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DEVELOPING A MAINTENANCE MANAGEMENT SYSTEM FOR WATER TREATMENT PLANTS

M.J.H. Al Graiti S. Naimi

Department of Civil Engineering, Altinbas University, Istanbul, Turkiye
mohammed.jalal.habib.4@gmail.com, sepanta.naimi@altinbas.edu.tr

Abstract- This research focuses on the development of a maintenance management system for potable water liquefaction units, a crucial aspect of infrastructure. The study explores the maintenance of drinking water liquefaction units, analyzing methods, frequency, and duration of maintenance activities. The goal is to create a modern, contextually fitting system for eight water liquefaction units. The existing system has several deficiencies, including inadequate documentation and reporting, and an absence of an evaluation system. This leads to an unstructured approach to planning, scheduling, and monitoring, lacking standardized controls for maintenance performance. The limited budget allocated to unit maintenance results in neglect of less critical tasks, leading to delays in completing essential activities. To address these issues, the researcher proposes multiple subsidiary systems, including a planning subsystem to optimize maintenance costs, a staff allocation subsystem based on unit capacity, a budgeting system, and a reporting subsystem for improved documentation. A project management program (Microsoft Project) is for leveraging its capabilities.

Keywords: Maintenance, Management, Water Treatment Plants.

1. INTRODUCTION

This thesis lays a solid foundation for a comprehensive study aimed at developing a new maintenance management system for water treatment plants. This paper, therefore, clearly highlights why such plants are vital because they are a source of potable water, which is a critical resource for the sustenance of community life [1]. The chapter brings out the high cost of construction and maintenance of such facilities and how this affects efficiency. It is not for the sake of being but rather because of acknowledging the linkages between quality, time, and cost "the management triangle" and the need to minimize maintenance expenses without impacting the quality of the produced water. In order to make headway with maintenance planning, the chapter presents planning techniques like Bar charts, CPM, PERT, PDM, Expert systems, and Simulation techniques [2]. This discussion indicates that it may be possible to use one or more of these techniques in project management to be applied in maintenance planning and follow-up. The justification for this research is robust, addressing the dire state of water treatment facilities, which suffer from technical and managerial inadequacies leading to exorbitant expenses and suboptimal productivity [3]. This condition is exacerbated in older plants, where the cost per cubic meter of potable water is higher than in newer installations. The chapter asserts the necessity of a system to diagnose and redress such inefficiencies.

The hypotheses set forth present the premises upon which the research builds: the quality of water and maintenance work is considered to be within acceptable standards, the value of money is assumed constant for the evaluation period, and the proposed system will adapt annually to reflect the country's specific circumstances and the plants' state. Focusing exclusively on the water treatment plants serving -excluding smaller, compact units due to their distinct maintenance and management needs- the chapter delimits its scope. It justifies this choice by citing the significant proportion of the population served by these plants and the various site-specific challenges they face, which necessitate specialized study [4]. The chapter then delineates the primary objective: to design a maintenance management system that can improve upon the shortcomings identified in the existing system, thereby optimizing the total maintenance cost.

To achieve this, the research methodology follows a systematic approach, starting with defining the problem, assessing objectives, reviewing literature and theoretical foundations, and studying the current state of maintenance. These steps culminate in the development of a suggested maintenance management system tailored to water treatment plants. The chapter concludes by outlining the structure of the thesis [5]. Subsequent chapters delve into the principles of maintenance management, literature review, detailed examination of water treatment plant maintenance, proposal of the new system, and finally, conclusions and recommendations. The systematic approach to presenting the research ensures a logical progression of ideas, setting the stage for an in-depth exploration of maintenance management systems in the critical infrastructure of water treatment.

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There are systems that calculate the total costs of projects through working hours and reduce the cost [6]. Heat exchangers are widely used in current business, and they exist in different structures and sizes to suit a wide range of applications [7].

2. MAINTENANCE

In order to explain the whole meaning of the word "maintenance", many definitions are given at this scope and as [8]:

a) Combination of any action carried out to retain an item in order to restore it to an acceptable condition. Then an acceptable standard must be sought to meet the definition requirement. This standard set by the organization, which is carrying out the maintenance.

b) Number of tasks that must be done for the aim of keeping the assets or repairing them and resuming these assets to the original situation or to an acceptable condition.

c) Preventive process aims to avoid failures and damages at any structure, or repairing failures or damages, and removing defects from the structure returning to a condition that the structure can does its function without any danger.

d) A try to keep assets in use through economic life, such that maximize revenues and minimize costs.

From the definitions above it's clear that the term maintenance is dealing with any action being taken to the assets that gives these assets the ability to work safely and economically (and this represents the researcher opinion). Figure 1 shows Maintenance classification according to the size are major maintenance, minor maintenance, and essential services.

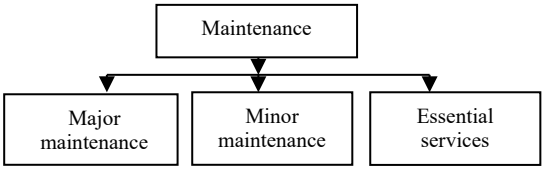

Figure 1. Maintenance classification according to the size

3. METHODOLOGY

3.1. Data Reporting

For purposes of maintenance control, data can express the state of the maintenance with various forms of reports, tables, and charts. The suggested documentation system in this research is the first step for this component. There is a number of reports which are useful for describing the state of the maintenance in water treatment plants, time basis reports shall periodically show the change and development in maintenance works and the deviations in time schedules and cost [9-11].

Microsoft project software is suitable for reporting as actual data is entered to this software reports and another project management aspect using the advantages of the software [12, 13]. This software can continue the planning according to the optimum maintenance cost, making full use of software facilities as resource allocation and any type of reports required as the researcher suggests in this paragraph.

3.2. Proposed System

Microsoft Office Project is a project management software developed by Microsoft, used in various industries like construction, engineering, information technology, and marketing. It assists project managers in planning, tracking, and managing projects of varying complexities. Key features include project planning, resource management, timeline and Gantt charts, task tracking, budgeting and cost management, reporting and analytics, and seamless integration with other Microsoft Office applications. Project allows users to create detailed project plans, allocate resources, set timelines, track progress, and analyze project performance. It also provides tools for estimating costs, setting budgets, and tracking expenses throughout the project's lifecycle. The software also offers reporting and analytics tools to help project managers assess performance and make data-driven decisions.

This article offers a detailed handbook on planning and running a project utilizing the Microsoft Project, a sophisticated application for project management. This chapter presents a step-by-step procedure that project managers can use to plan, implement, and monitor project activities. The system begins by explaining the basic interface of Microsoft Project, which is where the timeline feature comes in handy. This will help stakeholders know the project timeline with key tasks and milestone, Figure 2 shows the main interface. Where add tasks with dates to the timeline represents full working time.

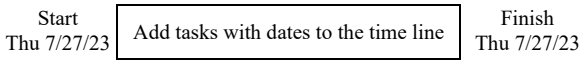

Figure 2. The main interface of the time line

Next step, attention is directed to task management, explaining the essence of task naming for clarity and orderliness in the project, Figure 3 shows task name, refers to the name or title given to individual tasks within a project.

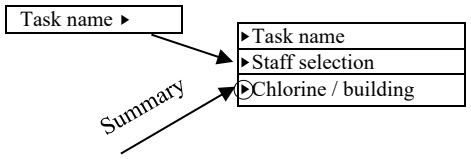

Figure 3. Task Name management

The task mode in the third step differentiates manual and automatic scheduling options in Microsoft Projects. Auto-scheduling is emphasized as the preferable mode due to its capability to leverage the software's advanced features for efficient task scheduling, Table 1 shows Task Mode, refers to how a task is scheduled. and how its duration is determined. Duration, as described in step four, is a pivotal factor in project planning, determining the timeline required to complete each task.

Table 1. Task mode scheduling

Code of Task	Task Mode ▸
1	
2	
3	

The report details the types of duration measurements "work hours, workdays, and calendar days" and their significance in the planning, Table 2 shows Duration, and refers to total amount of time it takes to complete a task.

Table 2. Duration of total time task

Code of Task	Task Mode ▸	Task Name ▸	Duration ▸
1		▸Staff selection	1 day
2		▸Chlorine /building	3 days
3		▸Sand filter	4 days

The concept of 'Predecessors' in project tasks is introduced in step five, explaining the dependencies between tasks and the importance of establishing a logical sequence for task execution, Table 3 shows predecessor, refers to a task that comes before another task and establishes a dependency between the two tasks.

Table 3. Predecessor in project task

Predecessors
25
54SS
98
107SS
136SS
148
181
192SS
209SS
1SF

Step six involves the Resource Sheet, a vital component for resource management within the project. It allows the manager to list and edit resource details such as names, types, availability, and associated costs, providing a platform for assigning resources to tasks effectively.

Table 4. Resource sheet management

Resource Name ▸	Type ▸	Max. Units	Std. Rate	Ovt. Rate	Cost/Use
Capacity (1000 m3/day) Professional Skilled	Material	100%	$1,000.00	$250.00/hr	$1,000.00
	Work	100%	$200.00/hr	$210.00/hr	$250.00
	Work	100%	$200.00/hr	$110.00/hr	$210.00

The subsequent selection of resources for tasks, showcasing the versatility of resource allocation. Table 4 shows Resource sheet is a view that allows you to manage and organize the list of resources that are required for your project. and Table 5 shows resource names, this is where you enter the names of the resources. Each resource should have a unique name to identify them in the project.

Table 5. Resource names management

Resource Name
Agricultural Eng. ▸

Capacity (1000 m3/day), Professional, Skilled, Unskilled, Chief Eng. (Mechanic).
Eng. (electrical), Senior Eng. (mechanic), Eng. (electrical), Eng. (mechanic), Eng. (chemical).

Adding the 'Complete %' column is an essential aspect of tracking progress within the project. It facilitates real-time updates on task completion levels, enabling a project manager to monitor ongoing progress against the project plan, Table 6 shows complete %, refers to the progress made on a task or the percentage of work that has been completed up to a specific point in time.

Table 6. Complete % real time

Add New Column ▸

Complete %▸
100%
50%

In step eight, the 'Project Information' dialog box is emphasized for its role in capturing the core project details. This includes project start and end dates, working times, and other significant project-related settings.

4. RESULTS

Lastly, the results of implementing the discussed steps are encapsulated through dashboards and cost analysis. The dashboards offer a strategic overview of the project's status, while the cost overrun figures provide critical insights into the financial health of the project, signaling areas that may require attention, Figure 4 and Table 7 show Value of Result of project overview.

Table 7. Value of result of project overview

Name of task	No. complete task %
Staff selection	100%
Transformer and high voltage switchboards electrical inspection checklist	75%
Chlorine /building	100%
Chlorine and alum building mechanical check list	75%
Sedimentation tank	100%
Mechanical inspection checklist	100%
Sand filter	0%
Sand filter/Mechanical checklist	100%
Internal and external lighting check list	100%
Diesel generators (main site) check list	50%
Intake pump station/Electrical inspection checklist	50%
Intake pump station/Electrical inspection checklist	75%

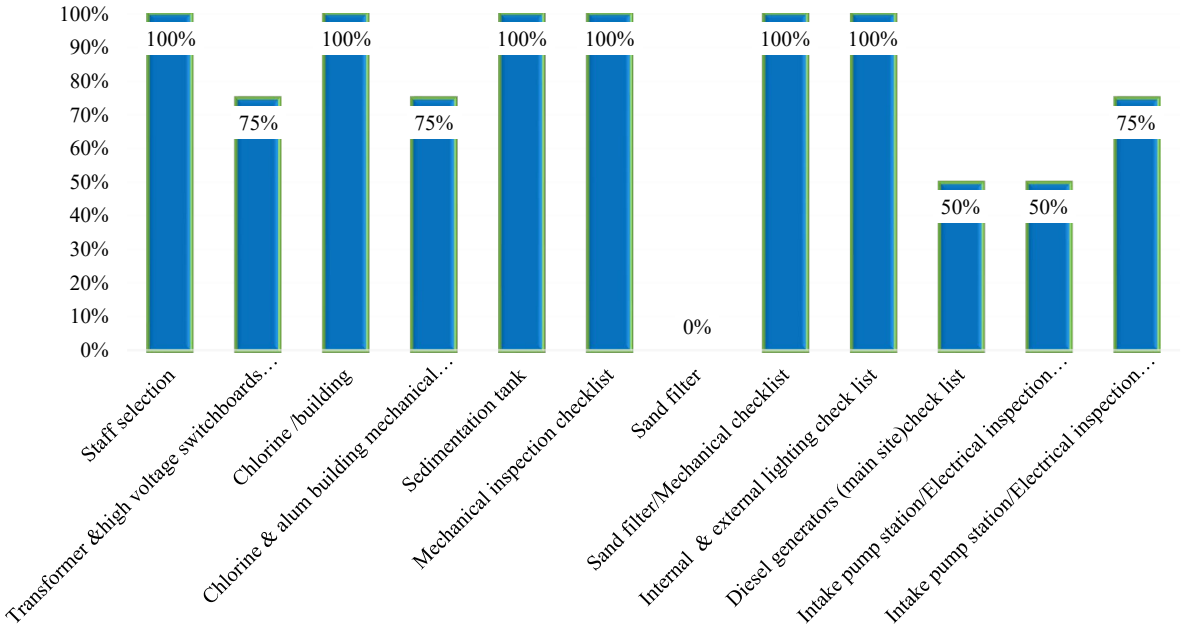

Figure 4. Value of Result of project overview

Cost overruns task cost variance/cost variance for all top-level tasks in the project. Figure 5 shows cost overruns task cost variance.

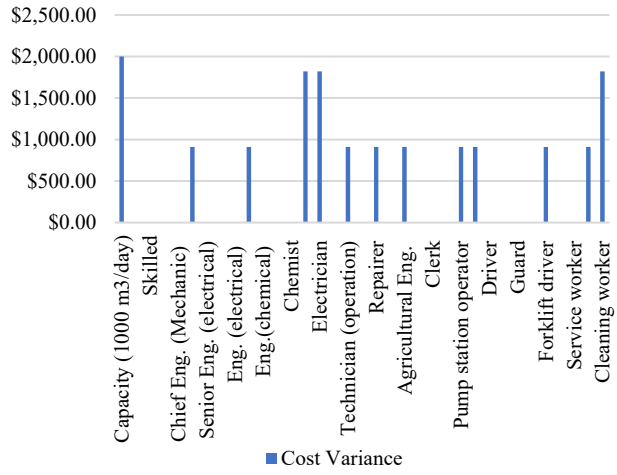

Figure 5. Cost overruns task cost variance

Resource cost variance/cost variance for all the work resources Figure 6 shows cost overruns resource cost variance.

5. CONCLUSIONS

The maintenance management system for water treatment plants has been suggested to address several issues, including a 48% loss in the piping system, potential for increased data revenues, and the need for updated automated control. The system's outdated approach and lack of scientific approach to maintenance management components also contribute to the issue. Limited budgets for maintenance can affect strategies and lead to high failure rates. Staffing in water treatment plants is based on available staff rather than required staff, necessitating a review of job specifications. The organization structure for NWA, operation, maintenance, and plaint self needs improvement due to weak points in management. A unified accounting system is needed to provide a clear picture of performance. Emergency maintenance due to limited budgets has affected data, necessitating scientific evidence. Evaluation criteria or standards for maintenance and management of water treatment plants are needed, with a suggested cost accounting section providing valuable data. Interim reports should be unified and gathered to aid management in decision-making. Feedback processes are rare, potentially changing planning and budgeting assumptions.

6. RECOMMENDATIONS

According to the conclusions of this research, the researcher reaches the following recommendations through developing a maintenance management system for water treatment plants. Adopting the suggested system with its requirements is very important to keep the system working.

1. All components of the suggested system have the same importance because they represent one unit, and any problem in any component certainly will lead to other problems at many locations of the system.
2. Reviewing the organizational structure of NWA, the operation and maintenance department, and the plant itself in a manner compatible with the suggested system.
3. Make annual preparations for changes that might happen due to circumstances such as strategy changes, budget increases, and so on.
4. Continuous updating of the data required for the suggested system.

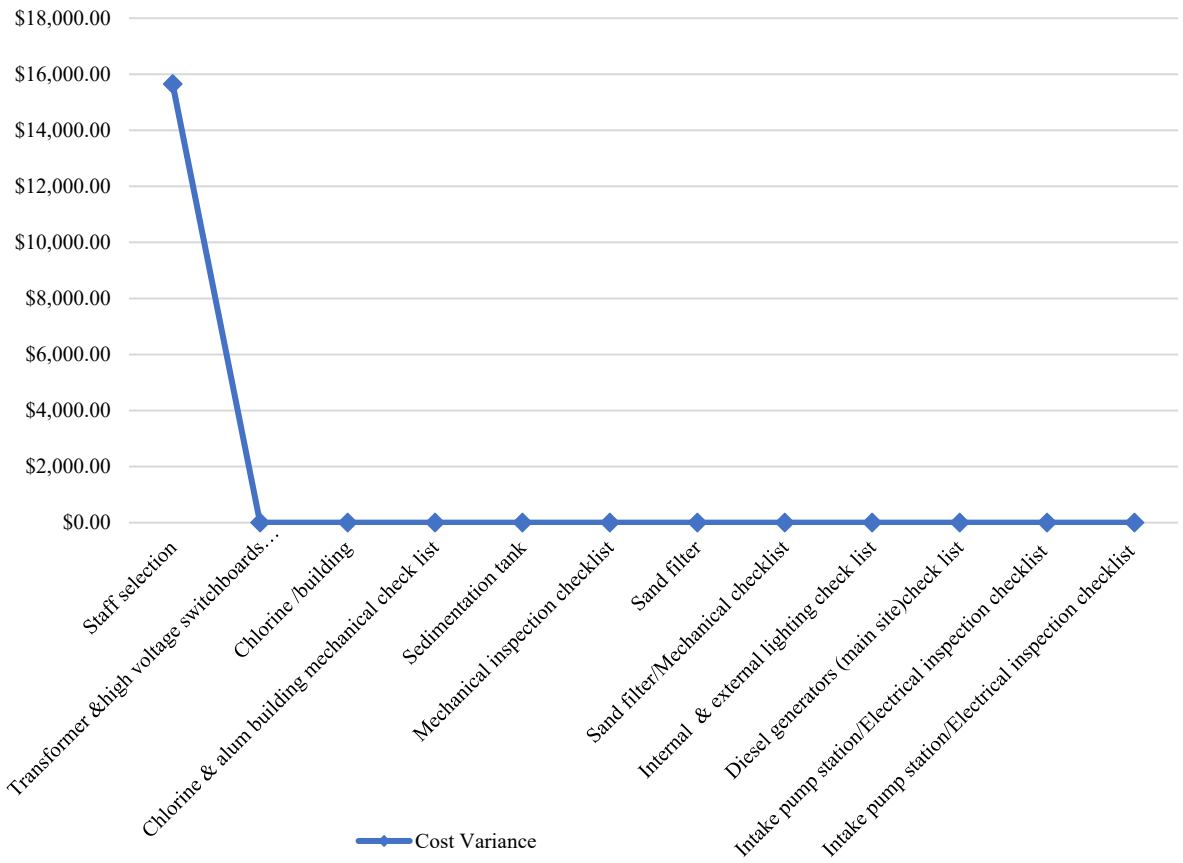

Figure 6. Cost overruns resource cost variance

7. FUTURES WORK

1. Studying the effect of increasing the frequency of periodic maintenance activities accurately on emergency maintenance activities in time and cost.
2. Studying the feasibility of the construction of a sludge packing unit to increase plant revenues.
3. Building a new evaluation system with required criteria for both water treatment plants and NWA to prove whether they are in the right way or not.
4. Studying the ability to automate water treatment plants and the feasibility of such work.
5. Studying the importance of the activities and the independent variable that is affecting this importance, reaching the right priorities for all maintenance activities, and building a model that represents these priorities.

NOMENCLATURES

Acronyms

NWA	Najaf Water Administration
SS	Start Start
SF	Start Finish
Max	Maximum
Ovt	Overtime

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BIOGRAPHIES

Name: **Mohammed**
Middle Name: **Jalal Habeeb**
Surname: **Al Graiti**
Birthday: 29.04.1997
Birthplace: Najaf, Iraq
Bachelor: Civil Engineering, University of Kufa, Najaf, Iraq, 2020
Master: Student, Civil Engineering Department, Altinbas University, Istanbul, Turkey, Since 2021
Research Interests: Construction Management, Water Resources and Structures

Name: **Sepanta**
Surname: **Naimi**
Birthday: 12.06.1976
Birthplace: Isfahan, Iran
Bachelor: Mechanical Engineering Department, Islamic Azad University, Isfahan, Iran, 2001
Bachelor: Civil Engineering Department, Beykent University, Istanbul, Turkey, 2010
Master: Mechanical Engineering Department, Eastern Mediterranean University, Gazimagusa, Northern Cyprus, 2007
Doctorate: Civil Engineering Department, Eastern Mediterranean University, Gazimagusa, Northern Cyprus, 2013
The Last Scientific Position: Assoc. Prof., Altinbas University, Istanbul, Turkey, Since 2019
Research Interests: Steel Structures, Finite Element Analysis, Construction Management Scientific
Publications: 80 Papers, 1 Book, 130 Theses
Scientific Memberships: Union of Chambers of Turkish Engineers