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Monitoring of physico-chemical parameter of effluent release from orient paper mill, Amalai and son river water in Shahdol District, M.P.

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Abstract
Pulp and paper mill are hypothesized to be leading contributors to environmental pollution through the dumping of effluents into local water body. This assumption in the past was more or less correct but now a day's efficiently proved by study. The samples took from Orient paper mill (OPM) and Son river in district Shahdol during July to December, 2015 for determine the water quality at the mill dumping site and below effluents receiving Son river water. The testing parameters included color, odor, pH, turbidity, electrical conductivity, TDS, TSS, hardness, alkalinity, sodium, potassium, calcium and magnesium. The inconclusive results matched from drinking water standard reported by Bureau of Indian standards (BIS, 2012) which proved that the paper mill was some more anthropogenic contributors to water way pollution for concerning region.

Keywords: Effluent, Son River, OPM, Water quality analysis

Introduction
Pulp and paper industry is a highly energy and water intensive industry and also one of the biggest polluting sectors of water bodies (being the sixth largest water polluting) as a previous study by (Pokhrel and Viraraghvan, 2004) [14]. The Son River runs near the, Amalai city in Shahdol district coming in contact with effluent of Orient paper mill including the Soda factory and wastewater of Amarkantak thermal power plant. Orient paper mill was questioned to be one of the most effluents discharged plant. In comparison to other industries fresh water requirement in pulp and paper industry is quiet high i.e. 150-200 m^3 per ton of paper product (Yadav and Garg, 2011) [21]. A paper mill effluent characteristically contains objectionable color, offensive odor, very high level of hardness and highly dissolved ions. Most of these industries effluents their insufficiently treated waste into the river, streams, and ground water which create serious problem to aquatic life (flora-fauna) and human being.
The present study was undertaken to the purpose of examining the level of pollution in effluents and also water quality variation of Son River at Shahdol district within 10km. distance from the mill. The Samples were collected from the Son River, located near Amalai city during July to December, 2015. The studies focus on effluent of OPM and water quality of its surrounded waters by comparing instantaneous data to drinking water permissible limits (BIS, 2012) [3]. Physico-chemical parameters evaluated included pH, turbidity, electrical conductivity, TDS, TSS, hardness, alkalinity, sodium, potassium, calcium and magnesium followed the method of APHA, 2005 [1].

Material and Methods
Study area
Amalai is located 22^0 11' 21'' N (North longitude) 78^0 41' 25'' E (East latitude) in (M.P.). Amalai is a census town of Shahdol and Anuppur districts combindly in the state of (M.P.). Orient Paper Mill is located inside Amalai and the biggest paper mill of Asia. OPM situated at the bank of Son River while distance between Orient Paper Mill and Son River is 2 km. The Son River is 784 kilometres long and is one of the largest river of India. 10 sampling stations were selected for present study out which of 6 sampling stations were effluent running region of the OPM and 4 sampling stations were nearby village area in Son river (Table-1).

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

Area of sampling	Sampling Station code	Sampling station details	Distance from source (km)
Effluent of OPM	SS-01	Near first paper mill	0.3
	SS-02	Near first boiler tunnel	0.6
	SS-03	Staff colony	0.9
	SS-04	Labour colony	1.0
	SS-05	Pokhrinala	1.2
	SS-06	Near Son river	2.0
Son river water	SS-07	Village Bargawan	3.0
	SS-08	Village Jarwahi	5.0
	SS-09	Village Changera	7.0
	SS-10	Village Birhuli	9.0

Field Procedures and Sample Analysis

Samples collected from effluents running regions of OPM, and Son river location to include samples at dump site and downstream. The samples were collected in clean high density polythene bottles and store below 4^0 C temperature to slow biological activity until each was analyzed in lab. For each site, the location, date and time of sampling was recorded in a data table. Sodium, potassium were analyzed by flame photometry method. Calcium and magnesium was analyzed with the help of inductive coupled plasma technique. All the analyses in this report were repeated two or three times until, concordant values were obtained. The water samples analysis was carried out as per standard method of water and wastewater (APHA, 2005) [1].

Result and Discussions

Color: The visual color was physically identified by own eyes during the study. The color of effluents from sampling stations SS-01 and SS-02 were milky colloidal, especially odd black brown color was at sampling station SS-04 near labour colony. Milky colloidal color was due to cellulose, lignin, chlorinated resin acids, chlorinated phenol and chlorinated hydrocarbons in the pulp and paper mill effluent (Pokhrel and Viraraghvan, 2004) [14]. Other samples of effluents in running sites were found yellowish in color. Water of Son river near village area at sampling stations SS-08, SS-09 and SS-10 free from any objectionable color, except sampling station SS-07.

Odor: The odor of samples were observed physically through the own noise. The odor of effluent from OPM was rotten egg and sulphurous. The offensive smell of sewer and decay could result from diethyl sulphide, dimethyl disulphide and methyl mercaptan commonly emitted from paper mill stacks (Chan, 2006) [4]. The water samples of Son river free from odor except sampling station SS-07.

Turbidity: The maximum mean values of turbidity were 394.5±2.3 and 390.8±2.6 NTU at sampling station SS-01 and SS-02 respectively in effluent of OPM during the study. The values turbidity was much higher, due to milky colloidal cellulose, lignin, chlorinated resin acids, chlorinated phenol containing effluent. The maximum mean values of turbidity in effluent of OPM were also found at sampling stations at SS-04, SS-05and SS-06 (Table 2). The turbidity in Son river water was above the drinking water standard at SS-07 and SS-08 due to effluent receiving estuary of river. The turbidity and total suspended solids for both treated and untreated effluents were above the permissible limits (Sharma and Ramotra, 2014) [17]. The lower values of turbidity were observed 6.2±0.2 and 6.1± 0.1NTU at SS-09 and SS-10 respectively in Son river water.

pH: The low mean pH was 6.2±0.05 and 6.3±0.1at sampling station SS-01 and SS-02 respectively. Decreased pH value occurred at sampling stations SS-01and SS-02, due to hot effluent and acidic material involved in paper making process near the paper mill. Other sampling stations of effluent of OPM and Son river water were under drinking water standard (BIS, 2012) [3]. Son river water was found alkaline 7.9±0.08 and 8± 0.06 at sampling stations SS-09 and SS-10 respectively due to self-recovery properties being existed in river water.

Conductivity: The maximum mean values of conductivity were 3216.2±7.0 μScm^{-1}, 3016.3±5.4 μScm^{-1} and 1941.8±35.5μScm^{-1} at sampling stations SS-04, SS-05 and SS-01 respectively. The higher value of EC was measured in the effluent from OPM, indicating high total dissolved solids (TDS) emanating from the various chemicals used during paper processing. Low conductivity was observed 498.5±9.3 μScm^{-1} at sampling station SS-10 in Son river water only. All sampling stations have higher conductivity during study with respect to drinking water desirable limits 750 μScm^{-1} BIS, 2012 [3], except in Son river water at sampling stations SS-8, SS-09 and SS-10 (Table 2).

TDS: Total dissolved solids are measurement of inorganic salts, organic matter and other dissolved materials in water. In general, TDS is the sum of the cations and anions in water (Tripathi *et al*. 2013) [20]. Table 2, indicate the values of TDS in effluent of OPM and Son river water. The higher mean values of TDS were 1992.8 ±210.5, 1655.7± 4.2 and 1027.5±13.5 mg/L at sampling stations SS-04, SS-05 and SS-01 respectively in effluent of OPM during Jul. to Dec. 2015. Water of Son river was below TDS concentrations according to drinking water standard BIS, 2012 [3]. The values of TDS in effluents from OPM, were attributed to the high content of ions in sodium hydroxide and potassium hydroxide, chlorine, bleaching reagents, barium chloride and potassium sulphate chemicals used in a paper industry. Discharge of wastewater with a high TDS level would have adverse impact on aquatic life.

TSS: This parameter called non-filterable residue (NFR). Suspended solids absorbs heat from sunlight, which increase water temperature and subsequently decrease levels dissolved oxygen in the warmer water holds less oxygen than cold water (Tripathi *et al*. 2013) [20]. The maximum mean TSS values were 165.5±17.1 and 147±1.4 mg/L at sampling stations SS-01 and SS-02 respectively in effluent of OPM. The high TSS was observed in effluents due to brown colloidal, cellulose, lignin and chlorinated phenol containing untreated effluent emit from paper mill at SS-01(Near first paper mill) and SS-02 (Near first boiler tunnel). The average value of TSS at all over sampling stations of effluent from OPM and Son river water were under the permissible limits of BIS, 2012 [3], except sampling station SS-01 and SS-2.

Hardness: The presence of calcium, magnesium, sulphate, and nitrate ions contributes to water hardness. The higher mean values of hardness were found as 586.3±144.8, 237.7±52.2, 263.8±6.1, 261.3±10.2, and 259.5± 48.9 mg/L at sampling stations SS-01, SS-02, SS-05, SS-06 and SS-07 in effluent and river water respectively. The study revealed high hardness in effluent due to more uses of bleaching powder, reducing reagents for tanning, coating and whitening of pulp in paper mill industry. Hardness generally represents the

concentration of calcium and magnesium ions, because these are the most common polyvalent cations. Water of Son river was low hardness and within the permissible limit of BIS, 2012 [3] during study period.

Alkalinity: The alkalinity is the measure of capacity of water to neutralize the acids. The finding indicates that altered values of alkalinity were occurred during all over the study in effluents and Son river water. The mean values of alkalinity were 123.8±4.8 mg/L and 125±4.1 mg/L at SS-01and SS-02 due to resin acids and phenol contents present in effluent water that caused decreased the alkalinity. Maximum average value of the alkalinity 236±47 mg/L was observed at SS-10 in Son river water. Higher alkalinity was due to used of chemical lime, Na_2CO_3, much surfactant, sodium phosphate emit in river water and insufficient treatment of wastewater from paper mill. Alkalinity of the effluent samples varied from 1475 to 5220 mg/L (Manikandan *et al*. 2015) [12].

Sodium: Maximum average value of sodium 128.3±1.9 mg /L was obtained at sampling station SS-04 due to used NaOH in bleaching process, Na_2O_2 (sodium peroxide) Na_2S, $Na_2S_2O_3$ (Sodium thiosulphate) during paper making process and $Na_2Al_2O_4$ (Sodium metaaluminate) also used in conjunction with alum to control pH. The mean values of sodium at all over sampling stations were under the permissible limits (BIS, 2012) [3] during the study July to December, 2015. The concentration of sodium was varied between 43.7± 2.7 mg/L to 128.3±1.9 mg/L in Son River and effluent of OPM during the study.

Potassium: The high mean value of potassium 48.7±1.2 mg/L was observed at sampling station SS-04. Due to disposal of industrial effluent, an increased level (48 mg/L) of potassium was observed in the final outlet (Saravana-Sundaram *et al*. 2014) [15]. Low mean values of potassium 6.3±0.2, 6.2±0.2, and 6.1±0.2 were observed at sampling stations SS-03, SS-09 and SS-10 respectively during study. Potassium in term the magnitude of its content in the earth crust and the solubility of its compounds was very similar to sodium. However, it was occured in lower concentration in surface water as it has weak migratory ability.

Calcium: The mean value of calcium was found maximum at SS-01 and minimum at SS-10 with value of 190.5±2.3and 49±1.6 mg/L respectively. The basic sources of calcium in effluent of paper mill were carbonate rocks (lime stone, dolomite) that dissolved by carbonic acid contained in water. The sources of Ca and Mg in natural water are various types of rocks, industrial wastes and sewage (Gupta *et al*. 2013) [8]. The content of calcium in effluent of OPM and Son river water was below the permissible limits (BIS, 2012) [3].

Magnesium: The mean value of magnesium was found 30.5 ±0.4 mg/L at sampling station SS-01 in effluent water. This content of magnesium observed due to some compound of Mg used in paper industry that are MgO (Agalite or talc) for it gives paper a greasy or soupy free, $MgCO_3$ for filler cigarette paper but Mg trapped through EDTA and ligands from effluent water. According to drinking water standard the concentrations of magnesium was below in effluents of paper mill and Son river water during the study. In the present investigation, the magnesium content was varied between 30.5 mg/L to 10 mg/L in effluent and river water.

Table 2: Average values of physicochemical parameters with SD of effluent from OPM and Son River water July to December 2015.

Parameters	Sampling stations									
	SS-01	**SS-02**	**SS-03**	**SS-04**	**SS-05**	**SS-06**	**SS-07**	**SS-08**	**SS-09**	**SS-10**
Color	Milky colloidal	Milky colloidal	Light yellow	Black brown	Yellow	Yellow	Light yellow	Clear	Clear	Clear
Odor	Sulphurous	Sulphurous	Sulphurous	Sulphurous	Sulphurous	Sulphurous	Sulphurous	Odourless	Odourless	Odourless
Turbidity (NTU)	394.5±2.3	390.8±2.6	9.7±0.8	30.3±1.6	17.2±0.8	16.2±0.8	14.5±2.3	11.9±1.6	6.2±0.2	6.1± 0.1
pH	6.2±0.05	6.3±0.1	6.6±0.2	7±0.2	7.2±0.04	7.4±0.07	7.5±0.2	7.7±0.2	7.9±0.08	8± 0.06
EC (μScm^{-1})	1941.8±35.5	1905.5±2.7	726.5±2.8	3216.2±7.0	3016.3±5.4	1741.2±52.6	1229.2±11.5	708.2±64.8	673.7±70.4	500.8±1.0
TDS (mg/L)	1027.5±13.5	979.5±2.2	411.7±1.9	1992.8±210.5	1655.7±4.2	859.3±54.2	362±5.0	358.5±6.4	252.8±28.7	216.5±35.5
TSS (mg/L)	165.5±17.1	147±1.4	14.8±1.2	18.5±1.0	15.8±0.8	15.2±1.0	12.7±2.0	11.5±2.0	5.3±0.7	4.8±0.3
Hardness (mg/L)	586.3±144.8	237.7±52.2	166±15.3	192.7±15.4	263.8±6.1	261.3±10.2	259.5±48.9	147±3.8	146.8±4.4	145±4.3
Alkalinity (mg/L)	123.8±4.8	125±4.1	178.5±7.2	168.3±21.1	209.3±20.3	234.7±3.2	155.5	151.7	152	152.67
Na (mg/L)	106.8±3.5	103.9±2.9	83.7±2.3	128.3±1.9	65.2±1.6	81.33±8.9	53.5±6.5	46.8±4.4	45.2±2.9	43.7±2.7
K (mg/L)	18.5±0.4	15.4±1.4	7.6±0.3	48.7±1.2	45.7±4.4	32±4.0	17.2±1.0	6.3±0.2	6.2±0.2	6.1±0.2
Ca (mg/L)	190.5±2.3	184±2.6	78±1.7	106.8±3.7	59.5±3.5	54.7±2.8	51.6±0.8	51±0.6	50±1.1	49±1.6
Mg (mg/L)	30.5±0.4	30±0.4	15.2±0.3	24.7±1.0	15±0.4	12.4±0.3	11.4±0.4	10.8±0.4	10.4±0.1	10± 0.1

Conclusion

The study revealed that the pulp and paper mill effluents were highly polluted and had variation in the pollution load on different sampling stations toward effluent running sites. The Son river water optimum affected from the wastewater of paper mill. Son river water was unfit for drinking purpose near paper mill effluent receiving region of river during the study.

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