Volume 11, Issue 5, May – 2026 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1013

Relationship Between Weather Conditions and the Physicochemical Indicators of Canal Water and Soil in the Gene Pool Garden of Shaki REM

Sevar Ahmadova[1*]; Vafa Atayeva[2]; Ilgar Ismayilov[3]; Murad Gahramanov[4]; Vafa Mammadli[5]

[1,2,3,4,5]Shaki Regional Scientific Centre, Azerbaijan National Academy of Sciences, Shaki, Azerbaijan
[2]Mingachevir State University, Mingachevir, Azerbaijan

Publication Date: 2026/05/28

Abstract: This study aims to evaluate the correlation between weather conditions and the physicochemical parameters (temperature, pH, Eh, and EC) of the irrigation canal and target soil area in the Gene Pool Garden of the Sheki Regional Scientific Center (SRSC). It further assesses the potential impact of these parameters on soil salinization and desertification processes. Monitoring was conducted from January to April 2026, during which 19 water samples and 7 soil samples were collected and analyzed. The results indicate that the canal water is consistently alkaline, with pH values ranging from 7.86 to 8.21. The redox potential (Eh) values were negative, varying between −38.9 mV and −91.6 mV, indicating a reducing environment. Electrical conductivity (EC) was recorded in the range of 11.0–44.1 µS/cm. While these low EC values suggest no immediate risk of secondary salinization, the exceptionally low mineralization of the water may lead to the degradation of soil structure over the long term. The combination of alkaline conditions and negative Eh creates a favorable environment for sodication and desertification tendencies. A clear correlation was observed between rising air temperatures and increases in both alkalinity and reduction potential. Soil analyses revealed more acute alkalization trends compared to the water samples. The soil pH rose from 7.27 to 8.46, while the Eh dropped from −26.4 mV to −109.9 mV, signaling the formation of a strong reduction environment. These findings serve as a scientific basis for adjusting irrigation regimes, preserving soil fertility, and preventing desertification in the region.

Keywords: *Canal Water, Ph, Eh, Soil Profile Alkalization, Salinization, Desertification, Gene Pool Garden, Biogeochemical Processes.*

How to Cite: Sevar Ahmadova; Vafa Atayeva; Ilgar Ismayilov; Murad Gahramanov; Vafa Mammadli (2026) Relationship Between Weather Conditions and the Physicochemical Indicators of Canal Water and Soil in the Gene Pool Garden of Shaki REM. *International Journal of Innovative Science and Research Technology*, 11(5), 1906-1912.
https://doi.org/10.38124/ijisrt/26may1013

I. INTRODUCTION

The physicochemical properties of irrigation water constitute a decisive factor directly affecting the ameliorative condition, fertility, and ecosystem sustainability of soils [1]. Under arid and semi-arid climatic conditions, where irrigation serves as the principal source of moisture, this impact becomes more pronounced and significantly reshapes the biogeochemical profile of soils [2]. In particular, the transfer of various chemical indicators from irrigation water into the soil environment leads to substantial alterations in the soil's internal energy balance, nutrient dynamics, and structural integrity.

In the present study conducted in the Gene Pool Orchard of the Scientific Research Institute of Horticulture and Subtropical Crops (SRIHSC), the effects of canal water temperature, pH, Eh, and EC parameters, together with atmospheric conditions, on soil salinization and desertification processes were investigated. Soil is not merely a passive recipient of water, but also a dynamic medium in which chemically transported elements accumulate and undergo complex reactions. Monitoring results demonstrated that the alkaline and reducing characteristics of canal water become further intensified within the soil environment, causing the soil pH to increase to 8.46 and the Eh value to decline to −109.9 mV. Such changes weaken the soil's self-regulatory capacity and create a significant risk of degradation [3].

The principal objective of this research was to monitor temporal variations in the physicochemical characteristics of canal water and to evaluate their direct relationship with soil salinization, sodification, and desertification processes. To better understand the dynamics of desertification, measurements conducted during the January–April period were analyzed in relation to temperature and humidity fluctuations. Particular attention was given to the role of the chemical load of irrigation water in the disintegration of fine soil particles responsible for maintaining soil structure, as well as in the development of oxygen-deficient conditions. This approach enables the assessment of the degree of disruption within the water–soil biogeochemical cycle and provides a scientific basis for forecasting and protecting soil fertility [4].

II. MATERİALS AND METHODS

The materials used in the study were collected from the irrigation canal and the surrounding soil within the Gene Pool Garden area of the Shaki Regional Experimental Station (Shaki RES). The pH, Eh, and mV parameters of both water and soil samples were measured using an S220-KIT SevenCompact pH/Ion Meter (Mettler Toledo). As presented in Table 1, canal water samples were collected on 15 January, 19 January, 26 January, 27 January, 30 January, 5 February, 11 February, 16 February, 25 February, 3 March, 5 March, 15 March, 19 March, 31 March, 6 April, 16 April, 22 April, 27 April, and 30 April 2026. As shown in Table 2, soil samples were collected on 15 January, 30 January, 16 February, 2 March, 16 March, 31 March, and 16 April.

For the water samples, water temperature (T, °C), active acidity (pH), oxidation–reduction potential (Eh, mV), and electrical conductivity (EC, µS/cm) were measured, and the results are presented in Table 1 [5], [6].

For the soil samples, soil temperature (T, °C), active acidity of the soil solution (pH), and oxidation–reduction potential (Eh, mV) were determined, and the results are presented in Table 2. The right-hand side of the table additionally includes the relative air humidity (%) and average air temperature (°C) corresponding to each sampling date.

III. RESULT AND DİSCUSSİON

Table 1 Physicochemical Parameters of Canal Water and Corresponding Meteorological Data (January–April, 2026).

Sample	Date	Temperature of water (°C)	pH	Eh (mV)	EC (µS/cm)	Humidity of weather (%)	Temperture of weather (°C)
1	15.01	16,3	8,03	-38,9	16,2	85	2,5
2	19.01	16,8	7,98	-66,8	14,5	92,5	1,5
3	26.01	18,0	7,97	-66,2	14,0	78,5	4,5
4	27.01	16,6	7,93	-63,8	12,9	91,0	4,0
5	30.01	17,2	7,86	-59,9	11,0	65,0	7,5
6	05.02	15,9	7,97	-65,7	14,0	89,0	1,5
7	11.02	16,2	8,17	-77,4	22,3	92,5	0,0
8	16.02	17,5	8,00	-67,9	15,0	67,5	14,0
9	25.02	6,7	8,21	-91,3	44,1	75,5	7,5
10	03.03	7,6	8,04	-82,2	29,9	69,0	6,5
11	05.03	9,9	8,15	-88,5	37,7	63,0	7,5
12	15.03	12,3	7,87	-76,6	22,5	81,0	7,5
13	19.03	15,6	7,96	-82,1	27,1	66,0	11,5
14	31.03	15,6	8,01	-84,9	30,1	70,0	11,5
15	06.04	13,5	7,98	-83,1	28,9	70,0	15,0
16	16.04	23,4	8,15	-91,6	36,1	53,5	12,0
17	22.04	21,4	8,02	-83,6	27,0	63,5	13,5
18	27.04	13,2	8,19	-91,2	40,3	58,5	18,0
19	30.04	15,4	8,10	-87,0	33,1	88,5	12,0

Table 2 Physicochemical Characteristics of Soil Collected from the Irrigation Canal and Corresponding Meteorological Data (January–April 2026)

Nümunə	Tarix	Torpağın T (°C)	pH	Eh (mV)	Hava rütubəti (%)	Hava T (°C)
1	15.01	16.6	7.27	-26.4	85	2,5
2	30.01	22.2	7,9	-62,9	92,5	7,5
3	16.02	24.9	8	-69.2	78,5	14
4	02.03	23.1	8.46	-109.9	91,0	4,0
5	16.03	19.1	7.7	-68.1	65,0	5,5
6	31.03	21.2	8.23	-98.5	89,0	11,5
7	16.04	21.2	8,23	-98.5	92,5	12

- *Temperature Parameters of Water and Soil Samples*

The temperature of the canal water varied between 6.7 °C (25 February, Sample 9) and 23.4 °C (16 April, Sample 16), corresponding to the gradual warming of weather conditions. The lowest water temperature was recorded at the end of February, while the highest was observed in mid-April.

The temperature of the soil collected from the irrigation canal ranged from 16.6 °C (15 January, Sample 1) to 24.9 °C (16 February, Sample 3).

- *Copmarative Analysis of pH and Eh Parameters*

The pH values of the canal water ranged between 7.86 (30 January, Sample 5) and 8.21 (25 February, Sample 9), with an average value of 8.03. Throughout the study period, the water exhibited an alkaline reaction, although slight fluctuations in alkalinity were observed. According to the classification of Ayers and Westcot (1985), the acceptable pH range for irrigation water is 6.5–8.5, and the measured values in this study fall within these limits. The relationship between the pH of the canal water and air temperature is illustrated in Figure 1.

For the soil samples, pH values varied between 7.27 (15 January, Sample 1) and 8.46 (2 March, Sample 4). Based on the classification of the US Salinity Laboratory (1954), pH values approaching the threshold of 8.5 indicate a critical risk of soil alkalization, specifically sodification. This should be considered a serious warning signal, as sodification leads to the degradation of soil structure and consequently accelerates the process of desertification. The relationship between soil alkalization and air temperature is presented in the graph shown in Figure 2.

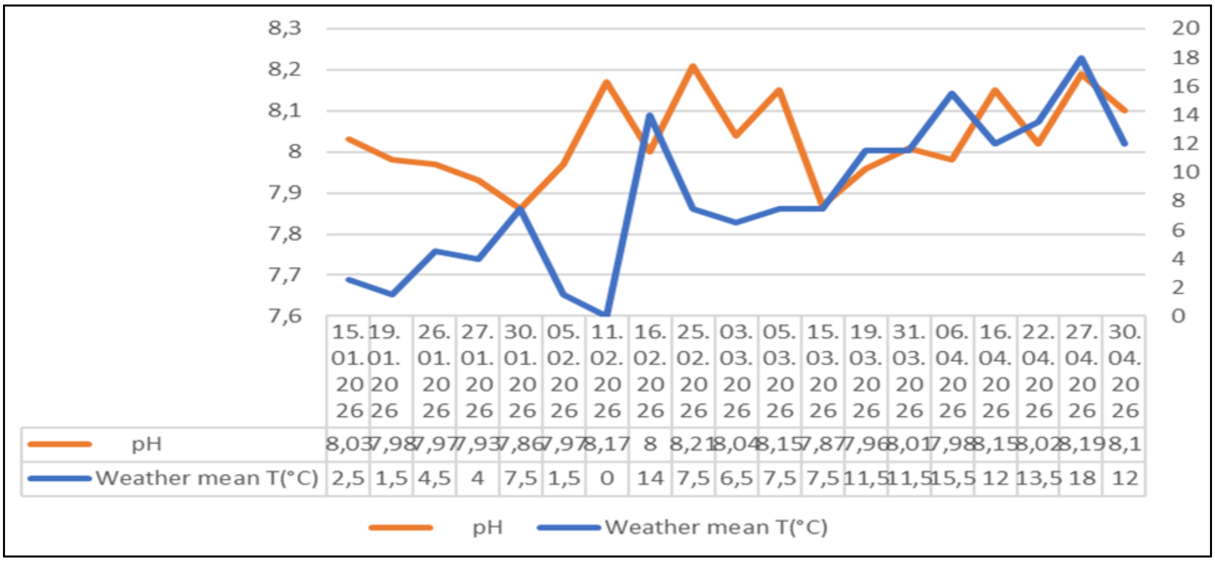


Fig 1 Graph Showing the Dependence of Canal Water pH on Air Temperature (T, °C) During the Study Period (January–April 2026)

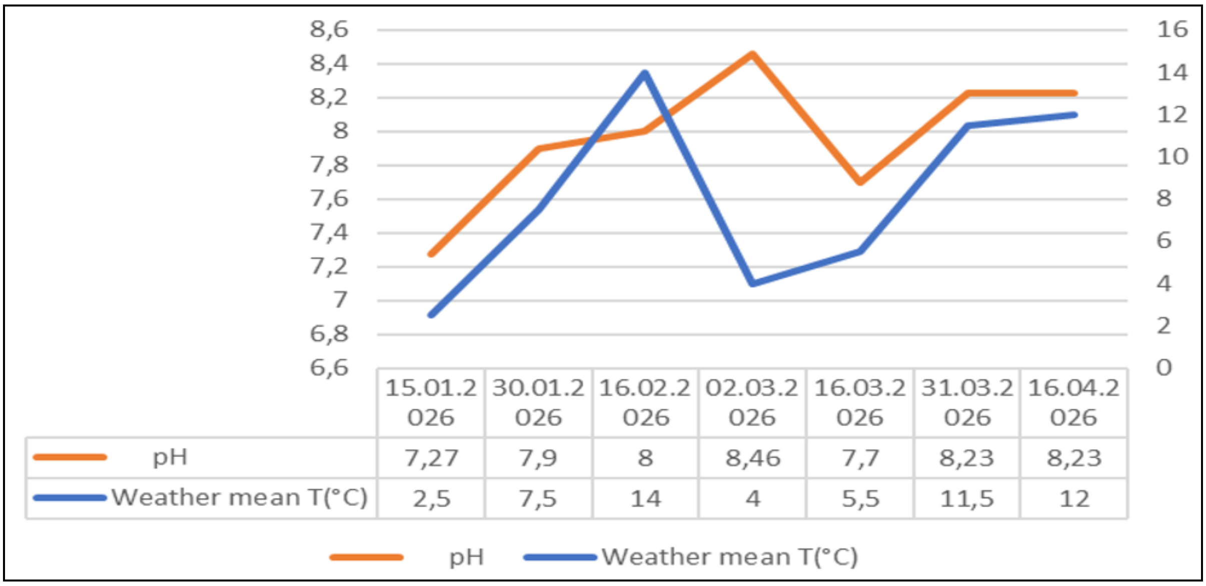


Fig 2 Graph Showing the Dependence of Soil Solution pH on Air Temperature (T, °C) During the Study Period (January–April 2026)

All Eh values recorded in the canal water were negative. The highest value was −38.9 mV (15 January, Sample 1), whereas the lowest value was −91.6 mV (16 April, Sample 16). The mean Eh value was −76.2 mV. These results indicate that the aquatic environment was characterized by reducing conditions [7]. As the study period progressed, particularly from the end of February onward, the Eh values became increasingly negative.

For the soil samples, the highest Eh value was −26.4 mV (15 January, Sample 1), while the lowest value was −109.9 mV (2 March, Sample 4). On the same date when the soil pH reached its maximum value (8.46 on 2 March), the Eh value declined to its most negative level (−109.9 mV on 2 March).

The recorded soil pH (8.46) and Eh (−109.9 mV) values indicate that the environment had shifted into a reducing zone [8].According to recent studies [9], [10], pH values approaching the threshold of 8.5 significantly increase the risk of soil alkalization. Furthermore, negative Eh values should be considered important biogeochemical indicators of oxygen deficiency in soils and the progression of desertification processes [11].

➢ *Comparison of Water and Soil Parameters*

A comparison of water and soil parameters measured at the same or closely corresponding dates revealed the following results (Table 3).

Table 3 Comparative Indicators of Canal Water and Soil Parameters on Corresponding Dates

Date	Water pH	Soil pH	Difference	Water Eh (mV)	Soil Eh (mV)	Difference
15.01	8,03	7,27	-0,76	-38,9	-26,4	+12,5
30.01	7,86	7,90	+0,04	-59,9	-62,9	-3,0
16.02	8,00	8,00	0,00	-67,9	-69,2	-1,3
02.03	8,04	8,46	+0,42	-82,2	-109,9	-27,7
31.03	8,01	8,23	+0,22	-84,9	-98,5	-13,6
16.04	8,15	8,23	+0,08	-91,6	-98,5	-6,9

The soil pH is generally higher than the water pH (exception: January 15). In contrast, the soil Eh is more negative than the water Eh, indicating stronger reducing conditions in the soil.

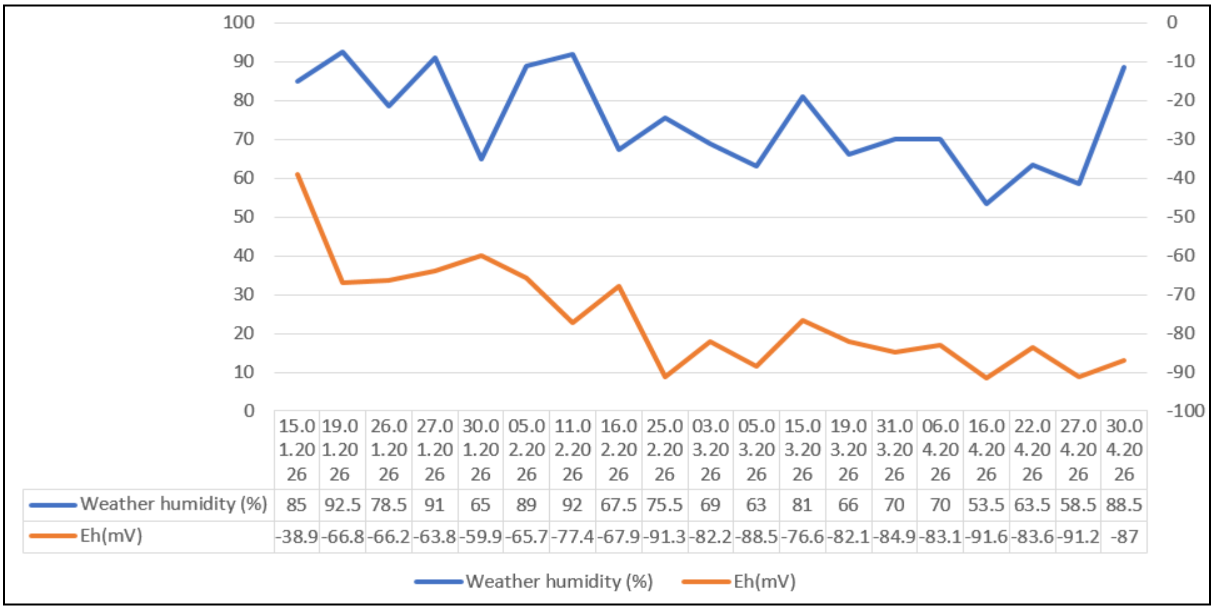
➢ *Mine Ralization (EC) and Risk of Soil Structure Degradation*

The EC values ranged from 11.0 µS/cm (sample 5, January 30) to 44.1 µS/cm (sample 9, February 25) for the water samples. During January and the first half of February, EC values remained within 11.0–16.2 µS/cm. After late February (February 25), EC increased to 22.3–44.1 µS/cm and remained within 22.5–40.3 µS/cm throughout March and April. According to the Food and Agriculture Organization (2021) classification, when EC is below 250 µS/cm, there is no salinization risk. Continuous Irrigation with Such Water May Contribute to the Deterioration of the Soil's Physical Structure.

➢ *Correlation of Weather Conditions (Temperature and Humidity) with Physicochemical Parameters*

Relationship with atmospheric conditions. As air temperature increases, water temperature also rises, which is an expected result. Air humidity varied between 53.5% (April 16) and 92.5% (January 19 and February 11). No clear correlation was observed between humidity and the other water parameters.

On days with high air humidity, the soil Eh value tended to shift more sharply toward negative values. High humidity and rainy weather can cause soil pores to become filled or saturated with water, thereby limiting soil aeration. The relationship between the Eh value of canal water and air humidity is presented in Figure 3.



	15.01.2026	19.01.2026	26.01.2026	27.01.2026	30.01.2026	05.02.2026	11.02.2026	16.02.2026	25.02.2026	03.03.2026	05.03.2026	15.03.2026	19.03.2026	31.03.2026	06.04.2026	16.04.2026	22.04.2026	27.04.2026	30.04.2026
Weather humidity (%)	85	92.5	78.5	91	65	89	92	67.5	75.5	69	63	81	66	70	70	53.5	63.5	58.5	88.5
Eh(mV)	-38.9	-66.8	-66.2	-63.8	-59.9	-65.7	-77.4	-67.9	-91.3	-82.2	-88.5	-76.6	-82.1	-84.9	-83.1	-91.6	-83.6	-91.2	-87

Fig 3 Dependence of the Redox Potential (Eh) of Canal Water on Relative Air Humidity during the Study Period (January–April, 2026).

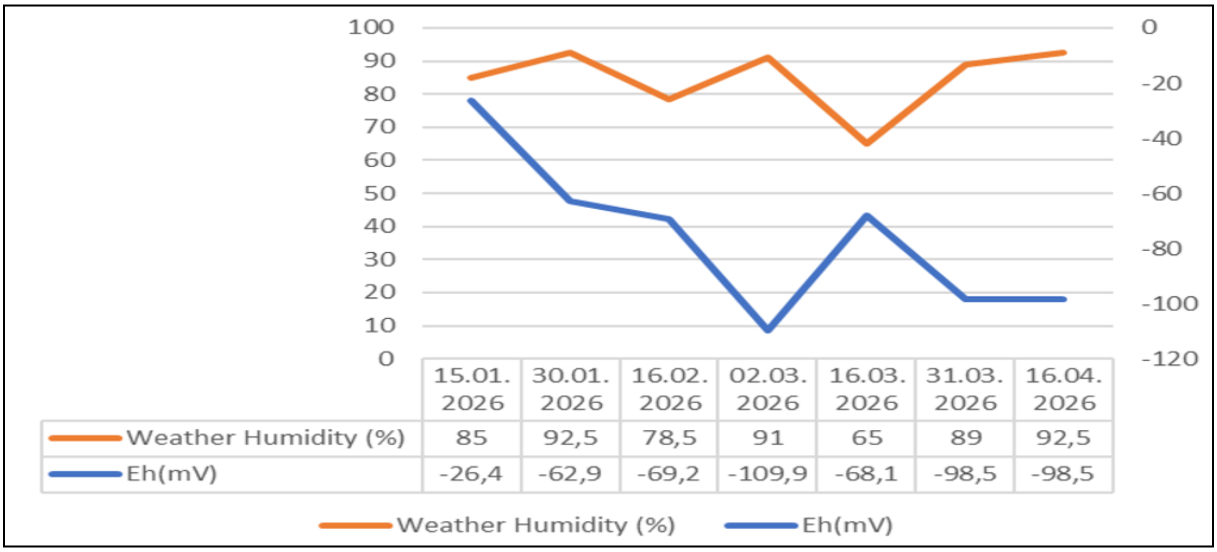
- *Relationship Between Parameters and Weather Conditions*

During the study period, the physicochemical parameters of water and soil samples showed the following variations under the influence of atmospheric factors.

During cold weather periods (January–February, air temperature 0.0–14°C), the pH of the water samples was slightly lower, ranging between 7.86 and 8.21. In April, when air temperature increased to 12–18°C, the pH rose to 8.19. This change is most likely associated with increased evaporation and alterations in the carbonate balance of the water [12]. In the soil environment, this process was more pronounced. While soil pH ranged between 7.27 and 7.9 in January, it reached a maximum value of 8.46 in early March, despite the air temperature being only 4.0°C. An inverse relationship was identified between Eh values and temperature. In canal water, the Eh value was less negative during cold weather (-38.9 mV), whereas with increasing temperature it decreased to more negative values (-91.6 mV). This indicates that reduction processes in water intensify as air temperature rises. The likely reason is the acceleration of anaerobic decomposition of organic matter [13].

Similar to the water samples, the physicochemical parameters in the soil environment also underwent specific changes depending on weather conditions. During cold periods (January–February, air temperature 1.5–4.5°C), soil pH values remained relatively lower, within the range of 7.27–8.0. With warming conditions (March–April, air temperature 4.0–12.0°C), soil pH increased up to 8.46.

The formation of reducing conditions in soil is directly related to air humidity. Under highly humid conditions, when air humidity ranged between 91.0% and 92.5%, the soil Eh values dropped to the most strongly negative levels, reaching -109.9 mV and -98.5 mV. This indicates that high atmospheric humidity restricts gas exchange within soil pores and thereby stimulates anaerobic conditions [14]. The more humid the air becomes, the lower the oxygen availability in the soil and the lower the Eh value. This relationship is clearly illustrated in Figure 4.



	15.01.2026	30.01.2026	16.02.2026	02.03.2026	16.03.2026	31.03.2026	16.04.2026
Weather Humidity (%)	85	92,5	78,5	91	65	89	92,5
Eh(mV)	-26,4	-62,9	-69,2	-109,9	-68,1	-98,5	-98,5

Fig 4 Dependence of Soil Redox Potential (Eh) on Relative Air Humidity during the Study Period (January–April, 2026).

- *Relationship Between Parameters and Weather Conditions*

- *Salinization:*

Based on the study results, EC values did not exceed 44 µS/cm. According to international classifications, this indicates very low salinity [15]. Irrigation with such water does not lead to salt accumulation in the soil. On the other hand, EC values below 50 µS/cm indicate that the water contains very low concentrations of essential cations such as calcium, magnesium, and potassium. Guliyev reported that long-term use of such water may increase the proportion of sodium in the soil adsorption complex, leading to sodification [16].

- *Alkaline Environment:*

In water samples, pH values exceeding 8.0, and in soil reaching up to 8.46 (sample 4), complicate nutrient cycling. Some researchs demonstrated that under alkaline conditions, the uptake of micronutrients such as iron, manganese, zinc, and copper by plants becomes limited, resulting in chlorosis (leaf yellowing). As noted by both local and international researchers, when soil solution pH rises to the range of 8.2–8.5, not only iron and manganese uptake but also phosphorus availability sharply decreases because phosphorus binds with calcium under alkaline conditions and transforms into insoluble forms [17].

- *Negative Eh:*

The negative Eh values recorded in soil samples, ranging from -26.4 mV to -109.9 mV, confirm the occurrence of strong anaerobic, oxygen-deficient processes within the soil environment. Negative Eh values indicate a lack of free oxygen in water and soil, which hinders root respiration and suppresses the activity of beneficial aerobic microorganisms.

- *Relationship between Canal Water and Soil Eh:*

The negative Eh values in canal water (-38.9 to -91.6 mV) contribute to the development of even more strongly negative values in the soil profile (-109.9 mV). This demonstrates that irrigation water is one of the main factors lowering the internal redox energy of the soil. When air humidity reached 91%, both water and soil Eh values dropped to their minimum levels. This correlation indicates that atmospheric humidity in the Shaki region is one of the key factors capable of creating anaerobic conditions within the water–soil system.

In conclusion, all three factors—low EC, alkaline pH, and negative Eh—collectively intensify desertification tendencies. This process does not occur immediately but becomes evident after many years of irrigation [18].

- *Biogeochemical Processes and Phytoremediation*

Under the alkaline and reducing influence of canal water, changes such as gley formation, development of carbonate horizons, and incomplete decomposition of organic residues may occur within the soil profile [19]. Such conditions accelerate soil degradation over the long term and increase the risk of desertification in arid regions [20].

If organic matter or iron–manganese compounds are present in the water—as suggested by the negative Eh values—phytoremediation may be feasible. Species such as Phragmites australis, Typha latifolia, and Juncus effusus may be used for this purpose. However, prior determination of iron, manganese, ammonium, and total organic carbon concentrations in the water is necessary.

The high alkalinity observed in the soil profile (pH 8.46) together with the strongly negative Eh value (-109.9 mV) are serious indicators of degradation. Oxygen deficiency caused by canal water promotes gley formation, hardening of carbonate horizons, and incomplete decomposition of organic matter. This condition reduces soil porosity, leading to compaction and accelerating desertification risk in arid regions such as Shaki. Species of Tamarix adapted to the climate of Azerbaijan are considered effective for the removal of excess salts and heavy metals [21].

IV. CONCLUSION

In the Genefond garden, the pH of water varied between 7.86–8.21, redox potential (Eh) between −38.9 and −91.6 mV, and EC between 11.0–44.1 µS/cm. In contrast, these parameters became more pronounced in the soil profile: pH ranged from 7.27–8.46, and Eh from −26.4 to −109.9 mV. This demonstrates that the alkaline and reducing influence of irrigation water becomes more intensified within the soil environment.

The combination of alkaline pH, negative Eh, and low EC creates conditions that enhance tendencies toward desertification.

PRACTICAL RECOMMENDATIONS

- Aeration of irrigation water before use (sprinkler irrigation systems are more suitable);
- Application of gypsum once or twice a year to regulate soil pH balance (200–300 kg/ha);
- When cultivating acidophilic plants (e.g., rhododendron, conifers), addition of peat and sulfur to the soil;
- Continuation of synchronized water and soil analyses for at least one year to monitor desertification processes;
- Inclusion of additional analyses for iron, manganese, ammonium, and total organic carbon.
- The results of this study can be used to optimize irrigation practices, preserve soil fertility, and prevent desertification.

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