*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **4(12),** 49-56, December **(2015)** *Int. Res. J. Environment Sci.*

Quality Assessment of Surface Water in Gandhamardan Iron ore Mining area of Keonjhar District, Odisha, India

Pradhan K[1]. Patra A.K[2]
[1]Department of Zoology, D.B. College, Turumunga, Keonjhar, Odisha, INDIA
[2]Department of Zoology, Utkal University, Bhubaneswar, Odisha, INDIA

Available online at: www.isca.in, www.isca.me
Received 77th September 2015, revised 12th October 2015, accepted 13th November 2015

Abstract

Surface run-off from the mining during exploration and excavation get laden with aluminous laterite soil from mine benches. Direct discharge of the surface runoff to the natural nallas (streams) affects the water quality. So in this context the present work focuses on surface water quality in Gandhamardan iron ore mining area. The physico-chemical characteristics were estimated during winter, summer and rainy seasons for two consecutive years 2011-12 and 2012-13. The parametes like p^H, Total hardness, Alkalinity, BOD, COD, TDS, Iron, Chloride, Sulphate were assessed at four sampling sites. The result showed that water qualities of all locations were within the permissible limits except for Dissolved Oxygen, Iron contents and Turbidity. DO contents ranged from 1.26mg/l to 3.03mg/l in 2011-12 and 1.0 mg/l to 3.08 mg/l in 2012-13, Iron ranged from 1.00 mg/l to3.50 mg/l in 2011-12 and 1.00 mg/l to 3.56 mg/l in 2012-13and turbidity (NTU) ranged from 15 to 24 in 2011-12 and 16 to 28 in 2012-13.

Keywords: Surface water, physico-chemical parameters, WHO standard.

Introduction

Water is precious to life. Besides drinking, it has been used in agriculture, industry and other domestic purposes. But, due to excess anthropogenic interferences the surface water as well as the ground water, it has been degrading its' physico-chemical properties day by day[1]. Natural resources degradation, deforestation, surface mining during exploration ,excavation and mineral processing contribute to affect the nearby flowing streams or Nallas bringing stress upon the aquatic life[2,3].

Keonjhar, one of the mineral rich districts of Odisha (figure-1) occupies huge reserve of high grade Iron ores fulfill the demand of both domestic and world markets. But the places where iron reserves are present are generally in hill tops with steep slopes and in dense forest areas. Two – third of forest land had been diverted for mining activities. Keonjhar is situated between 21^0 1' N to 22^0 10' N latitude and 85^0 11' E to 86^0 22' E longitude. The Gandhamardan hill of Keonjhar District where abundant iron ore resources are reserved is located between 21^0 37' 09" N to 21^0 40' 06" N latitude and 85^0 29' 20" E to 85^0 31' 30" E longitude. In Gandhamardan mining areas there is no mine water discharge and effluent discharge available but surface water (SW) nallas (streams) are available in the vicinity of the mining area. These are Nallas near Jharancrusher (SW_1),Jagar Nalla (SW_2), Ichinda Nalla (SW_3) and Nitigotha Nalla (SW_4) (table-1). Direct discharge of the surface runoff to the natural nallas affects the water quality of the nallas as well as rivers in the region.

Material and Methods

The water samples were collected in clean sampler bottles from four different study location sites which were Nalla near Jharana crusher (SW_1), Jagar Nalla (SW_2), Ichinda Nalla (SW_3) and Nitigotha Nalla (SW_4). The samples were collected quarterly i.e. winter, summer and rainy season of the year 2011-12 and 2012-13 respectively. After collection and preservation, the samples were analyzed in the laboratory. Using these samples different physico-chemical parameters like pH, BOD, COD, TDS, Alkalinity, TH, Fe, Chloride and sulphate tests were done as per the specified methods (table-2). The DO samples were collected in DO bottles and were fixed immediately on the spot. The obtained results for respective parameters of the water qualities of the Gandhamardan mining area were compared with BIS Standard of the surface water qualities (table-3).

Table-1
Locations of surface water sampling coordinate

Locations	Sample code	Latitude	Longitude
Nalla near Jharana crusher	SW_1	21^0 37' 47.40" N	85^0 20'43.38" E
Jagar Nalla	SW_2	21^0 38' 20.70" N	85^0 29'33.72" E
Ichinda Nalla	SW_3	21^0 40' 0.06" N	85^0 30'51.90" E
Nitigotha Nalla	SW_4	21^0 30' 50.64"N	85^0 30'53.88" E

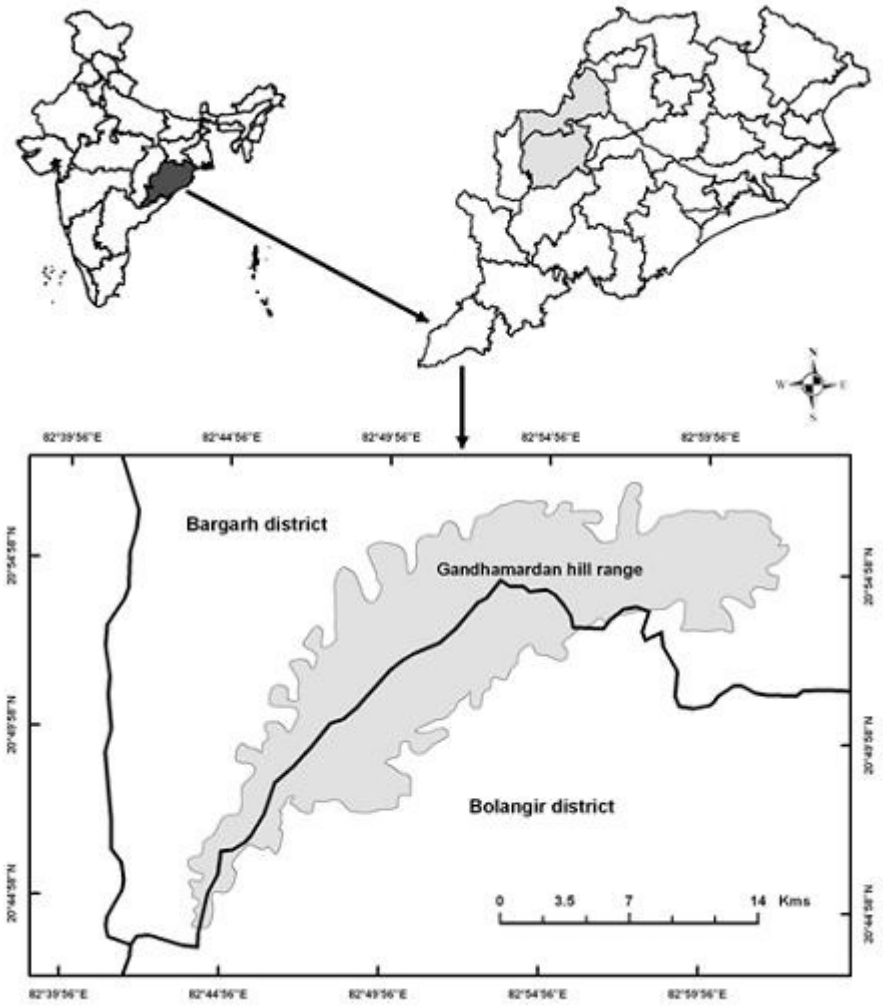

Figure-1
Map of Study Areas

Table-2
Methods of analysis of different parameters of the surface water qualities

Parameters	Methods of analysis
pH	P^H meter
TDS	Gravimetric method
BOD	5 days BOD test at 20^oC
COD	Open reflux method
T. Fe	1, 10 Phenanthroline Colorimetric method
Turbidity	Nephlo Turbidometric method
SO_4^{-2}	Spectrophotometer
TH	Titrometric Method Using EDTA

Table-3
Test characteristics of surface water (BIS Standard)

Parameters	Permissible Limit
pH	6.5-8.5
TDS (mg/l)	500
BOD (mg/l)	2.0
COD (mg/l)	20
TH (mg/l)	300
DO (mg/l)	5

Results and Discussion

Various physico-chemical parameters of surface water along with their seasonal variation (Winter, Summer, and Rainy season) during 2011-13 were recorded, analyzed and discussed below (tables-4 to 15).

pH: The pH of water samples varied from 6.0 to 7.40 during the year 2011-12 and 6.0 to 7.35 during the year 2012-13. The pH of water samples was minimum 6.0 at the location SW_2 during winter, summer and at SW_4 during summer. It suggested the water is found to be more acidic. In the year 2012-13 it was also found that at location SW_2 the pH value was 6.0 and highest 7.35 at SW_4 during rainy season which was slightly alkaline. The acidic nature of water is mainly because of mixing of lechates from mines which is acidic in nature. The permissible limit is 6.5 to 8.5.

TDS (Total Dissolved solids): Total Dissolved solids were mainly due to presence of organic and inorganic material in water body. TDS of the Nallas ranged from 100 mg/l to 234mg/l in 2011-12 and 110 mg/l to 240 mg/l in 2012-13. The recommended level of TDS for the protection of aquatic life, irrigation and domestic uses is 210-250 mg/l. All the locations during rainy season of both the year 2011-12 and 2012-13 showed the value within recommended level. This was within 210-234 mg/l in 2011-12 and 220-240 mg/l in 2012-13.

TH (Total Hardness): In general the hardness of water reflects the nature of the geological formations with which it has been in contact. During the analysis TH in samples was found in the range of 40 mg/l to 70mg/l in the year 2011-12 where as 40mg/l to 72 mg/l in the year 2012-13 which were within the permissible limit.

BOD (Biological Oxygen Demand): The variation in BOD is the direct and important indicator of organic pollution[6]. It is a measure of the quality of oxygen consumed by different microorganisms during the decomposition of organic matter. BOD of the study locations ranged from 1.0 mg/l to 2.7mg/l in the year 2011-12 where as 1.0mg/l to 2.9mg/l in the year 2012-13. BOD value was maximum at SW_3 and $SW_{4\ I}$ in rainy season during 2011-12 and 2012-13, than other two locations in both the years 2011-12 and 2012-13 which were having within permissible limit. BOD level of 3.0-6.0mg/l is the permissible protection range for aquatic life.

COD (Chemical Oxygen Demand): The chemical oxygen demand gives the total amount of organic matter present in the water. COD is used as a measurement of pollutants in waste water and natural water[7]. COD value of surface water was ranged from 5.0 mg/l to 6.9 mg/l in all the locations during 2011-12 where as it was 5.0 mg/l to 7.0 mg/l in 2012-13. COD was within permissible range.

Chloride: Chlorides in reasonable concentration are not harmful to human. At concentration above 250 mg/l, gives an unpleasant and undesirable salty taste. Chloride test served as the basis of detecting contamination of surface water as well as ground water[8]. Chloride value ranged from 11 mg/l to 25 mg/l at all the locations in the year 2011-12 where as 14 mg/l to 28 mg/l in 2012-13 at all the locations. According to WHO, the permissible limit of chloride percentage was 250 mg/l which is quite good for all types of fresh water life[9]. In these study locations chloride content was within the normal limit.

Turbidity (NTU): Turbidity is due to presence of colloids and suspended matters. Turbidity values of surface water ranged from 15 to 24 in the year 2011-12 where as 16 to 28 in 2012-13 at all the locations throughout all the seasons. Due to overburden and unending transport service inside the mining areas, the amount of turbidity in the water at all the sampling locations was above permissible limit. The turbidity limit according to WHO is 5 NTU.

Dissolved Oxygen (DO): Dissolved oxygen depends on temperature, solubility, solar illumination, respiration, productivity and abundance of phytoplankton. Animal as well as plant life depends upon the Dissolved Oxygen (DO). DO is depleted because of the pollutants. The increased pollutants lower the oxygen level in the water. A rise in temperature also decreases the oxygen content of water[10].

Table-4
pH value of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	6.1	6.2	6.98	6.2	5.5	6.88
SW_2	6.0	6.0	6.82	6.0	5.8	6.90
SW_3	6.25	6.68	7.25	6.5	6.0	7.12
SW_4	6.5	6.0	7.40	6.5	6.5	7.35

Table-5
TDS value (mg/l) of surface water at different locations of Gandhamardan mining area, Keonjhar 2011-12, 2012-13

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	134	120	234	135	130	230
SW_2	106	100	206	110	110	240
SW_3	118	110	218	125	118	220
SW_4	110	100	210	120	120	230

Table-6
BOD value (mg/l) of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	1.0	1.1	1.2	1.0	1.1	1.8
SW_2	1.0	1.0	1.0	1.1	1.0	1.5
SW_3	1.5	1.4	2.7	1.4	1.4	2.9
SW_4	1.8	1.3	2.4	1.5	1.3	2.5

Table-7
COD value (mg/l) of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	5.0	5.1	5.1	5.1	5.0	5.5
SW_2	5.0	5.3	5.9	5.2	5.5	6.0
SW_3	6.0	5.9	6.3	6.1	5.2	6.3
SW_4	6.0	6.1	6.9	6.0	5.4	7.0

Table-8
Turbidity (NTU) contents of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	20	21	22	16	18	25
SW_2	18	17	19	19	19	20
SW_3	17	15	24	18	21	28
SW_4	18	16	21	20	21	27

Table-9
DO (mg/l) contents of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	1.26	1.20	2.03	1.06	1.20	2.06
SW_2	2.05	1.45	3.00	1.08	2.00	3.06
SW_3	2.25	2.00	3.03	1.00	1.56	3.08
SW_4	1.45	1.50	2.05	1.40	1.36	2.09

Table-10
Total Hardness (mg/l) contents of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	40	41	40	42	40	45
SW_2	42	45	56	56	51	62
SW_3	44	55	64	55	52	65
SW_4	50	52	70	58	61	72

Table-11
Chloride contents (mg/l) of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	21	22	25	19	20	28
SW_2	16	17	19	19	20	21
SW_3	11	12	16	14	15	17
SW_4	17	18	21	17	16	22

Table-12
Iron contents (mg/l) of surface water at different locations of Ghandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	1.00	0.46	3.03	1.00	1.20	2.66
SW_2	2.00	1.00	3.50	1.08	1.50	3.56
SW_3	2.00	2.00	3.28	1.00	1.56	3.08
SW_4	1.00	1.50	2.50	1.30	1.46	2.09

Table-13
Sulphate contents (mg/l) of surface water at different locations of Gandhamardan mining area, Keonjhar

Locations	2011-12			2012-13		
	Winter	Summer	Rainy	Winter	Summer	Rainy
SW_1	11	12	14	16	15	17
SW_2	13	15	19	17	16	22
SW_3	14	15	16	17	14	18
SW_4	15	18	21	19	15	24

Table-14
Average results of physicochemical parameters of surface water at different locations of Gandhamardan mining area, Keonjhar during 2011-12

Parameters	Locations				Mean	Std. Dev.
	SW_1	SW_2	SW_3	SW_4		
pH	6.9	6.2	6.7	6.3	6.5	0.44
TDS	162	137	148	140	146	8.32
BOD	1.1	1.0	1.8	1.8	1.4	0.75
COD	5.0	5.4	6.0	6.3	5.6	0.51
Chloride	22	17	13	18	17.5	3.20
Iron	1.49	2.16	2.42	1.66	1.93	0.37
Turbidity	21	18	18	18	18.5	2.64
Sulphate	12	16	15	1.8	15.2	4.33
Total hardness	40	47	54	57	66	17.76

Table-15
Average results of physicochemical parameters of surface water at different locations of Gandhamardan mining area, Keonjhar during 2012-13

Parameters	Locations				Mean	Std. Dev.
	SW_1	SW_2	SW_3	SW_4		
pH	6.1	6.2	6.5	6.4	6.3	0.15
TDS	166	153	154	156	157	10.34
BOD	1.3	1.2	1.9	1.7	1.5	0.28
COD	5.2	5.5	5.8	6.1	5.6	0.33
Chloride	22	20	15	18	18.5	2.59
Iron	1.42	2.07	1.88	1.61	1.74	0.24
Turbidity	19	19	22	25	21.25	2.48
Sulphate	16	18	19	19	16.5	1.93
Total hardness	42	56	64	63	56.25	8.78

It was found that the DO content ranged from 1.26mg/l to 3.03 mg/l in 2011-12 and 1.00mg/l to 3.08mg/l in 2012-13 at all the sampling locations. This indicated the very low concentration of DO because of the mixing of mud, washed effluents from mine water to the Nallas. The low value of DO indicates the high growth of bacteria that utilized oxygen for their metabolic activities[11]. Generally DO level less than 3mg/l are stressful to aquatic organisms. The surface water of the locations like SW_1, SW_2, SW_3 and SW_4 were badly polluted during winter and summer in both the years.

Iron: The iron contents found very high ranging from 1.00 mg/l to 3.50 mg/l in 2011-12 and from 1.00 mg/l to 3.56 mg/l in 2012-13 at different locations. Water with very high iron contents is not suitable for human consumption. Unfortunately, the inhabitants are in continuous use of such water resulting in various skin diseases. Although, the permissible limit is 1.0 mg/l (WHO), health hazards have also been reported among the inhabitants of that area having iron content above 0.3mg/l[12].

Sulphate: The Sulphate contents ranged from 11mg/l to 21mg/l in the year 2011-12 where as in 2012-13 ranged from 14mg/l to 24mg/l. The mean Sulphate contents found are recorded to be 15.2±4.33 in 2011-12 and 16.5±1.93 in 2012-13. Although the minimum permissible sulphate. content in water is 600mg/l, such a low content of sulphate in the respective mining area was an indication of low growth of aquatic plants as well as animals in general and fish community in particular.

Mean and standard Deviation: After thorough analysis throughout the year 2011-12 and 2012-13, very slight deviation from mean value was found in all the parameters (figure-2).

Conclusion

The parameters of the surface water quality of the Gandhamardan iron ore area indicate that except DO, Turbidity and Iron contents, all others parameters were within permissible limits (B I S Standard).

Inadequate sulphate content followed by very low concentration of DO was due to the mixing of dust, mud, and washed effluents from mine water to the nallas and high turbidity level prevent the growth of aquatic flora and fauna. Similarly, high concentration of iron accumulation in the surface water of the study area became the cause of water-borne skin diseases. The overall picture that emerged out of the present study warrants sustainable management of the ecosystem of the Gandhamardan mining area. The Gandhamardan mining authority is hereby suggested to implement some action plans for monitoring of the surface water quality in the mining area properly.

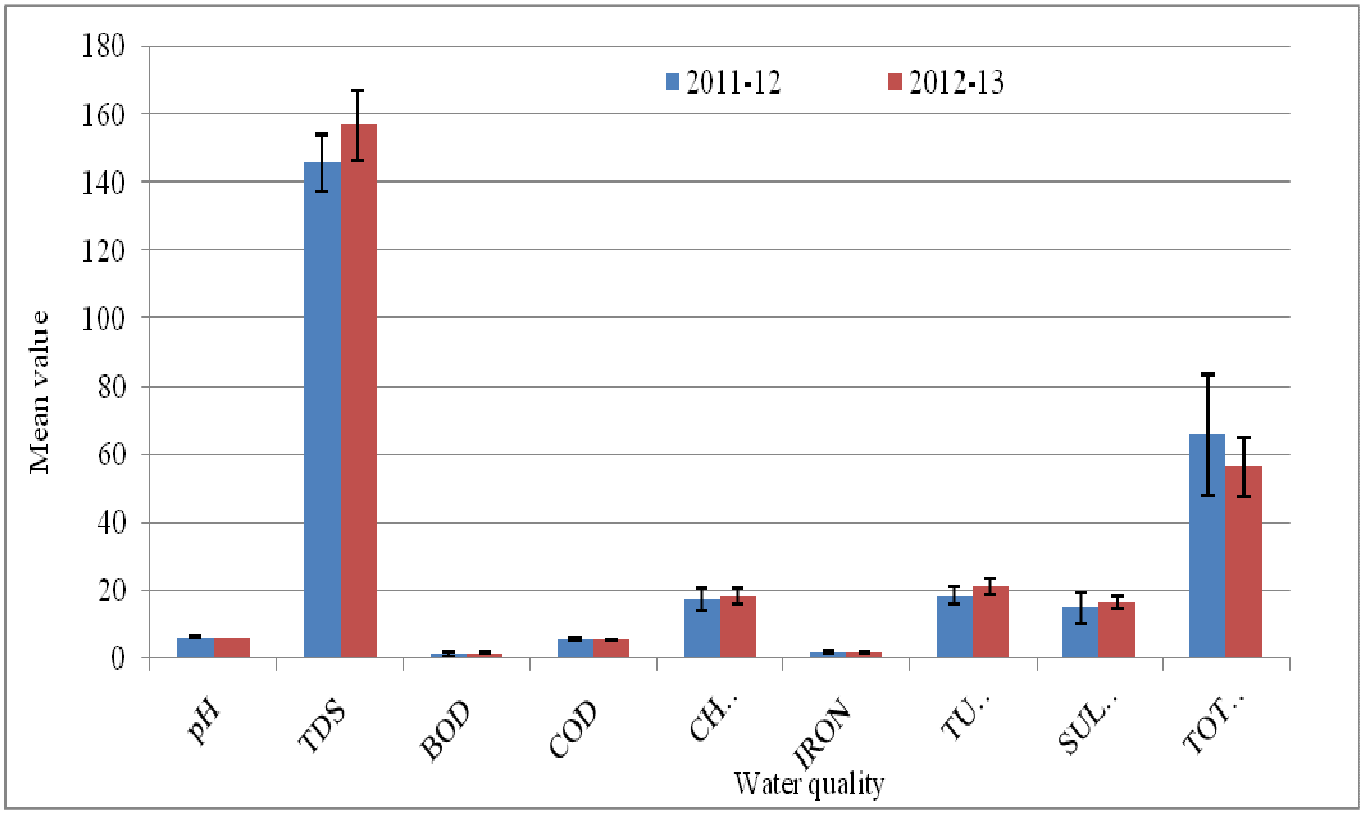

Figure-2
Mean values of surface water quality in the Gandhamardan mining area during 2011-13

References

1. Carpenter S.R., Caraco N.F., Correll D.L, Howarth R.W., Sharpley A.N. and Smith V.H., Nonpoint pollution of surface waters with phosphorus and nitrogen, *Ecol Appl.*, **8(3),** 559–68 **(1998)**

2. Jarvie HP, Whitton BA and Neal C., Nitrogen and phosphorus in east coast British rivers: speciation, sources and biological significance, *Sci Total Environ*, 210–211, 79–109 **(1998)**

3. APHA, Standard Methods for the Examination of water and waste water, 20th Edn. Washington D.C. **(2000)**

4. Trivedy R.K. and Goel P.K. Chemical and Biological methods for water pollution Studies, Environmental Publications, Karad, 1-112, **(1986)**

5. Simeonov V., Stratis J.A., Samara C., Zachariadis G., Voutsa D., Anthemidis A., Sofoniou M. and Kouimtzis T., Assessment of the surface water quality in Northern Greece, *Water Research*, **37** ,4119–4124 **(2003)**

6. Young J.C., Mcdermott G.N. and Jenkins D., Alterations in the BOD procedure for the 15th edition of Standard Methods for the Examination water and Waste Water, *Journal Water Pollution Control Federation,* **53**, 1253 **(1981)**

7. Ahmad M and Krishnamurty P.K., Hydrobiological Studies of water resources, Aurangabad, India, *J. Environ. Biol.,* **2 (3),** 335-343, **(1990)**

8. Bockris J.O.M., Environmental Chemistry, Plenum Press, New York, USA **(1978)**

9. Progatiswaran C., Paruthimal Kalaignan G., Purushothaman N. and Rajan R., Quality assessment of surface water in an industrially populated Town-Hosur during Premonsoon*, Indian Journal of Environmental Sciences*, **13(2),** 141-144 **(2009)**

10. Chandrasekhar N., Kumarsen S. and Jayasekhar T,, A Study on air pollution in Tuticorin, *Ind J Env Prot.,* **22(12),** 1331-1336 **(2002)**

11. Jameel A., Physicochemical Studies in Vyyakondan Channel water of Cauvery, *Pollution Research*, **17(2),** 111-114, **(1998)**

12. Pandey B.N., Das, P.K.L. and Jha A.K., Physicochemical analysis of drinking water of Purnea District, Bihar*, Acta Ecology*, **14(2),** 108-114 **(1992)**