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# OPTIMUM MAINTENANCE COST IN WATER TREATMENT PLANTS

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## ABSTRACT

**The main objective of this paper is to reach breakeven point between periodic planned maintenance and emergency maintenance, to reach this objective, periodic maintenance cost will be increased, then, it's necessary that emergency maintenance should decreased and visa verse. The first step in this research was preparing a list of all maintenance activities to be done in water treatment plants according the history records of these plants, categorizing these activities into two main lists the first for periodic maintenance and the second for emergency. The next step is studying the effect of intensifying periodic maintenance on emergency maintenance. Using simulation model and starting intensifying periodic maintenance the effect will be determined calculating both periodic and maintenance cost and finally total maintenance cost. At the end of much iteration the result will be optimum maintenance cost. The suggested approach represents a flexible model to reach the optimal point for total maintenance cost through the process of balancing between and periodic and emergency maintenance costs.**

**KEY WORDS :** Water, Treatment, Water treatment plants.

## INTRODUCTION

Maintenance is important in water treatment plants but at what costs (See Figure 1).

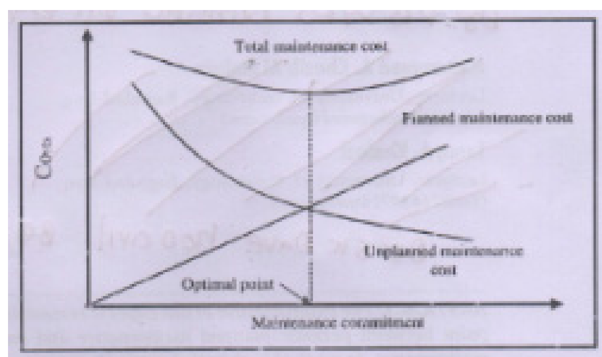


**Fig. 1.** Maintenance Cost (2)

## PREVENTATIVE MAINTENANCE OPTIMIZATION TECHNIQUES

Since the inception of the original reliability centered maintenance (RCM), methodology in this area has also grown rapidly. There is now a very large range of companies and products for optimizing the maintenance strategies of any industry, including a wide variety of software applications designed to assist in this area. This extends into specialized areas such as Root Cause Analysis, which is a becoming increasingly refined, and incorporates a variety of reliability engineering techniques (Mather, ).

## PLANNING AS A COMPONENT OF MAINTENANCE MANAGEMENT

Planning is one of the important components of maintenance management system, planning is one of the most important area.

### Planning for Optimum Maintenance Cost in Water Treatment Plants

components of any maintenance management system. Planning component consists of the total process of examining selecting the best course of action. Maintenance planning requires:

1. Specific goals s objectives
2. An estimate of the type and amount of work to

meet prescribed level of service.
3. Time table to do the work.
4. An allocation of budgeted resources , and
5. A data allocation and feedback system.

Planning activities result in a maintenance work plan that becomes the basis of monthly operating plans, daily schedules and performance evaluations. But several steps need to be taken before planning activities and program development can occur as follows in 4 steps.

Step 1: Defining maintenance activities clearly. A maintenance work activity is simply the name given to be different types of work performed. Normally, only work that is performed frequently and in significant amount is identified.

An activity should not be defined so broadly as to include numerous alternative objectives; however, it need not be so restrictive as to be limited to one step within a completed operation. Work measurement units for work activities should be ea, Ily identified and reasonable coding of maintenance work activities that usually follow the format associated with the organization's financial recording system.

Step 2: Compiling a maintainable-features Inventory. Ideally - a maintainable - features inventory will include a count of all maintainable features of the system within a specified area.

Step 3: Establishing Priorities Changes policy, available funds, equipment, or personnel often affect the level of service provided by maintenance organization.

Step 4: Establishing Standards: Standard values are necessary if a consistent method is expected to estimate resource requirement of maintenance programs and to evaluate individual or crew performance when standards are adopted, a tool is created - what is done with them determines the real degree of the managen any system.

Step 5: Compiling cost data: It's important because development of adytum late mathematical models for predicting various categories of maintenance cost requirement creates an extremely useful tool.

Most management systems collect costs for each work activity defined by the system, internally or by periodic surveys of the local market place. These are usually described in terms of costs for labor, equipment and materials and often stored in the computer cost data? file.

## MAINTENANCE COST WATER TREATMENT PLANT

Operation and maintenance (O&M) costs comprise the following elements:
1. Labor
2. Energy
3. Renewal and replacement
4. Chemicals
5. Waste disposal
6. Miscellaneous costs (taxes, insurance, etc.)

The basis for estimating each of these elements are presented in a table along with a partial list of commonly used sources for collecting the necessary data to prepare the O&M cost estimate.

The factors affecting O & M cost estimates are similar to those that affect capital cost estimate. O&M cost estimates are also impacted by long-term variables such as changes in the interest rate, inflation, and competition for labor, energy and chemicals. Because of these unknowns, an expected level of accuracy is typically not assigned to annual cost estimates. Table 1 shows the major elements of water treatment plant maintenance cost (Robert, 1999).

Then the annualized total cost of in aintenance action is calculated from a number of input parameters (6)
1. Cost of actual failure or breakdown.
2. Cost of primary maintenance actions.
3. Cost of secondary maintenance action, (this is corrective repair that is done as a result of an observation or warning condition observed as a result of conducting the primary action).
4. Frequency of failure for the equipment being maintained, based upon its life characteristic.
5. Probability of detecting and completing the secondary action within the warning time distribution.

For example operation and maintenance is US$ 10 Million per year while variable Operation and Maintenance US $0.007 per $m^3$/year.

These costs have been estimated based on historic values of similar facilities. These costs are not expected to vary widely and therefore cannot be changed by the model user.

## CASE STUDY

The researcher adopted water treatment plants as a case for this research. All data were collected by the researcher through eight water treatment plants in Baghdad city to reach the objective of the research. All these plant are run by Baghdad Water Administration (BWA).

Maintenance activities in these plants are performed in such a priority to match the budget assigned, so the less important activity can be delayed or put in other schedule.

Data collection form was a good mean to gather all data required for maintenance activities and other relevant information.

**Planning Criticisms**

Maintenance planning for both two major types (periodic and emergency) is not found. Even there was planning, but still without a clear study for planning. Emergency maintenance was the most common plan in most of The eight plants.

The absence of right scientific planning resulted in number of problems at the next functions of maintenance management as:

1. Lack of ,assessment of the activities and their quality, quantity, and standards, which are the activities to be done for conserving plant.

2. As a result of (1) there is another lack of priorities determination for the activities above.

3. 'There is a large difference between plants in maintenance activities implementation, the difference also includes the frequency of activity and the time required for the activity.

4. The time, assigned for these activities is not specific and with a wide range in executing the maintenance activities.

5. Unavailability of the data that might be used, as reference for the maintenance, which is can be useful for planning to the future.

**Model Description**

The important task in suggested model is reaching optimum cost of maintenance by balancing between periodic maintenance that includes all types of planned maintenance and emergency maintenance on the other side.

The major advantage of this system is self-maintainability that which means changing the plans and budget according to the economic situation, administration situation, and life of the plant as the system is running on.

**Cost Optimization Model**

The suggested model introduces a plan that can lead total optimized maintenance cost. The idea is considered original, -specially in Iraq, which presents an approach to reach the optimum cost of maintenance, and to build a Maintenance management system with optimum total maintenance cost.

There were many trials to approach an optimized total maintenance cost. As the case of the branch of the national office for drinking water Marrakech-Morocco (the body responsible for supplying drinking water at Morocco). The authority discovered that the maintenance system that is designed by DEGREMONT Co. is balancing between periodic and emergency maintenance, which were 60% and 40% respectively. Then, they replace this plan, with a new planning approach after studying the maintenance cost details they used 20% and 80% for periodic and emergency maintenance, and there was a significant drop in total maintenance cost.

The other case was at Kununerra Dam where the analysis resulted in a 70% reduction in overall maintenance cost against the originally recommended manufacturer/design schedules, annualized using 10 years net present value calculation(6). At this case, RCM approach was used to reach the point that represents optimum maintenance cost.

To apply the same approach to research case, there were many difficulties. The first was the large number of maintenance activities to be done whether they were periodic or emergency. The second challenge was the wide range of variation between the eight plants in capacities, streamline, actual life of plants, the method of mixing, method of sedimentation, type of filters, number of units, and others.

The suggested model highly depends on the data required for each plant in general and especially those related to maintenance to help the user of the system to reach the plan that fulfils cost optimization. To do so, the following steps explain all details of the suggested planning sub system.

Step 1: The first step is assessing the activity and its description, the time required, frequency, cost, and other data required for each, emphasizing that the frequency of the activities with its minimum, to start the curve -4- total maintenance cost from its beginning for aims of optimization. These date -can be gotten from a previous data or by experience from those related with maintenance of water treatment plants for the first application of system. In the second time of the system application, activities shall be saved in the system documents and reports with making required adjustment that is done by the system. Updating If the data manually is useful at circumstances of variations in different aspects of activities especially as editing activities or omitting them.

Step 2: Preparing periodic and emergency plans, after the data at step 1 is accomplished periodic and emergency maintenance plans must be prepared. These plans shall represent the first trial in the optimization process. Total maintenance cost will be calculated by addition of periodic maintenance cost to emergency maintenance cost.

Step 3: Once, the frequency of the periodic maintenance in its minimum, then, the frequency of each activity to be increased, this increasing can be done by changing the weekly activities to daily, monthly to weekly, seasonal to monthly, semiannual to seasonal, annual to two years , two years to for three years, and so. On the other hand emergency will be affected by this frequency increasing with decreasing the expected average frequency of the emergency activities.

This effect is calculated from an open questionnaire (see appendix A) with most of all those related to managing water treatment plants and especially with maintenance.

There were 20 answers for this question with a mean of 25.25%, as the effect of increasing frequency of periodic maintenance on emergency maintenance, standard deviation was 6.584%. The answers of this questionnaire are wide range dispersed. A simulation process for each trail to reach the effect that will be known of EPEP.

After the first two years of operation this system there is no need for 'he EPEP derived from the questionnaire, the data recorded in the system with using the equation 1 can calculate actual EPEP.

$$EPEP = P_n P_{n-1}(E2-£1/P2-P1) \quad .. (1)$$

Where $P_n$ = periodic maintenance cost for the last trail

$P_{n-1}$ periodic maintenance cost for the trail before the last.

E2 = emergency maintenance cost for the second year of system work.

El = emergency maintenance cost for the first year of system work.

P2 = periodic maintenance cost for the second year of system work.

P1 = periodic maintenance cost for the second year of system work.

The percentage of EPEP is calculated annually according to the new data saved in the documentation system, and there is no an annual adjustment for any error discovered.

Seep 4: Preparing new plans according to the new frequency of periodic maintenance and its effect on emergency maintenance.

Step 5: Comparing the first value of total maintenance cost which is calculated at step 2 (old cost) with the second value of total maintenance cost that is calculated at step 4 (new cost). If the old cost is greater than new cost, then there is a chance to-decrease the total maintenance cost and beginning in another trial.

Step 6: The steps from 3 to 5 shall be repeated till the old cost will be less than the new cost, the trail before the last trail will be the optimum total maintenance cost.

Step 7: The optimum total maintenance cost from step 6 will be adopted as the key for planning process. All plans shall be represented with bar chart or any other technique using Microsoft project software (or any other software) showing all periodic maintenance activities whether they daily, weekly, monthly, and so on.

Step 8: Activities delayed- may be given a priority for the next year run.

All the steps above are summarized in Figure 2.

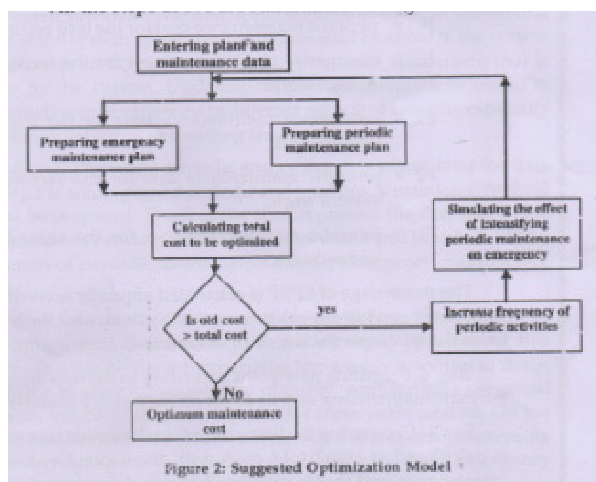


**Fig. 2.** Suggested Optimization Model

## CONCLUSION

The model suggested can be applied to give the decision taker the tool required for maintenance planning in water treatment plants. Using software prepared especially for the purpose of this model can make the optimization easier. The model is tested by entering a set of data for water treatment plant showing all activities of giving the minimum maintenance cost which was the objective of the research.

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