Performance Assessment of Urban Sewage Treatment Plant Using Fuzzy Rule Base Approach

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Abstract- *Performance assessment of wastewater treatment plant (WWTP) is carried out to know performance of different units in overall treatment plant. Influent and effluent characteristics were gathered and compared with the Standards lead state pollution control board. Also the discharge standards were studied, from which the discharge sources should be protected. Fuzzy logic approach is used in many fields like intelligent traffic systems, home appliances, project planning and management.Fuzzy rule base approach is one of its simplified ways, to make a decision; bound within structured rules under the close supervision of field experts. In the present research work, an attempt has been carried out to assess performance of municipal wastewater treatment plant on the basis of influent and effluent characteristics within the discharge standards lead by state Pollution Control Board. Triangular type membership functions were recommended with irregular grid. Influent was characterised by three parameters by suspended Solids, biodegradable organic wastes and Chemical organic wastes and define by 5 linguistic variables. Relative importance of each parameter was invited by experts from industries, academics and municipal authorities. Total 54 rule base were constructed to develop Fuzzy Rule Base Structure. The Fuzzy inference system was built using "Fispro 3.6".*

Keywords- Performance assessment, Fuzzy rule base, municipal waste water treatment plant, Fuzzy Inference, discharge standards.

I. INTRODUCTION

Wastewater is any water that is employed or wasted from trade, domestic or business or farming sectors, surface runoff or stormwater, and any sewer influx or sewer infiltration. Therefore, municipal waste matter could be a by-product of domestic, industrial, business or agricultural activities. Looking on the supply its characteristics vary. Waste matter will be classified as; domestic waste matter from households, municipal waste matter from communities (sewage) and industrial waste matter from industrial activities. It contains the pollutants which can be physical, chemical or biological (Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014)). Characterization of waste product has become a really vital parameter in management method of waste because of varied characteristics of waste product, regulation arranged by state-run or central pollution instrument panel on expulsion policy, etc.

A distinctive waste product treatment system for WWTPs consists of 3 treatment phases; specifically, principal treatment section to get rid of solids from waste product victimization gravitative sinking, flotation, and deposit, subordinate treatment section consisting bio-logical treatment victimization microorganisms, and tertiary treatment section of medical aid(Raut S.B., Anaokar G.S.,2017)Optimization in WWTP operation is important to be disbursed for higher consumption of all the resources concerned within the whole method of WWTP. At WWTP resources like workforce, vigor and chemicals square measure got to be used sanely, just in state of workforce these square measure persons without technical knowledgeoperating all functioning procedures(Raut S.B., Anaokar G.S.,2017)Such type of companies may face issue to take the notes found relating to waste water characteristic at totally unlikeStages of treatment. For MWWTP amount of influx is found to beuneven. Concentration and reductionchanges because of numerous issues like season amendment, carnivals, dry periods etc. the height periodattention is significantly above the remainder of the amount. Therefore the info gained is obscure. In such things fuzzy approach is a lot of variable(Raut S.B., Anaokar G.S.,2017). The circumstances of deciding with many influents and many effluents, fuzzy approach is that the best minimisingdevice. Formal logic may be a complicated measured technique that enables finding tough replicated issues with several intake and outturn variables. As all the characteristics area unit vary, the preciseperiod model ought to be known. In fuzzy approach these characteristics area unit is denoted within the style of verbal variables (Raut S.B., Anaokar G.S.,2017).

Present work deals with performance assessment of municipal wastewater and resolving wastewater quality index using Fuzzy rule base approach. This paper concentrates on determination ofmunicipal wastewater treatment plant's wastewater quality index by applying fuzzy rule base approach. A software "Fispro 3.6" was used to operate the fuzzy inference system and also to state WWQI.

II. LITERATURE REVIW

(Chen et al., 2015)studied Treatment performance index (TPI) to work out the general treatment performance of WWTP by analysing the TPI values and therefore the weights of individual treatment section for overall treatment performance. Three modules were prepared that were combined and utilised as a price realdevice to judge present and upcoming desires operational and administrational.**(Yel & Yalpir, 2011)**developed a fuzzy-logic-based identification system to work out the first treatment effluent quality in a very municipal effluent treatment plant (MWTP). The measured knowledge of variables were enforced the Mamdanitechnique'sFuzzy Inference System (FIS). The fuzzy management rule base was formed to outline crucialvalue parameters observed as pH, COD, anatomy and Suspended Solids outputs. Ensuing configuration tested a decent modelling approach for MWTP effluent quality estimation.**(Raut, Anaokar, & Dharnaik, 2017)**compared 3 waste product treatment plants for a one year duration. Characterization was administered on the idea of Temperature, Total dissolved solid (TDS), Suspended Solid (SS), Biological oxygen demand (BOD), Chemical oxygendemand (COD), Phosphate, Chloride (Cl^-), hydrogen ion concentration Sampling and characterization was administered as per APHA guideline. WWQI was outlined I the vary categoryone to class five**(Anaokar, Khambete, & Christian, 2018)**did the comparison between the performances of six municipal waste product treatment plants victimisation the Multi-criteria deciding (MCDM) Technique for Order of Preference by Similarity to Ideal resolution (TOPSIS) potency were supervised on the premise of 9 waste product characteristics and equated with the bounds established by the Central Pollution control board of Asian nation. Study showed the plants with most organic loading removal potency were found to be best when weights were applied as per guidelines of Saaty's scale.

III. MATERIAL AND METHODS

For study,three municipal wastewater treatment plant were selected, due to need of minimisation in wastewater treatment operation with position to consumption of electricity and cost of operation etc,the sampling drives for a period of a yearfor WWTP were carried out.

Three parameters BOD, COD and SS for analysing the readings of every month. The readings were arranged in influent and effluent manner and a Histograph was plotted as shown below.

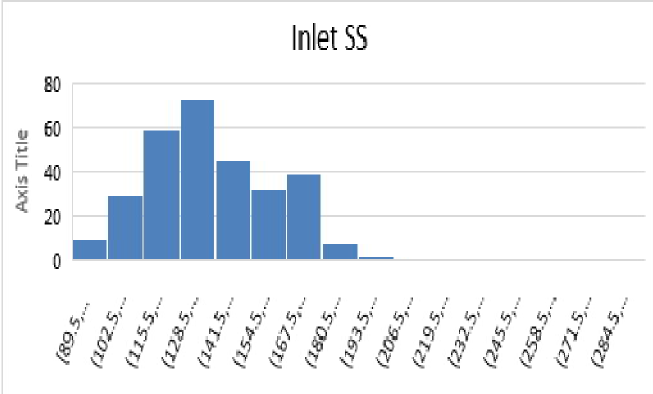

Figure 1. Histograph of inlet Suspended solid

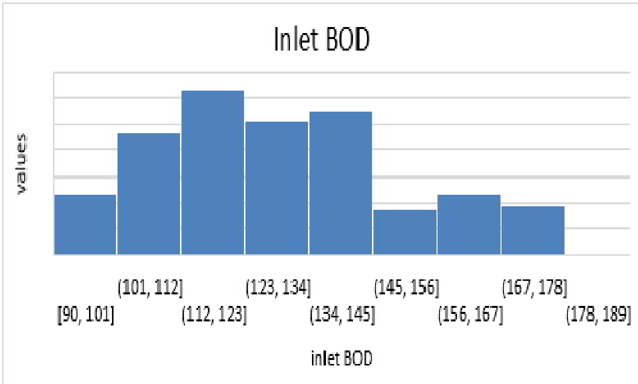

Figure 2. Histograph of inlet BOD

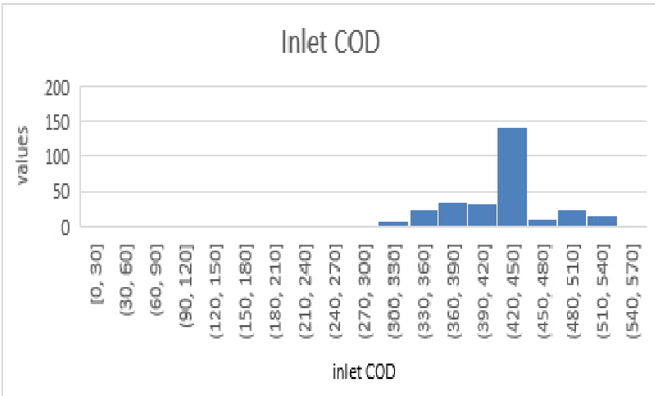

Figure 3. Histograph of inlet COD

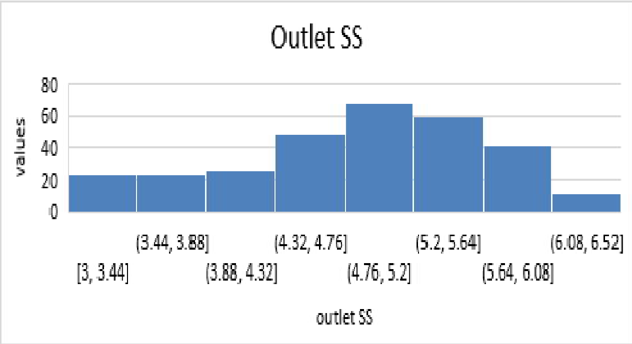

Figure 4. Histograph of outlet SS

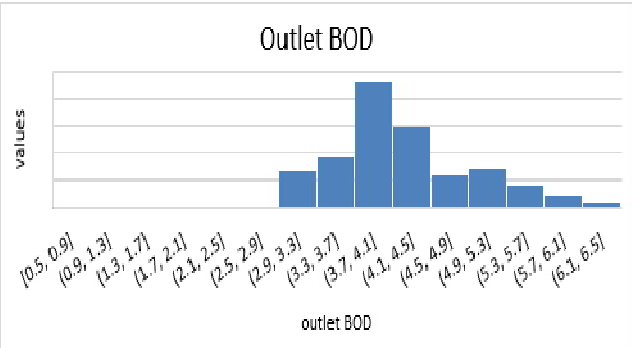

Figure 5. Histograph of outlet BOD

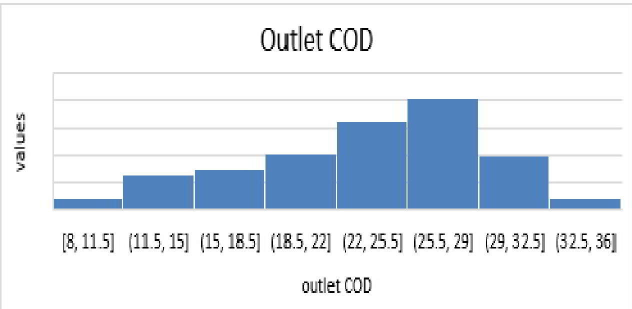

Figure 6. Histograph of outlet COD

Through this histography, five linguistic variables were arranged as extreme low, low, moderate, high, extreme high and were incorporated in "Fispro 3.6" software. Total three models were run in the software for WWQI. Triangular type membership functions were recommended with irregular grid. Various inputs and outputs were given in the software and the rules were constructed to develop Fuzzy Rule Base Structure.

IV. RESULTS AND DISCUSSION

The below are the software based results, which are obtained from the inputs and outputs of the treatment plant considering three parameters. Total 54 rules were developed for fuzzy inference system. This rules were constructed to know the performance evaluation of the treatment plant using 'If..then..' method, through which it is understandable that if BOD, COD and SS are extreme low then wastewater quality index is extreme low.

Table 1. Average values of Parameters

Parameters	Inlet SS	Inlet BOD	Inlet COD	Outlet SS	Outlet BOD	Outlet COD
Jan	121.95	115.1	350.85	5.2	3.9	22.53
Feb	125.96	112.98	360.26	5.61	4.12	27.05
May	134.75	116.53	403.7	5.6	4.1	26.9
June	131	120	361	3.6	3.6	16.5
July	149	139	420	4.2	4.1	23.9
Aug	150.77	142.3	430.8	4.7	4.4	25.5
Sept	171.1	168	497	6	5	31
Oct	168.4	141	420.79	5.3	5.1	26.6
Nov	146.13	129/16	385.6	4.15	3.82	16.93
Dec	116.7	110.7	334.2	4.75	3.9	20.53

The average values as shown above, were considered for further decision making process.

Stage 1:Fuzzy Inference Model (FIS) for Waste water influent

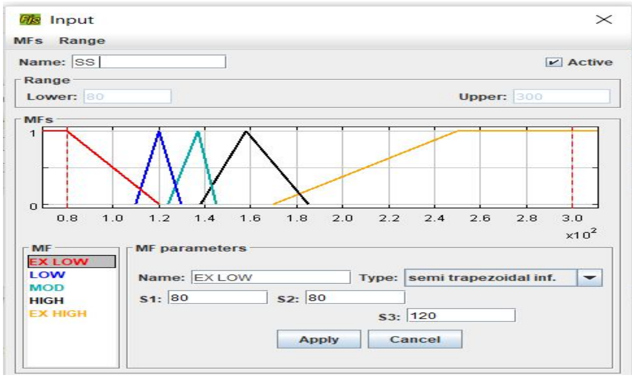

Figure1 : Irregular grid for input SS

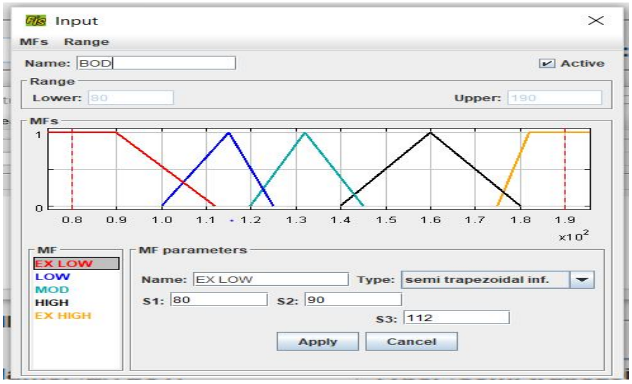

Figure 2: Irregular grid for input BOD

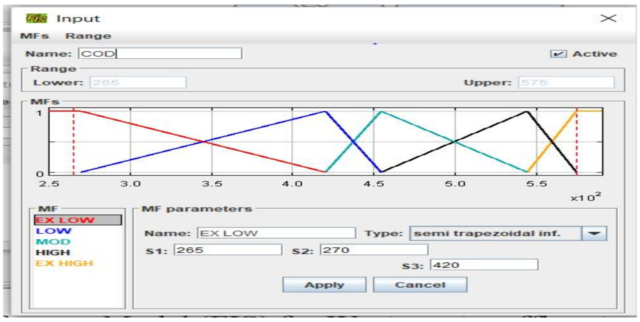

Figure 3: Irregular grid for input COD

Stage 2 :Fuzzy Inference Model (FIS) for Waste water effluent

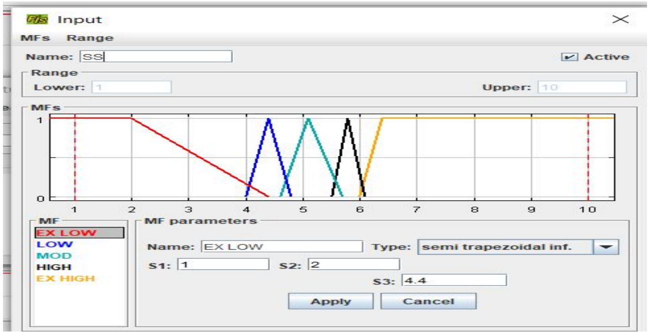

Figure 4: Irregular grid for output SS

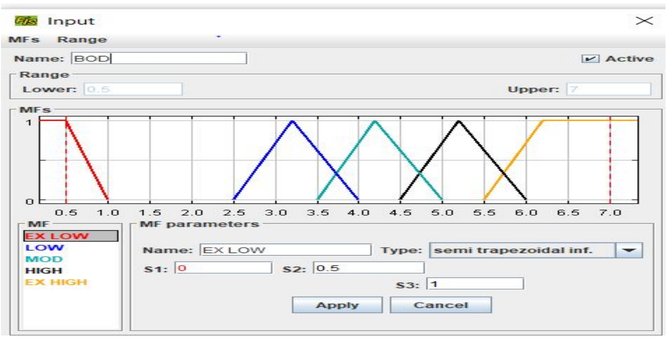

Figure 5: Irregular grid for output BOD

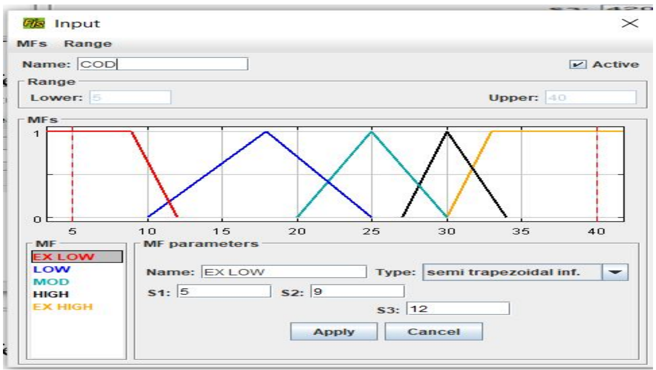

Figure 6: Irregular grid for output COD

Stage 3 :Fuzzy Inference Model (FIS) for WTP Performance

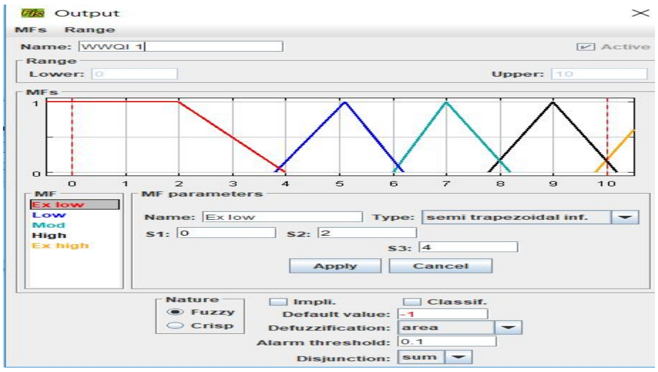

Figure 7: Irregular grid for WWQI 1

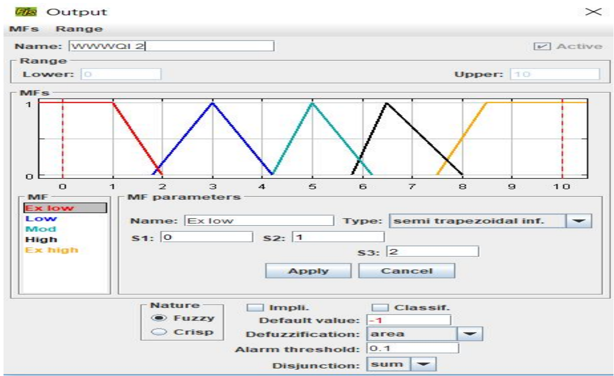

Figure 8: Irregular grid for WWQI 2

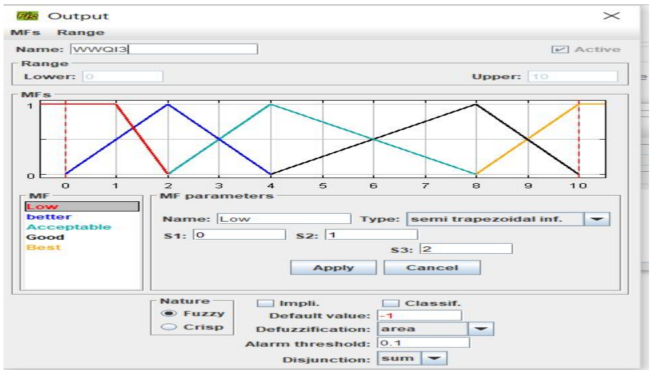

Figure 9: Irregular grid for WWQI 3

FIS has been developed for input as inference characteristic. Fig 1 indicates irregular grid pattern for influent SS & corresponding MF.Fig 2 indicates irregular grid pattern for influent BOD & corresponding MF.Fig 3 indicates irregular grid pattern for influent COD & corresponding MF.Fig 4 indicates irregular grid pattern for Effluent SS & corresponding MF.Fig 5 indicates irregular grid pattern for Effluent BOD & corresponding MF.Fig 6 indicates irregular grid pattern for Effluent COD & corresponding MF.Fig 7 indicates irregular grid pattern for influent WWQI & corresponding MF.Fig 8 indicates irregular grid pattern for effluent WWQI & corresponding MF.Fig 9 indicates irregular grid pattern for WTP performance & corresponding MF.

Rules

Rules Display

Rule	Active	IF SS	AND BOD	AND COD	THEN WWQI 1
1	✓	EX LOW	EX LOW	EX LOW	GOOD
2	✓	EX LOW	MOD	EX LOW	LOW
3	✓	LOW	MOD	LOW	LOW
4	✓	LOW	MOD	MOD	BETTER
5	✓	MOD	MOD	HIGH	BETTER
6	✓	MOD	HIGH	EX HIGH	ACCEPTABLE
7	✓	HIGH	HIGH	HIGH	ACCEPTABLE
8	✓	EX LOW	EX HIGH	EX HIGH	BETTER
9	✓	EX HIGH	HIGH	EX HIGH	BETTER
10	✓	EX LOW	HIGH	HIGH	LOW
11	✓	MOD	HIGH	EX HIGH	BETTER
12	✓	MOD	EX HIGH	EX HIGH	ACCEPTABLE
13	✓	MOD	EX HIGH	LOW	LOW
14	✓	EX LOW	EX HIGH	MOD	LOW
15	✓	EX LOW	EX HIGH	HIGH	LOW
16	✓	EX LOW	EX HIGH	EX HIGH	LOW
17	✓	LOW	EX LOW	LOW	LOW
18	✓	LOW	EX LOW	MOD	LOW

Figure 10: Rules generated for influent

Rules

Rules Display

Rule	Active	IF BOD	AND COD	AND SS	THEN WWWQI 2
1	✓	EX LOW	EX LOW	EX LOW	LOW
2	✓	EX LOW	LOW	LOW	LOW
3	✓	EX LOW	EX LOW	MOD	BETTER
4	✓	EX LOW	MOD	HIGH	BETTER
5	✓	MOD	HIGH	LOW	LOW
6	✓	MOD	HIGH	EX LOW	GOOD
7	✓	HIGH	HIGH	LOW	LOW
8	✓	HIGH	HIGH	MOD	ACCEPTABLE
9	✓	EX LOW	LOW	HIGH	LOW
10	✓	HIGH	LOW	EX HIGH	LOW
11	✓	EX LOW	MOD	EX LOW	LOW
12	✓	HIGH	MOD	LOW	LOW
13	✓	EX HIGH	EX HIGH	MOD	BETTER
14	✓	MOD	MOD	LOW	GOOD
15	✓	EX LOW	MOD	EX HIGH	LOW
16	✓	MOD	HIGH	EX LOW	LOW
17	✓	EX LOW	HIGH	LOW	LOW
18	✓	LOW	MOD	MOD	BETTER

Figure 11: Rules generated for effluent

Rules

Rules Display

Rule	Active	IF Input 1	AND Inp...	THEN W...
1	✓	Ex low	Ex low	better
2	✓	Ex low	Low	better
3	✓	Ex low	Mod	Acceptable
4	✓	Mod	High	Low
5	✓	Mod	MF5	Low
6	✓	Low	Ex low	Low
7	✓	High	Low	Acceptable
8	✓	High	Mod	Acceptable
9	✓	Low	High	Low
10	✓	Mod	MF5	Low
11	✓	Mod	Ex low	Low
12	✓	Mod	Low	Low
13	✓	Mod	Mod	Low
14	✓	High	Low	Good
15	✓	High	High	Low
16	✓	High	Ex low	Low
17	✓	Ex high	Low	Low
18	✓	Ex high	Mod	Low

Figure 12: Rules generated for WTP performance

According to FIS developed for performance assessment based on influent WWQI & effluent WWQI, the performance can be assessed based on influent & effluent indices as this approach is based on influent & effluent indices as this approach is based on field observations & expert recommendations. The performance assessment has been found more systematic. This approach provides better & realistic assessment than conventional approach behind is based on input output characterisation.

V. CONCLUSION

It is concluded that the quality index using fuzzy logic avoids the uncertainties and optimizes the resources. By using fuzzy approach minimisation in wastewater treatment plant with regard to consumption of electricity and cost of operations etc. can be achieved.Rule base were constructed to develop Fuzzy Rule Base Structure to optimise the resources of the plant, using 'if then..' rules. If input is high & output is moderate then WWQI is acceptable.

REFERENCES

[1] Anaokar G. S., Khambete A. K., Christian R. A. (2018) "Evaluation of a performance index for municipal wastewater treatment plants using MCDM – TOPSIS" ISSN 2086-9614.

[2] EsraYel, SukranYalpir, "Prediction of primary treatment effluent parameters by Fuzzy Inference System (FIS) approach", E. Yel, S. Yalpir / Procedia Computer Science 3 (2011) 659–665.

[3] Raut S. B; Anaokar G.S; Dharnaik A. S (2017) "Determination of wastewater quality index of Municipal wastewater treatment plant using fuzzy Rule base"ISSN: 2394 - 658X.

[4] Chen Z., Zayed T. and Qasem A.(Oct 2014) "An Efficiency-Centred Hierarchical Method to Assess Performance of Wastewater Treatment Plants" Int. J. Environ. Res., 9(1):1-8,Winter 2015 ISSN: 1735-6865.

[5] Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. Archived from the original on 8 April 2016.