Asian Journal of Water, Environment and Pollution, Vol. 10, No. 4 (2013), pp. 43–51.

Effect of Coal-based Industries on Water Quality

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Received April 23, 2012; revised and accepted September 9, 2013

Abstract: The commercial and economic successes of our country can be attributed to the coal industry to a great extent. Coal continues to be the primary energy source and to meet the energy and other requirements a number of coal-based industries have been established. These industries have the potential of generating and releasing large quantities of pollutants to the environment. Among these, the release of various liquid effluents, which are associated with coal during the carbonization, cleaning and combustion processes are a major concern. The coal-based industries, such as by-product coke-plants, coal washeries and thermal power plants release their liquid effluents, which need urgent attention for the treatment, before they are discharged into the fresh water streams. In the present work, water qualities of three coal-based industries from Odisha viz. National Aluminium Company (NALCO), Angul; Rourkela Steel Plant (RSP), Rourkela; and National Thermal Power Corporation (NTPC), Talcher, have been evaluated. Nine stations were selected for collecting water samples and were analyzed for nineteen physico-chemical parameters as per standard procedure. A careful study of the water quality results reveals that one water sample each from Nalco Ash Pond and RSP, Rourkela were comparatively more polluted than the other water samples.

Key words: Thermal power plant, ash pond, water pollution.

Introduction

Environmental impacts of waste water discharged from coal-based industries, such as by-product coke plant, coal washery and thermal power plant are numerous. The coke plant waste water contains high concentration of phenol, ammonia and cyanide, which have got detrimental effect on environment (Singh, 1990). In a few coal-based industries, waste water containing high concentration of coal fines is released, which creates a visible pollution in fresh water stream. A large amount of good quality coal is also lost by the washeries everyday (Jambrik and Bartha, 1994). In the thermal power plants, coal ash discharged in slurry form in the ash pond may affect the surrounding ground and surface water due to leachates generated from it.

In the thermal power plants, ash formed during combustion of coal is mixed with water and is discharged in slurry form in ash disposal ponds (Xing, 2010). If disposal ponds are not properly selected, constructed and managed, and the coal ashes are not properly assessed for disposal, the risk of ground and surface water contamination due to leaching of heavy metal ions in the coal ash or surface run-off is enhanced (Kar et al., 2008). Due to this the ground water gets polluted and may become unsuitable for domestic use. There is also the release of ash pond decant into the local water bodies from the coal-based industries. Such release of ash pond decant tends to deposit ash all along its path thereby causing fugitive dust nuisance when it dries up (Tiwary and Dhar, 1994; Ramachandra et al., 2012). Also, when such water mixes with a water body, it increases the turbidity of the water body,

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thereby decreasing the primary productivity (Junshum et al., 2004). Leakage and overflow of slurry from the ash ponds give diverse impacts on the chemical composition of water in downstream. This is harmful to the fisheries and other aquatic biota in the water body.

It is to be noted that Angul-Talcher region in Odisha is one of the most polluted areas of the country. The impact of fluoride pollution is also severe in this belt (Mukherjee et al., 2003). Incidence of white spots all over the body, incurable skin infections and lumps of dead skin are increasing among the population. A high percentage of gastro-intestinal parasitic infection was found in the fecal samples of cattle in the villages affected by effluents from coal-based industries and coal mining. It is also to be noted that breach of the ash pond of NALCO, Angul in December 2000, resulted in a flash flood in Nandira rivulet, a tributary of Brahmani river. This caused sudden flooding of about 12 villages on the river bank and large scale damage to agricultural land and water sources in the downstream. A breach in the embankment of an ash pond belonging to NTPC, Kaniha in June 2011 triggered panic among residents of Kaniha. The pond had developed cracks at several places and burst at one place, allowing ash water to gush out (*Times of India*, June 3, 2011). Recently, the pipeline transporting the fly ash slurry to NALCO ash pond got burst on October 15, 2011, releasing slurry into Balaramprasad village. The slurry submerged the panchayat road and entered some houses. It also contaminated the village ponds and wells and damaged paddy fields. However, this was the first time that the ash pipeline had leaked and affected the village (*The Telegraph*, October 16, 2011).

Study Area

In order to carry out the study, three coal-based industries of Odisha namely National Aluminium Company (NALCO) at Angul, Rourkela Steel Plant (RSP) at Rourkela belonging to Steel Authority of India Ltd. (SAIL) and thermal power plant of National Thermal Power Corporation (NTPC) at Talcher were selected.

NALCO is an integrated multi-locational aluminium complex. It has two units at Angul. The smelter plant produces 4.6 million tonnes of aluminium per annum. Discharge of effluents from the smelter plant of NALCO to the local water bodies at Angul is known to cause fluoride pollution in drinking water of wells and tanks through lateral and vertical movement in the ground (Sahu et al., 2006). The coal-based captive power plant of NALCO is of 960 MW capacity, which is being expanded to 1200 MW. The fly ash generated in the thermal captive power plant is mixed with water and disposed off in slurry form through pipelines to the company's ash ponds spread across 600 acres located nearly five kilometres to the north of the plant. Though the ash ponds are claimed to be of zero discharge, the overflows and effluents are being discharged into Nandira jhor regularly (Reza and Singh, 2010) which is a tributary of Brahmani river.

The integrated Rourkela Steel Plant has an installed capacity of one million tonnes and generates about 84,000 m^3 of waste water per day. The water generated in various sections is treated in primary treatment units existing in different sections and flows to the NSPCL ash dyke where the fly ash generated from the plant is also disposed. The wastes are allowed to settle in the ash dyke and then the water is discharged into Guradi nallah which finally mixes with river Brahmani.

The Talcher Thermal Power Plant of NTPC has a capacity of 460 MW and is one of the oldest power generation plants in Odisha. Earlier the waste water was discharged to the Brahmani river, but currently the effluents after being treated in the effluent treatment plant (ETP) and fly ash are transported to South Balanda Colliery of Mahanadi Coalfields Ltd. (MCL) for its disposal.

Materials and Methods

Nine water samples were collected from the aforementioned coal-based industries. The detailed locations from which the samples have been collected are presented in Table 1.

Sample collection was carried out as per the norms laid by Central Pollution Control Board (CPCB, 2003). The source from where the water was collected was in regular use. Before sampling, the source was adequately flushed. Water from the well was taken in the middle at mid depth. The water samples from other locations were near the off-take point (Nollet, 2007). The water was collected after clearing the suspended and floating matter. Water for chemical examination was collected in clean white plastic leak proof bottles of 100 ml or 250 ml or 500 ml capacity. Before collection of sample, the container was washed/rinsed with the water to be sampled at least two or three times. The water was then filled completely in the container without leaving any air space. A polythene sheet (10 × 10 cm) over the cap was placed and tied with a rubber band to avoid any leak.

Various water quality parameters were studied and their tests were carried out. Experimental investigations have been performed as per American Public Health Association (APHA, 1985). The water samples were filtered before analyzing.

Water Quality Tests

Water quality is the physical, chemical and biological characteristics of water. It is most commonly used by reference to a set of standards against which compliance can be assessed (Goel, 2000). Water quality studies are very essential for rational planning of pollution control strategies and their prioritization, to assess nature and extent of pollution control needed in different water bodies or their part, to evaluate water quality trend over a period of time and to assess assimilative capacity of a water body thereby reducing cost on pollution control (CPCB, 2009). The different method that were followed for different water quality tests are presented in Table 2.

Experimental Results of Water Quality Tests

The experimental results of the water quality tests of the water samples along with the Indian standards are presented in Table 3.

Table 1: Water sampling locations

Sample no.	*Location*
1.	Upstream, Nandira jhor
2.	Downstream, Nandira jhor
3.	NALCO ash pond
4.	Well at village Kurudol near NALCO ash pond
5.	Blast furnace clarifier, RSP
6.	NSPCL Ash dyke, RSP
7.	Guradi nallah
8.	Water sample before going to ETP, NTPC
9.	Old working of South Balanda Colliery, MCL

Table 2: Water quality tests methods

Sl. No.	*Tests*	*Procedure followed*
1	Colour	Visual comparison method
2	Turbidity	Nephelometric method – NTU
3	Total dissolved solids	OEM conductivity meter
4	Total suspended solids	PE 138 Water quality analyzer
5	Iron	Titration method
6	Arsenic	Atomic absorption spectrometer (AAS 200 Perkin Elmer)
7	Lead	Atomic absorption spectrometer (AAS 200 Perkin Elmer)
8	Calcium	EDTA Titrimetric method
9	Total hardness	EDTA Titrimetric method
10	Alkalinity	Titrimetric method
11	pH	PE 138 Water quality analyzer
12	Chloride	Argentometric method
13	Fluoride	Electrode method
14	Ammonia	Titrimetric method
15	Sulfate	Gravimetric method with ignition of residue
16	BOD	Dilution method
17	COD	Closed reflux titrimetric method

Table 3: Experimental results of water quality tests

Sl. No.	*Parameters*	*NALCO, Angul*				*RSP, Rourkela*			*NTPC, Talcher*		*IS*
	Sample Nos.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	
1	Alkalinity (mg/l)	230	199	240	200	101.2	102	306	132	76.5	600
2	Ammonia (mg/l)	1.2	1.1	1.3	1	4.8	0.61	1.22	2	0.5	5
3	Arsenic (mg/l)	0.001	0.02	0.03	0.01	0.01	0.03	0.005	0.04	0.02	0.2
4	BOD (mg/l)	26	27	29	25	12	16	10	14	13	30
5	Calcium (mg/l)	76	73	78	70	47.4	28.44	18.96	37.92	28.44	200
6	Chloride (mg/l)	131	129	126	121	101.2	121.4	60.72	105	40.48	1000
7	COD (mg/l)	74	68	56	96	69	76	64	62	58	250
8	Colour (Hazen Units)	6	7	8	5	10	20	5	10	5	25
9	Conductivity (micro siemens)	230	290	340	240	240.8	245.4	233.9	285.1	263.7	300
10	Fluorides (mg/l)	1.7	1.89	2.1	1.5	1.5	3	0.5	1.5	1	2
11	Iron (mg/l)	2.5	3.2	3.3	3.0	0.73	1.17	0.614	1.5	1.3	3
12	Lead (mg/l)	0.06	0.06	0.08	0.05	0.02	0.04	0.01	0.03	0.02	0.1
13	Odour	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	Un-object-ionable	–
14	pH	8.7	8.6	8.0	8.9	7.0	6.9	7.2	5.8	8.2	5.5-9.0
15	TSS (mg/l)	96	99	111	78	74	82	68	61	58	100
16	Turbidity (NTU)	3.4	4.9	13.4	2.6	4.9	21.7	4.5	6	5.5	10
17	TDS (mg/l)	112	119	140	108	132.5	136.1	129.4	154.9	141.3	500
18	Hardness (mg/l)	278	270	265	280	256.1	516.8	279.8	284.4	758.4	1000
19	Sulfate (mg/l)	34	36	31	32	38	160	35	50	40	200

IS: Indian Standard

Discussions

It may be observed from Table 3 and Figure 1 that the turbidity ranged from 2.6 to 21.7 NTU in the study area. The water sample S-3 (21.7 NTU) had a very high turbidity in comparison to other samples. The turbidity of the water sample S-3 was also found to be beyond the permissible limit. The turbidity of the rest of the water samples was within the limit. The colour varied from 5 Hz to 20 Hz in the study area and were within the permissible limit. The permissible limit of turbidity and colour are 10 NTU and 25 Hz (as per E.P. Rules, 1986, Schedule VI, Standards prescribed by SPCBs).

It may be observed from Table 3 and Figure 3 that the conductivity ranged from 234 to 340 micro-siemens in the study area. The water sample S-3 had high conductivity in comparison to other samples and the value exceeded the permissible limit. The total dissolved solids (TDS) ranged from 108 to 154.9 mg/l in the study area. The TDS of all water samples were within the limits. The total suspended solids ranged from 58 to 111 mg/l in the study area. The water sample S-3 had a high TSS (111 mg/l) in comparison to other samples which exceeded the permissible limit.

It may be observed from Table 3 and Figure 3 that the arsenic content ranged from 0.001 to 0.04 mg/l in the study area. The arsenic content of all water samples was within the limits. The iron content varied from 0.614 to 3.3 mg/l in the study area. The iron content of S-2 and S-3 was higher than the permissible limit.

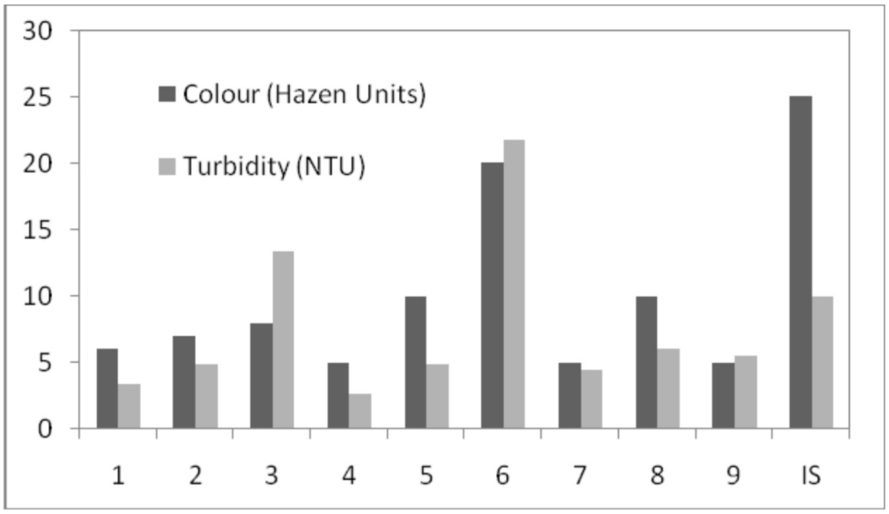

Figure 1: Colour and turbidity of water samples.

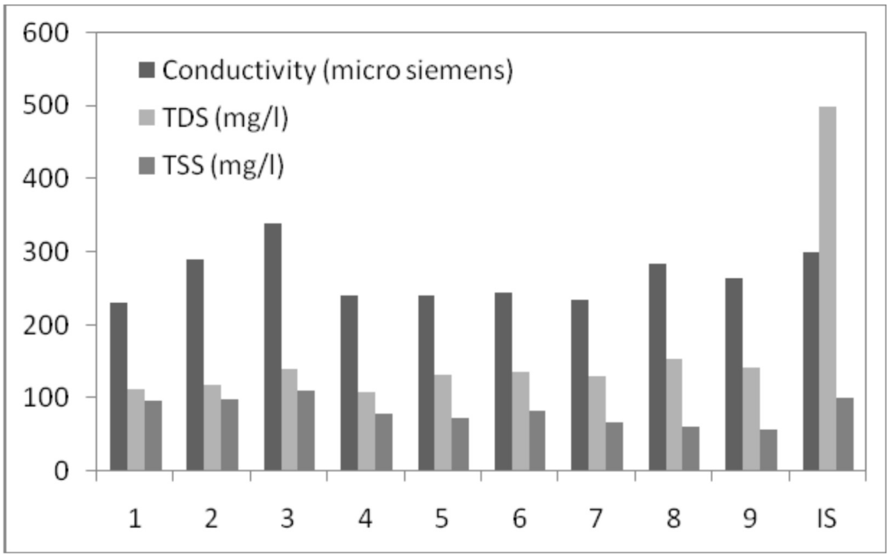

Figure 2: Conductivity, TDS and TSS of water samples.

The lead content varied from 0.01 to 0.08 mg/l in the study area. The lead content of all water samples was within the permissible limit. The fluoride content in the water samples ranged from 0.5 to 3 mg/l in the study area. The water samples S-3 and S-6 had a very high fluoride content which exceeds the permissible limit. The fluoride content of all other samples was within the limit.

It may be observed from Table 3 and Figure 4 that the chloride content varied from 40.48 to 131 mg/l in the study area, which was within the permissible limit. The chloride content of S-9 was lowest among all the water samples. The total hardness ranged from 256.1 to 758.4 mg/l in the study area.

It may be observed from Table 3 and Figure 5 that the pH in the water samples ranged from 5.8 to 8.2 in the study area. The water sample S-8 had a quite low pH in comparison with other samples. The pH of all samples was within the permissible limit. The ammonia content of the water samples ranged from 0.5 to 4.8 mg/l in the study area, which was within the limit.

It may be observed from Table 3 and Figure 6 that the alkalinity ranged from 76.5 to 306 mg/l, the calcium content varied from 19 to 78 mg/l and the sulphate

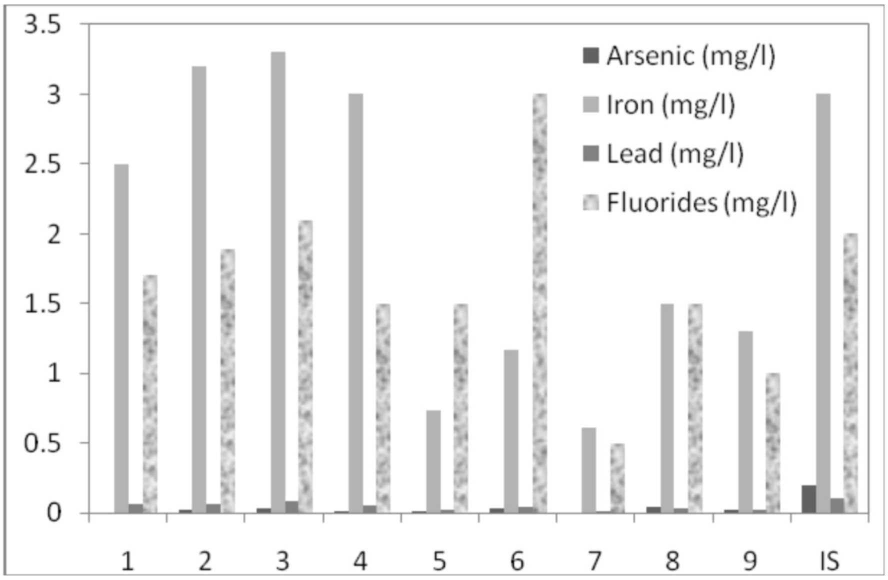

Figure 3: Arsenic, iron, lead and fluoride of water samples.

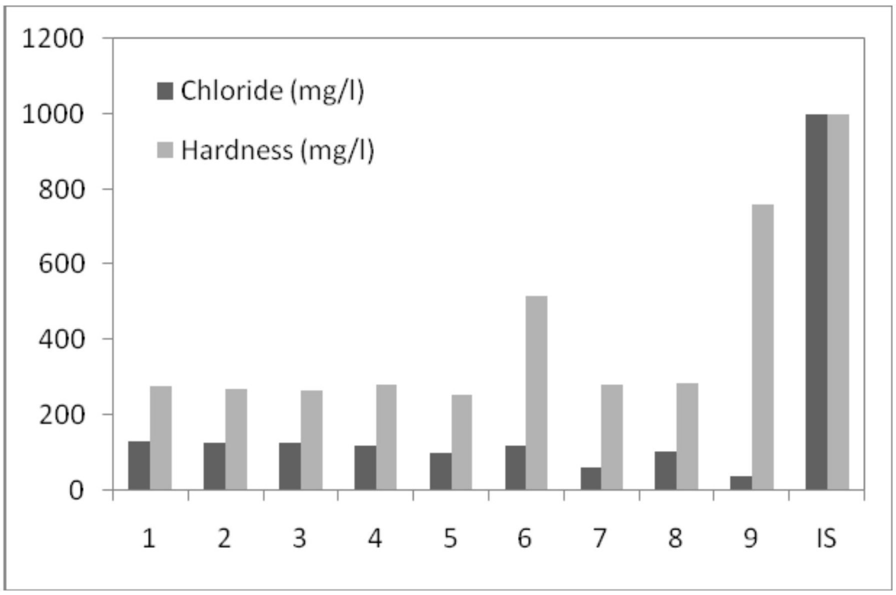

Figure 4: Chloride and hardness of water samples.

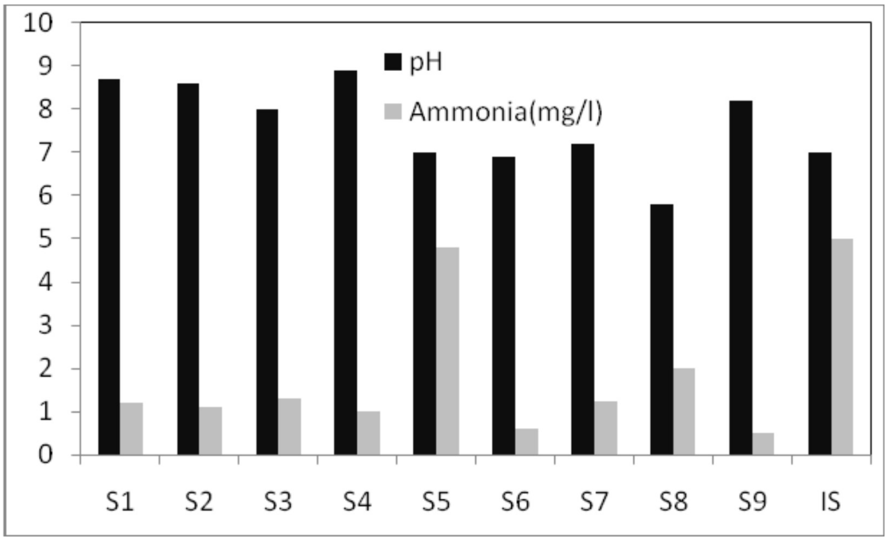

Figure 5: pH and ammonia content of water samples.

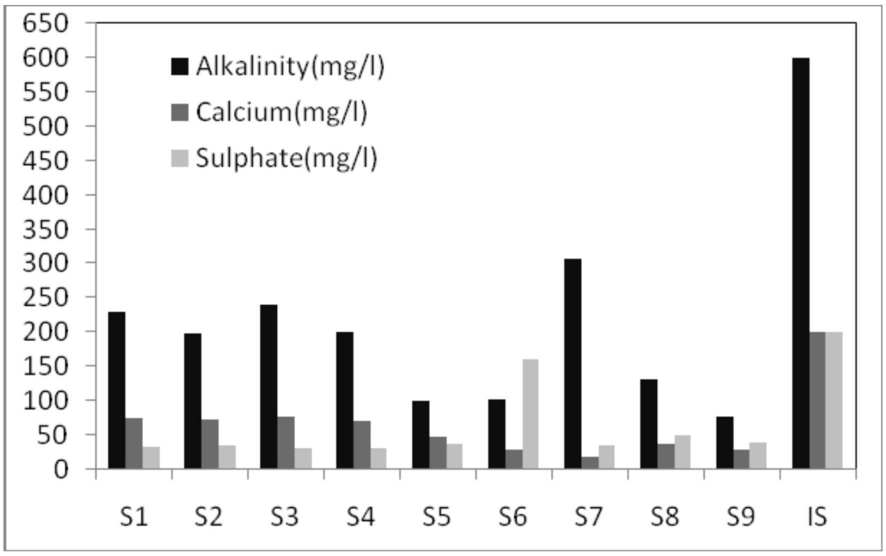

Figure 6: Alkalinity, calcium and sulphate content of water samples.

content of the water samples ranged from 31 to 160 mg/l in the study area. The alkalinity, calcium and sulphate content of all water samples were within the limit.

It may be observed from Table 3 and Figure 7 that the biological oxygen demand (BOD) of the water samples ranged from 10 to 29 mg/l in the study area. The BOD of S-1, S-2, S-3 and S-4 was comparatively higher than the other water samples. The BOD of S-3 was highest among the water samples. However, the values were within the permissible limit. The COD of the water samples ranged from 56 to 96 mg/l in the study area. The COD of all water samples were within the permissible limit.

Conclusions

There is a vast demand for power and steel in our country. A large amount of coal is being used for generation of power and production of steel. However, these coals contain large amount of impurities and thus large quantities of ash is generated in the utilization industries, which are usually stored in ash ponds. In this work, water samples were collected from three coal-based industries namely NALCO, Angul; Rourkela Steel Plant, Rourkela; and NTPC, Talcher. There have been instances of breach of the ash ponds in each case, contaminating water sources as well as paddy fields.

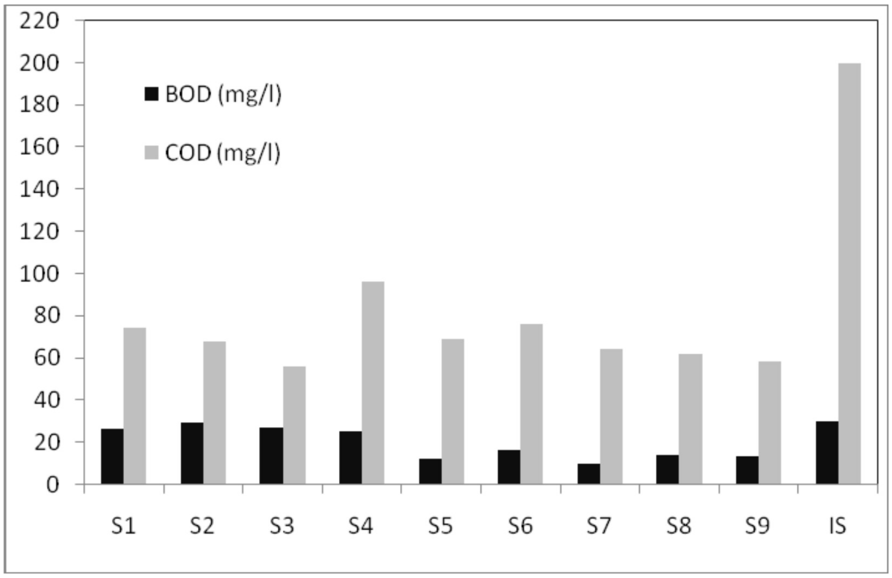

Figure 7: BOD and COD of water samples.

A careful study of the water quality results reveals the quality of water samples S-1, S-2, S-3 and S-4 with respect to alkalinity, aluminum, arsenic, calcium, colour, COD and conductivity was meeting the desired criteria. However, the conductivity, fluoride content, iron content, total suspended solids and turbidity of sample S-3 was found to be beyond the permissible limit. Similarly, it was observed that the water quality parameters for the sample collected from RSP, Rourkela were within the permissible limits, except the fluoride content and turbidity in sample S-6, which exceeded the permissible limit. The water quality parameters for the water samples collected from NTPC, Talcher were found to be within the permissible limits. The water sample S-3 from Nalco Ash Pond and S-6 from NSPCL ash dyke RSP, Rourkela were comparatively more polluted than other water samples, which have the quality of potable water. The increased quantity of fluoride in the water samples is a matter of concern and it demands urgent attention, in order to reduce the health hazards that may occur.

Acknowledgement

The authors are grateful to Er. S. Dash, Environmental Engineer, State Pollution Control Board, Bhubaneswar and Mr. Anup Mallick, Environmental Scientist, State Pollution Control Board, Rourkela Regional Office, for their help in carrying out some of the experiments at their laboratory.

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Asian Journal of Water, Environment and Pollution
Volume 10 Number 3 **July – September, 2013**

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