# The impact of climate change on the natural dendroflora of the greater caucasus

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**Abstract.** Against the background of global climate change, such processes as soil degradation, salinization, etc. have become pressing problems of our time, as they lead to a reduction in biodiversity. We have studied relict, endemic and rare plants of the southern slopes of the western part of the Greater Caucasus (Gakh), comprehensively analyzed the influence of anthropogenic, biotic and abiotic factors on modern flora. Favorable physical, geographical and climatic conditions of the region contributed to the formation of a rich and diverse vegetation cover. The forest area of 26,848 hectares of the Gakh district is classified as specially protected forest areas. The dominant species in the dendroflora of the Gakh district are representatives of the genera Fagus L., Carpinus L., Quercus L., Betula L., Tilia L., Fraxinus L., Acer L., Castanea Mill., Malus Mill., Prunus L., Pyrus L., Prunus L., Cornus L., Spiraea L., Juniperus L., Rosa L., Rubus L., Sorbus L., Cotoneaster Medik. The article examines the main features of the current state of vegetation in the region, reveals that anthropogenic factors have changed and impoverished the vegetation, and some species are currently on the verge of extinction. In the course of the study, based on the analysis of water taken from the Lakit River and soil samples taken in the villages of Kapychay and Lakit, certain changes in the mineralogical composition of water and soil were revealed. The soil layer of the Kapychay site 0-30 cm was found to have low organic matter (humus) content, and the magnesium level in water samples from the Lakit River was toxic. The data obtained during the study of climatic and anthropogenic impacts on the vegetation cover of the region can contribute to the development of measures aimed at developing scientific research and expanding environmental protection measures to preserve biodiversity in the future.

**Keywords:** Great Caucasus, Gakh, climate change, dendroflora, Lakit river, Kapychay.

## 1 Introduction

Global climate change is a result of industrialization and the utilize of fossil fuels, which started in the 1850s and has continued to the present day, and the excess carbon accumulation in the atmosphere has become the most crucial problem of our time. Global climate change,

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which threatens all living things and minimizes its possible effects, stands before us as our problem. In order to solve this problem, comprehensive measures should be taken at both individual and institutional levels. There is a two-way relationship between climate change and forest ecosystems. Although forest areas are adversely affected by changes in climate over time, forests mitigate these effects by creating carbon sequestration zones. The possible effects of climate change on forest ecosystems are the sensitization of forests, reduction of forest areas and biomass, changes in distribution areas, changes in species composition in forests, and increased likelihood of forest fires [1, 2].

The consequences of climate change have also affected the living and non-living nature of the Republic of Azerbaijan. Currently, soil cover is affected by salinization, irrigation, wind erosion, pasture erosion, hardening, leaching of humus layer, lack of nutrients, rise of groundwater level, desertification, etc. has been subjected to such degradation processes. Every process that takes place in the soil demonstrates itself in its morphogenetic diagnosis. Without investigating the diagnostic indicators of the soil, it is impossible to study its productivity and maintain its fertility. It is crucial to study the degradation processes (rain, wind, salinization, etc.) caused by climate change, intense anthropogenic effects, and natural factors on the southern slopes of the western part of the Greater Caucasus, which was the basic research object of the article, and fight with these processes from the point of view of protecting land, water and living resources.

## 2 Literature Review

The Gakh district, where the research was carried out, is a historical region of Azerbaijan, located in the north-western part of the country and on the southern slope of the western part of the Greater Caucasus. The northern and north-eastern parts of the district are included in the southern slopes of the Main Caucasus range, the central part is in the Ganikh-Haftaran valley, and the southern and southeastern parts are included in the Ajinohur foothills.The height of the area varies from approximately 100 m on the coast of Ajinohur Lake to 3480 m (Mountain Ahvay) on the slopes of the Main Caucasus Range. The territory of the district is 1494 $km^2$. The southern and central part of the area mainly has a plain relief and is composed of continental cobblestone, sand, sandstone, clay and chert (granular clay) of the Neogene and Quaternary periods [3, 4].

The climate of the region is dry subtropical in the southern part, moderately hot, semi-humid subtropical in the central part, and cold in the highlands. The average temperature in January is higher than 2$^o$ C in the plain area, up to -10$^o$ C in the mountainous area, and 26$^o$ C and 50$^o$ C in July, respectively. Annual precipitation is 300 mm in the south and up to 1600 mm in the north. The climate of the region is dry in the south, moderately warm and subtropical humid in the center, cold in the mountains, and characterized by regular distribution of precipitation. The soil cover of the district is grassy mountain-meadow, brown mountain-meadow, alluvial meadow-forest, alluvial-meadow, chestnut color and carbonate soils [5].

8 large rivers flow in the region. Its basic rivers are Ganikh (Alazan), Kurmuk and Ayrichay. The Ganikh River, which flows along the border with the Republic of Georgia, takes its source from Turkey and, passing through the territory of the district for a distance of 61 km, flows into the Mingachevir reservoir. Ajinohur lake is located in this area. The remaining of the rivers take their sources from the mountains range of the Great Caucasus. The length of the Kurmukchay is 54 km, the length of the Kapi River is 11 km, its tributaries are the Ganikh River, the estuary of the Lakit River is 8 km long, the tributary of the Kapi River, the estuary of the Zarna River is 11 km long, the tributary of the Kapi River and the Ayrichay (Agrichay), which originates from the Shaki River, flows 58 km through the territory of the district and flows into the Ganikh River. The source of Ayrichay is at an

altitude of 3200 m. The source of Kurmukchay is at an altitude of 3280 m in the south of Makhi mountain (3480 m). Ram-Rama waterfall in Ilisu village is 25 meters high. The unique waterfall in Lakit village has been registered and protected as a natural monument by the Cabinet of Ministers of the Republic of Azerbaijan since 2006 [6].

During the research in the territory of Gakh district, the comtemporary state of the plant gene pool, dendrochronological and dendroclimatic research of dominant species, phenological observations according to methodological guidelines, quality analyses, registrations, report evaluations were carried out. For the purpose of carrying out the research work, Kapychay village of Gakh region (41.49343- 46.81187) two 0-30 cm, 30-60 cm; 0-30 cm soil of Lakit village (41.49339- 46.81175) and water samples from Lakit river (41.291901- 46.512132) were taken and analyzed in laboratory conditions [7].

In Gakh, the area of forests is approximately 25-30% of the district area. The total area of forests is 43,700 hectares and consists of valuable tree species, various fruit trees and shrubs. In the plain area of the region, grass plants are spread in the Ganikh-Haftaran valley, and steppe and semi-desert plants are spread in the Ajinohur frontal highlands. Recreational forests located around the village of Ilisu is an area of 300 hectares. The protective forest strips along the Baku-Zagatala and Shaki-Zagatala roads and the railway are 865 hectares. 764 hectares of forest area along the Ganikh River is classified as a prohibited forest strip protecting the spawning grounds of valuable hunting fish. 4,867 hectares of gum and juniper trees on the densely divided slopes of Dashuz and Akharbakhar ridges belong to the specially valuable forest massif [8].

The basis of dendroflora of Gakh district is *Fagus orientalis* Lipsky, *Carpinus caucasica* Grossh., *Quercus iberica* Steven ex M.Bieb., *Quercus macranthera* Hohen., *Betula litwinowii* Doluch., *Tilia caucasica* Rupr., *Fraxinus excelsior* L., etc. consists of trees and bushes. The basic trees of the lower mountain belt (600-1000 m) are *Carpinus caucasica* Grossh. and *Quercus iberica* is Steven ex M.Bieb. Here, along with them, *Tilia* L., *Acer* L., *Castanea* Mill. other species belonging to the genus are also found. *Corylus avellana* L., *Philadelphus* L., *Hedera helix* L., *Ulmus glabra* Huds. and bushes are the second layer and the under the forest [3].

The forests of the medium mountain zone (1000-1700 m) are mainly composed of Fagus L. Accompanying trees and shrubs, *Quercus iberica* Steven ex M.Bieb., *Quercus macranthera* Hohen., *Fraxinus excelsior* L., *Acer* L. species, *Tilia* L., *Malus orientalis* Uglitzk., *Prunus cerasifera* Ehrh., *Sorbus caucasica* Zinserl., *Prunus padus* L., *Cornus* L., etc. are types. Grass cover mainly consists of cereals and legumes.

In the upper mountain forest zone (1600-1800 m) is dominated by *Fagus* L. (Decreases as you go up). Here, the landscape background is replaced by mixed forests of *Fagus* L., *Tilia* L., *Carpinus* L., *Acer* L., *Ulmus* L. species.

*Quercus macranthera* Hohen., *Ulmus* L., *Acer heldreichii subsp. trautvetteri* A.E.Murray, *Betula litwinowii* Doluch. etc. subalpine forests consisting of species are widespread. Lower shrub layer consists of *Spiraea* L., *Rosa* L., *Sorbus* L., *Cotoneaster* Medic. etc. *Aconitum* L., *Valeriana* L., *Betonica* officinalis L. are the grass cover of the area. Betula L. is mainly spreaded in the upper border of forests and river valleys.

In 2012-2019, 323 wild plants of 72 families and 211 genera of food significance were registered here by Azerbaijani scholars. In terms of number of species, the largest family is Asteraceae (35 species), followed by *Rosaceae, Apiaceae, Fabaceae, Brassicaceae, Lamiaceae, Malvaceae and Polygonaceae*. Of these, 29 species are trees, 18 are shrubs, 2 semi-shrubs, 1 liana, 69 annual, 27 biennial and 175 perennial plant species. Most of the food plants are more common in the northern and northeastern parts of the investigation area. 1 endemic of Azerbaijan (*Rubus buschii Grossh*.), 35 endemics of the Caucasus were recorded, and 25 species were included in the Red Book of the Republic of Azerbaijan.

8 types of vegetation typical for the Gakh region have been determined: 1) forest, 2) thicket, 3) meadow, 4) rock and reef, 5) swamp, 6) steppe, 7) semi-desert, 8) oasis. The main purpose of the article was to investigate the impact of climate disturbances on the presence of vegetation types.

To achieve the goal of the research work, the work was carried out in a certain sequence. Thus, the species composition of the flora of the Gakh region was determined, changes in vegetation were studied to protect plant diversity, economically important plant species were studied from the point of view of effective and sustainable use of flora, the impact of climate change on population density and distribution area was assessed. Pre-theoretical and practical knowledge was utilized in the research work. Based on recent research, it was determined that 1018 (965 species, 51 subspecies, 2 variations) of economically crucial plants belonging to 106 families and 467 genera are distributed in the general flora of the research area. Of these, 571 types of medicine, 485 types of dyes, 412 types of decorative, 373 types of food, 367 types of fodder, 336 types of flowers, 223 types of aromatic plants and 130 types of various technical properties are plants. In terms of life forms, it was determined that herbaceous plants dominate the spectrum of the region's flora with 88.37% (annual - 285, annual or biennial - 36, biennial - 54, biennial or perennial - 15, perennial - 757). It is known that the other 11.63% consists of woody plants (tree - 53, tree or shrub - 23, bush - 56, semi-shrub - 4, shrub - 9, semi-shrub - 2, bushy liana - 4) [5].

Global climate changes and its features in Azerbaijan, the dynamics of changes in precipitation frequency and temperature over years and months were analyzed. It has been illustrated that, according to model calculations, the average annual temperature may increase by several degrees in the next 25-30 years if effective measures are not implemented. Increases in heat waves and droughts, intense rainfall, longer crop growing seasons, and accelerated soil erosion ultimately affect agricultural productivity and biodiversity. It was clear from the conducted researches that due to climate change, the area of natural vegetation in the areas has decreased significantly and the species composition has been diluted. In the last 100 years, average annual temperatures in the territory of Azerbaijan have increased by 0.4-1.3$^0$C. The increase in temperature is unevenly distributed depending on the regions. The threat of ecological stress caused by global warming requires the implementation of complex measures in front of human society [6, 9].

Multi-year investigations conducted by scientists should be summarized, and the effect of temperature variation over the years on the condition of land and water resources of the area should be evaluated.

The conducted studies made reference to the results of recent years. However, the current results do not fully reflect the current situation. Thus, taking into account the increased environmental load, the population and the fact that the territory is a recreation area in the Gakh region, which was selected as the study area, regular monitoring and diagnostic analyses are necessary for this territory. The most important factor in monitoring the growth and decline of flora is the analysis of land and water resources. Changes in the chemical composition of the soil and water environment as a result of climatic and anthropogenic impacts are manifested against the background of the forest. Thus, when reviewing the literature, no results of analyses were found that reflect the current situation [10, 11].

## 3 Materials and methods

Scientific-research work was carried out in field and laboratory conditions. A.S. Hajiyev (1952), A.L. Lipa (1957), P.A. Shutov (1962), I.S. Gayevskaya (1972), S.G. Sakova (1983) and others have provided information on the height and development of some species in research conducted in various geographical regions. In order to determine the species composition of the flora of the district, field work was carried out in the research area, route, semi-stationary observations and methods were utilized. During the research, monitoring was carried out in the territory, herbarium, soil, water and dendrochronological samples were taken and analyzed in the relevant laboratories of the " Dendrology Garden" public legal entity. Classical and contemporary literatures were utilized during the determination of the collected herbarium materials.The scientific name of the plant was first determined based on the work "Flora Azerbaijan", then the contemporary literature was investigated, the last status and scientific name of the species was given based on the "World Flora Online" database, taking into account nomenclature changes and synonyms. The biomorphological analysis of the flora of the territory was carried out according to the systems of I.G.Serebyakov (1964) and K.K. Raunkier (1934). During the bioecological analysis of the flora of the area based on the water regime, the methodology of A.P.Shennikov (1964) was utilized. Endemic plants in the flora of the district were identified based on the works of A.M. Askerov (2016) and "Red list of the endemic plants of the Caucasus" (2014). The names and features of vegetation types of the district's vegetation are given according to V.C.Hajiyev (2014) and S.C.Ibadullayeva (2014), T.S.Mammadov (2019).

P.S.Pogrebnyak (1968) associated species replacement in the forest with the progress of ontogenesis, the effect of biotic and abiotic factors, and climate change. The method of studying natural regeneration by evaluating 1 ha area can be studied with M.E.Tkachenko "scale of natural regeneration".If the number of juveniles over 2 years old in 1 hectare of forest is more than 10,000, natural regeneration is considered "excellent", if it is 5-10 thousand "good", if 2-5 thousand are "satisfactory", if 0.1-2 thousand are "unsatisfactory". " and defined as "no recovery" if 0.1 thousand units. D. I. Tovstoles illustrates that if there are more than 5500 sprouts in 1 ha, the forest regeneration is going well, if there are 550-950 sprouts in 1 hectare, natural regeneration is bad, if there are 550 sprouts in 1 hectare, there is no natural regeneration. The monitoring of the self-recovery process is carried out by various methods: l) approximately; 2) count fruits on sample branches; 3) choosing model trees; 4) building seedbeds; 5) through counting for the seeds spilled in the recording fields.

In order to fulfill of the research, Kapychay village of Gakh district (41.49343- 46.81187) two 0-30 cm, 30-60 cm; Lakit village 0-30 cm (41.49339- 46.81175) soil, Lakit river water samples were taken and analyzed in laboratory conditions. "Mohr" method for determining the amount of Cl- in the water taken from the Lakit river basin, "GOST 26423-85" method for determining the electrical conductivity, pH and solid residues of the aqueous extract, "Volumetric" method for determining the amount of hardness and Mg (the concentration of a substance in the solution, evaluation by adding the same number of compounds of another substance present in a solution of known concentration) referred to.

The Kjedahl method or Kjedahl digestion was utilized for the quantitative determination of organic nitrogen and ammonium in the sample (Johan Kjeldahl, 1883). Determination of organic matter was carried out by Walkley-Black wet digestion method using organic carbon. For phosphorus determination, the Olsen sodium bicarbonate method was utilized for highly calcareous soils (pH greater than 7.4). The amount of total $K_2O$, Ca, Na, Mg (AAA apparatus) was calculated by the method of Masloviy ($CHCOONH_4$), Scheibler, and the amount of carbonate in the soil. The amount of elements Zn, Fe, Mn, Cu for neutral and calcareous soils was determined by DTPA test (Lindsay and Norvell 1978).

## 4 Results

A water sample was taken from the Lakit river for the aim of the research. A water sample was obtained from the highest flow part of the river in a pre-sterilized glass container from the highly populated area (41.46366-46.82874). When taking the sample, the glass container was submerged vertically, and the bottom layer sediments were prevented from entering the glass by turning the glass container upside down below the upper layer of water (fig. 1.).

**Fig.1.** Taking a water sample from a Lakit river

For determine the suitability of water to irrigation and drinking, it is first necessary to define the electrical conductivity (EC), anion and cation values. It is known that water with EC range between 0-0.25 dS/m is class I (best), EC between 0.25-0.75 dS/m is class II (easily used for watering all plants except salt-sensitive plants can be done), water with an EC of 0.75-2.25 dS/m is class III (not recommended for utilize in undrained areas), and water with an EC of 2.25 dS/m is class IV (not recommended for use in irrigation). As a result of the analysis of Lakit river water in laboratory conditions, it was found that the EC class II water is 0.36 mS/cm.

Sodium adsorption rate (SAR) is a fundamental parameter utilized to determine whether water is suitable for use on agricultural land. Class I excellent when SAR < 10, class II when 10 < SAR < 18, class III when 18 < SAR < 26, and class IV is when 26 < SAR (1).

$$SAR = \frac{Na}{\sqrt{\frac{(Ca+Mg)}{2}}} = \frac{2}{\sqrt{\frac{2+8,8}{2}}} \approx 0.1 \text{ (I class excellent)} \quad (1)$$

The percentage of sodium (Na %) is an vital parameter that indicates the suitability of water for utilize as irrigation water in farming. In order not to harm the soil and plants, the amount of Na% should not exceed 60% (Meq/l values of the parameters are utilized in the calculation) (2).

$$Na\,\% = \frac{Na}{(Ca+Mg+Na+K)} \times 100\% = \frac{2}{2+8,8+2+0,03} \approx 15\,\% \quad (2)$$
$$\text{(Na} < 20\,\% \text{ I class excellent)}$$

An essential parameter utilized to determine the suitability of water for irrigation is the Regular Sodium Carbonate (RSC) value (Meq/l values of the parameters are used in the calculation) (3).

$$RSC=(HCO_3+CO_3)-(Ca+Mg)=(3+2,8)-(2+8,8)= -5 \text{ (}RSC<1.25\text{, I class excellent)} \quad (3)$$

Potential salinity (PS) is one of the crucial parameters utilized in the assessment of irrigation water quality. Water with a PS less than 3 is suitable for irrigation, between 3-15 is moderate, and water above 15 is not suitable for irrigation (4).

$$PS = Cl + \left(\frac{SO_4}{2}\right) = 0.98 + \left(\frac{4.24}{2}\right) = 3.1\ (moderate) \quad (4)$$

According to Lakit water analysis results, the amount of Mg was 88%, exceeding the norm. Salt in water exists chemically in the form of NaCl. "Mohr" method is based on the principle of determination of sodium chloride by titration with AgNO3 solution. During the research, 0.1 N silver nitrate (AgNO3) solution and 5% potassium chromate (K2CrO4) solution were utilized. The amount of salinity and sulfate of the solution was determined by the method, and it was defined that the Cl- amount was lower than the norm at 0.98 meg/l (tab. 1.).

Two 0-30 cm, 30-60 cm from Kapychay village of Gakh district (41.49343-46.81187) for the aim of research work; a soil sample of 0-30 cm (41.49339-46.81175) was taken from Lakit village and analyzed in laboratory conditions. During the soil phosphorus determination, 1 gram of dried soil and 20 milliliters of 0.5 M sodium bicarbonate (NaHCO3) solution were shaken for 30 minutes. A blue color in the filtered extract is developed with molybdate-ascorbic acid reagent and measured at 880 nm with a Brinkman PC 900 probe colorimeter. Results are reported as parts per million (ppm) of phosphorus (P) in the soil. The upper reporting limit for this test is 50 ppm (tab.2.).

**Table 1.** Analysis results of mineralogical composition of Lakit river.

| Depth | cm | | | | |
|---|---|---|---|---|---|
| Coordinates | 41.46366 – 46.82874 | | | | |
| Description of the place | Lakit river | | | | |
| The name of the indicator | Reference method | Unit of measurement | Test result | Norm | Evaluation |
| Chlorine (Cl-) | Mohr's method (titration) | meq/l | 0.98 | 7-12 | class I - excellent |
| Sulphate ($SO_4$-) | Calculation | meq/l | 4.24 | 7-12 | class II - good |
| Saltiness EC | GOST 26423-85 | mS/cm | 0.36 | 0.250-0.750 | class II - good |
| SAR | Calculation | - | 0.1 | 18-26 | class I - excellent |
| RSC (residue $NaHCO_3$) | Calculation | meq/l | -5 | 1.25-2.5 | class I - excellent |
| Hardness ($Ca^{+}Mg$) | Volumetric method (titration) | meq/l | 5 | 8-12 | Soft water |
| Magnesium (Mg) | Volumetric method (titration) | % | 88 | <50 | Toxic |
| pH | GOST 26423-85 | - | 7.4 | 6.5-8.5 | |
| Potassium (K) | | meq/l | 0.03 | | |
| Sodium (Na) | | meq/l | 2 | | |
| $Ca^{2+}$ | | meq/l | 2 | | |
| $CO3^{2-}$ | | meq/l | 2,8 | | |
| $HCO_3$ | | meq/l | 3 | | |

**Table 2.** Analysis results of 0-30 cm soil layer of Kapychay village.

| Depth (cm) | 0-30 cm | | | | |
|---|---|---|---|---|---|
| Coordinates | 41.49343 – 46.81187 | | | | |
| Description of the place | S-1 4314 | | | | |
| The name of the indicator (analysis) | Reference method | Unit of measurement | Test result | Norm | Evaluation |
| Total nitrogen | Kjedahl | % | 0.156 | 0.09-0.17 | Medium |
| Organic matter (humus) | Walkley-Black | % | 1.94 | 2-3 | Weak |
| Phosphorus ($P_2O_5$) (Can be absorbed) | Olsen($NaHCO_3$) | kg/ha | 13.17 | 60-120 | Very weak |
| Potassium oxide ($K_2O$) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | kg/ha | 564 | 250-550 | High |
| Calcium (Ca) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 4890 | 1150-3500 | High |
| Sodium (Na) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 63 | 81-120 | Weak |
| pH | 1:2.5 Soil water mixture | - | 7.16 | 6.6-7.5 | Neutral |
| Saltiness (EC) | 1:2.5 Soil water mixture | mS/cm | 0.083 | 0-2 | Unsalted |
| Lime (carbonate) | Scheibler | % | 0.41 | 5-15 | Very weak |
| Water saturation | Saturation | ml | 65.2 | 51-70 | Granular clay |
| Zinc (Zn) (Can be absorbed) | DTPA | mg/kg | 1.28 | 1.0-2.4 | Medium |
| Iron (Fe) (Can be absorbed) | DTPA | mg/kg | 32.8 | 2.5-4.5 | High |
| Manganese (Mn) (Can be absorbed) | DTPA | mg/kg | 11.2 | 14-50 | Weak |
| Copper (Cu) (Can be absorbed) | DTPA | mg/kg | 4.8 | >0.2 | Sufficient |
| Magnesium (Mg) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 250 | 160-480 | Medium |
| $CO_3{}^{2-}$ (in the soil) | Saturation filtrate | | | | |
| $HCO^{3-}$ (in the soil) | Saturation filtrate | mel/l | 1.61 | | |
| $Cl^{1-}$ (in the soil) | Saturation filtrate | mel/l | 0.74 | | |
| $SO_4{}^{2-}$ (in the soil) | Saturation filtrate | mel/l | 0.22 | | |
| SAR (in the soil) | Calculation | Me/l | 0.52 | >12 | |
| $Ca^{2+}$ (in the soil) | Saturation filtrate | mel/l | 1.5 | | |
| Ca+ $Mg^{2+}$ (in the soil) | Saturation filtrate | | 2 | | |
| $Na^+$ (in the soil) | Saturation filtrate | mel/l | 0.52 | | |
| $K^+$ (in the soil) | Saturation filtrate | mel/l | 0.05 | | |

Hydrochloric acid was added to the carbonate in the sample to measure the lime in the soil, and the resulting pressure caused by the released CO2 causes a rise in the burette. The change in the burette level is equal to the amount of CO2 released, and the amount of carbonate is calculated from this (Table 3).

**Table 3.** Analysis results of 30-60 cm soil layer of Kapychay village

| Depth (cm) | 30-60 cm | | | | |
|---|---|---|---|---|---|
| Coordinates | 41.49343 – 46.81187 | | | | |
| Description of the place | S-1 4315 | | | | |
| The name of the indicator (analysis) | Reference method | Unit of measurement | Test results | Norm | Evaluation |
| Total nitrogen | Kjedahl | % | 0.278 | 0.09-0.17 | High |
| Organic matter (humus) | Walkley-Black | % | 5.01 | 2-3 | High |
| Phosphorus ($P_2O_5$) (Can be absorbed) | Olsen($NaHCO_3$) | kg/ha | 124.81 | 60-120 | High |
| Potassium oxide ($K_2O$) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | kg/ha | 1860 | 250-550 | Very high |
| Calcium (Ca) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 5220 | 1150-3500 | High |
| Sodium (Na) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 21 | 81-120 | Very weak |
| pH | 1:2.5 Soil water mixture | - | 6.52 | 6.6-7.5 | Weak sour |
| Saltiness (EC) | 1:2.5 Soil water mixture | mS/cm | 0.085 | 0-2 | Unsalted |
| Lime (carbonate) | Scheibler | % | 0.16 | 5-15 | Very weak |
| Water saturation | Saturation | ml | 68.6 | 51-70 | Granular clay |
| Zinc (Zn) (Can be absorbed) | DTPA | mg/kg | 2.56 | 1.0-2.4 | High |
| Iron (Fe) (Can be absorbed) | DTPA | mg/kg | 160 | 2.5-4.5 | High |
| Manganese (Mn) (Can be absorbed) | DTPA | mg/kg | 40 | 14-50 | Medium |
| Copper (Cu) (Can be absorbed) | DTPA | mg/kg | 2.16 | >0.2 | Sufficient |
| Magnesium(Mg) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 270 | 160-480 | Medium |
| $CO_3$ $^{2-}$ (in the soil) | Saturation filtrate | | | | |
| $HCO^{3-}$ (in the soil) | Saturation filtrate | mel/l | 3.12 | | |
| Cl $^{1-}$ (in the soil) | Saturation filtrate | mel/l | 1.72 | | |
| $SO_4$ $^{2-}$ (in the soil) | Saturation filtrate | mel/l | 0.62 | | |
| SAR (in the soil) | Calculation | Me/l | 0.91 | >12 | |
| $Ca^{2+}$ (in the soil) | Saturation filtrate | mel/l | 1 | | |
| Ca+ $Mg^{2+}$ (in the soil) | Saturation filtrate | | 3.8 | | |
| $Na^+$ (in the soil) | Saturation filtrate | mel/l | 1.25 | | |
| $K^+$ (in the soil) | Saturation filtrate | mel/l | 0.41 | | |

**Table 4.** Analysis results of 0-30 cm soil layer of Lakit village

| Depth (cm) | 0-30 cm | | | | |
|---|---|---|---|---|---|
| Coordinates | 41.49339 – 46.81175 | | | | |
| Description of the place | S-1 Lakit | | | | |
| The name of the indicator (analysis) | Reference method | Unit of measurement | Test result | Norm | Evaluation |
| Total nitrogen (N) | Kjedahl | % | 0.27 | 0.09-0.17 | High |
| Organic matter (humus) | Walkley-Black | % | 5.43 | 2-3 | High |
| Phosphorus ($P_2O_5$) (Can be absorbed) | Olsen($NaHCO_3$) | kg/ha | 216.41 | 60-120 | Very high |
| Potassium oxide ($K_2O$) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | kg/ha | 1236 | 250-550 | Very high |
| Calcium (Ca) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 9200 | 1150-3500 | High |
| Sodium (Na) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 15 | 81-120 | Very weak |
| pH | 1:2.5 Soil water mixture | - | 8.11 | 6.6-7.5 | Weakly alkaline |
| Saltiness (EC) | 1:2.5 Soil water mixture | mS/cm | 0.147 | 0-2 | Unsalted |
| Lime (carbonate) | Scheibler | % | 13.1 | 5-15 | Medium |
| Water saturation | Saturation | ml | 56.8 | 51-70 | Granular clay |
| Zinc (Zn) (Can be absorbed) | DTPA | mg/kg | 3.12 | 1.0-2.4 | High |
| İron (Fe) (Can be absorbed) | DTPA | mg/kg | 66.4 | 2.5-4.5 | High |
| Manganese (Mn) (Can be absorbed) | DTPA | mg/kg | 24 | 14-50 | Medium |
| Copper (Cu) (Can be absorbed) | DTPA | mg/kg | 2.48 | >0.2 | Sufficient |
| Magnesium (Mg) (Can be absorbed) | Maslovıy ($CH_3COONH_4$) | mg/kg | 245 | 160-480 | Medium |
| $CO_3^{2-}$ (in the soil) | Saturation filtrate | | | | |
| $HCO^{3-}$ (in the soil) | Saturation filtrate | mel/l | 3.84 | | |
| $Cl^{1-}$ (in the soil) | Saturation filtrate | mel/l | 0.25 | | |
| $SO_4^{2-}$ (in the soil) | Saturation filtrate | mel/l | 1.76 | | |
| SAR (in the soil) | Calculation | Me/l | 0.28 | >12 | |
| $Ca^{2+}$ (in the soil) | Saturation filtrate | mel/l | 4 | | |
| Ca+ $Mg^{2+}$ (in the soil) | Saturation filtrate | | 5 | | |
| $Na^+$ (in the soil) | Saturation filtrate | mel/l | 0.44 | | |
| $K^+$ (in the soil) | Saturation filtrate | mel/l | 0.41 | | |

0.28 Me/l was determined during the calculation of sodium adsorption rate (SAR) in soil analysis of Lakit village. Irrigating the soil with irrigation water with a high sodium concentration generally leads to an increase in the sodium content of the soil. The low salinity of the Lakit river water has also affected the soil layers (tab. 4.).

## 5 Discussion

In accordance with the research plan, herbarium, soil and water analyzes were studied in laboratory conditions in order to investigate the effect of anthropogenic and climate changes on the flora of the (Gakh) southern slope of the western part of the Greater Caucasus. It was found that the number of species of tree forms is low despite the fact that the forest is dense. The basis consists of shrubs, lianas and grasses. Trees such as beech, oak, asp, hornbeam, and birch dominate in the Gakh forest.

In compliance with the analysis consequences of the water sample taken from the Lakit river, no pollutants, odor and color changes were found in the water. It is soft water that does not adversely affect human health. The amount of Mg in the water is at a toxic level.

The amount of organic matter (humus) in the 0-30 cm soil layer of Kapychay village is 1.94% below the norm, and in the 30-60 cm layer, 5.01% is above the norm. This is basically ascribed to topsoil degradation, excessive leaching and soil utilize in the area. The amount of humus in the 0-30 cm soil layer of Lakit village is 5.43% higher than the norm. The soil sample obtained from both places was evaluated as granular clay soil.

## 6 Conclusion

As a result of climate change, the area of some plants in the forests has decreased, and some species have completely changed their habitats. According to research, the Gakh forest is assessed as a forest of different ages (young, middle-aged, mature or old species). No old tree species have been found. It is advisable to include such species as Acer L., Fagus L., Quercus L. in the absolutely dominant group of trees, and Ulmus L., Carpinus L. in the dominant group of trees. The forest type is assessed as a complex forest. In this case, it is advisable to name the complex forest type consisting of such species as 6A4P+V+F+G (60% birch (maple), 40% oak, hornbeam, beech, ash (fraxinus)).

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