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To cite this article: V S Bocharnikov *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **579** 012034

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Technology for preparation of contaminated water from poultry farms for irrigation

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Abstract. Studies of the possibility of using wastewater from poultry enterprises for irrigation of light chestnut soils using sprinkler machines have shown that wastewater needs preliminary treatment. Currently, it remains relevant to search for the most effective and cost-efficient ways to treat wastewater. We propose wastewater treatment by sedimentation on natural zeolite, after which the treated effluents can be discharged into storage ponds for further use in agriculture using sprinklers. For sewage treatment, the settling method was used, before which the particle size distribution of zeolite tuffs was selected and the size of fractions was selected using sieves. The sedimentation was carried out at regular intervals on a natural sorbent (zeolite tuffs). As a result of the study, the optimal contact time of the natural sorbent with the studied effluents was selected, which allowed to reduce the concentration of impurities present to the value below the maximum permissible one. As a result of settling for 80 minutes, there is a decrease in the concentration of chemical impurities in the studied poultry runoff to the maximum permissible concentration. Irrigation with wastewater diluted in 1: 4 with pure water increased the yield of spring wheat compared to the control option by a factor of 1.5. The absorption of organic substances by a soil layer 0.6 m thick is 80-100%. Agricultural use of wastewater diluted 6-7 times provides additional net income from the cultivation of spring wheat by 40%.

1. Introduction

In the arid regions of the country, one of the most important conditions for intensifying agriculture is a widespread development of irrigation and a significant increase in the efficiency of irrigated lands.

One of the most difficult problems is the cleaning, storage and use of the secretory masses of livestock complexes that pose a threat of environmental pollution. In this regard, the use of effluents in irrigation of crops will become of particular importance [1–5].

When irrigating crops with wastewater, it is important to know the chemical composition of the wastewater, the presence of toxic substances, mineralization, and other properties. The characteristics of the composition of wastewater in terms of mineral content, fertilizer value is diverse, so the suspended sediment, dry residue, and the reaction of the medium are in the range of 140 to 41338 mg/l, from 380 to 5445 mg/l and from 4.4 to 11.3 pH points, respectively. However, the runoff of livestock complexes have high fertilizing value, since they include all the elements necessary for the development and growth of plants, so in areas where the poultry runoff was introduced, the yield increased by 40-50% [6–10]. The use of undiluted effluents is unacceptable due to a high content of chemicals.



Irrigation of fields using diluted livestock runoff contributes to increased soil fertility [11–15]. The combined use of irrigation machines for irrigation with both clean water and diluted poultry runoff will allow the irrigation machine to be more fully loaded. Joint use of equipment will allow for a rational use of the nutrients contained in wastewaters and differentiated supply in an easily accessible form.

Plant nutrition can be regulated during the entire period of plant growth. A sprinkled solution enters not only the soil, but also the leaves of plants, entering the intracellular metabolism and contributing to strengthening of growth processes [16, 17].

2. Materials and methods

The object of study is poultry farm wastewater. In the agro-industrial complex there are many enterprises representing environmental danger, the specifics of which at present is an increase in the volume of goods turnover, and accordingly the danger to the environment, including for soils, is increasing. Studies of the possibility of using wastewater from poultry enterprises for irrigation of light chestnut soils of the Volgograd region showed that wastewater needs preliminary treatment.

In most cases, the so-called storage ponds are used to clean the effluents of poultry farms, where chicken droppings are taken out for drying in the open air. The same ponds usually also treat industrial wastewater.

We propose wastewater treatment by sedimentation on natural zeolite [18–20], after which the treated effluents can be discharged into storage ponds for further use in agriculture using sprinklers.

Sprinkling was carried with an intensity of 1.0 mm / min out until a continuous film appeared on the soil surface; the soil in the experiment was a light chestnut soil, droplet diameter was 1.1-1.5 mm. Fertilizer solutions were supplied in the following sequence: at the beginning of irrigation (solution-water), in the middle of irrigation (water-solution-water) and at the end of irrigation (water-solution). The exposure time of the soil to the solution ranged from 4 to 10 minutes.

For sewage treatment, the settling method was used, before which the particle size distribution of zeolite tuffs was selected and the size of the fractions was selected using sieves. The sedimentation was carried out at regular intervals (20, 40, 60, 80, 100 min) on a natural sorbent (zeolite tuffs). The chemical analysis showed a residual concentration of impurities in the filtered wastewater.

3. Results and discussion

The most important problems with the use of bird droppings are the content of heavy metals and excess ammonia impurities in the soil. In places of their disposal, increased total content of nitrogen and heavy metals (both total and mobile forms) is observed, resulting in reduced agricultural production.

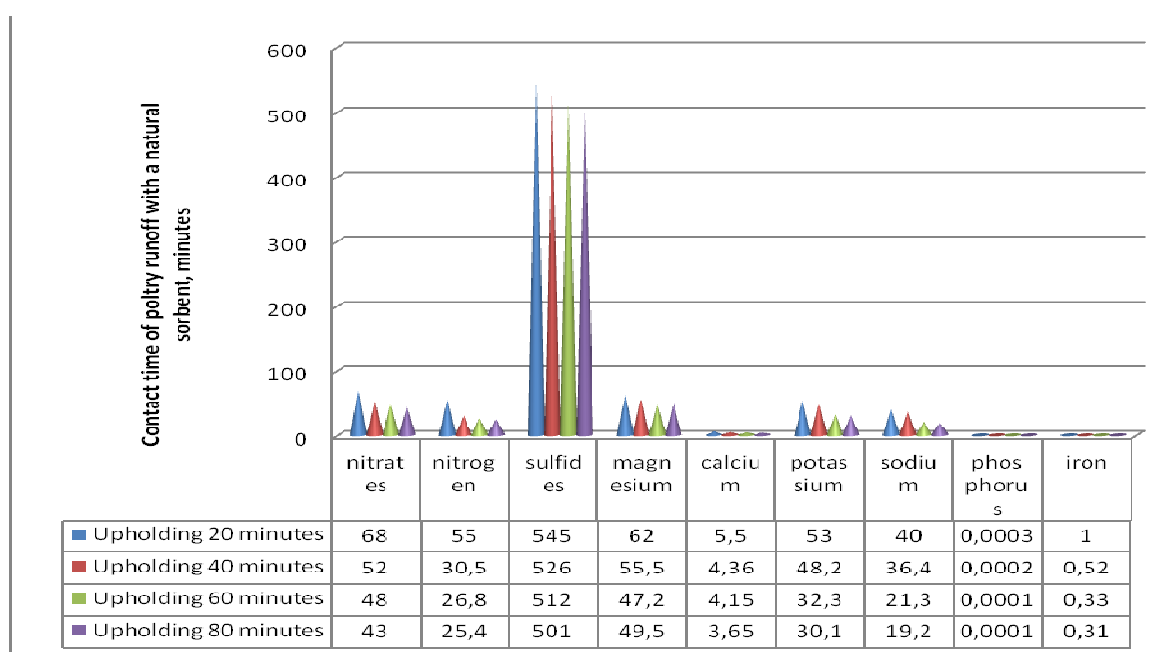
After chemical analysis, it was clear that the concentration of all the studied substances contained in poultry runoff exceeds the maximum permissible concentrations (Table 1).

Table 1. The chemical composition of the investigated wastewater of poultry enterprises

Chemical indicators	The concentration of impurities in the source water, mg/l	PDC, mg/l
nitrate	68	45
nitrogen	55	25
sulfides	545	500
magnesium	62	50
calcium	5.5	3.5
potassium	53	30
sodium	40	20
phosphorus	0.0003	0.0001
iron	1.0	0.3

Table 2. The result of sedimentation on a natural sorbent

Settling time, minutes	The concentration of impurities, mg / l								
	nitrate	nitrogen	sulfides	magnesium	calcium	potassium	sodium	phosphorus	Iron
20	68	55	545	62	5.5	53	40	0.0003	1.0
40	52	30.5	526	55.5	4.36	48.2	36.4	0.00027	0.52
60	48	26.8	512	47.2	4.15	32.3	21.3	0.00017	0.33
80	43	25.4	501	49.5	3.65	30.1	19.2	0.00012	0.31
100	No sorption								
PDC, mg/l	45	25	500	50	3.5	30	20	0.0001	0.3

**Figure 1.** Diagram of the absorption properties of a natural sorbent (zeolite tuffs) after sedimentation

It follows that wastewater treatment is necessary, since the concentration of impurities is very high and requires reduction to the maximum permissible concentration.

The sedimentation on zeolite tuffs was carried out under laboratory conditions in a 500 ml container, a natural sorbent was introduced and the studied wastewater was added. At regular intervals (20, 40, 60, 80, 100 min) through the sedimentation, a chemical analysis of the test water was carried out for the presence of a residual concentration of chemical elements (Table 2).

After 80 minutes of contact of the natural sorbent with poultry runoff, the nitrogen concentration decreased from 55 to 25.4 mg/l, the nitrite concentration dropped from 68 to 43 mg/l, the potassium ions showed a decrease in the range from 53 to 30.1 mg/l, for other chemical elements, a change in concentration was observed in the range of 20-50%.

As a result of settling for 80 minutes, there is a decrease in the concentration of chemical impurities in the studied poultry runoff to the maximum permissible concentration. In the process of settling and filtering, sorption properties have more technical, economic advantages.

Full automation during irrigation creates the conditions for the most complete and effective regulation of nutrient, thermal and air regimes of the soil. Nutrients must be brought into the area where the active root system is located. In the presence of moisture in the soil, plant roots develop mainly in fertilizer layers of the soil. By placing fertilizers in different layers of soil with irrigation water, one can influence the distribution of the roots in it, the use of nutrients by the roots, which will affect the ratio between the aboveground mass and the roots, and, therefore, achieve high yields.

High mechanization of high-quality irrigation using sprinkler technology allows the use of the energy of a water stream for fertilizing and irrigating crops. It becomes possible to produce a differentiated supply to spraying machinery in an easily accessible form, directly with irrigation water. All calculated norms of fertilizers are linked to certain phases of plant development, when the plants are most in need of nutrients and moisture. The ability to regulate the plant nutrition during the entire period of plant growth, regardless of the condition of row spacing, which is very important for continuous sowing crops.

When solutions were supplied at the beginning of irrigation, the filtration capacity of the soil, regardless of concentration and time of exposure, deteriorated, since the film on the surface appeared earlier than in the control version. The introduction of solutions into the sprinkler stream at the end of irrigation does not have a practical effect on water permeability, that is, a continuous film of water is formed during sprinkling over the same period of time as in the control version.

Vegetative irrigation of spring wheat was carried out with clarified poultry runoff in a ratio of 1: 4, which contributed to the achievement of the optimal content of potassium, magnesium, calcium and sodium (Table 3).

Table 3. The chemical composition of diluted poultry stocks

Clear water dilution	Indicators, mg / l				
	pH	Suspended matter	Dry residue	Bichromate Oxidation	BOD5
1:4	7.6	614	967	490	1462
1:3	7.8	682	1284	560	2028
1:2	8.2	1100	1624	760	3420
Undiluted drains	8.5	1550	1844	1120	5468

The studied wastewater has a weak alkaline reaction, a high content of suspended sediments, 614 mg / l, dry residue -967, BOD - 1462.

Studies have established that to eliminate the negative impact on the water permeability of the soil, the supply of solutions must be carried out at the end of irrigation.

4. Conclusion

The best option for irrigation when using poultry farming wastewater poultry is year-round irrigation. It helps fix nutrients in the soil, there is no need to apply nitrogen and phosphorus fertilizers to improve effective soil fertility. Irrigation with wastewater diluted 1: 4 with pure water increased the yield of spring wheat compared to the control variant by 1.5 times. The absorption of organic substances by a soil layer of 0.6 m is 80-100%. Absorbed organic substances in concentrations of 100-50 mg per liter were neutralized in soil and plants within 3-9 days after irrigation. Agricultural use of wastewater diluted 6-7 times provides additional net income when cultivating spring wheat by 40%.

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