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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECOLOGICAL AND PHYTOMELIORATIVE ASSESSMENT OF VEGETATION OF CONTAMINATED AREAS OF GANJA AND ITS OUTSKIRTS

Specialty: 2417.01 – "Botany"

Field of science: Biology

Applicant: **Ulviyya Tarlan Mahmudova**

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The dissertation work was carried out at the Department of Botany of Ganja State University.

Scientific supervisor: Doctor of Biological Sciences, Professor, Corresponding member of ANAS, Honored Scientist
Vagif Seyfaddin Novruzov

Official opponents: Doctor of Biological Sciences, Professor, Corresponding member of ANAS
Novruz Mahammad Guliyev

Doctor of Biological Sciences, Professor
Elman Osman Isgandar

Doctor of Philosophy in Biology, Associate Professor
Rana Tahmazovna Abdiyeva

Dissertation council of ED1.26 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Institute of Botany, Ministry of Science and Education of the Republic of Azerbaijan.

Chairman of the Dissertation Council: Doctor of Biological Sciences, Professor
Sayyara Jamshid Ibadullayeva

Scientific secretary of the Dissertation Council: Doctor of Philosophy in Biology, Associate Professor
Arzu Yusif Huseynova

Chairman of the scientific seminar: Doctor of Biological Sciences, Professor
Eldar Novruz Novruzov

GENERAL CHARACTERISTICS OF WORK

Relevance and degree of development of the topic:

In order to prevent the degradation of the ecological situation in the modern stage of scientific and technological progress and socio-economic development, especially in the regions where large industrial enterprises pollute the environment with phytotoxic wastes as a result of human activities, the study of the vegetation cover of these areas, the detection of pathological conditions in plants, the identification of resistant plants to the contaminated environment, their use for the improvement and optimization of the environment are among the most topical issues facing modern biological science. [1]

As we know, it is impossible to develop scientifically substantiated measures for the protection, efficient use and restoration of vegetation without a thorough study of its species composition and structure. Like other areas affected by anthropogenic impacts, the phytocenoses formed in the area under study have been exposed to natural factors and anthropogenic factors for many years. In particular, as a result of anthropogenic factors, there have been significant changes in species composition, areal of vegetation, structure and productivity of phytocenoses.[2]

A number of industrial facilities, scientific-educational, cultural institutions, etc. locate in the area. Therefore, the city of Ganja and its outskirts are subject to intense anthropogenic pressures, vegetation is destroyed. OneTPP (Thermal Power Plant) operates in Ganja. TPPs pollute the environment because they run on fuel. Ganja has a metallurgy plant operating with iron ore in Dashkasan, an aluminum plant, an automobile plant (various cars, trucks, tractors and garbage trucks are produced), and a carbide plant. Abundance of natural construction materials in Ganja-Gazakh economic-geographical region led to the establishment of Ganja construction integrated plant and Shamkir stone

[1] Məmmədov, Q.Ş. Ekologiya, ətraf mühit və insan / Q.Ş. Məmmədov, M.Y. Xəlilov, - Bakı: Elm, - 2006. - s. 193-194.

[2] Новрузов, В.С., Байрамова, А.А. Проблемы сохранение биоразнообразые природных и антропогенных екосистем Южного Кавказа // Материалы Первого Международного Симпозиума, - Телави: - 2012, - с. 130-133.

quarries. In these enterprises, a number of chemicals, dyes and varnishes are used and released into the environment without control.

Taking into account the urgency of the problem, the dissertation work on "**Ecological and phytomeliorative assessment of vegetation of contaminated areas of Ganja and its outskirts**" has been implemented.

Object of research. The object of research was plant samples taken from ecologically contaminated areas.

Aims and objectives of the research: The main purpose of the researchis the implementation of phytomeliorative measures in orderto study the vegetation cover of the contaminated areas of Ganja city and its outskirts (Goranboy, Goygol, Samukh), the adaptations that occur in plants, to classify plants and to restore endangered flora.

In order to achieve the set goal, the following tasks were considered important:

- ✓ Identification of the main anthropogenic factors affecting the vegetation cover (within 10 km);
- ✓ Determination of modern flora and bioecological features of areas exposed to anthropogenic factors;
- ✓ Determination of succulents in the vegetation cover as a result of chemical and mechanical effects;
- ✓ Study of bioecological features of plants in ecologically contaminated areas in comparison with plants in Gulustan settlement, which is considered to be relatively ecologically clean;
- ✓ Investigation of the dependence of the intensity of photosynthesis in plant leaves on environmental factors, including anthropogenic-man-made pollution;
- ✓ Comparison of morphophysiological traits of plants in contaminated areas with normal plants;
- ✓ Physicochemical analysis of soil samples taken from ecologically contaminated areas;
- ✓ Elemental analysis of some plants in ecologically contaminated areas;
- ✓ Development of scientifically based applied recommendations for the optimization of ecologically contaminated areas and restoration of vegetation cover.

Research methods. The study was carried out in route and

stationary, semi-stationary, chamber-laboratory and laboratory conditions. At the same time floristic, floristic-systematic, areological, botanical-geographical, phytocenological, statistical methods were taken into account. Coenopopulations of some species were assessed on the basis of delta-omaga criteria. Absorbed ammonia was determined in soil samples taken by TFK-2 photocolorimeter. The spectra of chlorophyll fluorescence radiation on leaves, as well as the excitation spectra, were captured by the Cary Eclipse spectrophotometer.

The main provisions submitted for defense:

1. As a result of research and analysis of literature, for the first time a conspectus of the flora of ecologically contaminated areas of Ganja city and its outskirts has been compiled.
2. Classification of vegetation on the basis of parameters was given by determining the species composition and structure of phytocenoses, successions occurring in phytocenoses as a result of chemical and mechanical influences were identified.
3. A system of phytomeliorative measures of ecologically contaminated areas of Ganja city and its outskirtshas been developed.

Scientific novelty of the work: For the first time, the biological traits of plants growing in ecologically contaminated areas of Ganja city and its outskirts were studied in detail. The response of plants belonging to 68 families, 244 genera and 441 species in the area to pollution was studied. Thus, due to the effects of environmental pollution, plants continue to live under stress. In parallel with anthropogenic-man-made pollutants, plants are directly affected by high and low temperatures, drought, harmful gases emitted by automobiles, soil salinization, high intensity light, etc. Under the influence of toxic substances, photosynthesis in plants is weakened, and most of the energy absorbed from the sun is released into the environment in the form of fluorescent radiation. This, in turn, affects the development of plastids, the efficiency of photosynthesis, overall metabolism, and leads to poor plant growth. Chemical analysis of plant ash in contaminated areas shows that most of the chemicals present in the area accumulate in plant organs. As a result, any stress creates free radicals in plants. This, in turn, causes the plant to stop growing.

The practical significance of the work. The inventory of flora consists of an assessment of the condition of vegetation cover of areas

under the anthropogenic impact of industrial enterprises.

In general, the materials of the dissertation are suitable for use in the compilation of textbooks on the teaching of botany and ecology, as well as in the planning and implementation of landscaping of ecologically contaminated areas, laying of field protection strips.

The main provisions to be defended can be used to improve the current state of vegetation cover of ecologically contaminated areas of Ganja and its outskirts and to develop methods of restoration.

Approbation and application. The work has been discussed at the International Scientific Conference of Young Scientists and Researchers on "Innovation Problems of Modern Biology" on the occasion of the 90th anniversary of academician Z. Aliyeva (Baku, BSU, 2013), XVIII Republican Scientific Conference of PhD students and Young Researchers, the Scientific Conferences on "Modern Problems of Chemistry and Biology" (Ganja, 2014-2016), IV Republican Scientific Conference on "Actual problems of ecology and soil science in the XXI century" (Baku, 2015),scientific conferences of professors, PhD students and young researchers of Ganja State University (Ganja, 2011-2014), The XIV İnternational Scientific Symposium "A person in History" (Turkey, 2021) Scientific Conference, the enlarged meeting of the Department of Botany, seminar and Scientific Council of the Institute of Botany of ANAS.

Publication. On the basis of research materials, 14 papers reflecting the main provisions of the dissertation have been published.

The organization where the dissertation work is carried out. The dissertation work was carried out at the Department of Botany of Ganja State University, Nano-research scientific laboratory of Baku State University, ecology department of Ganja Aluminum Plant, "Crystallography" laboratory of the Institute of Physics of ANAS.

Structure and scope of work. Dissertation work covers 185 pages consisting of introduction, 6 chapters, conclusion, recommendations, bibliography with 201 titles and appendices. The dissertation consists of a total of 260,045 symbols: introduction-9480, chapter I-17526, chapter II-14244, chapter III-12274, chapter IV-20674, chapter V -89432, chapter VI-15882, conclusions-4201, recommendations-1764. The literature list has 201 names, 72 are Azerbaijani, 78 are Russian, and 51 are foreign sources. The work contains 1 map, 13 schemes, 25 tables and 28 figures.

I CHAPTER. NATURAL GEOGRAPHICAL CHARACTERISTICS OF THE ECOLOGICALLY CONTAMINATED AREAS OF GANJA AND ITS OUTSKIRTS

The chapter presents the characteristics of the natural and geographical conditions of the study area. Geographical location, climatic conditions, soil cover, vegetation cover of the study area have been analyzed.

II CHAPTER. HISTORY OF STUDYING FLORA AND VEGETATION COVER OF GANJA AND ITS OUTSKIRTS (LITERATURE REVIEW)

The flora and vegetation cover of Ganja and its outskirts have been studied for many years, mainly in connection with the development of animal husbandry and for various purposes. Since the study area belongs to the North-Eastern part of the Lesser Caucasus, reference has been made to the scientific works of many scientists who conducted scientific research in the area, and a special place is given to the analysis of the data.

III CHAPTER. MATERIAL AND METHODOLOGY OF STUDY

The studies were conducted in ecologically contaminated areas and background areas in Ganja and within 10 km of its outskirts in 2011-2018.

The object of study was the vegetation cover in ecologically contaminated areas with large industrial facilities such as the Aluminum Plant, Gaj Plant, Brick Plant, Bentonite Clay Plant, Concrete Plant, Asphalt Plant, etc. which extremely pollute Ganja and its outskirts (Goranboy, Goygol, Shamkir, Samukh) with toxic substances.Experimental studies were conducted mainly in Ganja, as well as in Goranboy, Goygol and Samukh within a 10-kilometer distance that could be affected by technogenic pollution sources. The study was carried out in route and stationary, semi-stationary, chamber-laboratory and laboratory conditions.

Collected herbarium samples were given to the herbarium fund of the Department of Botany of Ganja State University and the Institute of Botany of ANAS. During the determination the books "Conspect Flora of

Caucasus"[3], "Conspect of Azerbaijan's flora"[4] have been used; geographical and areal types have been determined according to A.A. Grossheim,[5] N.N. Portenier;[6] phenological observations according to D. Brown;[7] endemic, rare and endangered plants according to the Red Book of Azerbaijan. At the same time the protection status of rare species has been determined in accordance with the IUCN Red List Categories & Criteria.[8,9]

Principles and methods developed by T.A. Rabatnov[10], A.A. Uranov[11] were used in coenopopulation studies.Classification of the type of coenopopulation was given on the basis of the principles of L.A. Jivotovskiy (w)[12].

Absorbed ammonia (by D.P. Konev method), nitrate (by Grandval-Lyasu method), mobile phosphorus (by B.P. Machigin method) were determined in TFK-2 photo colorimeter instrument in the taken soil samples. Exchangeable potassium was determined (by P.B. Protasov method, by looking at blazing photometer at 1% ammonium carbonate).[13]

To determine the substance content of the samples taken from the area XRD D2 PHASER (GERMANY, BRUKER) - X-ray diffractometer instrument was used.

The spectra of chlorophyll fluorescence radiation on leaves, as well

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[3] Конспект Флора Кавказа I, II, III 2012 год ст. 624

[4] Əsgərov, A.M. Azərbaycan florasının konspekti / A.M. Əsgərov. – Bakı: 2010, - 183 s.

[5] Гроссгейм, А.А. Анализ флоры Кавказа /А.А.Гроссгейм. -Баку: АзФАН СССР, - 1936. - 256 с.

[6] Портениер, Н.Н. Система географических елементов флоры Кавказа // - Москва: Ботанический журнал, - 2000. №9, - с. 26-33.

[7] Браун, Д. Методы исследования и учета растительности // - Москва: Наука, - 1957. - с. 38-47.

[8] Azərbaycan Respublikasının Qırmızı Kitabı Nadir və nəsli kəsilməkdə olan bitki və göbələk növləri / İkinci nəşr. - Bakı: Şərq-Qərb nəşriyyatı, - 2013. - 676

[9] IUCN Red List Categories & Criteria: (2003). Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland & Cambridge: UK. ii + 30 p.

[10] Работнов, Т.А. Вопросы изучения состава популяции для целей фитоценологии // - Москва:Проблемы ботаники, - 1950. №1, - с. 461-483.

[11] Уранов, А.А. Онтогенез и возрастной спектр популяций цветковых растений // Москва: Наука, - 1967. - с. 3-8.

[12] Животовский, А.А. Онтогенетические состояния, эффективная плотность и классификация популяций растений // Москва: Экология, - 2001. № 1, - с. 37.

[13] Granat, L. A global atmospheric sulphur budget. In: Nitrogen, Phosphorus and Sulphur - Global Cycles // SCOPE Rep. 7. Ecol. Bull. (Stockholm), - 1976. №22, - p. 102-122.

as the excitation spectra, were captured by the French Cary Eclipse spectrophotometer (Varian Inc., Les Ulis, France).[14] Wheat and corn were germinated and analyzed under the laboratory condition in soil with added pollutants.

EXPERIMENTAL PART
IV CHAPTER. FLORA OF GANJA AND ITS OUTSKIRTS

4.1.Systematic structure. Samples of herbariums collected during the study conducted in 2011-2018 were identified on the basis of determinants and literature data and 441 plant species belonging to 70 families, 241 genera were determined (Table 1). This makes up 8.7% of the flora of Azerbaijan (5,000 plant species) and 6.3% of the Caucasian flora (7,000 plant species)

Table 1.

Systematic structure of the flora of Ganja and its outskirts

№	Plant	Families		Genera		Species	
	Groups	Number	By total number, %-lə	Number	By total number, in %	Number	By total number, in %
1	Sporophytes	4	5,9	5	2	8	1,8
2	Gymnosperms	3	4,4	4	1,6	8	1,8
3	Angiosperms:	61	89,7	235	96,3	425	96,4
	a)monocotyledons	9	13,2	51	20,9	82	18,6
	b)dicotyledons	52	76,5	184	75,4	343	77,8
	Total:	68	100	244	99,9	441	100

Leading families of the flora of Ganja and its outskirts *Poaceae* Barnhart is represented by 38 genera (15,6%), 63 species (14,3%),

[14] Bidel et al. Responses of epidermal phenolic compounds to light acclimation: In vivo qualitative and quantitative assessment using chlorophyll fluorescence excitation spectra in leaves of three woody species // - Gain: Journal photochemistry and photobiology Biology, 2007. №88.3, - p. 163-79.

Fabaceae Lindl. by 23 genera (9,4%), 48 species (10,9%); *Asteraceae* Dumort by 15 genera (6,6%), 35 species (7,9%) *Brassicaceae* Burnett by 13 genera (5,3%), 18 species (4,1%); *Rosaceae*with 14 genera (5,7%), 27 species (6,1%); *Lamiaceae* Lindl. by 11 genera (4,5%), 21 species (4,8%); *Caryophyllaceae* Juss. by 10 genera (4,1%), 23 species(5,1%). Other families consist of 1-5 genera, 1-5 species. There are such genera with low numbers (*Juniperus* L., *Ephedra* L., *Cynodon* Rich., *Bromus* L., *Hordeum* L., *Salsola* L., *Polygonium* L., *Salsola* L., *Cydonia* Hill., *Peganum* L., *Tamarix* L.), which are also of great importance in the formation of vegetation type, aspect in their distribution areas.

Table 2.

Genera represented by more species in the flora of Ganja and its outskirts

No.	Genera	Number of species	In% by number of species
1	Avena L.	4	0,91
2	Poa L.	5	1,12
3	Hordeum L.	4	0,91
4	*Cerastium L.*	5	1,12
5	*Dianthus L.*	4	0,91
6	*Papaver L.*	5	1,12
7	Medicago L.	5	1,12
8	*Melilotus*Hill.	4	0,91
9	*Astragalus* L.	6	1,4
10	*Vicia* L.	5	1,12
11	*Euphorbia L.*	5	1,12
12	*Convolvulus L.*	4	0,91
13	*Teucrium L.*	4	0,91
14	*Salvia L.*	4	0,91
15	*Solanum L.*	4	0,91
16	*Verbascum L.*	4	0,91
17	*Plantago L.*	4	0,91
18	*Valerianella*	5	1,12
19	*Artemisia* L.	6	1,4
20	*Cirsium* Hill	4	0,91
21	*Taraxacum* Wigg.	4	0,91
	Total:	95	21,5 (from 441 species)

As can be seen from Table 2, the number of genera represented by the most species in the study area is 21, and the number of species is 95. This makes up 21.5% of the flora of Ganja and its outskirts. Other species combine in 220 genera and make up 78.5% of the flora (346 species). In particular *Astragalus* L. (6; 1,4%), *Artemisia* L. (6; 1,4%), *Poa L.* (5; 1,12%), *Cerastium L.* (5; 1,12%), *Papaver L.* (5; 1,12%), *Medicago L.*(5; 1,12%), *Vicia* L. (5; 1,12%) and etc.with the largest number of species in terms of the number of species in the floristic composition are numerically predominant.

4.2.Biomorphological analysis. Biomorphological analysis of the study area was conducted

As a result of the analysis of the flora of the study area, it was determined that perennial herbs in its composition predominate with 194 species (44%) (Table 3.). Due to the large number of species, the next place is occupied by annual-biennial herbs with 164 species (36.5%), of which 137 species are annuals, 21 species are biennials, and 6 species are annuals and biennials. In the flora of Ganja and its outskirts trees are represented by 24 species (5,4%), trees-shrubs by 3 species (0,7%), shrubs by 43 species (9,8%), shrub-trees by 1 species (0,2%), semi-shrubs by 11 species (2,5%), as well as low shrubs by 1 species (0,2%).

Table 3.

Life forms of plants in the flora of Ganja and its outskirtsaccording to I.G Serebryakov (1964)

№	Life forms	Number of species	Total number of species, in %
1.	Trees	24	5,4
2.	Tree-shrubs	3	0,7
3.	Shrubs	43	9,8
4.	Shrub-trees	1	0,2
5.	Subshrubs	11	2,5
6.	Small shrubs	1	0,2
7.	Perennial herbs	194	44
8.	Annual and biennial herbs	164	37,2
	Total:	441	100

Depending on the morpho-biological characteristics of the plants found in the flora of the area and the degree of pollution of the area, the plants have different life forms. From this point of view, C. Raunkiaer's

classification was considered as the main criterion and biomorphological analysis of higher plants distributed in the study area was carried out.

Table 4

Biomorphological (life forms) analysis of plants in the flora of Ganja and its outskirts (according to Raunkiaer)

№	Life forms	Number of species	Total number of species, in %
1.	Phanerophyte	64	14,5
2.	Chamaephyte	15	3,4
3.	Hemicryptophytes	229	51,9
4.	Cryptophyte	10	2,3
5.	Therophyte	123	27,9
	Total:	441	100.0

As can be seen from the Table (4), when analyzing the species of flora by life forms, hemicryptophytes predominatewith 229 species (51,9%); therophytes are represented by 123 species (27,9%) and cryptophytes by 10 species (2,3%), phanerophytes by 64 species (14,5%) and chamaephytes by 15 species (3,4%).

4.3.Geographical analysis. During the study, the geographical types, areal classes and types of plants belonging to the flora of the area were determined according to the latest system.

Table 5.

Analysis of species in the flora of Ganja and its outskirts by areal types

No.	Arealtypes	Number of species	Total number, in %
1	Ancient (III period forest)	13	3
2	Boreal	146	33,1
3	Steppe	26	5,9
4	Ancient Mediterranean	158	35,8
5	Caucasus	72	16,3
6	Adventive	11	2,5
7	Desert	7	1,6
9	Cosmopolite	1	0,2
10	Undefined	7	1,6
	Total:	441	100

As can be seen from Table 5, species belonging to the Ancient Mediterranean (35,8% with 158 species), Boreal (33,1% with 146 species) and the Caucasus (16,3% with 72 species) areal type predominate in the formation of species in the flora of Ganja and its outskirts. Other areal types are less numerous: adventive is represented by 11 species, 2,5%, Ancient (III period forest) areal type by 13 species, 2,9%, steppe by 26 species, 5,9%, desert by 7 species, 1,6%. The areal type of 7 species (1,6%) has not been determined. It should be noted that the analysis of the species distributed in the study area by geographical elements showed that the species belonging to the ancient Mediterranean areal type have a special role in the formation of flora.

4.4. Ecological analysis. Due to the need of plants for water and drought, the species composition of the flora of Ganja and its outskirts was referred to the ecological groups of xerophytes, mesophytes, mesoxerophytes, hydrophytes and halophytes (Table 6).

Table 6.

Analysis of the flora of Ganja and its outskirts by ecological groups

Ecological groups	Number of species	Total number of species, in %
Xerophytes	247	56
Mesoxerophytes	119	27
Mesophytes	67	15,2
Hydrophytes	7	1,6
Halophytes	1	0,2
Total:	441	100

As can be seen from the table, xerophytes - plants (56 %with 247 species) that tolerate high and long-term heat and drought predominateaccording to ecological groups.It should be noted that xerophyte plants are also of special importance in the formation of vegetation. Mesoxerophytes occupy the second place in the study area with 119 species (27%). Species belonging to this ecological group were formed as a result of xerophytization of plants growing in places with a lack of moistureover a long historical period. This makes up 27% of the flora (119 species). In

addition, mesophytes are represented by 67 species (15,2%), hydrophytes by 7 species (1,6%), halophytes by 1 species (0,2%).

4.5. Endemism. As a result of our study, 10 species Azerbaijan endemics were found in the flora of Ganja and its outskirts. This makes up 2.5% of the area's flora. Two of them are endemic to Azerbaijan (*Alchemilla raddeana* (Bus.) Juzz., *Euphorbia ledebourii* Boiss.), 8 species are subendemicsto Azerbaijan (*Cotoneaster saxatilis* Pojark, *Salsola nodulosa* (Moq.) İljin, *Delphium foetidum* Lamak, *Medicago caucasica* Vass., *Cirsium szovitsii* (C. Koch) Boiss., *Centarium umbellatum* Gilib., *Trapogon pusillus* Bieb., *Taraxacum desertorum* Schischk.). *Asteraceae* (2 species) predominates in the study area by families according to the number of endemic species.

V CHAPTER. MODERN STATUS OF VEGETATION OF ECOLOGICALLY CONTAMINATED AREAS OF GANJA CITY OUTSKIRTS

5.1. Geobotanical assessment of vegetation of Ganja city outskirts

For the modern vegetation of the area, 5 vegetation types, 11 formation classes, 14 formation groups, 49 associations have been identified, and their taxonomic classification has been compiled and described.

There are a number of perennial, annual and biennial plants in the formation of specific vegetation cover of the study area, which are found in different types of vegetation

Ephemeral group which includes brome grass (*Bromus yaponicus* Thunb.), rubens anisantha (*Anisanta rubens* (L.) Nevski), rigid rye-grass (*Lolium rigidum* Gaudin), Eastern Eremopyrum (*Eromopurum orientale* (L.) Jaub. et Spach), harel barley (*Hordeum leporinum* Link), doubtful oat (*Avena clauda* Durieu.), bulbous bluegrass (*Poa bulbosa* L.) and etc. from ephemerals dominate and subdominate in the semi-desert vegetation cover of the area.

In the groups of saltwort and herbs, wild rue (*Peganum harmala* L), alhagi (*Alhagi pseudoalhagi* (Bieb.) Desv.) from late-vegetative annual herbs, fragnant wormwood (*Artemisia fragrans* Willd) and tree-like saltwort (*Salsola dendroides* Pall.*)* from subshrubs are often found in the flora composition of phytocenoses. All cenoses in the vegetation

cover have 2 and 3-layer geobotanical structure. Project cover in phytocenoses varies between 35-65% depending on environmental and anthropogenic impacts.

Detailed geobotanical study of the vegetation cover of any area provides a basis for the creation of a scientific gene pool on its modern flora and biodiversity of vegetation. Studies conducted on the vegetation cover of ecologically contaminated areas of Ganja city show that the vegetation type forming zoning in the area is desert, semi-desert, meadow, steppe. Other plant groupings that show tolerance are kochia formation *(Kochiaeta prostrata)*, noaea formation *(Noeaeta mucronatae)*, saltbush formation *(Atriplexea tatarica)*, wormwood-nodose formation *(Artemisieta fragrans-Salsolleta nodulosa)*. Observations have shown that under the influence of environmental and anthropogenic factors, succession happens in wormwood (*Artemisieta)*, ephemeral (*Ephemereta)*, alhagi (*Alhagieta)* and wild rue (*Peganate)* phytocenoses in vegetation cover, and one plant groupings is replaced by another. In the taxonomic composition of the studied phytocenoses wormwood, ephemeral, annual saltwort-ephemeral, ephemeral-wormwood, wormwood-ephemeral-alhagi groupings occupy wider areas in the area.

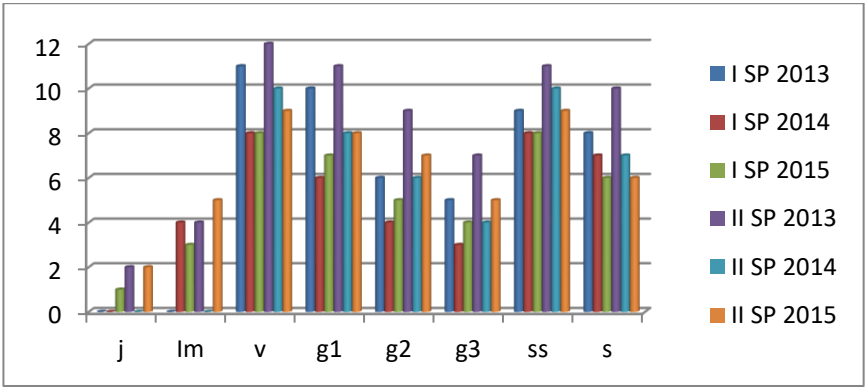
5.2.Phytocenotic assessment of some plants of Ganja city outskirt

In the current condition of increasing anthropogenic impact, the study of the species at the population level allows to clarify the reaction to abiotic, biotic and anthropogenic factors. Therefore, in order to understand the strategy of the plant, it must be approached comprehensively, studied at the level of coenopopulation. At present, the importance of coenopopulation study for the efficient use of rare and economically valuable plants, the restoration of natural phytocenoses and the creation of agrophytocenoses is irreplaceable.

During our study, species coenopopulations were also studied to determine the interaction between vegetation and environmental factors.Because environmental factors have a positive or negative effect on the ontogenesis of a species, they develop signs of adaptation to different conditions. As a result, it leads to the development or complete extinction of this species in the population.The study of the age and quantity composition of the coenopopulation, which is generally considered to be the structural unit

of plant groups, provides information about the past, present and future state of the species in the cenosis, and the life cycle in general. Development dynamics, age and efficiency, recovery and replacement indices, viability of the studied species were determined.

Coenopopulations of *Perenum harmala* L.- wild rue were identified in the plant formation of wormwood semi-deserts (Artemisietum) and were studied in *Artemisietum incana–Stiposum lessingiana* (Lessing feather grass –fragnant wormwood) association, *Alhagieta psedoalhagi–Ephemeretosum-Salsoletum dendroides (*ephemeral–tree-like saltwort-alhagi) association in 2013-2015 years. The study areas cover the contaminated areas of Ganja and Samukh region.



Diag.1. Development dynamics of *Peganum harmala* L. species in different plant associations for 2013-2015

As can be seen from the diagram (diag.1.) nine ontogenetic age conditions were identified in the ontogenesis of *Peganum harmala* L. species. The development of this species was not the same for 2013-2015 years. No juvenile and immature individuals were found in CP I in 2013, in CP II in 2014; and no juvenile individuals were found in CP I in 2014. Poor development of juvenile and immature individuals in the spectrum, low seed productivity, high number of subsenile and senile individuals are the main indicators of the delay in the development of the species.As a result, population fragmentation was observed, invasive-type populations were observed, and unequal conditions were identified.

As can be seen from Table (7.), an old coenopopulation type was

observed in CP I in 2013 (Δ-ω=0,56-0,61), and CP II in 2014 (Δ-ω=0,56-0,56) in *Peganum harmala* L. species. This is due to the poor development of juvenile and immature individuals, and the predominance of subsenile and senile individuals. This is an indication of the unsatisfactory future state of the coenopopulation. Other types of coenopopulation were transitional type(Δ=0,46-0,53; ω=0,53-0,56). It should also be noted that the majority of generative individuals were found only in CP II in 2013. In other years, it has developed at a low level. Such a low level of phytocenological status of *P. harmala* species in the study area will lead to a decrease in reserves in the future.

Table7.

Assessment of coenopopulations of *Peganum harmala* L.species

CP	CP type	Years	Ontogenetic age condition, in%								Indexes			
			j	im	v	g_1	g_2	g_3	ss	s	I_b	$I_ə$	Δ	□
I CP	Old	2013	-	-	22,4	20,4	12,2	10,2	18,4	16,3	0,5	0,3	0,56	0,61
	Transition	2014	-	10	20	15	10	7,5	20	17,5	0,9	0,4	0,51	0,53
	Transition	2015	2,4	7,1	19	16,7	11,9	9,5	19	14,3	0,7	0,4	0,50	0,53
II CP	Transition	2013	3,0	6,1	18,2	16,7	13,4	10,6	16,7	15,1	0,8	0,4	0,53	0,54
	Old	2014	6,25	-	20,8	16,7	12,5	8,3	20,8	14,6	0,7	0,4	0,56	0,56
	Transition	2015	3,9	9,8	17,6	15,7	13,7	9,8	17,6	11,8	0,8	0,4	0,46	0,53

In addition, the coenopopulations of species *Polygonum percicaria, M. Sativa* L., *Pinussylvestris* were comparatively studied between ecologically contaminated and clean areas. The ontogenesis of species *M. sativa* L. is not the same in the study areas. No juvenile individuals were found in the *Alhagieta psedoalhagi–Ephemeretosum-Salsoletum dendroides* associations in 2012-2013 and 2016 years. The number of individuals with generative age was low, and the number of individuals with subsenile (ss) and senile (s) was high. In this association no virginile and individuals in fruit and seed formation stages were observed in 2016. The development of species in *Glycyrrhizetum glabrae* association was normal. In *Alhagieta psedoalhagi–Ephemeretosum-Salsoletum dendroides* association only

transitional type was observed in 2015 (Δ–ω=0,54–0,45), others are old type (Δ-ω=0,56–0,51). In *Glycyrrhizetum glabrae* association, old in 2012 (Δ-ω=0,66–0,42), young in 2013-2014 (Δ-ω=0,34–0,55; Δ-ω=0,34–0,61), and transitional type in 2015-2016 (Δ-ω=0,44–0,57; Δ-ω=0,48–0,48) were observed and the area is considered normal for species development.

For the first time, we have studied the coenopopulations of *P. sylvestris*, which grow naturally in the contaminated areas, and assessed their viability. 12 sample plots (100 m^2) were established in the studied plant groups. Vegetation cover of the study area was also taken into account. The study of *Pinus sylvestris*-coenopopulations was conducted in July 2014.

Juvenile, immature, virginil, generative, subsenile and senile trees in the area were identified on the basis of morphometric indicators, coenopopulations were analyzed.

As a result of the study it was found that the development of *Pinus sylvestris* was low in the early stages of succession in contaminated areas. As a result of the deterioration of development conditions, a decrease in the density of the tree's umbrella and rapid shedding-defoliation of coniferous leaves, loss of the natural color of the umbrella-dechromation were observed. Studies have shown that latent fluctuations in trees of different ages depend on environmental and cenotic stresses. The number of severely weakened and dried trees in the study area (more than 50%) exceeded the total number of trees. In general, the response of the composition of the population of the species to environmental, anthropogenic, man-made influences on the environment is a key indicator of biological processes.

5.3.Monitoring of vegetation cover

5.3.1.Physical and chemical characteristics of soils near Ganja Aluminum Plant

Absorbed ammonia, nitrate, mobile phosphorus, exchangeable potassium were determined in the taken soil samples.

EC (electrical conductivity) was measured. The pH of soil samples was determined. KCl, NaCl, and total salinity (total dissolved solids — the sum of active anions and cations) were measured. The results of the measurements are given in Table 8.

Table 8.

Degree of provision of soils based on gradation

Sample No.	Sample name	pH	Degree of provision of soils based on gradation			EC (d/m S)	KCl (ppm)	Total salinity (mS)	NaCl (ppm)
			Nitrogen 40-120 mg/kg	Phosphorus15-60 mg/kg	Potassium300-600 mg/kg				
			Sample provision indicator						
			Nitrogen N/NH_4 mg/kg	Phosphorus P_2O_5 mg/kg	Potassium K_2O mg/kg				
1	Control sample	7.54	20.34	45.00	155.44	0.27	53.0	104	48.9
2	Red mud of Ganja Aluminum Plant	8.07	9.48	23.33	114.47	4.32	781	1540	782

Elemental analysis of the red mudsample revealed that it contained O, Fe, Al, Si, C, Ca, Mg, Na,K, P,Cl, S, V, Ti elements (Figure No.1. and Figure No.2).

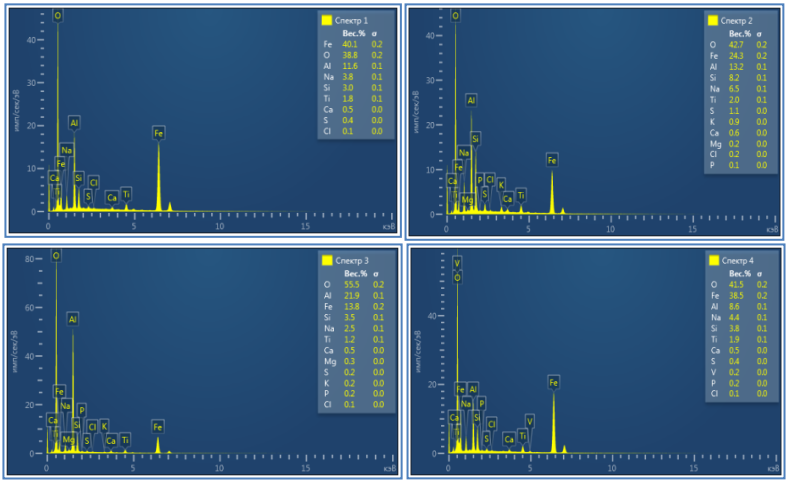


Figure.1. Results of elemental analysis of red mud sample 1,2,3,4

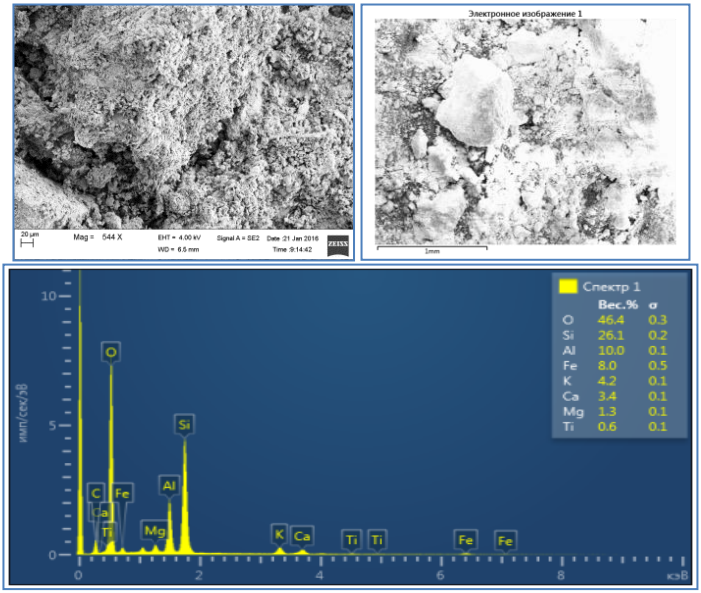


Figure 2. View of the control soil sample under the SEM microscope, the results of elemental analysis

The results of the study show that main chemical components of the red mud released during the production of Al_2O_3 from alunite and bauxite ores at the Ganja Aluminum Plant for many years consist of Al_2O_3, SiO_2, Fe_2O_3, CaO, TiO_2,Na_2O, K_2O and MgO oxides and small components of various complex compounds.[15] From elemental analyses of the red mud sample it is found out that it has O, Fe, Al, Si, C, Ca, Mg, Na, K, P, Cl, S, V, Ti in the composition. Based on the diffraction spectra of X-ray diffractometric analysis, we can say that the samples contain crystals with complex structures. Red mud containing these complex substances and elements can be economically valuable, as well as pose a serious threat to the environment (Figure No. 3.).

[15] Mahmudova Ü.T., Xəlilov R.İ. Gəncə Alüminium zavodu yaxınlığında torpaqların fiziki-kimyəvi xarakteristikası // GDU, "Müasir biologiyanın və kimyanın aktual problemləri" mövzusunda Elmi Konfransının materialları. 12-13 may, III hissə. Gəncə, 2016. s. 71-75

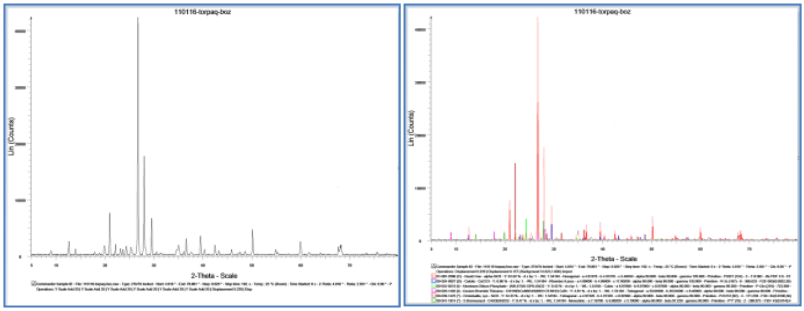


Figure 3. Diffraction spectrum of ecologically clean soil sample

5.3.2.Results of chlorophyll fluorescence radiation on the leaves of some plants collected from the area

In order to determine the chlorophyll fluorescence radiation of leaves, leaves of *Pinus sylvestris* - ordinary pine, *Peganum harmala* – wild rue, *Armoricia rusticana* - mustard, *Polygonum percicaria* - lady's thumb, *Medicago sativa* - alfalfa were used as the object of study in experiments. The plant samples used in the experiments were mainly taken from the areas near the aluminum plant.

In the initial experiments, chlorophyll fluorescence spectra were obtained from the leaves of wild rue and pine trees growing in ecologically normal areas, and their absorption-dependent characteristics were determined.

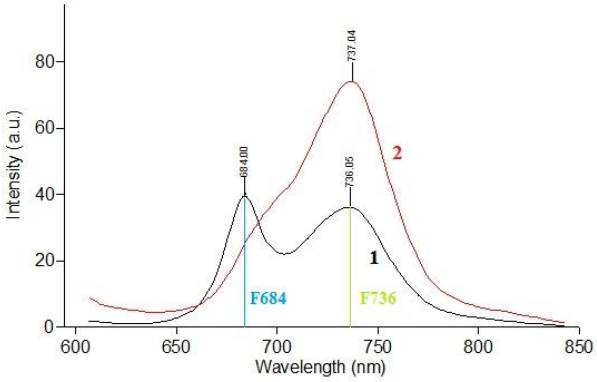


Figure 4. Chlorophyll red fluorescence spectra in the leaves of the wild rue. 1- on leaves taken from ecologically normal areas; 2 - on leaves taken from a relatively contaminated area.

Two peaks, 684 nm and 736 nm, characteristic to the spectrum of red chlorophyll fluorescence radiation, captured on the leaves of wild rue collected from the areas, which are considered to be ecologically normal and from relatively contaminated areas, were obtained. In Figure 4, the radiation spectra on the leaf of wild rue are captured on samples collected from the areas that are considered ecologically normal and (2) from relatively contaminated areas. The peak with 684 nm wavelength observed in red chlorophyll fluorescence radiation (1) was not observed in leaves (2) taken from a relatively contaminated area. However, the peak intensity with 736 nm wavelength (1) was significantly increased in leaves collected from relatively contaminated areas (2). The F684/F736 ratio was 1.05 for the first spectrum and 0.45 for the second spectrum. The same spectrum was captured on the leaves of pine trees growing under normal conditions and in relatively contaminated areas. Two peaks, 684 nm and 736 nm, which are also characteristic of the spectrum of red chlorophyll fluorescence radiation captured on the leaves of pine treescollected from the areas considered ecologically normal and from relatively contaminated areas, were obtained. The intensity of these peaks differed from the intensity of the peaks obtained on the leaves of wild rue.

The ratio of F684/F736 in pine leaves taken from areas considered ecologically normal was 1,5, and 0,48 in samples taken from relatively contaminated areas.[16]

The fluorescence spectra captured on the leaves of plants growing in areas that are considered to be very contaminated differ sharply from those of plants growing under normal conditions.Thus, both peaks, 684 nm and 730 nm underwent significant changesin the chlorophyll red fluorescence spectrum in the leaves of plants growing in the contaminated area. The nature of the spectrum has also changed. (Figure 5.) As can be seen, the F684/F736 ratio was much higher in plants growing under normal conditions. Thus, it should be noted that fluorescence spectra captured with a fluorometer vary significantly in trees growing in ecologically contaminated areas compared to trees growing under normal

[16] Mahmudova Ü.T., Novruzov V.S., Ahmadov I.S., Khalilov R.I. Monitoring of the ecological pollution created by Ganja Alminum plant in the surrounding areas and its impact on vegetation // Revue scientifique et technique office international des epizooties, 2018, Franco, Paris. vol.37.2, 304-314

conditions.

As a result, chlorophyll fluorescence, naturally occurring in thylakoid membranes, chloroplasts, plant tissues, and finally native leaves, is an important technique and a powerful tool for studying photochemical and non-photochemical processes.Chlorophyll red fluorescence radiation is well observed in plants under various stresses, high salinity, temperature anomalies, atmospheric pollution and low (or dark) light intensity. It is associated with the process of photosynthesis, which ensures its growth and normal existence. As a result, it can be noted that fluorescent radiation parameters can be used as a component in environmental monitoring and can be useful in risk assessment.

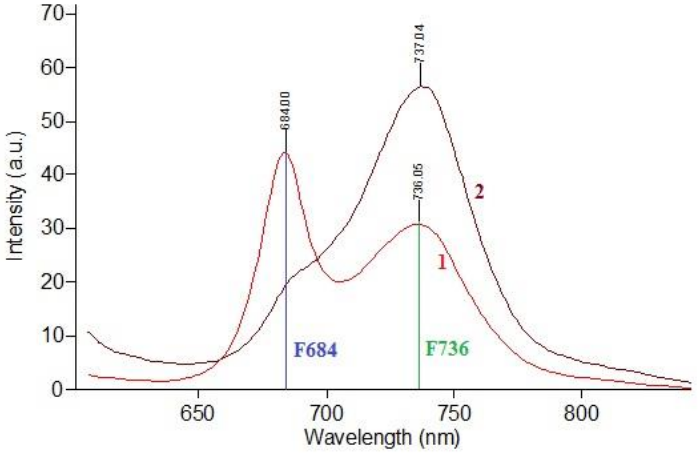


Figure 5. Chlorophyll red fluorescence spectra in the leaves of the Pine tree. 1 - on leaves taken from areas considered ecologically normal; 2 - on leaves collected from a relatively contaminated area.

5.3.3. Results of germination and growth dynamics of wheat and corn in soil with added pollutants under laboratory conditions

Under the laboratory condition, the spectra of chlorophyll fluorescence in the leaves of plants growing in soil added with different percentages of pollutants (10%, 20% , 30%, 40%, 50%, 70%, 100% pollutants)were compared with the spectra of chlorophyll fluorescence captured in the leaves of plants growing in soil taken

from non-contaminated control areas.

Fertile wheat (*triticum durum*) and Zagatala abundant crop corn seeds (*Zea mays*) and leaves were used for the experiment (Figure 6.). Two peaks, 690 nm and 735 nm,characteristic in the spectra of chlorophyll red fluorescence in the leaves of plants growing in normal control soil were obtained, and the ratio F690/F735 was determined. Based on the change in the ratio of F690/F735, the physiological condition of the plants, mainly the chlorophyll content in the leaves, was assessed.

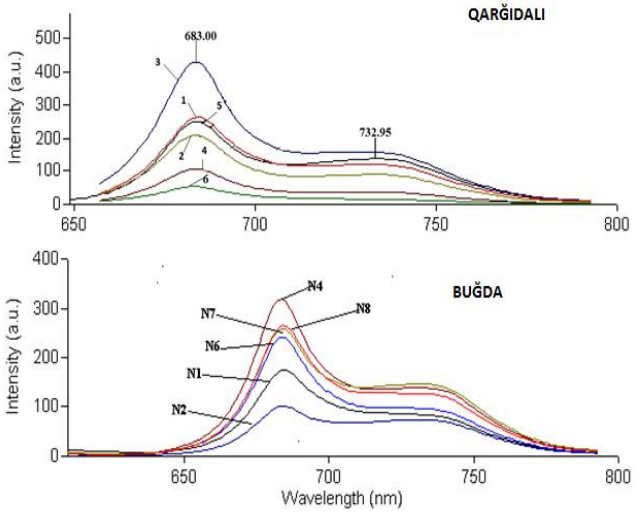


Figure 6. Fluorescence radiation on wheat and Zagatala abundant crop corn leaves

In our studies, delay in the development of these plants and decrease in photosynthetic activity under the influence of contaminants were observed. The experimental results show, first of all, that the F690/F730 ratio differs sharply when comparing the fluorescence spectrum between plants growing in contaminated and plants growing in normal areas. This indicates that some of the plants are more sensitive to environmental pollution. Plants try to maintain their chlorophyll content, regardless of the degree of pollution. However, when the level of pollution is high, the chlorophyll content in the leaves of plants changes significantly.

VI CHAPTER. IMPROVEMENT OF VEGETATION COVER AND PHYTOMELIORATIVE MEASURES IN ECOLOGICALLY CONTAMINATED AREAS

Ganja city and its outskirts have their own phytocenological and floristic features. Desert, semi-desert, steppe, type natural complexes, characterized by floristic richness and diversity, have been severely degraded. In many rare cases, landscapes, plant formations, the dominants and edificators that form them, as well as rare endemics and relics, have been virtually destroyed by human activity. Over the past half century, as a result of changes in hydrographic conditions, edaphic, physical, anthropogenic factors, the primary vegetation of Ganja has completely changed, urbanization, anthropogenic pollution, and other workshave accelerated this change. There is a danger of a complete violation of the ecological balance in the city of Ganja.

Studies show that by implementing phytomeliorative measures, these lands can be made usable and the remaining cenosis of natural floristic complexes can be protected. The strength of the dam can be increased by creating anti-erosion cenosis around the aluminum plant and along other factories. By cultivating irrigated forest strips there, it is possible to prevent filtration water, protect the surrounding (water) soils from salinization, and get high yields.

As a result of deteriorating environmental conditions in the study area, the areal of more than 45 flowering plant species has become extinct or endangered. Many of them are included in the “Red Book” of Azerbaijan [4].

Desert, semi-desert and steppe complexes in Ganja city and its outskirts should be separated as reference areas, their populations should be constantly monitored and protected at the state level.

RESULT

1. 441 species belonging to 68 families and 244 genera have been identified for Ganja city and its outskirts. *Poaceae* Barnhart (63 species), *Fabaceae* Lindl. (48), *Asteraceae* Dumort (35), *Rosaceae* (27), *Caryophyllaceae* Juss. (23), *Lamiaceae* Lindl. (21), *Brassicaceae* Burnett

(18) families predominate in the flora of areas affected by anthropogenic pollution.

2. In the flora of the study area perennial grasses are represented by 194 species (44%), annual-biennial grasses by 164 species (36.5%), trees by 24 species (5,4%), trees-shrubs by 3 species (0,7%), shrubs by 43 species (9,7%), shrub-trees by 1 species (0.2%), semishrubs by 11 species (2,5%), low shrubs by 1 species (0,2%), respectively 229 species (51,9%) are hemicryptophytes, 123 species (27,9%) - therophytes, 10 species (2,3%) - cryptophytes, 64 species (14,5%) - phanerophytes and 15 species (3,4%) - chamaephytes. The chamaephytes and cryptophytes around the city have been heavily contaminated.

3. The flora of the contaminated areas around Ganja city was analysed as per the areal types such as Ancient Mediterranean (35,8%, 158 species), boreal (146 species, 33,1%), the Caucasus (72 species, 16,3%), adventive (11 species, 2,5%), Ancient (III period forest) (13 species, 2,9%), steppe (26 species, 5,9%), desert (7 species, 1.6%). The areal type of 7 species (1.6%) has not been determined. Species belonging to the ancient Mediterranean areal type have a special role in the formation of flora.

4. In the flora of Ganja city and its outskirts, two species are Azerbaijan endemics (*Alchemilla raddeana* (Bus.) Juzz., *Euphorbia ledebourii* Boiss.), 8 species are subendemics (*Cotoneaster saxatilis* Pojark, *Salsola nodulosa* (Moq.) İljin, *Delphium foetidum* Lamak, *Medicago caucasica* Vass., *Cirsium szovitsii* (C. Koch) Boiss., *Centarium umbellatum* Gilib., *Trapogon pusillus* Bieb., *Taraxacum desertorum* Schischk.)

5. Five vegetation types, 11 formation classes, 14 formation groups, 49 associations were identified for the modern vegetation cover of the area. In contaminated areas, desert and semi-desert vegetation loses its natural features and develops only in the form of local openings. As a result of the influence of environmental and anthropogenic factors, succession happens in the phytocenoses of wormwood (*Artemisieta*), ephemeral (*Ephemereta*), alhagi (*Alhagieta*) and wild rue (*Peganate)* in the vegetation cover and one of the plant groupings is replaced by another.

6. Based on the results of the research, it was determined that the

main chemical components of the sludge (red mud) thrown around during the production of Al_2O_3 from alunite and bauxite ores at the Ganja Aluminum Plant are dominated by Al_2O_3, SiO_2, Fe_2O_3, CaO, TiO_2, Na_2O, K_2O və MgO oxides, various complex compounds, including O, Fe, Al, Si, C, Ca, Mg, Na, K, P,Cl, S, V, Ti elements.

7. Coenopopulations of some species (Peganum harmala L., Medicago sativa L., Polygonum percicaria, Pinussylvestris) growing in polluted areas and relatively less polluted areas were studied, and a regressive type of coenopopulation was found in polluted areas. Such a low level of phytocenological condition in the study area will lead to a decrease in its reserve in the future.

8. The fluorescence spectra of the leaves of the Pinus sylvestris - Scots Pine, Peganum harmala - harmel, Armoricia rusticana - horseradish, Polygonum percicaria- common persicaria, Medicago sativa - medicago sativa plants collected around the Ganja Aluminum Plant differed sharply compared to the plants growing under normal conditions, changes in the chlorophyll pigment of the leaves were detected. Delayed growth and development of plants, increased red fluorescence radiation of chlorophyll indicate that plants are in a state of stress.

9. Durum wheat (triticum durum) and Zagatala zea mays seeds taken for the experiment were cultivated in soils contaminated with sludge, and due to the influence of pollutants, a delay in the development of these plants and a decrease in photosynthetic activity was observed. The results of the experiments first of all show that the fluorescence spectrum of plants growing in polluted areas has a significantly different F690/F730 ratio compared to those growing in normal areas. Plants try to keep their chlorophyll content normal regardless of the degree of pollution, but when the level of pollution is high, the chlorophyll content in the leaves of plants undergoes significant changes

10. In order to restore and preserve the flora of areas exposed to ecological and anthropogenic influences, those lands should be made suitable by carrying out phytomeliorative measures, the remaining coenoses of natural floristic complexes should be protected, desert, semi-desert, steppe complexes in the city of Ganja and its surroundings should be allocated as reference areas, and permanent control over their populations should be organized and protected at the state level.

PRODUCTION SUGGESTIONS

1. Desert, semi-desert, steppe, floristic complexes described in the dissertation should be taken under state control as a whole, observations should be made on populations at the level of monitoring

2. Implementation of phytomeliorative measures for timely prevention of possible anthropogenic anomalies in the vegetation of Ganja city and its outskirts should be identified as an important problem.

2.1.To select trees and shrubs in accordance with the natural soil climate of the area;

2.2. To establish a forest strip in the eastern part of the sludge hill, which is a source of pollution, i.e. in the territory of Samukh region, with a width of 50 meters and a length of 2,000 meters (100,000 m2); (as can be seen from the figure below, there is no pollution on the east side, so broad-leaved oak, hornbeam, beech, ash, hawthorn, walnut can be easily grown).

2.3.To plant forests on an area 50 meters wide and 3,000 meters long (150,000 m2) consisting of Eldar pine and evergreen cypress trees that have become tolerant to pollution in the western part, i.e. in the Goranboy region.

2.4. To dig trenches 1.0-1.5 m deep and 2 m wide from north to south in the area of 126 hectares with waste, to fill trenches with fertile soil, to plant trees and shrubs such as horse chestnut, oriental plane, hackberries, tamarisk, sea buckthorns, oriental ash, acacia, etc. in the prepared areas

2.5. To cover the remaining areas on the sludge hill with soil 30 cm high. (because the surface of the waste should be moistened periodically, which uses a lot of electricity and water)

2.6. To carry out agro-technical maintenance works under irrigated conditions for 3 years to ensure normal growth of planted forest strips and trees and shrubs

The problem of efficient use, restoration and protection of vegetation cover on a biological basis in Ganja city and its outskirts should be implemented as an urgent task.

Materials on practical study of production suggestions are discussed in the relevant sections of the dissertation.

List of published scientific works on the topic of the dissertation

1. Mahmudova Ü. T. Gəncə şəhəri və ətrafının bitki örtüyünə təsir edən amillər// BDU "Müasir Biologiyanın İnnovasiya Problemləri" mövzusunda III Beynəlxalq Elmi Konfransın materialları, 7-8 may, Bakı 2013. s. 202-203
2. Mahmudova Ü. T., Əhmədov İ.S. Gəncə ətrafı ərazilərdə yayılmış bitkilərin yarpaqlarında xlorofil flüoressensiya şüalanmasının tədqiqi ilə ekoloji monitorinq// AMEA, GREM Xəbərlər məcmuəsi, №53. Gəncə, 2013. s. 29-35
3. Mahmudova Ü. T. Gəncə ətrafınının ekololoji çirklənmiş ərazilərində *Peganum harmala L., Pinus kochiana Klotzch in C.Koch* növlərinin monitorinqi// Doktorant və gənc tədqiqatçıların XVIII Respublika elmi konfransın materialları, Bakı, 2013. s. 125-127
4. Mahmudova Ü. T., Novruzov V.S. Gəncə şəhərinin ekoloji çirklənmə mənbələri və dendroflorası // Azərbaycan Aqrar Elmi nəzəri jurnal, №4, 2013, s. 98-100
5. Mahmudova Ü. T. Gəncə şəhəri və ətrafının ekoloji çirklənmiş ərazilərinin flora biomüxtəlifliyi // GDU, Elmi Xəbərlər, . Funda-mental, humanitar və təbiət elmləri seriyası. Gəncə, 2013, № 4. s. 35-39
6. Mahmudova Ü. T., Bayramov F.İ. Gəncə şəhərinin ekoloji çirklənmiş ərazilərinin aqroflorası // GDU, "Müasir biologiyanın və kimyanın aktual problemləri" mövzusun-da Elmi Konfransının materialları. 12-13 may, I hissə. Gəncə, 2014. s. 68-72
7. Mahmudova Ü. T., İsmayılova Z.M. Gəncə şəhəri ətrafının ekoloji çirklənmələrə davamlı tolerant formasiyalarının botaniki-coğrafi xarakteristikası // GDU, "Müasir biologiyanın və kimyanın aktual problemləri" mövzusunda Elmi Konfransının materialları. 5-6 may, I hissə. Gəncə, 2015. s.60-64
8. Mahmudova Ü. T. Gəncə şəhəri və ətrafının antropogen-texnogen çirklənmiş ərazilərinin monitorinqi // XXI əsrdə ekologiya və torpaqşünaslıq elmlərinin aktual problemləri- ıv resp elmi konfrans, 7-8 may, Bakı, 2015. s.142-145
9. Mahmudova Ü. T., Xəlilov R.İ.Gəncə Alminium zavodu

yaxınlığında torpaqların fiziki-kimyəvi xarakteristikası // GDU, "Müasir biologiyanın və kimyanın aktual problemləri" mövzusunda Elmi Konfransının materialları. 12-13 may, III hissə. Gəncə, 2016. s. 71-75
10. Mahmudova Ü. T., Novruzov V.S. Gəncə şəhəri ətrafının bitkiliyinin müasir vəziyyəti // AMEA, GRB Xəbərlər məcmuəsi, №72. Gəncə, 2018. s. 14-19
11. Mahmudova Ü. T., Novruzov V.S., Ahmadov I.S., Khalilov R.I. Monitoring of the ecological pollution created by Ganja Alminum plant in the surrounding areas and its impact on vegetation // Revue scientifique et technique office international des epizooties, 2018, Franco, Paris. vol.37.2., 304-314
12. Mahmudova Ü. T. Gəncə ətrafındakı bitki örtüyünün geobotaniki tədqiqi // Peşə təhsili və insan kapitalı, c. 3, №4. Bakı, 2020. s. 57-60
13. Махмудова У. Т. Ценотическая характеристика вида*Peganum harmala* L. в разной растительности // Бюллетень науки и практики, №5. 2021.
14. Mahmudova Ü. T. Gəncə şəhəri ətrafının bozqır bitkiliyinin müasir vəziyyəti // The XIV İnternational Scientific Symposium "A person in History" 26 may, Ankara, 2021. s. 332-335

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