# RESTORATION OF SOILS THAT HAVE LOST FERTILITY DUE TO UNFAVOURABLE CLIMATIC CONDITIONS

Najiba Shirinova
•
Azerbaijan Technical University
naciba.shirinova@aztu.edu.az

**Abstract**

*The article is devoted to the search for alternative ways to prevent the negative impact of climate change on precipitation. It is known that as a result of climate change, both on the scale of the Earth and within any country, excessive precipitation falls on one part of the territory, and on the contrary, drought occurs on another. This affects the productivity of agriculture engaged in the cultivation of crops. The physical and mechanical properties of the soil play a key role in crop production. As a result of climate change in arid areas, it is possible to restore soil fertility and increase productivity by improving soil properties - moisture capacity, water evaporation, dehydration and others with the help of various chemicals. For this purpose, the titanium-substituted organic compounds synthesized by us were tested on gray-brown soils. The introduction of various amounts of the proposed preparations into the soil increased the physical and mechanical properties of the soil. As a result, the yield of agricultural crops increased. Accumulation of the introduced compounds as residues in plant products was not observed. Therefore, by safely using them, it is possible to develop agriculture in arid areas and obtain abundant harvests.*

**Keywords**: climate change, drought, thiethane compounds, physical and chemical properties of soil

## I. Introduction

Climate change, which affects all countries of the world and every person, has a negative impact on all sectors of the economy. In each country, these changes manifest themselves locally. The impact of climate change on human development depends on the geographical location of the state, the existing climatic conditions in the country and other factors. These changes will be more pronounced in four main areas in each country:

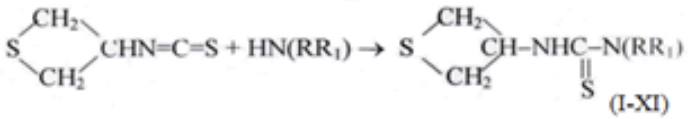
- There is a high probability of reduced agricultural productivity, especially crop production, with the emergence of drought and rainfall patterns in the area. Scientists estimate that by the 2080s, an additional 600 million people will suffer from acute malnutrition as a result of pressures on agriculture and food security caused by climate change [1].
- Shortage of drinking water is a problem. The cause of this problem will be an increase in the number of floods and deluges due to melting glaciers, as well as a decrease in the water level in many rivers during hot weather. This can be observed in the territory of Azerbaijan as well. The current decrease in the level of the Kura River has caused great problems among people living in the surrounding areas. If this problem is not prevented, the number of people suffering from water shortage will increase every year.

- The above problems will lead to the destruction of ecosystems in each area. This will lead to the destruction of biodiversity and the threat of extinction of many plant and animal populations. This will be especially noticeable in coastal areas.
- Climate change will also affect human health. The elderly, those suffering from nervous, cardiovascular, cardiac and respiratory diseases, and children are especially sensitive to these changes. In addition, the risk of infectious diseases is high in areas with floods and droughts.

The above-mentioned climate changes have a negative impact on agriculture. This has a particularly negative impact on the soil, which is the main element of agriculture. Providing the population of each country with food is one of the main directions of the state's economic policy. Work has been carried out in this direction in our republic. "The Food Security Program of the Republic of Azerbaijan" was approved by the Decree of the President of the country, and as a result of the work done within the framework of this Program, the production of agricultural and food products has increased significantly [2]. Reliable food supply is the main condition for economic stability and social stability of each country. In this regard, the Azerbaijani state is implementing comprehensive measures to ensure reliable food supply to its population and is implementing large-scale state programs aimed at developing the agricultural sector, on which food security directly depends. At present, reliable provision of the country's population with food is one of the main directions of the state's economic policy. Therefore, it is very important to constantly implement appropriate measures to fully meet the needs of each member of society for basic food products. In recent years, due to negative trends in the financial market of leading countries as a result of climate change, as well as increased demand for food as a result of population growth, increased floods and droughts, limited water resources and other reasons, prices for basic food products in world markets have begun to rise, and in some countries food shortages have begun to increase, which has become a real threat. Food production in our republic is below the existing potential and capabilities. There are few land plots in our country suitable for cultivation. 1.2 million hectares of land in the country are salinized to varying degrees, have been subjected to various types of erosion, more than 50 thousand hectares of land are polluted. In addition, the fertile layer of more than 1.4 million hectares of agricultural land has been damaged. It is necessary to take step-by-step measures to prevent the process of land degradation. These measures should include the adoption and implementation of land use rules, land management and preparation of relevant maps, as well as the implementation of measures aimed at land rehabilitation and improvement of land quality. One of such measures is the implementation of a set of measures and appropriate mechanisms for the protection and improvement of soil quality [3].

## II. Methods

Organic sulfur compounds are used in agriculture for various purposes - pest control, fertilizer production, soil reclamation, etc. For this purpose, we synthesized titanium-substituted compounds. First, 1,2-epithio-3-chloropropane was prepared in an aqueous medium by the reaction of 1,2-epoxy-3-chloropropane with thiourea [4]. Then, 3-thiatanyl isothiocyanate was obtained by the action of ammonium thiocyanate on 1,2-epithio-3-chloropropane in water. The corresponding 3-thiatanyl thioureas were synthesized by the action of various single and binary amines on 3-thiatanyl isothiocyanate [4].



(I-XI)

R=R₁=H (I); R=H, R₁=$CH_3$- (II), R=H, R₁=$C_2H_5$- (III), R=H, R₁=$C(CH_3)_3$- (IV), R=H, R₁=$C_{18}H_{37}$- (V), R=H, R₁=$C_6H_5$- (VI), R=H, R₁= $C_6H_5CH_2$- (VII), R=H, R₁= $C_{10}H_7$- (VIII), R= $CH_3$- , R₁= $CH_3$- (IX), R= $C_2H_5$-, R₁= $C_2H_5$-(X), R= $C_4H_9$-, R₁= $C_4H_9$-(X)

The coupling reactions of aliphatic amines with 3-thiatanyl isothiocyanate are carried out without a solvent, sometimes in benzene, the reaction is isothermal and is completed in 10-30 min. However, the interaction with aryl-substituted amines takes a relatively long time to complete, within 3-4 days. When triethiamine is used as a catalyst to increase the reaction rate, the reaction is completed within 1 day. The synthesized 3-thietanyl-substituted thioureas are white crystalline or oil-like substances. Thiourea can be dissolved in ethyl alcohol and purified by precipitation with benzene. The yield and physicochemical properties of the obtained substances are presented in the table (Table 1).

**Table 1:** *Physicochemical constants of 3-thiatanyl-substituted thiourea*

| № | R | R₁ | $T_{mel.}$ $^0C$ | Found, % | | | | Calculated, % | | | | Gross formula |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | C | H | N | S | C | H | N | S | |
| I | H | H | | 32,57 | 5,26 | 18,68 | 43,48 | 32,41 | 5,44 | 18,89 | 43,26 | $C_4H_8N_2S_2$ |
| II | H | -$CH_3$ | | 36,92 | 6,68 | 15,62 | 39,27 | 37,01 | 6,21 | 17,26 | 39,52 | $C_5H_{10}N_2S_2$ |
| III | H | -$C_2H_5$ | | 40,69 | 6,97 | 16,68 | 36,57 | 40,88 | 6,85 | 15,89 | 36,38 | $C_6H_{12}N_2S_2$ |
| IV | H | -$C(CH_3)_3$ | 120 | 47,19 | 7,51 | 13,82 | 31,23 | 47,02 | 7,89 | 13,71 | 31,38 | $C_8H_{16}N_2S_2$ |
| V | H | -$C_{18}H_{37}$ | 125 | 65,71 | 11,23 | 6,78 | 16,17 | 65,94 | 11,07 | 6,99 | 16,00 | $C_{22}H_{44}N_2S_2$ |
| VI | H | -$C_6H_5$ | | 53,54 | 5,52 | 12,23 | 28,89 | 53,54 | 5,39 | 12,49 | 28,54 | $C_{10}H_{12}N_2S_2$ |
| VII | H | -$C_6H_5CH_2$ | 165 | 55,71 | 6,18 | 11,47 | 27,12 | 55,43 | 5,92 | 11,75 | 26,90 | $C_{11}H_{14}N_2S_2$ |
| VIII | H | -$C_{10}H_7$ | 166 | 61,49 | 5,35 | 10,04 | 23,56 | 61,28 | 5,14 | 10,21 | 23,37 | $C_{14}H_{14}N_2S_2$ |
| IX | -$CH_3$ | -$CH_3$ | | 40,75 | 6,73 | 16,64 | 36,19 | 40,88 | 6,85 | 15,89 | 36,38 | $C_6H_8N_{12}S_2$ |
| X | -$C_2H_5$ | -$C_2H_5$ | | 47,32 | 7,59 | 13,54 | 31,13 | 47,02 | 7,89 | 13,71 | 31,38 | $C_8H_{16}N_2S_2$ |
| XI | -$C_4H_9$ | -$C_4H_9$ | 135 | 55,41 | 9,07 | 10,42 | 24,71 | 55,34 | 9,29 | 10,75 | 24,62 | $C_{12}H_{24}N_2S_2$ |

The IR spectrum of the synthesized 3-thiethane-substituted thioureas retains the absorption bands at 670-680, 720-730 and 1420-1445 $cm^{-1}$, characteristic of the four-membered thiethane cycle. The spectrum also contains an absorption band in the region of 1500-1510 $cm^{-1}$, corresponding to the stretching vibrations of the NHC(S) fragment. The absorption band corresponding to the isothiocyanate functional group is not observed in the IR spectrum at 2090 $cm^{-1}$. In the IR spectrum of 3-thiatanyl-substituted thioureas, recorded in a KBr prism, a broad absorption band observed in the region of 3320-3330 $cm^{-1}$ corresponds to the NH bond. When recording the IR spectrum of a 0.005 M solution of these substances in $CCl_4$, an absorption band is observed at 3380 and 3480 $cm^{-1}$, corresponding to vibrations of the free valence of the NH bond. In addition, an absorption band at

3040 $cm^{-1}$ is also observed in the spectrum of the dilute solution. This indicates the presence of an internal hydrogen bond NH….S and is consistent with literature data [6]. In the IR spectrum of the compound containing the $NH_2$ group, unlike other thiatane-substituted ureas, absorption bands are found in the IR spectrum at 3370, 3435 and 3470 $cm^{-1}$. According to literature data [7]. the absorption bands at 3370 and 3470 $cm^{-1}$ characterize asymmetric and symmetric stretching vibrations of the NH bond.

2.7-3.75 mg.h. in the NMR spectra of 3-titanium-substituted compounds. In the field, signals of protons of two equivalent methylene groups in the four-membered thietane ring are observed as a quintet in the ratio 1.4:6:4:1. The signal of the methine proton, located in the thietane ring, is 4.3-4.7 mg.h. as a quintet. appears in the field. The signal corresponding to the NH group in the thiourea fragment, located in the molecule of all synthesized thioureas, is singlet and is detected in the field of 7.05-7.75 mg.h.

One of the synthesized compounds (VII) was tested as a soil improver for gray-brown soils in greenhouse conditions. The preparation is given in the amount per hectare by dissolving the compounds in water 2.5; 5.0; 7.5; 15.0 kg. As a result of the studies, it was found that after the introduction of the compositions into the soil, the percentage of water-resistant particles >0.25 mm in size, moisture capacity, soil water permeability increases and the under-evaporation capacity decreases, which has a positive effect on soil fertility. Compared with the control, the yield of tomato plants per $m^2$ in the experimental area increased by 1.2-3.5 kg, and the yield of cucumber plants - by 1.9-4.0 kg.

**Table 2:** *Effect of 3-thiatanyl-substituted thiourea on the water-physical composition of gray-brown soil*

| Scheme of the experiment | Mechanical fraction, volume in mm, % | | | | | The volume of waterproof aggregates in mm., % | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1,0-0,25 | 0,25-0,01 | 0,01-0,001 | 0,001 | 0,01 | >1,0 | 1,0-0,25 | <0,25 | >0,25 |
| Option without preparation | 37,7 | 31,5 | 20,0 | 10,8 | 30,8 | 18,2 | 34,8 | 47,0 | 53,0 |
| Prototype 2,5 kq/hk | 34,1 | 35,6 | 22,2 | 9,1 | 31,3 | 20,0 | 35,07 | 46,3 | 53,7 |
| Prototip 5,0 kq/hk | 31,6 | 38,0 | 18,7 | 11,7 | 30,4 | 22,2 | 32,9 | 44,9 | 55,1 |
| Prototype 7,5 kq/hk | 27,7 | 42,6 | 19,0 | 10,7 | 29,7 | 20,8 | 34,1 | 45,1 | 54,9 |
| Prototype 15 kq/hk | 29,6 | 42,3 | 18,9 | 9,2 | 28,1 | 18,8 | 33,0 | 48,2 | 51,8 |
| Preparation 2,5 kq/hk | 4,8 | 57,1 | 19,9 | 18,4 | 38,1 | 10,4 | 41,2 | 48,4 | 51,6 |
| Preparation 5,0 kq/hk | 3,9 | 46,2 | 30,0 | 19,7 | 49,7 | 8,3 | 51,7 | 39,5 | 60,2 |
| Preparation 7,5 kq/hk | 3,2 | 31,1 | 36,5 | 29,7 | 65,7 | 6,6 | 71,2 | 22,7 | 77,3 |
| Preparation 15 kq/hk | 2,9 | 27,9 | 37,1 | 32,1 | 69,2 | 7,0 | 72,7 | 28,7 | 71,3 |

The quality of the grown products also improved. Currently, processed cumbrin [8], lignosulfonate [9] and acrylic acid [10] are used for this purpose. Lignosulfonate, taken as a prototype and improver of loamy soils by the mechanism of action, is expensive and has a limited raw material base. In addition, the technology for obtaining lignosulfonate is multi-stage and uses expensive metal

salts (Fe, Cu, Zn) and polyethyleneamine. The experiments were repeated 4 times on an area of 10 $m^2$. The results obtained on the effect of the newly synthesized compound and the prototype on the mechanical composition of the soil, water-resistant aggregates and the productivity of vegetable plants are presented in the following experiments.

## III. Results

**Experiment 1**.

The effect of the proposed compound on the water-physical composition of the soil was studied. The mechanical analysis of the soil was determined by treating a pipette with sodium pyrophosphate, and the water-resistant aggregate was determined by the Sabbinova method [11]. The results obtained are presented in the table (table 2). As can be seen, the amount of particles 0.001-0.01 mm in size in the control variant was 9.1-11.7 and 30.4-31.3%, and taking into account the effect of the new combination, this figure was 18.4-32.1 and 38.1-69.2%. If in the control variant the amount of water-resistant aggregate 40.25 mm thick was 51.8-55.1%, then under the influence of the new preparation it was 51.6-77.8%.

**Experiment 2.**

The effect of the synthesized compound on the moisture capacity, water evaporation and water permeability of the soil was studied and the results obtained are presented in the table (table 3). As can be seen from the table, the new preparation increased the moisture capacity of the soil, reduced water evaporation and increased dehydration, which led to an increase in soil fertility.

**Table 3:** *The effect of 3-thiatanyl-substituted thiourea on the moisture capacity, water absorption and water evaporation capacity of gray-brown soil*

| Scheme of the experiment | Moisture capacity, % | Evaporation,% | Humidity, % | Waterproof | |
|---|---|---|---|---|---|
| | | | | ml/ minute | ml / per day |
| Option without preparation | 24,5 | 9,4 | 6,1 | 0,5 | 17,1 |
| Prototype 2,5 kq/hk | 24,4 | 7,8 | 6,3 | 0,8 | 19,3 |
| Prototype5,0 kq/hk | 25,7 | 8,4 | 6,7 | 0,7 | 20,7 |
| Prototype 7,5 kq/hk | 27,3 | 8,7 | 7,2 | 1,3 | 28,4 |
| Prototype 15 kq/hk | 25,0 | 7,8 | 7,1 | 1,0 | 24,6 |
| Preparation 2,5 kq/hk | 24,9 | 5,4 | 8,4 | 0,7 | 26,4 |
| Preparation 5,0 kq/hk | 32,5 | 4,2 | 8,6 | 1,2 | 30,2 |
| Preparation 7,5 kq/hk | 44,6 | 3,2 | 9,2 | 1,8 | 35,1 |
| Preparation 15 kq/hk | 40,3 | 2,4 | 8,1 | 1,5 | 31,6 |

**Experiment 3.**

The effect of the studied compound on the productivity and quality of vegetable plants - tomatoes and cucumbers - was also studied. The results obtained are presented in the table (table 4). As can be seen from the obtained result, the productivity of tomato and cucumber plants increased by 1.2-3.5 and 2.6-4.9 kg/$m^2$, respectively, compared to the prototype. At the same time, as a result of mathematical calculations using the method of V.V. Pereguov, it was established that the quality of vegetable plants also increased.

**Experiment 4**.

The effect of the new preparation on the accumulation of residues in vegetable plants was determined colorimetrically using the method of O.A. Drozdova [11]. The results obtained are presented in the table (table 5). The results show that the new compound does not accumulate as a residue in plant organs.

**Table 4:** *The effect of 3-thietanyl-substituted thiourea on the yield and quality of vegetable plants in gray-brown soil*

| Scheme of the experiment | Tomato plant | | | | | Cucumber | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average yield, kq/m² | The difference kq/m² | Dry mass, % | Acidity, % | Vitamin "C" | Average yield, kq/m² | The difference, kq/m² | Dry mass, % | Vitamin "C" |
| Option without preparation | 7,9 | - | 4,4 | 0,32 | 16,7 | 9,1 | - | 3,8 | 5,2 |
| Prototype e2,5 kq/hk | 9,6 | - | 4,5 | 0,34 | 17,0 | 10,8 | - | 4,0 | 5,4 |
| Prototype 5,0 kq/hk | 11,3 | - | 4,7 | 0,36 | 17,6 | 12,1 | - | 4,2 | 6,2 |
| Prototype 7,5 kq/hk | 12,5 | - | 5,0 | 0,38 | 18,1 | 13,8 | - | 4,7 | 6,5 |
| Prototype 15 kq/hk | 10,4 | - | 4,8 | 0,37 | 17,9 | 11,9 | - | 4,4 | 5,7 |
| Preparation 2,5kq/hk | 10,8 | 1,2 | 4,9 | 0,39 | 18,0 | 12,6 | 1,9 | 4,6 | 5,8 |
| Preparation 5,0kq/hk | 13,3 | 2,0 | 5,3 | 0,37 | 18,5 | 14,9 | 2,7 | 4,8 | 6,4 |
| Preparation 7,5kq/hk | 16,0 | 3,4 | 6,4 | 0,43 | 19,4 | 17,9 | 4,0 | 5,9 | 6,7 |
| Preparation 15 kq/hk | 13,0 | 2,6 | 5,7 | 0,41 | 18,9 | 14,0 | 2,1 | 5,6 | 6,4 |

**Table 5:** *Effect of 3-thietanyl-substituted thiourea on the accumulation of residues after plant utilization*

| Scheme of the experiment | Tomato plant | | | Cucumber | | |
|---|---|---|---|---|---|---|
| | Past days | | | | | |
| | 5 | 15 | 30 | 5 | 15 | 30 |
| Option without preparation | - | - | - | - | - | - |
| Preparation 2,5kq/hk | not observed | not observed | not observed | not observed | not observed | not observed |
| Preparation 5,0kq/hk | | not observed | not observed | not observed | not observed | not observed |
| Preparation 7,5kq/hk | not observed | not observed | not observed | not observed | not observed | not observed |
| Preparation 15 kq/hk | not observed | not observed | not observed | not observed | not observed | not observed |

**Experiment 5**.

The toxic effect of the new compound was studied in the field. The results are summarized in a table and it is clear from the results that the new compound does not have a toxic effect (Table 6).

**Table 6:** *Toxic effect of 3-thiethane-substituted thiourea on vegetable plants, ($LD_{50}$ – kq/hk)*

| | |
|---|---|
| Prototype | 18,7 |
| Preparation | 20,5 |

From the experiments conducted and the results obtained, it can be concluded that the newly synthesized compounds increase the fertility of arid territories and uncultivated soils, making them vulnerable to cultivation and increasing the productivity of crops. We cannot accept the consequences of climate change. In addition to solving this problem with solidarity and joint cooperation of all countries of the world, it is necessary to find ways to solve problems using new achievements of science and technology.

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