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Impact of waste water of a pulp and paper industry on surrounding environment

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Abstract

To fulfill the demands of ever increasing population it becomes essential to escalate the industrial development in our country.Pulp and paper industry is considered to be one of the most polluting industries. This industry not only produces paper but also generates a large amount of waste.This study was conducted to assess and analyze the water quality and waste water of Pulp and Paper industry and to determine the impact on nearby environment. Different techniques were used to analyze the parameters of water quality and waste water. The entire mill was surveyed to understand and observe its operations and theraw material used in it.Regular visits were planned in order to gather the required data .Sampling was done manually according to the method described by APHA (USA) standard method for analysis of water and waste water. Twenty-nine parameterswere selected to check the water quality. All drinking water quality parameters, except TDS, pH and Chlorine, from nearby environment complied with National Drinking Water Quality Standards. TDS values were 1050 mg/l, 1126 mg/l, 1135mg/l, pH values were 8.14, 8.9, 8.6 and Chlorine values were 0.6mg/l, 0.9mg/l, and 0.6mg/l. To analyze wastewater quality of industry thirty-one parameterswere selected. All the analyzed parameters except BOD, COD and Phenols were in compliance with NEQS. For the three wastewater sampling points, BOD values were 88mg/l, 86mg/l,and 90mg/l while COD were 251mg/l, 245mg/l, 268mg/l and Phenols were 0.201mg/l,0.212mg/l, and 0.217mg/l. It is concluded from the study that most of the parameters of drinking water and waste water are wellwithin limit set by NEQS which shows the efficiency of filtration and effluent treatment plant.

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Introduction

Pakistan is a developing country and due to the increasing population the demands for rapid industrialization are increasing day by day. To fulfill the demands of ever increasing population it becomes essential to escalate the industrial development in our country (Pravin*et al*., 2013).Pulp and paper industry is considered to be one of the most polluting industries. This industry not only produces paper but also generates a large amount of waste. Due to chemical processes in pulp and paper industry potential pollutants emitted from this industry have adverse impact on environment. These pollutants can categorize into four classes' i.e. solid waste, liquid effluent, noise pollution and air pollution. Various gases like nitrogen oxide and sulfur compounds are the major pollutants which are emitted into the air. During the modern era, industrialization has been considered as one of the important means to accomplish the necessities of life. Pollutants like organic compound andmetals are discharged into the waste water. Paper and pulp waste water is composed of BOD, COD, solids, absorbable organic halides and sediments. Therefore, waste water undergoes primary and secondary treatment before it is discharged (Sarma, 2014).

Global paper consumption is unsustainable. Currently it is 350 million tons per year and will soon be million ton a day (Bajpai, 2000). With passage of time paper and paper products demand has increased; in 1980-81 its consumption was 1.2 million and now it has increased to 2.6 million tons (Gosh, 2011).

The impacts of industrial effluents on surrounding environment have been studied in the past. One of the largest Paper industry in the world is in India which ranks as 20th paper manufacturing country. By discharging waste water ecological balance of environment has been disturbed. It badly affects the aquatic life as well as flora and fauna. In 2010 capacity of mills was 8.3 million which is estimated to increase from 8.3 to 14 million tons in 2020 (Kesalkar*et al*., 2012).

The main objectives of the conducted study were tomonitor and assess the water and waste water quality of the selected industry and to assess its environmental impacts on the surrounding area.

Material and methods

Study area

The pulp and paper industry under study is located 62-km Lahore Multan highway N-5 district Kasur (Fig 1).

Fig. 1. Location map of study area.

The information and documents relevant to pulp and paper industry was collectedthrough internet, published articles and available literature; surveys and questionnaires. To analyze the quality of water, waste water and sludge, environmental monitoring was conducted. After analysis results were compared with NEQs of Pakistan. For the purpose of current study following methodology was adopted.Fig.2 shows detailed flow diagram of the methodology.

In-plant monitoring, surveys and questionnaires
The mill was surveyed to understand and observe its operations and the raw material used in it. This was completed with an aim to prepare questionnaire to identify all aspects and their impacts. And for better understanding interviews were carried out about the industry's processes and operations. Similarly, population survey was also conducted in which 50 questionnaires were administrated to50 different households from nearby industry.

Data collection
Data required to carry out monitoring was collected from the previous monitoring reports. Regular visits were planned in order to gather the required data.

Secondary data collection:Information relevant to physical, production processes and previous data relevant to environmental parameters such as water, waste water and sludge were gathered and reviewed.

Primary data collection
During primary data collection samples were collected from industry. These include drinking water and wastewater samples. All the samples were analyzed in laboratory for the drinking water and wastewater parameters.

Sampling procedure
Sampling was done manually according to the method described by APHA (USA) standard method for analysis of water and waste water. For collection of water samples manual procedures were adopted. Samples were collected in polythene bottles.1.5 liters of sample (volume) was collected in sterilized bottles for required analysis.After samples were collected in plastic bottles identification numbers were given immediately.

Wastewater monitoring
Wastewater samples were collected in plastic bottles from effluent outlet where the flow of water steady and homogenous. By using the grab sampling procedure sampling was done. Sample was collected from mid-points of channel. Onsite parameters were analyzed in the field. All parameters were compared with NEQS.

Drinking water monitoring
Drinking water samples were collected from two areas inside and outside (nearby environment) of the industry. Industry samples were collected from tap of 3 different messes. Outside industry samples were collected from different houses (taps of the kitchen) in sterilized plastic bottles, stored at 4 ^{o}C and were analyzed inlaboratory.

Results and discussion
This study was carried out to probe the impacts of paper and pulp industry on the environment. The current study has assessed the groundwater quality of the study area and also analyzed the two major potential contributing factors to water pollution i.e. waste water and sludge.

The selected paper and pulp industry is located in Kasur city. Waste water, drinking water and waste management practices were analyzed and health survey was carried out using questionnaires. Interviews were conducted with community inhabitant's which include shopkeepers, households and other community people etc.

Questionnaire Based Survey
Demographic data collected through the questionnaires (Table 3) revealed that majority of the respondents were married and ages between 31-50 years.

Table 1. Drinking water analysis of the surrounding area.

S.NO	Parameters	Months			Drinking water quality standards	
		August	September	October	NSDWQ	WHO
1	pH value	8.14	8.9	8.6	6.5-8.5	6.5-8.5
2	Color (Cu)	7.4	0.0	0.0	<15	<15
3	Taste	Normal	Normal	Normal	Not objectionable	Not objectionable
4	Odor (TON)	0.0	0.0	0.0	Not objectionable	Not objectionable
5	Turbidity (NTU)	0.0	0.00	0.00	<5	<5
6	Total Hardness (mg/l)	95.0	98.0	101.0	<500	.....
7	TDS (mg/l)	1050	1126	1135	<1000	1000
8	Aluminum (mg/l)	BDL	BDL	BDL	≤0.2	0.2
9	Antimony (mg/l)	BDL	BDL	BDL	≤0.0005	0.02
10	Arsenic (mg/l)	0.050	0.010	0.025	≤0.05	0.01
11	Barium (mg/l)	BDL	BDL	BDL	0.7	0.7
12	Boron (mg/l)	BDL	BDL	BDL	0.3	0.3
13	Cadmium (mg/l)	BDL	BDL	BDL	0.01	0.003
14	Chloride (mg/l)	64.0	60.0	68.0	<250	250
15	Chromium (mg/l)	BDL	BDL	BDL	<0.05	0.05
16	Copper (mg/l)	BDL	BDL	BDL	2.0	2.0
17	Cyanide (mg/l)	0.005	0.003	0.003	≤0.05	0.07
18	Fluoride (mg/l)	0.08	0.20	0.04	≤1.5	1.5
19	Nitrate (mg/l)	0.8	0.9	0.6	≤50	50
20	Nitrite (mg/l)	0.006	0.007	0.010	≤ 3	3
21	Lead (mg/l)	BDL	BDL	BDL	≤0.05	0.01
22	Manganese (mg/l)	BDL	BDL	BDL	≤1.5	0.5
23	Mercury (mg/l)	BDL	BDL	BDL	≤0.001	0.001
24	Nickel (mg/l)	BDL	BDL	BDL	≤0.02	0.02
25	Selenium (mg/l)	BDL	BDL	BDL	0.01	0.01
26	Residual Chlorine (mg/l)	0.6	0.9	0.6	0.2-0.5	....
27	Zinc (mg/l)	0.06	0.03	0.06	5.0	3
28	Total Coliforms (Cfu/100ml)	0	0	0	0	0
29	E.Coli (Cfu/100ml)	0	0	0	0	0

Most of them were employed and were working indifferent industries. 70% of them were those with monthly income between Rs 20,000- Rs 40,000. According to survey most of the people were residing in the study area for more than 6 years. Ninety percent residents complained about headache and seventy percent of them were suffering from water borne diseases due to industrial activities.

According to respondents, access of water for drinking and other purposes was satisfactory, but they reported that the quality of water was poor, non-transparent; having sharp odor and most importantly it was linked to their impaired health status.

There was no filtration plant located in their area. Most of them were of the view that government should take responsibility for water quality testing at least once in a month.

Physical Parameters

The study involves the analysis of water of pulp and paper industry (Table 1 and 2) to ensure that all the parameters were within limits but during maintenance period its parameter exceeded which can affect the nearby environment that leads towards the health problems. In nearby environment 29 parameters were analyzed in whichpH, TDS and chlorine was not with in permissible limit.

Table 2. Monthly Waste water analysis results of the selected industry for study period.

S.NO	Parameters	Results			NEQS*
		August	September	October	
1	Temperature(°C)	1.0	18.6	9.6	< 3
2	pH value	8.27	7.62	7.24	6-9
3	BOD (mg/l)	88.0	86.0	90.0	80.0
4	COD (mg/l)	251.0	245.0	268.0	150.0
5	TSS (mg/l)	52.0	58.0	64.0	200.0
6	TDS (mg/l)	1724	1628.0	1697.0	3500.0
7	Grease & oil (mg/l)	6.0	8.0	5.0	10.0
8	Phenolic Compounds (mg/l)	0.201	0.212	0.217	0.1
9	Chloride (mg/l)	40.0	42.0	54.0	1000.0
10	Fluoride (mg/l)	BDL	BDL	BDL	10.0
11	Cyanide (mg/l)	0.003	0.004	0.009	1.0
12	An-ionic detergents (mg/l)	0.118	0.113	0.115	20.0
13	Sulphate (mg/l)	125.0	128.0	137.0	600.0
14	Sulphide (mg/l)	0.052	0.047	0.043	1.0
15	Ammonia (mg/l)	2.35	3.25	2.63	40.0
16	Cadmium (mg/l)	BDL	BDL	BDL	0.1
17	Chromium (mg/l)	0.02	0.04	0.07	1.0
18	Copper (mg/l)	0.005	0.03	0.011	1.0
19	Lead (mg/l)	0.03	0.03	0.07	0.5
20	Mercury (mg/l)	BDL	BDL	BDL	0.01
21	Selenium (mg/l)	0.0019	0.0012	0.0015	0.5
22	Nickel (mg/l)	0.01	0.02	0.01	1.0
23	Silver (mg/l)	BDL	BDL	BDL	1.0
24	Total Toxic Metal (mg/l)	0.07	0.05	0.10	2.0
25	Zinc (mg/l)	1.47	1.54	1.43	5.0
26	Arsenic (mg/l)	0.003	0.005	0.008	1.0
27	Barium (mg/l)	BDL	BDL	BDL	1.5
28	Iron (mg/l)	0.01	0.01	0.03	8.0
29	Manganese (mg/l)	0.020	0.029	0.037	1.5
30	Boron (mg/l)	1.4	1.2	1.3	1.4
31	Chlorine total (mg/l)	0.06	0.04	0.01	1.0

*National Environmental Quality Standards (2012).

TDS is one of the important parameter as it measures the combined content of organic and inorganic substances (Stacia, 2015).

According to NEQS, permissible limit of TDS is 1000mg/l but in nearby environment it showed noncompliance with the standards. TDS also cause salinity in water which makes it unsuitable for drinking purposes (Fig. 3).

pH of water of nearby environment was also high. It was slightly saline and it is not suitable for drinking or irrigation purposes (Fig. 4). Even aquatic life cannot survive in such water as their population starts to decline and whole food chain gets disturbed (DeZuane, 2015).

Chemical Parameters

Chlorine was also high which may be due to chlorination (chlorine residual) for maintaining the drinking water quality or other industrial activities that are being carried out in the area (Fig 5).

It was observed that surrounding industries are directly discharging their effluent in nearby drain which is a serious damage to environment and nearby residents.BOD is the amount of dissolved oxygen (DO) consumed by microorganism to destroy organic

matter present in water at certain temperature in specific period of time (Berry, 2008).

High BOD tends to lower the oxygen of receiving water which results in stress to aquatic life ultimately disturbing the food chain because if aquatic life start decreasing with passage of time it diminishes DO level which result in less food supply and as well as economic destruction (Trived and Raman, 2002).

Table 3. Results of questionnaire based survey.

Age		Below 15	Percentage
		15-30	38%
		31-50	60%
		Above 50	2%
Gender		Male	64%
		Female	36%
Marital status		Single	30%
		Married	70%
Occupation		Student	6%
		Employed	76%
		Unemployed	18%
Monthly income		Below 20,000	30%
		20,000-40,000	70%
		41,000 -50,000	0%
		Above3 50,000	0%
Living/working in area		1year	0%
		Less than one year	2%
		3-6 year	26%
		More than 6 year	72%
Health Issues	Diarrhea	Never	0%
		Occasionally	70%
		Frequently	30%
	Headache	Never	0%
		Occasionally	10%
		Frequently	90%
	Typhoid	Never	0%
		Occasionally	50%
		Frequently	50%
	Dizziness	Never	0%
		Occasionally	75%
		Frequently	25%
	Malaria	Never	3%
		Occasionally	96%
		Frequently	1%
Industry responsible for water borne diseases		Yes	70%
		No	30%
Change in drinking water quality		Yes	58%
		No	28%
		Sometimes	14%
Easy access to drinking water		Yes	94%
		No	6%
Water quality cause health effects		Yes	92%
		No	8%
Color of water in area		Transparent	30%
			70%
		Yes	64%
Smell from water		No	36%
Satisfied from water quality		Yes	24%
		No	76%
Filter plant in area		Yes	0%
		No	100%
Type of water preferred		Tap water	10%
		Filter water	86%
		Or any other	0%
Water decorating due to industrial activity		Yes	78%
		No	22%
Water quality is being tested		Once in a week	0%
		Once in a month	0%
		Every two month	4%
		Every month	0%
		Never	96%
Any floating object in water		Yes	16%
		No	84%

According to a study 85% of water that is utilized in pulp and paper industry is has high BOD, COD, solids, absorbable organic halides and sediments (Yaday, 2006). The results of present study shows the concentration of COD as 251mg/l, 245mg/l, 268mg/l in first, second and third month respectively (Fig. 7).

Moreover the concentration of BOD was found to be 88mg/l, 86mg/l and 90mg/l in first, second and third month respectively (Fig 6). It is clear from above values that both parameters were not complying with NEQS.

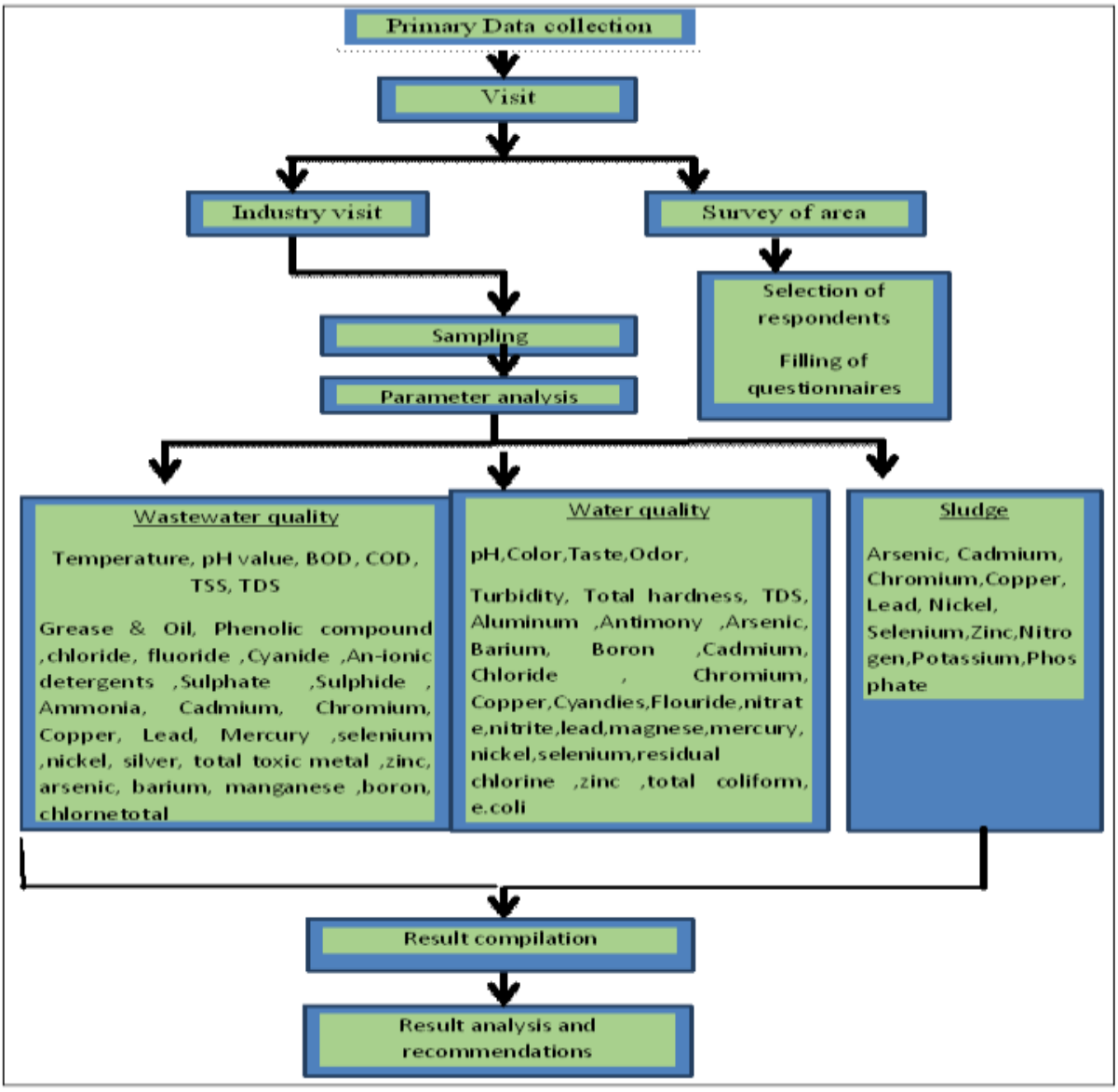

Fig. 2. Methodology flow chart.

Phenols are mostly found in industrial wastewater. Some of them have been reported to be very toxic and affects aquatic life (Berry, 2008).

According to US EPA people who lived near pulp and paper mills and those who eat fish can have chances of developing cancer 1000 times (Sarma*et al.*, 2000).

The current study also showed their non-compliance with their standard value i.e. 0.1mg/l(Table 2).

Sludge Disposal

Dewatering of secondary sludge is very difficult as compared to primary sludge.

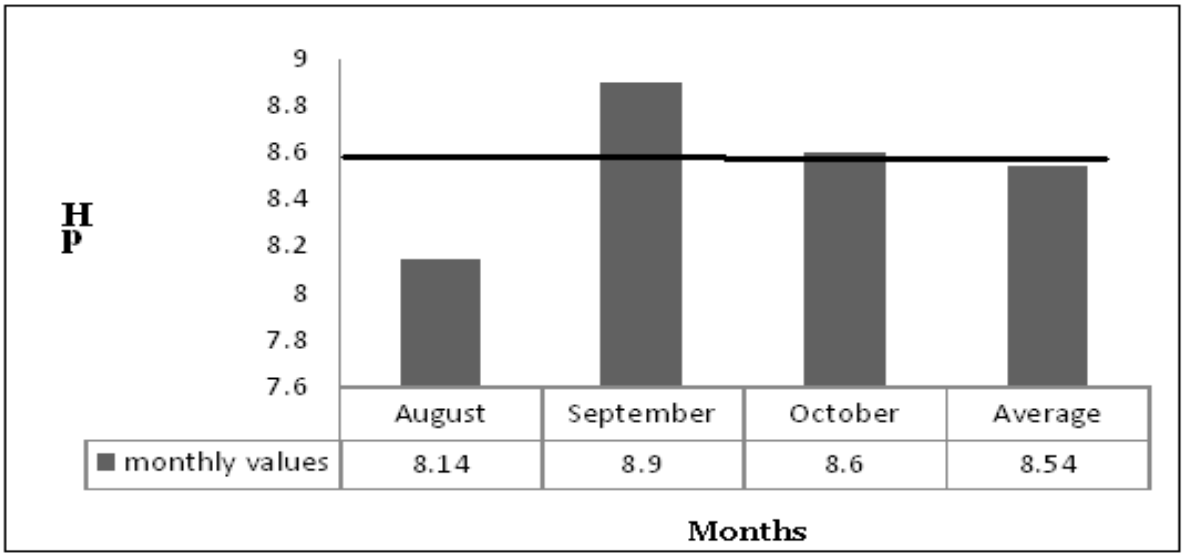

Fig. 3.TDS in waste water.

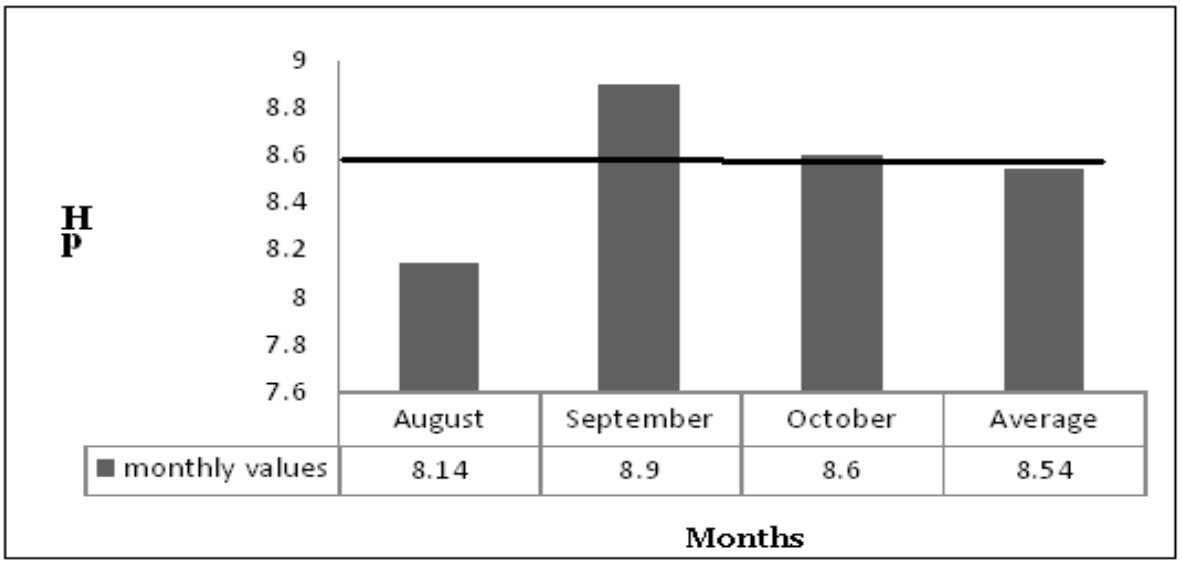

Fig. 4. pH of wastewater samples.

In the production of 1 ton of paper almost 50-60 kg of sludge(dry) is generated from which approximately 70% is primary sludge and 30% is secondary sludge (Mabee, 2013).

In the present study two samples of sludge were collected from the industry and eleven parameters were selected, analyzed and compared with USEPA standards.

Arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, nitrogen, potassium, phosphate were the parameters analyzed to check the quality of sludge that is being generated by this industry.

As shown in table 2 the analysis has revealed that the all analyzed parameters were under compliance with standards.

Industrial pollution is one of the major concerns in our environment. Industrial pollution can effect on both flora and fauna that result in decrease in their population and it also affect the whole food chain. As food chain is disturbed, itultimately affects the economy.

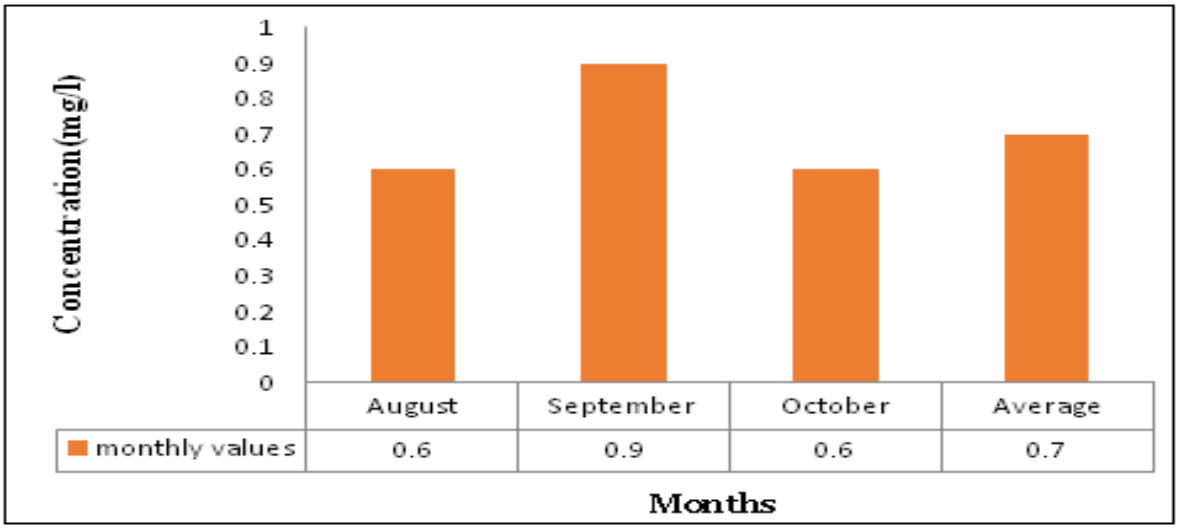

Fig. 5. Chlorine in waste water.

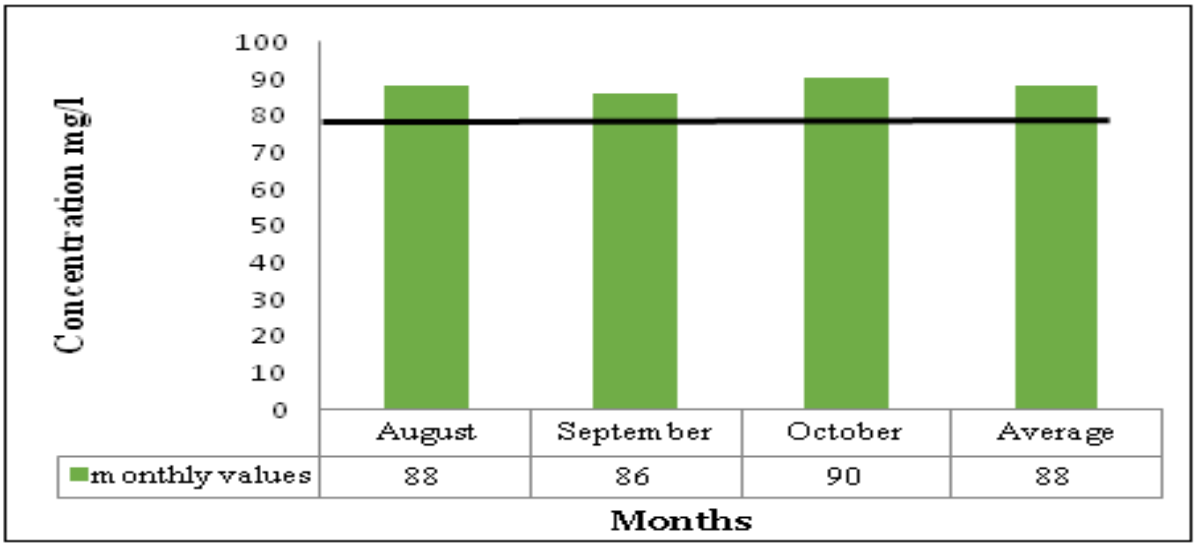

Fig. 6. BOD of wastewater.

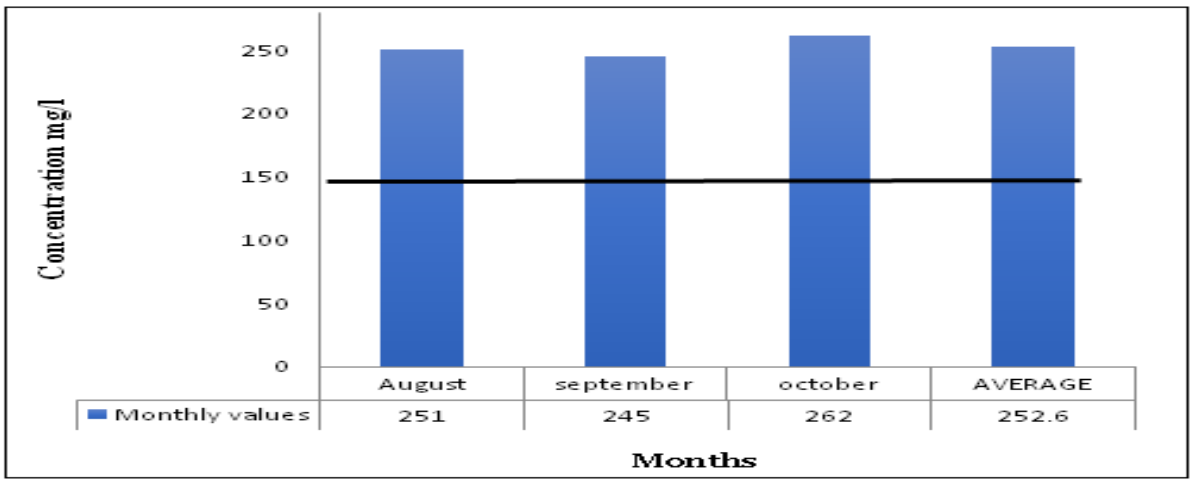

Fig. 7. COD of wastewater.

Conclusion

It is concluded from the study that most of the parameters of waste water are well within limit set by NEQS which shows the efficiency of effluent treatment plant. Similarly drinking water quality of industry was good as all parameters were within a limit which reveals that filtration plant is efficient but the drinking water sample collected from outside the industry shows that parameters were exceeding the NEQS limit that shows the poor water quality of project area. It was noteworthy that the values of waste water from the industry also exceeded during maintenance period of the industry.

For improving water quality some are the recommendations which should be considered.

Implementation of Environment legislation should be ensured by the industry.

Water Quality monitoring should be carried out by third party (EPA certified lab) as per the legal requirement for NEQS.

Deep well should be constructed with the depth of at least 500 ft. to ensure the absence of bacterial contamination.

Water Filter plants should be installed for nearby community inhabitants.Equipment and process modification for water practice can be optimized for enhanced/ better treatment of waste water. Industry should convince the top management to work on cleaner production techniques in order to comply with NEQS.

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