Sumerianz Journal of Scientific Research, 2020, Vol. 3, No. 8, pp. 103-108
ISSN(e): 2617-6955, ISSN(p): 2617-765X
Website: https://www.sumerianz.com

Original Article Open Access

Water Quality Indices Based Assessment of Groundwater Quality in Bhoghapuram, Pusapatirega and Denkada Mandals of Vizianagaram District, Andhra Pradesh, India

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Article History
Received: July 15, 2020
Revised: August 20, 2020
Accepted: August 24, 2020
Published: August 27, 2020

Abstract

The Water Quality Indices (WQI) of Canadian Council of Ministers of the Environment (CCME) and Weighted Arithmetic (WA) models were applied to the assessment of groundwater quality for drinking in Bhoghapuram, Pusapatirega and Denkada mandals of Vizianagaram district of Andhra Pradesh. The groundwater samples were collected from bore wells of 22 selected sampling locations at regular monthly intervals (from November 2018 to October 2019) in the study area. Various parameters such as pH, EC, TDS, TH, TA, Ca^{2+}, Mg^{2+}, Na^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-}, NO_3^{-}, F^{-} of samples were analyzed using standard laboratory procedures. Range and Mean for measured parameter values of each sample and terms of CCME index like Scope F1, Frequency F2, and Amplitude F3 were calculated. The overall quality was assessed using Canadian Council of Ministry of Environment Water Quality Index (CCME-WQI) and Weighted Arithmetic Water Quality Index (WA-WQI) Models. From CCME-WQI, it is observed that quality of about 4.6% of the water samples is Excellent, about 13.6% is Good, about 27.3% is Fair, about 22.7% is Marginal and remaining 31.8% is Poor. And from WA-WQI analysis, it is observed that quality of about 27.3% of the water samples is good, about 36.4% is poor, about 13.6% is very poor and remaining 22.7% is unsuitable for drinking purpose in the study area.

Keywords: Chloride; Calcium; CCME-WQI; Fluoride; Magnesium; Sulphate; WA-WQI.

1. Introduction

Water is an essential component for human life and industrial development. For many rural and small-scale communities, groundwater is the only source of drinking water. Groundwater is the accumulation of water below the ground surface, caused by rainfall and its subsequent percolation through pores and crevices. The groundwater occurs under water table and controlled by land form, structure and lithology. The groundwater table fluctuates due to changes in groundwater storage and draft in response to rainfall incidence, applied irrigation, influent and effluent seepages and draft from groundwater.

Groundwater quality is very essential in a sense of practical utility for domestic, agricultural and industrial purposes. Hence, present utility and future development programs are depending on the physical, chemical and bacterial character of the water. The quality of groundwater varies due to a change in chemical composition of the underlying sediments and aquifer. However, in the recent past groundwater quality is getting deteriorated due to various reasons and making it unsuitable for drinking purposes threatening the human health. Therefore, the groundwater quality assessment for drinking has become a necessary and important task for the present and future groundwater quality management.

Groundwater, in general, is less susceptible to bacterial pollution when compared with the surface water. But it contains several chemical elements like Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-} and SO_4^{2-} which play an important role in the classification and assessment of quality of groundwater. Keeping this in view, the present study aims at the assessment of the quality groundwater at different locations of the study area using Canadian water quality index method by analyzing groundwater samples month wisely over a period of one year.

Several studies have been conducted to assess the quality of surface water for aquatic life [1-4], for irrigation [5] and for drinking [6, 7] using CCME-WQI method. The groundwater quality assessment also was done by some researchers in Cauvery deltaic region for drinking [8] and in Kadava River basin for both drinking [9] and irrigation [10] using the same method. The studies related to assessment of groundwater quality using both Canadian and Weighted Average water quality indices in Vizianagaram district were not conducted earlier. Therefore, the present study aimed to apply both CCME and WA Water Quality Indices to study groundwater quality in the study area for drinking.

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1.1. Study Area

The study area considered for this work is Bhogapuram, Pusapatirega and Denkada mandals occupied by south eastern part of Vizianagaram district. It lies between17^0-56' and 18^0-08' of the northern latitudes and 83^0-24' and 83^0-39'of the eastern longitudes (Fig.1) and occupies an area of around 410 sq.km and comprises of 86 villages.

Fig-1. Location map of study area

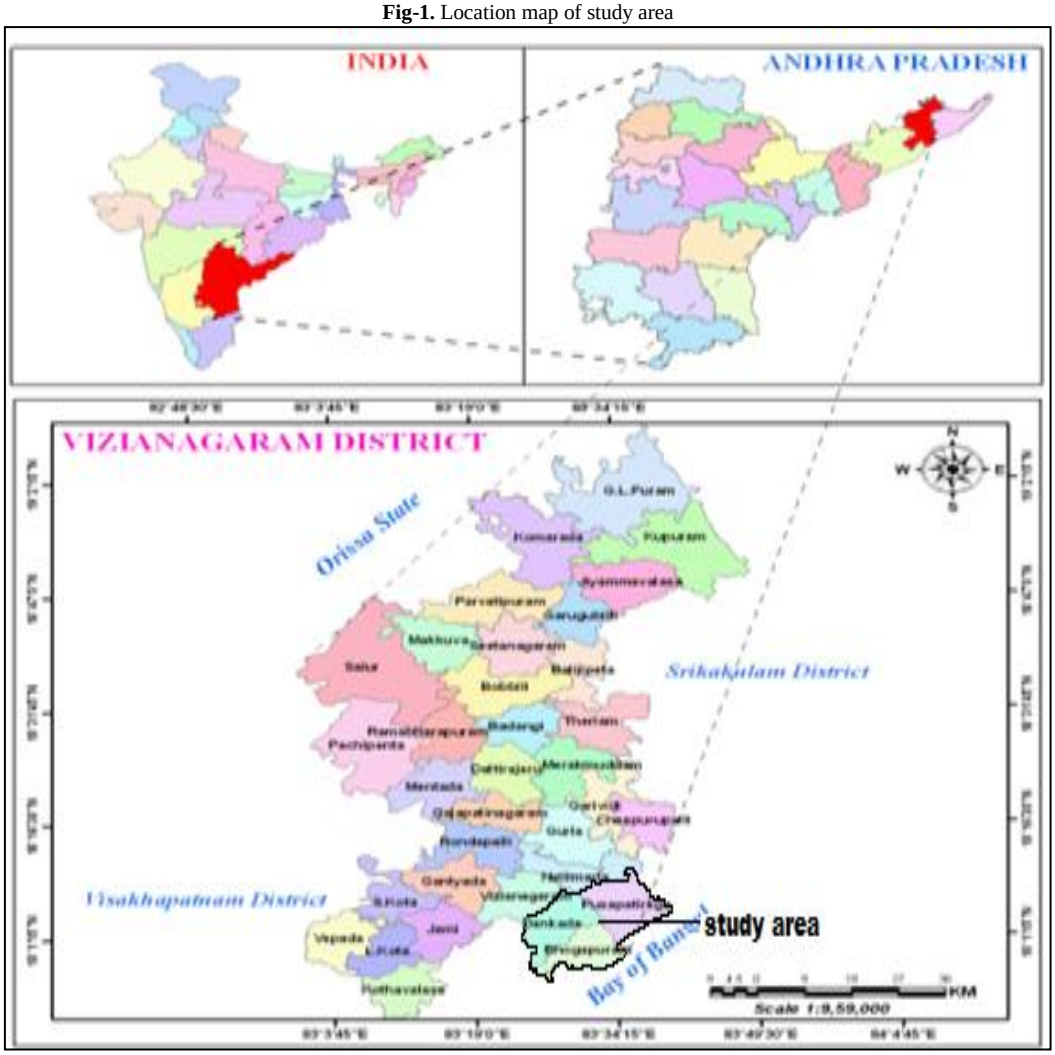

Table-1. Coordinates of Sampling Locations in the Study area

S No	Sample Id	Sampling Station	Mandal	Latitude	Longitude
1	DS1	Bhogapuram	Bhogapuram	18^{0}01'52"	83^{0}30'03"
2	DS2	Boyapalem	Bhogapuram	18^{0}01'42"	83^{0}29'31"
3	DS3	Gudepuvalasa	Bhogapuram	17^{0}59'28"	83^{0}30'22"
4	DS4	Gudivada	Bhogapuram	17^{0}56'24"	83^{0}25'17"
5	DS5	Kancheru	Bhogapuram	17^{0}58'53"	83^{0}32'14"
6	DS6	Nandigam	Bhogapuram	18^{0}01'37"	83^{0}32'05"
7	DS7	Polipilli	Bhogapuram	17^{0}57'39"	83^{0}26'03"
8	DS8	Savaravilli	Bhogapuram	17^{0}59'42"	83^{0}29'42"
9	DS9	Bantupalli	Denkada	18^{0}02'24"	83^{0}28'56"
10	DS10	Boddavalasa	Denkada	18^{0}01'49"	83^{0}24'15"
11	DS11	D kollam	Denkada	18^{0}07'46"	83^{0}28'81"
12	DS12	D thallavalasa	Denkada	18^{0}01'49"	83^{0}25'07"
13	DS13	Denkada	Denkada	18^{0}04'52"	83^{0}28'48"
14	DS14	Modavalasa	Denkada	17^{0}58'13"	83^{0}25'09"
15	DS15	Chintapalli	Pusapatirega	18^{0}04'22"	83^{0}38'42"
16	DS16	Chowdavada	Pusapatirega	18^{0}05'37"	83^{0}38'19"
17	DS17	Govindapuram	Pusapatirega	18^{0}05'34"	83^{0}36'41"
18	DS18	Kumili	Pusapatirega	18^{0}06'3"	83^{0}32'16"
19	DS19	Nadipalli	Pusapatirega	18^{0}03'1"	83^{0}32'59"
20	DS20	Pusapatirega	Pusapatirega	18^{0}01'44"	83^{0}29'24"
21	DS21	Rellivalasa	Pusapatirega	18^{0}05'18"	83^{0}31'26"
22	DS22	Rollichappidi	Pusapatirega	18^{0}04'33"	83^{0}37'47"

2. Materials and Methods

A total number of 264 groundwater samples were collected from different selected sampling locations (vide table 1) of the study area from November 2018 to October 2019. Samples were collected in polythene bottles, pre-cleaned by washing with non-ionic detergents, rinsed with water, 1:1 hydrochloric acid and finally with de-ionized water. Before sampling, the bottles were rinsed three times with sample water. Tube wells are operated at least five minutes before collection of the water samples. The water quality parameter estimation was done using standard methods and techniques [11]. pH and EC are measured using digital pH meter (Elico LI-120) and conductometer (Elico CL-351) respectively. TDS is determined by gravimetric method whereas parameters like Total Hardness (TH), Total Alkalinity (TA), Calcium, Magnesium, Chloride, Carbonates and Bicarbonates are determined by titrimetric method. Nitrate (NO_3^-) ion is determined using UV-visible spectrophotometer (Elico SL-177) with 1cm quartz cell, using Phenol Disulphonic Acid (PDA) method whereas Fluoride (F^- ion) is determined by SPADNS method and other parameters such as Sulphate is determined by turbidimetry using standard barium chloride solution. Sodium ion is measured by flame photometry (Elico CL-361).

2.1. Water Quality Indices

Several WQIs have been proposed by Researchers [12, 13] and used appropriately by Governmental agencies and researchers. They are Canadian Council of Ministers of Environment Water Quality Index (CCMEWQI), National Sanitation Foundation Water Quality Index (NSFWQI) and Oregon Water Quality Index (OWQI) and Weighted Arithmetic Water Quality Index Method (WAWQI).

2.2. CCME Water Quality Index

Canadian water quality index is the water quality index developed by the Canadian Council of Ministers of the Environment [14] and is used among the researchers in developing countries for simplifying the reporting of water quality data and delivers a broad overview of water quality data. It requires Water Quality Objectives (WQOs) and this model essentially consists of three measures of variance from selected WQOs (scope, frequency and amplitude) that combine to produce a value between 0 and 100 that represent the overall water quality. Scope represents the number of variables not meeting water quality objectives; frequency considers the number of times these objectives are not met; and amplitude is the measure of the amount by which the objectives are not met. In the CCME -WQI a value of 100 (excellent) is the best possible index score and a value of 0 (poor) is the worst possible. This index categorizes the quality of water for the overall use as well as for drinking, aquatic, recreation, irrigation and livestock rearing. Fourteen parameters are considered for calculating the water quality index. Based on CCME -WQI values, ranking of water is classified [14], as shown in the table 2**.**

Table-2. Classification of water quality based on CCME-WQI values

WQI range	Ranking of water quality	Remarks
95-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
80-94	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
65-79	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
45-64	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0-44	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

2.3. Weighted Arithmetic Water Quality Index

The WAWQI is also the most popular index [15] where the infrastructure for data collection is not extensive for the development of vast database of the water quality parameters and reliable rating curves are rare. This model consists of two steps. I step: measurement of Unit weight (W_i) and Quality rating (Q_i). II step: Product of these two measures to give a value between 0 and 100 that represent the overall water quality. Based on WA-WQI values, quality rating of water is classified [16] as shown in the Table 3.

Table-3. Classification of water quality based on WQI values

WQI range	Status of water quality
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unsuitable for drinking

3. Results and Discussions

The test results of varied parameters are showing some fluctuations based on chemical analysis. The Range and mean values of the analyzed parameters and permissible values as per WHO/ BIS are presented in table 4.

Table-4. Analysis of Groundwater samples: Minimum, Maximum and Average values of Physical and Chemical parameters

Sample ID	DS1			DS2			DS3			DS4			DS5			Permissible
Parameters	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	values (Si)
	MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		
pH	7.50	8.00	7.73	6.78	7.50	7.21	7.00	7.50	7.30	7.08	7.50	7.24	7.00	7.60	7.27	8.5
EC	4516.00	4548.00	4534.00	1345.00	1376.00	1360.42	2407.00	2446.00	2429.58	2080.00	2126.00	2103.33	985.00	1040.00	1017.00	1000
TDS	2910.00	2930.00	2921.25	880.00	900.00	890.25	1560.00	1585.00	1574.67	1351.00	1380.00	1365.83	650.00	685.00	670.42	600
NO3	67.00	72.00	69.89	8.00	13.00	9.95	22.00	27.00	24.00	19.00	24.00	22.17	7.00	12.00	9.27	50
TH	630.00	645.00	638.33	475.00	495.00	485.00	510.00	530.00	519.17	350.00	365.00	357.50	170.00	190.00	177.92	500
Ca	159.00	165.00	161.83	63.00	68.00	65.42	327.00	330.00	328.17	167.00	171.00	168.50	42.00	45.00	43.42	200
Mg	56.00	59.00	57.92	75.00	79.00	76.92	189.00	194.00	191.83	190.00	194.00	192.00	15.00	19.00	17.42	150
Na	550.00	556.00	553.83	144.00	149.00	146.67	465.00	475.00	470.83	387.00	394.00	391.17	76.00	81.00	79.00	200
Cl	845.00	860.00	850.83	215.00	230.00	223.33	690.00	707.00	700.08	590.00	610.00	600.42	120.00	124.00	121.75	250
SO4	17.00	23.00	20.50	11.00	15.00	13.17	19.00	25.00	22.17	85.00	89.00	87.33	10.00	14.00	11.75	250
CO3	12.00	20.00	16.00	52.00	58.00	54.08	476.00	486.00	480.75	250.00	270.00	257.92	12.00	22.00	17.50	30
HCO3	640.00	680.00	658.33	368.00	410.00	385.67	640.00	680.00	660.83	540.00	580.00	560.00	140.00	170.00	153.33	500
F	0.49	0.64	0.55	0.31	0.54	0.43	1.02	1.23	1.15	0.23	0.40	0.32	0.46	0.64	0.55	1.2
TA	660.00	700.00	678.33	388.00	430.00	405.67	660.00	700.00	680.83	560.00	600.00	580.00	160.00	190.00	173.33	200

Sample ID	DS6			DS7			DS8			DS9			DS10			Permissible
Parameters	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	values (Si)
	MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		
pH	7.10	7.60	7.29	7.00	7.63	7.25	6.63	7.40	7.09	7.50	8.00	7.74	7.00	7.40	7.24	8.5
EC	1268.00	1313.00	1291.83	6180.00	6204.00	6190.67	1485.00	1516.00	1500.33	3260.00	4548.00	3697.50	400.00	2632.00	2426.75	1000
TDS	831.00	860.00	845.33	3975.00	3990.00	3982.50	970.00	990.00	979.50	2106.00	2930.00	2386.00	1680.00	1704.00	1690.67	600
NO3	10.00	15.00	12.17	32.00	35.00	33.53	18.00	23.00	20.94	42.00	46.00	44.06	27.00	31.00	29.00	50
TH	325.00	345.00	335.83	1975.00	1990.00	1981.92	295.00	315.00	305.00	835.00	855.00	845.00	515.00	535.00	527.33	500
Ca	91.00	94.00	92.17	198.00	202.00	199.17	20.00	24.00	22.00	42.00	46.00	44.00	74.00	78.00	76.00	200
Mg	194.00	198.00	196.17	359.00	363.00	361.00	58.00	61.00	59.17	175.00	179.00	177.00	81.00	85.00	83.00	150
Na	154.00	159.00	156.00	1100.00	1107.00	1103.92	155.00	160.00	157.67	317.00	324.00	321.00	175.00	184.00	180.58	200
Cl	238.00	243.00	240.42	1643.00	1648.00	1645.33	238.00	245.00	241.25	485.00	502.00	493.00	265.00	285.00	275.00	250
SO4	121.00	125.00	122.67	152.00	157.00	154.33	64.00	68.00	66.00	157.00	161.00	159.00	87.00	91.00	89.00	250
CO3	210.00	220.00	215.33	400.00	406.00	402.25	0.00	12.00	8.00	94.00	99.00	96.67	5.00	10.00	7.83	30
HCO3	500.00	530.00	518.33	620.00	660.00	635.00	240.00	280.00	260.83	436.00	480.00	455.50	470.00	510.00	495.67	500
F	0.31	0.44	0.36	0.51	0.65	0.58	0.97	1.15	1.07	0.54	0.69	0.61	1.19	1.41	1.30	1.2
TA	520.00	550.00	538.33	640.00	680.00	655.00	260.00	300.00	280.83	456.00	500.00	475.50	490.00	530.00	515.67	200

Sample ID	DS11			DS12			DS13			DS14			Permissible
Parameters	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	values (Si)
	MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		
pH	7.19	8.00	7.67	7.30	7.90	7.57	7.60	8.10	7.85	6.90	7.40	7.11	8.5
EC	1538.00	1579.00	1561.75	907.00	954.00	935.83	3610.00	3673.00	3641.33	391.00	477.00	420.17	1000
TDS	1004.00	1030.00	1019.33	600.00	630.00	618.00	2330.00	2370.00	2350.00	270.00	325.00	288.33	600
NO3	5.00	9.00	7.00	15.00	19.00	17.00	32.00	36.00	34.00	4.00	7.00	5.68	50
TH	350.00	370.00	359.67	345.00	370.00	355.00	1230.00	1260.00	1248.33	180.00	194.00	189.00	500
Ca	75.00	79.00	77.00	85.00	89.00	87.00	137.00	141.00	139.00	27.00	31.00	29.00	200
Mg	39.00	43.00	41.00	32.00	36.00	34.00	215.00	219.00	217.00	27.00	31.00	29.00	150
Na	26.00	30.00	28.33	56.00	61.00	58.67	476.00	484.00	480.58	34.00	39.00	36.83	200
Cl	41.00	47.00	43.33	85.00	95.00	90.33	710.00	725.00	717.67	50.00	61.00	56.33	250
SO4	23.00	27.00	25.00	23.00	27.00	25.00	2.00	7.00	4.17	32.00	36.00	34.00	250
CO3	17.00	21.00	19.00	9.00	14.00	11.25	269.00	275.00	271.67	0.00	13.00	7.17	30
HCO3	320.00	350.00	331.00	340.00	390.00	365.00	720.00	770.00	748.83	140.00	180.00	164.17	500
F	0.36	0.53	0.44	0.27	0.44	0.35	0.54	0.68	0.61	0.51	0.65	0.57	1.2
TA	340.00	370.00	351.00	360.00	410.00	385.00	740.00	790.00	768.83	160.00	200.00	184.17	200

Sample ID	DS15			DS16			DS17			DS18			Permissible
Parameters	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	values (Si)
	MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		
pH	7.30	7.70	7.47	7.10	7.50	7.29	7.10	7.84	7.37	7.00	7.50	7.23	8.5
EC	4852.00	4891.00	4867.67	1657.00	1688.00	1672.33	1885.00	1923.00	1904.83	1445.00	1476.00	1461.50	1000
TDS	3125.00	3150.00	3135.00	1080.00	1100.00	1090.00	1225.00	1250.00	1238.75	945.00	965.00	955.00	600
NO3	25.00	29.00	26.77	13.00	16.00	14.64	19.60	26.00	21.88	21.00	26.00	23.42	50
TH	810.00	830.00	817.92	424.00	440.00	432.08	330.00	350.00	340.00	405.00	420.00	412.08	500
Ca	47.00	50.00	48.17	47.00	50.00	48.17	173.00	176.00	174.50	46.00	50.00	47.83	200
Mg	168.00	172.00	170.00	71.00	76.00	73.92	66.00	70.00	68.00	69.00	73.00	70.92	150
Na	268.00	275.00	272.25	191.00	197.00	194.17	340.00	346.00	342.83	219.00	223.00	220.83	200
Cl	409.00	414.00	411.33	285.00	295.00	291.00	535.00	546.00	540.50	335.00	340.00	338.00	250
SO4	41.00	45.00	43.00	29.00	33.00	30.75	51.00	56.00	53.25	50.00	56.00	52.75	250
CO3	159.00	168.00	162.00	14.00	21.00	17.25	115.00	123.00	119.00	30.00	38.00	33.50	30
HCO3	460.00	490.00	474.50	390.00	430.00	408.33	360.00	410.00	385.33	280.00	330.00	300.33	500
F	1.20	1.45	1.33	0.43	0.61	0.52	0.68	0.84	0.76	0.35	0.47	0.40	1.2
TA	480.00	510.00	494.50	410.00	450.00	428.33	380.00	430.00	405.33	300.00	350.00	320.33	200

Sample ID	DS19			DS20			DS21			DS22			Permissible values (Si)
Parameters	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	RANGE		MEAN	
	MIN	MAX		MIN	MAX		MIN	MAX		MIN	MAX		
pH	6.90	7.40	7.17	7.00	7.50	7.24	7.10	7.55	7.33	7.10	7.50	7.29	8.5
EC	1702.00	1750.00	1722.92	1126.00	1180.00	1154.67	1702.00	1750.00	1723.17	1960.00	1992.00	1976.75	1000
TDS	1110.00	1140.00	1122.92	741.00	775.00	758.75	1110.00	1140.00	1123.17	1275.00	1295.00	1285.00	600
NO3	19.60	26.00	21.88	21.00	26.00	23.75	19.60	26.00	21.88	5.00	9.00	7.29	50
TH	425.00	435.00	431.83	160.00	180.00	168.50	340.00	360.00	348.00	340.00	354.00	347.92	500
Ca	119.00	122.00	120.17	32.00	36.00	34.00	57.00	61.00	58.67	21.00	24.00	22.33	200
Mg	30.00	34.00	32.00	18.00	22.00	20.17	88.00	92.00	89.67	70.00	74.00	72.00	150
Na	230.00	234.00	232.33	31.00	35.00	33.17	130.00	135.00	133.00	55.00	61.00	58.25	200
Cl	343.00	347.00	345.00	49.00	52.00	50.83	201.00	205.00	203.08	84.00	95.00	88.33	250
SO4	22.00	25.00	23.00	31.00	35.00	32.83	51.00	55.00	53.00	53.00	57.00	55.00	250
CO3	0.00	21.00	16.08	10.00	14.00	11.83	14.00	24.00	17.50	10.00	15.00	12.33	30
HCO3	430.00	480.00	453.50	120.00	150.00	130.00	430.00	470.00	454.67	300.00	340.00	323.33	500
F	0.57	0.72	0.64	0.29	0.46	0.38	0.29	0.46	0.38	0.54	0.66	0.61	1.2
TA	450.00	500.00	473.50	140.00	170.00	150.00	450.00	490.00	474.67	320.00	360.00	343.33	200

All units are in mg/l except pH (no units) and EC (micro Siemens/cm). EC= Electrical Conductivity; TDS= Total dissolved solids; TH= Total Hardness; TA= Total alkalinity.

Table-5. Calculated values of CCME-WQI of analyzed samples in the study area

TERM OF CCME INDEX↓	DS1	DS2	DS3	DS4	DS5	DS6	DS7	DS8	DS9	DS10	DS11
TERM OF CCME INDEX↓											
F1 (SCOPE)	57.14	28.57	78.57	57.14	14.29	42.86	71.43	21.43	57.14	50.00	21.43
F2 (FREQUENCY)	57.14	28.57	73.21	57.14	13.69	42.26	64.88	21.43	57.14	42.26	21.43
NSE (NORMALISED SUM OF EXCURSIONS)	1.07	0.19	1.78	1.05	0.01	0.64	2.88	0.11	0.84	0.37	0.14
F3 (AMPLITUDE)	51.65	16.04	64.03	51.11	0.96	38.90	74.20	9.89	45.57	26.76	12.59
CCMEWQI	27.12	66.97	4.99	27.35	84.95	45.54	7.51	75.78	29.51	46.26	75.07
RANKING	POOR	FAIR	POOR	POOR	GOOD	MARGINAL	POOR	FAIR	POOR	MARGINAL	FAIR
SAMPLE ID→	DS12	DS13	DS14	DS15	DS16	DS17	DS18	DS19	DS20	DS21	DS22
TERM OF CCME INDEX↓											
F1 (SCOPE)	14.29	64.29	0.00	64.29	28.57	42.86	42.86	35.71	14.29	21.43	21.43
F2 (FREQUENCY)	13.69	64.29	0.00	63.69	28.57	42.86	42.26	35.71	14.29	21.43	21.43
NSE (NORMALISED SUM OF EXCURSIONS)	0.07	1.58	0.00	1.13	0.20	0.56	0.16	0.25	0.03	0.21	0.20
F3 (AMPLITUDE)	6.39	61.30	0.00	53.09	16.64	35.89	13.73	20.02	2.91	17.49	16.84
CCMEWQI	84.20	16.68	100.00	20.28	66.80	46.48	53.09	58.72	84.49	73.41	73.66
RANKING	GOOD	POOR	EXCELLENT	POOR	FAIR	MARGINAL	MARGINAL	MARGINAL	GOOD	FAIR	FAIR

Table-6. Calculated values of WA-WQI of analyzed samples in the study area

SAMPLE ID	DS1	DS2	DS3	DS4	DS5	DS6	DS7	DS8	DS9	DS10	DS11
WA-WQI	58.14	47.20	145.02	64.74	49.76	61.20	103.93	84.72	68.33	102.18	43.99
Status	Poor	Good	Unsuitable	Poor	Good	Poor	Unsuitable	Very poor	Poor	Unsuitable	Good

SAMPLE ID	DS12	DS13	DS14	DS15	DS16	DS17	DS18	DS19	DS20	DS21	DS22
WA-WQI	37.08	88.46	49.81	121.93	49.78	78.00	43.60	58.52	38.11	40.74	54.06
Status	Good	Very poor	Good	Unsuitable	Good	Very poor	Good	Poor	Good	GOOD	POOR

4. Conclusions

1. a) Based on CCME-WQI analysis, the results indicated that the water samples at 12 sampling stations(DS1, DS3, DS4, DS6, DS7, DS8, DS10, DS13, DS15, DS17, DS18, DS19) out of 22 (about 55%) of the study area do not meet the required standards for drinking purpose as they were ranked as poor and marginal.

   b) The water samples at 6 sampling stations (DS2, DS8, DS11, DS16, DS21 and DS22) were ranked as Fair. It is proposed that appropriate treatment and measures are to taken before the consumption of water collected from these stations.
2. Based on WA-WQI analysis, the results indicated that the water samples at 13 sampling stations (DS1, DS3, DS4, DS6, DS7, DS8, DS9, DS10, DS13, DS15, DS17, DS19, DS22) out of 22 (about 59%) of the study area do not meet the required standards for drinking purpose as their status was classified under unsuitable, very poor and poor category

References

[1] Giriyappanavar, B. S. and Patil, R. R., 2013. "Application of CCME WQI in Assessing Water Quality for Fort Lake of Belgaum, Karnataka, ." *Indian Journal of Applied Research,* vol. 3, pp. 32-33.

[2] Giriyappanavar, B. S. and Shivalli, P. B., 2013. "Assessment of Water Quality Using CCME WQI For Hubli Temple Tank, Karnataka State." *India International Journal of Recent Scientific Research,* vol. 4, pp. 1507-1511.

[3] Mahesh, K. M. K., Mahesh, M. K., and Sushmitha, B. R., 2014. "CCME water quality index and assessment of physico-chemical parameters of Chikkakere, Periyapatna, Mysore District, Karnataka State, India." *International Journal of Innovative Research in Science, Engineering and Technology,* vol. 3, pp. 15343-15347.

[4] Sataa, A., Al- Bayati, J. F., AL-Rifaie, K., and Noor, I., S., 2017. "Applied of CCME water quality index for protection of Aquatic Life for Al-Hussainiya River within Karbala City, Iraq." *International Journal of Current Engineering and Technology,* vol. 7, pp. 99-103.

[5] Giriyappanavar, B. S. and Shivalli, P. B., 2013. "Assessment of Water Quality Using CCME WQI For Hubli Temple Tank, Karnataka State, India." *International Journal of Recent Scientific Research,* vol. 4, pp. 1507-1511.

[6] Mahagamagea, M. G. Y. L. and Pathmalal, M. M., 2014. "Water quality index (CCME-WQI) based assessment study of water quality in Kelani River Basin, Sri Lanka." In *The 1st Environment and Natural Resources International Conference. Thailand.* pp. 199-204.

[7] Robert, D. and Pirro, I., 2013. "Evaluation of water quality index for drinking water." *Pol. J. Environ. Stud.,* vol. 22, pp. 1045-1051.

[8] Venkatramanan, S., Chung, S. Y., Ramkumar, T., Rajesh, R., and Gnanachandrasamy, G., 2016. "Assessment of groundwater quality using GIS and CCME WQI techniques: a case study of Thiruthuraipoondi city in Cauvery deltaic region, Tamil Nadu, India, ." *Desalination and Water Treatment,* vol. 57, pp. 12058–12073.

[9] Wagh, V. M., Shrikant, M., Dipak, P., Uday, S., Manesh, A., and Aniket, M. Y., 2019. "Development of CCME WQI model for the groundwater appraisal for drinking in Basaltic terrain of Kadava River basin, Nashik, India." *Indian J. MAR. SCI.,* vol. 48, pp. 1933-1940.

[10] Wagh, V. M., Panaskar, D. B., Muley, A. A., and Mukate, S. V., 2017. "Groundwater suitability evaluation by CCME WQI model for Kadava River Basin, Nashik, Maharashtra, India." *Modeling Earth Systems and Environment,* vol. 3, pp. 557-565.

[11] APHA/AWWA/WEF, 1998. "Standard methods for the Examination of water and waste water." In *American Public Health Association/ American water works association, Water Environment Federation, Washington DC, USA.* pp. 235-237.

[12] Bharti, N. and Katyal, D., 2011. "Water quality indices used for surface water vulnerability assessment." *International Journal of Environmental Sciences,* vol. 2, pp. 154-164.

[13] Shweta, T., Bhavtosh, S., Prashant, S., and Rajendra, D., 2013. "Water quality assessment in terms of water quality index." *American Journal of Water Resources,* vol. 1, pp. 34-38.

[14] Canadian Council of Ministers of the Environment CCME, 2001. "Canadian water quality guidelines for the protection of aquatic life: CCME water quality index 1.0." presented at the Technical Report, Canadian Council of Ministers of the environment winnipeg, MB, Canada.

[15] Satish, D., Chandra, S. S., and Asadi, M. V. S., 2017. "Raju Estimation of Water Quality Index by weighted arithmetic Water Quality Index method: A model study." *International Journal of Civil Engineering and Technology,* vol. 8, pp. 1215-1222.

[16] Chatterjee, C. and Raziuddin, M., 2002. "Determination of Water quality index of a degraded river in Asonsol Industrial area, Raniganj, Burdwan, West Bengal." *Nature, Environment and Pollution Technology,* vol. 1, pp. 181-189.