.65 million hectares) out of the 31 million hectares of Ukrainian arable land belongs to areas with a shortage of moisture. And about 3 million hectares of land in the steppe regions is in an area with a critical shortage of moisture (i.e. in a dry year, vegetation is impossible there) [1].

Under such conditions, the role of irrigation significantly increases as a stabilizing factor of agricultural production to obtain sustainable yields of crops in order to ensure food security of the country [2].

Currently, the planet irrigates more than 345 million hectares, which is 21% of the total arable land, which produces more than 40% of all agricultural products [3].

Estimation of quality of irrigation water according to DSTU 2730-94 testifies that quality of water in sources of irrigation of the Mykolayiv area on the majority of indicators is limitedly suitable (because of danger of secondary salinization and alkalinization of soils). Its use in irrigation is dangerous due to the possibility of burning leaves and roots of plants because of high total alkalinity in the water, toxic alkalinity and chlorine, as well as high content of $Na^+$ and $K^+$ (more than 40% from the content of the basics) which causes salinization of soils and deterioration of their characteristics [4].

Today, soil salinization is declared as one of the main global soil danger. According to the data of the UNO Institute of Water Recourse, Environment and Health, with a total affected area of about 1 billion hectares, the world loses up to 2,000 hectares of agricultural land every day due to soil damage from salinization. According to the FAO, about 22% of the land, used for agricultural, is saline. Every year their area grows.

Saline soils in Ukraine cover an area of 1.7 million hectares, and slightly salinized soils cover an area of 2.2 million hectares [5].

Therefore, the study of the impact of water under irrigation on soil quality indicators is an urgent problem, especially in the context of the global climate changes.

**Purpose:** to explore the influence of irrigation water on the chemical indicators of the soil.

**Practical importance of the topic:** The quality of the irrigation water flows into the structure of the soil, its chemical composition, and as a result, it flows into the structure of the soil. A lot of soluble salts in irrigation water causes the secondary salinity of soils, and a paucity of soluble salts in the water destroys the growth of plants.

**To achieve this goal it was necessary to solve the following tasks:**

1) to analyze the cationic and anionic composition of the soil under conditions of increase and without increase, on the example of Scientific-practical center of MNAU;
2) to determine the chemistry of soil salinization under conditions of increase and without increase; determine the content of toxic ions in soils;
3) to determine the total effect of toxic ions;
4) make recommendations for improving the physicochemical characteristics of the studied soils.

## II. LITERATURE ANALYSIS

### *2.1. General characteristics of the South Bug irrigation system*

The South Bug irrigation system irrigates the area of 13146 hectares in the Mykolayiv district of the Mykolayiv area. The water intake system is located in the village of Kovalivka.

The water system, from which the irrigation system replenishes its resources, consists of the cooling pond of the PU NPP (Tashlyk Reservoir), the Southern Bug River with tributaries of the Mertvovod River, and the Arbuzynka River.

Feeding the Southern Bug River is mainly happens due to melting snow in spring and winter, and in summer and autumn - due to rains. The underground feeding of the river is small. At the exit from the forest-steppe zone, the feeding conditions of the river deteriorate, so in the autumn-summer period of the year there is a stable low runoff. The maximum flow of spring floods is 5500 $m^3$ / s. In summer, the river receives almost exclusively feeding from soils and therefore in severe drought the river significantly shallows.

The water regime of the river is characterized by uneven runoff distribution at different times of the year and in the basin. The average annual specific water use varies along the river from 25.2 $m^3$ / sec to 102.0 $m^3$ / sec. The average monthly water use of the Southern Bug River is 92 $m^3$ / sec.

According to chemical parameters, the water of the Southern Bug River in different parts of it had different indicators (table 1). When in the upper part of the river the alkalinity was 4.8-5.0 mg-eq / l, then in the section of the river from the city of Nova Odesa to the city of Mykolayiv it reached 5.8-6.0 mg-eq / l. In the Bug estuary, as in the river itself, the water had a slightly alkaline reaction: the pH usually did not exceed 8.

The spatial change in the physicochemical properties of river water is seen in the example of changes in total mineralization. In the upper part of the river, this figure was equal to 500-600 mg-eq / l. Tashlyk reservoir is characterized by waters with high mineralization (up to 2000 mg-eq / l). In the area of water intake in the irrigation system (near the village of Kovalivka) the rate of mineralization was 680-700 mg-eq / l, and in the area of Mykolayiv it again increased to 1500 mg-eq / l.

In the area of Nova Odesa, not far from the water intake in the irrigation system, a constant river flow occurs only during floods, and the bottom is covered mainly with estuarine sediments. Under the influence of wind surges, water penetrates from the estuary into the river and in some cases reaches the city of Nova Odessa. The high content of chlorides at this point is 279 ± 13 mg / l, in comparison to other places upstream is 70 - 80 mg / l, this caused either by the influence of wind surges or by compensatory currents. In the upper parts of the river, in the area of Pervomaisk and Pivdennoukrainsk, these values in average were 45 ± 4 mg / l and 40 ± 2 mg / l, respectively. In the area of the village Kovalivka, N. Odessa the dry residue increases in the river water in 2 times, chlorides and sulfates – in 3-4 times, copper ions appear.

The total water hardness also increases to downstream from 6.3 ± 0.5 mg / l in the area of t. Pervomaisk, to 19.0 ± 1.1 mg / l in the area of the village Lymany. Significant values reach the indicator of the total hardness near the city of Nova Odesa and is 9.0 ± 0.3 mg / l and the city of Mykolayiv (9.3 ± 0.4 mg / l).

Thus, a characterized feature of the water from this water system is the change in the salt regime in the lower part of the Southern Bug River due to the mixing of river and estuarine waters and high indicators of salts in the Tashlyk reservoir [6].

Table1 - The mineral composition of the water of the Southern Bug, ponds and reservoirs of the Tashlyck South Bug irrigation system, mg-eq / l

| Sampling | Year | Total mineralization | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $SO_4^{2-}$ | $CO_3^{2-}$ | $K^+$, $Na^+$ | pH |
|---|---|---|---|---|---|---|---|---|---|
| r. S. Bug, v. Oleksiyivka | 2002 | 550 | 45 | 32 | 44 | 88 | 225 | - | 5,1 |
| Tashlyck reservoir | 2002 | 2050 | 143 | 174 | 280 | 978 | 425 | 370 | 5,6 |
| Main canal P-Buzka Z.S., village Kovalivka | 2002 | 710 | 80 | 39 | 91 | 236 | 320 | 120 | 6,5 |
| Dnipro - Buzsky estuary, Mykolayiv | 2002 | 1490 | 96 | 68 | 570 | 196 | 390 | 381 | 7.0 |

### 2.2. Soil salinization

Soil salinization is one of the most relevant problems of the modern world, conected with both natural processes and anthropogenic pressure on the environment.

Soil salinization is the process of accumulation water-soluble mineral salts in the soil, which interfere with the normal development of plants [7].

Approximately, almost 25% of all soils on our planet are saline. The most harmful to plants are easily soluble salts, which penetrate into the cytoplasm without much difficulty: $NaCl$, $MgCl_2$, $CaCl_2$. Less toxic are sparingly soluble salts: $CaSO_4$, $MgSO_4$, $CaCO_3$.

Excessive concentration of salts disrupts physiological processes in plants, because in such soils there is an increased osmotic potential of the soil solution. This significantly inhibits the absorption of water by plant roots. Therefore, saline soils, regardless of their humidity, are physiologically dry. In addition, when sodium, chlorine and other substances that cause salinity enter into plants, they disrupt the structure of chloroplasts, as well as the permeability of cell membranes, in particular plasmalemma, which loses the ability to selectively transporting substances. High concentration of sodium prevents the accumulation of other cations, including essential ones for plant life, such as potassium and calcium. Also, plants often disrupt nitrogen metabolism, accumulate ammonia and other toxic products. Plants on saline soils often (especially in the case of chloride salinity) have a sulfur deficiency [8].

There are primary (natural) salinization of soils and secondary, associated with human activities.

There are two types of natural salinization of soils: salt-marshes (solonchak) and saline alkali soils (solonetz).

Salt marsh is a special type of soil in which the upper horizons contain a significant amount of soluble salts, which interfere with the normal growth of most plant species. Depending on the chemistry of salinity, the salt content in the upper horizon of salt marshes is from 0.6-0.7 to 2-3% or more. In summer, the surface of the salt marshes dries and is covered with a crust of salt. The concentration of salts in the soil solution reaches a few dozen of percents, and sodium ions are contained not only in the solution, but also saturate the colloids of the soil absorption complex. These soils are formed in all natural areas, but mostly often in steppes, semi-deserts and deserts.

In the saline alkali soils salts are less and they lie much deeper (20 - 50 cm). The lower horizons are dense and saturated with sodium ions. Absorbed sodium is more than 20% of the absorbed capacity. The saline alkali soils cracks into columns when drying. Saline alkali soils are common in forest-steppe, steppe and semi-desert zones [8, 9].

Sources of water-soluble salts in soils are:

- Soil rocks;
- Mineralized groundwater at a depth of more than 2 m and affect the process of soil formation;
- Seas, bays, estuaries, from the surface of which salts are transported by wind (impulseization of salts);
- Some types of vegetation that pull out salts from saline rocks into the surface layers of the soil and accumulate them in the process of phytomass mineralization;
- Irrigation water, which can be an active factor in the secondary salinization of soils with improper irrigation.

Secondary salinization of the soil is connected with the accumulation of harmful salts for plants in its upper layers as a result of errors in irrigation works with the use of highly mineralized water for irrigation or with applying a large amount of mineral fertilizers to the soil.

The most widespread accumulation of such compounds as $Na_2CO_3$, $MgCO_3$, $Na_2SO_4$, $CaCO_3$, NaCl and others is in saline soils.

There are several main types of salinization depending on the composition of salts in the soil:

- Chloride - due to the content in the soil of NaCl, $MgCl_2$;
- Sulfate - due to the accumulation of $Na_2SO_4$, $CaSO_4$, $MgSO_4$;
- Soda (carbonate) - high content of NaHCO and $Na_2CO_3$ in the soil.

The most harmful are salts containing $Na^+$ and $Cl^-$ (NaCl, $NaHCO_3$, $Na_2CO_3$), moderately harmful are $Na_2SO_4$, $CaCl_2$, $MgCl_2$, the least harmful are $MgSO_4$, $CaSO_4$) [9].

## III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

*Object of research:* cationic and anionic composition of soil

*Subject of study:* changes in chemical composition of soil under the influence of irrigation by mineralized waters.

The research was conducted in the summer of 2019. The territory of the experimental farm belongs to the subzone of the southern steppe of Ukraine. The climate is temperate-continental, arid, warm, with unstable snow cover. Summer is very dry and hot. Winter is short with unstable snow cover and frequent thaws. In the winter months, precipitation falls mainly in the form of cereals, snow, and during the thaw there is rain. The soil of the experimental plot is represented by southern chernozems medium humus heavy loam, which has a significant amount of calcium carbonates.

In studying the effect of irrigation on soil properties, the method of soil keys was used, which consists in the study of soils that differ in only one indicator - irrigation, i.e. one soil is irrigated and the other is not. Soil samples were taken by drilling to a depth of 100 cm every 10 cm. Irrigated lands are irrigated for about 20 years using a drip irrigation system. Both research plots have a high level of processing and fertilization.

To analyze the soil, at first extracts were prepared and then it was determined the cationic and anionic composition of the soil by analytical methods: the content of $CO_3^{2-}$ and $HCO_3^-$ was determined acidimetrically [11], $Cl^-$ was determined argentometrically [12], $SO_4^{2-}$ was determined turbidimetrically [13], cations $Ca^{2+}$and $Mg^{2+}$ was determined complexometrically [14], $Na^+$, $K^+$ was determined flame photometrically [15].

## IV. RESULTS

Irrigation can be both positive (increasing fertility) and negative (salinization). It depending on the quality of irrigation water, its quantity, climatic and hydrogeological conditions of the region, irrigation technology, soil buffering.

The quality of water, entering the irrigation system, significantly affects the structure of the soil, its chemical composition, and as a consequence affects fertility. Water with a significant amount of soluble salts causes secondary salinization of soils, but if the salt content in the water is too low, the easily soluble salts are washed out of the soil and as a result the plant nutrition is disrupted.

Analysis of literature sources indicates that sodium and potassium ions predominate in the water intake place, as well as carbonate ions. Thus, the type of irrigated water is sodium carbonate. The total mineralization at the water intake place is low, the pH is 6.5.

Under the influence of irrigation changes were noted in the chemical composition of the soil.

Among the cations, there is a significant increase in the growth of sodium ions in the entire soil profile. However, the highest concentration is observed in the upper layer of the profile and its gradual decrease with increasing depth (fig. 1).

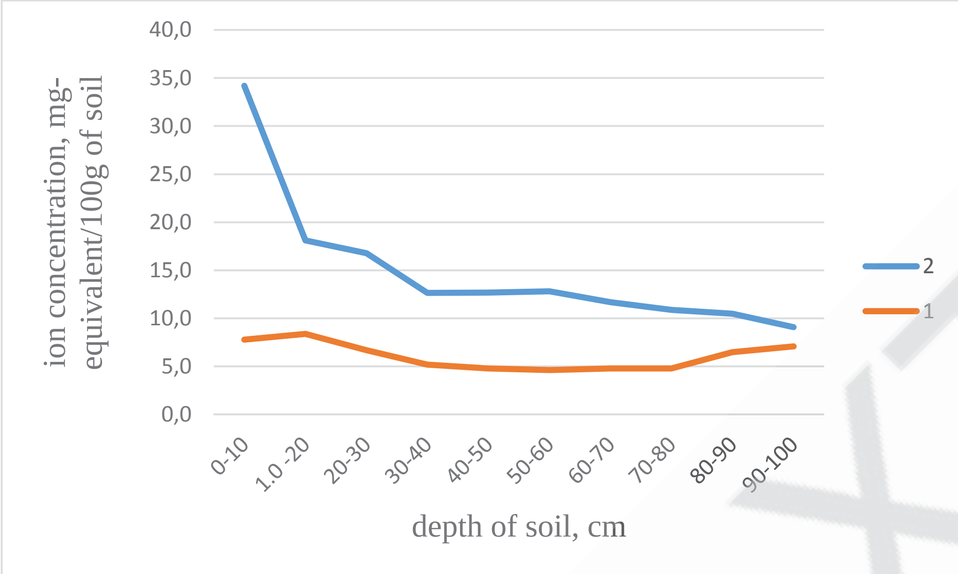


Fig.1 - Concentration of $Na^{+}$: 1 - without irrigation; 2 - under irrigation conditions

This causes to an increasing of electrokinetic potential, silt peptization, hydrophilicity, transformation of mineral and organic parts of the soil, deterioration of its agrophysical properties due to disaggregation, reduced filtration, crust formation, which reduces soil fertility and crop yields. Excessive accumulation of sodium ions prevents the entry of $Ca^{2+}$, $Mg^{2+}$, $K^{+}$ into the plant [9].

At the same time there is a significant decrease in calcium ions, which indicates its leaching. There is a tendency to increasing the concentration of calcium with increasing depth of soil (fig. 2).

Calcium deficiency in the soil causes the loss of humus, cousing increasing of specific soil density, deteriorating its structure and buffering, reduced soil nutrient supply, slows down the decomposition of plant residues, reduces plant resistance to fungal diseases, reduces the effectiveness of fertilizers and reduces crop yields.

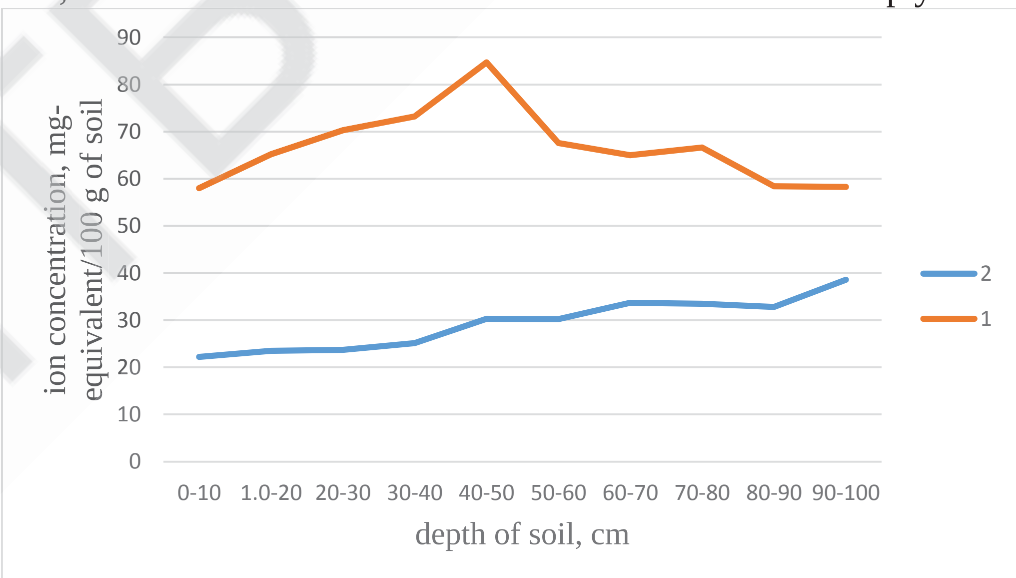


fig. 2 - Concentration of $Ca^{2+}$: 1 - without irrigation; 2 - under irrigation conditions.

Under the influence of irrigation there is a significant increase in magnesium ions throughout the soil profile, and the highest concentration is observed in the middle layer of the horizon (fig. 3).

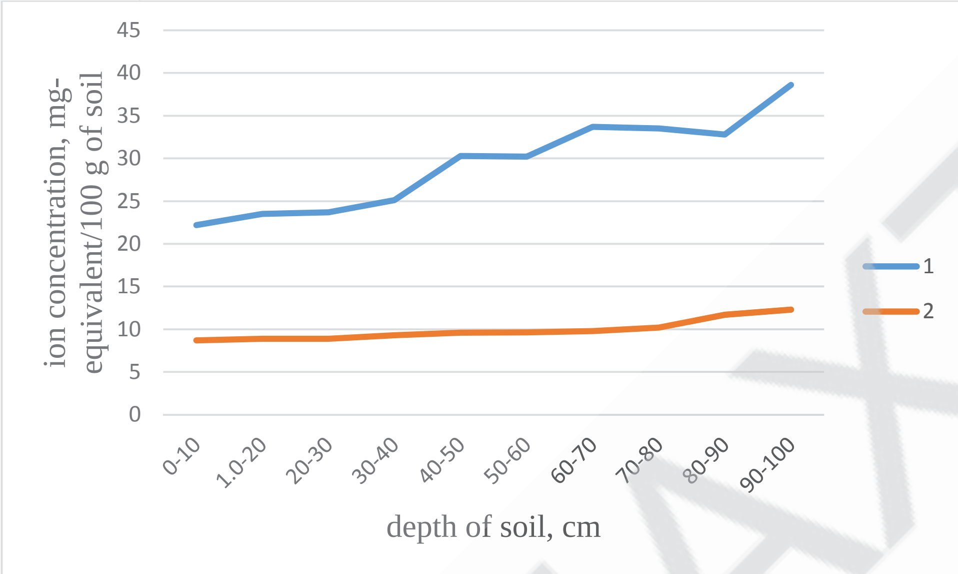


Fig. 3 - Concentration of $Mg^{2+}$: 1 - without irrigation; 2 - under irrigation conditions

The anions contain a significant increase in chloride ions throughout the horizon, their highest concentration was observed in the upper layer and gradually decreased, which may be due to their movement together with moisture in the horizons (fig. 4).

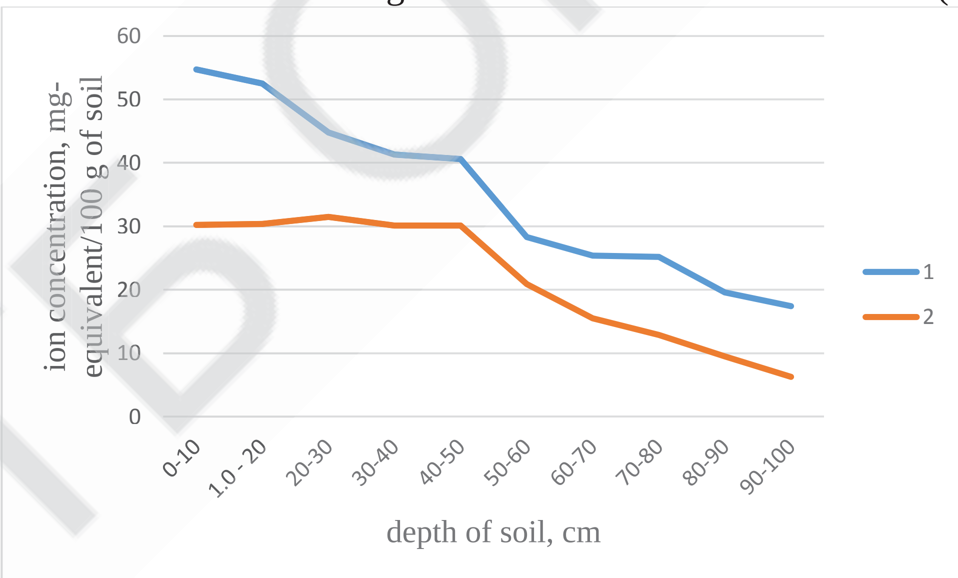


fig. 4. The concentration of $Cl^-$ : 1 - without irrigation; 2 - under irrigation conditions

As a result of irrigation, there is also a significant increase in hydrogen carbonate ions throughout the profile (fig. 5). Incrementating of $HCO_3^-$ indicates an increase of alkaline reserve, total alkalinity and pH. The obtained results indicate a poor alkalinization of soils (pH 8 - 8.5).

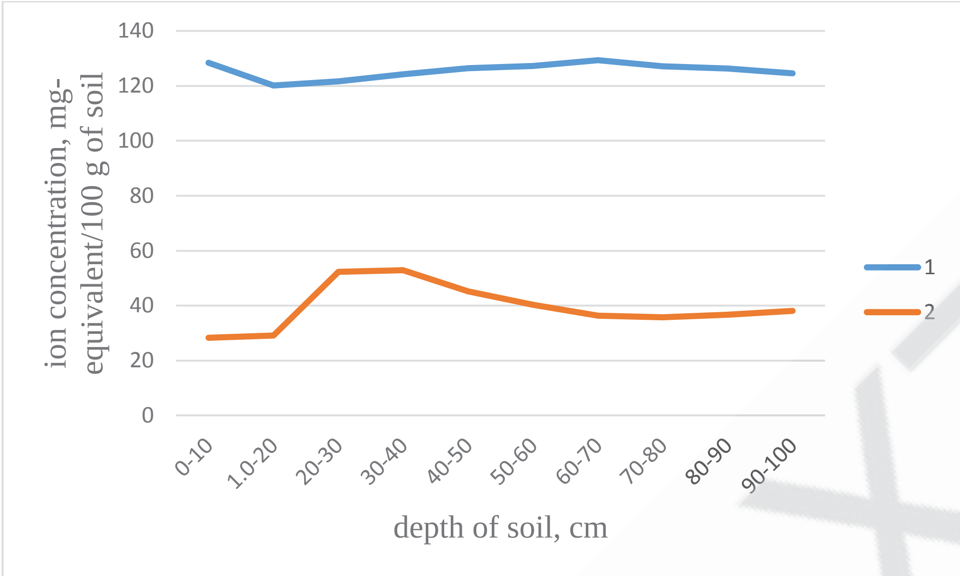


**Fig. 5 - Concentration of $HCO_3^-$: 1 - without irrigation; 2 - under irrigation**

The concentration of sulfate ions during irrigation did not change (fig. 6).

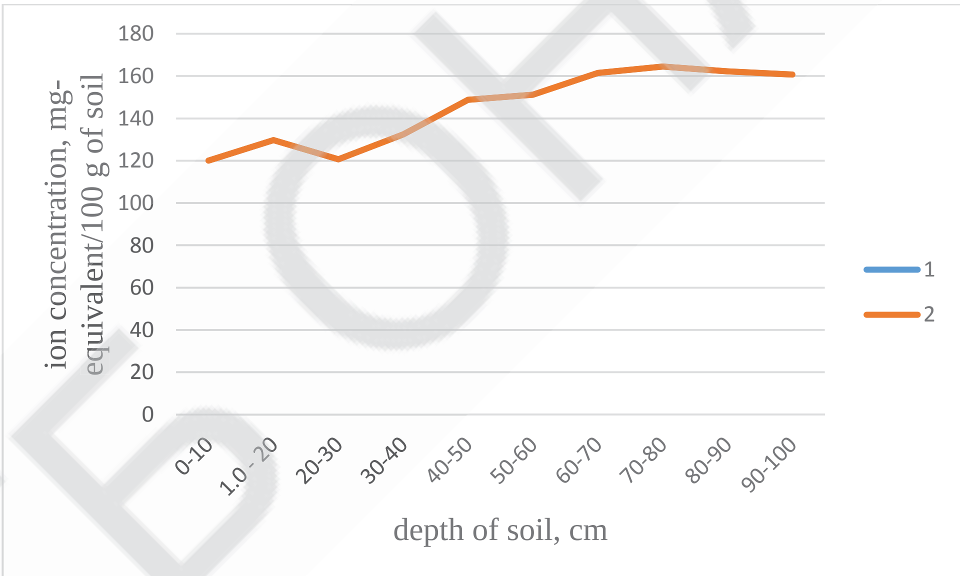


Fig. 6 - The concentration of $SO_4^{2-}$: 1 - without irrigation; 2 -under irrigation

*Determination the chemistry of soil salinity*

According to the results of the analysis of the cationic and anionic composition of the soil extract, it is possible to establish the chemistry of soil salinization.

When determining the type of soil salinity take into account primarily anions exceeding 20% of the sum of mg-eq anions. When determining the chemistry of soil salinity by cations, take the two cations that are present in the largest number. If the quantity of one of the two cations exceeds more than twice, only one cation is indicated (table 2, 3 )

Table 2 – Chemistry (type) of salinization of soils by anions (Bazilevich N.I.)

| Chemistry of salinization | Correlations of anions, mg-eq | | | Correlations of cations and anions |
|---|---|---|---|---|
| | $Cl^- /SO_4^{2-}$ | $HCO_3^-/Cl^-$ | $HCO_3^-/ SO_4^{2-}$ | |
| chloride | ≥2,5 | - | - | - |
| sulfate-chloride | 2,5 - 1 | - | - | - |
| chloride-sulfate | 1 – 0,2 | - | - | - |
| sulfate | < 0, 2 | - | - | - |
| sodium-chloride | >1 | <1 | >1 | $HCO_3 > Ca^{2+} + Mg^{2+}$ |
| sodium-sulfate | <1 | >1 | <1 | $Na^+ > Mg^{2+}$, |
| chloride-sodium | >1 | >1 | >1 | $Na^+ > Mg^{2+}$, |
| sulfate-sodium | <1 | >1 | >1 | $Na^+ > Ca^{2+}$ |
| sulfatic-hydrocarbonate or chloride-hydrocarbonate | any | >1 | >1 | $Na^+ < Ca^{2+}$, $Na^+ < Mg^{2+}$, $HCO_3^- > Na^+$ |

Table 3 – Chemistry (type) of salinization of soils by cations (Bazilevich N.I.)

| Chemistry of salinization | Correlations of cations, mg-eq | | |
|---|---|---|---|
| | $Na^+/Mg^{2+}$ | $Na^+/Ca^{2+}$ | $Mg^{2+}/Ca^{2+}$ |
| sodium | >1 | >1 | - |
| magnesium-sodium | >1 | >1 | >1 |
| calcium-sodium | >1 | >1 | <1 |
| calcium-magnesium | <1 | <1 | >1 |
| sodium-magnesium | <1 | >1 | >1 |
| sodium-calcium | >1 | <1 | <1 |
| magnesium-calcium | <1 | <1 | >1 |
| magnesium | <1 | <1 | >1 |

After analyzing the cationic composition of soil, it was found that non-irrigated soils have a calcium-magnesium type of salinity, and irrigated – sodium. The anionic composition of non-irrigated soils – sulfate type of salinity, and irrigated – sodium-hydrocarbonate.

*Determination the degree of salinity by the qualitative composition of salts*

Negative effect into development of plants has not only the quantitative content of easily soluble salts, but their qualitative composition.

The degree of soils salinization determinated by the presence of toxic ions and salts. Toxic salts include: $Na_2CO_3$, $MgCO_3$, $NaHCO_3$, $Mg(HCO_3)_2$, $Na_2SO_4$, $MgSO_4$, NaCl, $MgCl_2$, $CaCl_2$. According to the aqueous extract, you can calculate the content of toxic salts, taking into consideration the threshold of their toxicity.

The method of calculating toxic and non-toxic salts is based on a certain sequence of binding of ions in the salt, starting from the least soluble to more soluble. First carbonates are bound, then sulfates, and lastly chlorides are bound. The calculation is performed in mg-eq

$HCO_3^-$ ions can be caused by the presence of toxic salts such as $NaHCO_3$, $Mg(HCO_3)_2$ and non-toxic salt - Ca $(HCO_3)_2$.

$HCO_3^-{}_{toxic} = HCO_3^-{}_{general} - Ca^{2+}$, if $HCO_3^-{}_{general} > Ca^{2+}$,

If calcium ions are greater than hydrocarbonate ions, then all hydrocarbonate ions are considered non-toxic.

Sulfate ions can be caused by the presence of toxic ($Na_2SO_4$, $MgSO_4$) and non-toxic ($CaSO_4$) salts in the soil. Sulfate ions bind to the salt in the following sequence: $CaSO_4$, $Na_2SO_4$, $MgSO_4$.

$SO_4^{2-}{}_{toxic} = SO_4^{2-} - (Ca^{2+} - HCO_3^-{}_{general})$, if $HCO_3^-{}_{general} < Ca^{2+}$.

Clor ions are toxic.

The results of calculation of the content of toxic and non-toxic ions are entered in the table 4

Table 4 – Content of toxic and non-toxic ions in the soil

| condition | Profile of soil | ions | sum | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ |
|---|---|---|---|---|---|---|---|---|---|
| Without irrigation | 0 - 10 | Non-toxic | 116 | 28,3 | - | 29,7 | 58 | - | - |
| | | toxic | 137,1 | - | 30,2 | 90,4 | - | 8,7 | 7,8 |
| With irrigation | 0 - 10 | Non-toxic | 44,4 | 22,2 | - | - | 22,2 | - | - |
| | | toxic | 332,2 | 101 | 54,7 | 120,1 | | 22,2 | 34,2 |

The resulting of calculations converted into percentages by multiplying the value of mg-ev by the appropriate factor.

$CO_3^{-2}$ - 0,003; $Ca^{2+}$ - 0,02;
$HCO_3^-$ - 0,061; $Mg^{2+}$ - 0,0122;
$SO_4^{-2}$ - 0,048; $Na^+$ - 0,023.
$Cl^-$ - 0,0355;

Next, the mass fractions of all toxic ions are summed and determined the sum of toxic salts (table 5).

Table 5 - Content of toxic and non-toxic ions in the soil (in% by weight of soil)

| condition | Profile of soil | ions | sum | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ |
|---|---|---|---|---|---|---|---|---|---|
| Without irrigation | 0 - 10 | Non-toxic | 4,31 | 1,73 | - | 1,42 | 1,16 | - | - |
| | | toxic | 5,68 | - | 1,07 | 4,34 | - | 0,1 | 0,17 |
| With irrigation | 0 - 10 | Non-toxic | 1,74 | 1,3 | - | - | 0,44 | - | - |
| | | toxic | 14,8 | 6,1 | 1,95 | 5,7 | - | 0,27 | 0,78 |

After analyzing the obtained results, we can conclude that during irrigation the sum of toxic salts increased by 2.6 times.

According to the obtained results evaluate the degree of soils salinization (table 6). According to the table, the soils are very heavily salted.

Table 6 - Classification of soils by the content of toxic salts (in% by weight of soil) according to N.I. Bazilevich, E.I. Pankova

| Category of saline soils | Chemistry of salinization | | | |
|---|---|---|---|---|
| | sulfat $Cl:SO_4 \leq 0,3$ | sulfat-chloride $Cl:SO_4 > 2,5 - 1$ | hydrocarbonat-chloride and – chloride-hydrocarbonatic $Cl:SO_4>1$ $HCO_3>Cl$ $HCO_3<Cl$ | hydrocarbonat - sulfatic and sulfat-hydrocarbonatic $Cl:SO_4<1$ $HCO_3> SO_4$ $HCO_3< SO_4$ |
| none | <0,15 | >0,05 | <0,1 | <0,15 |
| mildly | 0,15-0,3 | 0,05-0,12 | 0,1-0,15 | 0,15-0,25 |
| moderately | 0,3-0,6 | 0,12-0,35 | 0,15-0,3 | 0,25-0,35 |
| heavily | 0,6-1,4 | 0,35-0,7 | 0,3-0,5 | 0,35-0,6 |
| very heavily | >1,4 | >0,7 | >0,5 | >0,6 |

*Determination the "total effect" of toxic ions*

Another way to assess the degree of soils salinity is to determinate the "total effect" of exposure to toxic ions. To do this, toxic ions are expressed in chlorine equivalents. This method does not take into account the type of soil salinization, only the content of toxic ions in the soil:

$$1Cl^- = 0,1CO_3^{2-} = (2,5\text{-}3)HCO_3^- = (5\text{-}6)SO_4^{2-}$$

Therefore, the total effect of toxic ions on non-irrigated soils is: 30,2 + 90,4/5 = 48,28

And the total effect of toxic ions on irrigated soils is: 54,7 + 101/2,5 + 120,1/5 = 119,12

Consequently, the "total effect" of toxic ions on irrigated soils is 2.5 times greater than on non-irrigated soils.

According to table 7 we establish that the soils belong to very saline soils.

Table 7 - Classification of soils according to the degree of salinity taking into account the "total effect" of toxic ions (Bazilevich N.I)

| degree of salinity | the "total effect" of toxic ions, mg-eq $Cl^-$ |
|---|---|
| none | < 3 |
| mildly | 0,31 – 1,0 (1,5) |
| moderately | 1,1 (1,6) – 3,0 (3,5) |
| heavily | 3,1 (3,6) – 7,0 (7,5) |
| very heavily | >7,0 (7,5) |

*Recommendations*

To improve the condition of the soil and restore its productivity under irrigation conditions, the following measures should be taken: constantly monitor the quality of irrigated water, adjust irrigation regimes, conduct chemical reclamation through the use of gypsum, and conduct biological reclamation.

The method of chemical reclamation is to displace sodium from the soil absorption complex by calcium gypsum or by other calcium salt. Lime, clay-gypsum, calcium chloride, a weak solution of sulfuric acid, etc. are also used as ameliorants.

The method of biological reclamation of saline soils is based on the use of halophytic plants for desalinization soils. They are capable to accumulate the salts, which are contained in the soil, in the aboveground part. The advantages of this method include its economic feasibility and the ability to remove harmful salts from soils of different degrees of salinity, without violating the natural environmental processes and soil properties. The use of halophyte plants contributes to the restoration of the ecological condition of saline soils and the restoration of natural biodiversity. The only disadvantage is the need to collect and dispose of the green part of the plants which accumulate salt. It is advisable to apply crop rotations using legumes (such as Burkun white and Burkun yellow). The use of phytomeliorants will stabilize the qualitative and quantitative salt composition of soils, increase the humus content, as well as reduce soil pH [16].

## V. CONCLUSIONS

1. Irrigation of the studied soils with water from the South-Bug irrigation system causes significant changes in its cationic-anionic composition: under irrigation conditions, there is a significant increase in chloride and bicarbonate ions, the concentration of sulfate ions does not change. Irrigation with mineralized water causes a significant accumulation of magnesium and calcium ions in the soil and significantly reduces the amount of calcium.

2. During soil irrigation with water from the South-Bug irrigated system the change of chemistry in soil salinization from sulphate-calcium to hydrocarbonate-sodium is observed and as a result the physicochemical characteristics of soil and its fertility is deteriorated.

3. Under soil irrigation with water from the South-Bug irrigated system observed the sum of toxic ions increased by 2.6 times.

4. According to the calculation of the “total effect” of toxic ions the studied soil are very heavily saline.

## VI. REFERENCES


1. O.O. Dekhtyar, I`.V. Vojtovich, G.V. Voropaj, S.V. Usatij, N.D. Bryuzgi`na, Ya.V. Shevchuk. (2019). Istoriya rozvitku, perspektivi budivnicztva, rekonstrukcziyi ta vodovidvedennya meliorativnikh sistem. Melioracziya i vodne gospodarstvo, 2, 40 -55.
2. Vorotinczeva L.I. (2016). Ekologo-toksikologichni aspekti zroshennya zemel v umovakh tekhnogennogo navantazhennya ta zakhodi z detoksikacziyi sistemi «grunt-roslina». Visnik agrarnoyi nauki, 61-66.
3. Vozhegova R.A. (2019). Zroshennya – golovnij element suchasnikh agrotekhnologij v umovakh pivdennogo stepu Ukrayini. Visnik agrarnoyi nauki, 11 (800), 67 – 74.
4. Regionalnij ofis vodnikh resursiv u Mikolayivskij oblasti (2018) Informacziya pro yakist zroshuvalnikh vod po Mikolayivskij oblasti na pochatok polivnogo periodu 2018 roku https://mk-vodres.davr.gov.ua/node/1225
5. Ministerstvo ekologiyi ta prirodnikh resursiv Ukrayini (2012) Naczionalna dopovid pro stan navkolishnogo prirodnogo seredovishha v Ukrayini u 2011 roczi. 258 s.
6. URL: https://lib.chmnu.edu.ua/pdf/monograf/23/36.pdf
7. Krasnov V.P., Shelest Z.M., Davidova I.V. Fitoekologiya z osnovami lisnicztva: navch. posibnik dlya stud. VNZ. Sumi : Universitetska kniga, 2012. 415 s.
8. *Sklyar V. G. Ekologichna fiziologiya roslin : pidruchnik. Sumi : Universitetska kniga, 2018. 271 s.*

9. S. G. Chornij. Oczinka yakosti gruntiv: navchalnij posibnik. Mikolayiv: MNAU, 2018. 227 s.
10. Suchasnij poglyad na kalczij. Agronom (2018). URL: https://www.agronom.com.ua/suchasnyj-poglyad-na-kaltsij/
11. Soil quality carbonates and bicarbonates ions definition in water extract URL: http://online.budstandart.com/ru/catalog/doc-page.html?id_doc=62857
12. Soil quality chlorine-ion definition in water extract URL: http://online.budstandart.com/ru/catalog/doc-page?id_doc=62772
13. Soil quality sulfates-ion definition in water extract URL: http://online.budstandart.com/ru/catalog/doc-page?id_doc=62773
14. Soil . quality calcium and magnesium ions definition in water extract URL: http://online.budstandart.com/ua/catalog/doc-page?id_doc=62859
15. Soil quality sodium and kalium ions definition in water extract URL: http://online.budstandart.com/ru/catalog/doc-page?id_doc=62858
16. Lavrik M. O., Pavlichenko A. V. Fitomelioracziya zasolenikh gruntiv vugledobuvnikh regioniv Ukrayini, 2013. ULR: http://dspace.nbuv.gov.ua/bitstream/handle/123456789/87347/09-Lavryk.pdf?se quence=1