



Monitoring Pesticide Residues in Agricultural Crops in the Republic of Azerbaijan

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ABSTRACT:

Introduction: The article presents studies (2020–2024) in Sheki-Zagatala economic region on the dynamics of pesticides to determine residual amounts of pesticides in plant samples of various agricultural crops as part of registration tests using gas and liquid chromatography methods. In order to reduce the risk of contamination of various classes of chemical compounds with pesticides, monitoring studies of the content of residual quantities of active substances of pesticides at trace levels in various agricultural crops are carried out as part of registration tests, which make it possible to assess compliance with pesticide application regulations and decide on the possibility of using the resulting products for food and feed purposes.

Methods: A method for determining microquantities of pesticides in plant products (apples, cucumbers, tomatoes, potatoes), soil and water has been developed.

Results: In the period 2020–2024, 366 units of preparations were analyzed, of which 86 in 2020, about 60–69 in 2020–2022 and 89 in 2023 on various samples of agricultural crops (green mass, grain, straw, seeds, oil). In winter grain crops (wheat, triticale, barley, rye) in the period 2020–2025, residual amounts of 31 AS were detected in various matrices, including in 30 cases in straw, where the MPL is not standardized, and in 5 cases in green mass, where the MPL is also not standardized. The following were detected in straw and green mass: propiconazole, cyproconazole, azoxystrobin, kresoxim-methyl, tebuconazole, spiroxamine, prothioconazole destio, fluopyram, fluoxastrobin, alpha-cypermethrin, and lambda-cyhalothrin - 0.006–0.9754 mg/kg. Three active fungicidal substances were detected in the harvest in the amount of 0.00280–0.01320 mg/kg without exceeding the MPL.

Conclusions: Based on the analyzed data obtained in the conditions of the pesticide dynamics laboratory, it can be concluded that contamination of food products with pesticides in the Azerbaijan Republic is practically absent, which is a consequence of the mandatory registration procedure for plant protection products. Thus, the use of recommended regulations for the use of preparations, compliance with their consumption rates and waiting periods makes it possible to guarantee a safe and clean harvest of agricultural crops.

1. Introduction

According to scientists, the agricultural sector is among the leaders in terms of anthropogenic load. Despite their environmental impact, pest and weed control chemicals are important in agriculture. We explore how humanity

can achieve more environmentally friendly food production. Ensuring the safe use of pesticides and, accordingly, obtaining high-quality food raw materials and food products is an important and popular task. An important tool in minimizing the negative consequences of pesticide use is analytical monitoring of their micro



quantities in environmental objects, in feed and food products as part of the mandatory registration procedure for chemicals in crop protection systems. Harmful effects of pesticides involve the occurrence of negative effects in non-target species (species that are not targets when pesticides are used) as a result of exposure [1,2]. Annual crop losses from pests, diseases and weeds without the use of pesticides can reach 30-40%. On the other hand, excessive use of pesticides leads to their accumulation in food products and environmental objects. In this regard, determining their residual quantities is an important task for ensuring the safety of human life. In the last decade, the analysis of pesticide residues in food and feed has changed significantly due to the advent of high-resolution mass spectrometers, which are used to identify and determine organic pollutants [3,4]. Registration studies are carried out to assess the biological and economic effectiveness of pesticides, on the one hand, to determine the content of their residual quantities in agricultural products and to develop application regulations (consumption rate, the period of the last treatment before harvesting the crop, the frequency of treatment, the maximum permissible level (MPL)) [5,6]. Among the general ecological problems, one can single out the global migration of pesticides, including through food chains, the impact on humans directly and through food products, the development of resistance in harmful organisms, and a number of others. The following are primarily exposed to the impact of pesticides: agricultural soil, vegetation, terrestrial and underground biota, water bodies, including groundwater. Pesticides accumulate in individual objects and environments and are included in various migration chains [7,8]. Impact or local monitoring is a system of observations in a region of the consequences of the entry of pesticides or other pollutants from established sources. Direct control over the accumulation levels of pesticide residues and their metabolites is a particular task of such monitoring [9,10]. Monitoring of the content of residual quantities of pesticides is carried out for the following purposes: assessment of the possibility of applying general recommendations for chemical plant protection in specific soil and climatic conditions and their zonal adjustment as necessary; verification of compliance with technology and regulations during application, including rules for transportation, storage, preparation and application of preparations, disposal of their residues and

containers from pesticides, as well as rules for the decontamination of machines and tools used in work on transportation, preparation and application of pesticides; establishment of the actual scale and levels of soil contamination with pesticide residues, including areas with possible increased content (adjacent to warehouses and burial sites of pesticides), and determination of the suitability of contaminated soils for subsequent cultivation of agricultural crops; determining the potential danger of secondary contamination with pesticide residues of environments and natural objects adjacent to contaminated soils; determining the actual levels of accumulation of pesticide residues in plants and the possibility of selling plant products for their intended purpose; determining possible losses of agricultural crop yields due to the phytotoxic aftereffect of herbicide residues in crop rotation. Pesticides are needed to control pests and weeds. If they are abruptly banned, agricultural productivity will decline and agricultural prices will rise [11,12,13].

2. Methods

Determination of residual quantities of pesticides in agricultural products was carried out according to official guidelines using gas and liquid chromatography. The following gas chromatographs were used in the work: GCMS-QP2010 Ultra with a mass spectrometric detector (Shimadzu, Japan), Crystal 5000.1, Crystal 5000.2 and a high-performance liquid chromatograph HP 1100 with a diode matrix detector, as well as auxiliary equipment (scales, water bath, centrifuge, rotary evaporator, chemical glassware, etc.). Samples of plant specimens were collected at different times, therefore the obtained and analyzed data are not tied to the waiting period, composition of the preparation, or formulation. Statistical processing of the occurrence of residual quantities of active substances in plant samples of agricultural crops was carried out according to the Junker method, which included an assessment of the relative frequency of determination of residual quantities of pesticides and an assessment of its confidence interval.

The experiments are carried out in 4-fold repetition on plots of 150-200 m. The experimental plots should have the shape of an elongated rectangle. A protective strip of 1.5-2 m wide is left between the plots. The accounting area of each plot is 100-150 m² in Sheki-



Zagatala economic region. The control variant also has 4-fold repetition [14,15].

3. Results

Pesticides affect the environment and ecosystems, leading to a reduction in biodiversity, especially by destroying weeds and insects, which are important elements of the food chain. Methods that reduce the need for pesticides, such as organic farming and biological plant protection methods, are being studied at the national and international levels [16]. Active substances (AS) are being developed, formulations are being improved, and new combination preparations based on two, three and four components with different properties are appearing. In the period 2020–2024, 366 units of preparations were analyzed, of which 86 in 2020, about 60–69 in 2020–2022 and 89 in 2023 on various samples of agricultural crops (green mass, grain, straw, seeds, oil). In winter grain crops (wheat, triticale, barley, rye) in the period 2020–2025, residual amounts of 31 AS were detected in various matrices, including in 30 cases in straw, where the MPL is not standardized, and in 5 cases in green mass, where the MPL is also not standardized [17,18]. The following were detected in straw and green mass: propiconazole, cyproconazole, azoxystrobin, kresoxim-methyl, tebuconazole, spiroxamine, prothioconazole destio, fluopyram, fluoxastrobin, alpha-cypermethrin, and lambda-cyhalothrin - 0.006–0.9754 mg/kg. Three active fungicidal substances were detected in the harvest in the amount of 0.00280–0.01320 mg/kg without exceeding the MPL. Residual amounts of 18 AS were detected in various plant samples of spring grain crops (triticale, wheat, barley, brewer's barley, oats), including 14 cases in straw and 3 cases in green mass (prothioconazole destio, tebuconazole, difenoconazole, propiconazole, cyproconazole, bixafen, prochloraz, lambda-cyhalothrin – 0.009–0.807 mg/kg). During the harvesting period, 6 cases of detection of AS not exceeding the MPL were recorded in the grain of spring crops, of which 4 AS had a fungicidal effect (0.00400–0.02560 mg/kg), 1 had an herbicidal effect (0.22000 mg/kg) and 1 had an insecticidal effect (0.00870 mg/kg). During the harvesting period of oilseed crops, thiamethoxam was detected in oil flax seeds (0.040 mg/kg) and tebuconazole in spring rapeseed seeds (0.046 mg/kg), in winter rapeseed oil haloxyfop-P-methyl ($C_{16}H_{13}ClF_3NO_4$) (0.007 mg/kg), which did not exceed the MPL specified in the hygienic standards.

Deltamethrin ($C_{22}H_{19}Br_2NO_3$), carbendazim, thiacloprid, flupyradifurone were detected in green mass in dynamics and in straw during the harvesting period, where the MPL is not standardized, the content of which ranged from 0.051 to 0.629 mg/kg. In crops of industrial crops - sugar beet, 31 active substances were analyzed, 4 of which were found in the tops: azoxystrobin ($C_{22}H_{17}N_3O_5$), difenoconazole ($C_{19}H_{17}Cl_2N_3O_3$), cyproconazole ($C_{15}H_{18}ClN_3O$), epoxiconazole ($C_{17}H_{13}ClFN_3O$) - 0.093–0.69 mg/kg. Epoxiconazole (0.013 mg/kg) and tebuconazole (0.008 mg/kg) were found in root crops on the 30th day after treatment.

Table 1. Results of determining the content of residual quantities of active substances in grain crops, oilseed, sugar beet, potato

Analyzed object	AS detected	Value, mg/kg	MPL, mg/kg
Grain crops			
Winter grains, grain	Propiconazole	0.00280	0.1
	Tebuconazole	0.01320	0.2
	Fluoxastrobin	0.00843	0.5
Spring grains, grain	Difenoconazole	0.01100	0.8
	Tebuconazole	0.02560	0.2
	Tebuconazole	0.00900	0.2
	Azoxystrobin	0.00400	0.5
	Pinoxaden	0.22000	1.0
	Imidacloprid	0.00870	0.1
Oilseed harvest			
Flaxseeds	Thiamethoxam	0.040	0.1
Spring rapeseeds	Tebuconazole	0.046	0.5
Winter rapeseed oil	Haloxyfop-P-methyl	0.007	0.05
Sugar beet			
Root crops 30 th day	Epoxyconazole	0.013	0.05
Root crops 30 th day	Tebuconazole	0.008	0.1
Potato harvest			
Tubers	Fipronil	0.006	0.02
Tubers	Thiamethoxam	0.023	0.05

Source: Laboratory experiment 2020–2024



Table 2. Results of determining the content of residual quantities of active substances in harvest of vegetable crops (cucumber, tomato, potato), trees (apple) and berry crops of protected soil in dynamics

Analyzed object	AS detected	Value, mg/kg	MPL, mg/kg
Cucumber fruits 0 th day	Difenoconazole	0.073	0.3
Cucumber fruits 3 rd day	Difenoconazole	0,025	0.3
Cucumber fruits 5 th day	Propamocarb hydrochloride	1.35	5.0
Cucumber fruits 7 th day	Propamocarb hydrochloride	0.39	5.0
Tomato			
Tomato fruits 1 st day	Propamocarb hydrochloride	2.551	2.0
Tomato fruits 3 rd day	Propamocarb hydrochloride	0.0459	2.0
Tomato fruits 4 th day	Propamocarb hydrochloride	0.407	2.0
Tomato fruits 5 th day	Propamocarb hydrochloride	0.664	2.0
Tomato fruits 6 th day	Propamocarb hydrochloride	0.762	2.0
Cucumber			
Cucumber fruits 2 nd day	Pyrimethanil	0.158	-
Cucumber fruits 3 rd day	Pyrimethanil	0.170	-
Cucumber fruits 4 th day	Pyrimethanil	0.188	-
Cucumber fruits 1 st day	Tebuconazole	0.078	0.2
Cucumber fruits 3 rd day	Tebuconazole	0.034	0.2
Tomato			
Tomato fruits 1 st day	Fluopicolide	0.0667	1.0
Tomato fruits 3 rd day	Fluopicolide	0.0104	1.0
Tomato fruits 4 th day	Fluopicolide	0.036	1.0
Tomato fruits 5 th day	Fluopicolide	0.033	0.5

Tomato fruits 6 th day	Fluopicolide	0.029	0.5
Cucumber			
Cucumber fruits 1 st day	Fluopyram	0.112	0.5
Cucumber fruits 3 rd day	Fluopyram	0.084	0.5
Cucumber fruits 2 nd day	Fluopyram	0.044	0.5
Cucumber fruits 3 rd day	Fluopyram	0.080	0.5
Cucumber fruits 4 th day	Fluopyram	0.070	0.5
Cucumber fruits 0 th day	Cyflufenamid	0.026	1.0
Cucumber fruits 3 rd day	Cyflufenamid	0.027	1.0
Apples			
Apple fruits 30 th day	Abamectin	0.017	0.02
Apple fruits 21 st day	Thiacloprid	0.012	0.7
Apple fruits 20 th day	Difenoconazole	0.029	1.0
Apple fruits 30 th day	Kresoxim-methyl	0.005	1.0
Apple fruits 30 th day	Kresoxim-methyl	0.005	1.0
Apple fruits 30 th day	Pyrimethanil	0.116	7.0
Apple fruits 21 st day	Propiconazole	0.005	0.1
Apple fruits 30 th day	Epoxiconazole	0.034	-
Berries			
Grapes 21 st day	Metalaxyl	0.022	2.0
Raspberries 20 th day	Tebuconazole	0.011	-
Raspberries 20 th day	Fluopyram	0.026	2.0
Blueberries 20 th day	Fluopyram	0.063	2.0



The main part of the preparations were 12 herbicides, which were not detected in any case; also, no residual amounts of pesticides were noted in the root crop harvest. Of the 64 AS studied on cucumbers and tomatoes in protected and open ground, onions, carrots, cabbage, and beets, 16 were detected. In cucumbers and tomatoes, residual quantities of pesticides were determined dynamically, as a rule, their content decreases from 0 to 5-7 days. AS with fungicidal action were most often detected in protected soil conditions [12,13]. Difenoconazole was detected in cucumber fruits on days 0 and 3 in the amount of 0.073 and 0.025 mg/kg, (the MPL is 0.3 mg/kg), and was absent on days 5 and 7. Propamocarb hydrochloride was detected in both tomatoes and cucumbers. In 2022, the content of this AS in tomato fruits on the first day was 2.551 mg/kg, which is higher than the MPL of 2.0 mg/kg, but already on the 3rd day its content drops to a safe level of 0.0459 mg/kg. Propamocarb hydrochloride was detected in tomatoes in 2024-2025, on the 4th day the value was 0.407 mg/kg, on the 5th - 0.664 mg/kg, on the 6th - 0.762 mg/kg, which is within the limits of hygienic regulations. In cucumbers in 2020, on the 5th day - 1.35 mg/kg, on the 7th - 0.39 mg/kg, which also does not exceed the MPL established for vegetables with edible fruits. Tebuconazole, fluopicolide, fluopyram, cyflufenamide were detected from 0.0104 to 0.112 mg/kg and did not exceed the MPL. Imidacloprid was noted in open-ground tomato fruits, its value was 0.07 mg/kg, which is within the MPL (0.5 mg/kg). In the potato crop in the period 2020-2025, about 45 drugs were analyzed, including 68 AS, 2 were detected: fipronil - 0.006 mg/kg and thiamethoxam - 0.023 mg/kg. In fruit crops (the main share of which was apple trees), as well as in vegetables, residual amounts of pesticides were most often found, which can be primarily associated with a high frequency of treatments with insecticides and fungicides, as well as the use of dynamic analysis to establish waiting periods. Thus, out of 44 tested AS, 9 were detected. Presence of insecticidal AS abamectin and thiacloprid, the values of which were 0.017 and 0.012 mg/kg, which is significantly lower than the MPL, as well as fungicidal action difenoconazole - 0.029 mg/kg, kresoxim-methyl (from two different preparations) - 0.005 mg/kg, pyrimethanil - 0.116 mg/kg and propiconazole - 0.005 mg/kg, while all detected concentrations do not exceed the permissible levels. Epoxiconazole was detected at 0.034 mg/kg, but the

maximum allowable level has not been established. Of the 13 AS, residual quantities of 5 were detected. The level of metalaxyl (mefenoxam), fluopyram was 0.022–0.063 mg/kg, which is significantly lower than the established values of MPL. Tebuconazole was detected in raspberries in dynamics at a level of 0.011 mg/kg, the MPL has not been established, for comparison, the MPL for grapes is 1.0 mg/kg. In plant samples of grain feed (corn) and grain legumes crops, residual quantities were found only in the green mass, where the MPL is not standardized. In crops such as flax, narrow-leaved lupine, alfalfa, buckwheat, millet, red clover, a small number of preparations (from 3 to 13) were analyzed and over the years of research, not a single pesticide was found in the residues. As a result of statistical processing of these data, the relative value of occurrence of residual amounts of AS was established (Fig. 1). It can be stated with a probability of 95% that the possibility of detecting the most frequently tested AS tebuconazole is in the range of 8.63–20.3%. Florosulam, with a large number of analysis performed, was never detected, accordingly, the relative frequency of its detection was 0.53% with a confidence interval of 0.08–3.07%. Prothioconazole destio and azoxystrobin were detected in 6.02–7.50% of cases with a confidence interval of 1.91–14.36%. During the accounting period, of the frequently analyzed AS, 2,4-D EGE, fludioxonil, acetamipride were not detected; the probability of their detection was in the range of 0.11–4.71%; picloram was analyzed twice less often (34 analysis); the relative frequency of detection was 1.47% with a confidence interval of 0.27–8.51%. Difenoconazole, cyproconazole, imidacloprid, clopyralid, nicosulfuron were analyzed from 33 to 40 times, the relative frequency of detection of the first two AS was at the level of 20.00-21.62% with a confidence interval of 8.28-36.65%, and the rest - 3.03-8.33% with a confidence interval from 0 to 19.86%. Propiconazole, fluopyram, epoxiconazole had a high level of relative detection frequency (25.00-45.83%) due to the small number of analysis performed. It should be noted that the smaller the number of analysis performed, the wider the confidence interval. Of all the AS that were not detected in the residues, the main share was occupied by herbicides, the probability of their detection is very low.

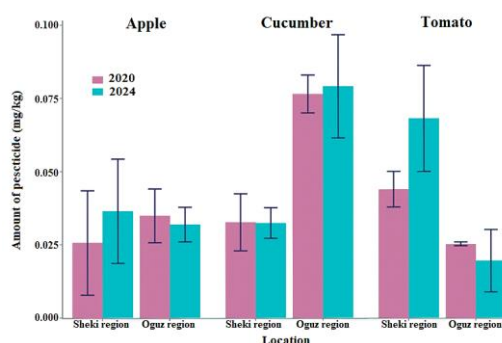


Fig. 1. Comparative indicators of herbicide use in the regions of Sheki and Oguz in different years

4. Conclusion

Based on the analyzed data obtained in the conditions of the pesticide dynamics laboratory, it can be concluded that contamination of food products with pesticides in the Azerbaijan Republic is practically absent, which is a consequence of the mandatory registration procedure for plant protection products. Thus, the use of recommended regulations for the use of preparations, compliance with their consumption rates and waiting periods makes it possible to guarantee a safe and clean harvest of agricultural crops.

Conflict of Interest Statement: The methodology used in this study was confirmed by experimental laboratory diagnostics in the field of environmental chemistry. The authors have no conflicts of interest. All authors participated in the laboratory diagnostics, writing, and publication.

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References

- Ahmadi S., Khazaei S., Mehri F. (2024). The concentration of pesticide residues in vegetables: A systematic review and meta-analyses. *Journal of Agriculture and Food Research*. 15, 101027, <https://doi.org/10.1016/j.jafr.2024.101027>.
- Didehban K., Sadigov R. A., Maharramova S. S., Abbasova S. E., Verma P. (2025). Recent advances in the synthesis of α -thiocyanatoketones and β -thiocyanato alcohols through the direct oxy-/hydroxy-thiocyanation of unsaturated hydrocarbons. *Chemical Review and Letters*. 8(1), 144-154, <https://doi.org/10.22034/crl.2025.495049.1499>.
- Hasanova T. A., Mammadova G. I., Bunyatova L. N., Gahramanova A. Y. (2021) Importance of biodiagnostics and irrigation grey-brown soils. *Universal Journal of Agricultural Research*, Horizon publishing. USA, CA. 9(3), 63-69, <https://doi.org/10.13189/ujar.2021.090301>.
- Bunyatova L. N., Mammadova G. I., Hasanova T. A., Gahramanova A. Y., Akhundova S. M., Alakbarli G. Y. (2025). Main eco-properties of hazelnut (*Corylus avellana* L.) on the Sheki-Zagatala economic region. *Int. J. Adv. Appl. Sci.* 14(1), 77-85 <http://doi.org/10.11591/ijaas.v14.i1.pp77-85>.
- Nasirova A. I., Aliyeva M. M., Mammadova R. N., Hasanova T. A. (2022). Bioecological Edificators of Gray-Brown Soils in Ganja-Gazakh Massif (Azerbaijan). *Environment and Ecology Research*, USA, CA. 10(3), 392-397, <https://doi.org/10.13189/eer.2022.100307>.
- Nazim R. M., Jafar S. S., Maharram S. H., Israphil G. I., Allahverdi T. A., Latif H. R., Ali G. I. (2025). Plant Leaves as a Biogeochemical Indicator of the Environmental State in Different Regions of Azerbaijan”, *C. R. Acad. Bulg. Sci.*, 78(11), 1601–1610, <https://doi.org/10.7546/CRABS.2025.11.03>.
- Verdiyeva, F.B., Hasanova, T.A., Ismayilova, M.E., Huseynov, E.Y., Jabiyeva, T.E., Asgarova, G.F. (2025). Bioecological characteristics of modern soil cover in subtropic regions of Azerbaijan. *International Journal of Advances in Applied Sciences*. 14(4), 113-121. <https://doi.org/10.11591/ijaas.v14.i4.pp113-121>
- Sadigov, R.A., Nazarova, M.K., Garayeva, I.E., Mammadova, G.I., Hasanova, T.A., Madnee, M. (2025). Modern research of using alternative energy resources in Azerbaijan. *International Journal of Advances in Applied Sciences*. 14(3), 907-915. <https://doi.org/10.11591/ijaas.v14.i3.pp907-915>
- Mustapha F. A., Jallow M. F., Dawood G., Mohammed S. (2017). Monitoring of pesticide residues in commonly used fruits and vegetables in



- Kuwait. *Int. J. Environ. Res. Publ. Health*, 14(8), 833
11. Mirzazadeh R.I., Ramazanova F.M., Hasanova T.A., Mammadova G.I., Asgarova G.F. (2025). Assessment of variations caused by biological activities in the Greater Caucasus forest soils used for agriculture. *SABRAO J. Breed. Genet.* 57(4): 1634-1643.
<http://doi.org/10.54910/sabrao2025.57.4.29>.
12. Shukurov, S.Kh., Ismayilova, A.A., Sadigov, R.A., Karimova, M.J., Hasanova, T.A., Asgarova, G.F. (2025). Determination of soil salinization by hyperspectral remote sensing in the Shirvan Plain. *International Journal of Advances in Applied Sciences*, 14(3), 662-670,
<https://doi.org/10.11591/ijaas.v14.i3.pp662-670>
13. Macnunlu K., Hasanova Baba-zade R., Hasanova T. (2025). Ecological sustainability of agroecosystem and productivity assessment in the Barda area using NDVI and SAVI. *Adv. Biol. Earth. Sci.* 10(1): 148-157.
<http://doi.org/10.62476/abes.101148>.
14. Ismayil A., Alakbar R., Gudrat V., Islam R., Allahverdi T. (2025). Soil salinization in Ujar region of Azerbaijan with index application and various methods comparison. *C.R. Acad. Bulg. Sci.* 78(6): 946-954.
<http://doi.org/10.7546/CRABS.2025.06.18>.
15. Mammadova, R., Hasanova, T., Aliyeva, M. (2025). Ecological state of modern soil cover in agrocenoses of the Greater Caucasus Sheki region. *Ecological Systems Modelling. Collective monograph. Scientific route publ. Tallin, Estonia. Chapter 3. pp. 57-73.* <https://doi.org/10.21303/978-9908-9706-6-0.ch3>.
16. Doran, J. W., Zeiss, M. R. (2000). Soil health and sustainability: managing the biotic component of soil quality," *Applied Soil Ecology*, 15(1), 3–11, Aug. 2000, doi: 10.1016/S0929-1393(00)00067-6.
17. Ismayilova, A., Shukurov, S., Hasanaliyeva, L., Osmanova, S., Asgarova, G., Hasanova, T. (2025). Modern soil cover of natural cenoses and agrosenoses landscapes of the Kur-araz plain. *Advances in Biology & Earth Sciences*. 10(2), 314-325. doi: 10.62476/abes.102314314.
18. Didehban, K., Sadigov, R. A., Maharramova, S. S., Abbasova, S. E., Verma, P. (2025). Recent advances in the synthesis of α -thiocyanatoketones and β -thiocyanato alcohols through the direct oxy-
/hydroxy-thiocyanation of unsaturated hydrocarbons, *Chemical Review and Letters*, 8(1), 144-154. doi: 10.22034/crl.2025.495049.1499