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EXTENDED ABSTRACT

Fuzzy Wastewater Quality Index (FWWQI) for Environmental Quality Assessment of Industrial Wastewater, a Case Study for South Pars Special Economic and Energy Zone

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1. Introduction

Environmental risk assessment is one of the most important parts of the environmental management system and plays a significant role in improving the quality indices and environmental performance. The cost of damage (direct, indirect, and intangible), and the consequences of pollution and environmental accidents are very high, causing significant damage to organizations and countries every year. Therefore, it is necessary that risk management, which involves identifying, assessing and controlling risk, is implemented at the level of companies that have the potential capacity for such events. In this research, the environmental quality assessment of the Pars Special Economic Region from 2011 to 2014 has been investigated using fuzzy logic. Fuzzy logic is a multi-valued logic that allows the grading of values to work with the user's values in a system.

2. Materials and Methods

In this research, after library studies, data were collected through field studies. Initially, the performance indicators of the organization and their qualitative / quantitative assessment were identified for each of the wastewater pollutants. In the following, the results of monitoring the performance of the organization in relation to indicators in 2013 were collected. Then, based on the data in the documentation of the FIS Fuzzy Inference System Databases, it has been developed. The most important parts of the fuzzy inference systems, such as membership function, fuzzy set operation, and deduction rules are defined below (Zadeh, 1965). The input domain is called the discussion world, and the output axis is called the membership function. If X is the discussion world and its elements are called x, then the fuzzy set is defined as:

$$A=\{X, \mu_A(x);\ Where: x \epsilon X \qquad (1)$$

The application of the standard fuzzy set contains the AND subset, the OR community, and the NOT complement. For the x element belonging to the world of discussion, the above acts are defined on two fuzzy sets A and B as follows:

$$\mu_A(x)\ OR\ \mu_B(x) = \mu_{A\cup B}(x) = Max\ \{\mu_A(x), \mu_B(x)\} \qquad (2)$$

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$$\mu_A(x)\ AND\ \mu_B(x) = \mu_{A \cap B}(x) = Min\ \{\mu_A(x), \mu_B(x)\} \quad (3)$$

$$NOT\ \mu_A(x) = 1 - \mu_A(x) \quad (4)$$

The Fuzzy inference system (FIS) is a popular computing framework based on the concepts of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning. In fact, FIS maps a given input to an output(s), which provides a basis from which decisions can be made, or patterns could be distinguished. FISs have been successfully applied in fields such as automatic control, data classification, decision analyses, expert systems and computer vision (Sarkheil et al., 2014 and 2018; Sarkheil, Rahbari, 2016). The process of fuzzy inference can be expressed in four phases: membership functions, inference rules (If-then rules), aggregation, and defuzzification (Cabanilas et al., 2010; Acosta et al., 2010). In this part of the study, FWWQI Mamdani type FIS is prepared for fuzzy wastewater quality assessment. The overview of the FWWQI fuzzy inference system schemes in Fig. 1.

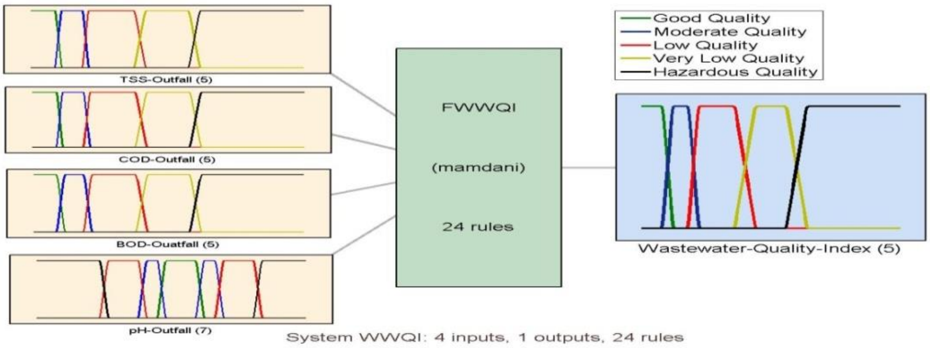

Fig. 1. Overview of FWWQI Fuzzy Inference System characteristics

FWWQI and its parameters are classified into 5 fuzzy classes determined as following (including fuzzy trapezoid number cut points):

1. Good quality wastewater (0, 0, 40 60)
2. Moderate quality of wastewater (40, 60, 90, 110)
3. Low-quality wastewater level (90, 110, 180, 220)
4. Very low level of wastewater (180, 220, 280, 320)
5. The level of hazardous wastewater (280, 320, 500, 500)

Contamination variables in wastewater are defined by using trapezoidal fuzzy numbers at five levels of quality as follows: {cut points: (a, b, c, d)} (Fig. 2):

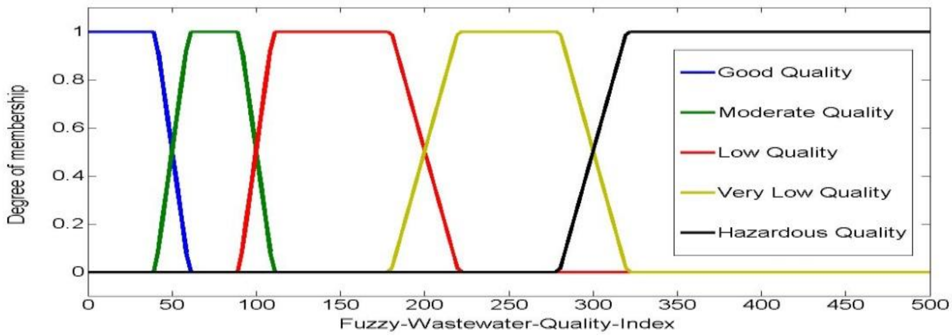

Fig. 2. Membership functions of COD as FWWQI.FIS input

3. Case Study

In this section, information on the pollution of wastewater in the field of discharge into the environment of refinery A in Pars special zone is discussed. Table 1 shows the average annual waste discharges from 2011 to 2014 in the effluent discharges in the area of discharge into the environment of Refinery A treatment plant.

Table 1. The output of pollutants into free waters in the case study

TSS Outfall	Cod Outfall	BOD Outfall	pH Outfall	year
12.8	91.0	32.6	8.2	2011
12.4	72.8	47.3	8.1	2012
9.3	40.9	27.8	8.0	2013
9.0	37.2	26	8.0	2014
40	60	30	6.5<pH<8.5	Standard

4. Results and Discussion

Based on the data presented in Table (1), all four pollutants COD, BOD, TSS, and pH can be received in 2013 and 2014 within the permitted limits of the Environmental Protection Agency, but COD and BOD pollutants in 2011 and 2012 levels have been above the limit. However, the two pollutants pH and TSS have always been in compliance with the standard limits. Using the data presented in Table (1). In the fuzzy model developed in this paper: the output values of the fuzzy wastewater quality index are calculated and shown in Table (2).

Table 2. The output of pollutants into free waters in the case study

Year	Situation	Fuzzy index of wastewater quality FWWQI	The main pollutant
2011	(Low quality Red)	107	COD
2012	(Low quality Red)	107	BOD
2013	Good (green)	48.8	BOD
2014	Good (green)	44	BOD

5. Conclusions

Based on the results presented in table (2), COD and BOD can be considered as the most important pollutants in the wastewater sector in the case study. The fuzzy logic in the present project has the ability to eliminate uncertainties and, with a wider and wider view, results in more accurate and accurate results.

6. References

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