International Journal of Advanced Science and Research
ISSN: 2455-4227; Impact Factor: RJIF 5.12
Received: 27-12-2019; Accepted: 28-01-2020; Published: 29-02-2020
www.allsciencejournal.com
Volume 5; Issue 1; 2020; Page No. 16-20

Studies on physicochemical parameters to assess the water quality of River Narmada for drinking purpose

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Abstract
A systematic find out about has been carried out to verify the water fantastic index of River Narmada in Amarkantak district Anuppur (M.P.). 60 water samples from 5 sampling stations have been collected and analysed for physico-chemical parameters (Temp, velocity, pH, dissolved oxygen, free CO_2, C.O.D., B.O.D., Carbonate, Bicarbonate, complete alkalinity, hardness, turbidity, calcium, magnesium, sodium, potassium, nitrate, phosphate, chloride, sulphate, electrical conductivity, complete dissolved solids and total suspended solids.) The learn about region experiences a seasonal local weather and generally divided into three seasons as wintry weather (November to February), Summer (March to June) and wet (July to October). The samples were accumulated and analysed for two consecutive years 2018 and 2019. Each parameter was once compared with the standard suitable restrict of that parameter in river water as prescribed by means of one-of-a-kind agencies. The analytical information of a number physicochemical parameters shows that some parameters like pH, electrical conductivity, complete dissolved solids, whole suspended solids, turbidity and sodium are found to be in extra than the prescribed limit in some water samples of the learn about areas. The WQI value suggests that water samples of some sampling stations are pretty unfit for drinking reason because of high fee of dissolved solids and sodium. It was once additionally observed that the water in the year 2018 was of a better exceptional than in the year 2019. Suitable tips were made to improve the high-quality of river water.

Keywords: water pollution, Narmada River water, physicochemical analysis, Water quality index, potability

Introduction

India has a network of rivers and blessed with snow cover in the Himalayan range that gives perennial rivers. However, with the rapid increase in the pollution of the rivers and the need to meet the increasing demand of irrigation, human and industrial consumption, the available water resources are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to discharge of untreated sewage and industrial effluents. River Narmada is one of the 13 prominent rivers of India which covers 98,797sq km of total water shed area. Narmada is the lifeline and west flowing river of the states of Madhya Pradesh and Gujarat. Only small amount of water that occurs in fresh water rivers, streams, lakes and tanks is available for the terrestrial life (Wetzel 1975) [1].

The indiscriminate and large scale deforestation and over grazing in the watershed areas of river basins have brought about soil erosion ensuing in good sized silting of dams and shrinkage of river flows. This leads to the flooding of the rivers at the time of immoderate rains (Goel, 2006) [2]. The disposal of waste leads to contamination of river and lakes chronically affecting the plant life and fauna. According to surveys carried out on selected stretches of vital rivers, it has been observed that most of the rivers are grossly polluted. The home sewage discharged from a population of about two hundreds of thousands gives upward shove to severa water-borne diseases like typhoid, cholera, dysentery, poliomyelitis and cysticercosis, thereby affecting the human fitness and deterioration of the water quality (Sharma *et al.* 1996) [3]. Narmada, the mighty Indian river originates from the Amarkantak hill Satpura, is the lifeline of millions of Indians. From its source to its entry in to the Bay of Khambhat Gujrat, it travels a distance of around 1312 Kms. Amar kantak is a pilgrim town and a Nagar Panchayat in Anuppur, Madhya Pradesh, India. The Amarkantak region is a unique natural heritage area and is the meeting point of the Vindhya and the Satpura Ranges, with the Maikal Hills being the fulcrum. Amarkantak is a combination of two Sanskrit words, amara (immortal) and kantaka (obstruction). The poet Kalidas has mentioned it as Amrakuta, which later became Amar kantak. Amarkantak is located in the state of Madhya Pradesh in India at 22.67°N 81.75°E. It has an average elevation of 1,048 metres (3,438 ft). Roads running through Rewa, Shahdol, Anuppur, Jabalpur, Katni and Pendra connect it. The nearest railway stations are Anuppur and Pendra Road 43 km via Keonchi and only 28 km via Jwaleshwar. The nearest airport is Dumna Jabalpur (Jabalpur Airport) in the city of Jabalpur, Madhya Pradesh (240 km) which has daily flight service to Delhi and Mumbai.

Description of sampling sites (Stations)

1. **Narmada Kund (origin place):** This station is the origin place of Narmada River. The historical Amar kantak temples are situated at this station. Tourists and Pilgrims found visiting this religious and beautiful place through out the year. They also takes holy dips in this kund.
2. **Narmada Kund (outer side):** It is a newly constructed kund. This site is located just out side of the temple parisar.
3. **Barphani ghat:** This station is located about 4 km

away from the station - I. The temples are located at the bank of river near this site. The several religious activities are being conducted at this site during the Mahashivratri mela and other times.

4. **Kapil Dhara:** This site is famous for a big fall on the river Narmada. It is 6 kms away from Narmada temple on its western side. It is connected by all-weather road to Amar kantak. The fall here 150 ft. high. This is sage Kapils site of worship. This area is also rich in vegetation. The peoples takes holy dips per day.
5. **Dudh dhara:** This site is about 200 mtrs away from Kapil dhara. Here river Narmada makes a small water fall from a height of 10 ft. Here river becomes broad, hence the fall looks beautiful. As the area is moist there is a rich vegetation thus becoming one of the potential site for plants collection. The tourists takes holy dip per day.

Accurate and timely information on the quality of water is necessary to shape a sound public policy and to implement the water quality improvement programmes efficiently. One of the most effective ways to communicate information on water quality trends is with indices. Water quality index (WQI) is commonly used for the detection and evaluation of water pollution and may be defined as "a rating reflecting the composite influence of different quality parameters on the overall quality of water" (Mishra and Patel, 2005) [4]. The indices are broadly characterized in to two parts: the physico-chemical indices and the biological indices. The physico-chemical indices are based on the values of various physico-chemical parameters in a water sample, while biological indices are derived from the biological information and are calculated using the species composition of the sample, the diversity of species, their distribution pattern, the presence or absence of the indicator species or groups etc. (Trivedy and Goel, 1984) [5]. Here attempt has been made to calculate the water quality index of the Narmada river water in Amar kantak district Anuppur (M.P.) on the basis of Harkins (1974) [6]., Lohani (1981) [7]. and subsequently modified by Tiwari *et.al.*(1986)[8] based on physico-chemical data.

Methodology

A total of 60 water samples were collected from five different spots during different seasons over a period of two years (November 2017 to October 2019). The samples were taken in BOD bottles and plastic jerry canes and brought to the laboratory with necessary precautions. All samples were labeled properly. Some parameters like temperature, velocity, pH and dissolved oxygen were measured on site. Grab sampling was generally applied during the sampling. Water samples were analysed by standard methods (Khanna, 1993, APHA, 1998, Villanveva *et al.* 2008, Trivedi And Goel, 1986, Mathur, 1982, Manivaskam, 1986) [9-14]. The samples were analyzed for following physicochemical parameters:

Water Temperature (ºC), velocity(m/s), pH, hardness (mg/l), turbidity (JTU), total dissolved solids (mg/l), total suspended solids (mg/l), electrical conductivity (µmho/cm), free CO_2(mg/l), dissolved oxygen (mg/l), B.O.D. (mg/l), C.O.D. (mg/l), alkalinity (mg/l), chloride (mg/l), calcium (mg/l), magnesium (mg/l), sodium (mg/l), potassium (mg/l),carbonate (mg/l), bicarbonate (mg/l) and sulphate (mg/l). Eleven parameters were taken for calculation (Kelly, 1951) [15] of water quality index: Ca, Mg, Na, K, NO_3^-, SO_4^{2-}, Cl^-, hardness, TDSD, B.O.D. and total alkalinity.

It is an established fact that the more harmful a given pollutant is, the smaller is its standard permissible value recommended for drinking water. Therefore, the "Weights" for various water quality characteristics are assumed to be inversely proportional to the recommended standards for the corresponding parameters (APHA, 1998) [10]. that is,

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

Where W_i is the unit weight and S_i is the recommended standard for the I^{th} parameter P_i. The constant of proportionality K in equation can be determined from the condition

$$\sum W_i = K \sum \left(\frac{1}{S_i}\right)$$

The quality rating q_i for the i^{th} parameter P_i is calculated from the following equation:

$$q_i = 100 \left(\frac{V_i}{S_i}\right)$$

Where V_i is the observed value. The sub index S_i for the parameter P_i is given by

$$(S_i) = (q_i w_i)$$

The overall WQI can be calculated by aggregating the quality rating (q_i) or subindices, linearly, and taking their weighted mean, *i.e.*

$$WQI = \left[\left(\frac{\Sigma q_i w_i}{\Sigma w_i}\right)\right]$$

Results and Discussion

The results obtained from analysis of water samples of river Narmada are shown in table 1 and table 2.

Table 1: Mean and Standard deviation of different parameters at different sampling stations.

S. No.	Parameters	Sampling sites									
		Narmada Kund (origin place)		Narmada Kund (Outer side)		Barphani Ghat		Kapil Dhara		Doodh Dhara	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	S.D.
1.	Water Temp	16.65	4.256	16.24	4.183	16.43	4.1024	15.56	4.043	14.72	4.028
2.	Velocity	1.19	0.756	1.26	0.452	1.54	0.567	1.23	0.479	1.35	0.531
3.	pH	8.06	0.161	7.48	0.272	7.36	0.352	7.32	0.287	7.45	0.345
4.	DO	9.29	1.468	9.14	1.598	9.41	1.874	9.51	1.912	9.35	1.784
5.	Free CO_2	3.01	1.582	3.48	1.584	3.15	1.546	3.13	1.637	3.23	1.638

6.	COD	3.86	1.365	9.42	2.737	8.72	3.017	9.05	2.198	9.48	2.945
7.	BOD	2.53	0.861	2.92	0.703	2.56	0.730	2.42	0.714	2.92	0.862
8.	CO_3^{2-}	2.49	1.229	0.22	0.124	0.22	0.077	0.16	0.067	0.15	0.068
9.	HCO_3^-	63.62	20.568	52.41	13.734	50.81	14.496	50.27	14.051	50.32	13.182
10.	Total Alkalinity	65.76	19.791	52.68	13.673	51.05	14.469	50.52	14.219	50.62	13.368
11.	Hardness	100.48	9.950	109.87	7.546	102.42	11.398	117.09	26.631	108.65	10.364
12.	Turbidity	235.83	281.481	211.91	282.669	208.51	278.023	208.21	276.778	203.16	267.041
13.	Ca	16.78	2.371	19.15	2.434	20.78	3.589	15.57	2.382	13.62	2.324
14.	Mg	4.27	0.563	5.68	0.788	6.58	0.565	4.23	0.697	3.49	0.785
15.	Na	12.157	6.065	14.519	6.923	15.198	8.337	15.553	7.876	15.447	7.223
16.	K	2.23	0.567	2.05	0.582	2.07	0.877	2.06	0.811	2.07	0.846
17.	NO_3^-	0.037	0.032	0.048	0.0362	0.042	0.039	0.041	0.025	0.047	0.033
18.	PO_4^{3-}	0.064	0.057	0.106	0.076	0.081	0.0508	0.108	0.0676	0.0987	0.065
19.	Cl^-	6.13	5.157	5.75	4.824	5.71	4.821	5.78	4.906	5.84	4.912
20.	SO_4^{2-}	27.24	6.1971	24.52	6.3475	23.51	4.2921	22.76	3.4552	22.96	3.757
21.	Ec	224.56	146.512	201.47	108.951	196.93	119.890	199.83	121.435	197.76	117.962
22.	TDS	274.87	229.865	332.21	294.7332	392.26	396.492	409.91	401.951	407.83	397.674
23.	TSS	1151.72	1348.997	1123.15	1369.568	1169.91	1452.363	1143.09	1406.98	1155.24	1401.194

Risk of getting cardiovascular diseases and in women toxemia associated with pregnancy. From WQI values, it is suggested that further improvement is required to treat the Narmada water at Amarkantak, Auppur district (M.P.).

Table 2: Mean of different parameters in different sampling stations

S.No.	Parameters	Values	Mean
1	Water Temp.	8.16-16.72	14.12
2	Velocity	0.38-2.17	1.29
3	pH	7.04-8.66	7.66
4	DO	7.18-11.76	9.38
5	Free CO_2	1.16-5.41	3.15
6	COD	4.54-13.76	8.10
7	BOD	1.34-3.92	2.71
8	CO_3^{2-}	0.02-3.50	0.63
9	HCO_3^-	34.0-89.25	53.51
10	Total Alkalinity	33.34-91.6	54.15
11	Hardness	86.56-119.62	108.76
12	Turbidity	18.12-606.14	211.62
13	Ca	10.8-27.6	17.16
14	Mg	2.4-7.5	4.85
15	Na	6.74-28.33	14.72
16	K	1.23-3.44	2.10
17	NO_3^-	0.012-0.102	0.03
18	PO_4^{3-}	0.036-0.23	0.10
19	Cl^-	1.95-13.46	5.83
20	SO_4^{2-}	16.42-37.14	24.42
21	Ec	94.76-410.62	201.41
22	TDS	40.56-536.62	363.44
23	TSS	109.08-3022.74	1142.76

Table 3: Drinking water quality standards (Maximum permissible limit) Standards are taken according to WHO, ISI, CMR etc.

S.No.	Parameter	Standard value (Si)	$W_i=1/S_i$
1	Ca	75	0..133
2	Mg	50	0.02
3	Na	20	0.05
4	K	10	0.1
5	NO_3^-	20	0.05
6	SO_4^{2-}	200	0.005
7	Cl^-	250	0.004
8	Hardness	300	0.0033
9	TDSD	500	0.002
10	BOD	5	0.2

Table 4: WQI Result for the years 2018-2019

S.No.	Sampling Station	Winter		Summer		Rainy	
		2018	2019	2018	2019	2018	2019
1	Narmada Kund (origin place)	25.30	26.85	37.46	38.13	47.31	48.78
3	Narmada Kund (Outer side)	29.44	32.16	42.12	40.16	51.37	54.58

5	Barphani ghat	23.82	31.16	32.44	36.68	51.26	54.65
7	Kapil Dhara	24.17	31.08	33.12	35.71	49.39	59.82
9	Doodh Dhara	25.12	34.34	37.94	37.56	51.68	59.25

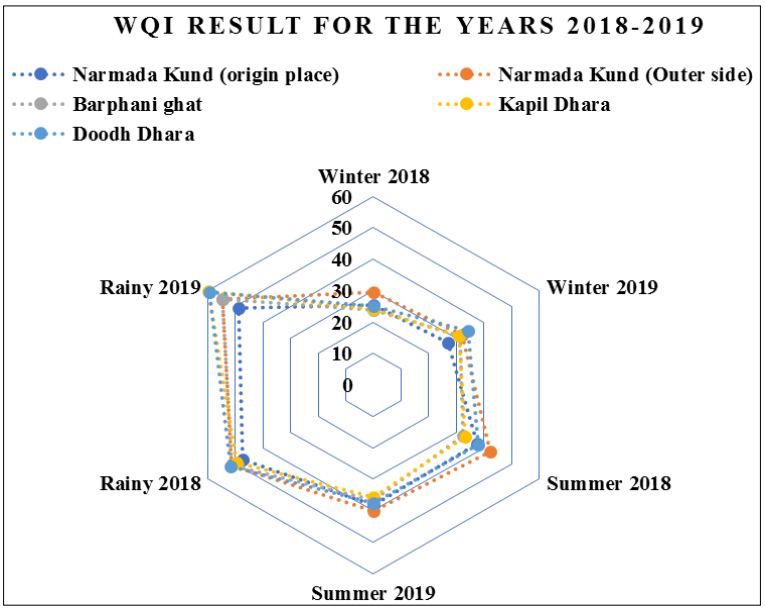

Fig 1

The reported values refer to the mean value of water samples collected in different seasons at different areas along the stretch of Narmada river. The results indicate that the quality of water varies considerably from location to location. A summary of the findings is given below:

The water temperature of the Narmada at Amarkantak district Anuppur ranged between 8.16ºC to 16.72ºC. The water temperature showed an upward trend from winter season to summer season followed by a downward trend from rainy season onwards.

The velocity was found to be directly proportional to the flood level and also with gradient of the river stretch. The maximum velocity 2.17 m/s of the Narmada at Amarkantak district Anuppur was recorded in monsoon season and the minimum velocity 0.38m/s was observed in winter season.

The pH of the Narmada river at Amarkantak was slightly alkaline. It ranged from 7.04 to 8.66. The Narmada water contained highest dissolved oxygen during winter season, followed by a gradual decrease to its lowest values during monsoon season. The higher concentrations of dissolved oxygen during winter season was probably due to low water temperature, no turbidity and increased photosynthetic activity of the green algae found on the submerged stones and pebbles. The maximum 11.76 mg/l oxygen content of water was recorded in winter season and minimum 7.18 mg/l in rainy season. From monsoon season the water of Narmada starts becoming turbid which reduces the photosynthetic activity of the algae and thus decreases oxygen concentration.

Free carbon dioxide in the Narmada water was invariably present throughout the year. It fluctuated from 1.16mg/l in winter season to 5.41 mg/l in rainy season. The free carbon dioxide was found to be maximum in monsoon season and minimum in winter season.

The C.O.D. ranged from 4.54mg/l to 13.76mg/l. The minimum C.O.D. was recorded in monsoon season and maximum in winter season.

The B.O.D. was maximum 3.92 mg/l in monsoon season and minimum 1.34 mg/l in winter season. Total alkalinity throughout the year ranges from 33.34 mg/l in winter season to 91.6 mg/l in summer season. The alkalinity due to carbonates was more or less nil.

The conductivity of water is affected by the suspended impurities and also depends upon the amount of ions in the water. The highest conductivity 410.62µmho/cm of the Narmada water was observed in monsoon season. From monsoon season onwards the conductivity decreased and minimum conductivity 94.76µmho/cm was observed in winter season.

The turbidity in the river Narmada at Amar kantak was lowest during winter season. The maximum turbidity 606.14 JTU was observed in monsoon season and minimum 18.12 JTU was observed in winter season.

Total solids may affect water quality. Water with high total solids generally is of inferior potability. Total dissolved solids were observed maximum 536.62 mg/l in rainy season and minimum 40.56 mg/l in winter season. Total suspended solids were recorded maximum 3022.74mg/l in monsoon season and minimum 109.08 mg/l.

Maximum calcium 27.6 mg/l was found in rainy season. Minimum calcium 10.8 mg/l was found in winter season. Similarly, maximum magnesium 7.5 mg/l was found in rainy season and minimum magnesium 2.3 mg/l was found in winter season. Concentration of Calcium was always greater than that of magnesium.

The hardness was higher in the monsoon season (119.62mg/l) and lower in the winter season (86.56mg/l). Calcium ions make major contribution to the hardness of river water.

Maximum concentration of Sodium 28.33 mg/l was found in rainy season and minimum 6.74 mg/l in summer season. Similarly, maximum concentration of potassium 3.44 mg/lit was found in rainy season and minimum 1.23 mg/l in summer season. Sodium was found to have greater values than potassium throughout the study.

Maximum amount of nitrate (0.102mg/l) was found in rainy

Season and minimum amount (0.012mg/l) was found in summer season. Nitrate concentration depends upon the activity of nitrifying bacteria. The total phosphate was highest in monsoon season (0.23mg/l) and lowest in winter season. (0.036mg/l).

Total sulphate was maximum in monsoon season (37.14mg/l) and minimum in winter season (16.42 mg/l).The chloride was observed maximum (13.46 mg/l) in rainy season and minimum (1.95 mg/l) in winter season.

Water quality index represents the integrated effects of the relevant water quality variables. Table 3 shows drinking water quality standards and unit weights for all the parameters used in calculating WQI. For Narmada river water, the rating of WQI of water samples was calculated and represented in table 4. Graphical representation of variation of WQI at all sampling stations.

It may be stated that the water quality requirements differ from one age to another and thus any polluted water may be considered suitable for some of the beneficial uses but may remain unsuitable for other purposes. Maruthi and Rao, (2004) [16]. gave the rating of water quality as shown below:

Table 1

WQI level	Water quality rating
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit for drinking purpose.

In the present study about water of river Narmada was once found to be in suitable and wonderful pleasant at all the five sampling stations as the WQI ranged from 23.82 to 49.39 for both the years. Water of River Narmada used to be discovered to be of poor fantastic in wet season as WQI at all sampling stations levels from 51.26 to 59.82. The WQI starts off evolved growing from wintry weather to summer season and it similarly will increase from summer time to wet season. It was additionally observed that the water in the year 2018 used to be of higher fantastic than in year 2019.

Conclusion

From existing investigations I concluded that the best of most of the water samples beneath find out about was once appropriate for ingesting motive without in rainy season. In rainy season WQI increases due to accelerated awareness of sodium and dissolved solids. Because of excessive attention of sodium, there is manageable risk of getting cardiovascular ailments and in women toxemia related with pregnancy. From WQI values, it is cautioned that in addition enhancement is required to treat the Narmada water at Amar kantak District Anuppur (M.P.).

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