Research of agrochemical and mechanical properties of soils processed with hydrogel

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Abstract. The results of many years of research on the effect of polymer hydrogels for agriculture on soil structure were presented. By sampling soils at various depths, the biological changes of microorganisms that occur under the influence of hydrogels were studied. It was shown that the use of hydrogels leads to an improvement in the basic physicochemical properties of non-irrigated agricultural lands and an increase in soil fertility. The use of hydrogel absorbent on typical non-irrigated lands allowed increasing soil moisture and improving its properties.

1. Introduction

In the Republic of Uzbekistan, as part of the implementation of state programs aimed at increasing the productivity of irrigated territories, improving their reclamation status and water supply, large-scale irrigation and reclamation measures are being carried out [1]. In order to further develop agriculture, it is envisaged to carry out tasks to improve the agrochemical and biological properties of soils, to increase their fertility, as well as to implement measures for the effective use of the country’s land and water resources [2-6].

One of the non-traditional methods for solving the above problems is the use of hydrogels with high swelling and water-saving ability. A number of works are devoted to studies on the synthesis of water-saving polymer hydrogels for agriculture and their effect on the biological properties of soils [7-10].

In previous works, we studied the synthesis of hydrogels in the presence of hydrolyzed polyacrylonitrile (HIPAN), carboxymethyl cellulose (CMC), starch and other substances in various versions, as well as the effectiveness of their use in agriculture [11-13].

The article presents the results of studies on the production of hydrogels for agriculture with a wide complex effect. Various mineral fertilizers (ammophos, ammonium sulfate, urea, etc.) and stimulants in different ratios were used as additives to hydrogels. The processes of swelling of the obtained hydrogels in various soil and climatic conditions were studied [14-17].

Soil is the environment in which the processes of vital activity and reproduction of various microorganisms occur. Microorganisms have high biological activity, they decompose organic and mineral substances in large quantities and synthesize their various forms. In this case, the basic processes of transformation of nutrients occur and...
the main biologically active substances are released. Microorganisms contribute to increasing soil fertility, with their direct participation in the soil, the processes of accumulation of mineral elements necessary for plants occur. Along with this, microorganisms have a positive effect on increasing crop yields. The processes of soil formation, namely biological weathering, also occur with the participation of microorganisms.
2. Materials and Methods

2.1. The study of the biological properties of typical non-irrigated soils

Almond seedlings planted in an arid experimental plot of 0.4 ha on soils treated with hydrogel were used as the object of research. For 2 years, agrobiological observations of the growth and development of seedlings were carried out, after which soil samples were taken for research at a depth of 30 and 50 cm near the roots of the tree. At the same time, control tests were conducted on soils without the use of a hydrogel (Figure 1).

Studies have shown that the number of mushrooms in the studied typical non-irrigated lands varies between 16000-18000 per 1 g of soil profile. These results can be explained by adverse soil and climatic conditions, lack of moisture and organic matter, excessive alkalinity of the soil, its increased density, as well as other factors. If on the upper (0-30 cm) layers of typical non-irrigated soils where hydrogel was not used, the average number of fungi was 15000 / g, and on the middle (30-50 cm) soil layers their number was 22000 / g, whereas on soils where hydrogel was used, the number of fungi on the above soil layers was 12,000 and 20,000 / g, respectively. On the upper layers of the above soils, these indicators were significantly higher (42000 and 32000 / g, respectively). From all this we can conclude that leaching processes occurring in the upper layers of the soil lead to a reduction in the number of mushrooms (Figure 2).

![Figure 2. The number of microorganisms in 1 g of soil samples](image)

It is known that actinomycetes are important in the life of soils. They participate in the decomposition of organic substances in soils, both containing and not containing nitrogen. Actinomycetes contribute to the processes of transformation of compounds, they contain active enzyme systems that provide the decomposition of lignin, chitin, cellulose and humic substances, sparingly soluble phosphate compounds and other similar substances. Actinomycetes are considered one of the types of microorganisms most resistant to drought, they can develop in conditions of low content of organic substances in the soil [18-20].

The number of actinomycetes in typical non-irrigated soils is usually 60,000 cells, and 15,000 cells on the surface of the arable layer. In the experimental soils, the number of actinomycetes participating in the nitrogen circulation has changed to a noticeable degree, namely, if in the control variants the surface arable layer contains 15000-30000 cells, in the experimental variants this number was 30000-40000 cells.

The intensity of microbiological processes, the quantity and quality of microflora is largely directly related to temperature, humidity, soil texture, water and air conditions, the availability of organic matter,
the terrain, the degree of susceptibility to erosion, as well as ongoing agricultural activities, namely, the use of mineral fertilizers, the depth of the arable layer and other factors.

### Table 1. Dynamics of soil moisture in the experimental and control areas

| Number and title of the section | The depth of the soil layer, cm | Soil Moisture (June) | Moisture loss | Relatively baseline, % |
|--------------------------------|--------------------------------|----------------------|---------------|------------------------|
| K-1 Using hydrogel             | 0-30                           | 8.2                  | 198.4         | 6.2                    | 198.8                   | 60.0                    |
| K-2 Without the use of a hydrogel | 0-30                   | 4.9                  | 122.9         | 7.2                    | 191.2                   | 61.7                    |
|                                | 30-50                          | 11.4                 | 1680.4        | 7.5                    | 887.0                   | 38.6                    |
|                                | 30-50                          | 7.5                  | 1135.0        | 8.8                    | 1297.1                   | 57.5                    |

A clean plowed field makes it possible to preserve natural moisture in the soil, use technical means in weed control, efficiently and gently apply fertilizers and chemical plant protection products, and also helps to increase yield and improve the quality of agricultural products. In the Republic of Uzbekistan, on elevated hilly areas that are half-wetted by atmospheric precipitation, clean virgin lands in the summer months are once cultivated with plane cutters or heavy disk harrows. As a result, in the autumn period of sowing grain crops (October month), soils accumulate an average of 790-800 m³/ha of moisture, and in the rainy months the soil can store 1200-1500 m³/ha of water. In dry years, the value of pure arable land especially affects the yield of autumn crops and stubble, namely on sown areas freed from grain, you can get a higher crop than in sown areas.

### 2.2. The study of the mechanical properties of typical non-irrigated soils

In recent years, a monoculture of wheat has been sown on virtually all non-irrigated areas of the country, which impedes the introduction of a wheat sowing system - plowing and reducing the area of pure plowing. Due to the fact that the areas allotted for autumn plowing are not cultivated in a timely manner, livestock grazing occurs on them, resulting in soil compaction, reduction in its porosity, erosion and degradation [22-25].

The mechanical composition of the soil is one of its most important characteristics, which have a great influence on the fertility of the cultivated areas, the efficiency of the use of agricultural machinery, which ultimately ensures an increase in the yield of cultivated crops. The mechanical composition of the soil is closely related to the composition of parent rocks, its properties are improved as a result of high-quality cultivation and crop rotation [26-28].

The mechanical composition of non-irrigated sown areas at various depths (0-30 and 30-50 mm), the soils of which were treated with hydrogel (Table 2), was studied.

As can be seen from Table 2, the use of a hydrogel led to the aggregation of small fractions, which positively affected the increase in the content of particles larger than 0.05 mm. It was shown that in areas treated with hydrogel (K-1), the content of physical clay at a depth of 0-30 mm is 35.4%, and at a depth of 30-50 mm its amount is 34.9%. In areas untreated with hydrogel (K-2), the content of physical clay at a depth of 0-30; 30-50 mm is respectively 33.6 and 35.6%.
The content of organic substances in soil is an important component of the soil and the main source of plant nutrition. They actively participate in adsorption processes and have a positive effect on soil moisture, water permeability and air permeability, thermal conditions and its structure. The content of organic substances, including humus, varies widely in different soil layers of arable land.

### Table 2. The mechanical composition of non-irrigated soils

| Number and title of the section | Depth, cm | Mechanical composition (weight of fractions),% | The name of the mechanical composition |
|---------------------------------|----------|-----------------------------------------------|--------------------------------------|
|                                 |          | >0.25 0.25-0.10 0.10-0.05 0.05-0.01 0.01-0.005 0.005-0.001 <0.001 | Physical clay |
| K-1 (using hydrogel)            | 0-30     | 1.6 0.4 18.3 44.3 9.1 18.0 8.3 35.4 | medium sand |
|                                 | 30-50    | 2.0 0.5 18.9 43.7 9.8 17.4 7.7 34.9 | medium sand |
| K-2 (without the use of hydrogel)| 0-30     | 1.2 0.3 17.1 47.8 8.4 18.6 6.6 33.6 | medium sand |
|                                 | 30-50    | 0.8 0.2 17.4 46.0 10.2 18.5 6.9 35.6 | medium sand |

### Table 3. Agrochemical index of non-irrigated areas

| Number and title of the section | Depth, cm | General, % | Assimilable form, mg/kg | C:N | pH | CO₂, % |
|---------------------------------|----------|------------|------------------------|-----|----|-------|
|                                 |          | humus,%    | N P K N-NO₃ P₂O₅ K₂O |     |    |       |
| K-1 (using hydrogel)            | 0-30     | 1.280 0.138 0.148 1.750 10.8 24.2 245 | 5.4 | 7.0 | 6.80 |
|                                 | 30-50    | 0.925 0.115 0.127 1.650 8.4 22.3 238 | 4.7 | 7.8 | 7.20 |
| K-2 (without the use of hydrogel)| 0-30     | 1.612 0.101 0.260 0.883 6.0 33.0 417 | 9.3 | 7.7 | 9.24 |
|                                 | 30-50    | 1.438 0.120 0.250 0.964 5.2 15.0 495 | 7.0 | 7.7 | 8.92 |

It is known that nitrogen reserves are fully concentrated in the soil, phosphorus and sulfur are partially, and elements such as potassium, calcium, magnesium and others are concentrated in small quantities in organic substances. Soil humus is a complex of high molecular substances with nitrogen-containing compounds. Its amount depends on a number of factors and conditions, depending on the quantity and quality of biomass, its chemical composition, environment, natural and climatic conditions, thermal conditions, and physical and mechanical properties of the soil. Studies were carried out on elevated hilly non-irrigated agricultural lands, which are moistened by precipitation at half the rate. Samples of non-irrigated soils treated with hydrogel, which were selected at various depths, were studied, and their main agrochemical parameters were studied. As a control, soil samples were used on which the hydrogel was not used (Table 3).
The study of the main agrochemical indicators showed that with increasing soil depth, the content of humus and nitrogen in their arable and subsurface layers significantly decreases and sharply decreases in the parent rock. It was found that the total content of phosphorus and potassium in irrigated fields with and without hydrogel is 0.114–0.260% and 1.750–0.883%, while the content of assimilable phosphorus (P$_{2}$O$_{5}$) and potassium (K$_{2}$O) corresponded to 24.2–33.0 mg/kg and 245–417 mg/kg.

4. Conclusion
The use of hydrogel absorbent in typical non-irrigated virgin areas allowed increasing soil moisture in the upper layer and 30 cm thick layer by 1.2% compared to the control. In the subsurface layer, an increase in soil moisture was 0.3–2.3%.
The use of absorbent hydrogel provided an increase in moisture reserves in the soil layer of 0-50 cm in the moisture range of 94.4-145.0 m$^{3}$/g compared with the control variant in which the hydrogel was not used.

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