WATER QUALITY INDEX COMPUTATIONS AT SELECTED LOCATIONS: A CASE STUDY OF BRAHMANI RIVER BASIN, ODISHA, INDIA.

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ABSTRACT: Brahmani is the second largest river in Odisha. It originates by the confluence of Sankh and Koel river at the Vedavyasa, Sundaragarh district Odisha. The water of Brahmani is used for domestic purpose in urban area, agricultural and industrial purposes. At the same time waste water released those contaminate the river flow and are the major cause of deterioration of quality of Brahmani water. This paper aims to assess the water quality of the Brahmani River with the help of water quality index specified as by existing norms . There are so many methods for evaluating water quality index: Canadian Council of Ministers of the Environment Water Quality Index (CCEM-WQI), Water Quality Index method based on Sub Index Calculation, Overall Index of Pollution, Universal Water quality Index (UWQI) or Arithmetic method. In this paper the water quality index is computed by Universal Water quality Index (UWQI) or Arithmetic method. In the present investigation 19 sampling stations about 800Km apart are selected along the river for two years. The selected parameters are for WQI computations: BOD, DO,PH, EC, TSS, TDS, Turbidity, Total Alkanity, Nitrate-N, FC, Ca, Cl, F, Fe, Mg, Na, K, So_4 , Nickel, Zinc, Cromium, Hg, Lead. In this study the WQI of the river varies from good to unfit for drink. Mainly the locations Panposh D/S, Rourkela D/S, Dhenkanal U/Sand Dhenkanal D/S are the highly polluted area and the water unfit for drinking. WQI value is high at the monsoon period and less at post monsoon period.

Key words: WQI, CCEM-WQI, UWQI.

1. INTRODUCTION

For a sustainable world water is an important part. In earth 70% is saline water, 2% is river glassier. water and 1% is ground water. Due to rapid growth of population and Industry, scarcity of ground water takes place. To fulfill the need of ground water, river water is used as drinking water and as such establishing its quality is very much necessary. Water in the rivers get deteriorated due to excedance of contaminant parameter values than standard permissible values. It is very difficult to evaluate the water quality only by tabulating and visualizing the parameters (pesce and Wunderlin 2000;Akkoyunlu and Akiner 2012). Water quality index (WQI) helps to evaluate and understanding the water quality status of surface water as well as ground water (Tyagi et al. 2013) (Seth et al.2014) (Yadav et al. 2015) (Krishna et al. 2016). The study area of this paper is Brahmani river. The water of Brahmani river is polluted by the industries like Talcher Industrial jone (Panda et al.)

2. STUDY AREA

Brahmani river is the second largest river of Odisha. The Brahmani basin is situated with $20^0$28' to 20^0 35'North and 83^0 52 ′ to 87^0 03′ East approximately. The river is formed by the confluence of the major tributaries Sankh and Koel at Vedavyas and emptying into Bay of Bengal at Dhamara. The important towns of the basin are Rourkela, Talcher, Angul, Dhenkanal, Jajpur and Rajgangpur. This basin is rich in mineral resources like Coal, Iron ore, Copper, Bauxite, Chromite, Lime stone, Manganese, Dolomites, Iead, Fire clay and China clay, so the river basin is full of Industries and Towns. Some of the major industries are steel plant at Rourkela, thermal power plant at Talcher, Naclo at Angul and mining industries at Jajpur.

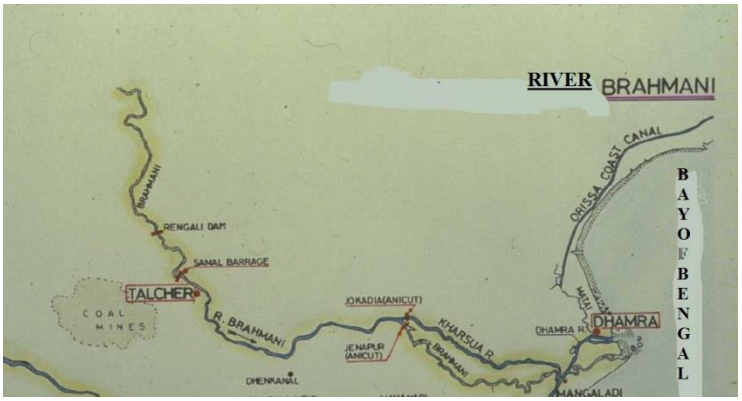

Fig1: The Brahmani River

3. METHODOLOGY

WQI is a single number provides information about water quality of surface as well as groundwater. WQI is easily determined and use for different purposes. In this study the water is collected from twenty sampling station (Panposh U/S, Panposh D/S, Rourkela D/S, birtola, Attaghat, Bonaigarh, Rengali, Samal, Talcher U/S, Talcher D/S, Kamalanga D/S, Kamalanga FD/S, Dhenkanal U/S, Dhenkanal D/S, Bhuban, Kabatabanda, Dharmasala D/S, Pottamundai) during the pre monsoon, monsoon and post

monsoon season over a period of one year January 2016 to December 2017. PH, EC, BOD, DO, TSS, TDS, Turbidity, Total Alkanity, Nitrate-N(NO3-N), Fecal colliform (FC), Ca, Cl, F, Fe, Mg, Na, K, So4, Nickel, Zinc, Chromium, Hg, Lead parameters are consider for water quality analysis. Here WQI is calculated by Weighted Arithmetic Index Method by using Horton's equation (Brown et.al. 1970).

$$WQI = \frac{\sum QnWn}{\sum Wn} \quad \text{----------(1)}$$

Where WQI = water quality index,

Q_n = Quality rating of n^{th} water quality parameter

W_n = Unit weight of n^{th} water quality parameter

3.1 Quality rating (Q_n)

$$Q_n = [(Vn - Vid)/(Sn - Vid)] \times 100 \text{----------(2)}$$

Where Vn = Estimated value of n^{th} water quality parameter at a given sample location.

V_{id}= Ideal value for n^{th} water quality parameter in pure water.

S_n = Standard permissible value of n^{th} water quality parameter.

3.2 Unit weight (W_n)

$$W_n = \frac{K}{Sn} \text{----------(3)}$$

Where

S_n = Standard permissible value of n^{th} water quality parameter.

k = Constant of proportionality and it is calculated by using the expression given in equation

$k = [1/\sum 1/Sn = 1,2,3..]$

In this paper 2 water quality parameters have been considered for assessment of WQI. The standard permissible value of the parameter has given in table no 1

Table-1 water quality parameters and its permissible limit by WHO

Sn No	Parameter	Permissible limit(Sn)	Unit	Vn	Vid	1/Sn	K	Wn	Qn
1	PH	8.5		8.3	7	0.117647	0.00085	0.000100 0489	86.66667

2	EC	700	mS/cm	137	0	0.001429	0.00085	0.000001 2149	19.57143
3	BOD	3	mg/l	1	0	0.333333	0.00085	0.000283 4720	33.33333
4	DO	6	mg/l	9	0	0.166667	0.00085	0.000141 7360	150
5	TSS	100	mg/l	6	0	0.01	0.00085	0.000008 5042	6
6	TDS	500	mg/l	82	0	0.002	0.00085	0.000001 7008	16.4
7	Turbidity	5	NTU	2.8	0	0.2	0.00085	0.000170 0832	56
8	Total Alkanity	200	mg/l	64	0	0.005	0.00085	0.000004 2521	32
9	Nitrate-N(NO3-N)	100	mg/l	0.269	0	0.01	0.00085	0.000008 5042	0.269
10	FC	1.8	MPN/ 100 ml	490	0	0.555556	0.00085	0.000472 4534	27222.22
11	Ca	75	mg/l	38	0	0.013333	0.00085	0.000011 3389	50.66667
12	Cl	250	mg/l	7.8	0	0.004	0.00085	0.000003 4017	3.12

13	F	1.5	mg/l	0.47	0	0.666667	0.00085	0.0005669440	31.33333
14	Fe	0.3	mg/l	0.62	0	3.3333	0.00085	0.0028347202	206.6667
15	Mg	30	mg/l	22	0	0.033333	0.00085	0.0000283472	73.33333
16	Na	200	mg/l	5.2	0	0.005	0.00085	0.0000042521	2.6
17	K	10	mg/l	1.7	0	0.1	0.00085	0.0000850416	17
18	So4	250	mg/l	4.1	0	0.004	0.00085	0.0000034017	1.64
19	Nickel	0.02	mg/l	0.002	0	50	0.00085	0.0425208033	10
20	Zinc	3	mg/l	0.005	0	0.333333	0.00085	0.0002834720	0.166667
21	Chromium	0.05	mg/l	0.013	0	20	0.00085	0.0170083213	26
22	Hg	0.001	mg/l	0.00006	0	1000	0.00085	0.8504160661	6
23	Lead	0.01	mg/l	0.0043	0	100	0.00085	0.0850416066	43

According to the water quality index (WQI), the status and the uses of water is described in table no 2

Table-2 status of water w.r.t WQI and possible uses of water

S. No	WQI	Status	Possible Usages
1	0-25	Excellent	Drinking , Irrigation and Industrial
2	25-50	Good	Domestic, Irrigation and Industrial
3	51-75	Fair	Irrigation and Industrial
4	76-100	Poor	Irrigation
5	101-150	Very Poor	Restricted use for Irrigation
6	Above 150	Unfit for Drinking	Proper treatment required before use

4. Results and Discussion

For water quality analysis, site selection and parameter are the two major tasks. Here 19 sites have been chosen for analysis which are situated near industrial area, urban area and agricultural areas. Monthly samples for a period of two years were collected for the purpose of evaluating WQI. 23 parameters are taken including fecal coli form (FC) and heavy metals. PH indicates the acidity and alkali of water samples. The average of the PH value is within the standard limit. The value of PH is higher in monsoon season with respect to the pre and post monsoon. TDS, TSS and Turbidity indicated the presence of suspended and dissolved solid in water. The concentration of TDS, TSS and Turbidity is high in monsoon and less in post monsoon. Dissolved Oxygen(DO) concentration depends upon the physical, chemical and biological activity of the water body. In this study the concentration of DO varies from 5.8-9.9mg/l. Biological oxygen demand is the total amount of oxygen required for degradation of organic water present in water. BOD is a indicator of organic pollution of water. Higher value of BOD shows the higher level of pollution of water. In this study the BOD concentration varies from0.4-5.4. Chloride is an important parameter for analysis of water quality index. It found in water in the form of salt (NaCl), potassium (KCl), calcium chloride. The source of chloride is weathering of rock, surface runoff, agricultural field and animal fields. In this study the concentration of Cl varies from 5-50 mg/l High concentration of sulphate causes intestine disease. High concentration of floride in water causes various diseases in body and mainly affects to brain and teeth. The presence of fecal coli form indicates the contamination of water body. Fecal coli form is the origin of all other causing agents. High concentration of fecal coli form affects the human as well as environment. In this study the concentration of fecal coli form is very high, mainly at urban areas and very less at Samal and Rengali. The source of heavy metals in water are mainly the industries. The presence of heavy metal in water causes various diseases like cancer, organ damage, nervous system damage and in extreme cases death. In this study the heavy metals are within the standard limit prescribed by WHO.

4.1 WQI

In this study the Water Quality Index Assesment has done by using “Weighted Arithmetic Index”. In this method first “unit weight” has to assigned to every parameter consider for calculation. After that calculation of quality rating has to be done and at last the WQI value will determined by the summation of the product of weight and quality ration. Here maximum weight is assigned to mercury (Hg), which

indicates the significances of mercury in water quality assessment and impact on the index. Table no 3 and 4 indicating the calculated Water Quality Index of the sampling stations for the years 2015 and 2016. In this study the water quality varies from good to unfit for drinking. The four areas i.e. Panposh D/S, Rourkela U/S, Dhenkanal U/S, Dhenkanal D/S shows a very high WQI that indicates the water in that area is highly polluted. Samal and Rengaly shows very less WQI. Figure 2, 3 shows the monthly water quality index of the sampling station in the year 2015 and 2016 respectively.

Table 3: Monthly WQI of the year 2015

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	AVG	STATUS
PANPOSH	74.5766	41.06685	337.8841	56.85746	76.70775	117.145	89.02472	81.99536	169.6575	107.699	154.3254	68.54299	114.6236	Very Poor
Panposh D/S	188.319	160.9743	756.2895	1444.841	171.9736	495.4327	500.7407	1021.862	407.5745	591.9608	1569.422	665.9999	664.6158	Unfit for Drinking
Rourkela D/S	290.877	119.561	252.8849	237.0988	113.5819	247.5823	235.2354	226.919	465.9602	249.6495	625.6765	614.9199	306.6622	Unfit for Drinking
birtola	37.3049	115.5166	46.97762	27.99764	45.93168	49.05154	157.3053	223.1016	168.9962	56.7584	85.59149	138.3656	96.07488	Poor
Attaghat	54.8695	798.9106	10.07434	81.19271	48.83108	114.5244	83.46809	147.5935	242.1013	70.59431	53.52828	67.82927	147.7931	Very Poor
Bonaigarh	12.0064	12.00636	112.6098	21.13591	14.77244	58.5116	287.5398	141.9585	379.4556	27.63235	105.2342	28.6887	100.1293	Very Poor
Rengali	10.4102	9.077349	40.31174	20.95303	42.98139	44.08585	58.76563	130.5232	260.7249	44.40731	86.29329	58.22762	67.23013	Fair
Samal	47.5326	144.3556	22.71198	46.34334	10.31417	105.9951	292.1583	208.7379	358.5416	46.60785	121.2177	86.44651	124.2469	Very Poor

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Pottamundai	dharmasala D/S	Dharmasala U/S	Kabatabandha	Bhuban	dhenkanal D/S	Dhenkanal U/S	Kamalanga FD/S	Kamalanga D/S	Talcher D/S	Talcher U/S
22.77	31.3978	154.356	10.045	22.5666	290.501	1060.67	47.2312	730.462	17.7908	17.6766
48.13969	697.6093	520.7305	11.6944	35.55617	108.9589	156.8204	19.73258	56.76095	29.16822	24.65059
15.412	13.52345	33.40637	25.17561	29.99868	39.18464		17.62868	29.96128	18.76691	11.49441
435.1626	304.219	255.0061	14.38468	23.86655	33.01609	103.389	646.1945	31.7308	21.67327	98.73664
186.1099	158.0894	144.5826	75.0739	432.9946	54.59968	442.0993	116.5764	171.4801	76.59035	30.89496
359.3373	161.1088	169.562	78.51223	110.1542	56.21539	933.0325	102.2364	202.2509	82.74575	65.30991
101.4011	110.0216	88.51914	43.87819	49.33402	922.3942	491.4995	272.6311	289.9	269.1208	32.17555
275.8125	2467.173	496.1905	127.7013	105.148	2496.388	1486.874	206.7355	350.6895	267.7405	206.6961
215.0608	298.4625	229.4408	138.1002	218.4617	2493.993	275.3	84.84486	172.4626	119.5034	97.7798
112.1479	183.0574	173.3233	100.4471	89.55932	2493.993	4235.646	132.2428	83.85835	110.3659	207.5457
58.61836	264.8189	147.6985	67.0278	64.9699	2495.919	246.705	44.58528	64.7066	44.55239	30.56119
86.02949	106.8224	74.7421	29.84918	137.4004	1444.792	1469.06	28.6916	117.5587	55.89303	36.10357
159.6668	399.692	207.2965	60.15747	110.0008	1077.496	908.4246	143.2776	191.8185	92.82594	71.63542
Unfit for Drinking	Unfit for Drinking	Unfit for Drinking	Fair	Very Poor	Unfit for Drinking	Unfit for Drinking	Very Poor	Unfit for Drinking	Poor	Fair

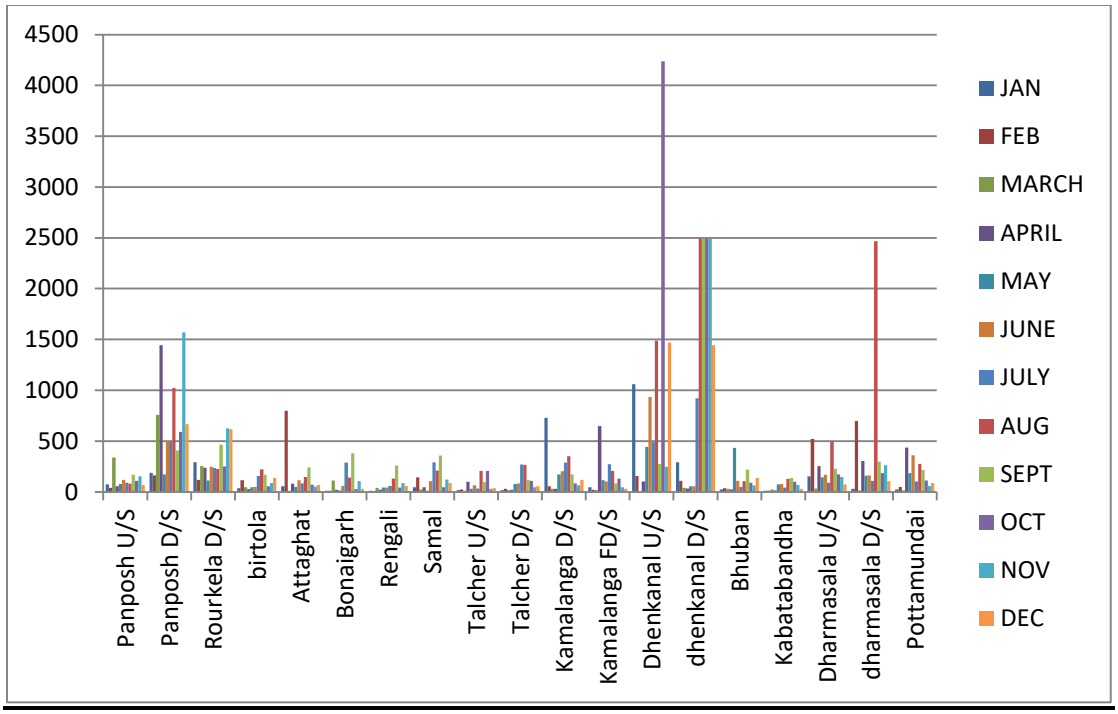

Fig 2: Monthly variation of WQI 2015

Table 4: Monthly WQI of the year 2016

STATION	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	avg	status
Panposh U/S	58.426	60.37106	70.66969	220.0922	934.1874	1431.359	75.2941	32.63169	224.2781	151.857	113.8212	23.14487	283.011	unfit for drinking
Panposh D/S	483.098	476.3835	1450.418	671.2485	1472.982	4249.33	997.4736	4223.312	315.6682	1434.103	1439.206	470.1309	1473.613	unfit for drinking
Rourkela D/S	473	371.1132	310.3948	471.5516	583.4513	2453.382	944.5071	951.7937	231.0534	4483.772	234.9734	365.5056	989.5415	unfit for drinking
birtola	101.5	47.90231	34.82751	34.14992	52.81733	63.15587	116.0211	376.2503	204.4571	57.73911	53.05296	58.76083	100.0529	very poor

Bhuban	dhenkanal D/S	Dhenkanal U/S	Kamalanga FD/S	Kamalanga D/S	Talcher D/S	Talcher U/S	Samal	Rengali	Bonaigarh	Attaghat
229.3966	1450.785	949.6665	53.51421	147.4797	109.8769	75.11615	67.42418	30.29188	21.73976	137.5318
85.57784	949.0595	946.8178	89.2704	267.3513	101.246	107.6783	76.55832	35.43789	33.98504	72.34816
22.8582	228.7028	221.3666	139.613	140.8977	39.28907	35.21037	24.76192	15.32903	104.2573	39.89838
22.74022	220.6765	356.3543	20.41469	58.77328	51.39994	17.46753	59.58368	19.1213	76.28208	34.57277
466.3176	53.76263	82.11115	63.61015	65.89969	51.86152	81.59289	54.86579	75.00454	25.31588	319.7426
147.5917	111.6642	592.3585	36.47947	94.95776	80.19144	55.53722	111.6103	24.32425	28.76947	1450.935
200.4972	148.899	114.7806	227.3931	462.8428	229.4677	145.6401	121.2008	29.32944	87.26056	476.8266
64.94445	102.0249	73.3657	59.89789	121.3017	74.40937	48.63714	39.72008	167.8249	110.0512	471.3375
39.25992	198.1321	431.8307	59.07869	239.2763	225.6966	145.7618	40.33699	147.7047	78.65818	464.949
29.27734	615.5806	1431.565	34.52626	115.69	73.62713	82.90199	55.2226	35.25523	52.13893	208.7422
43.90308	66.5586	1434.848	98.08996	304.9616	2084.913	18.39822	54.65328	47.88572	380.4703	215.498
23.1994	204.107	141.502	32.0458	25.13808	15.25333	12.7243	32.87	117.7791	22.38711	22.69985
114.6303	362.4961	564.7139	76.16114	170.3808	261.436	68.88883	61.56733	62.10733	85.10965	326.2568
very poor	unfit for drinking	unfit for drinking	very poor	unfit for drinking	unfit for drinking	fair	fair	fair	poor	unfit for drinking

Kabatabandha	33.15796	77.73536	34.55525	229.5286	361.1428	148.6154	175.8958	57.0598	25.02457	48.54348	52.81265	430.458	139.5441	very poor
Dharmasala U/S	17.53077	51.86056	26.20039	49.51488	16.71454	51.52789	59.78442	95.38155	28.03488	58.46759	15.14651	25.8151	41.33159	good
dharmasala D/S	74.54002	202.2945	76.3938	77.62883	38.34811	51.9547	151.7939	81.21952	22.26985	56.55883	38.45363	45.9261	76.44848	poor
Pottamundai	63.1185	76.31726	57.29717	154.201	16.71454	24.32425	512.5846	677.306	29.40792	153.0236	133.4282	30.0952	160.6515	unfit for drinking

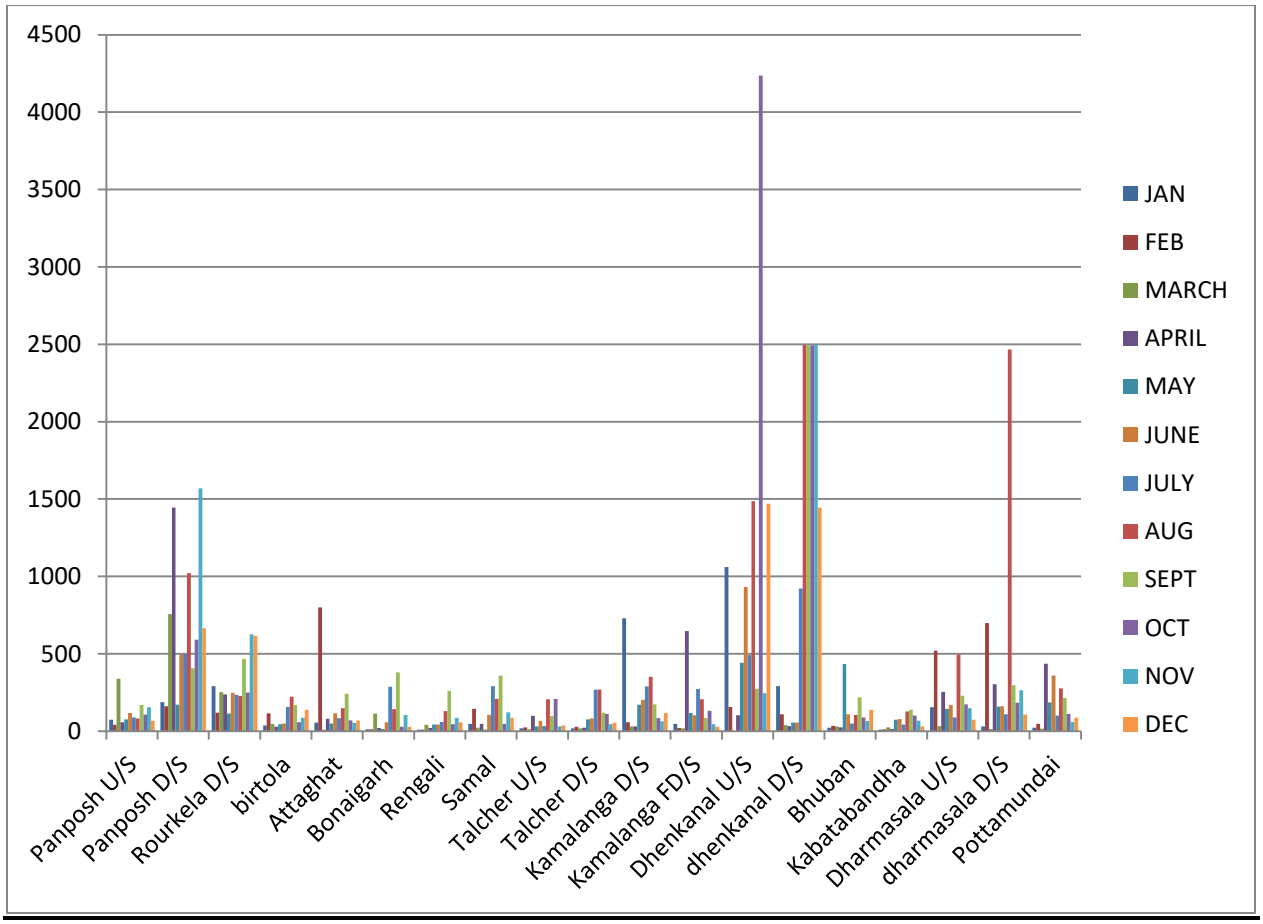

Fig 3: Monthly variation of WQI 2016

5. Conclusion

The water quality within the study area for the years 2015 and 2016 varies from good to unfit for drinking. From the analysis made in the present study, it has been found that Dharmasala upstream shows Good quality of water (WQI<50). The WQI at 11 numbers of locations are unfit for drinking (WQI>150) and required attention towards treatment before attempting for any use.

S .No	Stations name	WQI	Status
1	Panposh U/S	283.011	Unfit for Drinking
2	Panposh D/S	1473.613	Unfit for Drinking
3	Rourkela D/S	989.5415	Unfit for Drinking
4	birtola	100.0529	Unfit for Drinking
5	Attaghat	326.2568	Unfit for Drinking
6	Talcher D/S	261.436	Unfit for Drinking
7	Kamalanga D/S	170.3808	Unfit for Drinking
8	Dhenkanal U/S	564.7139	Unfit for Drinking
9	dhenkanal D/S	362.4961	Unfit for Drinking
10	Bhuban	114.6303	Unfit for Drinking
11	Kabatabandha	139.5441	Unfit for Drinking
12	Pottamundai	160.6515	Unfit for Drinking

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