

Influencing Factors on Water Treatment Plant Performance Analysis Using Fuzzy Logic Technique

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Abstract

The aim of this study is to analyze the major factors affecting the water treatment plant. We conduct a case study in a water treatment plant in Chennai, India, with the purpose to identify the influencing factors in the water treatment in order to improve the plant performance. With inputs from the experts' we get meaningful solution after applying those inputs in a fuzzy logic controller and we identify the vital factors which affects water treatment plant process.

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1 Introduction

Quality drinking water is a basic need for good health and it is also a basic right of humans. But clean water is already in limiting resource in many parts of the earth. In the future it will become even more limiting due to population increase, urbanization and change of the climate [1]. In developing countries, unfortunately the drinking water quality is continuously being contaminated due to high population, expansion in industries, waste water from industries and chemical effluents into canals water sources. The recent estimates also shows, that the available quantity of water in developing area quality of water is failing rapidly due to fast urbanization, deforestation, land degradation etc. So the water treatment processes are major infrastructure important to safe guard

the environment and human facilities. Recent days there is a strong attention in increasing the good organization of water treatment processes and manufacture at countrywide and worldwide level.

2 Literature Survey

Claudio Macuada, Astrid Oddershede [2] was proposed analytic hierarchy process to assess Technological system in water treatment plants and waste water treatment. Kiggundu *et al.* [3] studied about the impact of daily and seasonal variation of raw water quality on conventional water treatment through the jar testing process. Sudesh Singh Rana, [4] was developed PID like FLC algorithm for industrial applications. He compared FLC and PID and conclude that FLC is better than the PID. Tayal and Prema K.V [5] was analyzed the water quality parameter by using fuzzy logic controller. The method has been found capable of estimating the quality of drinking water. B. Tchórzewska-Cieślak [6] was analyzed risk of failures in drinking water technical system.

3 Fuzzy Logic Control Design

The fuzzy logic is proposed by L.A. Zadeh in 1965 [7]. The fuzzy logic is similar to human logic thinking. It is based on experts system. This control system is more useful when the problem is more complex, vague and imprecise. In this system fuzzification and defuzzification steps are very important. The fuzzy logic controller has four main components:

1. Fuzzification: In this stage the crisp input values transformed into fuzzy value.
2. Knowledge Base: It contains data base and rule base.
 - (i) Data base: It gives necessary information about the fuzzification, rule base, defuzzification.
 - (ii) Rule base consist set of rules to represent in a structure way to the control policy.
3. Fuzzy Inference system: It consist algorithm that deals with the rules that represent the knowledge of an experts opinion. These procedures can be implemented on a computer when it is necessary quick processing.
4. Defuzzification: In this stage the fuzzy output value transformed into crisp output.

4 Affecting Factors in Water Treatment Process

Factors affecting water treatment plant process are listed below:

- Variations in Raw water quality
- Equipment Design
- Maintenance of Water Treatment plant
- Operators skill
- Chemicals used in Plant
- Testing and monitoring

4.1 Variations in Raw water quality

A natural calamity changes the water quality. So the water has to be tested and monitored very often and adjusts the water treatment plant to produce at least nearer to the desired quality. The water treatment plant is designed according to different type of raw water. Sometimes Equipment may not fit at all when the water quality deviations are very wide. Water treatment plant all are designed based on the raw water that is if the water quality became further poor from the original design, proportionately treated water quality also come down. If the raw water quality changes to good, then the treated water quality also yield fine.

4.2 Equipment Design

As we say in the first factor we fix the parameter and we have design the water treatment plant. The plant design should match with raw water, requirement, and quantity of output water .The usage of the plant is suitable for drinking plant or industrial plant or farming plant. The plant process should use for long time and should give the better quality water continuously. Equipment should be user friendly. System has to be designed in such way that in chemical and physical manner in the plant and finally ends with desired quality. The system has to be designed to work even moderate changes in input quality and other parameters. Samples of water have to be taken in different seasons. As we said in the first factor, quality of water depends on seasonal variation, so the plant should design to meet all variation, so this is one of the affecting factors among them.

4.3 Maintenance of Water Treatment plant

Maintenance of the water treatment is also an affecting factor that affects process of the plant. Because of the seasonal variation in raw water (during summer and rainy) affects the process and other factors will change in quality output water. So the proper maintenance is very important to ensure that the system is maintained properly so that desired result is reached. The maintenance of water treatment, which includes Monitoring agreement, Daily data about the process of plant, and the plant productivity observation.

4.4 Operator's skill

One of affecting factors of water treatment plant is operator's skill .water treatment plant operator should know the entire process of the plant which includes knowledge about the raw water quality, raw water source, Equipment design, plant operation, chemicals used in the plant, and water output quality, maintenance of the plant Operators .Need basic knowledge about biological and chemical properties basic computer knowledge because of the computer controlled equipments. Operator has a skill to operate the chemical device in the plant and identify the level of chlorine in water, doing performance analysis. Also they do minor repair for example valve adjustment, (or) speed adjustment etc. Operator has a capacity to face emergency conditions, for example during the rainy season overflow of water can damage the raw water quality and plant process .They have to handle such type of conditions. Whatever be the machines, operator is responsible for the production, quality of the product and the plant performance. Management has to appoint an efficient and experience person to operate and Maintenance of the equipment. He has to take necessary training to get familiar with all machines and instruments. Manual operational error is one of the biggest problems to attain quality.

4.5 Chemicals used in Plant

Chemicals used are to be good batch and expiry of chemicals has to be checked. Because of bad quality product end result vary. Chemicals strength also to be tested. Chemicals that are used must be in good quality and it will not affect the output water quality. Chemicals used in the water treatment plant should be analyzed properly and quantity of the chemicals also maintained. Number of chemicals was used in different stages. For example Lime is used in conjunction with alum or iron salts for coagulating suspended solids incident to the removal

of turbidity from raw water. It serves to maintain PH for satisfactory coagulation condition. If the raw water source has an unusually high hardness chemicals such as lime and soda ash are added to reduce the level of calcium and magnesium. So the chemicals that are added are one of the affecting factors in water treatment plant.

4.6 Testing and monitoring

Testing of source water daily in own laboratory and maintain in log book. Few parameters can be checked in different intervals. Periodically check the water in other labs to verify. In the same way treated water also to be tested daily from online instrument and laboratory. Log Book and data to be maintained and supervisors to be acknowledge the documents

5 Mathematical Model Formulation

In our problem, we use the fuzzy logic controller (FLC) concept to analyze our data. First we convert our factors into fuzzy sets using Triangular Fuzzy sets. Then we design a Fuzzy logic controller and define Fuzzy inference rules for the first three factors (as inputs) to analyze the plant performance (output) and then define Fuzzy inference rules for the next three factors (as input) to analyze the performance of the plant (output). Then we define another set of Fuzzy inference rules by using the above two outputs (output -1, output-2) as input and analyze the complete performance (See Figure 1(a)). Fuzzy rules interact between input and output. Now we are going to use the fuzzy TECH 5.54 d software professional edition to design our fuzzy logic controller. The following diagram will help us to illustrate our discussion. In fuzzy rules the software helped to show the result and analyze the output performance of influencing factors of water treatment plant process.

6 Membership function

All the factors are define in the interval $[0,1]$ that is we express value of each factors is 0 to 1 point scale. For example the plant design level is good then we may give 0.7. Now we define triangular fuzzy sets to our input factors as well as output factors in the following manner. See Figure 1(b). Now we define fuzzy inference rules (Rule block -1-RB1) to the first three factors as input with plant performance as output in following way using Mamdani method. Now we define fuzzy inference rules (Rule block-2-RB 2) to the next three factors as input with plant

performance as output in following way using Mamdani method. Now we define fuzzy inference rules (Rule block-3-RB 3) to factors machine power and man power as input with plant performance as output in following manner. In Figure 1(d), first three factors as input which gives out put result.

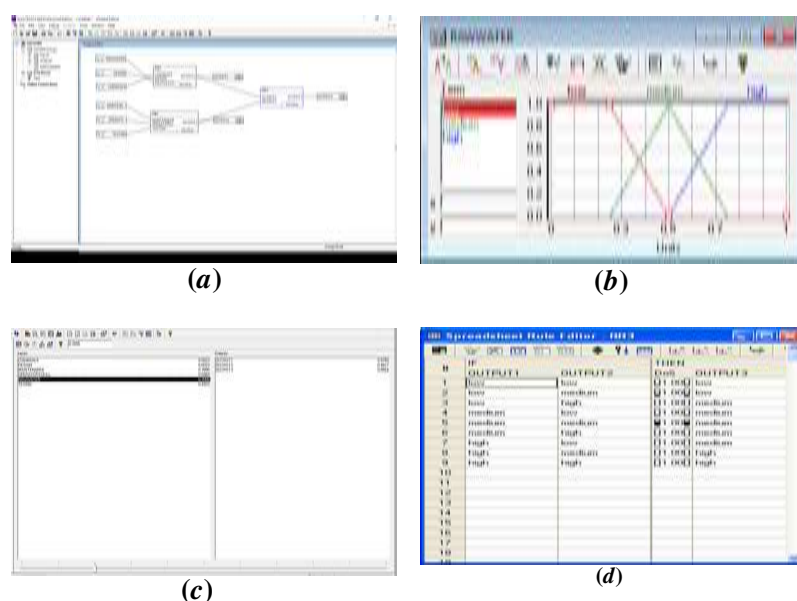


Figure 1: (a) Graphical Representations: Water Quality Parameter, (b) MF editors for raw water, (c) Output result in plant performance and (d) Rule editors for the system Rule-3

7 Results and Discussions

Table 1: Result Analysis of water treatment plant performance

Factors	Case 1		Case 2		Case 3		Case 4	
	Input	Output	Input	Output	Input	Output	Input	Output
Chemicals	0.30		0.30		0.30		0.30	
Design	0.20	0.5000	0.70	0.7981	0.70	0.4237	0.50	0.2067
Maintenance	0.40	0.5957	0.40	0.5957	0.40	0.5969	0.50	0.5814
Operators skill	0.50	0.5000	0.50	0.7852	0.50	0.4090	0.50	0.2067
Raw water	0.20		0.20		0.80		0.20	
Testing	0.55		0.55		0.55		0.55	

Table 1 shows analysis of different cases. In all cases, given various input values which gives different output. In case 1 we get final output

is 0.50 which represents the plant process is in medium level. In case 2 design 0.70 and other factor values similar to case 1, the final output value is 0.7852. It means the changes in any other factors, will affect the final output as well as plant process. In same manner we can analyze all other factors, it will give different output according to the various input. In general the quality of input decides the quality output. Suppose the changes in other factors will improve the plant process. In this paper we proposed fuzzy logic control to analyze the above factors. These factors are equal weight age in the water treatment process. So compare to existing model fuzzy logic control model is suitable and best model and we can analyze easily. When we analyzing other model, it was taking too much time to get the solution. But fuzzy logic model function is to reach a best solution by doing only limited experiments. We have conducted a number of experiments by entering different input values and all the time the system is giving exact outputs as it was assumed according to the experts opinion.

8 Conclusion

In our study we discussed some important factors influencing the water treatment plant performances. We use fuzzy logic controller, to design, analyze and solve our problem with proper fuzzification and defuzzification methods. The reason for selection of fuzzy logic model in this study is that system provides effective results. In general the quality of water decides the out of the treated water. Our researches suggest that not only quality of water, that design of treatment plant, chemicals used for treatment can also change the output value as well as plant performance. In our research the input raw water quality was taken for analysis, and few output result was analyzed. When the raw water quality is 0.20 (Figure 1(c)) which represent the impurities level is low then plant performances is 0.85 (Figure 1(c)), it represent the plant performance is good so the output quality is good. The above diagram shows if the poor quality in the input raw water affects more in the plant performance. Also any changes in other factors will affect the plant performance as well as water output quality. Using FLC we can add a number of factors and analyze easily. From the output result we predict the affecting factors in the water treatment plant. An efficient water treatment process is possible through analyzing the influencing factors and fuzzy logic controller is excellent tool to achieve the ultimate result.

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