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Planning for Optimum Maintenance Cost in Water Treatment Plants in Baghdad

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ABSTRACT

The main objective of this paper is to develop model to reach breakeven point between periodic planned maintenance and emergency maintenance. Hence, intensifying periodic maintenance would lead to cost increased, accordingly the emergency maintenance should decreased and visa verse. The effect of this intensifying periodic maintenance on emergency maintenance is to be determined using simulation model based on data collected for 8 working water treatment plants. Many attempts have been seen to reach this point in Morocco and Australia, however , definitely the circumstances are different from firm to another and from country to another this paper is an another attempt to prove the ability to reach optimum point of total maintenance cost. After much iteration the result will be optimum maintenance cost. The suggested model represents a flexible technique to reach the optimal point for total maintenance cost through the process of balancing between and periodic and emergency maintenance costs.

Keywords: *Planning, Water, Treatment*

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INTRODUCTION

If anyone asks, “Is planned maintenance limited or flout" the answer of this question is “maintenance cost can give that". Whereas conations planned maintenance means increasing its cost " represented by cost of inspection; minor repairs etc “, at the same time cost of failure and emergency maintenance will be reduced. So maintenance cost cannot be increased; because it will be uneconomic, that balanced with increased cost. Figure 1 shows the relationship between maintenance costs [1].

RESEARCH METHODOLOGY

Optimal performance of machinery is a must for economic viability of any capital-intensive industry. Maintenance functions play a vital role towards achieving higher production targets, however, the cost of production operation must be within the laid down limits. To this end every industry establishes a maintenance department to achieve their requirements effectively. One of the important areas of decision making in the maintenance department is economic consideration. Economic aspects of maintenance is looked into from different perspectives. The prevailing methodologies include the life cycle costing, value function, performance-auditing, and the like. The economic analysis is also necessary for the management of inventory and adoption of the replacement policy [2].

It's clear in figure 1 that there is a point where planned maintenance curve and unplanned curve are intersected; accordingly this point represents the minimum total maintenance cost (which is a yield of both planned maintenance cost and unplanned maintenance cost). The main objective of this paper is to introduce an approach to reach the optimum total maintenance cost.

This objective has been reached through an number of steps consisting the methodology of this paper , the first step was to prepare the theory part and literature review of the main topic which the maintenance of water treatment plants, the second step was field study where many water treatment plants in Baghdad were visited for about 9months to study the actual situation of maintenance in both shapes (planned and unplanned) and then analyzing data collected thoroughly to develop an approach that help decision maker to reach optimum maintenance cost. The last step is the test of this approach where actual data fed to the software prepared for optimization purpose.

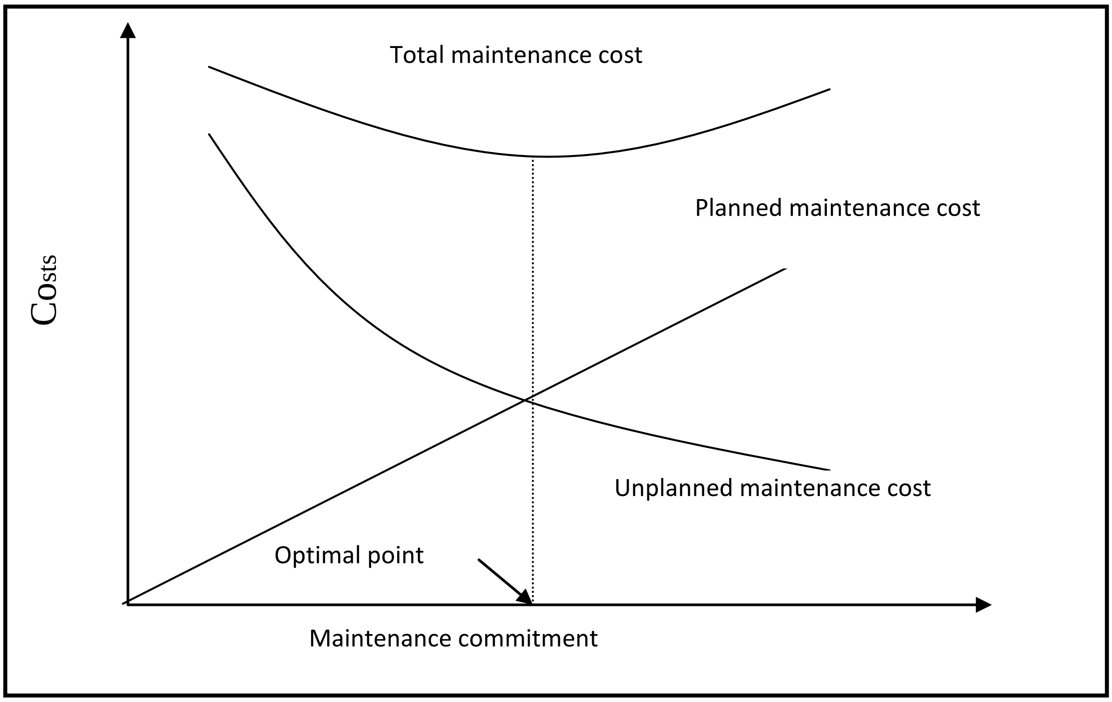

Fig. 1 Maintenance Cost

LITERATURE REVIEW

Many researchers have written for the topic of maintenance of water treatment plants planning and how to be optimized covering many aspects of this topic.

[3] assessed how should maintenance be dealt with as part of an asset management model and what is the relationship between operating costs and capital investment that maximizes financial benefits whilst optimizing asset performance[3].

[4] aimed in his paper to assess how water utilities can apply reliability-centered maintenance (RCM) to new and existing infrastructure and evaluate costs and benefits of RCM programs at water utilities [4].

[5] described the findings of the 2005 civil maintenance benchmarking programme; here, they report on the latest round of mechanical and electrical maintenance benchmarking carried out in [5].

[6] attempted to address the issue of optimal Whole Life Costing (WLC) rehabilitation and maintenance strategy of water distribution assets using genetic algorithm technique. The whole life cost approach for rehabilitation and maintenance of water distribution systems is aimed to optimize the present value of pipe replacement, repairs and cleaning costs over a defined analysis period while requirements for water standards are fulfilled. The WLC analysis depicts a rehabilitation strategy over a defined analysis period together with the corresponding cost profile [6] Uganda to demonstrate that the genetic algorithm can assist in planning of rehabilitation of water distribution systems [6].

[7] described a simulation-optimization model aimed at helping water utilities determine the best way to operate large-scale multisource water-supply systems. The operation of water systems is optimized taking into account the principal planning objectives defined for interventions that include reducing operating costs, satisfying demand, delivering water of appropriate quality, and not prompting the use of emergency sources. The model allows that these planning objectives may not be completely fulfilled in critical circumstances (e.g., droughts) when goals have to be prioritized by the water utilities. The model is a highly nonlinear programming problem and is solved with the general algebraic modeling system (GAMS), using the MINOS algorithm (GAMS/MINOS). The application of the model to the multimunicipal urban water-supply system of the Algarve shows its capabilities for optimizing the operation considering economic and noneconomic goals included in the objective function and to cope with future shortages in critical circumstances by improving the conjunctive use of the different

water sources with interannual planning time horizons [7].

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 [8].

Planning as a Component of Maintenance Management

Planning is one of the important components of maintenance management system. Planning component consists of the total process of examining and 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. Several steps need to be taken before planning activities and program development can occur as follows [9]:

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 easily 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 management system.

Step 5- Compiling cost data: It's important because development of adequate 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 for Water Treatment Plant

Operation and maintenance (O&M) costs for water treatment plant comprise the following elements:

1. Labor
2. Energy
3. Renewal and replacement
4. Chemicals
5. Waste disposal
6. Miscellaneous costs (taxes, insurance, etc)

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 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 [10].

Then the annualized total cost of maintenance action is calculated from a number of input parameters [11]:

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 m3/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 [12].

CASE STUDY

The researcher adopted water treatment plants as a case for this research. Baghdad city consists of eight main water treatment plants in various capacities. All data was collected by the researcher through these 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 activities 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, it may be the right choice but it isn't enhanced by any scientific prove.

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

1. Lack of assessment of the maintenance activities and their quality, quantity, and standards.
2. Lack of priorities determination for maintenance activities.
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.

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 to total optimized maintenance cost. The idea is considered original, especially in Iraq, which presents an approach to reach the optimum cost of maintenance.

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). As per the discussion with Mr. Ahmed who's the regional manager of this office, 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 (11). At this case, RCM approach was used to reach the point that represents optimum maintenance cost.

To apply the same approach on 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: Assessing the all expected activities(periodic and emergency) and their description, time required, frequency, cost, and other data required for each, emphasizing that the frequency of the activities in minimum. These data can be collected through previous data or by experience from those related with maintenance of water treatment plants for the first run of the model.

Step 2: Preparing periodic and emergency plans, based on the data in step. 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: Intensifying periodic maintenance by increasing the frequency of each periodic maintenance activity (can be done by changing the weekly activities to daily, nthly to weekly, seasonal to monthly, semiannual to seasonal, annual to two years , two years to for three years, and so). Emergency maintenance will be affected by this frequency increasing in term of decreasing the expected average frequency of the emergency activities.

The effect is determined using open questionnaire distributed for those related to managing water treatment plants and particularly 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 the 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-E1/P2-P1) ……………..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.

E1 = 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.

Step 4: Preparing new plans according to the new frequency of periodic maintenance and its effect on emergency maintenance and calculating a new total maintenance cost.

Step 5: Comparing the total maintenance cost calculated in the step 4(new cost) with total maintenance cost calculated in step1 (old cost). If the new value of cost is less than the old 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 new value will be higher old value; the optimum point is the step before the last trail as the optimum total maintenance cost is reached.

Step 7: the optimum total maintenance cost from step 6 will be adopted as the key for planning process.

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

All the steps above are summarized in Figure 2 below.

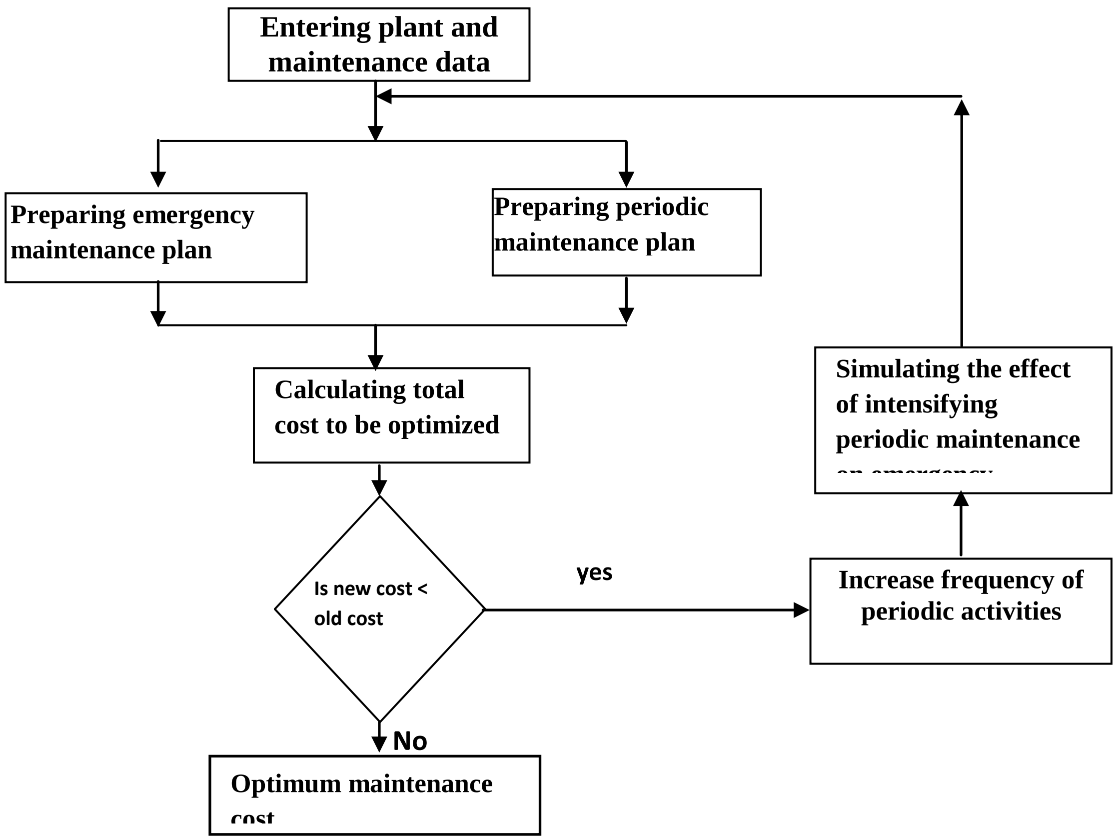

Fig. 2 Suggested Optimization Model

Model Test

To achieve self-maintainability that would enhance adopting suggested model, the effect of increasing periodic maintenance activities on emergency can be determined either by calculating the real effect according to the historic data or by experience; otherwise, it can be simulated according to the questionnaire answers.

It's difficult to collect, estimate duration, determine frequency, and cost estimate for all maintenance activities, then processing according to the suggested model in term of manual calculation, it's tend to be impossible, therefore, a computer program is design for doing so.

The model is being tested through data collected from Al Rasheed water treatment plant in Baghdad for model test, these data were entered to the designed program, and finally the results show the optimum plan for both periodic and emergency activities.

Figure. 3 shows data entering to the software, while Figure 4 shows test results (optimum activities). These results prove the ability of the suggested model to reach optimality between periodic and emergency maintenance.

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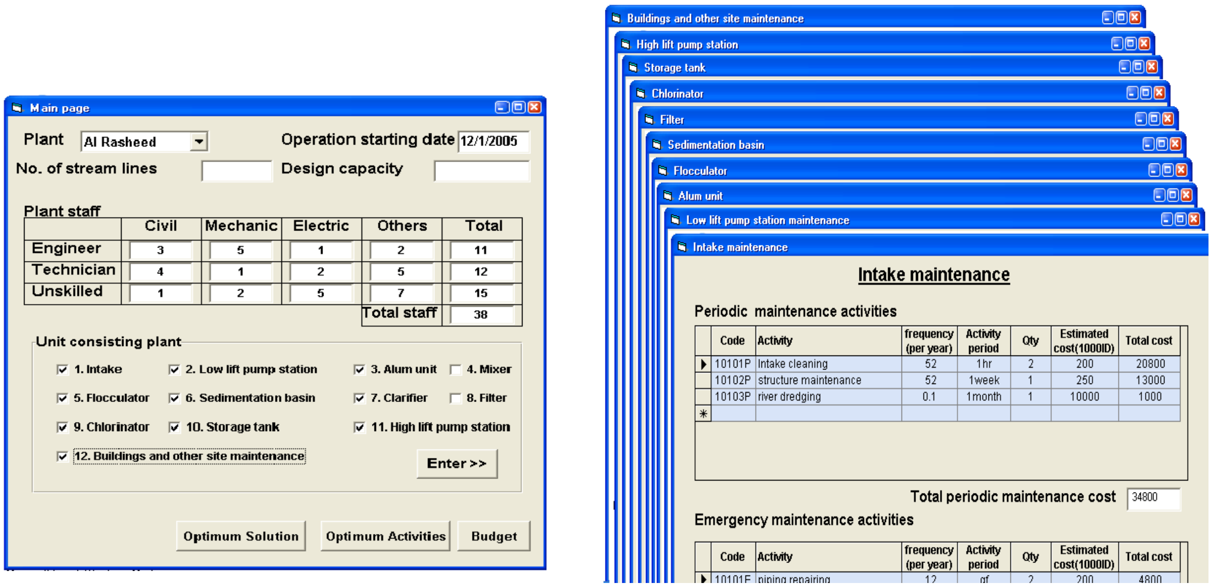

Fig. 3 Data Entering

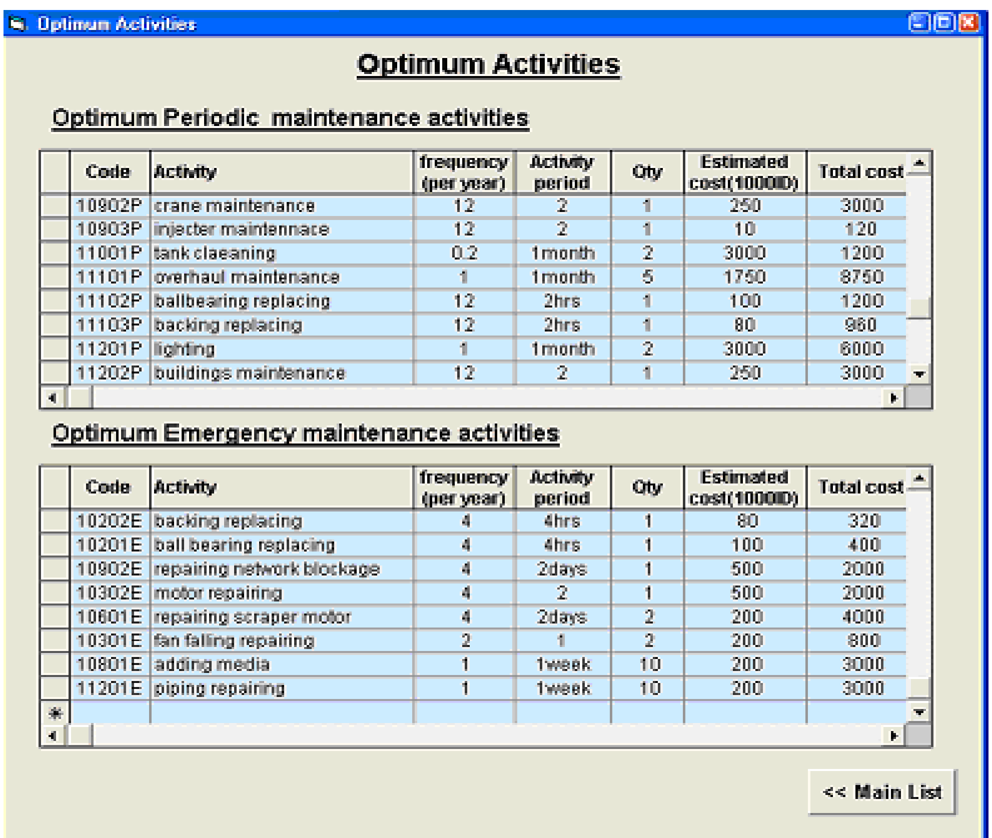

Fig. 4 Optimum Activities

CONCLUSION

The suggested model can be adopted to give decision takers 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 giving the minimum maintenance cost which was the objective of the research.

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