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**ASSESSMENT OF THE SANITARY CONDITION OF SOILS  
DISTURBED BY UNAUTHORIZED WASTE DISPOSAL**

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**Abstract**

This article represents the research of the impact of violations in the storage, warehousing and usage of wastes including animal wastes on the sanitary state of soils. The above research was held to determine the degree of soil's biological pollution including sanitary and bacteriological indexes. Due to the fact that soil is inhabited by countless plant and animal organisms with various activities that participate in the formation and evolution of the soil as factors in the synthesis of humic substances and determining soil fertility. The assessment of the degree of accumulation of sanitary-indicative organisms of the *Escherichia coli* group has been carried out. The value of the enterococcus index in the upper soil layer has been established in the conditions of violation of the requirements for waste disposal and storage. The degree of biological contamination of soils was established when solid and liquid wastes of a livestock complex were placed on them. The level of contamination by pathogenic bacteria of the *E. coli* group and faecal streptococcus in the upper soil layer was revealed. The objects and methods of research were sod-podzolic and grey forest soils of the territories of agricultural lands. Taking into account the possibility of the production of toxic substances by microorganisms-mycotoxins during soil fatigue and the prevailing environmental conditions conducive to the manifestation of this process, the danger of soil contamination with mycotoxins that pose a serious threat to humanity becomes real.

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*Keywords:* Sanitary organisms, coli index, enterococcus, streptococcus, waste storage, sustainability



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## 1. Introduction

The soil is inhabited by countless plant bodies and animal organisms with various activities. They are participating in the formation and evolution of the soil as factors in the synthesis of humic substances and determining soil fertility. Along with this, they participate in the transformation of substances used by higher plants for nutrition (Stepanova et al., 2020a). More and more high-profile research is carried out in the field of social and environmental problems which are associated with the production and consumption of animal meat along with climate change (Dobrovolsky & Nikitin, 2015). Over the past 100 years, the net worldwide consumption of meat has grown exponentially, as the world's population has grown significantly (Stepanova, 2020b). The intensification of animal farming, which underlies the growth in product consumption, has a huge impact on the planet's ecosystem in the form of fertilizers as a result of the digestive activity of animals (Stepanova & Pisareva, 2019). The importance of living organisms which are located in the soil is very high, as all-natural reactions which occur in the soil directly or indirectly has biochemical nature (Stepanova et al., 2019a). Soil fatigue is a natural phenomenon, which is caused by many reasons, viz namely, the removal of nutrients, the spread of specific weeds, pests, diseases and microorganisms. The deterioration of the water-physical properties of the soil could be eliminated to a certain extent as a result of use of fertilizers, pesticides, agricultural technology, crop rotations (Trifonova, 2020b). For example, in the work (Ksenofontov, 2018; Ksenofontov & Goncharenko, 2018), a scheme is proposed that excludes the transportation of toxic substances in sludge into the environment. The obtained experimental data correlate well enough with the existing methods (Ksenofontov, 2019; Ksenofontov & Antonova, 2016). However, there are factors that cause soil fatigue. They are associated with the accumulation of physiologically active toxins in the soil, which are extracted by plant roots and microorganisms; the reproduction of specific pests, diseases and weeds. They also could be associated with decomposition products, violation of the conditions for the use of organic and mineral fertilizers (Stepanova et al., 2019b). It has been shown that human activity and anthropogenic impact on the environment lead to the loss of properties that ensure normal life and safety of human health (Stepanova et al., 2019c). The ecological functions of soil are not unlimited and could be disturbed during certain economic activities of a person; an example of such a violation is soil fatigue (Kaurichev et al., 2014). However, today, most of the researches are limited to studying the relationship between individual ecosystem services and biodiversity (Tebenkova, 2019). It is known that antibiotics enter the soil with the manure of cattle, pigs and poultry and sewage sludge from biological treatment plants used as organic fertilizer. Thus, the authors represented a study of the effect of antibiotics of various groups on the cellulolytic activity of sod-podzolic soil under their individual and combined exposure by the method of laboratory modelling (Trifonova, 2020a, 2020b).

In this regard, it is relevant to research the impact of violations in storage, warehousing and usage of animal wastes on the sanitary state of soils. The research should be done in terms of the degree of biological contamination of soils using sanitary and bacteriological indexes.

## 2. Problem Statement

The violation of technologies for the storage and usage of fertilizers which are based on cattle wastes and solid household wastes on an agricultural land plot with sod-podzolic and grey forest soils led to a deterioration in the sanitary state of the studied soils in terms of sanitary and bacteriological indexes. It was due to the presence of sanitary indicative organisms of the groups of *E. coli* (CGB-coli-index) and faecal streptococcus (enterococcus index).

The storage of wastes from the livestock breeding complex on the soil surface of the land plot in unstandardized quantities and in violation of the requirements for the arrangement of the land area led to the formation of a high-risk agricultural land area on an area of 3970 m<sup>2</sup> with a pollution category: “contaminated”.

## 3. Research Questions

The tasks are:

- assessment of the degree of accumulation of sanitary-indicative organisms of the *E. coli* group (CGB-coli-index) and faecal streptococcus (enterococcus index) in the arable soil layer at a depth of 0-5 cm and 5-20 cm in conditions of violation of the requirements for the placement and storage of animal wastes on agricultural land;
- establishing of the biological contamination degree of sod-podzolic and grey forest soils of agricultural lands during the process of placing solid and liquid wastes from the livestock breeding complex on them;
- revealing the level of contamination by pathogenic bacteria of the *E. coli* group and faecal streptococcus in the layer 0-5 cm and 5-20 cm and assessing the sanitary state and ecological stability of the researched soils;
- establishing of the degree of ecological stability and buffering of the researched soils to biological contamination and the intensity of the biological load on the soil by the number of sanitary-indicative organisms.

## 4. Purpose of the Study

The task is to determine the degree of change in the sanitary state of sod-podzolic and grey forest soils of agricultural lands. It is necessary due to the violation of storage technologies and the usage of fertilizers based on dressings obtained as a result of the digestive activity of animals and solid household wastes.

## 5. Research Methods

The studies were carried out on sod-podzolic and grey forest soils of agricultural lands. Bacteriological analysis was carried out according to the "Methods of microbiological soil control" Guidelines (app. 24.12.2004, No. FC/4022) to assess the sanitary state of the soils.

The methods of sampling and preparation of soils for chemical, bacteriological, helminthological analysis were carried out according to GOST 17.4.4.02-84.

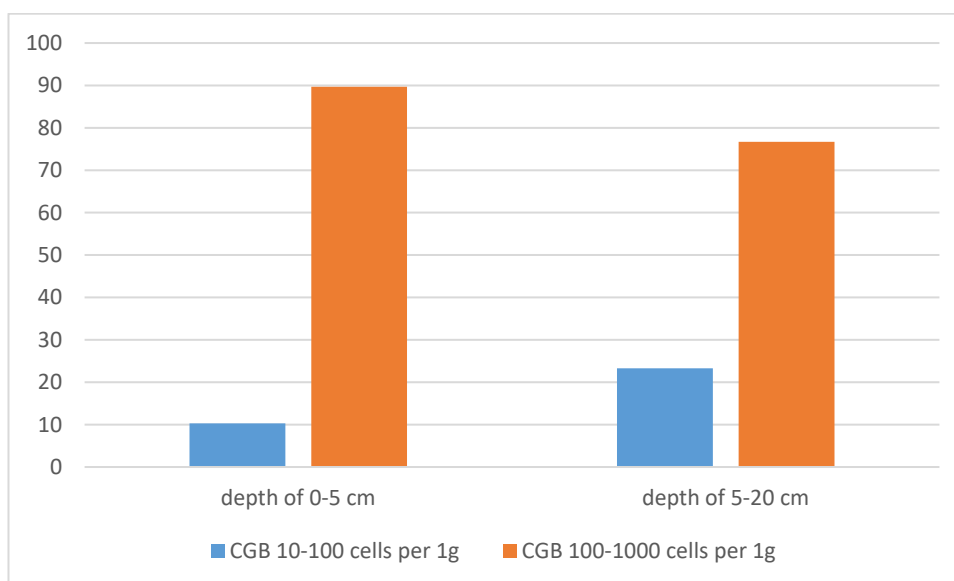
For bacteriological analysis, 10 pooled samples were taken from one test site. Each combined sample was made up of three-point samples weighing from 200 g to 250 g each, taken layer from a depth of 0-5 cm, from 5-20 cm.

## 6. Findings

Researches have shown a sharp deterioration in the sanitary state of sod-podzolic soil in terms of the degree of biological pollution based on sanitary and bacteriological indirect indexes. The deterioration in the soils condition is due to the presence of sanitary-indicative organisms of the *Escherichia coli* group - the CGB-coli-index and faecal streptococcus - the enterococcus index.

In all studied samples of sod-podzolic and grey forest soils, both at a depth of 0-5 cm and at a depth of 5-20 cm, the presence of pathogenic bacteria in quantities exceeding the values of the indices of sanitary-indicative microorganisms more than ten cells in 1 gram of soil was established. The above gave us the possibility to consider the investigated soils as "contaminated". At the same time, the degree of soil contamination with sanitary indicative organisms of the *E. coli* group - the CGB-coli-index changes with the depth of sampling.

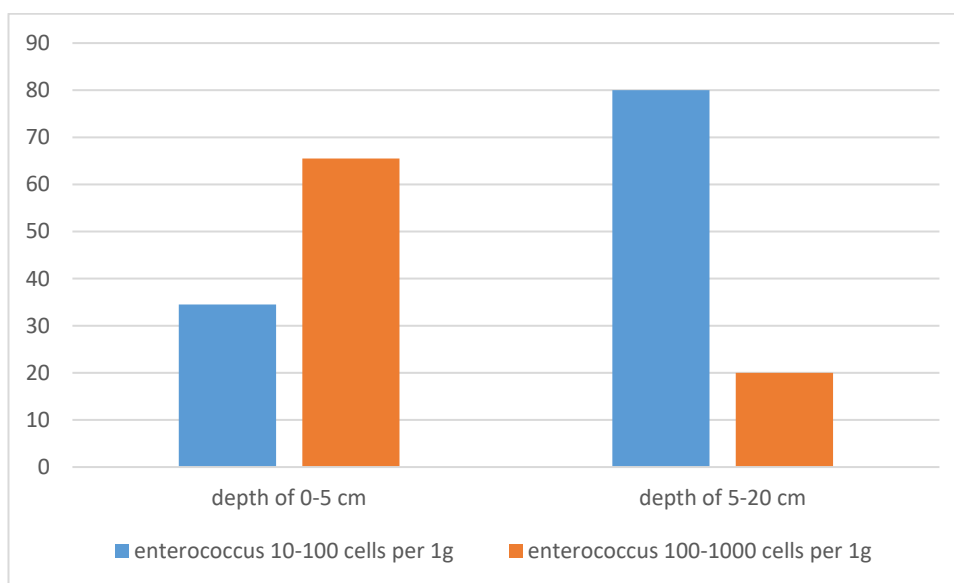
Based on the results of the sanitary and bacteriological analysis of soil samples of a land plot with grey forest soils in connection with the placement of liquid food waste of animal origin on it, it is noted that of all studied soil samples, 89.7% of the studied soil samples taken from a depth of 0-5 cm, the value of the CGB-coli-index was 1000 microbial cells in 1 g of soil. It characterizes the "dangerous" level of contamination by the sanitary-indicative groups of *E. coli* organisms on the investigated land sampling area (Figure 1).



**Figure 1.** Influence of liquid food wastes of animal origin on quantitative indicators (%) of organisms of the *E. coli* group (CGB-coli-index) in grey forest soils

At the same time, 10.3% of the studied soil samples characterize a "moderately hazardous" level of pollution with the number of 100 microbial cells in 1 g of soil at a depth of 0-5 cm. Such a high level of intensity of the biological load on the soil was also established for the studied soil samples which were taken from the depth of 5-20 cm. Thus, in 76.7% of the studied soil samples, the level of contamination by *E. coli* organisms amounted to 1000 microbial cells in 1 g of soil. And only in 23.3% of the analyzed soil samples it was proved that it was "moderately dangerous level" (10-100 microbial cells in 1 g of soil), turning into a "dangerous level" of soil contamination by organisms of the *E. coli* group (100-1000 microbial cells in 1 g of soil).

The number of organisms of the group of faecal streptococcus (enterococcus index) in the soil layer of 0-5 cm varied from the "dangerous" level of pollution in 65.5% of samples which were taken from the contaminated land area. And 34.5% of the samples taken from the contaminated land area characterized the "moderately hazardous" level of contamination of grey forest soil at a depth of 0-5 cm (Figure 2).



**Figure 2.** Influence of liquid food wastes of animal origin on quantitative indicators (%) of organisms of the group and faecal streptococcus (enterococcus index) in grey forest soils

Soil samples which characterize the sanitary and bacteriological state of the soil at a depth of 5-20 cm confirmed the "dangerous" level of contamination on 20% of the studied area by the organisms of the group of faecal streptococcus - 1000 microbial cells in 1 g of soil.

At the same time, in 80% of the studied soil samples, the indicator of the intensity of the biological load on the soil through the presence of faecal streptococcus (enterococcus index) was 100 microbial cells in 1 g of soil at a depth of 5-20 cm, and it was assessed with a "moderately dangerous" degree of pollution.

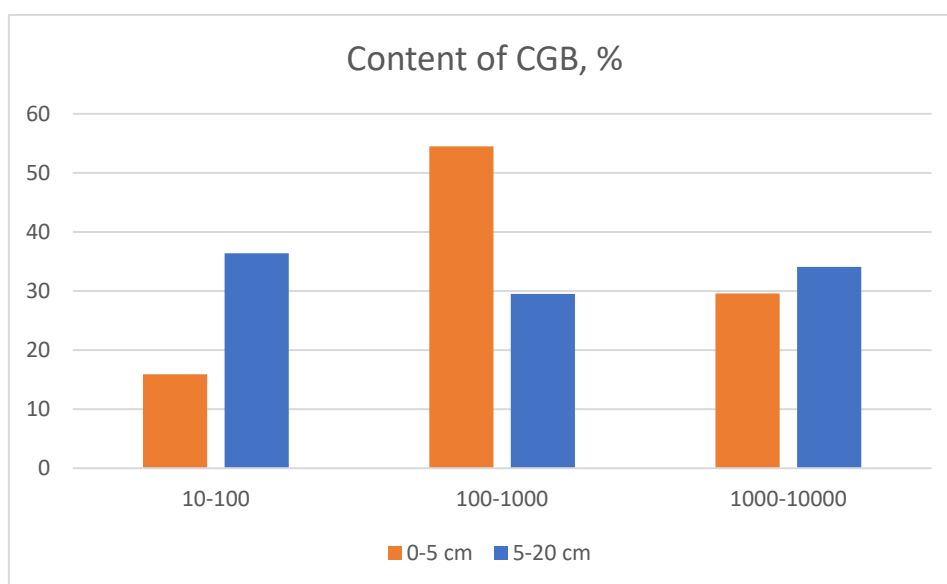
Consequently, the analyzed grey forest soils of agricultural lands which were disturbed by the placement of liquid food waste of animal origin together with the conditions of its warehousing and

storage, contain sanitary-indicative organisms of the group of faecal streptococcus in an amount from 10 to 1000 microbial cells per 1 g of soil. These soils are assessed as "contaminated".

Thus, the storage of liquid food waste of animal origin on grey forest soils of an agricultural land plot worsened the sanitary condition of the soil and increased the intensity of the biological load on the soil through the presence of sanitary-indicative organisms of the *E. coli* group (CGB-coli-index) and faecal streptococcus (enterococcus index) to the category "contaminated" with "moderately hazardous" and "dangerous" degree of soil pollution. This fact leads to the increase in soil toxicity and negative impact on public health and environmental quality and requires recultivating works.

Of particular interest are the results of microbiological tests of samples of sod-podzolic soils, disturbed by failure to comply with the requirements for the placement and storage of food waste of animal origin (cattle). It was found out that the storage of food waste of animal origin in unstandardized quantities on the soil surface of the land plot and in violation of the requirements for the arrangement of the land area led to the formation of an area of soils of agricultural land of increased risk with the category of pollution: "contaminated".

It is a proved fact, that the genetic characteristics of soil resistance to anthropogenic influences have an effect on the sanitary state of soils of agricultural lands. Thus, a sharp deterioration in the sanitary state of sod-podzolic soil according to the degree of biological pollution based on sanitary and bacteriological indirect indicators, namely through the presence of sanitary-indicative organisms of the *Escherichia coli* group - the CGB-coli-index and faecal streptococcus - the enterococcus index, was established. In all investigated soil samples, taken both from a depth of 0-5 cm and from a depth of 5-20 cm, there are pathogenic bacteria in quantities, which are exceeding the values of indexes of sanitary-indicative microorganisms more than ten cells in 1 gram of soil and evaluating the studied soils as "contaminated". At the same time, the degree of soil contamination with sanitary-indicative organisms of the *E. coli* group - the CGB-coli-index changes with the depth of soil sampling (Figure 3).



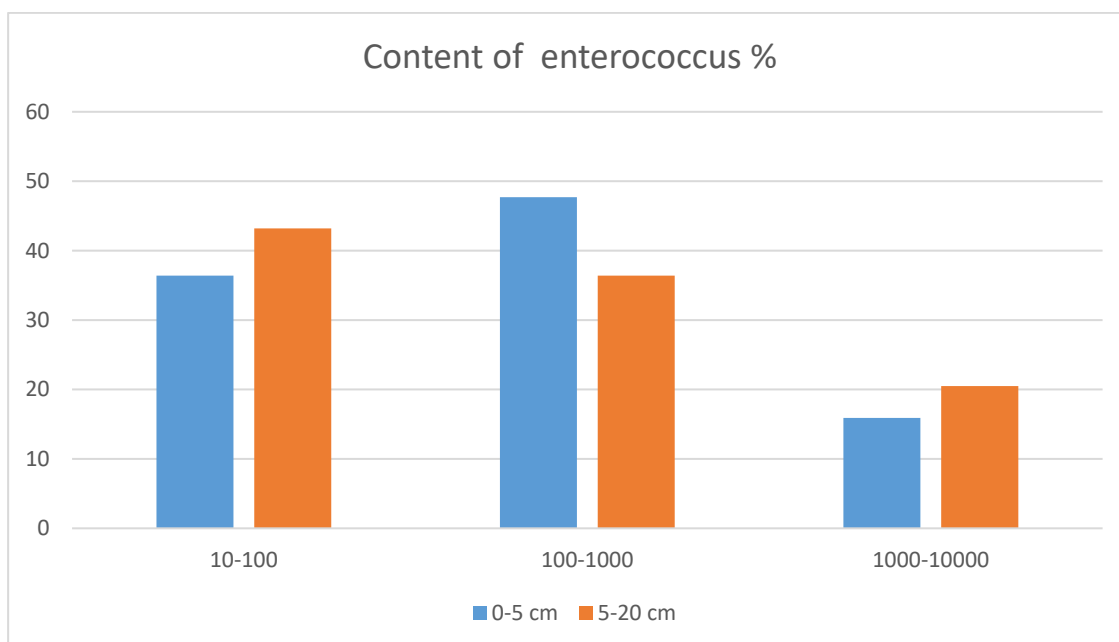
**Figure 3.** Influence of liquid food wastes of animal origin on quantitative indicators (%) of *E. coli* organisms (CGB-coli-index) in sod-podzolic soils

Thus, for the soil samples taken from the depth of 0-5 cm, 29.6% of the analyzed soil samples are characterized by an “extremely dangerous” degree of pollution with a CGB-coli-index of more than 10,000 cells in 1 gram of soil. Only 16% of the samples were characterized by a “moderately hazardous” degree of contamination with the CGB-coli-index value equal to 100 cells in 1 gram of soil.

At the same time, together with a change in the depth of taking a soil sample, the intensity of bacteriological pollution by sanitary-indicative organisms of the Escherichia coli group changes. The highest value of the CGB-coli-index, i.e. more than 1000 cells in 1 gram of soil, is shown in 63.6% of soil samples taken from a soil depth of 5-20 cm, and it is characterized by an "extremely dangerous" level of pollution according to the value of the index of sanitary indicative organisms. It should be noted that in 35% of the analyzed soil samples, which are taken from a depth of 5-20 cm, the CGB-coli-index exceeds 10,000 cells per gram, which characterizes the "extremely dangerous" level of pollution by organisms of the E. coli group.

Of particular interest are the data characterizing the intensity of soil contamination with faecal streptococcus both at the depth of 0-5 cm and at the depth of 5-20 cm.

So, in the soil layer of 0-5 cm, 63.6% of soil samples for the presence of sanitary-indicative organisms of the group of faecal streptococcus are characterized by an "extremely dangerous" level of pollution with an enterococcus index of more than 1000 cells in 1 gram of soil. However, even at this level of pollution, 15.9% of soil samples have an enterococcus index of more than 10,000 cells in 1 gram of soil. And only 36.4% of soil samples had an index of sanitary-indicative organisms of faecal streptococcus of more than 100 cells per 1 gram of soil, which characterizes a “dangerous” level of pollution (Figure 4).



**Figure 4.** The influence of liquid food wastes of animal origin on the quantitative indicators (%) of organisms of the group and faecal streptococcus (enterococcus index) in sod-podzolic soils

In the soil layer of 5-20 cm, i.e. with an increase in the depth of soil sampling, the number of pathogenic microorganisms and the degree of soil contamination change. Thus, in 43.2% of soil samples, a "dangerous" degree of microbiological contamination by faecal streptococcus was established, i.e. more than 100 cells per 1 gram of soil, and 56.8% of analyzed soil samples at a depth of 5-20 cm characterized an "extremely dangerous" level pollution: more than 1000 cells per 1 gram of soil, while 20.5% of the samples of the specified degree of pollution characterized the level of contamination of more than 10,000 cells per gram of soil.

Thus, the storage of food wastes of animal origin that have not passed the full stage of decomposition, i.e., the removal of fresh or semi-rotted food waste of animal origin, creates the danger of soil contamination with pathogenic microorganisms. It increases the intensity of the biological load on the soil and adjacent lands, with a sharp deterioration in the sanitary state of the soil and the creation of the danger of possible soil contamination with Salmonella. So, it becomes necessary to develop measures for the remediation of contaminated land and predict the degree of danger to the health and living conditions of the population. The genetic characteristics of the sod-podzolic soil and the leaching type of water regime in the soil profile should be taken into the account while the above development.

## 7. Conclusion

The deterioration of the sanitary state of grey forest and sod-podzolic soils of agricultural lands in terms of sanitary and bacteriological indicators in connection with the violation of the technology of preparation, storage and use of the fertilizing properties of food waste of cattle origin has been proved. An excess of the permissible level of the presence of sanitary-indicative organisms of the Escherichia coli group was established both at a depth of 0-5 cm and in a soil layer of 5-20 cm by the value of the CGB-coli-index within 10-100 cells and more than 100 cells in 1 gram of soil, characterizing "moderately dangerous" and "dangerous" degree of pollution of grey forest soils and CGB-coli-index within 1000-10,000 cells and more per 1 gram with "extremely dangerous" degree of contaminated of sod-podzolic soil. A "moderately dangerous" and "dangerous" degree of contamination by faecal streptococcus of grey forest and sod-podzolic soils of the studied lands at a depth of 0-5 and 5-20 cm was revealed. It predetermines the danger of penetration and spread of pathogenic bacteria in deeper layers of the soil profile. The established value of the index of sanitary indicative organisms (CGB and enterococcus) in the amount of ten cells or more per 1 gram of soil can be evidence of soil contamination with Salmonella.

The concentration of coliphage, which is established by sanitary and bacteriological researches, in the soil at the level of 10 CFU per 1 gram or more is evidence of soil infection with enteroviruses. The necessity to develop measures for the recultivation of agricultural lands with a "dangerous" and "extremely dangerous" level of biological contamination of grey forest and especially sod-podzolic soils, which are characterized by low self-cleaning ability and sanitary and bacteriological resistance, has been proved. They require the development of measures for the recultivation of contaminated lands, prevention of infectious and non-infectious diseases, solutions for integrated environmental protection measures.



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