On Water Quality Standards and Water Quality Indices

Priyanka Chugh¹, Amarjit Kaur², Harpreet Kaur³, Satish Kumar⁴ and H.S. Sahota*

¹Research Scholar of Punjab Technical University & Asst. Prof. Rama Devi S.D. Kanya Mahavidyalaya Pathankot, Punjab, India
²Associate Professor Govt. College Hoshiarpur, Punjab, India
³Assistant Professor SBSBIET, Khiala, Distt. Jalandhar, Punjab, India
⁴Principal JSS Degree College, Kauli, Patiala, Punjab, India
*Dean Research and Development JSS Group of Institutes, Kauli, Patiala, Pb(India)

Abstract: The quality of water is expressed through a number called Water Quality Index. Physico-chemical and Biological parameters available in water under examination are used to arrive at this number. Measured content of the pollutant, ideal content and standard content for safe use determine this number. Whereas the ideal content and measured one are fixed for a sample, the standard content varies from country to country and from agency to agency. Thus, WQI arrived at by using different standards may vary; if the standard values differ. Presently measured results and standard values of different countries/agencies yield drastically varying WQI in some cases in present measurements. The Australian, Canadian, WHO, ICMR and BIS standards give very high values of WQI. The standards of EPA and EU respectively yield WQI, 67 and 64. They are in reasonably good agreement and yield fairly good quality of drinking water.

Keywords: Water pollution, Water Quality Index, Standard values, Physico-chemical and Biological Parameters

1. Introduction

Water is essential for survival of life on earth. It is most precious natural resource. In our country ground water is the major source of drinking water. The quality of ground water degrades as the content of its chemical constituent’s increases. Leachate from solid waste dumping sites adds to ground water pollution. Use of fertilizers, pesticides and weedicides also lead to water pollution of shallow aquifers. Hence ground water becomes unfit for use. Health is also affected due to high concentration of fluorides, chlorides, sulphates, nitrates, ions and arsenic, chromium, manganese, mercury, cadmium, etc. cations. Quality of water is a major factor in determining the welfare of society. Water quality management is thus fundamental for human welfare [1]. So it is very important to measure the level of contamination in water resources. The introduction of Water Quality Indices (WQI) is an effective tool for measurement of level of contamination. WQI is defined as, “a rating reflecting the composite influence of different water quality parameters on overall quality of water” [2], [3]. Extensive research has been carried out by different workers in assessing water quality profiles of rivers and lakes using different pollution stress parameters [4],[5]. Environmental departments and agencies of Australia [6], Bureau of Indian Standards [7], Canada [8], Environmental Protection Agency of USA [9], European Union [10], Indian Council of Medical Research [11] and World Health Organization [12] have given considerable attention to quality of water. The standards of EPA and EU respectively yield WQI, 67 and 64. They are in reasonably good agreement and yield fairly good quality of drinking water.

The method is based on finding the unit weight of a standard or reference value say $V_s$ for a measured parameter. The sums of weights of all the measured parameters are normalized to one in order to find the constant of proportionality K. For calculation of WQI, a quality called Quality Rating $Q_n$ is defined as:

$$Q_n = \frac{V_n - V_i}{V_s - V_i} \times 100$$

(1)

where the symbols have the usual meanings[14]

$$W_i = \frac{K}{V_1}$$

considered here for five parameters

$$\sum_{n=1}^{5} W_n = 1$$

(2)

Sub indices are given by

$$(SI)_n = (Q_n)^{W_n}$$. The over all WQI is calculated by taking geometric mean of these sub indices as given by:

$$WQI = \text{Antilog} \left[ \frac{1}{5} \sum_{n=1}^{5} W_n \times \log Q_n \right]$$

(3)

Even ranges, proposed for quality of water differ in case of different agencies. For example, according to National Foundation and Sanitation [13] range between 91-100 is excellent, 71-90 is good, 51-70 medium, 26-50 fair, 0-25 is poor but according to Canadian Council of Ministers of Environment, water quality index [8] WQI 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 [14] use WQI less than 50 as excellent and between 80-100 water is contaminated. Thus, there exists an ambiguity in expressing excellent or poor quality of water even through WQI. In order to prove that WQI calculated using standards proposed by different countries differ widely even through $V_s$ values are same and method used to calculate WQI is same [14] we present the results of our recent measurements.
The results of our present measured parameter values $V_n$ and standards $V_s$ for various countries are given in Table 1. The unit weights $W_n$, quality ratings $Q_n$ and WQI calculated using the method of Tiwari and Mishra [14] are listed in Table 2.

### Table 1: Measured $V_n$, $V_s$ of various agencies and K values. All values are in mg/l.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measured $V_n$</th>
<th>Standard values $V_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate</td>
<td>278.18</td>
<td>500</td>
</tr>
<tr>
<td>pH</td>
<td>8.70</td>
<td>8.0</td>
</tr>
<tr>
<td>EC</td>
<td>1345.0</td>
<td>2500</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>322.1</td>
<td>300</td>
</tr>
<tr>
<td>Chloride</td>
<td>20.46</td>
<td>250</td>
</tr>
<tr>
<td>Value of K</td>
<td>7.424</td>
<td>8.408</td>
</tr>
</tbody>
</table>

A perusal of Table 2 reveals that WQI using Australian, Canadian and WHO standards are quite high, EU and EPA, WQI are quite close respectively 67 and 64 and reasonably acceptable, whereas BIS and ICMR, WQI are higher and identical.

### Table 2: Unit weights $W_n$, Quality rating $Q_n$ and WQI using various standards.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_n$</td>
<td>0.029696</td>
<td>0.033634</td>
<td>0.030932</td>
<td>0.034584</td>
<td>0.008048</td>
<td>0.008048</td>
<td>0.014848</td>
</tr>
<tr>
<td>$Q_n$</td>
<td>8.18</td>
<td>8.18</td>
<td>8.18</td>
<td>8.18</td>
<td>8.18</td>
<td>2.05</td>
<td>2.05</td>
</tr>
<tr>
<td>WQI</td>
<td>151</td>
<td>67</td>
<td>105</td>
<td>105</td>
<td>64</td>
<td>129</td>
<td>129</td>
</tr>
</tbody>
</table>

### 3. Conclusions

The water quality index WQI, depends upon basically two factors $W_n$ and $Q_n$ besides the measured values of chosen parameters. $W_n$ in itself is unit weight of a standard normalized through a constant K in which K times sum of unit weights is put = 1. Thus lower the limit of a parameter towards pollution, higher will be its contribution to WQI. The other factor $Q_n$ is directly connected to $V_n - V_i$, and inversely to $V_s - V_i$. Both $W_n$ and $Q_n$ are important in the calculation of WQI. On, $V_n = V_s$, i.e. no parameter has any pollution and the content is only equal to ideal content $V_i$, the numerator for $Q_n$ becomes zero and WQI = 0, the water quality will be excellent. For $V_n = V_i$, the $Q_n = 1$ and the water quality will be just tolerable, beyond this water will not be fit for consumption. If now we look at our Table 1, we find that K value for different countries / agencies standards are not very different whereas the standards themselves differ widely thus giving rise to large variation in $W_n$. Similarly $Q_n$ also differs widely. Thus WQI too differ widely, between 64 and 67 for EU and EPA respectively to 151 for WHO. For CAN, AUS, BIS and ICMR standards also the water quality is unfit for drinking. Thus we are left to conclude that some sort of uniformity of standard tolerable content fixation is utterly desirable.

### 4. Acknowledgements

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