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Optimizing Water Distribution through EPANET-Based Intermittent Scheduling: A Case Study of Dapitan City Water District, Philippines

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Abstract

Water scarcity has become a growing concern in many developing communities, including Dapitan City, Philippines, where increasing household demand has exceeded the capacity of existing water sources. This study assessed the accessibility of water services provided by the Dapitan City Water District (DapCWD) and developed an improved intermittent water distribution schedule using EPANET hydraulic simulation software. Data were obtained from DapCWD records and a household survey involving 370 randomly selected respondents from 17 barangays using Slovin's Formula. Hydraulic analyses were performed through manual computations and EPANET simulations to evaluate water demand and flow distribution under different scheduling scenarios. Findings revealed that consumers experienced irregular water supply schedules and expressed dissatisfaction with the existing distribution system. Two scheduling strategies, namely Phase A and Phase B, were developed and simulated. Results showed that both schedules maintained total water demand below the available source capacity of approximately 43.5 L/s after accounting for non-revenue water, thereby improving distribution efficiency and service coverage. The study demonstrates that intermittent scheduling supported by hydraulic modeling can enhance water accessibility without requiring immediate development of new water sources.

Keywords: EPANET, water distribution, intermittent scheduling, hydraulic simulation, Dapitan City Water District

1. Introduction

Access to clean and sufficient water is essential for public health, economic development, and environmental sustainability. However, rapid population growth and limited water resources have contributed to recurring water shortages in many Philippine cities. Dapitan City Water District (DapCWD) supplies water to seventeen barangays using three primary sources located in Ambogoc, Diwa-an, and Oyan. Despite these sources, many households continue to experience irregular and insufficient water supply due to increasing demand and aging infrastructure.

To address this challenge, hydraulic modeling tools such as EPANET can simulate water distribution systems and evaluate alternative operational strategies before implementation. This study aimed to assess the current water distribution system of DapCWD and develop an optimized intermittent scheduling strategy that improves water accessibility while maximizing the existing supply capacity.

2. Literature Review

Water scarcity affects billions of people worldwide and continues to threaten sustainable development. Previous studies have shown that population growth, climate variability, and inefficient water management contribute significantly to water shortages. The Asian Development Bank projected increasing water demand in the Philippines due to urbanization, industrialization, and agricultural expansion. Similarly, the World Bank predicted that continued population growth would intensify water scarcity in Philippine cities. Hydraulic simulation software such as EPANET has become an effective tool for analyzing water distribution systems. It allows engineers to model pressure, flow, and demand under various operating conditions, making it useful for evaluating scheduling alternatives and improving system efficiency. Previous applications have demonstrated that optimized valve operations and intermittent scheduling can improve service reliability in water-limited systems.

3. Materials and Methods

This study employed a descriptive and simulation-based research design. Data regarding the water distribution network were obtained from DapCWD, including pipe characteristics, pump operations, storage facilities, and consumer demand. Manual hydraulic computations using the Hazen-Williams, Darcy-Weisbach, and Chezy-Manning equations were performed to validate EPANET simulation results. A household survey involving 370 respondents selected through Slovin's Formula was conducted across seventeen barangays to assess water accessibility, supply frequency, and consumer satisfaction. Statistical analyses were performed using Microsoft Excel, while EPANET software simulated different intermittent scheduling strategies. Two scheduling approaches (Phase A and Phase B) were developed and evaluated based on demand satisfaction and available flow rates.

4. Results and Discussion

Survey results and hydraulic simulations were analyzed to determine the effectiveness of the proposed intermittent water distribution schedules. Consumer responses revealed the prevailing issues in the existing water supply system, while EPANET simulations validated the feasibility of the proposed scheduling alternatives.

4.1 Household Survey Results

A total of 370 households from 17 barangays participated in the survey. The responses indicated that a large proportion of consumers experienced irregular water supply schedules and were dissatisfied with the current distribution system. Most respondents also expressed support for the development of additional water sources and improved water distribution management.

Table 1. Summary of Household Survey Findings

SURVEY INDICATOR	SUMMARY OF FINDINGS
Total Respondents	370 households
Participating Barangays	17
Satisfaction with current water supply	Generally low
Regularity of Water Distribution	Irregular among most barangays
Need for additional water sources	Majority agreed
Need for improved scheduling	Strongly Supported

The survey demonstrates that consumer dissatisfaction is primarily associated with inconsistent water availability rather than the quality of water itself. These findings emphasize the need for a more systematic and efficient distribution strategy.

4.2 Water Supply Availability

The survey further revealed that water availability varied considerably throughout the day. The hourly status of water supply during both the Ante Meridiem (AM) and Post Meridiem (PM) periods showed that several barangays received water only during limited hours, while others experienced intermittent supply. This unequal distribution contributed to consumer dissatisfaction and highlighted the limitations of the existing scheduling system.

The observed variation in water availability justified the development of alternative distribution schedules that could better allocate the available water supply across all service areas.

4.3 EPANET Hydraulic Simulation

Hydraulic simulations were performed using EPANET to evaluate the proposed intermittent scheduling schemes. Both **Phase A** and **Phase B** schedules were successfully simulated without producing negative pressure within the network. Furthermore, all proposed schedules maintained total demand below the available system flow rate of **43.5 L/s**, indicating that the proposed valve operations were hydraulically feasible.

Table 2. Summary of EPANET Simulation Results

Proposed Schedule	Water Demand (L/s)	Available Flow (L/s)	Simulation result
Phase 1A	25.35	43.50	Successful (No Negative Pressure)
Phase 2A	34.95	43.50	Successful (No negative pressure)
Phase 1B	25.36	43.50	Successful (No negative pressure)
Phase 2B	30.71	43.50	Successful (No negative pressure)
Phase 3B	23.30	43.50	Successful (No negative pressure)

The results indicate that **Phase 2A** recorded the highest demand at **34.95 L/s**, while **Phase 3B** recorded the lowest demand at **23.30 L/s**. Despite these variations, all schedules remained below the available flow capacity, demonstrating that the proposed intermittent scheduling strategy can adequately satisfy consumer demand without compromising hydraulic performance.

4.4 Discussion

The findings indicate that the primary challenge faced by Dapitan City Water District is not only the limited availability of water but also the inefficient distribution of the existing supply. Consumer feedback revealed widespread dissatisfaction with irregular water schedules, while hydraulic simulations confirmed that optimizing valve operations and implementing intermittent scheduling can significantly improve distribution efficiency.

The EPANET simulations demonstrated that all proposed schedules operated within the available flow capacity of the water sources and maintained acceptable hydraulic conditions throughout the distribution

network. These findings suggest that operational optimization can substantially improve service delivery before investing in additional water sources or major infrastructure expansion.

Overall, integrating consumer perception with hydraulic modeling provides a practical and cost-effective approach for enhancing water distribution management in local water districts experiencing intermittent water supply. This supports the use of EPANET as an effective decision-making tool for planning and managing municipal water distribution systems.

5. Conclusions

The study concluded that water shortages in Dapitan City are primarily caused by increasing consumer demand relative to available water supply. Existing water production is insufficient to continuously serve all 4,924 households, resulting in irregular distribution schedules and consumer dissatisfaction.

The proposed Phase A and Phase B intermittent scheduling strategies, developed using EPANET hydraulic simulations, successfully maintained water demand below the available supply capacity while improving distribution efficiency. These findings demonstrate that optimized scheduling can serve as a practical and cost-effective water management strategy. Future studies should investigate additional water sources, leakage reduction, and smart monitoring technologies to further improve water service reliability.

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