Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 9(3), 2021: 393-407
http://dx.doi.org/10.7770/safer-V0N0-art2347

An investigation of monthly variation of different physicochemical parameters of dairy industry effluent.

Una investigación de la variación mensual de diferentes parámetros fisicoquímicos del efluente de la industria láctea.

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ABSTRACT

Industrialization no doubt enhances the productivity, but also results in release of toxic substances into the environment, creating health hazards. Dairy industry ranks as one of the most polluted industries in India. For cleaning and washing procedures, dairy industry plants generate large volumes of waste water, which is 2.5 times milk volume processed. Dairy effluent contains high load of organic matter. This study was aimed at assessing the monthly variation of different physicochemical parameters of effluent like pH, Temperature, Turbidity, Electrical Conductivity, Chemical Oxygen Demand, Biological Oxygen Demand, Total Solids, Total Dissolved Solids, Total Suspended Solids, Chlorides, Sulfates, Oil & Grease, Proteins, Lipids etc. The pH was recorded for values between 7.3 to 8.2 whereas overall mean value was 7.7±0.37 (S.D.) in all month's data collected which is ambient for the microbial population to grow. Maximum temperature was reported in May (33°C) while lowest value was reported in December (24°C). Mean value of turbidity was recorded as 762±207 NTU. Maximum EC value was reported in January (650 µS/cm) while minimum value was reported in May (354 µS/cm). BOD values reported were between 268 to 950 mg/lit. Maximum BOD values were reported in August and October while minimum was reported in the month of July. Mean value was recorded at 597±208 mg/lit. COD mean value was recorded at

2184±417 mg/lit. Maximum COD values were observed during August and September while minimum during February to April. TDS was noted down to be between 960 to 1362 mg/lit. TS mean value was around 1412 ± 108 mg/lit. TSS was found to be between 245 to 365 mg/lit during the year 2013-14. Maximum TSS value was reported in November and September while minimum in March. Maximum chloride value was reported in March (562 mg/lit) while minimum in September (256 mg/lit). Mean value of sulfate was 247 ± 98 mg/lit. Mean value for oil and grease was recorded as 163 ± 44 mg/lit. Maximum protein value was reported in November (260 mg/lit) while minimum in the months of May and September (154 mg/lit). Mean value of lipid was recorded to be 600±63 mg/lit indicating obvious variation during batches. The present study has been aimed at procuring dairy industry effluents & characterizing them for different parameters in order to check the fluctuation in organic loads.

Key Words: Dairy industry effluent, Assessment, Physicochemical parameters, Organic load.

RESUMEN

Sin duda, la industrialización mejora la productividad, pero también da lugar a la liberación de sustancias tóxicas al medio ambiente, lo que genera riesgos para la salud. La industria láctea se ubica como una de las industrias más contaminadas de la India. Para los procedimientos de limpieza y lavado, las plantas de la industria láctea generan grandes volúmenes de aguas residuales, que es 2,5 veces el volumen de leche procesada. El efluente lácteo contiene una alta carga de materia orgánica. Este estudio tuvo como objetivo evaluar la variación mensual de diferentes parámetros fisicoquímicos de efluentes como pH, Temperatura, Turbidez, Conductividad Eléctrica, Demanda Química de Oxígeno, Demanda Biológica de Oxígeno, Sólidos Totales, Sólidos Totales Disueltos, Sólidos Totales Suspendidos, Cloruros, Sulfatos, Aceite Grasa, proteínas, lípidos, etc. El pH se registró para valores entre 7,3 y 8,2 mientras que el valor medio general fue de 7,7 ± 0,37 (DE) en todos los datos del mes recogidos, que es el ambiente para que crezca la población microbiana. La temperatura máxima se informó en mayo (33 ° C) mientras que el valor más bajo se informó en diciembre (24 ° C). El valor medio de turbidez se registró como 762 ± 207 NTU. El valor máximo de CE se informó en enero (650 µS / cm) mientras que el valor mínimo se informó en mayo (354 µS / cm). Los valores de DBO informados estuvieron entre 268 y 950 mg / litro. Los valores máximos de DBO se informaron en agosto y octubre, mientras que los mínimos se informaron en el mes de julio. El valor medio se registró en 597 ± 208 mg / litro. El valor medio de DQO se registró en 2184 ± 417 mg / litro. Los valores máximos de DQO se observaron durante agosto y septiembre, mientras que los mínimos durante febrero a abril. Se anotó que el TDS

estaba entre 960 y 1362 mg / litro. El valor medio de TS fue de alrededor de 1412 ± 108 mg / litro. Se encontró que el TSS estuvo entre 245 y 365 mg / litro durante el año 2013-14. El valor máximo de TSS se informó en noviembre y septiembre, mientras que el mínimo en marzo. El valor máximo de cloruro se informó en marzo (562 mg / litro) mientras que el mínimo en septiembre (256 mg / litro). El valor medio de sulfato fue 247 ± 98 mg / litro. El valor medio de aceite y grasa se registró como 163 ± 44 mg / litro. El valor máximo de proteína se informó en noviembre (260 mg / lit) mientras que el mínimo en los meses de mayo y septiembre (154 mg / lit). Se registró un valor medio de lípidos de 600 ± 63 mg / litro, lo que indica una variación obvia durante los lotes. El presente estudio ha tenido como objetivo adquirir efluentes de la industria láctea y caracterizarlos para diferentes parámetros con el fin de verificar la fluctuación en las cargas orgánicas.

Palabras clave: Efluentes de la industria láctea, Evaluación, Parámetros fisicoquímicos, Carga orgánica.

INTRODUCTION

Water is the key factor for life on earth. In India, approximately 70% of fresh water has been polluted because of dumping of industrial waste and domestic waste into natural water streams like lakes, ponds and rivers (Sangu and Sharma, 1987), which has seriously affected normal operations of ecosystem, flora & fauna (Porwal et al. 2015). Food industrial sector consumes highest amount of water & it is one of the biggest producers of effluent per unit of production (Palela et al. 2008). Dairy industry ranks as one of the most polluted industries in India. Ramasamy et al. (2004) reported that cleaning and washing procedures of dairy industry plants generate large volumes of waste water, which is 2.5 times milk volume processed. Dairy waste water commonly contains milk, by products of dairy processing operations, agents used for cleaning & additives of different types, probably used during operations. According to Patil & Kurhekar (2018) reports discharge of partially treated or untreated dairy waste water increases the pollution load of water and land. If untreated effluent is disposed off in natural water bodies, there is a possibility of eutrophication due to high content of elements like Nitrogen, Phosphorus, Carbon etc. (Eckles et al. 2000). Biotreatment which leads to bioconversion of material in the dairy waste is found to be a very cost effective method in management of waste utilization. Shivsaran and Wani (2017) studied different physicochemical characteristics like pH, Temperature, COD, BOD, TS, TSS, TDS of dairy effluents from Katraj Dairy Pune, over the period of March 2011- December 2015.

Microorganisms play an important role in uptake of organic and inorganic compounds occurring in waste water (Britz *et al.,* 2006). Vanerkar et al. (2015) reported that, treatment and recycling of industrial waste water is a major part of research in recent years. Currently both aerobic & anaerobic treatment methods are employed for the dairy effluent processing. As per the investigation by Shete & Shinkar (2013) as dairy effluent has more COD & sludge (organic content), aerobic treatment requires high energy. Bioremediation is an ecofriendly process which involves the use of efficient microorganisms for complete transformation of waste to its clean up state. Microbiota of waste water is adapted to different conditions like pH, temperature and other physicochemical parameters, which is very important for biodegradation of waste water (Dawson, 2005). Dairy industry processes variety of products simultaneously in different production lines which ultimately produces composite effluent having high organic content. For the treatment of dairy industry effluent, it is vital to understand the approximate composition of incoming waste water & whether it changes seasonally. The present study has been aimed at investigating monthly variation of various physicochemical parameters of dairy industry waste from Katraj dairy, Pune. This physicochemical assessment study was done during October 2017- September 2018.

MATERIAL & METHODS

Area of Study: in present study, one of the major dairy industry named as Katraj Dairy (Pune), from Maharashtra, India has been taken into consideration. The written consent has been taken from dairy authorities in order to sample the effluent from effluent treatment plant (ETP). Katraj Dairy, situated in Pune District of Western Maharashtra, India was established in 1960. It lies between 18° 26' 42.3204'' North to 73° 52' 8.3280'' East latitude. Dairy plant is located at an altitude of 673 meters. Presently, the dairy has 2.00 lakh liters milk collection per day. It has been certified by ISO 22000:2005 from Det Norskey Veritus. As the production of variety of products is ongoing every day, it will ultimately generate large amounts of waste water. Katraj dairy has well established Effluent Treatment Plant (ETP). ETP includes primary, secondary & tertiary treatment. Treated effluent from the dairy is employed in irrigation.

Sampling: the effluent sampling was carried out in sterile glass bottles from equalization tank by using Jacks & Piper method. Effluent samples were transported immediately to laboratory and kept at 4ºC in refrigerator after labeling. Time to time physicochemical analysis of samples was performed in dairy laboratory and other parameters were studied in the laboratory at Sangli.

Physiochemical Analysis of Effluent: during this study, dairy industry effluent samples were taken during October 2017 to September 2018 and analyzed as per the guidelines set by the APHA 2005; Trivedy and Goel, 1984. In all 12 samples of effluent were checked from Katraj Dairy. Sampling was done once in a month, four samples each were collected in summer, rainy and winter seasons. The seasonal changes in waste water were recorded and overall data has been showed to understand comparative changes in dairy waste water and to ascertain the level of waste load as per MPCB and CPCB norms (Maharashtra Pollution Control Board and Central Pollution Control Board respectively). Effluent samples were analyzed for following parameters:

The pH was analyzed by Electrometric method. Readings were recorded three times and documented. On site temperature of waste water was recorded by taking the waste water samples in clean glass beaker and by using the thermometer, temperature (°C) was recorded for each sample from collection site. Clean glass bottles were used to collect samples and immediately analyzed for the color to avoid any biological or physical changes occurring in the storage. Turbidity of the sample was taken within 24 hrs as it unadvisable to store for prolonged period. All samples were shaken vigorously before examination and turbidometric readings were observed; results were presented as NTU. Electrical conductivity (EC) has been measured as per the instruction manual supplied with the instrument and the results were expressed as mS/m or mS/cm. Biochemical Oxygen Demand (BOD) was estimated by using Titrimetric Method. Chemical Oxygen Demand (COD) was calculated by Open Reflux Method. Estimation of TS & TDS i.e. Total Solids & Total Dissolved Solids were carried out as per method given by Howard, 1933. Chloride & Sulphate of effluent sample was checked by Argentometric & Turbidimetric method respectively (Rossum & Villarruz, 1961). Oil and Grease was calculated by Partition-gravimetric method whereas, estimation of protein & lipid content of effluent sample was done by Lowry & Soxhlet extraction method respectively.

RESULTS & DISCUSSION

During this investigation, analysis of different physicochemical parameters of 12 samples from Katraj dairy was done and results presented (Table 1). Statistical evaluations have been presented in Table 2.

Table 1: Monthly variations of various parameters of the Katraj dairy effluent

*Note- Color (MW) - Milky white

Sr. No.	Parameters (Units)	October 2017	November 2017	December 2017	January 2018	February 2018	March 2018	April 2018	May 2018	June 2018	July 2018	August 2018	September 2018
1	pH	8.2	7.4	8.0	7.6	8.2	8.2	7.5	7.4	7.3	7.3	7.9	7.5
2	Temperature (°C)	29	26	24	25	26	29	32	33	31	29	28	26
3	Color	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
4	Turbidity (NTU)	986	861	865	789	652	795	810	815	860	806	152	753
5	E. C. (µS/cm)	564.2	456.5	568.3	650.2	485.5	526.1	456.2	354.2	451.6	452.3	540.1	562.8
6	BOD (mg/lit)	950	650	784	652	512	652	425	632	458	268	856	325
7	COD (mg/lit)	2020	2032	2015	1892	1863	1865	1864	2056	2045	2651	2945	2965
8	TDS (mg/lit)	1000	1052	1256	1086	1069	960	1362	1236	1098	1060	1086	1065
9	TS (mg/lit)	1320	1417	1521	1344	1325	1205	1625	1494	1424	1410	1431	1430
10	TSS (mg/lit)	320	365	265	258	256	245	263	258	326	350	345	365
11	Chlorides (mg/lit)	289	356	421	326	426	562	489	512	325	365	345	256
12	Sulfates (mg/lit)	145	165	158	136	256	265	245	236	235	398	456	265
13	Oil and Grease	85	123	156	210	156	190	185	145	196	205	210	95
14	(mg/lit)	214	260	230	245	190	178	163	154	165	180	160	154
15	Protein (mg/lit)	485	560	659	653	657	690	654	593	546	573	598	532
	Lipids (mg/lit)												

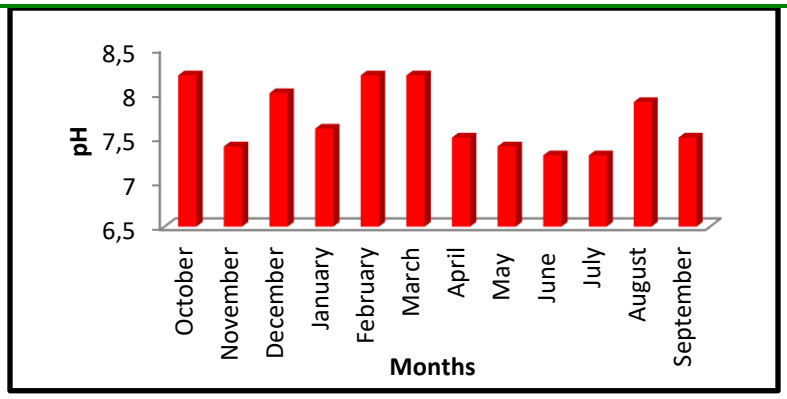

Fig. 1 Monthly variation of pH of effluent (Oct 2017- Sept 2018)

Table 2: Statistical analysis of dairy waste from Katraj Dairy

	pH	Temperature	Turbidity	E.C.	BOD	COD	TDS	TS	TSS	chlorides	Sulfates	O & G	Protein	Lipids
Minimum	7.3	24	152	354	268	1863	960	1205	245	256	136	85	154	485
25% Percentile	7.4	26	762	453	433	1872	1054	1330	258	325	160	129	161	550
Median	7.6	29	808	506	641	2026	1078	1421	293	361	241	171	179	596
75% Percentile	8.2	31	861	564	751	2502	1202	1478	349	473	265	203	226	656
Maximum	8.2	33	986	650	950	2965	1362	1625	365	562	456	210	260	690
Mean	7.7	28	762	506	597	2184	1111	1412	301	389	247	163	191	600
Std. Deviation	0.37	2.9	207	78	208	417	115	108	48	94	98	44	37	63
Std. Error	0.11	0.82	60	23	60	120	33	31	14	27	28	13	11	18
Lower 95% CI of mean	7.5	26	630	456	465	1919	1038	1344	271	330	185	135	167	560
Upper 95% CI of mean	7.9	30	894	555	729	2449	1184	1481	332	449	309	191	215	640
Sum	93	338	9144	6068	7164	26210	13330	16946	3616	4672	2960	1956	22936	7200

pH: Effluent samples were immediately checked for pH and overall pH range has been statistically analyzed. The pH was recorded to be between of 7.3 to 8.2 during the year. Maximum pH value was recorded in months October, February and March while minimum value was recorded in the months June and July. This pH range has indicated that microbial community can tolerate such pH conditions and treatment plant receiving water could be treated with them; it was observed that shift of pH was not so high from mean so it obviates the every time check of samples for treatment (Table 1, Figure 1). As per Table 2, overall mean value was 7.7±0.37 (S.D.) in all month's data collected which is ambient for the microbial population to grow. In similar reports, it has been noted that dairy waste water with pH 7-8 remains the most suitable for treatment by the process of Nano-filtration. Similarly during this study it was observed that pH of all dairy industries was in the same range as suggested by Luo et al. (2011). It has been observed during the study that since our reported dairy is milk reception center and categorized into mixed dairy types, this may be the reason for pH ranging between 7-8, as mentioned by Luo et al. (2011). As per it has been evident in studies that dairy industry effluent varied in pH which makes the task tough to apply same methodology to all dairy industry effluents. As per evidence, in a number of reports varying pH was recorded with the type of production and process carried out in the dairy production plants. For example: mixed dairy represents pH 4-11 (Britz et al. 2006, Cristian, 2010, Karadag et al. 2015); Ice cream industry pH 5.1-6.96 (Yang et al. 2007, Karadag et al. 2015); cheese industry pH 3.38-9.5 (Britz et al. 2006, Schifrin et al. 1981, Tsachev, 1982, Demirel

et al. 2005); cottage industry effluent reported pH 3.38-9.5 (Rosenwinkel et al. 2005); milk permeate waste effluent reported pH 5.55-6.52 (Farizoglu et al. 2007; Wang et al. 2009). In another study of Kolhe and Pawar, (2011) dairy effluent maintains pH 8.8 with I.S.I value 6.5-8.0 while after treatment it reaches 7.4. Overall it has been evident that pH of dairy effluent remains varied in pH, which needs to be monitored during every treatment.

Temperature: temperature of effluent was reported between 24 to 33°C. Maximum temperature was reported in May while lowest value was reported in December. Overall mean temperature recorded to be around 28±2.9°C (Table 2) which certainly highlighted that the water could be directly used in treatment process without any prior cooling or heating. Temperature range of untreated dairy effluent from collection site was 25 to 34°C, which is in accordance with records reported by Kolhe and Pawar (2011).

Turbidity

Effluent turbidity was found to be between 152 to 986 NTU. Maximum turbidity value was reported in October while minimum in August. As per Table 2, overall mean value of turbidity was 762±207 NTU. As per observation water turbidity certainly remains varied in the treatment process, its dilution factor and exact turbidity needs to be considered always for better treatment through microbial community and could be the checkpoint for better treatment.

Electrical Conductivity: effluent electrical conductivity was observed to be between 354 to 650 µS/cm. Maximum EC value was reported in January while minimum in May. Mean values was recorded to be 506±78 µS/cm (Table 2) and overall results indicated that electrical conductivity changes per batch and needs careful monitoring for better treatment.

Biological Oxygen Demand (BOD): BOD was reported to be between 268 to 950 mg/lit. Maximum BOD values were observed in August and October while minimum in July (Figure 2). Overall mean value was recorded at 597±208 mg/lit (Table 2). In a similar manner, Kolhe and Pawar (2011) reported that dairy effluent shows BOD 760 mg/lit, close to our values recorded. In other reports, BOD of milk processing effluents was recorded to be as follows; 240-5900 mg/lit in mixed dairy; 800 mg/lit in milk reception; 1008-2081 mg/lit in dairy/sewage=7:3; 500-1.3 mg/lit in fluid milk; 220-2065 mg/lit in butter industry; 2600 mg/lit in cottage cheese; 27000-60000 mg/lit in cheese whey industry; 9000 mg/lit in hard cheese whey which indicates that recorded BOD in our effluent was observed quite below than average as in comparison with other industries (Tsachev, 1982, Demirel et al. 2005, Yang et al. 2007, Janczukowicz et al. 2007, Tawfik et al. 2008, Najafpour et al. 2008).

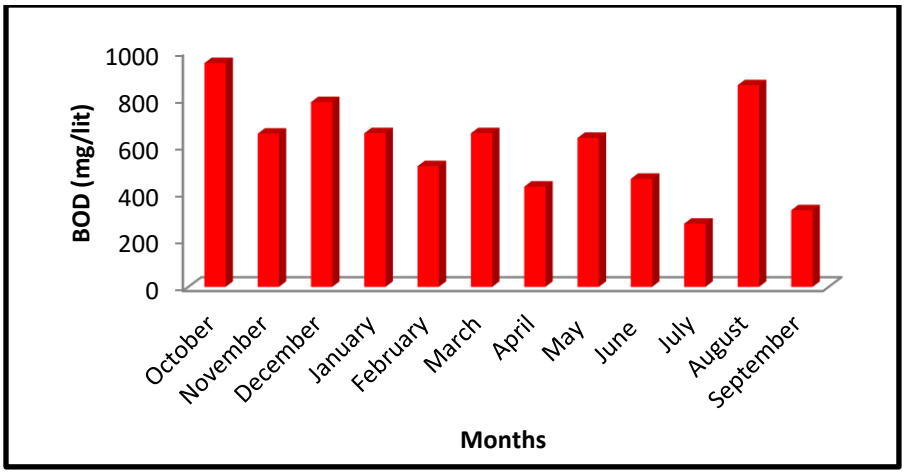

Fig. 2 Monthly variation of BOD of effluent (Oct 2017- Sept 2018)

Chemical Oxygen Demand (COD): COD recorded between 1863 to 2965 mg/lit. Maximum COD values were noted down during August and September while minimum during February to April (Figure 3). As per Table 2 mean value was recorded at 2184±417 mg/lit. Geilman et al. (1992) reported COD as 1007-2018 mg/lit in a whey processing effluent, which matches with our reports of COD in dairy effluents. Our report of COD is in accordance with record of Damirel et al. (2005) where fluid milk processing industry effluent recorded 950-2400 mg/lit of COD. As per our report COD is marginally high, when compared with Kolhe and Pawar (2011) report, with 1230 mg/lit.

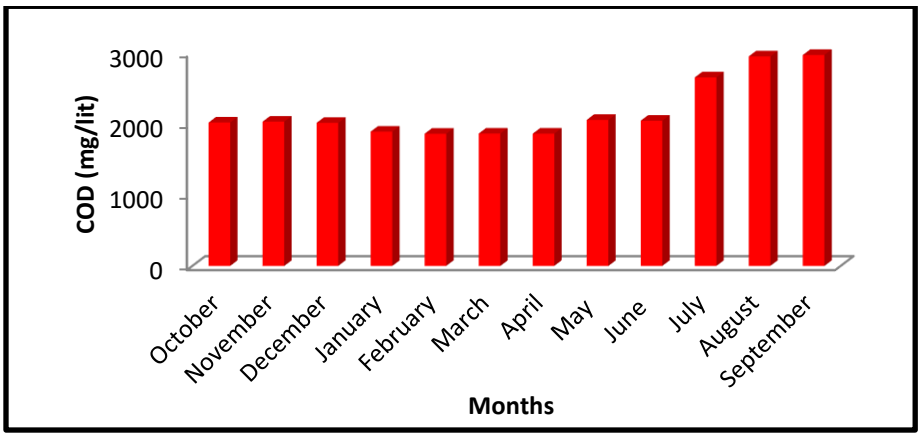

Fig. 3 Monthly variation of COD of effluent (Oct 2017- Sept 2018)

Total Dissolved Solids (TDS): TDS was recorded as between 960 to 1362 mg/lit. Maximum TDS value was reported in April while lower value was reported in March. As per

Table 2 mean value was reported at 1111±115 mg/lit, which matches with the report published by Kolhe and Pawar (2011) with 1000 mg/lit.

Total solids (TS): Total Solids (TS) was recorded to be within 1205 to 1625 mg/lit which indicates the presence of heavy load solids in waste water samples. Maximum TS value was reported in April while minimum value was reported in March (Figure 4). Overall mean value was around 1412 ± 108 mg/lit (Table 2). Our findings are very much similar to the records of Kolhe and Pawar (2011) with the value of 1310 mg/lit. In other studies a range of total solids was observed to be varying right from 700-7000 mg/lit (Rosenwinkel et al. 1999, Britz et al. 2006, Nadais et al. 2010, Karadag et al. 2015).

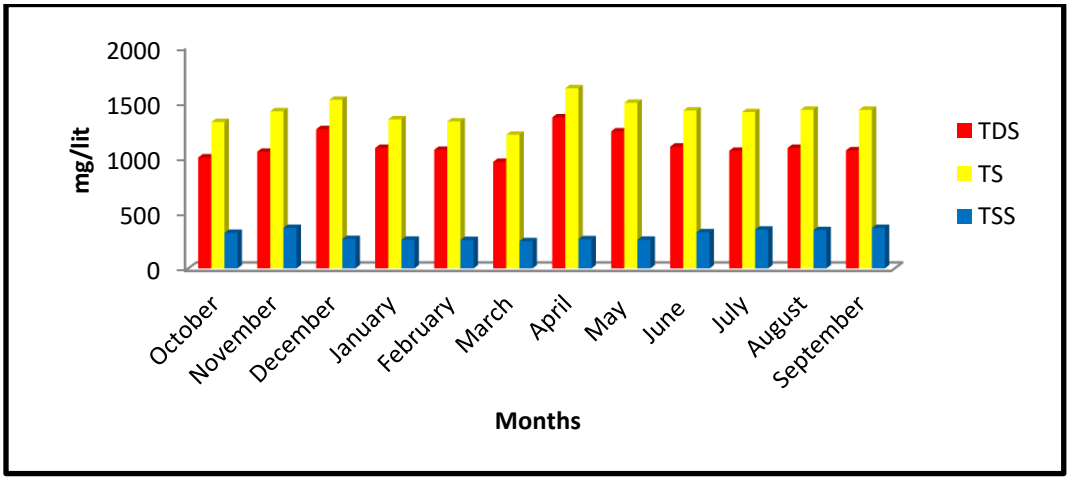

Fig. 4 Monthly variation of TDS, TS & TSS of effluent (Oct 2017- Sept 2018)

Total suspended solid (TSS): Total Suspended Solids (TSS) was recorded to be between 245 to 365 mg/lit. Maximum TSS value was reported in months November and September while lower value was reported in March (Figure 4). As per Table 2 mean value was recorded as 301±48 mg/lit. According to Kolhe and Pawar, (2011) TSS level in dairy effluent remains to be 310 mg/lit which is very much the same as reported earlier. According to Schifrin et al. (1981), Scchwarzenbeck et al. (2005), Jauczukowicz et al. (2007) dairy waste water remained varied in the TSS level with the value of 60 mg- 5080 mg/lit and these reports also cover the range recorded in the present study.

Chloride: Chloride values were reported between 256 to 562 mg/lit. Maximum chlorides value was reported in March while minimum in September (Figure 5). In a similar study Kolhe and Pawar (2011) reported the chloride level slightly higher i.e. 630 mg/lit.

Sulfates: Sulfates value of dairy effluent was reported in the range 136 to 456 mg/lit. A maximum sulfate value was reported in August while lowest in January (Figure 5). As per

Table 2 mean value of sulfate is 247 ± 98 mg/lit. In a similar study, level of sulphate reported was at higher value than recorded as 395 mg/lit (Kolhe and Pawar, 2011).

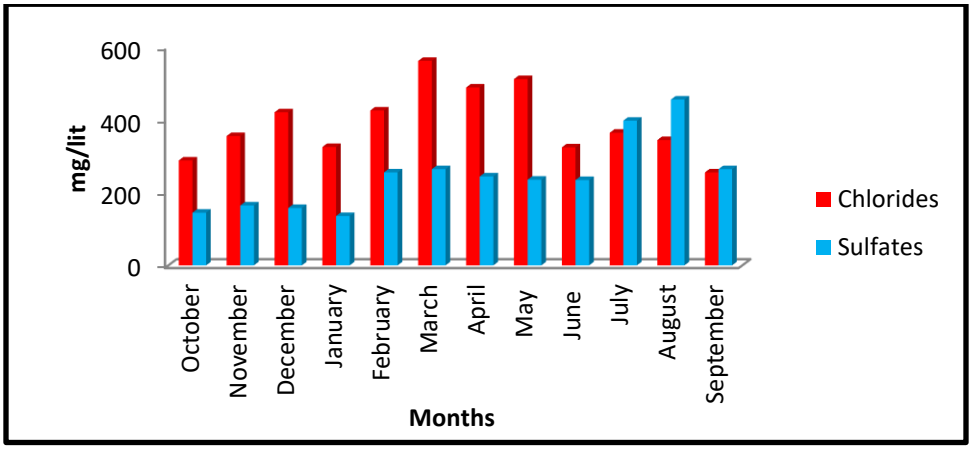

Fig. 5 Monthly variation of Chlorides & Sulfates of effluent (Oct 2017- Sept 2018)

Oil& Grease: In effluent, moderate oil and grease level was recorded between 85 to 210 mg/lit. Maximum oil and grease value was reported in months January and August while lower value was reported in October (Figure 6). As per Table 2, oil and grease mean value was recorded as 163 ± 44 mg/lit. According to Janczukowicz et al. (2007) very high levels of fat, oil and grease, about 1000 mg/lit was recorded in an effluent received from milk reception industry. Tawfik et al. (2008) reported the fat, oil and grease level in dairy/sewage mixed up effluent as 240-290 mg/lit. Worker Un et al. (2013) while studying butter industry effluent recorded the fat, oil and grease level as 2088 mg/lit which was many folds higher than that we recorded in the present study. According to Kolhe and Pawar, (2011) oil and grease level in dairy effluent remains to be around 80 mg/lit, similar to our recording.

Protein: The protein value was reported to be between 154 to 260 mg/lit. Maximum protein value was reported in November while lower value was reported in months May and September (Figure 6). Mean values of protein content reported as 191 ± 37 mg/lit (Table 2).

Lipid: It is observed from Table 1 that as per yearly samples data record of lipid content value was reported ranging between 485 to 690 mg/lit. Maximum lipid content was reported in March while lower value was reported in October (Figure 6). As per Table 2 mean value was recorded to be 600±63 mg/lit which indicates that shift in lipid contents shows obvious variations during batches.

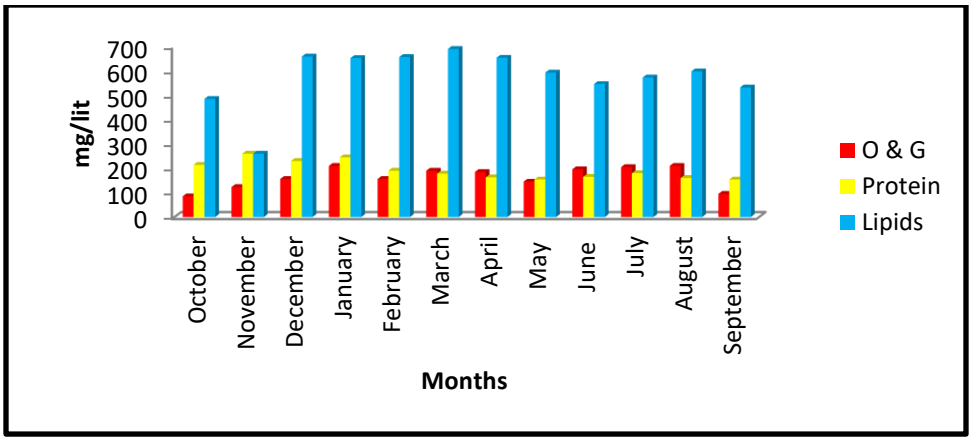

Fig. 6 Monthly variation of oil & grease, proteins & lipids of effluent (Oct 2017- Sept 2018)

As conclusion an overall analysis indicates that, parameters such as color remains unchanged, for pH and temperature narrow change in the range while wide variation in values of turbidity, electrical conductivity, BOD, COD, TDS, TS, TSS, chlorides, sulfates, oil and grease, proteins and lipids was observed. It suggest: 1) The monthly analysis of different physicochemical parameters of dairy industry effluent were done and found to have wide variation in values. The results clearly indicate that, these values are higher than permissible limits. These variations are probably because of climatic change, product under production, time of sampling, time of clean in process etc. Therefore it is needed to set up water quality regulations for effluent treatment plant. 2) Proper treatment of dairy industry effluent is needed before their safe discharge into environment. 3) Industry must set up the ETP having biological treatment process like reactors containing highly potential microbes for biodegradation of waste water, which is ecofriendly and low cost investment process.

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Received: 19th October 2020; Accepted: 17th December 2020;

First distribution: 06th January 2021.