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Assessment of Water Quality Index in Subarnarekha River Basin in and around Jharkhand Area

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Abstract: *The present investigation is aimed at assessing the current water quality standard along the Subarnarekha river in Jharkhand .Eight samples were collected along the stretches of Subarnarekha basin during the period (Water Year) June-2012 to May-2013 on the first working day of every month.Various physico-chemical parameters like pH,TDS, EC,DO, BOD, Total Hardness, Total alkalinity sodium,potassium,calcium,magnesium etc. were analysed. Eight parameters namely pH,Dissolved Oxygen, Biochemical Oxygen Demand ,Nitrate,Phosphate,Total Dissolved Solids and Faecal Colliform were considered to compute Water Quality Index (WQI) based on National Sanitation Foundation studies.Our findings highlighted the deterioration of water quality in the rivers due to industrialization and human activities.*

Key Words: *NSF Water Quality Index, TDS, EC, DO, BOD, Total Hardness,Faecal Colliform*

I. Introduction

The study is carried out in Subarnarekha river which flows through the East Singhbhum district,which is one of the India's important industrialized areas known for ore mining, steel production, power generation, cement production and other related activities.The Subarnarekha river is the eighth river in India by its flow(12.37 billion m^3/year) and length. The River Subarnarekha is a rainfed river originating near Nagri village ($23^0 18^1 02^{11}$ N, $85^0 11^1 04^{11}$ E) in the Ranchi district,runs through several major cities and towns such as Ranchi, Muri, Jamshedpur, Ghatshila, Adityapur etc covering a distance about 400 km. It finally joins the Bay of Bengal at Kirtania Port($21^0 33^1 18^{11}$ N, $87^0 23^1 32^{11}$ E) in Odisha. Before falling in to the Bay Of Bengal the River flows through Ranchi, Saraikela and East Singhbhum district of Jharkhand, West Midnapur district of West Bengal and Balasore district of Odisha.Of its total length 269 km are in Jharkhand,64 km in West Bengal and 62 km in Odisha.The Subarnarekha basin covers an area 19,300 km^2.This area is nearly the 0.6% of the total national river basin area and yields 0.4% of the country's total surface water resources.Its important tributaries include Kanchi,Karkari,Kharkai and Sankh rivers.

As water is one of the most basic needs of the habitants , its safeness must be studied before use. The present study aims at detecting the quality of water in respect of Water Quality Index based on National Science Foundation Studies. The possible number of such parameters necessary to completely specify the quality of water are very large, out of which taking eight parameters in to consideration the NSF WQI is calculated from which the status of water quality can be assessed. The WQI may help in evaluating base line water quality conditions and developing trends in general water quality(Wills Martin and Irvin Kim N,1996)[1].

Sample Code	Name of the station	River/Tributary	State	District	Latitude	Longitude
S_1	Muri	Subarnarekha	Jharkhand	Ranchi	$22^0$48'56"	$86^0$12'47"
S_2	Adityapur	Kharkai	Jharkhand	Purb Sighbhum	$22^0$47'29"	$86^0$10'06"
S_3	Kulpatanga	Kharkai	Jharkhand	Dumka	86^0 06' 10"	22^0 49'04"
S_4	Jamshedpur	Subarnarekha	Jharkhand	Purb Sighbhum	22^0 47'00"	86^0 12'00"
S_5	Baridhi Nalla	Subarnarekha	Jharkhand	Paschim Singhbhum	86^0 14'33"	22^0 49'05"
S_6	Ghatshila	Subarnarekha	Jharkhand	Purb Sighbhum	22^0 34'49"	86^0 20'08"
S_7	Ghatshila Road Bridge	Subarnarekha	Jharkhand	do	22^0 35'15"	86^0 27'12"
S_8	Jamsholaghat	Subarnarekha	Jharkhand		22^0 13'08"	86^0 43'00"

II. Materials And Methods:

Water samples were collected every month, from June 2012 to May 2013 from eight different stations as mentioned below, in clean and dry polythene bottles.The water samples were collected and preserved for testing of various parameters at 10^o C throughout the period of chemical analysis. The water samples were grouped under following categories:

S_1 =Subarnarekha at Muri

S_2 = Kharkai at Adityapur
S_3 = Kharkai at Kulpatanga
S_4 = Subarnarekha at Jamshedpur
S_5 = Baridhi Nallah
S_6 = Subarnarekha at Ghatshila
S_7 = Subarnarekha at Ghatshila Road Bridge
S_8 = Subarnarekha at Jamsholaghat

The water samples were analysed in the Central Water Commission laboratory, Bhubaneswar using standard methods(APHA 2005). The pH and Dissolved Oxygen of water samples were measured immediately after sampling at the field itself. Samples were subjected to filtration before chemical analysis. The determination of TDS was done by gravimetric process while the total hardness was carried out by EDTA complexometric titration method (APHA 2005).The Winkler's alkali iodide-azide method was followed for the estimation of DO and BOD. Nitrate was determined colorimetric procedure(APHA 2005)[2].Faecal colliform population was analysed by MPN /100 ml method by growing on M-FC medium at temperature 44.5^0 C and counted after 48 hours.

National Sanitation Foundation Water Quality Index (NSFWQI):

In order to summarize water quality data different type of WQ indices have been developed. One such index was developed by Brown et al[3] which was later referred as NSFWQI.As many as 142 WQ experts of USA were contacted and important parameters affecting water quality were assessed along with their respective weightages. Nine parameters were finally accepted to summarize the composite effect on water quality using a single numerical expression. The single numerical index helps to classify the water in to five different classes. Such classification helps to identify river water requiring immediate action on a priority basis. The parameters, their weightings, their classification and the corresponding numerical ranges are given in Tables 1 and 2 respectively.[4,5]

Table 1: NSF WQI Parameter and Weights:

Parameters	**WQI Weight**
Dissolved Oxygen	0.17
Faecal Colliform Density	0.15
pH	0.12
BOD_5	0.1
Nitrates	0.1
Total Phosphates	0.1
Temperature Change	0.1
Turbidity	0.08
Total Solids	0.08

Table 2: WQI Value Ranges (From Mitchell and Stapp,1995)

Classification	WQI Range
Very Bad	0-25
Bad	26-50
Medium	51-70
Good	71-90
Excellent	91-100

III. Calculations:

As per the requirements of NSFWQI, nine parameters were measured for each sample following the standard procedures of APHA every month. All the measured values were used in the online calculation to get their respective index values except dissolved oxygen(mg/l).The dissolved oxygen in mg/l was converted to its percentage saturation value by using DOTABLES software. It is an online programme that converts DO in mg/l to its percentage saturation by using sample parameters such as temperature, pressure and specific conductance. The value of the percentage saturation of dissolved oxygen was used in the online calculation to get its index value. The overall WQI is an online calculation, which is done by putting the the index values against the respective weights.[5]

IV. Result And Discussion:

Table 3,4 and 5 give the min, max and average values of the nine measured parameters at the eight sampling points. Tables 6,7.8,9,10,11,12 and 13 gives the monthly values of these parameters and the resulting Water Quality Index of the eight sampling points During the study period the temperature remains high during summer and rainy season and low during winter. It varied within the range 22^0C to 35^0C.The temperature variation in the river basin is about 12^0C.The pH of most raw water sources lies within the range of 6.5-8.5[3].All

the 96 water samples are found to have pH value within the limit. But some samples have excess pH value. The average pH value ranges from 7.3 to 8.7. The surface water of Subarnarekha at Muri has higher pH than the water from other sources,

Total dissolved solid at a given temperature is the material residue left in the vessel after evaporation of a filtered sample and subsequent drying in an oven. TDS contains different kinds of nutrients and have been proved to be a very useful parameter. A sudden rise in TDS content can often indicate pollution by an extraneous source. Excess amount of TDS may disturb ecological balance and causes imbalance in osmotic regulation and suffocation in aquatic fauna even in presence of a fair amount of dissolved oxygen[4].

Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supply and normally less palatable and may induce an unfavorable physiological reaction in the transient consumer. In the present investigation, it is seen that TDS value of S_2,S_3 and S_5 were slightly ahead of the permissible limit, but water samples of other sources are within the safe limit of TDS value. Dissolved oxygen is one of the most important parameters of water quality assessment and reflects the physical and biological processes prevailing in the water and show metabolic balance. A high DO level in a community water supply is good because it makes drinking water taste better. However, high DO levels speed up corrosion in water pipes. For diverse fish population the DO level must ranges from 4-9 mg/l. However, according to European Economic Community the standard value of DO is 5mg/l of drinking water. Except S_5 all samples were contains more DO values because of domestic sewage effluents and dumping of garbage,Table-8. This causes microbiological contamination consuming the DO [6].

The degree of microbial mediated oxygen consumption in water is known as biochemical oxygen demand. This parameter is commonly measured by the quantity of oxygen utilized by suitable micro-organisms during 5 days period at 20^oC . It is not a pollutant but an indicator to what extent the water is polluted.[9] Its value 6.0 mg/l or more in water body is said to be polluted. Present study reveals that S_1,S_2,S_5 samples contain more BOD values in some months, Overall the river water is not suitable for drinking purpose[7].

The parameter of greatest concern in this study appears to be Faecal Colliform .High values of Faecal Colliform were recorded at many points throught the year(28000 MPN/100ml) The value of nitrate was high at Baridhi ,Jamshedpur.The value of phosphate is very low in most of the places during the study.The lowest value being 0.01 in most of the places and the highest value being 0.14 mg/l at Baridhi and Jamshedpur.

Nowhere in the river stretch,water quality was found to be excellent. High values of NSFWQI was observed at the downstream of Kharkai at Kulpatanga and at the down stream of Subarnarekha at Ghatshila, Ghatshila Road Bridge and Jamsholaghat.Water quality of Subarnarekha is at its lowest from Muri to Jamshedpur region.It may be due to the industrial activities.From the months of January to June and for the months of November and December the water quality at all the sampling stations were good.[8].Water quality at the effluent Baridhi Nallah was bad almost throughout the year.During the month of August water quality at most of the stations were bad.

V. Conclusion

The present study reveals that the presence of Faecal Colliform in Subarnarekha basin is significant.It is due to the lack of the sanitary awareness among the inhabitants of the adjoining localities. High values of TDS during rainy seasons may be due to massive soil erosion.The poor water quality of Baridhi Nallah is due to the improper treatment of the effluents from Jamshedpur steel plant. The prime duty of the educated public should be to spread awareness in the rural as well as the urban areas. City drains connecting the safety tanks should not be allowed to directly fall in to the river. Proper treatment of the solid wastes should be made especially in urban areas. Deforestation should be strictly checked to control soil erosion due to which the TDs and Turbidity increases significantly during monsoon. Above all a long term action plan and online monitoring is a must to ensure the river water quality.[10]

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Table No: 3

Parameters	Categories								
	S_1 (Muri)			S_2 (Adityapur)			S_3(Kulpatanga)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	7.3	8.7	7.85	7.3	8.0	7.57	7.4	8.1	7.80
Turbidity	1.6	328	95.0	2.4	520	103.57	1.8	482	97.5
Total solids	143	455	219.3	143	650.6	279.1	143	118.5	318.8
D.O.	1.6	7.9	6.55	2.0	8.9	6.06	5.4	8.3	6.75
B.O.D	0.2	19.9	2.44	0.4	39.6	4.48	0.1	1.8	0.89
Faecal Colliform MPN/100ml	1200	28000	4641	620	4300	1569	220	5300	1469
Total phosphate	0.01	0.08	0.05	0.01	0.16	0.05	0.01	0.09	0.04
Nitrate	0.18	0.96	0.61	0.36	1.94	0.80	0.18	1.21	0.60
WQI	44	79	69	49	78	70	70	79	74

Table No: 4

Parameters	S_4(Jamshedpur)			S_5(Baridhi Nallah)			S_6(Ghatshila)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	7.1	7.7	7.49	6.9	7.5	7.30	6.2	8.4	7.50
Turbidity	1.4	490	128.5	28.6	560	156.0	1.8	320	79.6
Total Solids	130	195	147.9	149.5	754	389.45	92.95	572	218.99
DO	4.8	7.0	6.00	0.0	7.6	3.23	2.8	10.3	6.45
BOD	0.3	2.2	1.09	0.4	59.8	17.35	0.4	1.4	0.79
Faecal Colliform MPN/100ml	240	7000	2157	1100	24000	5463	170	4600	1350
Total phosphate	0.01	0.14	0.06	0.02	0.24	0.06	0.01	0.06	0.02
Nitrate	0.12	0.83	0.43	0.32	1.38	0.51	0.24	1.26	0.81
WQI	68	78	73	40	73	56	61	78	73

Table No: 5

Parameters	S_7(Ghatshila Rd Bdge)			S_8(Jamsholaghat)		
	Min	Max	Mean	Min	Max	Mean
pH	7.4	8.5	7.70	7.2	8.0	7.50
Turbidity	1.6	392	102.5	1.2	285	84.41
Total solids	143	292.5	213.41	148	253	196.45
D.O.	4.8	10.1	6.9	5.2	6.6	5.85
B.O.D	0.2	3.0	0.96	0.2	1.2	0.58
Faecal Colliform MPN/100ml	220	3800	1458	620	4200	1546
Total phosphate	0.01	0.12	0.03	0.01	0.18	0.04
Nitrate	0.38	1.26	0.79	0.24	1.18	0.65
WQI	69	79	73	68	78	70

Table No: 6 Monthly Water Quality Index at Muri

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	8.4	7.7	7.9	7.6	7.6	7.3	7.7	7.4	8.0	7.9	8.7	8.0
Turbidity	42.6	132	168	328	280	128	32	12	8.2	6.8	1.6	1.2
Total solids	286	279.5	162.5	162.5	149.5	149.5	208	143	156	175.5	305.5	455
D.O.	6.6	1.6	6.6	7.0	6.0	7.6	7.9	7.9	7.9	6.8	6.8	6.0
B.O.D	2.2	19.9	0.4	1.2	0.4	0.6	0.6	0.2	0.4	0.4	2.6	0.4
Faecal Colliform MPN/100ml	4000	5200	1800	1200	1100	1600	28000	1200	3200	2400	2800	3200
Total phosphate	0.04	0.06	0.08	0.06	0.01	0.02	0.06	0.08	0.04	0.06	0.08	0.02
Nitrate	0.42	0.54	0.18	0.56	0.62	0.74	0.42	0.82	0.94	0.68	0.73	0.96
WQI	67	44	69	70	69	73	75	79	78	76	61	72
Classification	Med	Bad	Med	Good	Med	Good	Good	Good	Good	Good	Med	Good

Table No: 7 Monthly Water Quality Index at Adityapur

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.6	7.8	7.7	8.0	7.9	7.5	7.5	7.3	7.6	7.4	7.3	7.3
Turbidity	32.4	122.6	520	320	180	36.2	12.4	8.2	2.4	2.8	3.2	2.7
Total solids	487.5	143	111.2	143	169	169	188.5	214.5	279.5	318.5	650.5	474.5
D.O.	2.0	6.0	5.8	6.8	6.2	7.9	8.9	7.0	6.2	3.2	5.8	7.0
B.O.D	39.6	1.8	0.6	1.2	0.4	0.8	1.6	2.0	3.0	0.4	0.4	2.0
Faecal Colliform MPN/100ml	920	740	830	620	960	1800	2400	4300	2100	1230	1520	1410
Total phosphate	0.04	0.08	0.01	0.06	0.12	0.02	0.01	0.01	0.16	0.02	0.04	0.01
Nitrate	0.46	0.52	0.52	0.38	0.36	0.82	0.98	0.84	1.94	0.78	0.92	1.10
WQI	49	68	69	70	68	76	78	74	71	68	71	73
Classification	Bad	Med	Med	Good	Med	Good	Good	Good	Good	Med	Good	Good

Table No: 8 Monthly Water Quality Index at Kulpatanga

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	8.1	7.9	7.7	7.8	8.0	7.4	7.4	7.6	8.1	8.0	7.9	7.9
Turbidity	24.6	116	181	482	260	62	16.2	12.6	8.6	1.8	2.8	2.4
Total solids	214.5	143	108.5	149.5	162.5	149.5	182	175.5	182	188.5	234	240.5
D.O.	5.4	6.0	5.4	6.4	8.1	7.4	8.3	7.0	7.9	7.0	6.8	5.4
B.O.D	1.2	1.0	0.4	0.8	1.8	0.6	1.8	0.2	0.6	0.4	1.0	1.0
Faecal Colliform MPN/100ml	720	430	380	220	620	1800	2100	5300	2400	1260	1300	1100
Total phosphate	0.01	0.01	0.02	0.06	0.04	0.02	0.01	0.05	0.09	0.01	.04	0.01
Nitrate	0.62	0.72	.52	.24	0.18	0.32	0.48	0.84	0.62	1.21	0.81	0.68
WQI	71	71	70	73	72	75	77	76	77	79	78	74
Classification	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Table No: 9 Monthly Water Quality Index at Jamshedpur

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.7	7.7	7.5	7.5	7.7	7.6	7.1	7.3	7.5	7.6	7.4	7.3
Turbidity	34.6	180	360	490	360	82	18.6	8.6	2.8	1.4	1.8	1.6
Total solids	162.5	149.5	136.7	130	130	175.5	195	156	162.5	175.5	156	169
D.O.	5.4	6.8	4.8	6.0	7.0	5.0	6.0	7.2	6.4	6.4	6.2	4.8
B.O.D	2.2	1.0	0.8	2.0	0.4	0.8	1.2	0.6	0.8	1.0	2.0	0.6
Faecal Colliform MPN/100ml	920	560	410	360	240	380	4000	4600	7000	3200	2400	1820
Total phosphate	0.01	0.02	0.01	0.04	0.08	0.06	0.01	0.12	0.14	0.08	0.06	0.04
Nitrate	0.28	0.32	0.24	0.12	0.18	0.78	0.83	0.76	0.64	0.46	0.32	0.28
WQI	69	73	68	70	75	69	73	78	76	78	76	73
Classification	Med	Good	Med	Good	Good	Med	Good	Good	Good	Good	Good	Good

Table No: 10 Monthly Water Quality Index at Baridhi Nallah

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.4	7.5	7.4	7.0	7.7	7.0	7.2	6.9	7.4	7.5	7.2	7.4
Turbidity	152	280	560	362	260	48.6	38.2	28.6	36.1	47.2	30.2	29.4
Total solids	650	520	559	253.5	149.5	208	195	169	520	754	520	175.5
D.O.	0.0	2.8	0.0	3.0	6.6	7.6	7.6	6.0	4.0	0.0	0.0	1.2
B.O.D	59.8	19.9	60.0	40.0	0.8	2.0	1.6	1.8	1.6	0.4	20.0	0.4
Faecal Colliform MPN/100ml	1800	1960	1100	1260	1300	2400	12000	9500	24000	4200	3640	2400
Total phosphate	0.02	0.02	0.01	0.06	0.04	0.08	0.08	0.14	0.08	0.06	0.06	0.01
Nitrate	0.32	0.47	0.68	0.12	0.43	0.80	0.71	0.68	0.52	0.46	0.42	0.51
WQI	40	44	40	47	71	71	73	69	59	53	44	61
Classification	Bad	Bad	Bad	Bad	Good	Good	Good	Med	Med	Med	Bad	Med

Table No: 11 Monthly Water Quality Index at Ghatshila

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.4	7.4	7.4	6.2	7.7	7.3	7.7	7.9	8.4	7.4	7.7	8.0
Turbidity	28.2	210	128	320	168	65	18.2	8.3	3.2	1.8	1.9	2.8
Total solids	169	175.5	169	143	143	93	260	208	221	572	221	253.5
D.O.	5.5	5.4	4.4	6.2	6.2	8.3	10.3	8.3	7.9	2.8	6.8	5.4
B.O.D	0.7	0.8	1.4	0.6	0.4	1.4	0.6	0.6	0.4	0.8	1.2	0.6
Faecal Colliform MPN/100ml	960	420	320	170	460	420	2100	2400	1500	4600	1600	1260
Total phosphate	0.02	0.04	0.01	0.01	0.01	0.04	0.01	0.06	0.01	0.01	0.02	0.01
Nitrate	0.38	0.72	0.64	0.58	0.56	0.92	0.83	0.94	1.26	0.95	1.12	0.93
WQI	73	69	66	70	72	77	75	78	78	61	78	74
Classification	Good	Med	Med	Good	Good	Good	Good	Good	Good	Med	Good	Good

Table No: 12 Monthly Water Quality Index at Ghatshila Road Bridge

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.6	7.6	7.5	7.4	7.6	7.5	7.6	7.7	8.5	7.8	8.1	7.9
Turbidity	63	280	392	240	182	52	8.6	3.2	1.6	1.8	2.8	2.4
Total solids	234	195	175.5	143	149.5	273	260	214.5	214.5	292.5	156	253.5
D.O.	5.6	5.8	5.2	6.0	6.4	8.3	8.5	7.9	10.1	6.4	8.5	4.8
B.O.D	0.4	1.2	1.2	0.2	0.8	1.0	0.6	0.2	2.0	0.4	3.0	0.6
Faecal Colliform MPN/100ml	1100	640	560	220	650	830	2100	3000	3600	1600	1800	1400
Total phosphate	0.01	0.01	0.02	0.01	0.06	0.01	0.01	0.12	0.08	0.01	0.01	0.01
Nitrate	0.78	0.86	0.54	0.38	0.46	0.82	0.92	0.82	1.26	0.96	0.82	0.88
WQI	70	69	67	73	72	76	79	79	73	77	76	72
Classification	Good	Med	Med	Good	Good	Good	Good	Good	Good	Good	Good	Good

Table No: 13 Monthly Water Quality Index at Jamsholaghat

Parameters	June 2012	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013
pH	7.5	7.3	7.3	7.2	7.7	7.8	7.5	8.0	8.0	7.3	7.8	7.6
Turbidity	25.6	240	285	260	120	52	16.2	5.2	3.2	1.2	1.8	2.8
Total solids	228	196	178	138	162	281	253	188	125.5	218	148	242
D.O.	5.3	5.2	6.2	5.8	6.6	5.4	6.1	5.8	5.6	6.1	6.4	5.8
B.O.D	0.4	0.6	0.4	0.6	0.8	1.2	0.6	0.2	0.4	0.2	1.2	0.4
Faecal Colliform MPN/100ml	720	640	620	800	860	1800	4200	3400	1800	1200	1560	960
Total phosphate	0.01	0.01	0.06	0.06	0.08	0.01	0.01	0.12	0.06	0.01	0.04	0.01
Nitrate	0.52	0.46	0.32	0.24	0.38	0.68	0.86	0.92	1.18	0.84	0.68	0.72
WQI	72	68	71	70	71	68	74	74	75	78	78	76
Classification	Good	Med	Good	Good	Good	Med	Good	Good	Good	Good	Good	Good

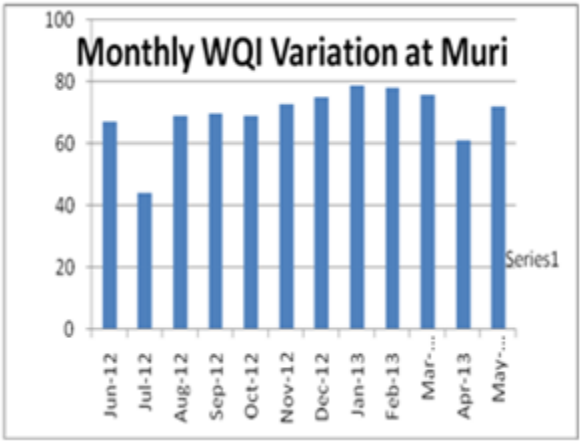

Figure-1

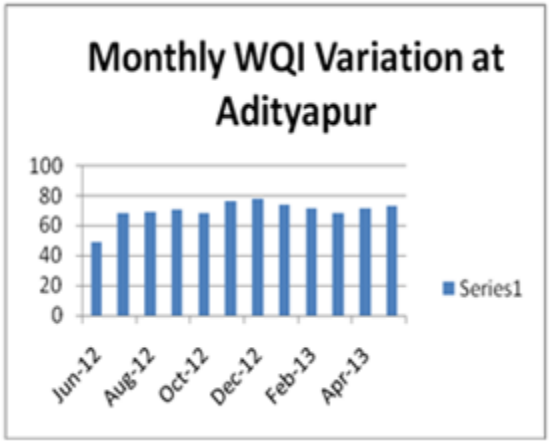

Figure-2

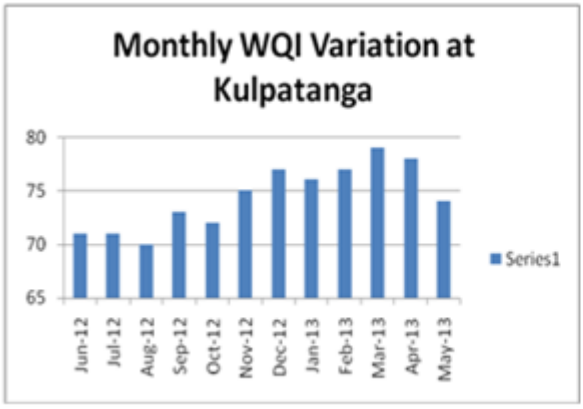

Figure-3

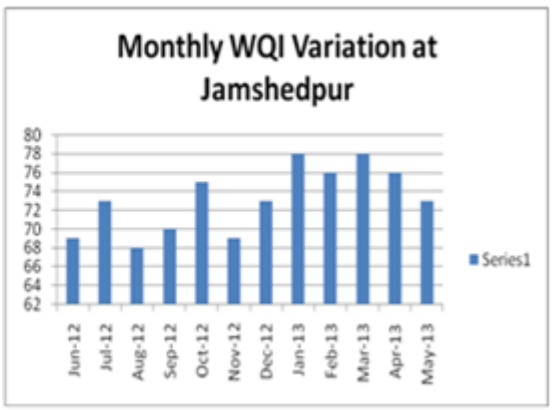

Figure-4

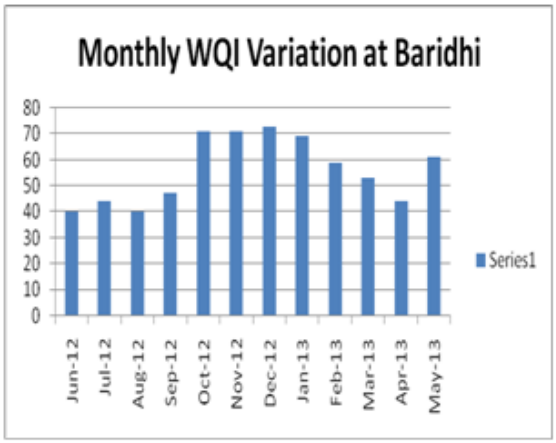

Figure-5

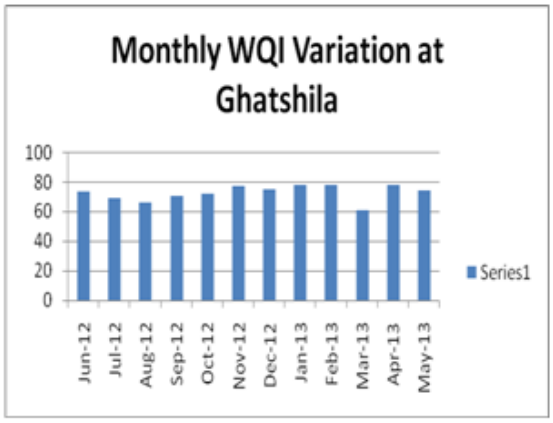

Figure-6

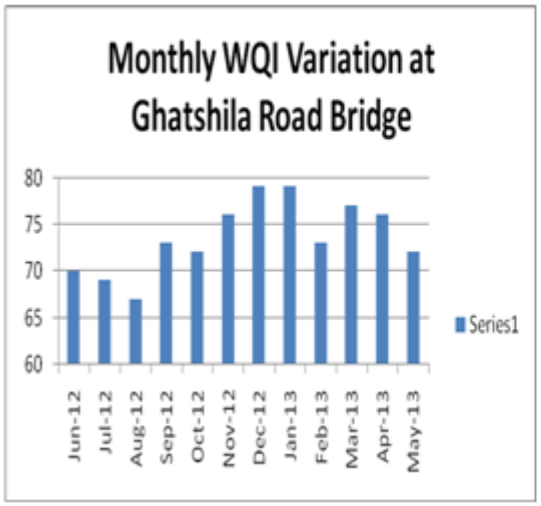

Figure-7

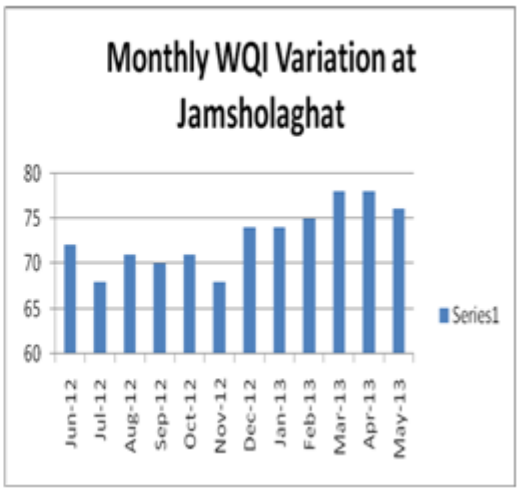

Figure-8