Development of Wastewater Quality Index for Disposal in to Environmental Sink – "Inland Surface Waters"

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ABSTRACT

Quality of water or wastewater is very important considering both use and disposal. To check the quality of water or wastewater various parameters are available but for common people it is difficult to understand all the parameter. In 1970s concept of Water Quality Index (WQI) has been developed for easy understanding of quality of water by representing it as numeric value i.e. 0 (Poor) to 100 (Excellent). WQI has become an important decision making tool for authorities. In the same line development of Wastewater Quality Index (WWQI) will become an important tool for authorities and easy to understand for common people. Different methodologies are available for determination of WQI. This paper is attempted to discuss the various methodologies of WQI, which can be used for determination of WWQI as well as concept of model and its consideration.

General Terms

WQI, WWQI, WWPI, COD, BOD, SS, TDS, UNEP, GEMS, CWQI, GWQI.

Keywords

Water Quality Index (WQI), Wastewater Quality Index (WWQI), Important Tool.

1. INTRODUCTION

Water is the most important element of our body. 70 % of body made up of water. Without it there will be no survival or existence of life. Out of 100 % water, only 2.5 % is fresh water and from which only 0.4 % fresh water is available as surface and atmospheric water for our uses.

The prime usage of water is for:

1. Agriculture
2. Domestic
3. Industrial

For all the above mentioned usages, the required water should be of the different and specific quality. The quality of water is checked by measuring various parameters like pH, Dissolved Solids, Hardness etc. An International organization dealing with the health related matter i.e. World Health Organization (WHO) has given criteria for drinking water. But to understand all these standards for common people is difficult. It is also difficult for the authority to make any decision based on these different parameters. Hence a new approach has been developed i.e. Water Quality Index (WQI), which represent the water quality in terms of numeric i.e. 0 to 100. The WQI is an important tool for decision makers.

The wastewater is generated from any type of usage of water. For discharge of wastewater, particularly into the rivers, two approaches or systems are adopted, i.e.

a) Effluent Standards &
b) Stream Standards

In India Effluent Standards are followed for disposal of wastewater, where different limits are given for different parameters like pH, Chemical Oxygen Demand (COD), Bio-chemical Oxygen Demand (BOD), Heavy Metals and many more for discharge in to different Environmental Sinks. The current legal requirement is that all the parameters vary as the specified in the 'Consent' must be satisfied prior to the discharge. Failure to do so invite the legal action may be a 'Closure' of the industry. Developing the WWQI on the line of WQI is expected to be more practical in implementation and can become effective decision making tool for authority.

2. METHODOLOGIES TO DETERMINE WQI AND WWQI

2.1 Wastewater Polishing Index (WWPI) [1]:

To assess the quality achieved by different polishing treatments for discharge of wastewater into surface water body or for reuse purpose the new index has been defined i.e. Wastewater Polishing Index (WWPI). WWPI is defined by the 'weighted average' of the following six parameters:

Suspended Solids (SS)

Bio-chemical Oxygen Demand (BOD5)

Chemical Oxygen Demand (COD)

Ammonia (NH4)

Total Phosphorous (as P)

Escherichia Coli (E. Coli)

Index has been validated and tested on a pilot plant including a rapid sand filtration, a slow filtration through a horizontal subsurface flow system and a lagooning, in addition to their combinations.

Index is equal to 0, when none of the six pollutants are present in the effluent and equal to 100, when all six parameters are equal to their corresponding Italian legal limits for discharge into surface water body. When all the six parameters are equal to their corresponding Italian legal limits for Reuse; the value of WWPI is 36.

The Index is good tool for:

a) Rapid comparison of water quality

b) Rapid evaluation of treatment options

c) Rapid evaluation of the improvement in water quality

The index could be of great help for management and decision makers while planning for water resources, in particular, for comparing water quality level achieved by different wastewater treatment sequences.

The Wastewater Polishing Index has been determined by preparing Normalization curve to find out the sub-index for all the parameters as shown in the **Error! Reference source not found.** where minimum value equal to 0 and maximum value 100 equal to the Italian legal limit for discharge of effluent.

Normalized sub – index is to be determined from the Graph

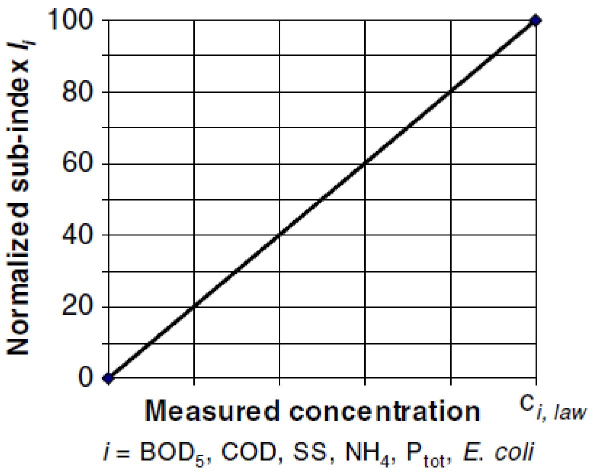

Fig 1: Normalized Curve

Substitute the value of sub – index, the WWPI is calculated by using the relationship as

$$\mathrm{WWPI} = \frac{\sum_i I_i^{n_i}}{\sum_i 100^{n_i}} \times 100$$

$$= \frac{I_{BOD_5}^{1} + I_{COD}^{1} + I_{SS}^{1} + I_{NH_4}^{1} + I_{P}^{1} + I_{E.coli}^{1.4}}{5 \times 100^{1} + 100^{1.4}}$$

Where,

$I_{BOD_5}^{1}$ = Value of Normalized Sub – index for BOD_5

I_{COD}^{1} = Value of Normalized Sub – index for COD

I_{SS}^{1} = Value of Normalized Sub – index for SS

$I_{NH_4}^{1}$ = Value of Normalized Sub – index for NH_4

I_{P}^{1} = Value of Normalized Sub – index for Phosphorous

$I_{E.coli}^{1}$ = Value of Normalized Sub – index for E. coli

The experiment was done for different treatment systems as described below:

1. Rapid Filter (RF)
2. Horizontal Subsurface Flow System (H-SSF)
3. Rapid filter + Horizontal Subsurface Flow System (RF + H-SSF)
4. Rapid filter + Horizontal Subsurface Flow System + Lagoon (RF + H-SSF + L)

The above mentioned systems were used for different time periods in different seasons as shown in **Error! Reference source not found.**

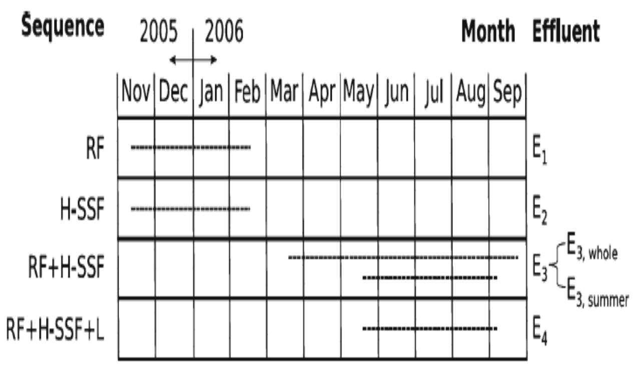

Fig 2: Time Period for Different System

Italian Legal Limits along with avg. values and sub-index for each parameter at each stage and WWPI are given in **Error! Reference source not found.**

Table 1. Average Values with sub-index at each stage and Italian Legal Limits

Sr. No.	Parameter	Italian Legal Limits	E1		E2		E3, Whole		E3, Summer		E4	
			Avg. Value	Sub-index	Avg. Value	Sub-index	Avg. Value	Sub-index	Avg. Value	Sub-index	Avg. Value	Sub-index
1	BOD5	25	13	52	7	28	7	28	6	24	8	32
2	COD	125	18	14.4	13	10.4	13	10.4	12	9.6	12	9.6
3	NH4	15	2	13.33	1	6.67	0.8	5.33	0.65	4.33	0.3	2
4	SS	35	5	14.30	6	17.15	2	5.72	2	5.72	4	11.5
5	Ptot	1	1.6	160	1.6	160	1.2	120	1.1	110	1.1	110
6	E.coli	5000	2200	44	1600	32	1500	30	90	1.8	50	1
WWPI		100	--	40.14	--	31	--	25.33	--	10.25	--	14.69

The results for different treatment systems are as shown in **Error! Reference source not found.**

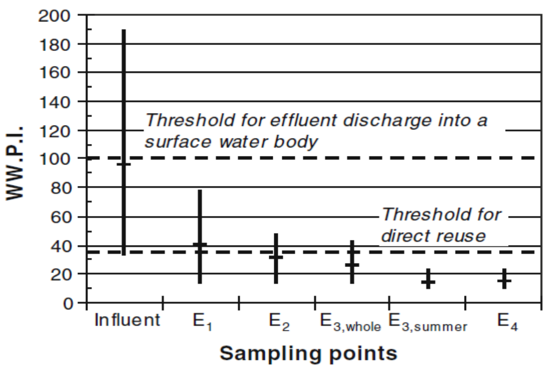

Fig 3: WWPI for Different Treatments

The concept of WWPI, established for Reuse and Discharge, can be effectively explained for control as well.

2.2 Canadian Water Quality Index [2]:

An International body for Environment, The United Nations Environment Programme (UNEP) was tasked by UN – Water to assess worldwide freshwater quality under World Water Assessment Programme (WWAP), which is known as Global Water Quality Index (GWQI). UNEP delegated this responsibility to its body Global Environmental Monitoring System (GEMS). To carry out GWQI GEMS had studied different models. They found Canadian Water Quality Index (CWQI) as suitable model for this task.

The CWQI is calculated using three factors as follows:

$$\mathrm{WQI} = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right)$$

F1 represents Scope: The percentage of parameters that exceed the guideline

$$F_1 = \left(\frac{\#\ \text{failed parameters}}{\text{Total}\ \#\ \text{of parameters}}\right) \times 100$$

F2 represents Frequency: The percentage of individual tests within each parameter that exceeded the guideline

$$F_2 = \left(\frac{\#\ \text{failed tests}}{\text{Total}\ \#\ \text{of tests}}\right) \times 100$$

F3 represents Amplitude: The extent (excursion) to which the failed test exceeds the guideline. This is calculated in three stages. First, the excursion is calculated

$$\text{excursion} = \left(\frac{\text{failed tests value}}{\text{guideline value}}\right) - 1$$

NB: in the case of pH where a minimum and maximum guideline is given, the excursion equation must be run as above as well as in reverse i.e. guideline value/failed test value.

Second, the normalized sum of excursions (nse) is calculated as follows:

$$\text{nse} = \left(\frac{\sum \text{excursion}}{\text{total}\ \#\ \text{of tests}}\right)$$

F3 is than calculated using a formula that scales the nse to range between 1 and 100:

$$F_3 = \left(\frac{\text{nse}}{0.01\text{nse} + 0.01}\right)$$

The designation according to index value and its descriptions are given in table2.

Table 2. Designation and Description for Index Value

Designation	Index Value	Description
Excellent	95 -100	All measurements are within objectives virtually all of the time
Good	80 – 94	Conditions rarely depart from natural or desirable levels
Fair	65 – 79	Conditions sometimes depart from natural or desirable levels
Marginal	45 – 64	Conditions often depart from natural or desirable levels
Poor	0 – 44	Conditions usually depart from natural or desirable levels

3. DISCUSSION

Methodology used for determination of WWPI is based on the Normalized graph importance of the parameter, while Canadian Water Quality Index (CWQI) methodology is more depend on the frequency and numbers of result of the parameter. CWQI require huge number of data collection. WWPI is dependent on a single result of the parameter and it shows less variation in Index, where else CWQI is dependent on the number of samples analyzed for a long period. WWPI is a faster process and less time consuming, while CWQI requires much time for determination. WWPI has already been used for treated wastewater, whereas CWQI has been used for only drinking water.

4. CONCLUSION

Based on the above discussion and the literature study conclusion can be drawn that both methods are suitable to determine WWQI. Considering technical and practical feasibility methodology of WWPI is more suitable for determination of WWQI for all the parameters as it gives quick and more accurate results. This method is based on graph, hence it is easy to understand and implement.

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6. REFERENCES

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