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MDPI

Supplementary

Modification of the Water Quality Index (WQI) Process For Simple Calculation Using the Multi-Criteria Decision-Making (MCDM) Method: A Review

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Table S1: This shows the valuable information about a few common steps to use in WQI development for overall reviewed.

Indexing method	Parameters	Range	Classification	Sub-indices, weights, aggregation	Equation	Purpose and region of application
Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) [12]	At least 4 parameters, maximum number of parameters is not specified	95–100	Excellent	No sub-indices, no weights, no aggregation	$CWQI = 100 - \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}$ where F_1 (scope: the variable percentage above the guideline) is the number.of variables whose objectives are not met/total number. of variables ×100, F_2 (frequency: number of times by which the objectives are not met) is the number. of failed tests/total number. of tests × 100, F_3 (denote amplitude: the amount by which the objectives are not met); (a) $Excursion_i$ = (failed test $value_i$/$objective_j$) −1, (b) normalized sum of excursions (nse).	WQI was used by Horton for the weightings, and the scales of rating measures, in order to determine the relative significance in the water quality of each parameter.
		80–94	Good			
		60–79	Fair			
		45–59	Marginal			
		0–44	Poor			

					$= \sum_{i=1}^{n} \text{excursion}_i$ $-$ no of test and (c) F_3= (nse/0.01nse+0.01)	
British Columbia Water Quality Index (BCWQI) [13,112]	At least 4 parameters, maximum number of parameters is not specified	0–3 4–17 18–43 44–59 60–100	Excellent Good Fair Borderline Poor	No sub-indices, no weights, no aggregation	$BCWQI = \frac{\sqrt{F_1^2 + F_2^2 + (\frac{F_3}{3})^2}}{1.453}$ This index is similar to the CWQI, where parameters for water quality are calculated and their violation by comparison to a prescribed limit is identified.	In 1970, the Brown's group established a new WQI similar to Horton's index, dependent on weights to the individual parameter.
Modified Canadian Water Quality Index (MCWQI) [120]	At least 4 parameters, maximum number of parameters is not specified	91–100 81–90 71–80 51–70 21–50 0–20	Excellent Very good Good Fair Marginal Poor	No sub-indices, no weights, no aggregation	$V_1 = \frac{\sum P_i x C}{\sum P_i}$ $nse = \frac{\sum_{i=1}^{n} SI_{i,k} x P_i}{\sum_{i=1}^{n} P_i}$ $V_2 = \frac{nse}{0.005nse + 0.005}$ $MCWQI = 100 - \frac{\sqrt{V_1^2 + V_2^2}}{1.414}$ where C = count factor for 1 or 0, P_i = relative weight, SI = subindex, i = paramter order, k = order for each step.	The article conducts the modified CWQI aggregation that used the following amendment: V1(Scope) shows that the percentage of failed parameters is changed through parameter relative weights, and V2 (frequency and amplitude) is combined with fréquence and amplitude.
Water Contamination Index (WCI) [18]	6 parameters: pH, BOD, DO, NO_2, petroleum products, ammonium ion	0–0.2 0.2–1.0 1–2 2–4 4–6 6–10 >10	Very clean Clean Moderate clean Polluted Dirty Very dirty Extremely dirty	Equal weights (sum of weights = 1)	$WCI = \frac{1}{n} \sum_{i=1}^{n} \times \frac{C_i}{MAC_i}$ where C_i is the parameter concentration, n is the no of indicators, and MAC_i is the established value of the standard for the relevant type of water body.	The USSR Goskomgidromet developed the WCI method and is one of the most widely used indicators for water quality evaluation. This measure is a typical additive coefficient which represents the mean above MAC in a relatively narrow number of individual components.
Overall Index of Pollution (OIP) [14]	8 Parameters: pH, DO, BOD, TH, TDS, total coliform, As, F^-	0–24 25–49 50–74 75–94 95–100	Polluted Poor Fair Good Excellent	Individual sub-indices and equal weights	$OIP = \sum \frac{P_i}{n}$ where Pi is the pollution index and no of ith parameters	Based on measurements and subsequent classification of parameters for Indian rivers, an OIP has been developed by Sargaonkar and Deshpande.

Dojlido Index [101]	7 parameters BOD, ammonia, COD, Cl, DO, dissolved oxygen, BOD, SS, phosphates	76–100	Excellent	The root of the square harmonic mean	$WQI = \sqrt{\frac{n}{\sum_{i=1}^{n}\frac{1}{x_i^2}}}$ where n is the number of indices taken into account, and x_i is the unit index of parameter i.	The water quality assessment of the Vistula basin in Poland using WQI and comparing the results of water analysis with permissible values of parameters given for three classes, according to the Disposition of Minister of Environment.
		51–75	Good			
		26–50	Marginal			
		0–25	Unsuitable			
Contact Recreation Index (NZ Recreation Index) [114]	8 parameters: FC, color, dissolved inorganic nitrogen, dissolved reactive phosphorus, five-day BOD, pH, turbidity, and visual clarity	Phase 1	Suitability	Minimum operator, It was done graphically with phases	$WQI = \prod_{i=1}^{n} W_i Q_i$ where Qi is the rating value of the parameter and Wi is the weighting factors.	WQI has been used for contact recreation in freshwaters in New Zealand. Ideally, indicators of recreational water quality are microorganisms or chemical compounds that can be quantitatively associated with swimming and health hazards.
		Phase 2	Unsuitability			
Hallock [83]	8 parameters: DO, FC, pH, T, total nitrogen, total phosphorus, turbidity, and total suspended sediments	100–75	Excellent	Additive	$[WQI = a + b_1(paramter) + b_2(parameter)^2]$ where a is the subindices and b_1-b_2 is the weights of parameters.	Hallock (2002) gave information about the creation of a WQI for the Freshwater monitoring unit of the Washington State Department of Ecology based partly on the NSF Index.
		74–50	Good			
		49–25	Fair			
		25–0	Unsuitable			
Hanh Water Quality Index (Hanh's WQI) [119]	11 Parameters: ammonium nitrogen, COD, BOD, DO, orthophosphate, total coliform (TC), SS, T, turbidity, and toxicity	91–100	Excellent	Parameters are directly taken as sub-indices using the permissible limits of water standards, Additive, and multiplicative functions	$\left[WQI = \left(1/5\prod_{i=1}^{n} C_i \left[\sum_{i=1}^{5} Q_i 1 /2\sum_{j=1}^{2} Q_j \times Q_k\right]\right)^{1/3}\right]$ where C_i is the coefficients addressing the sub-indexes, Q_i, Q_j, Q_k is the sub-indices of organic and nutrients, particulates, and bacteria, respectively.	Hanh (Hanh et al., 2011) proposed a method to investigate spatial and temporal variation in surface water quality in Vietnam and also applied to toxic substances that led to water pollution, in particular for organic and nutrients, particulates, and bacteria, respectively.
		76–90	Good			
		51–75	Fair			
		26–50	Marginal			
		1–25	Poor			

Kaurish Index [115]	9 parameters: FC, pH, BOD, total nitrates, total solids, T, turbidity, conductivity, and phosphates	40	Good	Additive	$\mathrm{WQI} = (\mathrm{P}_1 \times \mathrm{P}_2 \times \mathrm{P}_3 \ldots\ldots \mathrm{P}_\mathrm{N})^{\frac{1}{n}}$ where P is the water quality parameters and (1,2,3, ... N is the number of ith parameters).	WQI has been applied for the determination of surface water quality of the City of Greensboro, Mecklenburg County.
		20–40	Average			
		0–20	Poor			
Schiff Index [116]	7 parameters: TDS, SS, FC, nitrate, phosphate, chloride, and sulfate	>7.9	Good	Modified additive	$\left[\mathrm{WQI} = 10 - \left(\frac{10}{7}\right) \times \sum_{i=1}^{n}\left(\frac{\mathrm{P_i}}{\mathrm{P_{max}}}\right)\right]$ Where P_i is the average of the ith parameter, and P_{max} is the highest value of the parameter	Schiff and Benoit have described the use of WQI modified in a study of the watershed near New Haven, Connecticut, to indicate the levels of urban-derived non-point source (NPS) pollution.
		7.9–3.4	Average			
		<3.4	Poor			
River Status Index or Lius Index [11]	13 Parameters: DO, BOD, ammonia nitrogen, FC, turbidity, SS, T, Cd, Pb, Cr, Cu, Zn. Scaling only for DO because every parameter has a different rank	6.5	Good	Parameters are directly taken as sub-indices using the permissible limits of water standards. Used additive and multiplicative functions	$\left[\mathrm{TWQI} = \mathrm{C_T C_{pH} C_{tox}} \left[\left(\sum_{i=1}^{3} \mathrm{I_i W_i}\right) \times \left(\sum_{j=1}^{2} \mathrm{I_j W_j}\right) \times \left(\sum_{k=1}^{1} \mathrm{I_k}\right)\right]^{1/3}\right]$ where Ii denotes the subindex values for the "organics"Ij represents the subindex values for the "particulates" Ik is the measurement of fecal coliform.	A better overall index of water quality in Taiwan and its application in the Keya River is proposed by analyzing the behavior and limitations of traditional methods for quality assessment. Numeric quality scales are developed for each parameter to measure improvements in quality and to communicate results to others comprehensively.
		4.5–6.5	Low polluted			
		2.0–4.5	Moderate polluted			
		2	Gross polluted			
Said [64]	5 parameters: DO, FC, turbidity, specific	3	Very good		$\left[\mathrm{WQI} = \log\left[\frac{(\mathrm{DO})^{1.5}}{(3.8)^{\mathrm{TP}}(15)^{\mathrm{FC}/10000}(\mathrm{Turb})^{0.15} + 0.14(\mathrm{SC})^{0.}}\right.\right.$	The new index was applied to the Big Lost River Watershed in Idaho, and the results
		3–2	Acceptable			

	conductivity, and total phosphates (TP)	2–0	margi nal	where this is a specific linear function, DO is dissolved oxygen, turb is turbidity, TP is the total phosphorus, FC is the fecal coliform, SC is the specific conductivity	gave a quantitative picture of the water quality situation.

Table 2. shows the valuable information about four common steps to used in WQI development for overall reviewed, since the 1960s.

Indexing	Parameters	Range	Classification	Sub-indices and weights	Equation	Purpose and region of application
Horton Water Quality Index (HWQI) [8]	8 Parameters: Alkalinity, DO, pH, EC, T, Cl^-, alkalinity, coliforms	<100	Excellent	A rating scale of Horton and unequal weights (1 to 4) and arithmetic weighted mean function	$HWQI = \frac{[W_1S_1 + W_2S_2 \ldots. W_nS_n]}{W_1 + W_2 \ldots W_n} M_1M_2$ where C_i is the rating of ith parameter concentration, W_i is the weighting of ith parameter, nis the parameter number, M_1 and M_2 is the additional parameters.	WQI was used by Horton for the weightings and the scales of rating measures in order to determine the relative significance in the water quality of each parameter.
		100–150	Good			
		150–250	Poor			
		>250	Unsuitable			
National Sanitation Foundation Water Quality Index (NSFWQI) [9]	11 Parameters: T, pH, FC, DO, turbidity, TS, NO_3^-, BOD, total phosphates, pesticides, toxic metal	0–25	Excellent	Sub-indices used Standard, Sum of weight is 1 and additive	$NSFWQI = \sum_{i=1}^{n} W_i \times Q_i$ where Q_i is the sub-index of ith parameter, W_i is the weight associated with ith parameters.	In 1970 the Brown's group also established a new WQI similar to Horton's index dependent on weights to the individual parameter.
		26–50	Good			
		51–75	Poor			
		76–100	Very poor			
		> 100	Unsuitable			
Oregon Water Quality Index (OWQI) [15]	8 Parameters: DO, pH, FC, BOD, total phosphorus, NO_3^- + ammonia, T	90–100	Excellent	Sub-indices used Standard, Sum of weight is 1 and additive (1st version)	$OWQI = \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{SI^2}}}$ where n = subindices number, SI = subindex of ith parameter.	The OWQI is a single number that represents water quality, taking into consideration 8 water quality parameters. The original OWQI was developed according to the NSFWQI in which the parameter selection was carried out by the Delphi method.
		85–89	Good			
		80–85	Fair			
		60–79	Poor			
		0–59	Unsuitable			
Bascarón Water Quality Index (BWQI) [90]	26 Parameters: pH, BOD, TC, color, SO_4, oil and grease, NO_3, Cl, EC, Mg, P, NO_2, turbidity, Ca,	91–100	Excellent	Sub-indices used Standard, Sum of weight is 1 and modified additive	$BWQI = \frac{\sum P_i \times C_i}{\sum P_i}$ where C_i is the sub-index value and P_i is the relative weight of each parameter.	The Bascarón index is designed specifically for Spain by Bascarón (1979). This index has been included in
		61–90	Good			
		31–60	Fair			
		16–30	Poor			
		0–15	Very poor			

	permanganate, and apparent aspect					many reports, in particular in Latin America, India, and New Zealand.
Scottish Research Development Department (SRDD) [10]	10 Parameters: DO, BOD, TO, N, P, SS, T, EC, ecsheria coli, free and saline ammonia	90–100 80–89 70–79 40–69 30–39 20–29 0–19	Excellent Good Fair Tolerable Low polluted Polluted Piggery waste	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{SWQI} = \frac{1}{100}\sum_{i=1}^{n}(W_i \times Q_i)^2$ where Q_i is the sub-index of ith paramter, W_i is the weight associated with ith parameters	In 1976 that general WQI was developed and improved by the Scottish Research Department (SRDD) Index, which was designed by the SRDD Development Division based on the phases comparable to those in the NSF WQI.
Bhargava Method Water Quality Index (BMWQI) [16]	4 four various groups: heavy metals, coliform organisms, physical parameters, organic and inorganic parameters	90–100 65–89 35–64 11–34 0–10	Excellent Good Acceptable Polluted Severe water quality	Sub-indices used Standard, Sum of weight is 1 and modified multiplicativ e	$\mathrm{BMWQI} = \left[\prod_{1=1}^{n}\int_i (P_i)\right]^{\frac{1}{2}} \times 100$ where fi (Pi) for each variable the sensitivity function, such as the impact of the associated variable weight concentration of the activity (0–1) and n the number of variables.	Bhargava approach has been used in several nations and it is simple to use the curves of sensitivity functions that have a value of between zeros to one to manage relative parameters for different use.
Malaysia Water Quality Index (MWQI) [17]	6 parameters: DO, BOD, COD, SS, pH, and ammonia nitrogen (AN)	81–100 60–80 0–59	Excellent Low polluted Polluted	Sub-indices used Standard, Sum of weight is 1 and additive	$MWQI = 0.22\,\mathrm{SI_{DO}} + 0.19\,\mathrm{SI_{BOD}} + 0.16\,\mathrm{SI_{COD}} + 0.15\,\mathrm{SI_{AN}} + 0.16\,\mathrm{SI_{SS}} + 0.12 SI_{pH}$ Where SI is the sub-index	The MWQI is the WQI calculation method developed by the Department of Environment Malaysia. This method has been successfully applied to measure water quality for 462 rivers in Malaysia.
VedPrakashi Water Quality	4 parameters: DO, FC, pH,	64–100 50–63	No polluted Low polluted	Sub-indices used	$\mathrm{GWQI} = \sum^{n} W_i \times l_i$	The GWQI index has been

Index (VedPrakashi's index) [7]	BOD	38–49	Medium polluted	Standard, Sum of weight is 1 and additive	where W_i is the unit weight of the ith parameter, and l_i is the sub-index function of the ith parameter.	developed to assess the overall water quality profile of the Ganga River. It was based on the NSFWQI and also had a weighted multiplication type with minor variations in weights, which indicated that the water quality standards were complied with for various categories of uses provided by the Central Water Pollution Board, India.
		37–0	High polluted			
Dinius Water Quality Index (DWQI) [109]	12 parameters: DO, BOD, EC, T, NO_3, pH, hardness, color, alkalinity, coliform form, specific conductivity, and Escherichia coli count	0–40	Not acceptable	Sub-indices used Standard, Sum of weight is 1 and multiplicative means	$\mathrm{DWQI} = \sum_{i=1}^{n} W_i \times l_i$ where $W_i$is the unit weight of the ith parameter, and l_i is the sub-index function of the ith parameter.	Dinius is a multiplicative WQI method that is used for six water categories usage such as drinking water supply, domestic, fish, shellfish, agriculture, and industry.
		40–50	Doubtful			
		50–80	Treatment			
		80–90	Minor purification			
		90–100	Not purification			
Anzali Water Quality Index (AWQI) [110]	9 Parameters, COD, DO, ammonia, nitrate, phosphate, pH, T, TSS, and EC	87.5–100	Clean	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{AWQI} = \sum_{i=1}^{n} W_i \times Q_i$ where Q_i is the sub-index of the ith parameter, W_i is the weight associated with ith parameters.	A water quality index was developed for integrating the combined impact of various physical, chemical, and biological parameters studied at 18 different locations in the area and some watercourses within the basin
		70–87.5	Good			
		54–70	Marginal			
		37.5–54	pollution			
		>37.5	High pollution			

						during the past five years by the Bureau of Reclamation of Anzali Wetland.
Fuzzy-based water quality index (Fuzzy Index) [102]	No guidelines	100–80 80–60 60–40 40–20 0–20	Excellent Good Moderate Poor Unacceptable	Using fuzzy logic	$\left[f(x; a, b, c, d) = \max\left(\min\left(\frac{a-x}{a-b}, 1, \frac{d-x}{d-c}\right), 0\right)\right]$ $\left[FWQI = \frac{\int z\mu(z)zdz}{\int \mu(z)zdz}\right]$ where FWQI is the fuzzy-based water quality index value (between 0 and 100), and a, b, c, and d are membership function parameters and z is the independent variable of the output fuzzy set in each rule.	Fuzzy Logic (FL) has helped researchers to induce user information and experience to address the complexity and ambiguity involved in evaluating natural systems ever since its introduction by Zadeh. Fuzzy Logic maps input to output using the Fuzzy Inferencing System (FIS) which combines FL and knowledge of experts through four main components, namely fuzzification, fuzzy rules of inference, aggregation and defuzzification. [1].
Smith's Water Quality Index (SWQI) [69]	7 Parameters: SS, turbidity, DO, T, BOD, FC, ammonia	100–80 80–60 60–40 40–20 20–0	Extreme Good suitable Unsuitable Total unsuitable	Sub-indices used Standard, Sum of weight is 1 and minimum operator	$\left[I_{min} = \sum \min(I_{sub1}, I_{sub2}, \ldots \ldots I_{subn})\right]$ where I_{min} equals the lowest value of the subindex.	Smith developed an index for four purposes of water such as fish spawning, water supply, general, and bathing. The development of this index was related to the recommendation of the water

						quality standards for New Zealand water legislation.
Tiwari and Mishra WQI (TMWQI) [108]	14 parameters: pH, EC, TDS, TH, Ca, Mg, Na, K, Cl, F, nitrates, carbonates, bicarbonates, sulfates	<26	Excellent	Sub-indices used Standard, Sum of weight is 1, and logarithmic aggregations	$\mathrm{TMWQI} = \mathrm{Antilog} \sum W_n \log q_n$ where q_n is the quality class for the nth variable, and W_n is the relative weight of the nth parameters.	Tiwari and Mishra have been proposed a logarithmic WQI method for the assessment of the quality of major Indian rivers.
		26–50	Good			
		51–75	Medium			
		76-100	Poor			
		>100	Unsuitable			
Aquatic toxicity Water Quality Index (ATWQI) [112]	12 Parameters: DO, pH, turbidity, TDS, F^-, Zn, Mn, Cr, Cu, Pb, Ni, and potassium	0–50	Unsuitable	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{ATWQI} = \frac{1}{100}\left(\frac{1}{n}\sum_{i=1}^{n} q_i\right)^2$ where q_i is the quality of the ith parameter.	Wepener developed the ATWQI to evaluate the health of aquatic ecosystems. Because a wide range of fish toxicity databases is available, the toxic health indicators of the aquatic ecosystem are the impacts of distinct water quality on fish.
		51–59	Fair			
		60–100	Suitable			
Catalan Water Agency Water Quality Index (CAWQI) [117]	5 Parameters: T, DO, TOC, SS, EC	91–100	Excellent	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{CAWQI} = \mathrm{SI_{temp}}(\mathrm{SI_{TOC}} + \mathrm{SI_{SS}} + \mathrm{SI_{DO}} + \mathrm{SI_{EC}})$ where SI is the sub-indices of ith parameters, temp, TOC, SS, DO, and EC are the temperature, total organic carbon, suspended solids, dissolved solids, and electric conductivity, respectively.	The Simplified is used by the water agency in Catalan. This is primarily a correlation between DO, TOC, SS, and EC with a weight vector of 0.30, 0.25, 0.25, and 0.20, respectively.
		71–91	Good			
		51–70	Medium			
		26–50	Poor			
		0–25	Very poor			
Universal Water Quality Index (UWQI) [116]	12 Parameters: Cd, cyanide, Hg, Selenium, As, F, Nitrate-N, DO, BOD, T phosphorus, pH, and TC	95–100	Excellent	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{UWQI} = \sum_{i=1}^{n} W_i \times I_i$ where *Wi* is the weight for the ith parameter and *Ii*is the sub-index for the ith parameter.	Under the water quality standards defined by the Council of the European Communities, the Turkish water pollution control
		75–94	Good			
		50–74	Fair			
		26–49	Marginal			
		0–25	Poor			

						regulations and other scientific details, UWQI was developed by Boyacioglu.
Weighted Arithmetic Water Quality Index Method (AW-WQI) [104]	2 parameters: pH, DO main	0–25 25–50 51–75 75–100 >100	Excellent Good Poor Very Poor Unsuitable	Sub-indices used Standard, Sum of weight is 1 and additive	$AW-WQI = \frac{\sum_{i=1}^{n} l_i W_i}{\sum_{i=1}^{n} W_i}$ Where l_i is the quality rating, Wi is the unit weight.	The WA-WQI method categorized the quality of water as per purity using the most frequently calculated variables of water quality.
House Index [89]	9 parameters: DO, ammonia, pH, BOD, Cl, total coliform, total phosphorus, nitrates, and T	71–100 51–70 31–50 10–30	Good Fair Marginal unsuitable	Additive	$WQI = \frac{1}{100}\left(\sum_{i=1}^{n} Q_i W_i\right)^2$ where Q_i is the quality rating, Wi is the unit weight, and n is the number of parameters.	WQI has been applied to all the data for an annual or longer time series as a means of detecting cycles and trends in river water quality
Dalmatian Water Quality Index (Dalmatian Index) [60]	9 parameters: BOD, DO, corrosion coefficient, mineralization, protein N, T, total coliform, total nitrate, and total phosphorus	75–100 50–74 25–49 0–24	Excellent Good Poor Unsuitable	Sub-indices used Standard, Sum of weight is 1 and multiplicative	$WQI = \frac{WQE}{WQE_{MAC}}$ where WQE is the water quality evaluation, MAC is the maximum admissible limit.	Four separate indices have been used in the water quality assessment of Dalmatia waters in southern Croatia: an arithmetic index, arithmetic modified index, geometric modified index, and Solway-modified index.
Almeida Water Quality Index (Almeida's Index) [96]	9 parameters: COD, FC, detergents, nitrates, Escherichia coli, enterococci, nitrates, phosphate, pH, and total	75–100 50–74 25–49 0–24	Excellent Good Poor Unsuitable	Sub-indices used Standard, Sum of weight is 1 and additive	$RWQI = \prod_{1}^{n} Q_i^{W_i}$ Where Qi is the rating value of parameter i and Wi are the weighting factors ($\sum W_i$=1).	The aim of this method was to established a new RWQI as a tool to ensure the health of swimmers and to make practical decisions.

	coliform					
Harkins Index [105]	No parameter guidelines: any number of parameters may be used to compute the WQI value depending upon the intended ultimate use and or objective of the evaluation	91–100 71–90 51–70 26–50 0–25	Excellent Good Medium Bad Very bad	Sub-indices used Standard, Sum of weight is 1 and Statistical procedures through Multivariate Kendall's statistic	$\mathrm{WQI} = \sum_{i=1}^{n} \frac{(R_{in} - R_{ic})^2}{\mathrm{var}_i}$ where R_{in} is the rank of ith compared values of the parameter R_{ic} is the control value of the ith parameter, var_i is the rank variance of ith parameter.	The latest index is proposed by Harkin's, based on the nonparametric ranking method of Kendall's multivariate.
Prati Index [68]	13 parameters: ammonia, COD, DO, BOD, Fe, Mn, nitrates, pH, SS, alkylbenzene sulfonates, chlorine, carbon chloroform extract	0–1 1–2 2–4 4–8 >8	Excellent Acceptable Low polluted Polluted Heavy polluted	Sub-indices used Standard, Sum of weight is 1 and additive	$\mathrm{WQI} = \prod_{1}^{n} q_i^{w_i}$ where q_i is the quality rating, w_i is the unit weight, and n is the number of parameters.	In particular, because of the use as a source of urban water supply, Prati et al. evaluated the physical, chemical, and biological parameters of natural water resources.
Ross Water Quality Index (Ross WQI) [106]	4 parameters: ammonia nitrogen, DO, BOD and SS	95–100 75–94 50–74 26–49 0–25	Excellent Good Fair Marginal Poor	Sub-indices with rating curves developed by expert's opinion, Additive	$\mathrm{WQI} = \sum_{i=1}^{n} W_i \times Q_i$ where Q_i is the sub-index of the ith parameter, W_i is the weight associated with ith parameters.	WQI has been established for the determination of water of surface water.
Stoner Index [70]	13 parameters (for water supply): Cl, color, Cu, ammonia nitrogen, F, FC, methylene active blue substance [MBAS], sulfate, Zn, pH, phenols, Fe, and nitrate-nitrogen	80–91 72–79 65–71 59–64 55–58 50–54	Excellent Good Fair Marginal Poor Very poor	Sub-indices used Standard, Sum of weight is 1 and additive aggregation	$\left[\mathrm{WQI(A)} = \sum_{i=1}^{n} (\mathrm{QF})_I (\mathrm{RF})_I + \sum_{j=1}^{n} T_j\right]$ where WQI (A) is the WQI for specific use A, n is the number of parameters, $(QF)_I$ is the type of quality function, $(RF)_I$ is the ranking factor and T_j is the value of jth type parameters.	WQI was developed to assess waters for two specific uses such as public water supply and irrigation.
Storage and Retrieval of	No specified list of	0 (−1)–(−10)	Good Low polluted	Having three sub-indices	$\mathrm{WQI} = \sum^{n} W_i \times Q_i$	STORET index was developed

Water Quality Data (STORET) Index [107]	parameters, Parameters are categorized into 3 classes (physical, chemical, and biological)	(−11)–(−30)	Highly polluted	for physical, chemical, and biological. Additive	where Q_i is the sub-index of the ith parameter, W_i is the weight associated with ith parameters.	and has been used to assess the status of surface water bodies in Indonesia.
		≥(−30)	Heavy polluted			
Walski and Parker [104]	10 parameters: coliform count, color, grease, nutrients, odour, pH, SS, T, toxicity, and turbidity	1.0	Excellent	Sub-indices used Standard, Sum of weight is 1 and, Modified multiplicative	$\text{WQI} = \left[\prod_{1=1}^{n} \int_{i}^{a_i} (P_i)\right] \times \left(\sum_{i=1}^{n} a_i\right)$ where P_i is the value of the ith parameter, $\int_{i}^{a_i}(P_i)$ is the sensitivity function for ith variable, a_i is the weight of parameters.	The geometric mean of the quality of each variable represented by a number (ranging from 0 to 1) took Walski & Parker (1974) to be named "sensitivity function". They proposed different curves and formulas for the sensitivity functions of the measured concentrations.
		1.0–0.8	Good			
		0.5–0.8	Satisfactory			
		0.2–0.5	Poor			
		0.01–0.2	unacceptable			
Vaal Water Quality Index (Vaal WQI) [120]	15 parameters: ammonia, Ca, Cl, EC, TH, Mg, Mn, nitrate, pH, sulfate, total alkalinity, turbidity, chlorophyll 665, and orthophosphate	95–100	Excellent	Sub-indices used Standard, Sum of weight is 1 and additive	$\text{VWQI} = \sum_{i=1}^{n} W_i I_i$ where W_i is the weighted coefficient for the *ith* parameter presented, I*i*is the sub-index for the *ith* parameter and n is the total number of parameters.	WQI has been developed for the Vaal Water Management Area (VWMA) in South Africa, which is founded on scope, frequency and amplitude of explanatory variables differing from the targeted values and/or guidelines.
		75–94	Good			
		50–74	Fair			
		26–49	Marginal			
		0–25	Poor			
Wanda Water Quality Index (Wanda's Index) [121]	7 parameters: pH, EC, BOD, FC, T, turbidity, and nutrients (nitrogen and phosphorus)	0–25	Poor	Sub-indices used Standard, Sum of weight is 1 and modified additive	$\text{WQI} = \frac{1}{100}\left(\sum_{i=1}^{n} q_i w_i\right)^2$ where q_i is the quality rating, wi is the unit weight, and n is the number of parameters.	WQI has been used for the investigationof the water quality index ratings of water in the Mpumalanga and North West provinces, South
		26–50	Fair			
		51–70	Average			
		71–90	Good			
		91–94	Very good			
		95–100	Excellent			

						Africa.
Deininger Water Quality Index (Deininger Index) [76]	11 parameters: DO, BOD, turbidity, TS, nitrates, phosphates, pH, T, FC, pesticides and toxic elements	90–100 80–89 60–79 26–59 0–25	Excellent Good Average Fair Poor	Sub-indices used Standard, Sum of weight is 1 and additive	$WQI = \sum_{i=1}^{n} W_i Q_i$ where Q_i is the quality rating, Wi is the unit weight, and n is the number of parameters.	A water quality indices in the form established and defined here IS gaining significant acceptance in the United States and other countries.
Medeiros Water Quality Index (Medeiros WQI) [122]	11 parameters: T pH, TDS, TSS, DO, BOD, thermotolerant, FC, total nitrogen, total phosphorus, and turbidity	0–19 20–36 37–51 52–79 80–100	Worst Bad Regular Good Excellent	Sub-indices used Standard, Sum of weight is 1 and multiplicative	$WQI = \prod_{1}^{n} q_i^{w_i}$ where q_i is the quality rating, wi is the unit weight, and n is the number of parameters.	WQI has been used for the investigationof the water quality of the Murucupi River in the industrial areas of Para, Brazil.
García-Ávila Water Quality Index (García-Ávila Index) [123]	13 parameters: turbidity, T, EC, pH, TDS, TH, Ca, Mg, alkalinity, Cl, nitrates, sulfates, phosphates	<50 51–100 101–200 201–300 >300	Excellent Good Poor Very Poor Inappropriate	Sub-indices used Standard, Sum of weight is 1 and additive	$WQI = \sum SI_{i-n}$ where SI_i is the sub-indices, $SI_i = q_i w_i$	Physical-chemical parameters to assess and analyze the quality of drinking water in the city of Azogues using the water quality index (WQI).
West Java Water Quality Index (WJWQI) [124]	17 parameters: T, SS, COD, DO, nitrate, total phosphate, detergent, phenol, Cl, Zn, Pb, mercury, and FC	100–90 90–75 75–50 50–25 25–5	Excellent Good Fair Marginal Poor	Sub-indices used Standard, Sum of weight is 1 and geometric	$AI = \prod_{i=1}^{n} Si^{w_i}$ where AI is the aggregated index; n is the number of sub-indices; w_i is ith weight and Si is the ith sub-index.	WJWQI developed to replace the currently used indices in West Java, Indonesia. The application of WJWQI for the province of West Java has been revealed using monitoring data from 2001 to 2011 to spatially and temporally assess the general status of water quality.
Drinking-Water Quality Index (DWQI)[88]	17 parameters: pH, EC, Na, Cl, sulfate, alkalinity, TH, Ca, Mg, Fe, F,	95–100 85–95 75–85 60–75 40–60	Excellent Good Fair Marginal Poor	Sub-indices used Standard, Sum of weight is 1	$DWQI = \prod_{i=1}^{n} Si^{w_i}$ Si is the ith sub-index, n is the number of sub-indices, w_i is	The purpose of this study is to evaluate the quality of the drinking water in

	nitrate, Mn, Zn, Pb, Cr and Cu	40–0	Very poor	and Geometric	ith weight factor of ith parameter.	and around Mayiladuthurai taluk using DWQI.
Wastewater water quality Index (WWQI) [57]	23 parameters: Turbidity, TSS, EC, TDS, Ca, Mg, Na, SAR, Cl, pH, BOD, COD, nitrate, Phosphate, boron, Mn, Cd, Cr, Pb, Ni, Fe, total coliform, and FC	91–100	Excellent	weighted arithmetic mean aggregation function	$\left[\mathrm{WWQI} = \sum_{i=1}^{N}\left(\left(\prod_{i=1}^{n}(\mathrm{SI}_i)^{W_i}\right)_j W_j\right)\right]$ where Wj is the relative weight of the jth group; N is the number of groups; and SI_i, W_i,and n are the sub-index value of the ith parameter, the relative weight of the ith parameter	This research aims to was established a Wastewater Quality Index (WWQI) to determine the quality of effluents from the North Wastewater Treatment Plant (WWTP) of Isfahan for agriculture.
		71–90	Good			
		51–70	Regular			
		26–50	Bad			
		10–25	Very bad			