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CCME & TM Method for WQI Calculations - A Comparison

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Abstract: WQI ***i.e. water quality index has been calculated on the basis of methods suggested by Tiwari& Mishra (TM) and Canadian Council of Ministers of Environment (CCME) The calculations are based on the studies of parameters for underground water of seven sights of Bullowal in Hoshiarpur Distt. (Pb.). A comparison of values thus found on TM and CCME methods has been made. Efforts have been also made to arrive at a better option of the two for WQI calculations. Fairly close agreement of values of WQI calculated on CCME method among different agencies i.e. WHO, EPA, CAN, EU, BIS, ICMR and AUS is seen, whereas variation of values for the TM method is wider.***

Keywords: Water Quality Index; Permissible Standard Limits; Unit Weights; Objective assessment

1. Introduction

Water being exelcer of life, its quality is of vital concern for the welfare of the society, it being directly linked to health of living beings. Quality of water is being hampered because of various factors. Use of fertilizers, pesticides, insecticides weedicides, industrial waste, human waste etc. lead to water pollution. It is very vital for us to check and control quality of drinking water. Only 2 to 3% of available water is fit for drinking. This %age is still coming down because of pollution of water by responsible factors. Water quality management is thus essential for human welfare.

An index indicating quality of water for use was much needed. The index should integrate the significant physico-chemical and biological constituents of water and present them in a simple, yet scientifically defensible manner. Attempt have been made to check the degree of purity since mid of twentieth century [2, 3].Different water quality indices being used till date were reviewed [4, 5].

The introduction of Water Quality Indices (WQI) is an effective tool for measurement of level of contamination. WQI is defined a "a rating reflecting the composite influence of different water quality parameters on overall quality of water"[6,7].Reference values for various water quality parameters involved in calculation of WQI somehow differ for some parameters of different environmental agencies and departments[8]. The ranges of WQI proposed for quality of water also differ in case of different agencies. For example a range between 91-100 is excellent, 71-90 is good, 51-70 medium, 26-50 fair, 0-25 is poor as per National Foundation and Sanitation [9], According to CCME i.e. Canadian /Council of Ministers of Environment, water quality index [10] range between 95-100 is excellent range 80-94 is good, 65-79 is fair, 45-59 is marginal, 0-44 is poor. Some workers [11] use WQI less than 50 as excellent and between 80-100 water as contaminated.

2. Sampling and Experimental Details

The samples from scattered but selected hand pumps were taken in 2 liter P.E.T bottles .Before sampling bottles were rinsed with 0.1N chromic acid and twice washed with double distilled water. After collection samples were kept in the laboratory for analysis. Analysis for CL^-, SO_4, EC, pH and hardness was carried out using analytical methods. The pH has been determined using digital pH meter, using two standard solutions (pH 4.7 and pH 10 buffers) as pH had to be determined for drinking water which ranges generally between pH 4.7 to 10. PH meter used had to 0.01 resolution. Electrical conductivity has been measured by titrimetric methods. Total hardness has been determined by complexomtric titration **TABLE II:** [EDTA].Sulphate have been determined spectrophotometrically using a filter of 420 nm [12, 13]

3. Methodology of Calculation

WQI values as calculated on the basis of method as used by Tiwari and Mishra have been already reported in our publication [14]. The values reported have been compared with WQI values as calculated on CCME method [10]. WQI as reported in [14] is

$$WQI=\text{Antilog}\ [\sum_{n=1}^{5} Wn=1 \log Qn] \quad \text{.....(1)}$$

$$\text{Here, } Qn= V_n\text{-}Vi/Vs\text{-}Vi * 100 \quad \text{.....(2)}$$

the symbols have usual meaning [11].

$W_1= k/V_1$, considered for five parameters

$$\sum_{n=1}^{5} Wn = 1 \quad \text{.....(3)}$$

As per CCME method factors F_1,F_2& F_3 have been first calculated from data and then WQI.Using standard values

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for each parameters as per WHO,EPA,CAN,EU,BIS,ICMR and AUS agencies.

The index is based on combination of three factors:-

1) The number of variable whose objectives are not met (scope) F_1
2) The frequency with which the objectives are not met (Frequency) F_2
3) The amount by which the objectives are not met (Amplitude) F_3

These are combined to produce a single value (between 0 and 100) that describes water quality.

$$F_1=\frac{Number\ of\ failed\ variables}{total\ number\ of\ variables}*100 \quad \ldots\ldots\ldots (4)$$

$$F_2=\frac{Number\ of\ failed\ tests}{total\ number\ of\ tests}*100 \quad \ldots\ldots\ldots (5)$$

F_3 represents the amount by which failed tests values do not meet their objectives. F_3 is calculated as:-

$$F_3=\frac{nse}{0.01nse+0.01} \quad \ldots\ldots\ldots (6)$$

F_3 is calculated by an asymptotic function that scales the normalized sum of recursions from objective (n se) to yield a range between 0 and 100.

$$Nse=\frac{\sum_{i=0}^{n} excursions\ i}{number\ of\ tests} \quad \ldots\ldots\ldots (7)$$

The number of times by which an individual concentration is greater than (or less than, when objective is a minimum) the objective is termed an 'excursion' as follows. When the test value must not exceed the objective:

$$Excursion\ i=\frac{Failed\ Test\ Value}{objective\ i}-1 \quad \ldots\ldots\ldots (8)$$

For cases in which the test value must not fall below the objective.

$$Excursion\ i=\frac{objective\ i}{Failed\ Test\ Value\ i}-1 \quad \ldots\ldots\ldots (9)$$

Objective i=standard value
Failed test value=Exceeded (or less) value

WQI value as per CCME is given as

$$WQI=100-\frac{\sqrt{F1^2+F2^2+F_3 2}}{1.732} \quad \ldots\ldots\ldots (10)$$

The divisor 1.732 normalizes the resultant values between 0 and 100 where zero (0) represents the "worst" water quality and 100 represents the best water quality

Table 1: Site-wise average of Vn values of 5 parameters measured at seven places. All values are in mg/L except pH and EC.

Parameter	I	II	III	IV	V	VI	VII	Av.V_n.
Cl	13.9	17.5	28	20.8	18.5	20.8	23.6	20.4
SO_4	324.	303.1	282.5	217.8	278.9	266	274.2	278.2
Ph	8.5	8.1	8.8	8.8	8.9	9	8.8	8.7
EC	198.	1401.	1511.	1342.	1392.	1367	1201.	1345
TH	309.	349.8	361.5	330.5	330.3	282.	290.5	322.1

Table 2: Vs values of seven Agencies / countries

Agency/ Country	WHO	EPA	CAN	EU	BIS	ICMR	AUS
Cl	250	250	250	250	1000	1000	250
SO_4	500	250	500	250	400	400	500
Ph	8	9.5	8.5	9.5	8.5	8.5	8.5
EC	2500	1500	500	2500	300	300	1500
TH	300	200	200	500	300	300	200

Table 3: WQI values according to CCME and CM method

Agency country	*WHO*	*EPA*	*CAN*	*EU*	*BIS*	*ICMR*	*AUS*
TM	151	67	105	64	129	129	105
CCME	74.1	57.7	59.2	84.7	49.3	49.3	59.2

4. Results and Discussion

Average values of V_n for different parameters measured six times during 2012-2013 for samples of water taken from Hoshiarpur Distt (Pb) Standard Values Vs of seven agencies and WQI calculated by Tiwari Mishra method [11] and CCME method [10] are recorded in Tables No. 1, 2, and 3 respectively. WQI values as reported earlier [11] calculated by TM method indicate wide variation ranging from 64 [EU] to 151[WHO]. Lesser value of WQI is attributed to very good or good and up to 100% is Tolerable quality. WQI above 100% value indicate water to be unfit for drinking [6]. Calculations from Tiwari & Mishra method show that the water is unfit for drinking according to standards of WHO, CAN, BIS, ICMR & AUS agencies. Values of WQI obtained by using EPA & EU agency indicate water to be fairly fit for drinking. Calculations by using CCME method show fairly good approximation (proximity) of WQI values for standards of all agencies except WHO and EU. The values obtained form EPA, CAN, BIS, ICMR & AUS agencies standards indicate water to be of marginal and fair quality for drinking whereas values from WHO and EU agency standards indicate water to be of good quality for drinking. Comparison of both the type of calculation indicate that CCME method seems to be better way of calculation of WQI because of the fact that Majority of the values are fairly close and give same type of results for conclusion whereas TM method gives wide variation and a definite conclusion cannot be drawn**.**

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