IJE TRANSACTIONS B: Applications Vol. 31, No. 8, (August 2018) 1196-1204

International Journal of Engineering

Journal Homepage: www.ije.ir

Fuzzy Wastewater Quality Index Determination for Environmental Quality Assessment under Uncertain and Vagueness Conditions

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PAPER INFO

Paper history:
Received 14 January 2018
Received in revised form 08 March 2018
Accepted 09 March 2018

Keywords:
Wastewater Quality
Fuzzy
Chemical Oxygen Demand
Total Suspended Solid

ABSTRACT

Utilization of water in different parts of industrial life cycles brings a huge concern on environmental water and wastewater pollutions. In this research, environmental quality assessment of wastewater is studied using fuzzy logic. Fuzzy appliance is due to existance of statistical considerations (including standard deviations), various uncertainties, non-linearity and complexity of functions. A Mamdani fuzzy inference system (FIS) is developed for prediction of a fuzzy wastewater quality index (FWWQI) where four variables of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and pH are considered. To assess the performance of the proposed index under actual conditions, water quality data of refineries at South Pars Special Economic and Energy Zone, Iran, are employed in the time interval from 2011 to 2014. Findings of this research indicated that only BOD and COD were the dominant pollutants for about 66% and 34% of analyzed time, respectively, which exceeds the standards. Moreover, the time pattern for the output indices represents that FWWQI varied from "Moderate" in 2011 to "Good" in 2014. In addition, comparison of the FWWQI results with two conventional classic methodologies indicated that the proposed fuzzy method well covers the two classic methodologies. Finally, it is noticed that all three proposed WQIs exhibit correspondingly "Good" level in the year 2014. Thus, the time pattern for the parameters and indices express continual improvement as outcome of ISO 14001 and HSE-MS.

***doi**: 10.5829/ije.2018.31.08b.06*

1. INTRODUCTION

Yearly various and vast quantities of environmental pollutants are emitted into the environment (water, air and soil), which can have unpleasant results on the quality of the local and global environment as well as human health and live species. The assessment of damages is accomplished by the quantity and quality of the released pollutant materials and the susceptibility of risk receptors: the ecology and lives [1]. Recently, global worries around water quality have been intensified. United Nations developed an index for assessment of Water Quality Index (WQI). The UN Environment Plan, which is an alert and active plan for environmental considerations -governed by UN-systematically assess and manage freshwater quality and aquatic ecology, the mainWorld Water Assessment Program (WWAP) output, and the World Water Development Report (WWDR) series. Some parts of this function comprise preparing global water quality indicators as well as a Global Water Quality Index (GWQI). The aim has been to set up a worldwide experts' workshop designed to implement the indices requirements [2].

Some countries and regions utilize aggregated water quality data in the development of WQIs for their definite purposes [2]. It is found that water quality assessment is a totally case sensitive phenomenon and there is not any absolute approach.

The defined wastewater pollutants are often summed according to their influencing weight to compute overall accumulative water quality and the index is calculated as the statistical weighted average of all pollutants [3-6].

The most applied and common index WQI was developed by the National Sanitation Foundation (NSF).

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Please cite this article as: H. Sarkheil, Y. Azimi, S. Rahbari, Fuzzy Wastewater Quality Index Determination for Environmental Quality Assessment under Uncertain and Vagueness Conditions, International Journal of Engineering (IJE), IJE TRANSACTIONS B: Applications Vol. 31, No. 8, (August 2018) 1196-1204

Since then, various modified water quality indices have been designed and proposed on the basis of the WQI [6-8].

It is well known that the effluents discharged from the wastewater Treatment Plants may constitute the most important source of priority pollutants reaching the water resources whether surface or subsurface [9]. The main sources for pollutions of ground and underground waters would be the wastewaters from industrial outfall basins, the septic, the sanitary, solid wastewater landfills and soil pollutions. This is while, monitoring and assessment of the naming sources including the specified standardizations are of great importance for Environmental Management Systems(EMSs) such as ISO 14001.

Establishment of HSE management system (HSE-MS) and ISO 14001 in industries is served as important managerial factor which achieves the requirements of health, safety, environment and sustainable development [10].

Thus, scientists and environmental officials try to develop various methodological WQIs for effective assessment and successive management of waterpollutions. Environmental Quality Indices (EQIs) should include all the characteristics and/or properties which have major influence on the quality under assessment for progressive managements [1]. Correspondingly, WQIs include pollutants such as: pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Oil which are so vital for trustworthy quality assessment of waters and waste waters having the major attributes [11-14].

Some recent researchers have focused to develop new logical water and wastewater quality indicators using fuzzy sets theory which was first invented by Zadeh[15].Incorporating Fuzzy Logic with environmental evaluations has considerably changed evaluations both in approaches and outcomes. The power of fuzzy logic approaches is in its skill in emulating the human mind remarkable ability of storing and to processing information that is steadily imprecise, uncertain, and resistant to classification [16]. Moreover, fuzzy logic is a suitable mathematical tool to treat uncertain and inaccurate heterogeneous information. Examples are the cases of the data handled in many environmental studies frequently received by subjective decision makings and assessments [17-20].

The Environmental Performance Index (EPI) proposed by Esty, Levy [21]; utilizes Proximity to Target (PTT) measurement for environmental impacts assessment. Using Fuzzy logic a novel method in water quality assessment proposed by Gharibi, et al. [22] for Iranian surface water quality. They involved twenty parameters based on critical importance of parameters on overall water quality and potential impact on human health [22]. Verlicchi et al. [23] presented a Water Polishing Index (WPI) with scope of environmental monitoring and assessment for discharge of wastewater into surface water.

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 [24-27].

Some researches [28] highlighted applications of soft modeling for wastewater treatments. In mentioned study artificial neural network ANN approach was studied for modeling of mercuryadsorption from aqueous solution by *sargassumb* algae [24].

This paper presents a new methodology to assess the Wastewater Quality Index (WWQI) of Chemical Process Industry (CPI) based on fuzzy logic, a well-known theory to deal with uncertainty and vagueness, especially in the environmental field where data are often not fully available [9, 25-28].

2. MATERALS AND METHODS

The information and the respective data required to develop an environmental quality index should be supplied by a panel. The panel has to include environmental researchers' systematic thoughts and designs in all the various aspects related to the environmental quality under assessment and their ecologic and socioeconomic implications and requirements [17]. Accordingly, this study tried to provide the fuzzy inference system as the responsible systematic panel for preparing fuzzy wastewater quality index. In this paper, four parameters in wastewater pollutants of pH, COD, BOD and TSS were studied, indexed and assessed via three methodologies: (1) GWQI by UNEP (Part 2.1), (2) Aggregative weighted WQI (Part 2.2) and (3) Fuzzy Wastewater Quality Index (Part 2.3). Table 1 illustrates two standards for standardizations of the studied parameters.

TABLE 1. Studied criterion for wastewater pollutants

Pollutant	Iranian Standard	Italian Standard
COD	60	125
BOD	30	25
TSS	40	35
pH	6.5-8.5	6.5-8.5

2. 2. Global Water Quality Index by UNEP In this part, it is dealt with index equation being based on the water quality index (WQI) prepared by the Canadian Council of Ministers of the Environment [28]. As advantages of the Canadian Water Quality Index (CWQI), the index allows categorizations of the frequency and extent to which pollutants deviate from their respective standard at each monitoring station. Therefore, the index reflects the quality of water for both health requirements and levels of acceptability, as coordinated by the World Health Organization (WHO) [29]. The proposed index is computed yearly resulting in an overall rating for each station per year [2]. The formulation for calculation of GWQI is demonstrated as followings:

$$GWQI \equiv CWQI = 100 - \sqrt{F_1^2 + F_2^2 + F_3^2} \Big/ 1.732 \quad (1)$$

Where the corresponding terms are introduced in Table 2. Table 3 shows the scale designation of GWQI levels including the corresponding descriptions of parameters.

TABLE 2. Introduction of GWQI terms

Term	**Formulation**	**Representation**	**Definition**
F_1	$\frac{\text{No.of Failed Param.s}}{\text{Total No.of Param.s}} \times 100$	Scope	percentage of parameters exceeding the Standard
F_2	$\frac{\text{No.of Failed Tests}}{\text{Total No.of Tests}} \times 100$	Frequency	percentage of individual tests within each parameter exceeding the Standard
F_3	$\frac{\text{nse}}{0.01\ \text{nse}+0.01}$	Amplitude	extent excursion to which the failed test exceeds the Standard
nse	$\frac{\sum \text{excursion}}{\text{Total No.of Tests}}$	Normallized Sum Excursion	Normallized Sum Excursion
excursion	$\frac{\text{Failed Tests Value}}{\text{Standard Value}} - 1$	excursion	Measure of Deviation of Test value from Standard value

TABLE 3. Scale designation of GWQI by UNEP

Designation	Index Value	Green	Description
Excellent	95-100	Yellow	Allmeasurementsarewithinobjectives virtually all of the time
Good	80-94	Orange	Conditionsrarelydepartfromnatural or desirable levels
Fair	65-79	Red	Conditions sometimes depart fromnatural or desirable levels
Marginal	45-64	Purple	Conditionsoftendepartfromnatural or desirable levels
Poor	0-44	Green	Conditionsusuallydepartfromnatural or desirable levels

2. 2. Aggregative weighted WQI (AWWQI) AWWQI is defined as the weighted average of WQI of each parameter. AWWQI is formulated as following:

$$\text{AWWQI} = \sum_{i=1}^{n} w_i q_i \quad (2)$$

Where: n is the number of parameters, w_i is the respective weight of each pollutant an q_i is the respective WQI of the i'th parameter being linearly distributed as equal to <u>100</u> for amounts close to nil pollution and equal to <u>0</u> for amounts of 5 times standard. AWWQI and its parameters are classified into 5 classes determined as:

1. Very Good AWWQI: 90-100
2. Good AWWQI: 80-90
3. Moderate AWWQI: 60-80
4. Bad AWWQI: 40-60
5. Hazardous AWWQI: 0-40

Respective weights of parameters are distributed equally as wpH=wCOD=w BOD=wTSS=25. It is noted that the number of parameters is not high and the importance of all naming parameters does not meaningfully vary from one to other.

2. 3. Fuzzy Wastewater Quality Index (FWWQI) The process of fuzzy inference can be expressed in four phases: membership functions, inference rules (If-then rules), aggregation, and defuzzification [1, 30-35].

In this part, FWWQI Mamdani type FIS is prepared for fuzzy wastewater quality assessment. The overview of the FWWQI fuzzy inference system is schemed in Figure 1.

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

1. Very Good AWWQI: (87.5, 92.5, 100, 100)
2. Good AWWQI: (77.5, 82.5, 87.5, 92.5)
3. Moderate AWWQI: (55, 65, 78.5, 82.5)
4. Bad AWWQI: (35, 45, 55, 65)
5. Hazardous AWWQI: (0, 0, 35, 45)

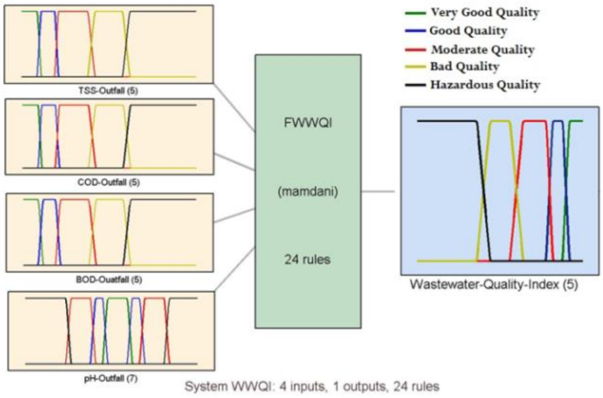

Figure 1. Overview of FWWQI Fuzzy Inference System characteristics

Figures 2 and 3 represent the distribution of membership functions for COD and FWWQI, respectively. Rule base of FWWQI comprise 24 one-to-one rules with same designation like: “If the COD is Good then the FWWQI is Good”.

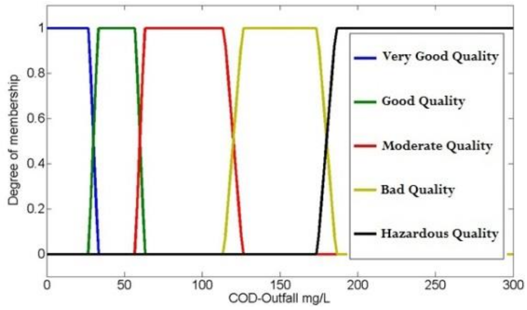

Figure 2. Membership functions of COD as FWWQI.FIS input

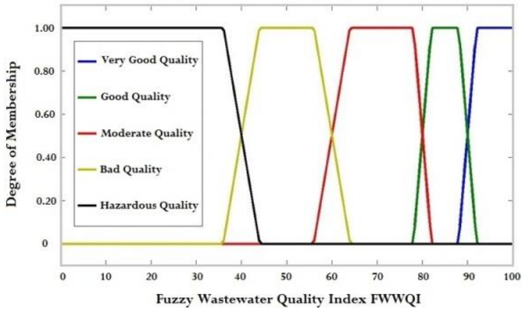

Figure 3. Membership functions of FWWQI as FWWQI.FIS output

3. CASE STUDY

In this research, South Pars Special Economic and Energy Zone is proposed as case study. This zone is located Persian Gulf coast and 300 Km. East of Port of Bushehr and 570 Km west of the Port of Bandar Abbas and approximately 100 Km away from the South Pars Gas Field (Continuation of the Qatar’s Northern Dome). Data relate to refinery A in the South Pars Gas Complex (SPGC). The corresponding data for concentrations of WQI pollutants are presented in Figure 4.

4. RESULTS AND DISCUSSION

4. 1. Global Water Quality Index by UNEP The Canadian WQI is applied for the case study. The results of the GWQI are demonstrated in Table 4. As it is obvious the parameters pH and TSS have standard values and they exhibit no failed tests.

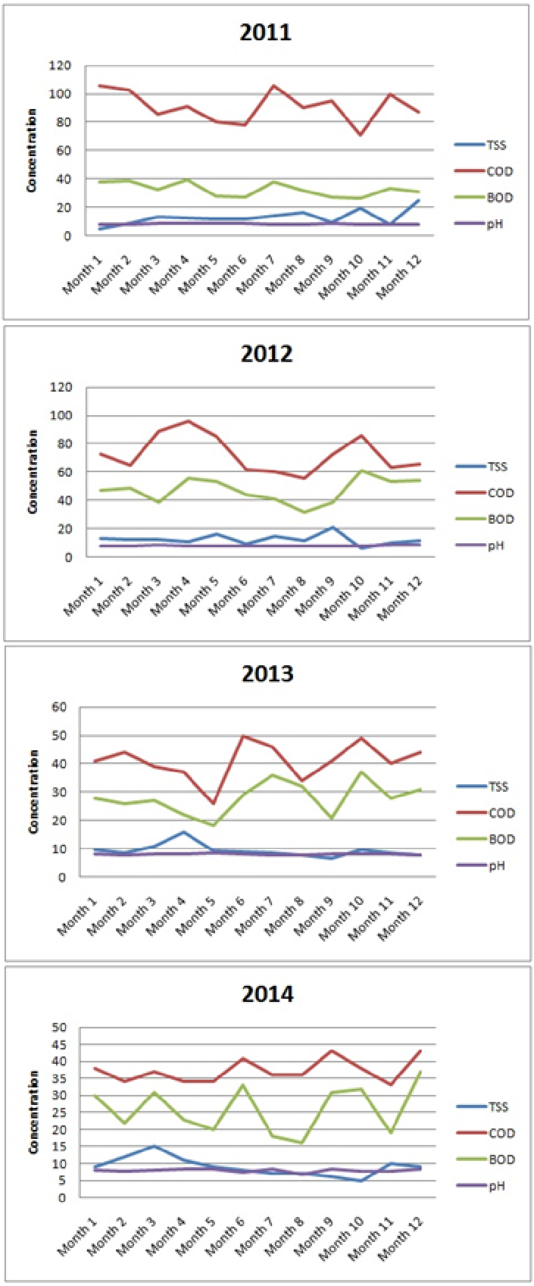

Figure 4. Time pattern for concentrations of case study WQI pollutants

4. 2. Aggregative weighted WQI (AWWQI) The results of the proposed AWWQI are exhibited in Table 5. The “Q” notation denotes the respective WQI for the indexed parameter (e.g. Q_{TSS} denotes WQI of TSS). As it can be found in Table 5, the classes of each parameter is highlighted by the predefined colors and dominant pollutant is identified for each month and year, respectively.

TABLE 4. Applied GWQI methodology for case study

Failed Tests		Excursions	
COD Deviation	**BOD Deviation**		
14.3399	6.0074	-0.82075	-0.92491
10.3403	1.74116	-0.87075	-0.97824
8.6738	6.47402	-0.89158	-0.91907
6.674		-0.91658	
6.0074		-0.92491	
3.6743	5.3408	-0.95407	-0.93324
10.007	1.3412	-0.87491	-0.98324
11.6735		-0.85408	
13.34		-0.83325	
15.3398	2.0078	-0.80825	-0.9749
9.0071	0.6746	-0.88741	-0.99157
10.36808	1.746715	-0.8704	-0.97817
4.3409	11.54018	-0.94574	-0.85575
1.6745	12.6734	-0.97907	-0.84158
9.6737	6.0074	-0.87908	-0.92491
12.0068	17.3396	-0.84992	-0.78326
8.3405	15.3398	-0.89574	-0.80825
0.6746	9.3404	-0.99157	-0.88325
0.008	7.3406	-0.9999	-0.90824
8.6738	1.3412	-0.89158	-0.98324
4.3409	6.0074	-0.94574	-0.92491
	20.6726		-0.74159
2.0078	15.3398	-0.9749	-0.80825
1.0079	16.0064	-0.9874	-0.79992
4.28535	11.57907	-0.94643	-0.85526
	4.0076		-0.94991
	1.3412		-0.98324
	4.6742		-0.94157
	0.6746		-0.99157
	0.008		-0.9999
	0.6746		-0.99157
	0.6746		-0.99157
	1.3412		-0.98324
	2.6744		-0.96657
	4.6742		-0.94157
15.3398	5.3408	-0.80825	-0.93324

Continued TABLE 4. Applied GWQI methodology for case study

nse	F1	F2	F3	GWQI	Year
-0.2225	25	27.88	28.63	72.78-Fair	Total
-0.2200	50	41.46	28.21	59.04-Marginal	2011
-0.1150	6	-13	12.5	89.58-Good	2012
-0.081	5	8.33	8.9	92.95-Good	2013
-0.117	4	14.58	27.13	88.6-Good	2014

TABLE 5. Applied AWWQI methodology for case study

Year	QTSS	QCOD	QBOD	QpH	AWWQI	Dominant Pollutant
2011	97.70	64.66	74.66	86	80.75	QCOD
	95.65	65.66	73.99	88	80.83	QCOD
	93.55	69.65	78.26	80	80.37	QCOD
	93.65	71.33	73.53	82	80.13	QCOD
	94.20	73.33	81.33	83.8	83.16	QCOD
	94.25	73.993	81.99	85	83.81	QCOD
	93.10	76.33	74.66	89	83.27	QBOD
	91.75	69.99	78.66	87	81.85	QCOD
	95.25	68.33	81.99	85	82.64	QCOD
	90.15	66.66	82.66	87	81.62	QCOD
	96.20	64.66	77.99	88	81.71	QCOD
	87.60	70.99	79.33	90	81.98	QCOD
Average	93.59	69.632	78.25	85.9	81.84	QCOD
2012	93.50	75.66	68.46	90	81.90	QBOD
	93.75	78.33	67.33	86	81.35	QBOD
	93.95	70.33	73.99	84	80.57	QCOD
	94.50	67.99	62.66	88	78.29	QBOD
	92.00	71.66	64.66	92	80.08	QBOD
	95.50	79.33	70.66	92	84.37	QBOD
	92.50	79.99	72.66	88	83.29	QBOD
	94.00	71.33	78.66	90	83.50	QCOD
	89.50	75.66	73.99	90	82.29	QBOD
	97.00	81.33	59.33	96	83.41	QBOD
	95.00	77.99	64.66	82	79.91	QBOD
	94.00	78.99	63.99	78	78.75	QBOD
Average	93.77	75.71	68.42	88	81.47	QBOD
2013	95.20	86.39	81.53	90.00	88.28	QBOD
	95.70	85.32	82.66	98.00	90.42	QBOD
	94.50	86.99	81.99	90.00	88.37	QBOD
	92.00	87.66	85.32	88.00	88.25	QBOD
	95.35	86.32	87.99	78.00	86.92	QCOD
	95.50	83.33	80.66	88.00	86.87	QBOD
	95.70	91.32	75.99	92.00	88.75	QBOD
	96.15	88.66	78.66	96.00	89.87	QBOD
	96.60	84.66	85.99	88.00	88.81	QCOD
	95.20	83.66	75.33	90.00	86.05	QBOD
	95.80	86.66	81.53	90.00	88.50	QBOD
	96.20	85.32	79.33	92.00	88.21	QBOD
Average	95.33	86.36	81.41	90.00	88.27	QBOD

Continued TABLE 5. Applied AWWQI methodology for case study

Year	QTSS	QCOD	QBOD	QpH	AWWQI	Dominant Pollutant
2014	95.50	87.32	79.99	86.00	87.20	QBOD
	94.00	87.92	85.32	96.00	90.81	QBOD
	92.50	87.62	79.33	86.00	86.36	QBOD
	94.50	88.66	84.66	84.00	87.95	QBOD
	95.50	86.99	86.66	82.00	87.79	QBOD
	96.00	86.32	87.32	98.00	91.91	QCOD
	96.50	85.66	87.99	82.00	88.04	QCOD
	96.50	87.99	89.32	112.00	96.45	QCOD
	97.00	88.99	79.33	82.00	86.83	QBOD
	97.50	87.32	78.66	94.00	89.37	QBOD
	95.00	88.99	77.33	96.00	89.33	QBOD
	95.50	87.19	75.33	82.00	85.00	QBOD
Average	95.50	87.58	82.60	90.00	88.92	QBOD

4. 3. Fuzzy Wastewater Quality Index (FWWQI)

Table 6 illustrates the designation of fuzzy levels for the FWWQI including predefined colors and descriptions. The results of the proposed FWWQI are presented in Table 7.

According to results, BOD and COD have been the only parameters exceeding standard in the studied time. This is a quite justified phenomenon, because the case study relates to SPGC which is a gas producer and deals mostly with organic pollutants –majorly hydrocarbons– bringing about increases in BOD and COD of the wastewater although the roles of other pollutants like pH and TSS are kept into analysis. BOD was the dominant pollutant in both FWWQI and AWWQI methodologies for more than 65.38% of analysis time, while COD has dominated for about 34% of time.

4. 4. Case study Cross Validations

In this part, three studied methodologies for the defined case study are brought into comparison for the aim of cross validation.

TABLE 6. Scale designation of FWWQI levels

Designation	Index Value	Color	Description
Very Good	90-100	Green	Pollutants are far below Standard levels
Good	80-90	Yellow	Pollutants are within Standard levels
Moderate	60-80	Orange	Pollutants are above Standard levels
Bad	40-60	Red	Pollutants are far above Standard levels
Hazardous	0-40	Purple	Pollutants are hazardously above Standard levels

Accordingly, Figure 5 presents curve fitting of FWWQI Vs AWWQI in the case study computed by Matlab R2013a CF tool. The statistics of the fitting are presented in Table 8.

As it is found, the FWWQI underestimates the AWWQI. However, the indices are acceptably close to each other by the degree such that the maximum absolute error occurred in the case study equals 9.92%. The closeness of data in FWWQI and AWWQI indicates that the proposed fuzzy methodology has proper sophistication and is well designed.

Table 9 presents relative errors for annual methodological WQIs. Accordingly, FWWQI overestimates the GWQI with +13.05% relative errors, while FWWQI underestimates AWWQI with relative error of -3.33%. .

It is found that relative error of FWWQI Vs AWWQI _in absolute value_ is smallerin comparison to that of FWWQI Vs GWQI. This is because categorizations of both parameters and index levels in fuzzy and aggregated methodologies had the same allocations. On the other hand, GWQI utilizes *Scope*, *Frequency* and *amplitude* of the parameters which are not listed in the methodology of FWWQI and AWWQI.

TABLE 7. Applied FWWQI methodology for case study

Time	FWWQIs			
	Year			
	2011	2012	2013	2014
Month1	78.6	78	90.2	82.6
Month2	78.6	78.2	90.2	90.2
Month3	79.3	78.4	90.2	81
Month4	79	78	90	90
Month5	79.9	78.6	90	90.2
Month6	79.9	78.8	85.4	90.2
Month7	78	79.3	78	90.2
Month8	78.5	78.6	79.9	90.2
Month9	79.9	79.7	90.4	81
Month10	80	72.4	80	79.9
Month11	78.4	79	90.2	80
Month12	80	79.7	81	79.8
Total	78.6	78.6	90.2	90.2
Average FWWQIs	79.17	78.22	86.29	85.44

TABLE 8. Statistics for FWWQI vs. AWWQI Fitting in case study

Curve Fit	Confidence Bounds	Goodness of Fit	
		R Square	RMSE
$Y=0.8827X+7.149$	95%	0.4924	3.603

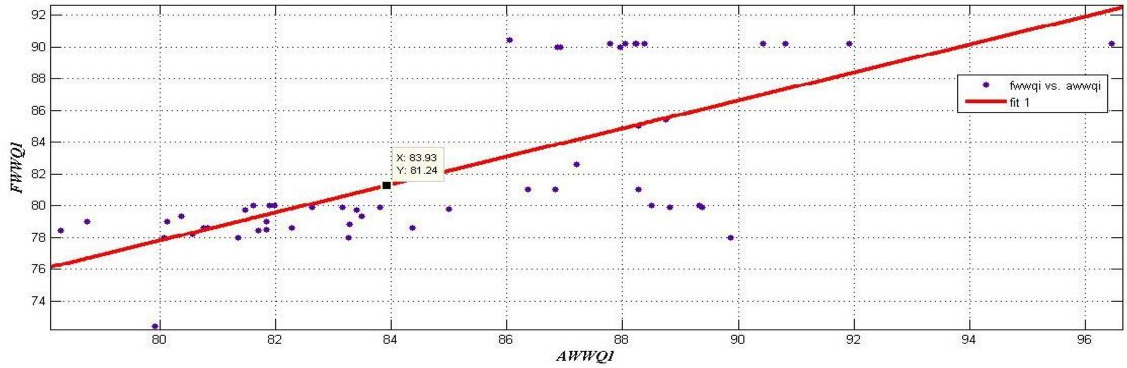

Figure 5. FWWQI vs. AWWQI cross validation in case study

TABLE 9. Relative errors for annual WQIs in the case study

Year	**FWWQI**		**GWQI**		**FWWQI Vs GWQI Relative Error**	**AWWQI**		**FWWQI Vs AWWQI Relative Error**
	Index	Level	Index	Level		Index	Level	
2011	79.17	Moderate	59.04	Marginal	+34.09%	81.84	Good	-3.26
2012	78.22	Moderate	89.58	Good	-12.68%	81.74	Good	-4.31
2013	86.29	Good	92.95	Good	-7.16%	88.27	Good	-2.24
2014	85.44	Good	88.61	Good	-3.57%	88.92	Good	-3.91
Total	82.28	Good	72.78	Fair	+13.05%	85.12	Good	-3.34

5. CONCLOUSIONS

In this study, a new model based on fuzzy inference system has been introduced to assess environmental quality of industrial wastewater. As a case study, the concentrations of four pollutants COD, BOD, pH and TSS for Phase A SPGC in the period between 2011 and April 2014 are brought into assessments via GWQI, AWWQI and FWWQI methodologies. The results express closeness of three methods for the case study. In the case study, the FWWQI estimations were closer to AWWQI by having a relative error equal to -3.33%. This is while; estimation of FWWQI Vs GWQI is acceptably limited to a relative error of 13.05%. The time pattern of the indices in the case study best represents the continual improvement approach being present in the Environmental Management System and HSE-MS of the SPGC.

The most important reasons for the utilization of fuzzy inference are Statistical considerations (including standard deviations), various uncertainties, non-linearity of functions, and complexity of relations in the realm of wastewater environmental quality assessment.

The number of parameters that the proposed system can handle are limited to four namely: COD, BOD, pH and TSS. This is because of the predominance of the naming parameters in the case study. As an advantage of this methodology is that sensibility analysis approves that engagement of more pollutants does not make major differences in indices values. This matter is approved via substance of pollution sources in case study which is a gas refinery and it is aimed to monitor and control the naming parameters in HSE programs.

As the results of proposed WQIs express, in the case study the mean values of FWWQI, GWQI and AWWQI respectively exhibit +7.89%, +50.08% and +8.65% increases in 2014 with respect to their index values in 2011. As well, the corresponding WQI levels changed respectively from Moderate in 2011 to Good in 2014 (FWWQI), from Marginal in 2011 to Good in 2014 (GWQI) and from Good in 2011 to Good in 2014 (AWWQI).

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Fuzzy Wastewater Quality Index Determination for Environmental Quality Assessment under Uncertain and Vagueness Conditions

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PAPER INFO

Paper history:
Received 14 January 2018
Received in revised form 08 March 2018
Accepted 09 March 2018

Keywords:
Wastewater Quality
Fuzzy
Chemical Oxygen Demand
Total Suspended Solid

چکیده

استفاده از آب در صنایعمختلف امری اجتناب ناپذیر بوده و می‌تواند موجب آلودگی‌های زیست محیطی شود. آلودگی پساب‌های صنعتی تاثیرات نامطلوبی بر بهداشت عمومی، سامانه‌های اکولوژیکی و منابع آب‌های سطحی و زیرسطحی دارد. بدین منظور، نظام‌های مدیریت زیست محیطیEMSs و نظام مدیریتیکپارچهHSE-MS از روش‌های کارآمد ارزیابی‌های زیست محیطی و ارزیابی ریسک زیست محیطی بهره می‌جویند. در این پژوهش به مطالعه ارزیابی کیفیت زیست محیطی پساب با استفاده از سامانه استنتاج فازی ممدانی پرداخته شده است. متغیرهای ورودی شامل: BOD، COD، TSS و pH بوده و متغیر خروجی شاخص فازی کیفیت پساب FWWQI تعیریف شده است. متغیرها در بازه [0, 100] در پنج دسته تابع عضویت ذوزنقه‌ای با عناوین: 1-کیفیت بسیار خوب، 2-کیفیت خوب، 3-کیفیت متوسط، 4-کیفیت بد و 5-کیفیت خطرناک طبقه بندی شده‌اند. تعداد قوانین فازی 24 مورد تعیین شده‌اند. روش‌های کلاسیک:1- شاخص کیفیت آب جهانیGWQI و 2-شاخص وزنی تجمعی کیفیت آب AWWQI جهت مقایسه کارآمدی روش فازی پیشنهادی، مطالعه گردیده‌اند. مطالعه موردی مربوط به منطقه ویژه اقتصادی انرژی پارس در بازه زمانی سال میلادی 2011 الی 2014 می‌باشد. مقایسه روش شناسی فازی پیشنهادی و روش‌های کلاسیک گویای این مطلب است که مقادیر سالیانهFWWQI در مقایسه با GWQI دارای خطای نسبی +13.05٪ بوده در حالی که مقادیر سالیانهFWWQI در مقایسه با AWWQI دارای خطای نسبی -3.33٪ برآوردشده‌اند. بر اساس روش شناسی‌ها، روش فازی به روش وزنی تجمعی نزدیکی بیشتری داشته است. در مطالعه موردی، تنها BOD و COD از محدوده استاندارد خارج گردیده‌اند به طوری که BOD با 66٪ و COD با 34٪ انحراف از حالت استاندارد به عنوان آلاینده‌های محدود کننده تعیین گردیده‌اند. بر اساس مطالعه الگوی زمانی شاخص‌های خروجی؛ شاخص فازی از سطح کیفیت متوسط در سال 2011 به سطح خوب در سال 2014، شاخص جهانی از سطح مرزیmarginal در 2011 به سطح خوب در 2014 و شاخص وزنی تجمعی از سطح خوب در 2011 به سطح خوب در 2014 بهبود یافته‌اند. قابل توضیح است که هر سه مورد شاخص در سال 2014 نمودار سطح کیفیت خوب می‌باشند که از جمله مهم ترین دستاوردهای استقرار نظام های مدیریتیISO 14001 و HSE-MS می‌باشد.

***doi**: 10.5829/ije.2018.31.08b.06*