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Study of Heavy Metal Pollution from Effluent of Orient Paper Mill, Amalai, (Shahdol), M.P.

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Abstract:
The present study is an attempt to assess the heavy metal pollution in the effluent of Orient Paper Mill (OPM), Amalai around the mill (Zone-1) and Son River water nearby village area (Zone-2). System to identify the major point source of metal pollution ten sampling stations were selected under two zones during January to June2014. The heavy metals Fe, Hg, Cd, Pb, Cr and Zn were determined using inductive coupled plasma (ICP) and Atomic absorption spectrometer (AAS). Except metals other chemical parameters such as pH, electrical conductivity (EC), turbidity, total hardness (TA), total dissolved solid (TDS), total suspended solid (TSS) were also analyzed.The results demonstrated that two of six heavy metals including Hg and Cd exceeded permissible safe levels as established by Bureau of Indian Standard (BIS2012). Only low levels of Zn, Pb, Cr, and Fe were detected. The highest average metal concentration occurred in effluent of OPM,Amalai with up to 0.057mg/L for Hg, 0.086 mg/L for Cd, 0.021 mg/L for Pb, and 0.150 mg/L for Zn. Heavy metals, especially Hg and Cd were found to be an important problem to these environments.

Keywords: *Heavy metal, Effluent, TDS, Son river pollution, Orient Paper Mill, Mercury, Turbidity*

1. Introduction

Water contamination by heavy metals have become a striking problem for last two decades as a result of increasing pollution. The environment of urban areas is degrading rapidly due to the large scale of industrial growth, more use of agrochemical, modern life study of dwellers, etc. All these activities promote the degradation of environment. Most of the heavy metals are non-biodegradable so once they get into the soil or water, they persists for a longer duration. However, ions of heavy metals and their discharge have increased greatly in aquatic ecosystem in recent years. The contamination of aquatic and terrestrial ecosystem with some heavy metals is a major environmental problem. Some of these metals are potentially toxic or carcinogenic at sufficient concentration and can cause serious human health hazards, if they enter the food chain.

At elevated concentrations toxic metals like Cr, Co and Hg can accumulate in soils and enter the food chain leading to serious health hazards and threatening the long-term sustainability of the local ecosystem (Khan et al. 2005). Pollution of a river, first affect its physicochemical characteristics, then systematically destroy the community, they districting the delicate food web and as also hazardous to the public health. Therefore, it has become important to assess immediate water quality of river and to predict future change in water quality resulting from the development activities in the region. Heavy metals, especially chromium copper and lead appear to be an important problem to these freshwater environments (Gagneten et al. 2007). The effluent of Orient Papermill, Amalai picks up a large number of heavy metals reaches toaquatic system contaminate local terrestrial ecosystem and Son River water directly. The usage of contaminated water causes the disease.

At the most contaminated sites more than 60% cadmium, Cobalt, Chromium, Copper, Manganese, Nickel, lead, zinc, was transported in suspended form whereas Arsenic and Molybdenum occurred mainly in soluble form (Sulymanov et al.2010).The parameters responsible for water quality variations are mainly related to organic pollution (municipal effluents), inorganic, pollution (industrial effluents and waste disposal areas) nutrients (agricultural runoff), and dissolved salts (soil leaching and runoff process) (Akbal et al. 2011).It is also a fact that lead concentration is increasing in the environment due to the increased anthropogenic activity. The risk of heavy metal contamination is pronounced in the environment adjacent to large industrial complexes (Velea et al. 2009). Some health deteriorating chemicals in drinking were at dangerous level and thereafter water could be a major health threat for local resistant (Garg et al. 2009).

Significance part of the heavy metal contamination can be carried by magnetic fly-ash spherules. A part of contamination is bound to coarse-grained fluvial facies indicating that the magnetic spherules can be transported as bed load sediment. Magnetic pollution and heavy-metal pollution can therefore coincide in the river bed deposited (Famera et al. 2013).The effluent of Orient Paper Mill, Soda factory, Amalai and ash of Amarkantank thermal power plant causes Son River water pullution in various way. In view of the above facts present article or paper was undertaken in order to assess and monitor the quality variation in water of Son River caused by discharges of effluent of orient paper mill and soda factory Amalai.

2. Material and methods

2.1. Description of Study Area

Amalai is located 22^0 11` 21`` N $78^0$ 41` 25`` E in (M.P.). Amalai is a census town of Shahdol and Anuppur districts combinedly in the state of (M.P.)(fig.1).

As of 2001 India census, Amalai had a population of 30292. Orient Paper Mill is located inside Amalai and biggest paper mill of Asia (Figure 3). OPM situated bank of Son river, while distance between paper mill and Son river is 2 km. Total discharge and waste water effluent directly flow into Son river.

Son River originates from Amarkantak, just east of the headwater of the Narmada River and flows along with bank of OPM, Amalai. Thereafter, it flows pattern to Kymore hill and passes through east North West Uttar Pradesh, Jharkhand and Bihar states and finally join to the river Ganga just above Patna .The Son River is 784 km. long and is one of the largest river of India. In view of the above facts present study was undertaken in order to assess and monitor the quality variation in water of Son River caused by discharges of effluent of OPM and Soda Factory Amalai. Ten sampling stations were selected for present studies out which of 6 sampling stations are around the paper mill and 4 sampling station are nearby village area where Son River runoff. Excess water of Son River is freely available to all human being and animals, regularly utilized by a variety of animals including water buffaloes, cattle pigs and dogs. Unhygienic drinking water and wastewater were responsible for diseases like; dysentery cholera and hepatitis are frequently reported in the surrounding villages. The layout of the study area are shown as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 stand for sampling station code SS-01, SS-02, SS-03, SS-4, SS-05, SS-06, SS-07, SS-8, SS-09, SS-10 respectively (Figure 2).

Figure 1: District Shahdol

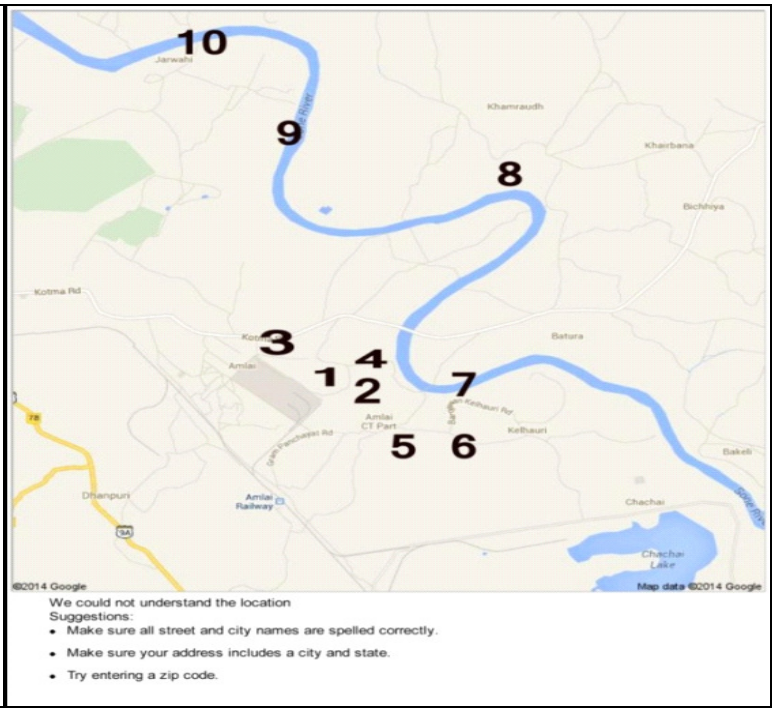

Figure 2: Location of sampling stations

Figure 3: Orient Paper Mill

2.2. Sample Collection

Wastewater sampling preservation and analysis by standard method (APHA 2005). Wastewaters were collected from the tunnel of effluent of OPM, Amalai and Son River water nearby village area during the month of January to June 2014 (Table 1).

Zone	Sampling Station code	Sampling station details	Distance from source (km)
Zone -1	SS-01	Near first paper mill	0.3
	SS-02	Near first boiler tunnel	0.6
	SS-03	Staff colony	0.9
	SS-04	Labor colony	1.0
	SS-05	Pokhrinala	1.2
	SS-06	Near son river	2.0
Zone -2	SS-07	Village bargwan	3.0
	SS-08	Jarwahi	5.0
	SS-09	Changera	7.0
	SS-10	Birhuli	9.0

Table 1: Details of sampling stations, zone, and distance from the mill

Chemical Parameter	BIS limits (mg/L)	
	Desirable	Permissible
Turbidity (NTU)	1	5
pH	6.5	8.5
EC µS/cm	750	2250
TDS (mg/L)	500	2000
TSS (mg/L)	100	-
TH (mg/L)	200	600
TA (mg/L)	200	600
Na (mg/L)	100	200
K (mg/L)	12	-
Ca (mg/L)	75	200
Mg (mg/L)	30	100
Fe (mg/L)	0.3	No relaxation
Hg (mg/L)	0.001	No relaxation
Cd (mg/L)	0.003	No relaxation
Pb (mg/L)	0.01	No relaxation
Zn (mg/L)	5.0	15
Cr (mg/L)	0.05	No relaxation

.Table 2: Analytical methods adopted along with (BIS 2012) limits.

2.3. Analytical Procedures

All samples were collected from each sampling station for analysis in new1L, plastic containers pre-rinsed with dilute nitric acid then fill the effluent and labeled them accordingly. The samples were acidified with 1N, nitric acid solution as to prevent adsorption for the

metal to the walls of the container. All the analysis in this study was repeated two or three times, until concordant values were obtained and all the tests were carried out according to the standard method (APHA2005).The heavy metals Fe, Hg, Cd,Pb, Cr and Zn were determined using inductive coupled plasma (ICP) and Atomic absorption spectrometer (AAS) (Table 2)

2.4. Statistical Analysis

The data were statistically analyzed by setting up and calculating a mean and standard deviation, ranges for the various parameters. Ranges (Table 3) mean and standard deviation (SD) (Table 4) Correlation coefficient (Table 6) were conducted to determine water quality variation between different parameters. Correlation matrix existed between 14 parameters.

2.5. Interrelation of Chemical Parameters

The correlation coefficient (r) is calculated for different parameters in effluent of OPM, Amalaiand Son river water(Table 6). The pH was strong negatively correlated with different parameters TDS, TSS, TH, TA, Ca, Fe and pH.Electric conductivity was strong positively correlated TDS, TA, Na, Ca, Fe and Pb. Total dissolved solids was strong positively correlated with TA, Na, K, Ca, Fe, Pb and Cr. Sodium was good positively correlated with K,Ca,Fe, Pb and Cr. Calcium was strong positively correlated with turbidity, EC, TDS, TSS, TH, TA, and Na, except pH. Iron showed good positive correlation with turbidity, EC, TDS, TSS, TA, Na and Ca, except pH. Lead content showed positive relation with all different parameters, except pH

3. Results and Discussion

3.1. Physico-Chemical Analysis of Wastewater

Turbidity changed throughout the study period. Turbidity showed high variability and much difference during the study period in each sampling stations (Figure 4). Most of the turbidity is due to colloidal and extremely fine dispersion (Ravikumar et al. 2013). The mean turbidity values in effluent of OPM, Amalai and Son River water were reported in(Table 5) during January to June2014.The turbidity nature of effluent in SS-01, SS-02 was very high the permissible limit of 5 NTU (BIS 2012).The average pH value in SS-01and SS-02 were varied the permissible limit of 6.5-8.5 in studied area (Figure 5). Though pH has no direct effect on human health, but shows close relation with some other chemical constituents of water (Garg et al. 2009). Electrical conductivity mean values in effluent of OPM,Amalai and Son River water were reported in(Table4)during January to June 2014. Electrical conductivity a measure of a materials ability to conduct an electric current. Higher conductivity indicates the enrichment of salt in the effluent of OPM, Amalai and Son River water. The value of electrical conductivity in effluent of OPM, Amalai were higher the permissible limit of2250 µS/cm (BIS 2012). Conductivity was high relatively all sampling station,exceptSS-01, SS-02, SS-03, SS-07, SS-08, SS-09 and SS-10 (Figure6).Highest values were recorded in sampling station SS-04, SS-05 and SS-06 etc.

The total dissolved solids (TDS) which indicate total dissolved ions in the wastewater. TDS mainly consists of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium,magnesium, sodium, potassium, iron and small amounts of organic matter (Ravikumar et al. 2013). TDS mean values in effluent of OPM, Amalai and Son River water were reported during January to June 2014 (Table 5). High mean value of TDS observed from the region of OPM, Amalai in SS-01, SS-02, SS-04, SS-05, SS-06, and SS-07. Value of high TDS varied 1236.3±2.0 to 2097.0±360.3 mg/Ldue to over discharges of effluent from OPM, Amalai and Soda factory (Figure 7). According to the WHO maximum acceptable concentration of TDS in water for a domestic purpose was 500 mg/L and excessive permissible limit is 1500 mg/L (Garget al. 2009).The mean values of TSS in effluent of OPM and Son River water were reported during January to June 2014. The values of TSS in sampling station SS-01 and SS-02 was very high besides these sampling station the value of TSS were below the permissible limit of 100 mg/L (BIS, 2012).The range values of TSS in different ten sampling stations were shown in (Table 3).Hardness is a very important property of water from its domestic application point of view hardness, causes problem in boiler in industries (Garg et al. 2009).The average total hardness in effluent of OPM and Son River water in different sampling stations were reported during January to June 2014 (Table 5). The degree of hardness of drinking water has been classified (WHO2004) in term of its equivalent $CaCO_3$ concentration (Table 3) accordingly water of all sampling stations respectively belong to hard and very hard category (Figure 8).

Classification	Hardness rang (mg/L)
Soft	0.75
Medium soft	75-100
Hard	150-300
Very hard	Above 300

Table 3: Classification of water depending upon the hardness (WHO2004). (Ravikumar et al. 2013).

Alkalinity is a measure of ability of water to neutralize acids, it is due to the presences of bicarbonate and carbonates and hydroxide of calcium magnesium, sodium, potassium and salts of weak acids and strong bases as borates, silicates, phosphates etc. Large amount of alkalinity, a bitter taste harmful for irrigation, as it damage soil and hence, reduces crop yields (Ravikumar et al. 2013).The result showed that alkalinity values in effluent of OPM, Amalai were below the permissible limit of 600 mg/L (BIS, 2012). Only SS-04 shoed higher value of alkalinity in (Zone 1) (Figure 9).

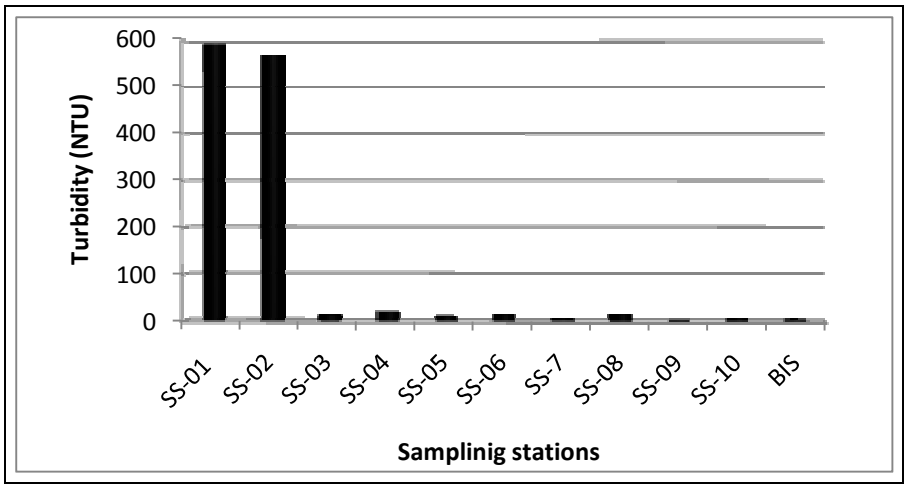

Figure 4: Average value of turbidity in various sampling stations during January to June 2014

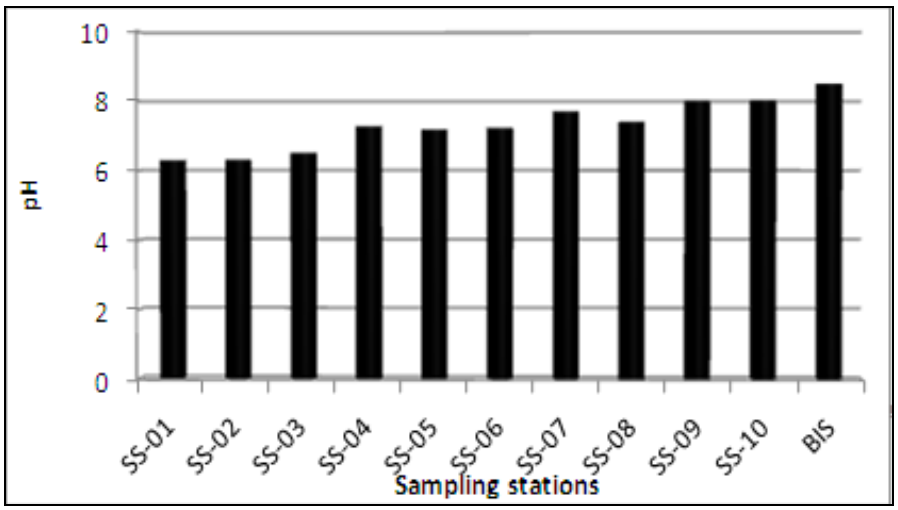

Figure 5: Average value of pH in various sampling stations during January to June 2014

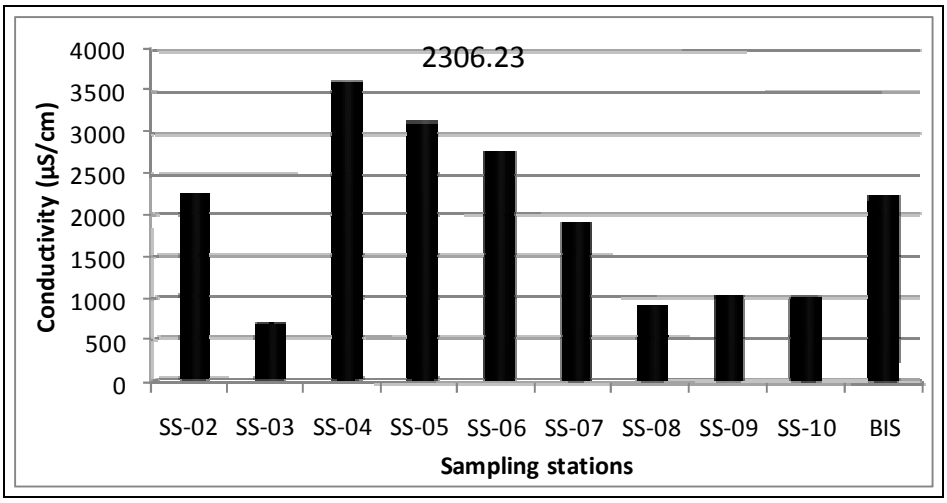

Figure 6: Average value of conductivity in various sampling stations during January to June2014

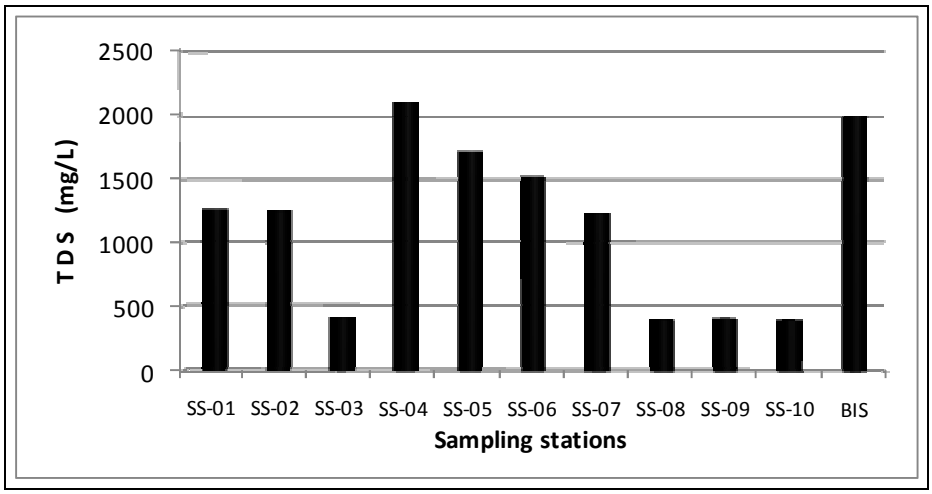

Figure 7: Average value of TDS in various sampling stations during January to June 2014

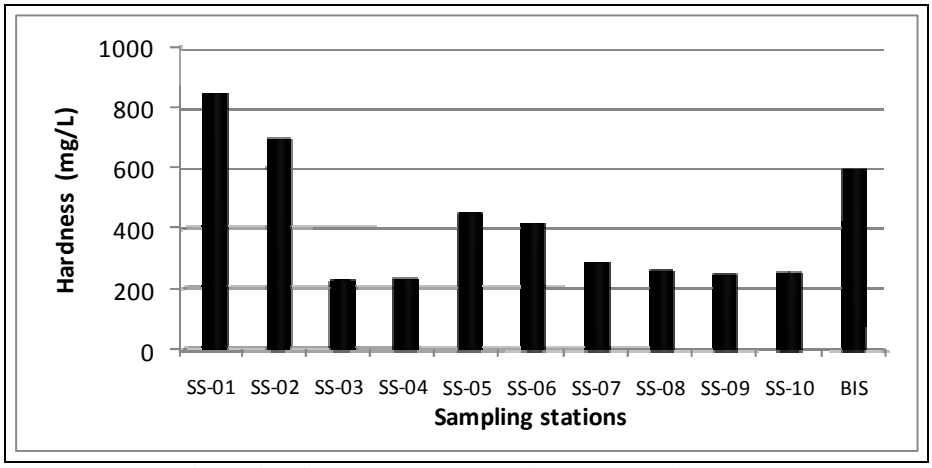

Figure 8: Average value of hardness in various sampling stations during January to June 2014

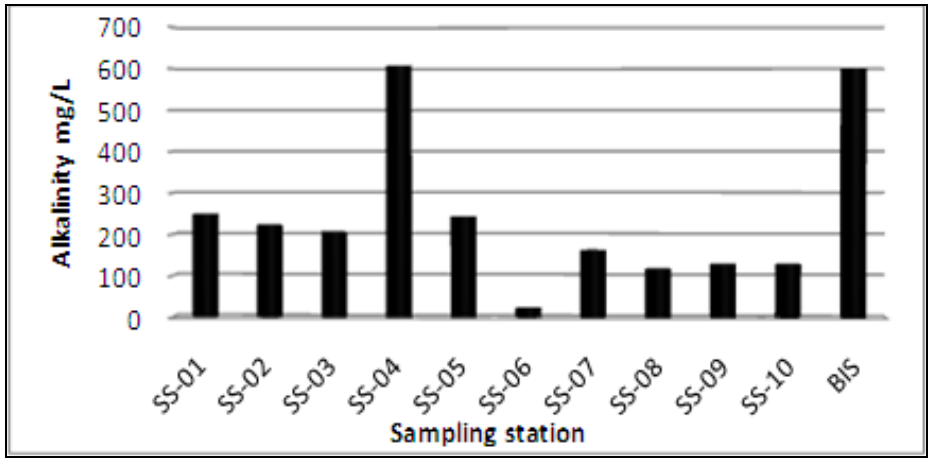

Figure 9: Average value of alkalinity in various sampling stations during January to June 2014

3.2. Major Ions Chemistry

In effluent of orient paper mill, Amalai and Son River water the predominant trend was in the order of $Ca^{2+}>Na^{+}>Mg^{2+}>K^{+}$in different sampling station showed average concentration of ion in the sampling station(Table 5).

The mean concentration of calcium in effluent of OPM, Amalai and Son River water were reported during January to June2014.Sampling station SS-01 showed high calcium content compared to the permissible, whereas calcium content in other all sampling stations were below the permissible limit of 200 mg/L (BIS 2012). The average magnesium values in effluent of OPM,Amalai and Son River water were reported during January to June 2014 (Table 4). It is evident that concentration of magnesium within the permissible limit of 100mg/L. It is evident that effluent of OPM, Amalai and Son River water showed sodium values within

the permissible limit of 200 mg/L (BIS 2012) (Table 4). The average potassium concentration in effluent of OPM,Amalai and Son River water were reported during January to June 2014(Table 4). The results indicate that higher potassium content occurred in SS04, SS-05, and SS-06with respect to permissible limit of 12 mg/L (Figure 10). Favoring the fact that contents of sodium and potassium in effluent were due to over dosing of different type of salt during pulp cum paper forming process.

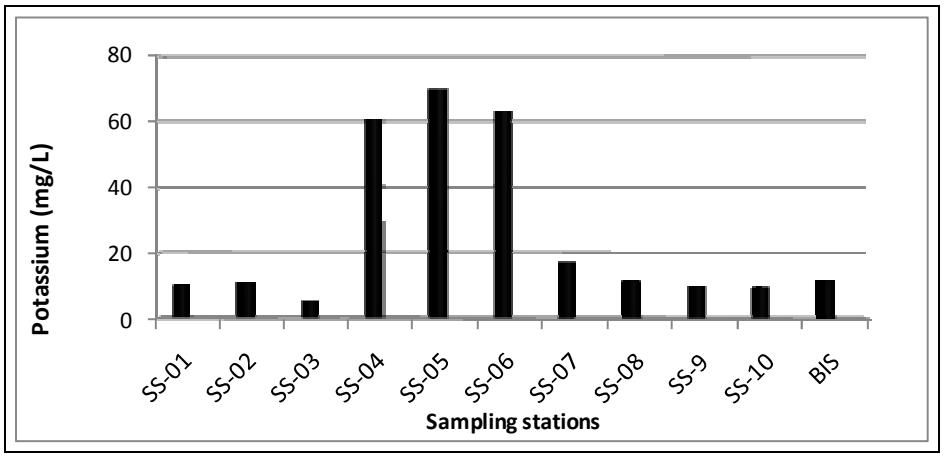

Figure 10: Average value of potassium in various sampling stations during January to June 2014

3.3. Heavy Metal Characterization

The mean Fe values in effluent of OPM,Amalai and Son River water were reported during January to June 2014(Table 4). Sampling stationsSS-01, SS-02 and SS-04 showed mean iron concentrations higher the permissible limit of 0.3 mg/L (BIS 2012). Iron indicated a high average spatial variation in SS-04 value of 1.77mg/L. Orient Paper Mill. Amalai and Soda factory directly release their effluents into the water system all of which contributing greatly to significant level of Fein SS-04.The suitability of theHg intrusion technique to evaluate the pore structure and related information of different kind of woods used for pulp production, pulp hand sheet and commercial paper sheets. The meanHg values in effluent of OPM, Amalai were reported (Table 4) during Januaryto June 2014. Contents of Hg in Son River water were below the permissible limit 0.001mg/L in sampling stations SS-07, SS-08, SS-09 and SS-10 (Zone-2).The effluents of OPM, Amalai showed higher Hg values compared to the permissible limit of 0.001 mg/L (BIS 2012). It is evident that higher concentrations of Hg aroundthe OPM, Amalai (Figure12) due to intrusion of Hg used for pulp production and development of porosity in pulp cum paper forming process.It is evident that effluent of OPM, Amalai and Son River water had Pb concentration within the permissible limit of 0.01 mg/L (BIS, 2012) (fig, 13).It is apparent that sampling station SS-01, SS-02 and SS-04showed higher Cd content besides,these sampling stations all within the permissible limit of 0.003 mg/L (Figure 14)**.** The mean concentration of Cr in effluent of OPM,Amalaiand Son River water were reportedduring January to June 2014 (Table-4). It is evident that effluent of OPM, Amalai and Son River water had Cr concentrations within the permissible limit of 0.05 mg/L (Figure15).

The average values of Zn in effluent of OPM, Amalai were reported during January to June 2014. As result this heavy metal content had low loading in each sampling stations (Zone-1) and(Zone-2) permissible limit of 15 mg/L (Figure 16). Zinc biologically important trace elements are present in many enzymes, necessary for metabolism of carbohydrates lipid and protein (Charkhabi et al. 2005).Table 3 give range values of all parameters in effluent of Orient Paper Mill, Amalai and Son River water.

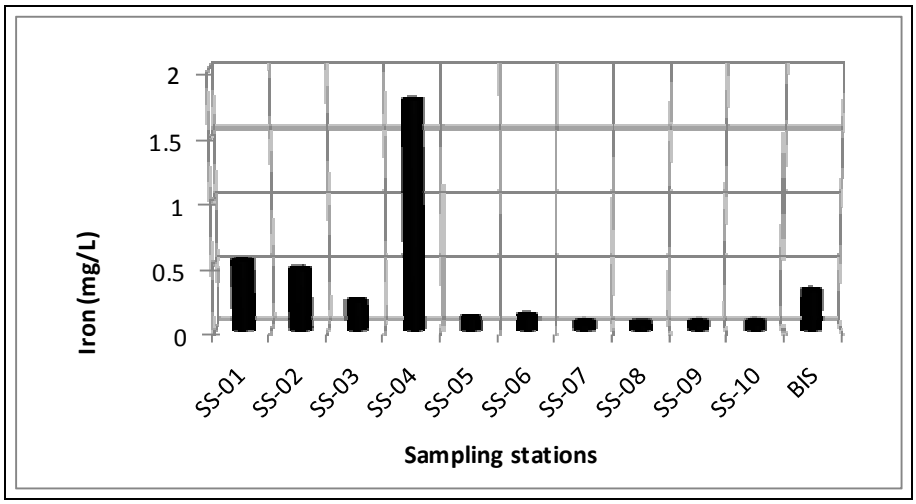

Figure 11: Average value of iron in various sampling stations during January to June 2014

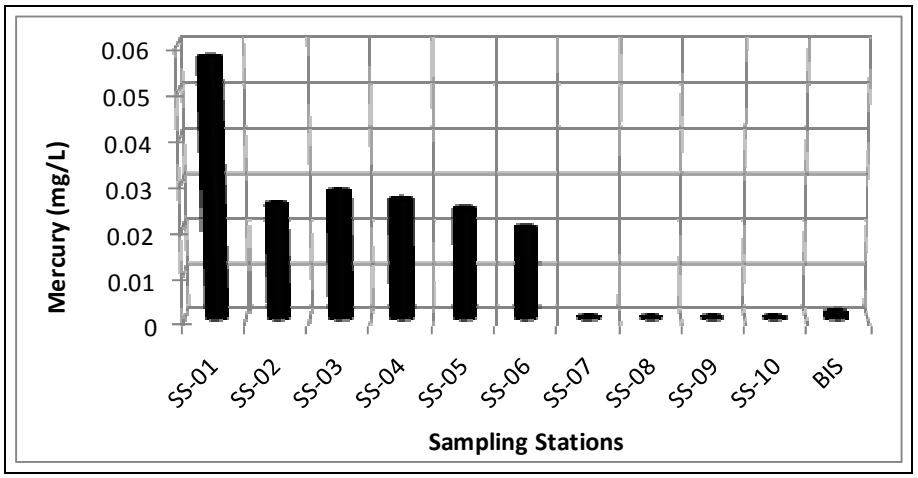

Figure 12: Average value of mercury in various sampling stations during January to June 2014

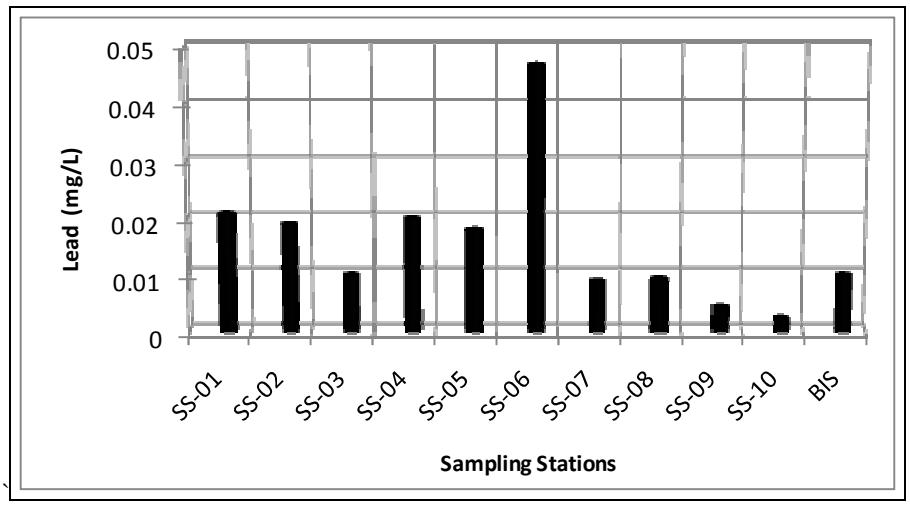

Figure 13: Average value of lead in various sampling stations during January to June 2014

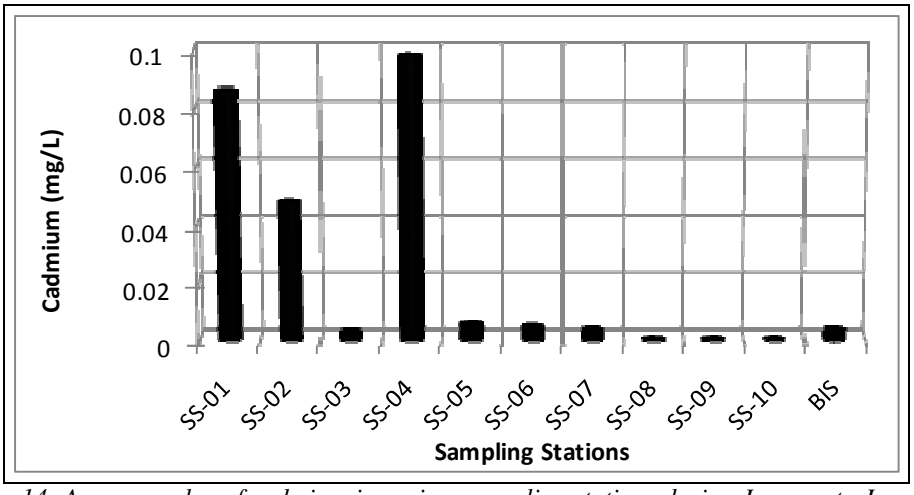

Figure 14: Average value of cadmium in various sampling stations during January to June 2014

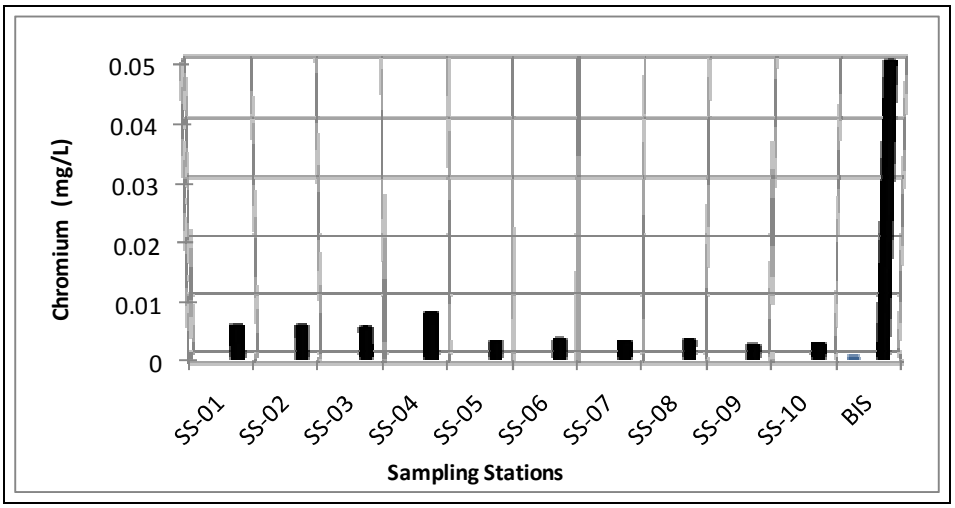

Figure 15: Average value of chromium in various sampling stations during January to June 2014

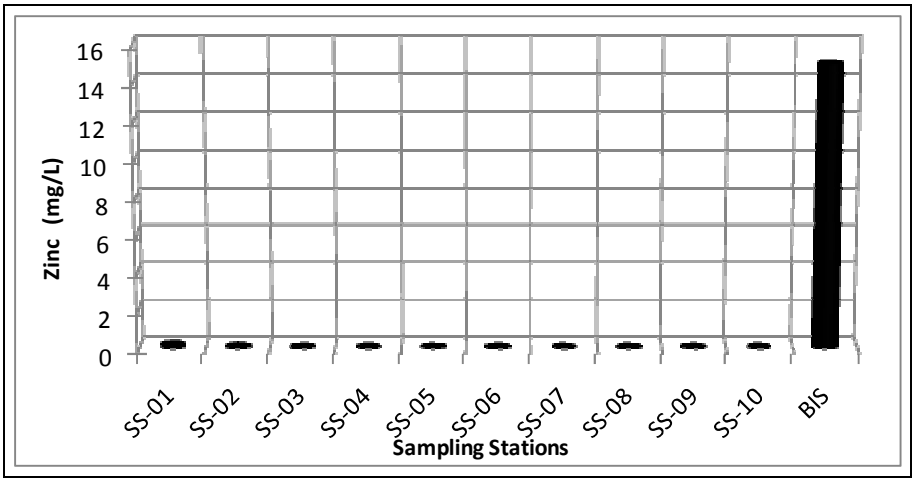

Figure 16: Average value of zinc in various sampling stations during January to June 2014

Parameter	SS-01	SS-02	SS-03	SS-04	SS-05	SS-06	SS-07	SS-08	SS-09	SS-10
Turbidity NTU	450-706	202.932	3.0-20.1	15-23	6.2-19	10-20	4.9-6.1	13-17	2-2.4	1.2-12.2
pH	6.1-6.4	6.0-6.6	6.2-7.0	6.9-7.5	6.9-7.7	7.1-7.4	6.9-8.6	7.0-7.8	7.4-8.4	7.8-8.5
EC µS/cm	1920-2522	2260-2272	630-774	3590-3680	3128-3228	2529-3025	1856-2012	521-1296	521-1550	423-1560
TDS mg/L	970-1556	963-1528	299-524	1674-2456	1711-1715	1352-1699	1234-1240	263-545	261-567	258-547
TSS mg/L	189-316	90.8-315	3.1-9.2	10.8-14.8	5.1-6.0	9.1-11.8	4.7-6.8	11.5-12.8	1.5-2.5	1.1-8.1
TH mg/L	848-852	670-728	165-270	147-312	283-626	184-658	280-306	147-364	147-364	136-380
TA mg/L	240-259	99-299	140-248	352-745	211-298	198-248	140-183	91-140	114-146	120-142
Na mg/L	95-104	93-110	48-61	98.6-128	102-108	101-115	83.1-108	52-69	44.6-71.1	45.1-71.2
K mg/L	10-10.9	11-11.2	4.7-6.2	56-70.1	65.1-74	60-66.3	15.2-18.6	9.1-13.7	6.6-13.0	4.4-15.6
Ca mg/L	205-210	185.5-192	62.1-65	90.1-95	117-126	48-53	45-50	45.1-48.2	44.8-47.7	45.1-48.8
Mg mg/L	30.1-32.1	26.1-30.41	9.6-13.5	18.2-24.9	10.1-14.78	9.8-11.5	9.8-21.48	10.8-23.1	10.4-25.8	10.1-21.0
Fe mg/L	0.31-0.62	0.42-0.52	0.21-0.24	1.31-2.11	0.072-0.084	0.062-0.121	0.040-0.047	0.005-0.076	0.040-0.047	0.015-0.09

Hg	mg/L	0.05-0.066	0.001-0.05	0.002-0.047	0.002-0.051	0.041-0.009.	**0.020-0.020**	BDL	BDL	BDL	BDL
Cd	mg/L	0.004-0.166	0.01-0.1	0.001-0.0038	0.0124-0.187	0.003-0.009	0.004-0.004	0.003-0.003	BDL	BDL	BDL
Pb	mg/L	0.019-0.024	0.007-0.026	0.002-0.018	0.017-0.023	0.007-0.24	0.031-0.06	0.003-0.016	0.004-0.017	0.002-0.007	0.001-0.006
Zn	mg/L	0.12-0.17	0.004-0.094	0.0023-0.027	0.011-0.011	BDL	BDL	BDL	BDL	BDL	BDL
Cr	mg/L	0.0041-0.007	0.002-0.009	0.0029-0.008	0.0046-0.01	0.0017-0.004	0.003-0.003	0.0017-0.004	0.002-0.0038	0.002-0.0	0.002-0.0024

Table 4: Physico-chemical composition of effluent of OPM, Amalai and Son river water in sampling stations during January to June 2014

BDL= below detection limit. The detection limit of the instrument was 0.00001 mg/L.

Parameter	SS-01	SS-2	SS-03	SS-04	SS-05	SS-06	SS-07	SS-08	SS-9	SS-10
Turbidity	594.5±109.70	570.83±323.54	12.25±7.61	19.3±3.19	10.46±4.16	14.3±3.10	5.45±0.48	14.83±1.40	2.18±0.15	6.63±4.08
pH	6.3±0.09	6.31±0.21	6.51±0.30	7.28±0.21	7.18±0.24	7.23±0.12	7.7±0.61	7.41±0.32	8.01±0.31	8.03±0.23
EC	2306.33±203.71	2267.2±4.60	703.3±68.73	3635.2±42.87	3130.6±47.70	2776.2±245.10	1933.5±75.50	912.6±382.12	1037.8±506.50	1029±525.60
TDS	1261.6±84.20	1249.2±272.0	421.5±102.43	2097±360.32	1712.8±1.70	1525.6±168.70	1236.3±2.0	405±137.70	415.2±148.80	404.3±139.70
TSS	251.5±61.80	210.95±102.52	6.63±2.44	12.6±1.50	5.6±0.30	10.5±0.88	5.6±0.73	12±0.41	1.9±0.37	4.01±2.34
TH	850.2±1.30	699.6±26.50	229.6±38.37	234±76.69	456.6±155.80	419.6±233.10	293±10.50	263±96.29	250.3±109.0	256.16±117.88
TA	249±7.40	222.83±69.47	206.33±41.41	607.5±115.18	242.6±28.56	222.5±21.22	162.5±1634	118±19.33	129.8±10.90	129.83±8.45
Na	100.3±3.30	101.6±6.59	54.35±5.53	115.6±10.97	105.3±2.21	109±4.36	95.51±8.03	60.3±7.13	60.85±10.25	61.31±9.59
K	10.35±0.88	11.1±0.07	5.27±0.50	60.63±4.55	70.03±2.61	63.1±2.38	17.10±1.27	11.78±1.6	10.06±2.52	9.98±5.45
Ca	207.3±1.61	190.41±0.85	63.9±1.06	92.30±1.54	121.5±3.68	49.8±1.70	48.3±1.70	46.75±1.13	45.85±1.03	47.28±1.31
Mg	31.2±0.81	28.66±1.50	11.59±1.49	21.45±2.19	11.64±1.49	10.58±0.65	14.88±4.87	16.74±5.86	18.06±7.19	15.36±5.17
Fe	0.53±0.090	0.46±0.030	0.22±0.013	1.77±0.320	0.078±0.004	0.096±0.020	0.044±0.002	0.039±0.032	0.044±0.002	0.048±0.032
Hg	0.057±0.007	0.025±0.023	0.028±0.018	0.026±0.023	0.024±0.017	0.020±0.000	BDL	BDL	BDL	BDL
Cd	0.086±0.057	0.048±0.037	0.0024±0.0008	0.098±0.085	0.005±0.002	0.004±.0.000	0.003±0.0	BDL	BDL	BDL
Pb	0.021±0.001	0.019±0.006	0.01±0.005	0.02±0.003	0.018±0.005	0.047±0.010	0.0089±0.005	0.0093±0.005	0.0045±0.002	0.0023±0.001
Zn	0.15±0.017	0.048±0.044	0.0025±0.001	0.011±0.000	BDL	BDL	BDL	BDL	BDL	BDL
Cr	0.0055±0.001	0.0055±0.003	0.0052±0.003	0.0077±0.002	0.0026±0.001	0.003±0.000	0.0026±0.001	0.0029±0.0005	0.002±0.000	0.0022±0.0001

Table 5: Spatialmean value of physico-chemical parameter in effluent of OPM, Amalai and Son river water during January to June 2014

All parameters are expressed in mg/L, except pH, turbidity and conductivity

BDL= below detection limit. The detection limit of the instrument was 0.00001 mg/L.

		Turbidity	pH	EC	TDS	TSS	TH	TA	Na	K	Ca	Mg	Fe	Pb	Cr
Turbidity	**Turbidity**	**1.00**	**-0.83**	**0.43**	**0.43**	**0.97**	**0.43**	**0.54**	**0.37**	**0.12**	**0.72**	**0.53**	**0.79**	**0.76**	**0.89**
Ph	**pH**		**1.00**	**-0.28**	**-0.52**	**-0.73**	**-0.50**	**-0.67**	**-0.25**	**-0.08**	**0.86**	**-0.19**	**-0.78**	**-0.74**	**-0.46**
EC	**EC**			**1.00**	**0.92**	**0.34**	**0.42**	**0.66**	**0.96**	**0.77**	**0.56**	**0.17**	**0.53**	**0.70**	**0.40**
TDS	**TDS**				**1.00**	**0.46**	**0.33**	**0.81**	**0.87**	**0.72**	**0 .70**	**0.04**	**0.67**	**0.80**	**0.59**
TSS	**TSS**					**1.00**	**0.47**	**0.54**	**0.37**	**0.21**	**0.70**	**0.52**	**0.75**	**0.77**	**0.91**
TH	**TH**						**1.00**	**0.18**	**0.41**	**0.38**	**0.56**	**0.28**	**0.19**	**0.46**	**0.17**
TA	**TA**							**1.00**	**0.60**	**0.27**	**0.87**	**0.19**	**0.89**	**0.68**	**0.72**
Na	**Na**								**1.00**	**0.77**	**0.54**	**0.11**	**0.56**	**0.68**	**0.44**
K	**K**									**1.00**	**0.23**	**-0.20**	**0.11**	**0.49**	**0.15**
Ca	**Ca**										**1.00**	**0.31**	**0.85**	**0.72**	**0.73**
Mg	**Mg**											**1.00**	**0.31**	**0.09**	**0.38**
Fe	**Fe**												**1.00**	**0.76**	**0.90**
Hg	**Pb**													**1.00**	**0.78**
Cd	**Cr**														**1.00**
Pb															
Zn															
Cr															

Table 6: Correlation coefficient of analyzed parameter of effluent of OPM, Amlai and Son river water

4. Conclusion

The concentration of some analyzed parameters viz. chemicals and heavy metals in effluent of OPM, Amalai (Zone-1) were higher than the standard maximum acceptable concentration. Although the results showed that there is considerable metal pollution in Son River, Metal pollution in effluent of OPM, Amalai sampling station SS-01, SS-02 and SS-04were higher than the acceptable permissible limit. Concentration of Hg, Pb and Cd in effluent of OPM had higher mean concentration, compared to the standard maximum acceptable permissible limit. Quality of Son River water for domestic and irrigation with reference to the concentration of TDS, hardness, K, Ca which are more than the prescribed limit, at most locations. The Son River water quality characterized by average concentration of EC, K is not safe with respect to the acceptable concentration limit and corrosion had been seen in many locations. This study clearly suggested that heavy metal pollution in effluent water of OPM, Amalai occurred. The study will also be used as baseline data for an environmental analysis, undertaken plant and area.

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