Effect of humate substances on biological activity and physical properties of eroded soils: a case study of Uzbekistan

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Abstract. Worldwide, approximately 3 million hectares of land degraded due to erosion, and every minute approximately 44 hectares of agricultural land are being lost. In fact, agricultural area situated in arid zone is vulnerable to erosion, which leads to decline in agricultural productivity due to low quality soil. Evidently, the vital activity of microorganisms is interlinked with the assimilation of minerals by plants in irrigated lands, that is, the production of high and quality crops. Therefore, this research was intended to see effect of humate substance on biological activity and physical properties of eroded soils, that is, investigate how humate substance impact on overall structure of soils in the Pskent district of Tashkent province. The results extracted from field and laboratory experiments showed that poultry manure in moderately eroded soils and humus and poultry manure variants in washed-out soils ranged from 2.2x10^7 KHB/g to 7.5-3.0x10^6 KHB/g. Oligonitrophilic microorganisms were found to be the same in all variants. Micromycetes were observed in humus variants with an average erosion of 2.2x10^4 KHB/g, and in washed-out soils of 7.5x10^3 KHB/g. The amount of actinomycetes in samples 3 and 4 was 7.5x10^3 KHB/g per 1 gram of soil, while in samples 1, 2, 5 and 6 they were not found at all. This means that the amount of actinomycetes was slightly reduced in summer, but the relative changes between the options were 1.1-8.3x10^8 KHB/g in washed-out soils with moderate erosion in less washed soils, and 7.5-8.3x10^7 KHB/g in moderately washed and washed soils. Furthermore, influence of humic biofertilizers, organic fertilizers on general physical properties of eroded typical gray soils was also studied. Accordingly, the effect of fertilizers in the control variant was 1.30g/cm^3, followed by the variant with the use of mineral fertilizers humate 1.27g/cm^3, and the application of poultry manure 1.29g/cm^3. In moderately eroded soils, the values were found to be 1.40 g/cm^3, 1.35 g/cm^3, 1.33 g/cm^3, respectively, and 1.25 g/cm^3, 1.31 g/cm^3, 1.29 g/cm^3 in washed out soils.

1. Introduction

It is known that there are two main types of soil degradation, such as water and wind, and they are destructive to soil cover, consequently, the water-physical, agrophysical and water regime of soil are worsened [1]. Around the world, more than 3 million hectares of land are being degraded by erosion, and every minute approximately 44 hectares of agricultural land are being lost [2]. Furthermore, erosion also causes reduction in agricultural productivity, especially agricultural land situated in arid zone [3-8].
Currently used fertilizers in the irrigated arable land located in different the conditions of the Republic of Uzbekistan are nitrogen, phosphorus, potassium, small amounts of organic fertilizers [9, 10]. It is vitally important investigate effect of macronutrients, micronutrients and new biological precursors, which used for getting higher yield from sowed cotton, wheat, rice and corn, on the composition and number of microorganisms in the soil towards boosting the fertility of the soil. Evidently, the vital activity of microorganisms is interlinked with the assimilation of minerals by plants in irrigated lands, that is, the production of high and quality crops [9]. The relationship between agricultural culture, and the composition and quality of mineral fertilizers given to the land has been studied. Furthermore, a number of studies has been conducting on analysis of agrochemical, physical-chemical properties, humus state, the interaction of biological activity of soil with environmental factors. Nowadays, large-scale land reclamation and research within the framework of the state programs are being done towards improving the reclamation of irrigated lands, maintaining, increasing their productivity and effective use, and certain results have been achieved [11, 12]. Microorganisms live in the soil that they have direct and indirect effect on human life and living conditions; reduction of microorganisms in the soil affects the productivity of agricultural crops, which in turn reduces the income of the farmer or type of microorganisms, such as bacteria can cause infectious, flu and measles.

It is stated that in soils of irrigated land, ammonia slats formed by ammonification processes are oxidized to nitrate salts. Ammonia is oxidized and converted into nitric acid through the intermediate phase, the form of nitric acid. This process was invented in 1870, it has a very large autonomy in agriculture. Vinogradsky S.H., who is famous Russian biologist, stated that several types of bacteria are produced as result of the process of ammonia oxidation and transition to nitric acid, and classified them as Nitrosomonas, Nitrosocystis, Nitrosospira [11, 12]. It was found that the mineralization of organic phosphorus in the phosphorus compounds present in the soil was carried out under the influence of putrefactive bacteria (Bac. Megatherium and others). Clearly, experiments conducted at Agricultural Academy named after K.A. Timirzayev identified that there was the great influence of nitrifying bacteria on the dissolution of phosphates [13, 14]. Those experiments showed that nitric acid, which was formed as a result of nitrification processes in the field, can convert phosphate to calcium monophosphate. Although soils of irrigated lands were rich in phosphorus compounds, there was a lack of active type of phosphorus.

It is identified that some of phosphorus fertilizers are washed away during the irrigation on slope area. Consequently, 30-40 tons of organic fertilizers per hectare of that irrigated lands are required, in order to restore the necessary fertilizers for the agricultural activities [15]. Today it is a bit difficult to meet with that demand, therefore, around the world, enrichment of soils in agricultural lands with organic fertilizer and mineral compost got great attention, including in Uzbekistan. Accordingly, in recent years, the development of new ways, methods, and technologies for the enrichment of soils with organic matter was set as a main task in the state programs for agricultural development. Among these fertilizers, liquid and solid nitrogen-humus fertilizers obtained on the basis of Angren brown coal deposit, which have a natural origin, are being introduced. The benefits of these fertilizers have been seen in research conducted in a number of Commonwealth of Independent States. Humic fertilizers improve the agrophysical properties of the soil. Humic fertilizers have been shown to improve soil water-physical properties: capillary and field moisture, capacity of light soils, increase water permeability of soils with heavy mechanical composition, improve soil structural condition and water resistance, and reduce soil volume weight [2]. A number scientists studied and are being studied the formation of erosion processes, the effect of erosion on soil fertility and its basic properties. The influence of water erosion, the nutritional regime of plants and the physical properties of the soil deteriorate [13]. The pertinent results of that scientific research showed that for the formation of 1 g of dry matter in strongly washed soils, soil moisture was used several times more than unwashed soil, while the moisture storage property in washed soils was slightly lower than in unwashed soils [15]. Evidently, erosion causes a violation of the natural laws of the process of soil formation. In water-
washed slopes, the thickness of the humus (humus) layer and genetic layers of the soil decreases, the mechanical composition decreases, the supply of nutrients decreases, the water regime changes.

However, further analysis of current situation showed that effect of humate substance on biological activity and physical properties of eroded soils has not studied well yet, especially in the Pskent district of Tashkent province, therefore, this research aimed investigating how humate substance impact on overall structure of soils in the district. Besides, the main objective of the study was to research the main texture-properties, biological activity of irrigated soils, the coefficient of transformation of organic matter and biofuels.

2. Materials and Methods
For this research, the Pskent district of Tashkent province was selected where the main characteristic features of irrigated typical burlap soils, spread of organic matter and agrophysical properties and three methods, field experiment, laboratory experiment and dispersion analysis were used toward reaching the study objective.

Field experiment was employed in this research toward collecting primary data such as samples of burlap soils, organic matter, and humus, which were needed to analyze effect of humate substance on biological activity and physical properties of eroded soils. Clearly, field experimental research was conducted using the written instructions, such as “The method of field and vegetative experiments with cotton in irrigation conditions” and "methods of conducting field experiments. Furthermore, different variants (options) for field experiment were formulated:

1. Na\textsubscript{2}00 P\textsubscript{150} K\textsubscript{100}-condition (natural)
2. Condition + poultry manure, 2 tons/ha
3. Condition+humate-Na

Where, Na - is sodium, P - is phosphorus, and K - is potassium.

Normally, the assimilation of minerals by plants in irrigated lands, that is, the production of high and quality crops is closely linked with the vital activity of microorganisms in the soil. Therefore, the question of the relationship between the development of agricultural culture and the composition and quality of mineral fertilizers applied to the land is being studied. So, the issue of production and application of biological fertilizers attracts the attention of many scientists around the world. During the study, it was observed a change in the species and number of microorganisms living in the soil depending on the degree of soil erosion, its effect on the agronomically valuable properties of the soil, especially influence on cotton yields. Furthermore, effects of sodium humate taken from the Angren coal mine in the Piskent district on cotton plants sowed in gray eroded soils in the irrigated agriculture were studied.

Laboratory experiment was used to analyze properties and structure of soils, the levels of available humus and fertilizers in the soil. The soil analysis was carried out based on manual of E.V. Arinushkina on "Chemical analysis of soil", and the manual of D.G. Zvyaginstev, "Methods of soil microbiology and biochemistry" was used for analyzing availability of microorganisms in the soil.

Data extracted from the field experiment and laboratory experiment was analyzed using dispersion method towards identifying distribution of certain fertilizers in particular soil.

3. Results and Discussion
In the field experiment, samples from low, moderately eroded and washed-out soils were taken, and the amount of the main physiological group of microorganisms in the soils were determined (Table 1). According the outputs of the research, poultry manure in moderately eroded soils and humus and poultry manure variants in washed-out soils ranged from 2.2x10\textsuperscript{7} KHB/g to 7.5-3.0x10\textsuperscript{6} KHB/g. Oligonitrophilic microorganisms were found to be the same in all variants. Micromycetes were observed in humus variants with an average erosion of 2.2x10\textsuperscript{4} KHB/g, and in washed-out soils of 7.5x10\textsuperscript{3} KHB/g. Result of microbiological analysis (Table 1) showed that the amount of ammonifier
bacteria in one gram of soil was 1.1-8.3x10^8 KHB/g in samples 1, 2, 4 and 6, and in samples 3 and 5 less than one order, that is, of 7.5-8, 3x10^7 KHB/g. Furthermore, phosphorus-degrading bacteria were found in samples 1, 2, 3, and 6 and ranged from 3.7–9.0x10^7 KHB/g, whereas they were not found in samples 3 and 4, respectively. The number of oligotrophilic microorganisms growing in a nitrogen-free environment was found in the same order in all soil samples and was found to be 1.2–3.0x10^6 KHB/g per 1 gram of soil. Whereas, micromycetes were less common in 3 samples at 3.0x10^5 KHB/g per 1 gram of soil, and in samples 2, 3 and 4 at 7.5x10^3 KHB/g, and in samples 1 and 6 they were not found at all.

Table 1. Microorganisms of the main physiological group in soils

| Samples | Washing rate | Bio substances, organic fertilizers | Ammonium fixatives | Phosphorus-degrading bacteria | Oligotrophic bacteria | Micromycetes | Actinomycetes |
|---------|--------------|----------------------------------|--------------------|------------------------------|----------------------|------------|-------------|
| 1       | Less washed  | Control                           | 1.5x10^7           | 6.5x10^7                    | 1.6x10^6             | not determined | not determined |
| 2       |              | Humate Na                         | 1.5x10^8           | 6.7x10^7                    | 2.3x10^6             | not determined | not determined |
| 3       |              | Poultry manure                    | 1.1x10^8           | 9.0x10^7                    | 1.1x10^6             | 7.5x10^3    | not determined |
| 4       | Moderately washed | Control                  | 6.9x10^7           | 2.5x10^7                    | 2.0x10^6             | 6.5x10^3    | 5.5x10^3    |
| 5       |              | Humate Na                         | 7.5x10^7           | 3.7x10^7                    | 3.0x10^6             | 7.5x10^3    | 7.5x10^3    |
| 6       |              | Poultry manure                    | 8.3x10^8           | not determined              | 1.7x10^6             | 7.5x10^3    | 7.5x10^3    |
| 7       | Washed and collected | Control                  | 7.2x10^7           | not determined              | 0.9x10^6             | 2.1x10^3    | not determined |
| 8       |              | Humate Na                         | 8.3x10^7           | not determined              | 1.2x10^6             | 3.0x10^3    | not determined |
| 9       |              | Poultry manure                    | 1.5x10^8           | 3.7x10^7                    | 1.6x10^6             | not determined | not determined |

The amount of actinomycetes in samples 3 and 4 was 7.5x10^3 KHB/g per 1 gram of soil, while in samples 1, 2, 5 and 6 they were not found at all. This means that the amount of actinomycetes was slightly reduced in summer, but the relative changes between the options were 1.1-8.3x10^8 KHB/g in washed-out soils with moderate erosion in less washed soils, and 7.5-8.3x10^7 KHB/g in moderately washed and washed soils. Phosphorus-degrading bacteria were not found at all in moderately eroded soils. The highest value of micromycetes was 3.0x10^5 KHB/g in the humus variant in the washed soils.

Knowledge of agrophysical and hydrophysical properties in the context of irrigated agriculture plays an important role in improving the productive properties of the soil. Normally, active and useful water and nutrients in the soil are often determined by physical and hydrophysical properties. Physical-water, physical-mechanical properties of soil, specific gravity, volume weight, porosity, moisture capacity, water permeability and fertility depend on the mechanical composition of the soil. Erosion processes, the direct impact of the parent rock layers on the physical properties of the soil was high.
It was researched that humus biofertilizer, organic fertilizer, poultry manure fertilizer affected on the general physical properties of typical eroded gray soils. Accordingly, the effect of fertilizers in the control variant was 1.30 g/cm³, followed by the variant with the use of mineral fertilizers humate 1.27 g/cm³, and the application of poultry manure 1.29 g/cm³. In moderately eroded soils, the values were found to be 1.40 g/cm³, 1.35 g/cm³, 1.33 g/cm³, respectively, and 1.25 g/cm³, 1.31 g/cm³, 1.29 g/cm³ in washed out soils. Clearly, the overall porosity of the soil also changed. Such a pattern was observed in the variants where the highest rate was 53.18% in the washed and accumulated soil, where humus was applied with mineral fertilizers (Table 2). When biofertilizers and poultry manure were applied to the soil on the basis of mineral fertilizers, the erosion rate was relatively high in moderately eroded soils, the soil density decreased and the porosity increased (Table 2).

Table 2. Influence of humic biofertilizers, organic fertilizers on general physical properties of eroded typical gray soils

| Samples Washing rate | Bio substances, organic fertilizers | The bulk density of the soil (g/cm³) | The specific gravity of the soil (g/cm³) | Total porosity (%) |
|----------------------|-------------------------------------|-------------------------------------|----------------------------------------|-------------------|
| 1 Less washed Control | Control 1.30 | 2.65 | 50.94 |
| 2 Humate Na Control | Humate Na 1.27 | 2.69 | 52.78 |
| 3 Control Moderately washed | Control 1.29 | 2.70 | 52.22 |
| 4 Control | Control 1.40 | 2.68 | 47.76 |
| 5 Humate Na Moderately washed | Humate Na 1.35 | 2.68 | 49.62 |
| 6 Control Washed and collected | Control 1.33 | 2.70 | 50.74 |
| 7 Control Washed and collected | Control 1.25 | 2.67 | 53.18 |
| 8 Humate Na | Humate Na 1.31 | 2.69 | 51.30 |
| 9 Control Washed and collected | Control 1.29 | 2.72 | 52.57 |

4. Conclusions

Summarizing all points mentioned above, the most optimal indicator of the general physical properties of the soil was observed in the variants applied with mineral fertilizers and humus. In short, the general physical properties of the soil were manifested differently in all the processes that took place in it. In particular, the effect of erosion processes on the physical properties of the soil was observed during the study.

Phosphorus-degrading bacteria were not found at all in moderately eroded soils. The highest value of micromycetes was 3.0x10⁵ KHB/g in the humus variant in the washed soils. When biofertilizers and poultry manure were applied to the soil on the basis of mineral fertilizers, the erosion rate was relatively high in moderately eroded soils, the soil density decreased and the porosity increased.

In general, the presence of microorganisms in the soil and artificial fertilizers have been found to increase soil fertility, and in irrigated agriculture, this research once proven that the risk of erosion on humus rich layer of soil was high.
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