Design of Wastewater Treatment Plant

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Abstract

This project presents the detailed engineering design of a municipal wastewater treatment plant using the Complete Mix Activated Sludge (CMAS) process with nitrification. Designed for an average flow of 11,600 m³/day (serving ≈ 50,000 persons), the plant achieves substantial removal of organic matter (BOD, COD) and ammonia, producing Class A biosolids suitable for agricultural use. Key design outputs include a 4,455 m³ aeration tank, a 300 m³ anaerobic digester, and a peak-flow influent pumping system (0.215 m³/s).

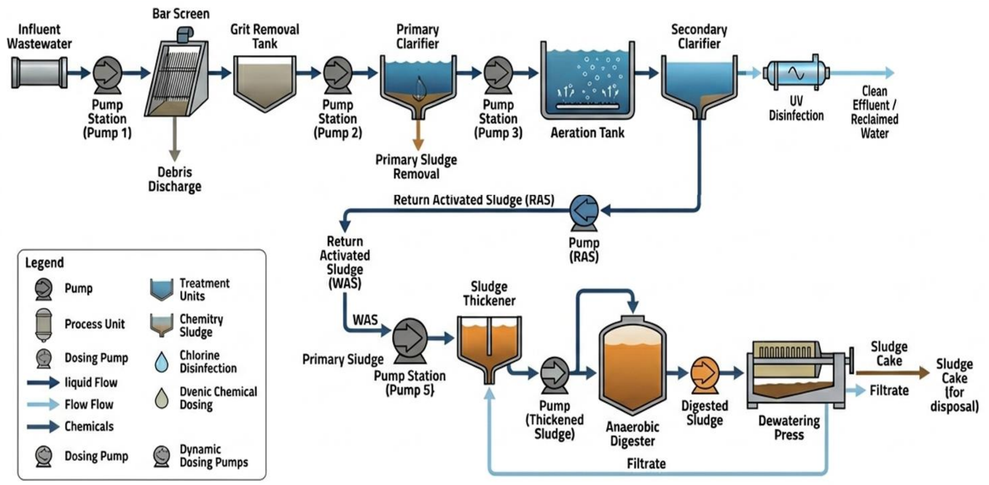
Introduction and Problem Statement

Wastewater contains organic pollutants, pathogens and nutrients that must be removed before discharge or reuse; untreated effluent generates odors, pathogens, and toxins harmful to public health and ecosystems. Many arid regions face water scarcity due to low rainfall and high consumption, with heavy reliance on groundwater. Over-extraction lowers water tables, increases salinity, reduces agricultural yields, and raises pumping costs. Thus, effective treatment and reuse are essential. The specific challenge is to design a reliable, easy to operate biological system that achieves nitrification and produces stable biosolids suitable for land application.

Objectives

- Evaluate alternative activated sludge configurations (EAAS, CAS, SBR, CMAS) for municipal wastewater.
- Perform steady-state material and energy balances for all major units.
- Size primary and secondary clarifiers, aeration tank, anaerobic digester, sludge thickener, dewatering press, and pumping station.
- Develop a safety plan including hazard identification, PPE, and emergency procedures.
- Estimate capital and operating costs using the Turton bare-module method.

Flow Diagram



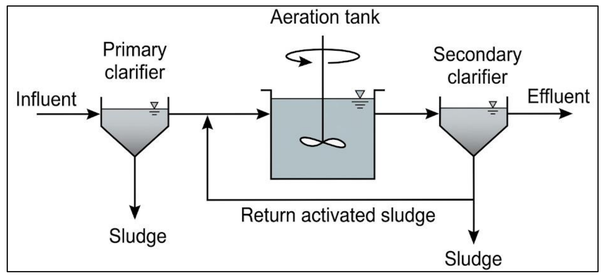
Equipment Design Specifications

1-Complete mixing Activated Sludge

- Aeration Tank Volume: 4,455 m³
- Hydraulic Retention Time (HRT): 5.76 h
- Solid Retention Time (SRT): 5 days
- Mixed Liquor suspended solid (MLSS): 3,000 g/m³
- F/M: 0.33 kg BOD/(kg MLVSS·d)
- Air flow rate: 0.867 m³/s
- Blower power: 90 kW

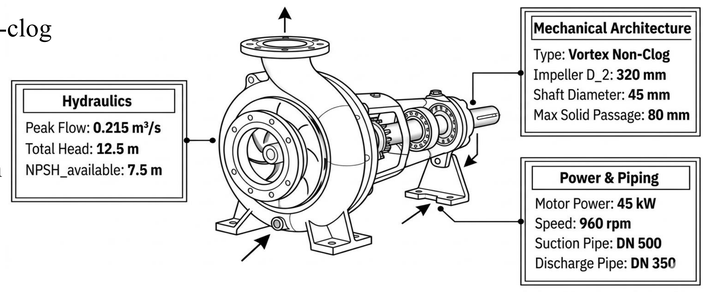
2-Secondary clarifier diameter

- Secondary clarifier diameter: 32 m
- RAS flow rate (Q_R): 10,601 m³/day
- WAS flow rate (Q_w): 334 m³/day



3-In-Flow Pump

- Type: centrifugal Vortex non-clog
- Service: Raw wastewater
- Peak Flow: 0.215 m³/s
- Total Dynamic Head: 12.5 m
- Shaft Power: 40.8 kW
- Pump Efficiency: 65%



Energy Balance

System	Power (kW)	Note
Aeration Blower	90	50–70% of total
Belt Filter Press	17.7	Dewatering
UV Disinfection	16	Medium-pressure
DAF Thickener	9.77	Sludge thickening
Anoxic Mixers + Scrapers	7.0	4.0 + 3.0
All Pumps (P101–P106)	≈ 49.9	6 stations

O_2 req = 1,248.7 kg/d → Air = 74,900 m³/d → Blower = 90 kW

Annual Utilities

Electricity	2,200,000 kWh/y	$176,000/y
Natural gas	2,800 GJ/y	$33,600/y
Total	—	**$236,600/y**

Conclusions

A technically sound CMAS-based wastewater treatment plant with nitrification has been designed for a flow of 11,600 m³/day. The design meets all process objectives: BOD and TSS reduction, nitrification, and production of Class A biosolids.

The CMAS design also includes robust safety systems, energy efficiency measures (fine bubble aeration, VFD pumps), and sludge-to-fertilizer conversion.

The plant provides treated water for non-potable reuse and stabilizes sludge for safe land application. The design methodology encompassing material/energy balances, equipment sizing, safety protocols, and cost estimation can be directly applied to similar small-to-medium municipal plants.

For more details