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Evaluation of the Efficiency of Al-Dhibai Wastewater Treatment Plant in Salah Al-Din Governorate

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Abstract: The Al-Dhibai wastewater treatment plant in Tikrit City, Salah Al-Din Governorate, was evaluated from March to August 2024. The study assessed environmental pollution parameters for both influent and effluent water, including biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), pH, phosphate concentration (PO_4), nitrate concentration (NO_3), chlorides (Cl^-), and the concentration of certain heavy metals such as lead (Pb), cadmium (Cd), and zinc (Zn). The plant's efficiency in removing pollutants was found to be 55.29% for BOD5, 74.26% for COD, and 79.54% for TSS. The plant's design capacity is 20,000 m^3/day, with an available capacity of 20,000 m^3/day. The incoming wastewater volume is approximately 12,000 m^3/day, while the treated water output ranges between 8,000 and 10,000 m^3/day.

Introduction:

The discharge of untreated or inadequately treated wastewater into rivers poses a significant threat to aquatic ecosystems due to the high concentrations of environmental pollutants in such wastewater. This issue is prevalent in Iraq, where most cities are situated along riverbanks. The consequences include **disruptions in ecological balance**, **eutrophication (excessive nutrient enrichment leading to undesirable organism growth at the expense of vital aquatic species such as fish)**, the proliferation of pathogenic microbes, and elevated concentrations of pollutants such as carcinogenic phenolic compounds and oxygen-depleting waste (1, 2, 3). The problem is exacerbated by **sharp declines in river water levels and reduced flow velocity** (4).

Literature sources (3, 4, 5, 7, 9) emphasize that **effective wastewater treatment is crucial** to minimizing these hazards by efficiently removing contaminants, breaking them down into less harmful compounds, and employing treatment methods such as sedimentation, aeration, filtration, and chlorination. However, studies evaluating the efficiency of wastewater treatment plants (5, 6) and effluent water quality (4) indicate that pollutant levels often exceed the permissible limits set by Iraqi river pollution standards.

The **Al-Dhibai Wastewater Treatment Plant** is currently the only operational treatment facility in Tikrit. It is located in the **Ain Al-Faras area**, southwest of Tikrit, approximately **8 km from the city**. The plant processes wastewater from the main sewage network, initially removing large and small solid particles through coarse and fine metal screens, followed by sand removal and grit chamber processing.

The **primary treatment phase** occurs in sedimentation basins, where **74% of sediments and 15% of BOD5** are removed. The wastewater is then directed to the **secondary treatment stage**, which includes aeration and secondary sedimentation, achieving a **total BOD5 reduction of 55% and sediment removal of 79%**. Finally, the treated water is directed to the **chlorination unit (currently under construction)**. Meanwhile, the remaining sludge is concentrated, digested, dried, and sold as fertilizer.

Research Objective:

This study was conducted to evaluate and enhance the performance of the wastewater treatment plant in Salah Al-Din Governorate to develop recommendations aimed at improving the aquatic environment in Iraq.

Recommendations:

1. **Upgrade the wastewater treatment plant** in Salah Al-Din by expanding its capacity, activating the chlorination unit, and adding additional units for phosphate, nitrate, and heavy metal treatment.
2. **Establish additional treatment plants** similar to this one to manage household and other waste effectively.
3. **Strengthen and support environmental protection committees** to ensure they carry out their duties efficiently.
4. **Implement a monitoring program** to prevent unauthorized use of the sewage system by farmers with agricultural lands near the treatment plant.

Results and Discussion:

Pollution Indicators in Wastewater:

The study results showed a significant increase in pollution indicators in the influent water entering the treatment plant, as detailed in Tables (1 and 2). This was an expected outcome for untreated wastewater, highlighting the risks of discharging such water into the **Tigris River** without proper treatment, especially given the decreasing water levels of the river.

The recorded **BOD (Biochemical Oxygen Demand) values** ranged between **90.5–65.2 mg/L**, while **COD (Chemical Oxygen Demand) values** ranged from **245.9–201.1 mg/L**, and **TSS (Total Suspended Solids) values** varied between **169.2–148.6 mg/L** (Table 1). Comparing these values with the permissible limits for wastewater pollutants (7) underscores the **importance of treating such wastewater before discharge into the river**.

- **High BOD and COD levels** indicate **a high concentration of organic matter**, which consumes dissolved oxygen, leading to **aquatic organism migration and mortality** (8).
- **Elevated TSS levels** make the water unsuitable for human use and **harm aquatic life that cannot tolerate saline environments**, while also increasing **light blockage** in aquatic ecosystems.

The **pH values** recorded in **Table 1** ranged between **7.6 and 7.2**, which are within the limits set by **Iraqi water pollution standards (7)**. Maintaining appropriate **pH levels is crucial** for the activity of **aerobic bacteria** in the **aeration processes** at the plant and helps reduce **corrosion in metal equipment** (9).

Phosphate Concentrations and Eutrophication Risk:

Phosphate concentrations exceeded permissible limits in some months (Table 1). Discharging phosphate-rich wastewater into rivers contributes to **eutrophication**, leading to excessive **algal growth**, which, upon decomposition, **reduces dissolved oxygen levels**, endangering aquatic life (1,2,3).

Studies confirm that **household waste** plays a major role in eutrophication, primarily due to the presence of **phosphorus-based detergents**. The most common **phosphate-based detergent additive** is **sodium tri-polyphosphate (STPP)**, which hydrolyzes rapidly into simpler components (1), as illustrated by the following reaction:

Na5P3O10+H2O→3NaPO3+2NaOH\text{Na}_5\text{P}_3\text{O}_{10} + H_2O → 3\text{NaPO}_3 + 2\text{NaOH}Na5P3O10+H2O→3NaPO3+2NaOH

This highlights the necessity of **phosphate removal measures** in wastewater treatment plants to prevent further deterioration of Iraq's aquatic ecosystems.

Decomposition of Organic Phosphorus Compounds and Nitrate Oxidation:

Phosphorus-based organic compounds decompose due to bacterial activity, leading to the formation of **phosphate ions (PO_4^{3-})** (3,9):

Organic compound+O2→PO43−+H2O+CO2\text{Organic compound} + O_2 \rightarrow PO_4^{3-} + H_2O + CO_2Organic compound+O2→PO43−+H2O+CO2

However, **nitrate concentrations** did not show improvement. This could be attributed to the **lack of activity of aerobic bacteria**, which are responsible for oxidizing nitrogenous compounds into ammonia, then nitrite, and finally **nitrate (3)**.

Chloride and Heavy Metal Concentrations:

- **Chloride concentrations** remained **within permissible limits** (10) as shown in **Table 1**, with values ranging from **322 to 562 mg/L**, which aligns with previous studies (12,15).
- **Lead (Pb) levels** exceeded environmental limits (Table 2), likely due to the **direct discharge of untreated hospital wastewater** into the city's sewage network, which then reaches the treatment plant (14).
- **Cadmium (Cd) was undetectable** in both influent and effluent water.
- **Zinc (Zn) concentrations** remained within **permissible limits** (Table 2).

Treated Water Quality and Plant Efficiency:

Tables **1 and 2** present the **average concentrations of studied pollutants** in the influent (i=in) and effluent (o=out) wastewater, as well as the **semi-annual treatment efficiency (%), calculated using the following formula**:

Efficiency=(Semi-annual influent concentration−Semi-annual effluent concentrationSemi-annual influent concentration)×100\text{Efficiency} = \left(\frac{\text{Semi-annual influent concentration} - \text{Semi-annual effluent concentration}}{\text{Semi-annual influent concentration}} \right) \times 100Efficiency=(Semi-annual influent concentrationSemi-annual influent concentration−Semi-annual effluent concentration)×100

The efficiency results were as follows:

- ✓ **BOD5 removal efficiency: 55.29%**
- ✓ **COD removal efficiency: 74.26%**
- ✓ **TSS removal efficiency: 79.54%**

These values indicate a **moderate treatment efficiency**, considering that the **design efficiency for BOD5 removal is 100%**. The reduced efficiency is likely due to the plant **operating beyond its design capacity**. Despite this, **the final effluent values remain within the allowable limits**.

Aeration and pH Variations:

Efficient aeration enhances **oxygen dissolution**, which is essential for activating aerobic bacteria that feed on suspended and dissolved organic waste, ultimately converting it into **carbon dioxide (CO_2) (1,13)**. Additionally, aeration helps **cool down the water temperature**.

Regarding **pH variations (Table 1)**, treated water was **more alkaline** than the influent water. This is a **natural outcome** due to increased concentrations of **certain alkaline-inducing compounds**, such as nitrates, during treatment.

Phosphate and Nitrate Treatment:

- **Primary and secondary sedimentation** significantly reduced **phosphate concentrations** in treated water. However, phosphate levels **remained above permissible limits in some months** due to the **absence of a dedicated phosphate treatment unit**.
- **Nitrate concentrations remained within permissible limits (11)**, primarily due to aeration, which **oxidizes nitrogenous compounds into nitrates**. However, further treatment is needed to prevent their transformation into ammonia.

Heavy Metal Removal Efficiency:

- **Lead (Pb) and Zinc (Zn) levels in the effluent were lower than in the influent (Table 2)**, indicating partial removal of these metals.

General Assessment:

Despite the **basic and conventional treatment methods** used in the **Al-Dhibai Wastewater Treatment Plant**, and the **absence of advanced pollutant removal technologies**, the **treated water meets the permissible limits** for **the three key parameters: BOD5, COD, and TSS**. However, further improvements are necessary to enhance efficiency and ensure better environmental protection.

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