# OPTIMIZING URBAN WASTEWATER TREATMENT PROCESSES: TECHNOLOGICAL APPROACHES AND APPLIED PERSPECTIVES IN THE ROMANIAN CONTEXT

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**ABSTRACT:** Urban wastewater treatment is a critical component of environmental protection and public health, particularly in the context of rapid urbanization, intensified economic activity, and increasing pressure on water resources. Municipal wastewater treatment plants play a central role in ensuring the quality of discharged water, contributing significantly to the preservation of aquatic ecosystems and compliance with environmental legislation. Urban wastewater contains a wide range of pollutants originating from both industrial activities and households—including organic matter, nutrients, hazardous chemicals, and pathogens. Effective treatment requires the implementation of advanced technological processes that meet increasingly stringent national and European standards. In this regard, Directive 91/271/EEC on urban wastewater treatment sets clear requirements, which Romania is committed to fulfilling through investments in infrastructure modernization and expansion. However, many treatment plants face challenges related to treatment efficiency, adaptation to emerging pollutants, and sludge management. Therefore, a rigorous scientific approach is essential to identify and apply modern, sustainable, and economically viable technical solutions. This study aims to investigate the treatment processes in urban wastewater facilities, focusing on enhancing technological performance, reducing environmental impact, and valorizing resulting by-products. Through experimental research, process analysis, and comparative evaluations, the work contributes to the development of applicable models tailored to the specific context of urban areas in Romania.
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**KEY WORDS :** wastewater, environmental protection, treatment plants, urban areas.

## 1. INTRODUCTION

Urban wastewater treatment stands as one of the most vital environmental protection measures in modern cities. As urban areas expand, water consumption increases, and new pollutants emerge, the proper treatment of residual waters becomes essential for safeguarding public health and preserving natural resources. Wastewater treatment plants play a key role in reducing the pollutant load of discharged waters, ensuring compliance with environmental quality standards. These facilities help prevent the contamination of watercourses, the eutrophication of ecosystems, and the spread of waterborne diseases. Consequently, the efficiency of wastewater treatment processes serves as a crucial indicator of the quality of public water and sanitation services. [1,2,3]

## 2.TYPES OF POLLUTANTS AND SOURCES OF CONTAMINATION

Urban wastewater typically consists of domestic sewage and compatible industrial effluents, sometimes mixed with stormwater. Its composition varies but generally includes:

- Biodegradable organic matter (proteins, carbohydrates, fats)
- Suspended solids (floating or settleable particles)
- Nutrients (nitrogen and phosphorus), which contribute to eutrophication
- Toxic substances (detergents, heavy metals, pharmaceutical compounds)

- Pathogenic microorganisms (bacteria, viruses, protozoa)
- Treatment systems must be designed to effectively reduce these pollutants so that the treated water does not negatively impact natural receptors.
- Conventional Wastewater Treatment Technologies
- Traditional treatment plants are structured in three main stages:
- Primary (Mechanical) Treatment – removes coarse materials and settleable particles using screens, grit chambers, and primary settlers
- Secondary (Biological) Treatment – relies on microbiological processes to break down organic matter, typically using activated sludge systems
- Tertiary (Advanced) Treatment – optional, focuses on nutrient removal (nitrogen and phosphorus) or effluent disinfection

These systems, robust and well understood, remain widely used in small and medium sized cities across Romania.

Legislative Framework and Compliance Requirements. In the European Union, urban wastewater treatment is regulated by Directive 91/271/EEC, which sets strict requirements regarding:

Treatment levels based on agglomeration size

- Maximum allowable concentrations of pollutants ($CBO_5$, CCOCr, suspended solids, nitrogen, and phosphorus)
- Effluent quality monitoring

As an EU member state, Romania is obligated to ensure proper operation of treatment plants in accordance with the National Implementation Plans for the Water Directive and domestic legislation (Water Law no. 107/1996, as amended). [4,5,6]

## 3 TECHNOLOGICAL FLOW OF THE TÂRGU JIU WASTEWATER TREATMENT PLANT

The Târgu Jiu wastewater treatment facility is designed to follow a structured and efficient technological flow, ensuring the progressive removal of pollutants from raw sewage to produce clean, environmentally safe effluent. [7,8,9,10] The process is divided into several key stages:

**1. Preliminary Treatment**

**Coarse and Fine Screens (1 and 2)**: These remove large debris and fine particles that could damage downstream equipment.

**Grit Chamber (4)**: Separates sand and other heavy inorganic materials.

**Grease Separator (5)**: Extracts oils and fats that can interfere with biological processes.

**2. Primary Treatment**

**Wastewater Channel (3)**: Directs flow toward sedimentation units.

**Primary Settling Tanks (4)** Allow heavier solids to settle, reducing suspended solids before biological treatment.

**3. Secondary (biological) treatment**

**Aeration Tank (7)**: Introduces air to stimulate microbial activity that breaks down organic matter.

**Secondary Clarifier (8)**: Separates activated sludge from treated water.

**Activated Sludge Pumping Station (9)** and **Reservoir (11)**: Recirculate biomass to maintain biological activity.

**Settled Sludge Pumping Station (10)** and **Reservoir (12)**: Handle excess sludge for further processing.

**4. Sludge Treatment**

**Sludge Dewatering Station (15)**: Reduces water content in sludge for easier handling.

**Dewatered Sludge Reservoir (13)** and **Pumping Station (22)**: Store and transport final sludge product.

**Neutralization Station (16)**: Stabilizes sludge chemically before disposal or reuse.

**5.Tertiary Treatment and Disinfection**

**Chemical Dosing and Preparation Stations (17 and 18)**: Add reagents for nutrient removal or conditioning.

**Chlorination Station (19)**: Disinfects treated water to eliminate pathogens.

**Treated Water Reservoir (14)** and **Pumping Station (21)**: Store and distribute clean effluent.

**6. Supporting Infrastructure**

**Air Supply Station (20)** and **Air Pipeline (6)**: Ensure oxygenation for biological processes.

**Chemical Pipeline (7)**: Delivers reagents to various treatment stages.

**Administrative and Operational Buildings (C1–C6)**: Include offices, labs, workshops, and garages for maintenance and monitoring.

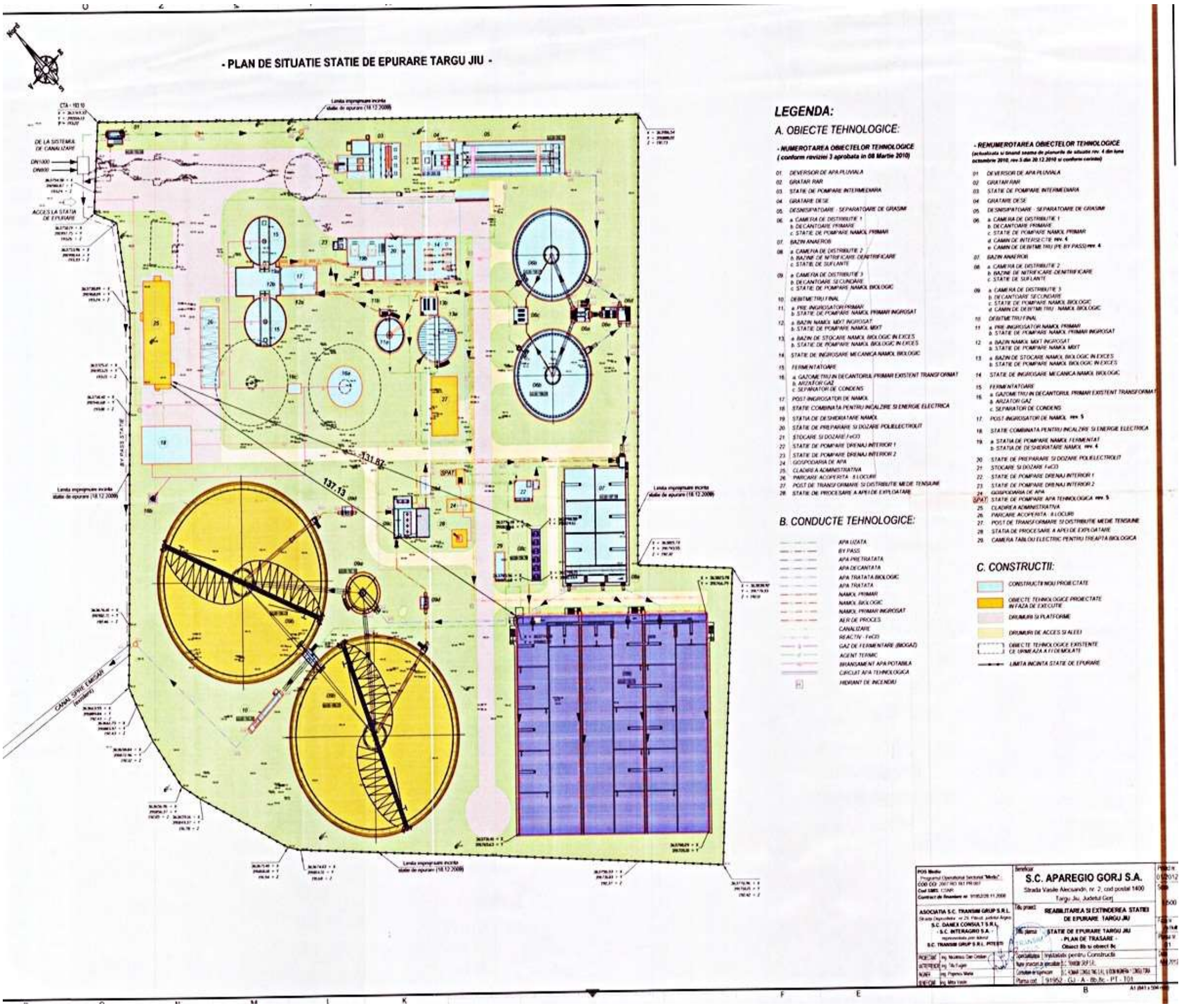


Fig. 1 Plan de situatie statia de epurare a apei uzate Targu Jiu

## 4.OPERATIONAL SIGNIFICANCE AND INTEGRATION

The facility's layout reflects a well-integrated system where each component supports the next in a logical sequence. The presence of multiple pumping stations ensures hydraulic continuity, while the separation of sludge streams allows for tailored treatment and disposal. The inclusion of tertiary treatment and disinfection highlights the plant's commitment to environmental safety and regulatory compliance. Moreover, the supporting constructions—such as the laboratory and transformer station—enable real-time monitoring and uninterrupted operation, essential for maintaining high treatment standards.

## 5.CHALLENGES AND MODERN SOLUTIONS IN WASTEWATER TREATMENT

Despite the structured design and technological capabilities of facilities like the one in Târgu Jiu, urban wastewater treatment in Romania still faces several challenges:

**Underutilized Infrastructure**: Many plants operate below capacity due to low connection rates or outdated sewer networks.

**Technological Obsolescence**: Some systems rely on aging equipment that no longer meets EU efficiency or environmental standards.

**Operational Inefficiencies**: Limited automation and real-time monitoring reduce responsiveness to fluctuations in pollutant loads.

**Sludge Management Issues**: Disposal and reuse of sludge remain problematic due to insufficient treatment and lack of sustainable outlets.

To address these issues, modern solutions are being explored and implemented:

**Advanced Biological Processes**: Technologies like membrane bioreactors (MBRs)

**Digital Monitoring and Automation**: SCADA systems and IoT sensors enable real-time data collection, predictive maintenance, and optimized energy use.

**Green Infrastructure Integration**: Constructed wetlands and nature-based solutions help manage stormwater and improve ecological resilience.

**Circular Economy Approaches**: Recovery of nutrients, biogas production, and reuse of treated water support sustainability goals.

# CONCLUSION

Urban wastewater treatment is not merely a technical necessity—it is a cornerstone of public health, environmental protection, and sustainable urban development. The Târgu Jiu facility exemplifies the complexity and importance of integrated treatment systems, combining mechanical, biological, and chemical processes with robust infrastructure.

As Romania continues to align with European standards and invest in modernization, the efficiency and adaptability of wastewater treatment plants will play a decisive role in shaping cleaner, healthier cities. By embracing innovation and addressing systemic challenges, we can ensure that facilities like Târgu Jiu not only meet current demands but also anticipate future ones.

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