Growth, Development and Productivity of Corn Under Irrigation with Wastewater from Poultry Farms on Meadow Soils of Tashkent Region

Mansur Tukhtamishev[a], Nematulla Xudaybergenov[b], Shavkat Abdurahimov[c] and Umbetali Sultanov[d]
Tashkent State Agrarian University, 100140, University str. 2, Tashkent, Uzbekistan

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Abstract: The article highlights the composition of wastewater from poultry farms and their suitability for irrigation of agricultural crops. It was found that the chemical demand of wastewater from poultry farms is 480-850 mg O2/l, which indicates high pollution with organic products. Coarse and fine substances vary within 430-720 mg/l, and the biochemical oxygen demand on the fifth day (BOD_5) is within 0.39-0.74 g O_2/l, and at the time of mass discharges of wastewater it reached 15-1.6 g O_2/l. The titer of E. coli was equal to 10-6, the number of microbes fluctuated between 48.5 x 106 and 61.6 x 106. Determination of the suitability of wastewater based on generally accepted methods showed that they are quite suitable for irrigation of agricultural crops without additional melioration measures.

1 INTRODUCTION

Water for irrigation in the conditions of the arid zone of Central Asia, including the Republic of Uzbekistan, is a necessary factor in agriculture. In the Republic of Uzbekistan, the main factor in food security is irrigated agriculture. Free water resources are needed to expand the area of irrigated agriculture, although the existing water resources in the republic can expand the area of irrigated agriculture by 4.8 million hectares. With the existing level of irrigation technology, there is a severe shortage of irrigation water (Tukhtamishev et al., 2021).

Anthropogenic transformations of water in the region have already reached global proportions: the intensive development of irrigated agriculture in the second half of the 20th century led to a significant increase in water withdrawal from the Syr Darya and Amu Darya basins, which caused the shallowing of the Aral Sea. Currently, the volume of the sea is only 28% of the 1960 figure. A. Kurtov argues that the lack of water for the Republic of Uzbekistan is a disaster in the literal sense of the word: due to the lack of water in a number of regions of the republic, especially in Karakalpakstan, we can already talk about a social and economic crisis (Tukhtamishev et al., 2021). There is not enough water not only for agricultural purposes, but also for purely domestic needs. If before 2000, low-water years in the region were observed every 6-8 years, then at present this phenomenon is repeated every 3-4 years. In 2018 and 2019, water availability decreased significantly (Tukhtamishev et al., 2022).

A pressing issue at the current stage of economic and social development of the republic is environmental protection and, in particular, eliminating the danger of negative impact on it from the growing volume of wastewater from poultry enterprises. One of the polluters of the republic's water bodies is the intensively developing poultry

[a] https://orcid.org/0009-0002-9350-8892
[b] https://orcid.org/0009-0002-1600-1991
[c] https://orcid.org/0009-0007-2412-6088
[d] https://orcid.org/0009-0007-2372-9768

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farms and enterprises. The artificial treatment facilities used are often ineffective, retaining only 50-60% of the ingredients found in wastewater, since the technological process of mechanical and biological treatment at treatment facilities functions poorly due to their unsatisfactory operation, imperfection of the technological process of treatment itself, and they operate with a greater overload. Therefore, soil neutralization of wastewater and its use for irrigation of fodder and grain crops seems very promising from the national economic and hygienic positions, which allows increasing water supply, land productivity and is a powerful means of increasing soil fertility, as well as an effective way of their additional purification in natural conditions (Tukhtamishev et al., 2022). In general, wastewater from poultry farms in the republic can be used to irrigate and fertilize 10-12 thousand hectares of land. However, the problem of using wastewater for irrigation of agricultural crops requires a regional approach, i.e. it is necessary to take into account the characteristics of the soil and hydrogeological conditions of the territory (Musirmonov et al., 2023, Juliev et al., 2023). In connection with the above, special attention is paid to the productive use of available water resources in the republic. On November 27, 2017, the decree of the President of the Republic of Uzbekistan "On the state program for the development of irrigation in 2018-2019 and improving the melioration state of irrigated lands" was adopted. According to this decree, a number of measures are being carried out, including the introduction of water-saving irrigation technologies.

In the conditions of a severe shortage of irrigation water, the Tashkent State Agrarian University pays special attention to conducting research work on issues of more careful and productive use of the existing water resources, including local runoff.Level of study of the issue. In the CIS republics, including the former All-Union Scientific and Production Association VNPO Progress (All-Union Scientific Research Institute for Agricultural Crops), Volgograd Agricultural and Ukrainian Hydromelioration Institutes, Uzbek Research Institute of Sanitation, Hygiene and Occupational Diseases and other institutions, numerous studies have been conducted to study the suitability of domestic and livestock wastewater for irrigation of agricultural crops. However, scientific research on the issue of utilization of wastewater from poultry farms has been almost not conducted (Tukhtamishev et al., 2020).

The purpose of the research: to study the composition and suitability of wastewater from poultry farms for irrigation of agricultural crops in various soil and hydrogeological conditions of the republic as an effective measure to prevent pollution of water resources and save river water, to determine their impact on the growth, development and yield of cultivated crops, the sanitary and hygienic condition of irrigation fields.

Research objectives: to establish the influence of irrigation with wastewater from poultry farms on the growth, development and yield of cultivated forage and grain crops.

Objects of research: the objects of research are wastewater from poultry farms and feed and grain crops irrigated by them in meadow and gray soil conditions of the Tashkent region.

2 MATERIALS AND METHODS

The materials of the conducted research are wastewater from the poultry farms Uzbekistan and Urtachirchikparranda, located on gray and meadow soils of the Tashkent region and the forage and grain crops irrigated by them. The suitability of wastewater for irrigation of agricultural crops was determined according to Budanov, Mozheiko and Vorotnik, Kelly, Eaton and Stebler, according to the method of the US Department of Agriculture (SAR) (Tukhtamishev et al., 2022).

3 RESULTS AND DISCUSSION

Long-term studies to determine the quality of wastewater and their suitability for use in irrigation of agricultural crops have shown the following: wastewater from poultry farms is characterized by a specific (often ammonia) odor, turbid color, slightly alkaline reaction of the environment (pH = 7.1–7.3), carbonate-sulphate, calcium-magnesium composition, according to the classification of Yu. P. Lebedev and had coarsely dispersed and finely dispersed substances, which were contained in an amount of 430–720 mg/l on average, therefore, reusing wastewater in the production process or discharging it into open water bodies without thorough cleaning is unacceptable, since the concentration of most ingredients in them exceeds the maximum permissible for reuse and discharge into water bodies (Tukhtamishev et al., 2020).

Oxidability (COD – chemical oxygen demand) is of great importance when assessing the quality of water for irrigation of agricultural crops. This indicator characterizes the total content of organic and inorganic substances in water that react with strong oxidizers (Juliev et al., 2023). A high COD value (480–850 mg O_2/l) indicates high pollution of wastewater (MPC for a reservoir is 30 mg/l) with products of organic origin. The degree of pollution of wastewater with organic matter contained in the form of non-sedimenting suspended and colloidal particles can also be determined by the content of oxygen consumed for biochemical oxidation of these substances in 1 liter of sample during the life of aerobic bacteria. This indicator is called BOD – biochemical oxygen demand – and it varied in the discharged waters of poultry farms within the range of 0.39–0.74 mg/l (the maximum permissible concentration for a reservoir is 3 mg/l) on the fifth day (BOD_5), and at the time of salvo discharges of wastewater it reached 1.5–1.6 g O_2/l, i.e. the quality of the discharged water deteriorated almost twofold (Table 1).

Table 1: Characteristics of wastewater from poultry farms and river water supplied for irrigation of agricultural crops.

№	Indicators	Unit of measurement	PF Uzbekistan			Urtachirchik Parranda
			2018 y.	2019 y.	2020 y.	
Wastewater from poultry farms						
1	pH	–	7,3	7,2	7,2	7,1
2	Suspended solids	mg/l	430	650	720	580
3	COD	mg/l	480	750	800	850
4	BPK_5	mg/l	1100 390	1500 680	1430 610	1200 760
5	Total nitrogen	mg/l	70,7	61,4	56,5	66,4
6	Total phosphorus	mg/l	0,2	0,2	0,4	0,6
7	Gross potassium	mg/l	14,5	11,1	12,6	23,7
8	Calcium	mg/l	58,5	50,0	53,5	69,2
9	Magnesium	mg/l	68,4	75,6	54,3	30,6
10	Sodium	mg/l	21,8	20,9	14,7	37,9
11	Chlorine	mg/l	16,7	32,8	22,4	23,6
12	Sulfates	mg/l	95,4	99,8	73,2	78,7
13	Bicarbonates	mg/l	434,3	410,7	373,5	326,1
River water						
1	pH	–	7,3	7,5	7,4	7,3
2	Suspended solids	mg/l	236,3	208,5	310,6	274,4
3	COD	mg/l	23,4	14,3	18,8	28,6
4	BPK_5	mg/l	960 280	1120 430	1080 390	980 280
5	Total nitrogen	mg/l	5,9	4,5	4,0	5,1
6	Total phosphorus	mg/l	0,05	0,03	0,04	0,04
7	Gross potassium	mg/l	3,3	2,5	2,6	3,5

In terms of nitrogen content, the wastewater is characterized by high fertilizing value - from 51 to 87 mg/l, the potassium content varied within 10-32 mg/l. Qualitative assessment of wastewater by the total concentration of dissolved salts, the content of chlorides, hydrocarbonates, biogenic elements, toxic salts, environmental reaction (pH), anion-cation composition and sodium adsorption coefficient (SAR) shows that the wastewater of poultry farms is quite suitable for irrigating corn grown for grain and silage, winter wheat, alfalfa, combined crops of alfalfa + oats, corn + soybeans + sunflower without dilution and in dilutions with river water in ratios of 1: 1 and 1: 2, fodder beet on meadow and sierozem soils without additional melioration measures (Table 2).

Table 2: Assessment of the suitability of wastewater from poultry farms for irrigation of forage crops

№	Name of the method and its essence	Poultry farms	
		Uzbekistan	Urtachirchik Parranda
1.	According to Budanov: 1) Na : (Ca + Mg) ≤ 0,7 2) Na : Ca ≤ 1	 0,09–0,11 0,24–0,37	 0,27 0,48
2	According to Mozheiko and Vorotnik: (K + Na) · 100 : (Ca + Mg+ Na) ≤ 65%	11,87–13,47	27,26
3	According to the US Department of Defense (SAR) method: Na : $\sqrt{(Ca + Mg)}$: 2 ≤ 8	0,34–0,46	27,26
4	According to Kelly: Ca ·100 : (Ca + + Mg + Na + K) ≥ 35%	24,95–32,68	41,50
5	According to Eton: (CO_3 + HCO_3) – (Ca + + Mg) < 2,5	1,5–2,1	0,68
6	According to Stabler (K > 6) K = 288 : (rNa + 4rCl)	61,94–100	66,0

In addition to the above ingredients, waste and river water contains a large number of microorganisms that require careful study when using water for irrigation of agricultural crops. The results of sanitary and bacteriological studies indicate that waste water used for irrigation of agricultural crops was significantly contaminated according to the studied indicators. Thus, the titer of E. coli was equal to 10-6, the number of microbes fluctuated between 48.5 x 106 and 61.6 x 106. At the same time, with each cubic meter of waste water, from 48.5 x 1012 to 61.6 x 1012 microorganisms entered the field (Juliev et al., 2001).

After purification in artificial structures, these indicators were respectively equal: the titer of E. coli - 10-4, the number of microbes in 1 ml of water - from 40.9 x 106 to 52.0 x 106 pcs. River water was characterized by the following indicators: the number of microbes in 1 ml of water - from 3.7 x 106 to 4.5 x 106, and the coli titer - 0.0004.

In conclusion, it should be noted that wastewater from poultry farms is quite suitable for irrigation of agricultural crops, but the final suitability of wastewater in terms of mineralization must be clarified in the process of constant monitoring of the accumulation of salts in the soil during the cultivation of agricultural crops.

In addition to the accumulation of salts in the soil, wastewater also has a fertilizing value, which depends on the presence of nutrients and beneficial microorganisms in it. When undergoing purification at artificial facilities, a significant amount of nutritional elements is lost; when they are discharged into open water bodies, thousands of tons of fertilizers are carried away; they would play a major role in soil fertility and increasing the yield of cultivated crops.

As a result of the influx of large amounts of nutrients and beneficial microorganisms during irrigation of lands with wastewater, microbiological processes are significantly enhanced, resulting in improved soil fertility.

In our experiments, wastewater that underwent mechanical treatment was used for irrigation of corn. During the water supply, the amount of nutrients (total nitrogen, phosphorus, and total potassium) was determined. The data presented in Table 1 show that the concentration of total nitrogen varied widely and was from 51.3 to 86.8 mg/l during the irrigation period, phosphorus was contained in insignificant quantities – 0.2–0.8 mg/l, and potassium – 10.2–31.8 mg/l. Or: with each 1000 m3 of wastewater, 50–90 kg of nitrogen, about 1 kg of phosphorus, and 10–32 kg of potassium per hectare entered the field.

According to the classification of V.T. Dodolina (1975), the wastewater from the Tashkent Poultry Farm and the Urtachirchikparranda poultry farm, in terms of nitrogen content, is classified as wastewater of medium fertilizing value, and in terms of potassium and phosphorus content, it is classified as low.

These nutrients are in a dissolved and accessible form, getting into the soil, they are easily absorbed by plants, simultaneously solving the problems of water and food regime for corn plants. In addition, many organic substances and microorganisms get into the soil with waste water, as a result of which microbiological processes are activated and the potential and effective fertility of the soil increases.

The calculations performed to determine the amount of nutrients supplied to the field with irrigation water showed that when irrigating corn with wastewater at an irrigation rate of 3650–3900 m3/ha, 179–220 kg of nitrogen and 42–92 kg of potassium were supplied to each hectare of crops (taking into account the coefficient that takes into account the loss of nutrients from runoff during irrigation, which is 0.85 for nitrogen and 1 for phosphorus and potassium. At an irrigation rate of 4400–4650 m3/ha, 218–264 and 51–110 kg per hectare, respectively; under dilution conditions at an irrigation rate of 3700–3930 m3/ha – 98–122 kg of nitrogen and 16–53 kg of potassium, and at an irrigation rate of 4550–4620 m3/ha at 118–150 and 31–63 kg per hectare. phosphorus was supplied with irrigation water in insignificant quantities.

The use of poultry wastewater for feeder and vegetation irrigation during winter wheat cultivation on sierozem soils contributed to the improvement of plant growth and development, and significantly increased the yield of grain and straw. If, when carrying out feeder and vegetation irrigation with river water, the grain yield on average for 3 years was 45.2 c/ha and straw 56.5 c/ha, in the variant with feeder irrigation with river water and vegetation irrigation with wastewater, it was 51.0 and 64.2 c/ha, respectively. In the variant where feeder irrigation was carried out with wastewater and vegetation irrigation with river water, 3.7 c of grain and 7.6 c of straw were obtained more than in the control variant. The highest yield – 55.5 c/ha of grain and 70.2 c/ha of straw was obtained in the variant with feeder and vegetation irrigation with wastewater. When feeder irrigation was carried out with river water, and vegetation irrigation with wastewater diluted with river water and vegetation irrigation with wastewater, 40.2 c/ha of grain and 50.9 c/ha of straw were obtained, which is 5.0 and 5.6 c/ha less, respectively, than in the control variant.

Diluted with river water and undiluted wastewater from poultry farms, when used for irrigation in combination with mineral fertilizers on meadow soils, contributed to obtaining high yields of silage, grain and air-dry leaf-stem mass of corn. The yield of silage mass reached 530.6–608.3 and 564.2–641.1 c/ha, respectively, against 508.4–564.3 c/ha, and grain – 77.8–82.9 and 80.6–86.4 c/ha against 68.6–74.6 c/ha; air-dry leaf-stem mass – 191.4–208.8 and 204.1–255.3 c/ha against 182.3–198.4 c/ha in the control variant.

It has been established that in the hot climate of Uzbekistan, soils irrigated with wastewater become clean to standard 10-15 days after irrigation. With proper organization and implementation of surface irrigation with wastewater, contamination of above-ground plant organs and groundwater is completely eliminated. In case of accidental contamination of individual parts of plants, they can be considered clean to standard 10-15 days after irrigation.

4 CONCLUSIONS

Our long-term studies confirm the feasibility and high efficiency of cleaning and recycling wastewater in agriculture by using it for irrigation of agricultural lands, especially in the arid zone of Uzbekistan. Wastewater from poultry farms is quite suitable for irrigation of fodder and industrial crops without additional melioration measures.

When irrigating with wastewater, a significant amount of nutrients enters the field, which play a major role in providing plants and improving soil fertility. It is advisable to use the following wastewater disposal scheme: sewerage - mechanical treatment facility - storage ponds - irrigation fields. Wastewater from poultry farms is quite suitable for irrigating forage crops used to produce vitamin flour, haylage, silage, forage, and forage root crops. The most acceptable option for irrigation is the use of diluted wastewater with river water in a 1:1 ratio in combination with mineral fertilizers, since the soil self-cleaning process occurs on the 15th day after irrigation. Under the same conditions, for irrigation of alfalfa in the 2nd and 3rd years of standing, diluted wastewater from poultry farms with river water in a 1:1 or 1:2 ratio (one part wastewater and 1 or 2 parts river water). In this case, the irrigation rate should be set according to the alfalfa's need for water. In this case, the irrigation scheme is 1-2-2-1. A single irrigation rate is 900-1100 m3/ha.

On meadow soils with groundwater at a level of 2-2.5 m in the Chirchik-Angren Valley, it is advisable to use wastewater from poultry farms diluted with river water in a ratio of 1:1 for irrigation of corn grown as a second crop after winter crops and the use of mineral fertilizers (at a rate of N - 180, P_2O_5 - 100 K_2O - 90 kg / ha). The timing of irrigation should be determined by the lower threshold of moisture in the active soil layer of 70-75-65% of the soil's FPV. The irrigation rate should be within 4.4-4.6 thousand m3 / ha, inter-irrigation periods of 15-20 days. Vegetation irrigation should be completed 15-20 days before harvesting.

Irrigation and irrigation rates for cultivated crops are determined by their total water consumption, and irrigation times are determined by the moisture deficit in the active soil layer. Irrigation rates for silage corn are calculated at a lower soil moisture threshold of 75–80% of the maximum permissible moisture content, for grain corn – 70–75–65%. Irrigation rates in meadow soil conditions should be 3.4–4.0 and 4.4–4.6 thousand m3/ha, respectively. For forage alfalfa of the first year of standing with four cuts on meadow soils, the irrigation scheme should be 1-1-1-1, and for alfalfa of the second year and subsequent years with five and six cuts 0-1-1-1-1 and 0-1-1-1-1-1 with irrigation rates of 1000–1100 m3/ha and irrigation rates from 4.0–4.4 to 5.0–5.5 thousand m3/ha.

The irrigation scheme for alfalfa in its first year of growing on sierozem soils with deep groundwater should be 1-2-2-1 with irrigation rates of 900–1100 m3/ha and irrigation rates of 5.4–6.6 thousand m^3/ha, and for alfalfa in its second year of growing and subsequent years – 0-1-2-2-1 with irrigation rates of 1000–1200 m^3/ha and irrigation rates of 6.0–7.0 thousand m^3/ha.

The irrigation regime for fodder beets consists of 5 irrigations with irrigation rates of 800–1300 thousand m3/ha and irrigation rates of 6.0–7.0 thousand m3/ha.

In conditions of meadow soils with groundwater at a level of 1.5–1.8 m, after sowing wheat, it is necessary to carry out feeder irrigation with wastewater at a rate of 700–730 m^3/ha and vegetation irrigation with wastewater diluted with river water in a ratio of 1:1 at a rate of 700–850 m^3/ha and an irrigation rate of 3080 (taking into account feeder irrigation 3810) m^3/ha.

Moisture-charging and fertilizing irrigation on gray soils should be carried out in deep furrows according to a dead-end scheme at a rate of 800-1000 m^3/ha, and they are stopped 2-3 weeks before sowing. Monitoring the sanitary and hygienic condition of the soil when using wastewater for irrigation is carried out on the 15th day after irrigation. When irrigating with wastewater, it is necessary to comply with sanitary and anti-epidemic rules, especially in the first 20 days. When using wastewater for irrigation, the inter-irrigation periods should be at least 15-20 days to ensure the normal course of soil self-purification processes. In case of a delay in the process of soil self-purification from pathogenic microorganisms, irrigation should be carried out with river water. Vegetative irrigation with wastewater is completed 15-20 days before harvesting.

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