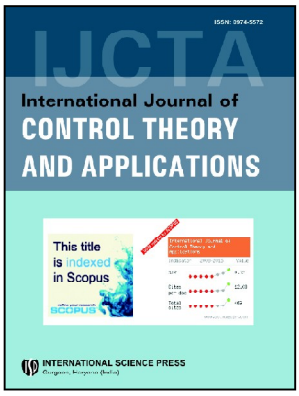


International Journal of Control Theory and Applications

ISSN : 0974-5572



Volume 10 • Number 6 • 2017

# Identifying the Risk Factor of Water Treatment Plant: An MCDM Approach

**Sudipa Choudhury[1], Mrinmoy Majumder[2] and Apu Kumar Saha[3]**

*[1] Department of Mathematics, National Institute of Technology, Agartala, Tripura, India*
*E-mail: [1]Sudipachoudhury032@gmail.com; [3]apusaha.nita@gmail.com.*
*[2] Civil Engineering Department, National Institute of Technology, Agartala, Tripura, India*
*E-mail: [2]mmajumder15@gmail.com*

***Abstract:*** Water covers about 70% of Earths surface, makes up about 70% of our mass and is essential for the life. But, now-a-days, most of the people don't have potable water for household usage. Water supply chain management and optimization is evolving as one of the most difficult and urgent problems, since the water's demand and availability vary significantly from year to year, seasonally and even daily also. The trend of urbanization in India is exerting stress to provide safe drinking water. On a recent survey, it was found that nearly 75% of the three million early deaths are water borne. So, treatment of water, supply of good quality water has a high importance now. That is why, the surface or waste water treatment plants are installed to provide treated water to the local consumers. The water treatment plant was first established in 1952 with one pumping station (WRK I), and expanded in 1967 with a second pumping station (WRK II).

If the performance of the treatment plant falls below the expected level, it can impact on public health. Thus, evaluation of the performance of the WTP is adopted to prevent quality degradation in the water supplied to the dependent population. But the problem with the available evaluation methods is that it gives equal importance to each of the parameters of evaluation. The present study tried to improve this discrepancy by introducing a cognitive and objective index developed with the help of Multi Criteria Decision Making (MCDM) methods. The index was applied to some case studies which encourages the authors for further application of the tool. The case illustrated in this paper refers to the selection of the most sustainable parameter of surface water treatment plants of Tripura, India through the application of MCDM method.

***Keywords:*** MCDM, Water treatment Plant.

## I. INTRODUCTION

Water is a symbol of identity, power and citizenship [3] and drinking water is a symbol of power demarcation. So, the management of drinking water is essential. But this management is not just influenced by natural and scientific technical factors, it also motivated by society. Drinking water must be free of organisms and chemical concentrations that are harmful for human being. Also, it should be free from suspended particles, bad testes,

colors, smells [1]. The rate of increasing water-borne illness has been a chief source of consideration when regarding the consumption of water in the last few decades. Treating water is an important process in maintaining a healthy society. The treatment of water removes germs and viruses from the water that can cause disease and sickness in humans. Water treatment is a process of making impure water safe to drink and use. Water that is both safe and acceptable is known as 'Potable'. It will be a best way to develop a source that is naturally potable or that needs a treatment. The process of treatment of water is often expensive and always requires attention. That is why, water treatment plants were developed. A Water Treatment Plant aims to ensure that water is: (a) Safe for human consumption, (b) Pleasant to consumers, (c) Provided at a reasonable cost [2].

The present investigation tries to propose a new index based method to analyses and monitor the performance of a Surface Water Treatment Plant (SWTP). In the present research study, MCDM was at first used to find the importance of parameters which are related to performance of water treatment plant. The importance was represented by the weights, a magnitude which is less than 1 but more than 0 and is directly proportional to the parameter importance. The parameters were collected based on a Literature Survey and according to their citation frequency the top ten cited parameters were considered as input to the model. In this regard Fuzzy Logic in Decision Making (FLDM) is utilized as a MCDM method due to its capability in "both way decision making process" which compares alternatives with alternatives with respect to the criteria and then compares criteria with criteria with respect to the alternative (Literature Review).

***Study Objective:*** The objective of the present study is to evaluate the performance quality of surface water treatment plants. This study utilized the decision making ability of MCDM methods to find an objective, non preferential and relative way to estimate the performance of water treatment plant. The novelty of the method is the application of equivalent output from MCDM method to determine the magnitude of weights which is directly related to the significance of the factors. Then the factors are used as an index to represent the performance of the water treatment plant. The study also utilizes the below MCDM method to estimate the weight vectors of the parameters.

## II. METHOD ADOPTED

***2.1. MCDM Technique- Fuzzy Logic in Decision Making (FLDM):*** Fuzzy Logic was initiated in 1965 by Lotfi A. Zadeh, professor for computer science at the University of California in Berkeley [3], [5]. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". Fuzzy Logic incorporates a simple, rule-based IF X and Y THEN Z approach to a problem rather than attempting to model a system mathematically. The inference mechanism based on these rules makes use of fuzzy sets [4].

FLDM is applied widely to solve decision making problems like new product development, fault diagnostic in DC motor, scheduling Tillage operations etc.

**Strength of FLDM:** The strengths of FLDM are:

(a) Fuzzy Logic describes systems in terms of a combination of numeric and linguistics (symbolic). This has advantages over pure mathematical (numerical) approaches or pure symbolic approaches because very often system knowledge is available in such a combination.

(b) Fuzzy logic sometimes uses only approximate data, so simple sensors can be used.

**Weakness of FLDM:** The weaknesses of FLDM are:

(a) In areas that have good mathematical descriptions and solutions, the use of fuzzy logic most often may be sensible when computing power (i.e. time and memory) restrictions are too severe for a complete mathematical implementation.

(b) Proof of characteristics of fuzzy systems is difficult or impossible in most cases because of lacking mathematical descriptions; especially in the area of stability of control systems this is an important research item.

## III. METHODOLOGY

**Application of MCDM:** The application of MCDM involves selection of criteria, alternatives and method as detailed below. Each of the parameters selected for evaluation of water treatment plant was identified by a group of Experts. Then the relative importance of the parameters is determined by Literature review, Hazard potential, consumer's feedback, and Engineers feedback. The relative weights of importance are then estimated by the application of MCDM methods. In this paper, FLDM is used to find the weightage of the parameters.

**Selection of criteria:** Some criteria have to be identified with respect to which the alternatives will be compared and the difference in importance can be determined. In this regard the following factors are considered as Criteria:

**a)** **Literature review (LR):** The literatures were surveyed to find the citation of the parameters in related studies. Then the number of literatures which mention about the parameters are divided by the total number of literature and then normalized.

**b)** **Hazard Potential (HP):** A survey was carried out within the engineers, consumers and stakeholders to find out about the hazard potential of the parameters. The survey participants were asked to rate the parameters according to their potential to create hazards to the plant and cost of mitigating the same. Then the ratings are normalized.

**c)** **Consumers Feedback (CF)**: A survey was carried out within consumers where participants were asked to suggest about the role of the considered factors on the performance of the water treatment plant participants. Then the number of consumers who replied is divided by the total number of consumer surveyed and then normalized.

**d)** **Engineers Feedback (EF)**: A survey was carried out within the Engineers of the plant where they were asked to suggest the parameters they give importance to maintain and improve the performance efficiency of the plant. Then the number of engineers who participated is divided by the total number of engineers surveyed and then normalized.

**Selection of alternative:** Some alternatives are identified according to the criteria and after comparing, the weightage can be determined.

**Table 1**
**Table shows the alternatives recommended by WTPs**

| *Sl.No.* | *Alternatives* |
|---|---|
| 1 | Processing Time |
| 2 | Length and density of pipelines |
| 3 | Weather pattern |
| 4 | Labour efficiency |
| 5 | Quality of incoming water |
| 6 | Type of treatment |
| 7 | Availability of docing chemicals |
| 8 | Efficiency of instrument |

**Development of Index:** After the weightage of importance was determined, an index was developed with the help of the weightage and the magnitude of the parameters. The weighted average of all the parameters is proposed as the index given in the following equation,

$$I = \frac{\Sigma_{i=1}^{n}(w_i \times l_i)}{\Sigma_{i=1}^{n} w_i} \tag{1}$$

Where, $w_i$ is the weightage of importance of the parameters as determined in the previous section.

## IV. RESULT AND DISCUSSION

The score for the criteria was calculated and depicted in Table 2.

**Table 2**
**Table shows the score assigned to the criteria**

| *Criteria* | *Score (in %)* | *Rank* |
|---|---|---|
| Literature Review | 34.29 | 4 |
| Hazard Potential | 85 | 1 |
| Consumers Feedback | 80 | 2 |
| Engineers Feedback | 66.67 | 3 |

**MCDM results:** The weightage of criteria and alternatives are given in the following tables. Table 3 and 4 shows the weightage of criteria and alternative respectively.

**Table 3**
**The weightage of importance by FDM for each of the criteria considered**

| *Criteria* | *Weightage of importance* |
|---|---|
| Literature Review | 0.2399 |
| Hazard Potential | 0.2945 |
| Consumers Feedback | 0.2617 |
| Engineers Feedback | 0.2039 |

**Table 4**
**The resultant weightage of importance by FLDM for each of the alternatives considered**

| *Alternatives* | *weightage* | *Rank of importance* |
|---|---|---|
| Processing Time | 0.9807 | 7 |
| Length and Density of pipelines | 0.6098 | 8 |
| Weather Pattern | 1.3580 | 6 |
| Labour efficiency | 4.9840 | 1 |
| Quality of incoming water | 1.5957 | 5 |
| Type of treatment | 1.91928 | 3 |
| Availability of dosing chemicals | 1.7393 | 4 |
| Efficiency of instrument | 2.2594 | 2 |

**Discussion:** In case of criteria selection Hazard Potential seems to be most and Engineers feedback is the least important criteria according to FLDM method which is obvious as the rank determined the difference of importance between the factors (Table 2). Although in FLDM method Labour Efficiency is the most important alternative as it has the maximum weightage value.

This study provides a new tool for performance analysis of WTPs in both an objective and cognitive manner. This indicator based method also provides an opportunity for engineers and managers involved in the operation of WTPs to monitor and regulate the performance of WTP on a real time basis and avoid uncertainty by adopting mitigate measures and reducing operating costs. The versatility of platform independent model also means that it can be embedded with any monitoring system and used in a portable manner; it can also be uploaded online to enable long distance monitoring and regulations.

## V. CASE STUDY

On the based on the proposed model, one case study is given from Bordowali, Agartala WTP. The weight function (Eqn. 1) was calculated with the weights determined by the new method. The results are given in Table 5.

**Table 5**
**Table shows the normalized value and index value of Bordowali WTP**

| *Alternatives* | *Bardowali WTP (Tripura) L74MLD* |
|---|---|
| Processing Time | 7.00 |
| Length and Density of pipelines | 7.00 |
| Weather Pattern | 7.00 |
| Labour efficiency | 13.00 |
| Quality of incoming water | 26.00 |
| Type of treatment | 13.00 |
| Availability of dosing chemicals | 13.00 |
| Efficiency of instrument | 9.00 |
| Index value | 12.61 |

## VI. CONCLUSION

In the present study an index was developed with the help of the Multi Criteria Decision Making so that the parameters for evaluation of the water treatment plants can be assigned importance as per their influence on the quality of the treated water. The parameters were identified with the help of literature review, expert, consumer's survey and hazard potential. The weight of the importance of the parameters with respect to the quality of the treated water was determined by MCDM and the index was prepared as the weight function of the parameters and their weights of importance. The sensitivity of the index was also verified and the results encourage further application of the tool. The development of the index will enable the evaluators to analyses the performance of the water treatment plants in a logistic and objective manner.

## REFERENCES

[1] Bonne P.A.C, Hofman J.A.M.H., *et al.*, (2000), Scaling control of RO membranes and direct treatment of surface water, Desalination 132, 109-119.

[2] Colmenarejo, M.F. *et al.*, (2006), Evaluation of municipal wastewater treatment plants with different technologies at Las Rozas, Madrid (Spain), *Journal of Environmental Management* 81 399–404.

[3] MOSSE, D. (2008): "Epilogue: The Cultural Politics of Water - A Comparative Perspective." *Journal of South African Studies* 34(4): 939-948.

[4] Zadeh L.A. (1965), Fuzzy Sets, Information and Control.

[5] Zadeh L.A. (1973), Outline of A New Approach to the Analysis of Complex Systems and Decision Processes.

[6] Zadeh L.A. (1968), "Fuzzy algorithms," Info. & Ctl., Vol. 12, pp. 94-102.

[7] Zadeh L.A. (1984), "Making computers think like people," IEEE. Spectrum, 8, pp. 26-32.