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MK Ahirwar
Research Scholar,
Department of Chemistry
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya
Chitrakoot, 485331, M.P., India.

GS Gupta
Associate Professor,
Department of Energy and Environment Faculty of Science and Environment Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, 485331, M.P., India.

N Kirar
Research Scholar,
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya
Chitrakoot, 485331, M.P. India.

P Ahirwar
MSc Student, Chemistry,
Pt. S.N.S. Govt. College, Shahdol
484001, M.P., India.

Correspondence:
MK Ahirwar
Research Scholar,
Department of Chemistry
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhalaya
Chitrakoot, 485331, M.P., India.

Monitoring of heavy metals in effluent of orient paper mill, Amalai (Shahdol), M.P.

MK Ahirwar, GS Gupta, N Kirar, P Ahirwar

Abstract
This study investigates the pollution in the effluent of Orient Paper Mill (OPM), Amalai and Son river water in the state of M.P., India. Son river originate from Amarkantak (M.P.) and flows along with bank of Orient Paper Mill, Amalai. Effluent of OPM and Son river water were collected periodically from July to December 2014 for this study. These samples were tested and analyzed to find the concentrations of Na, K, Ca, Cd, Hg, Pb, and Cr. The toxic mercury concentration was found 0.070 ppm in sampling station SS-01 in August 2014, cadmium 0.004 ppm and lead 0.024 ppm in SS-04 in Zone-1 September 2014. The level of contamination is higher than the WHO limit of drinking water standards but Chromium content is within the limit. The toxic mercury concentration was found below detection limit in sampling station SS-07 during July to December 2014, cadmium 0.005 ppm and lead 0.008 ppm in SS-07 in Zone-2 September 2014. On the other hand, the water samples taken from Son river nearby village area are non-polluted, and the analysis shows that heavy metals are within the limits of WHO standard, except cadmium at SS-07.
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Keywords: Heavy metals· Mercury · Son river water · Orient paper mill · Effluent.

Introduction
Water is a vital resource necessary for all aspects of human and ecosystem survival and health. Depending on the quality of river water may be used for human consumption irrigation purpose and live stock watering. Heavy metals are stable and persistent environmental contaminant since, owing to their refractory nature. Pollution is being added to the surface water system or river water system through human, natural process and industrial process. The solid wastes from Orient Paper Mill are being dumped near the mill and treated effluent directly received by Son river. The Effluent of Orient Paper Mill, Amalai and other directly discharge of wastewater into Son river water picks up a larger degree of heavy metal and pollutants. The usage of the contaminated surface and ground water cause the various diseases (Puthiyaseker *et al*. 2010) [5]. Water quality has become a global concern due to over increasing populating and development activities that had over exploit and polluted the water resource available to us (Gupta *et al*. 2009) [2]. The presence of heavy metals in water and waste water is one of the main causes of water and soil pollution (Oliveira *et al*. 2007) [4]. In lakes, the peak of water pollution by toxic metals due to discharge of industrial wastewater was reached in the middle of the twentieth century (Thevenon *et al*. 2012) [7]. All these workers concluded that there is need to monitor water quality on a regular basis. The increase in concentration of heavy metals in potable and river water will increase the threat to human health and life. In this report, spatial variation in heavy metal concentration and composition in water of the Son river and in effluent from the Orient Paper Mill, Amalai were assessed during July to December 2014.

Material and Methods
Description of Study Area
Amalai is located 220 11’ 21’’ N 780 41’ 25’’ E in (M.P.). Amalai is a census town of Shahdol and Anuppur districts combindly in the state of (M.P.). As of 2001 India census, Amalai had a population of 30292. 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. Son river originated from Amarkantak, Madhya Pradesh 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 Uttar Pradesh, Jharkhand and Bihar states and finally join to the river Ganga just above Patna. The Son river is 784 kilometer long and is one of the largest river of India. In view of the above facts present study was undertaken in order to asses and monitor the quality variation in water of Son river caused by discharges of effluent of OPM and Soda Factory, Amalai. Figures of study area and sampling stations were given elsewhere.

Table 1: Details of zone, sampling station code and distance from the mill.

Zone	Sampling Station code	Sampling station details	Distance from source (km)
Zone-1 (Orient Paper Mill)	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 (Son river)	SS-07	Village bargwan	3.0
	SS-08	Village Jarwahi	5.0
	SS-09	Village Changera	7.0
	SS-10	Village Birhuli	9.0

Sampling and Analysis

10 sampling stations were selected for present study out which of 6 sampling stations were eastern region of the OPM and 4 sampling stations were nearby village area in Son river. In this study all sampling station expressed by sampling stations code and area of sampling divided by 2 zones Table 1. Out of 10, 6 sampling stations were downstream of effluent from OPM (Zone-1) and 4 sampling stations were in Son river nearby village (Zone-2). Effluent samples were collected from tunnel of OPM, Amalai and water samples from Son river. Samples were collected from effluents of OPM, Amalai (Zone-1) and Son river water nearby village area (Zone-2) during the month of July to December 2014. The sample containers were cleaned by 1N nitric acid and left for two days followed by rinsing with distilled water. The bottles were rinsed before sampling and tightly sealed after collection and labeled in the field. Sodium, potassium were analyzed by flame photometry method. Calcium, mercury, lead, Chromium and Cadmium were analyzed by inductively coupled plasma- optical emission spectrometry (ICP-OE, Perkin-Elmer Model Optima 2100 DV, Massachusetts, USA). All the analyses in this report were repeated two or three times until, concordant values were obtained. The analysis was carried out as per standard method of water and wastewater (APHA 2005) [1]. Metal contents were expressed in ppm.

Results and Discussion

Variation of metal contents in the various sampling station are shown in (fig. 12 3 and 4) during July to December 2014. Limits for drinking water standard as per WHO were Hg 0.001 ppm, Cd 0.003 ppm, Cr 0.05 ppm and Pb 0.01 ppm.

The analytical data showed that mercury concentration varied from 0.001 to 0.070 ppm at sampling Zone-1. The high concentration of mercury was observed in Zone-1 SS-01, SS-02, SS-03, and SS-04 due to discharge of untreated effluent directly flows from the Orient Paper Mill. Sampling stations SS-05 and SS-06 contained treated effluent of OPM from wastewater treatment plants distance between sampling stations given in Table 1. In Son river water nearby village area Zone-2 at SS-07, SS-08, SS-09 and SS-10 the concentrations of mercury were found below detection limit (BDL= 0.0001 ppm). Mercury contamination can cause severe neurological lung and kidney damage. Mercury exposure at high levels can harm the brain, heart, lungs and immune system of people of all ages. It was found that knowledge on flows and emission sources on a large geographical scale is limited due to a lack of information on emission factors from various industrial process and waste systems, especially for the mercury being discharges in water and land (Sundseth *et al*. 2012) [6].

Table 2 give an overview of some reported heavy metal concentration in effluent of OPM, Amalai Zone-1 and Son river water Zone-2 for different sampling station.

The concentration of lead in the collected effluent samples varied from 0.005 to 0.03 ppm. Low level of lead was observed in the water samples of Son river at SS-07, SS-08, SS-09, and SS-10 Zone-2. High level of lead was observed in the effluent samples at SS-01, SS-04 Zone-1 during July to December 2014. The discharges of untreated effluent contained lead by pulp cum paper making process it is one of the reasons for detectable levels of lead present in effluent of OPM, Amalai and Son river water Table-2. Sampling station SS-01 registered high level of lead during July and December 2014. Water samples of Son river the concentration of lead varied from 0.006 to 0.008 ppm. The untreated effluents of OPM, Amalai containing lead readily form complexes with aquatic substances. Higher concentration of lead has adverse effect on central nervous system, gastrointestinal system and may cause brain damage.

The concentration of cadmium in collected effluent samples varied from 0.001 to 0.05 ppm. Low level of cadmium was observed in sampling stations SS-05 in Zone-1. High level concentration of cadmium was observed in the sampling stations SS-02 during July 2014. In water samples of Son river at SS-07, SS-08, SS-09, and SS-10 Zone-2 the concentration of cadmium was found below detection limit (BDL= 0.0001 ppm) during July to December 2014. The high concentration of cadmium (0.005 ppm) was observed in sampling station SS-07 only Zone-2. The harmful effect was mainly caused by heavy metals specially Cd, Cr, Ni, and Cu (Zhang *et al*. 2014) [8].

The concentration of Chromium was varied from 0.004 to 0.009 ppm in effluent samples of OPM, Amalai, Zone-1 and 0.002 to 0.005 ppm nearby village area in the Son river water Zone-2. The results indicate that levels of Chromium in the Son river water and effluent of OPM, Amalai within the WHO limit. Industrial complex generate huge quantities of solid and liquid wastes that are contaminated with heavy metals (Cu, Zn, Mn, Fe, Ni, Cd, Cr, Co, Pb and Hg) some of these are toxic or carcinogenic in sufficient concentrations (Khan *et al*. 2005) [3].

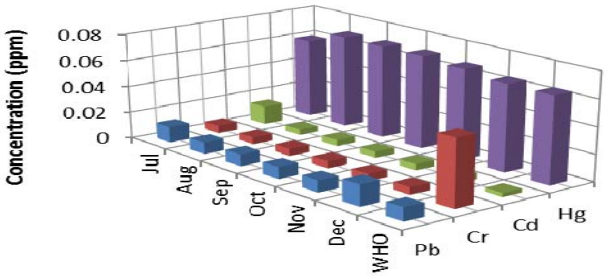

Fig 1: Heavy metals contamination in SS-01 during July – December 2014

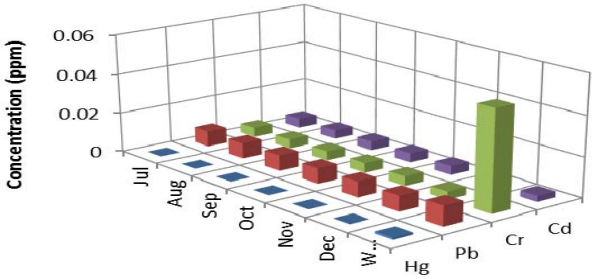

Fig 3: Heavy metals contamination in SS-07duringJuly – December 2014

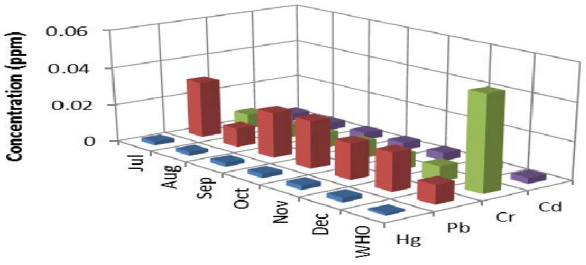

Fig 2: Heavy metals contamination inSS-04during July – December 2014

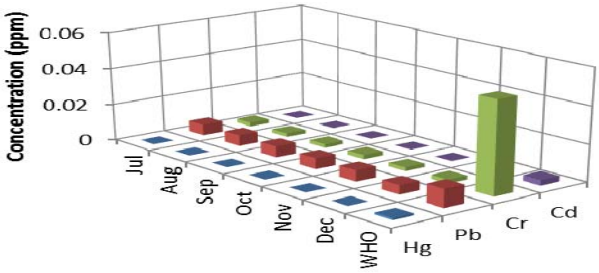

Fig 4: Heavy metals contamination in SS-10during July – December 2014

Table 2: The concentration of heavy metals in the effluent of OPM, Amlai and Son river water, during July to Dec., 2014.

Zone	Sampling station	Heavy metal	Concentration (ppm)					
			Jul. 2014	Aug. 2014	Sep. 2014	Oct. 2014	Nov. 2014	Dec. 2014
Zone-1	SS-01	Hg	0.070	0.070	0.070	0.070	0.070	0.060
		Pb	0.012	0.009	0.009	0.009	0.009	0.016
		Cr	0.006	0.005	0.006	0.005	0.005	0.006
		Cd	0.014	0.004	0.005	0.005	0.005	0.005
	SS-02	Hg	0.030	0.030	0.030	0.031	0.032	0.032
		Pb	0.009	0.007	0.007	0.008	0.008	0.008
		Cr	0.006	0.006	0.006	0.006	0.006	0.006
		Cd	0.015	0.004	0.005	0.005	0.005	0.005
	SS-03	Hg	0.002	0.002	0.002	0.002	0.002	0.002
		Pb	0.008	0.006	0.007	0.007	0.007	0.007
		Cr	0.005	0.006	0.006	0.005	0.006	0.006
		Cd	0.004	0.003	0.004	0.004	0.004	0.004
	SS-04	Hg	0.002	0.002	0.002	0.002	0.002	0.002
		Pb	0.030	0.020	0.024	0.025	0.019	0.020
		Cr	0.008	0.007	0.008	0.009	0.008	0.008
		Cd	0.004	0.004	0.004	0.004	0.004	0.004
	SS-05	Hg	0.000	0.000	0.000	0.002	0.002	0.002
		Pb	0.009	0.009	0.009	0.009	0.008	0.008
		Cr	0.004	0.004	0.004	0.004	0.004	0.004
		Cd	0.001	0.001	0.001	0.004	0.001	0.001
	SS-06	Hg	0.000	0.000	0.000	0.001	0.002	0.002
		Pb	0.005	0.005	0.005	0.005	0.006	0.006
		Cr	0.004	0.004	0.004	0.004	0.004	0.004
		Cd	0.006	0.007	0.007	0.007	0.007	0.007
Zone-2	SS-07	Hg	0.000	0.000	0.000	0.000	0.000	0.000
		Pb	0.008	0.008	0.008	0.008	0.008	0.008
		Cr	0.005	0.005	0.005	0.005	0.005	0.004
		Cd	0.005	0.004	0.005	0.005	0.004	0.004
	SS-08	Hg	0.000	0.000	0.000	0.000	0.000	0.000
		Pb	0.008	0.008	0.007	0.007	0.008	0.006
		Cr	0.004	0.004	0.004	0.004	0.004	0.004
		Cd	0.000	0.000	0.000	0.000	0.000	0.000
	SS-09	Hg	0.000	0.000	0.000	0.000	0.000	0.000
		Pb	0.005	0.005	0.005	0.005	0.007	0.005
		Cr	0.002	0.002	0.002	0.002	0.002	0.002
		Cd	0.000	0.000	0.000	0.000	0.000	0.000
	SS-10	Hg	0.000	0.000	0.000	0.000	0.00	0.000
		Pb	0.006	0.006	0.006	0.006	0.006	0.005
		Cr	0.002	0.002	0.002	0.002	0.002	0.002
		Cd	0.000	0.000	0.000	0.000	0.000	0.000

It was observed that calcium exceeded the drinking water standard as per WHO permissible limit due to intrusion of bleaching powder ($CaOCl_2$) into pulp cum paper hence, higher concentration of calcium occurred. The concentration of Ca exceeded the limit of 200 ppm prescribed by WHO as standard. Calcium rich water cause the hypercalcemia osteoporosis and renal failure. All analyzed water samples of Son river indicate that the level of calcium was within the limit. High level sodium and potassium was observed in effluent of Orient Paper Mill at SS-01, SS-02 and SS-04 Zone-1. Intake of high level of sodium causes blood pressure and hyperosmolarity. High water soluble potassium causes damage to germinating seedling, inhibits the uptake of other minerals and decreases the quality of crop. These chemical pollutants affect human health directly or indirectly. The analysis showed that concentrations of mercury, cadmium, calcium and potassium exceeded the permissible limit as per drinking specification of WHO. Hence, it is recommended that suitable water quality management is essential to avoid any further contamination in the study area.

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