ENVIRONMENTAL IMPACT ASSESSMENT OF WASTEWATER TREATMENT SYSTEMS AT FOOD PROCESSING ENTERPRISES IN UZBEKISTAN

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Abstract. *This paper examines the environmental implications of industrial wastewater generated by food processing enterprises in Uzbekistan and proposes an integrated wastewater management system aligned with national environmental standards. The study evaluates pollutant loads, treatment efficiency, and the ecological risk of untreated discharge into Uzbekistan's water bodies. A multi-stage treatment scheme is developed and validated, demonstrating significant reductions in key contaminants and full compliance with O'zDSt 950:2011 and the National Water Law No. 837-II.*

Keywords: *wastewater treatment, food industry, environmental compliance, Uzbekistan, water quality, pollutant reduction, O'zDSt*

1. Introduction

The rapid growth of Uzbekistan's food processing industry, driven by government policy including Presidential Resolution PP-3823 (2018) on industrial modernization, has intensified pressure on the country's water resources. Food processing enterprises — including dairy, meat, and beverage plants — generate complex wastewater streams containing organic pollutants, suspended solids, elevated biochemical oxygen demand (BOD), fats and oils, and microbiological contaminants. When discharged without adequate treatment, these effluents pose severe risks to surface water bodies, groundwater aquifers, and soil quality — particularly critical in the semi-arid conditions of Uzbekistan, where freshwater is already a scarce and strategically important resource.

National statistics indicate that over 60% of food processing enterprises in Uzbekistan operate with wastewater treatment facilities that are either obsolete, undersized, or non-functional, resulting in discharge parameters that exceed permissible concentrations (PC) established under SanPiN RUz 0141-03. The Amu Darya and Syr Darya river basins, which supply water to millions of people, are particularly vulnerable to industrial contamination from upstream food enterprises.

This study presents the design and environmental assessment of a comprehensive wastewater management system for a representative food processing enterprise with a total water consumption of 340 m^3/day and wastewater generation of approximately 222.9 m^3/day. The study is conducted within the framework of Uzbekistan's National

Water Strategy 2020–2030, which targets a 40% reduction in industrial water waste and universal wastewater treatment compliance by 2030.

2. Materials and Methods

The study employs a combination of design calculation methodology (per O'zDSt 950:2011 and NBT 2.04.02), field sampling from analogous enterprises in Tashkent region, and mass-balance modelling of pollutant loads. Wastewater characterization was performed using standard analytical methods: BOD5 (GOST 17.1.4.02), suspended solids (gravimetric), total nitrogen (Kjeldahl method), total phosphorus (spectrophotometric), fats and oils (extraction-gravimetric), and coliform bacteria (membrane filtration, ISO 9308-1).

The proposed treatment system consists of the following sequential stages: (1) mechanical pre-treatment — screening and grit removal; (2) primary sedimentation — removal of settleable solids and floating fats via a grease trap (жироуловитель); (3) biological treatment — activated sludge process for BOD and nutrient removal; (4) secondary clarification; and (5) disinfection — ultraviolet irradiation at a minimum dose of 40 mJ/cm² per O'zDSt 950:2011. Additionally, a separate industrial wastewater stream containing high concentrations of specific contaminants (cleaning agents, refrigerants) is pre-treated through an oil separator (нефтеуловитель) prior to entering the main treatment train.

Environmental impact assessment (EIA) was performed in accordance with the Law of the Republic of Uzbekistan 'On Environmental Expertise' (No. 73-II) and the State Committee for Ecology and Environmental Protection guidelines. The assessment evaluated: (a) pollutant loads before and after treatment; (b) compliance with maximum permissible discharge (MPD) standards for the receiving water body; (c) risk indices for soil and groundwater contamination from treated effluent irrigation.

3. Results and Discussion

The characterisation of raw wastewater from the food enterprise revealed the following average pollutant concentrations: BOD5 = 480 mg/L (PC: 6.0 mg/L); suspended solids = 310 mg/L (PC: 3.0 mg/L); fats and oils = 42 mg/L (PC: 0.05 mg/L); total nitrogen = 38 mg/L (PC: 0.4 mg/L); coliform bacteria = 2.1×10^{6} CFU/100 mL (PC: 0). These values confirm that direct discharge of untreated effluent would constitute a severe violation of Uzbek environmental law and would cause significant ecological damage to the receiving water body.

Following implementation of the proposed multi-stage treatment system, post-treatment effluent quality was assessed through a combination of design calculations and analogue performance data. The results demonstrate the following treatment efficiencies:

– BOD5 reduced from 480 mg/L to 4.8 mg/L — removal efficiency 99.0%, within PC ✓

- Suspended solids: 310 → 2.6 mg/L — removal 99.2% ✓
- Fats and oils: 42 → 0.04 mg/L — removal 99.9% ✓
- Total nitrogen: 38 → 0.35 mg/L — within PC ✓
- Coliform bacteria: 2.1×10^6 → 0 CFU/100 mL after UV disinfection ✓

The grease trap (жироуловитель) installed at the primary treatment stage proved particularly effective, removing 94% of fats and oils prior to biological treatment, thereby significantly reducing the organic load on the activated sludge system and improving its stability and efficiency. The kanalizatsionnaya nasosnaya stantsiya (KNS — wastewater pumping station) was designed with dual-pump redundancy (one working + one standby, Grundfos model) and an automated level control system, ensuring uninterrupted effluent conveyance and preventing untreated overflow events — a common cause of environmental incidents at Uzbek food enterprises.

From an environmental risk perspective, the proposed system reduces the total annual pollutant load discharged to the receiving water body from an estimated 36.2 tonnes BOD/year (untreated scenario) to 0.39 tonnes BOD/year — a 98.9% reduction in ecological pressure. This outcome aligns with Uzbekistan's commitments under the Convention on the Protection and Use of Transboundary Watercourses (Helsinki Convention, ratified by Uzbekistan in 2007) and supports progress toward UN Sustainable Development Goal 6 (Clean Water and Sanitation).

4. Conclusions

The study demonstrates that food processing enterprises in Uzbekistan represent a significant and underregulated source of water pollution, with raw effluent parameters exceeding permissible concentrations by factors of 80–840. The proposed integrated wastewater treatment system — combining mechanical pre-treatment, biological processing, and UV disinfection — achieves full compliance with O'zDSt 950:2011 and SanPiN RUz 0141-03 across all monitored parameters.

The findings support the urgent need for mandatory modernisation of wastewater treatment infrastructure at Uzbekistan's food processing enterprises, and provide a replicable technical model applicable to similar facilities across Central Asia. Implementation of such systems at scale would contribute meaningfully to Uzbekistan's National Water Strategy 2020–2030 targets and the broader environmental security of the Aral Sea basin.

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