CHARACTERIZATION AND TREATMENT OF WASTEWATER OF DAIRY INDUSTRY

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A**BSTRACT:** Now a day's dairy industry has become very popular. The present study has been conducted to identify the characteristics of dairy industry's wastewater as well as its treatment. It was concluded that the BOD values of untreated wastewater are in the range of 738 mg/L- 83l mg/L and treated wastewater is in the range of 80 mg/L- 126 mg/L. COD values were in the range of 739 mg/L-839 mg/L and 125mg/L-134 mg/L. The TSS value is in the range of 1038 mg/L-1049 mg/L and 193mg/L to 214 mg/L respectively. The Total Dissolved Solids in the waste water is in the range of 992 mg/L and 1056 mg/L for untreated and between 938 mg/L- 949 mg/L for treated water. Oil and grease values for untreated wastewater are in the range of 936 mg/L-944 mg/L while the treated water values are in the range of 83 mg/L-94 mg/L. The pH of wastewater is 8.3. The temperature of waste water varies. The fat is the most important constituent in the untreated wastewater contained about 1.5% fat in the given wastewater sample while the treated water contained about 0.5 % fat in the given sample. The values of BOD, COD and TSS in the treated wastewater were greater than the standard values, whereas the values of TDS were less than the standard values.

Key Words: Characterization, Treatment, Wastewater, Dairy Industry

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INTRODUCTION

All over the world, the dairy plants are found and they tremendously vary in sizes and the kinds of products manufactured. The dairy plant encompasses processing raw milk into various products like yogurt, consumer milk, cheese, butter, milk powder (dried milk) and ice cream using many processes that include pasteurization, homogenization and chilling. Traditional by-products consist of butter milk, whey and their by-products (Fagnani *et al.,* 2022). The dairy industry has numerous production sectors such as;

Milk Receiving: Regardless of the specific product, there is a section where milk is transported and stored.

Liquid Milk Products: In advance economies, raw milk undergoes the processes of decreaming and subsequent pasteurization or sterilization. Following these steps several milk-based products are prepared for marketing (Economopoulos and World Health Organization, 1993). Conversely, in less developed nations where refrigeration facilities are scarce, milk preservation methods may involve boiling and fermentation. Typically, this is done by sanitizing methods in which the vessels used for milk storage are smoked, and fermented milk can be consumed in its fermented form (Mostafa *et al.,* 2018).

Cheese: Globally, approximately 500 diverse cheese products exist, and these can be categorized into nine primary cheese families. These varieties are prepared through different types of production processes (Mostafa *et al.,* 2018).

Butter /Cheese: In developed countries, butter is prepared from cream which is then separated into sweet butter and sweet butter milk. In contrast, in developing areas, fermented milk production technology and the methods used to make butter and ghee are very similar. From fully soured whole milk that is charred, traditional butter is prepared (Syamlal and Sayantan, 2023).

Milk Powder: Raw milk, skim milk, or sweet buttermilk are used to make milk powder after being pasteurised, decreamed, etc. Through the process of evaporation, the moisture content from the milk is removed (Syamlal and Sayantan, 2023).

Condensate / Cream: Khoya is a product that is specifically prepared in Pakistan and India and is prepared by thermal evaporation of milk until it reaches a concentration of 60-70%. During the evaporation process, a portion of water is removed to condense milk and cream. It is in a solid state and is considered as an essential ingredient in a variety of sweets (Syamlal and Sayantan, 2023).

Waste Water: Depending on the variety of goods that are producing waste water from the dairy sector, each division generates waste water of a particular composition. This waste water comes from various sources such as tank, truck, and storage tank cleaning, pipeline cleaning, and sandizing all produce waste water. It includes milk waste, detergents, and sanitizer (Flayyih and Ali, 2023).

Sugars and protein are dissolved in dairy waste water, which may also contain additives. The important variables are total dissolved solids at 100–1000 milligrams per liter (mg/L), total suspended particles at 0.8–2.5 kg/t of milk in the untreated effluents, and biochemical oxygen demand (BOD), which is usually about 1.5 times the BOD level. The main sources of BOD in waste water are the manufacture of cream, butter cheese, and whey, which contain phosphorus (0–100 mg/L) and nitrogen (approximately 6% of the BOD level). One kilogram (kg) of milk fat equals three kg of COD, one kg of lactose equals one kg of COD, and one kg of protein equals one kg of COD. Pathogens from manufacturing processes or contaminated materials may be found in the waste water. (Gough *et al.*, 1990). A dairy often produces odor and, occasionally, dust, both of which need to be under control. A significant number of solid wastes may be converted into different products and by products (Alexander, 1993).

In a dairy processing waste water treatment plant, the estimation of BOD from other pollutant parameters was investigated. There are four parameters: BOD, COD, total suspended solids (TSS), and total solid (TS). For the aerated Dagon system, a 95% confidence level estimate of BOD value was calculated using an equation for predicting BOD based on COD, TSS, and TS (Gough *et al*., 1990).

Adsorption, coagulation, precipitation, and filtration were used to treat dairy processing waste water (1000mg COD/L) in fish pound fallow to remove COD at 85% efficiency. To reduce the COD value and recover butter oils from high load water (920,000 mg COD/L), oil water separation and fermentation at 30° were employed as pretreatments (Cheng *et al*., 1990).

Procedure was developed for the characterization and control of domestic and dairy industry waste water for discharge into a river. The procedure includes:

1. Evaluation and selection of the analysis Technique
2. Setting and control of the methods and working techniques and determination of critical point.
3. Control of river waters and samples of industrial and domestic waste water.
4. Analysis of data the technique used in the control of the waste water is in the Standard. Method, for examination of the water and waste water the sample from and dairy industry was obtained. The normal values of oxidizabilty BOD, pH and Total Solids, Sediments were obtained. From analysis of domestic waste water maximum values of mid-day BOD were obtained. Good correlation between the BOD and COD were obtained. The proposed method was adequate for the analysis of waste water. (Marin *et al*., 1999).

The dairy industry produces significant quantities of white, highly turbid liquid waste materials that are not suitable for further processing within the industry and must be disposed of. These waste byproducts contain a substantial amount of organic material, which can be present in dissolved or colloidal states, leading to elevated levels of total solids and biological oxygen demand (BOD). In a variety of liquid waste streams, earthworms can reduce the BOD5 by more than 98%, the COD by 80–90%, the total dissolved solids (TDS) by 90–92%, and the total suspended solids (TSS) by 90–95%. This remarkable capability stems from their ability to ingest and biodegrade organic pollutants, heavy metals, and solid particles (Sinha *et al*., 2007).

MATERIALS AND METHODS

The present study study was conducted in the R& D lab and waste water treatment lab of a dairy Industry for academic purpose. The name of dairy industry was kept confidential to maintain the integrity of that industry on which basis we were allowed to take samples.

Materials: In order to study the wastewater samples from dairy industry various apparatus, equipments and chemicals were used for experiments. the details are shown in table 1, 2 and 3.

Table 1. The apparatus used in experiments.

`	**Apparatus**	**Made**
1	Sample bottles *(25m1,* 50m1)	(Pyrex)
2	Graduated Cylinder *(25m1,* 100ml)	(Pyrex)
3	Beakers (250ml)	(Pyrex)
4	Measuring flasks (100ml)	(Pyrex)
5	Conical flask (250ml)	(Pyrex)
6	Measuring Pipette (1ml, 2m1, 5m1, 10ml)	(Boro-Silicate)
7	Whattman Filter papers	------
8	Burette (50m1)	(Boro-Silicate)
9	Thermometer	(GH Zeal Ltd. Made in London)
10	Ember bottle (250ml)	(Pyrex)
11	Separating funnel (250 ml)	(Pyrex)
12	Stopper	------

Table 2. The chemicals used in experiments.

Sr. No.	Apparatus	Made
1	Sulphuric acid (98 **%)**	(E. Merck)
2	Double distilled water	
3	Hydrochloric acid (3 7%)	(E. Merck)
4	Iso amyl alcohol	(E. Merck)
5	Diethyl ether	(E. Merck)
6	Buffer solution,	
7	Lithium hydroxide	(E. Merck)
8	Potassium dichromate	(E. Merck)
9	Phenolphthalein (1%)	(E. Merck)
10	Sodium hydroxide (0.1N)	(E. Merck)

Table 3. The equipments used in experiments.

Sr. No.	Apparatus	Made
1	Electronic balance	(A.E. Adam, AFA-2 1 OLC, four-digit accuracy)
2	Microwave Oven	(PEL, 2450MHZ, PM036)
3	Spectrophotometer	(DR2020 (HACH)
4	BOD Track	(HACH)
5	CODs Reactor	(HACH)
6	Magnetic stirrer	----
7	Dessicater	----
8	Incubator	(HACH)
9	Thermometer (0-100°C)	----
10	pH meter	(Crison, micropH200 1/England)
11	Butyrometer	(HBG milk 65°C, HBG butter 65°C, made in Germany)
12	Gerber Machine	(Made in Germany model 2005)

EXPERIMENTAL WORK

Estimation of Biochemical Oxygen Demand (BOD) in wastewater sample:

Procedure: Appropriate sample was taken in a beaker and is cooled to maintain temperature upto20°C. Sample was taken as per table 4 in an ember bottle with the help of graduated cylinder.

Table 4. Estimation of BOD (Biochemical Oxygen Demand) in wastewater

BOD range (mg/lit)	Required Volume of Sample (lit)
0-35	420
0-70	355
0-350	160
0-700	95

The magnetic stir bar was put in the ember bottle and then a nutrients buffer pillow was added after shaking the sample. By using a funnel to apply grease to the seal lip of the bottle and the top of each seal cup, the seal cup was placed on the neck of each bottle. In order to prevent lithium hydroxide particles from falling into the container, a pillow of lithium hydroxide powder was put to each lip of the bottle. The bottles were positioned on the BOD track's chassis, coupled with tubes, and tightened firmly. Then instrument was adjusted in the incubator at 20^0C. The instrument was started by switching on. The instrument test duration and BOD range was selected with help of arrow keys in the BOD instruments BOD result was obtained directly from the reading displayed on the instrument.

Estimation of Chemical Oxygen Demand (COD) in the Waste Water Sample

Procedure: 100ml effluents water sample was taken and was shaked in the blender for 30second by using 0.1ml pipette 0.2mL sample of effluents was taken and added in the high range (0-l500ml/lit) reagent vial at angle of 45-degree.

The vial was placed in preheated COD reactor for 120 minutes after that the vial was taken out from the COD reactor and then cooled at room temperature. Placed the vial in the spectrophotometer and COD program 435 was entered the wavelength of 620nm was selected by adjusting the spectrophotometer. Reading was noted in (mg/lit) (Hach Procedural Manual)

Total Suspended Solids (TSS) in Water (Spectrophotometer Method)

Procedure: 500 ml effluent sample was taken in a beaker and blend it in blender for 2 minutes. Stirred the sample and poured 25rn1 of the blended sample in the sample cell and filled the sample with 25m1 of tape water or deionized water (the blank and place the blank in cell holder. Now spectrophotometer was adjusted by entering store program for suspended solids. For Suspended solid the program was 630 than adjusted the wave length for a given program to 810nm by rotating the dial up to 810nm. By adjusting the wave length the display has showed 0 samples than mg/L suspended solids by pressing 0 the display would show 0 mg/L. By cleaning the sample cell form outside place, the sample cell holder and light shield was closed. The spectrophotometer show reading and these reading were noted in mg/L.

Estimation of Oil and Greases in Effluent Water

Procedure: Separatory funnel washed with detergents and 5m1 of organic solvent was rinsed to remove any oil film with walls of separatory funnel. The 350 ml of well shaked effluent water sample was taken in the 500ml of separatory funnel. The 4m1 1:1 HC1 solution was added to the separatory funnel. 2O ml of di-ethyl ether was

added in separatory funnel. The funnel was closed and was inverted to the release gases from it. The funnel was shaked vigorously for two minutes. The funnel was hold in stand and wait for 10 minutes to ensure the lower water layer and upper solvent layer. The lower water in 500ml conical flask was drained. The 125m1 dried distillation flask was weighed nearest to 0.1mg on analytical balance. The solvent layer with oils and grease in 125ml pre weighed distillation flask was obtained.

The extraction process was repeated three times. The separator funnel was rinsed with 5m1 of Di-ethyl ether to get any oil film left on funnel walls. The solvent was evaporated in oven completely. The distillation flask was placed in desiccators containing silica gel for 30 minutes and was weighed accurately. The apparatus was washed with detergent after completion of test.

Calculation:

$$\text{Oil \& Grease (mg/L)} = \frac{(B-A) \times {}^{*}1000 \times {}^{**}1000}{\text{Vol. of sample taken}}$$

Where,

A = Initial weight of 125 ml distillation flask
B = Final weight of 125 ml distillation flask
$^{*}1000$ = to convert grams into milli grams
$^{**}1000$ =to convert milli liters into liters
In case, if sample taken is 350 ml, then simplify
Oil & Grease (mg/L) = (B-A) x 2857.14

Total Dissolved Solid (TDS) of Water

Procedure: The 50 ml sample of water was taken in beaker. The TDS meter was immersed into sample and digital display was noted on the TDS meter. The reading was multiplied with 10 or 100 to get the total dissolved solids in parts per million (ppm)

pH

Procedure: To measure pH. pH meter (WTW) was calibrated with buffer solution of pH 7.01. Before measuring pH, temperature of waste water was adjusted at 20°C. The electrode of pH meter was dipped into waste water sample and waited till the reading was stable and consistent reading was noted.

Fat Percentage

Procedure: By Gerber method, fat percentage was determined. For which the water sample was warmed to 40°C and then cooled to 20^{0}C. 10 ml of sulfuric acid were taken in butyrometer and added 10.94 ml water sample and at last 1 ml of iso-amyl alcohol. Stopper was inserted and the contents were mixed. Butyrometer was placed in centrifuge machine at 1100 rpm, 65 ^{0}C for three minutes. Fat column was noted which was % age of fat in Waste Water.

RESULTS

The waste water volume discharged by the dairy industry was different from day to day. The amount and strength of the wastewater discharged during the process varies due to variation of products daily. The main characteristics of the waste water and the parameters which were studied include: Color, temperature, oil and grease, fat percentage, BOD, COD, TSS, TDS and pH (Al-Wasify *et al*., 2017; Asgharnejad *et al.,* 2021; Kaur *et al*., 2021; Shivsharan *et al*., 2013; Tikariha *et al.,* 2014).

The difference in samples of both untreated and treated waste water was analyzed at different time. The results of these parameters are given in the following tables 5, 6 and 7.

Table 5. Analysis of difference in sample of both untreated and treated waste water at different time.

Sr. No.	Parameters	Sample-I		Sample-II		Sample-III		**NEQS
		Before Treatment	After Treatment	Before Treatment	After Treatment	Before Treatment	After Treatment	
		Result (Values)	Result (Values)	Result (Values)	Result (Values)	Result (Values)	Result (Values)	
1	**Oil and Grease**	944 mg/L	94mg/L	944 mg/L	92 mg/L	936 mg/L	83 mg/L	10 mg/L
2	**BOD**	835 mg/L	98mg/L	736 mg/L	122mg/L	821 mg/L	126mg/L	80 mg/L
3	**COD**	763 mg/L	141mg/L	682 mg/L	176mg/L	710 mg/L	164mg/L	150mg/L
4	**TDS**	1056 mg/L	938 mg/L	1049 mg/L	925mg/L	992 mg/L	949mg/L	3500mg/L
5	**TSS**	984 mg/L	193mg/L	941 mg/L	194mg/L	947 mg/L	214mg/L	L50mg/L
6	**pH**	8.4	8.3	8.4	8.1	8.2	7.2	6-10
7	**Temperature**	30°C	33°C	33 °C	32°C	33 °C	30°C	40 °C
8	**Fat %**	1.5%	0.5%	1.65%	0.57%	1.75%	0. 75%	*N.M
9	**Colour**	White	Colourless	White	Colourless	White	Colourless	Colourless

Table 6. The mean of difference in sample of both untreated and treated waste water analyzed at different time

Sample	Oil & Grease		NEQS	BOD		NEQS	COD		NEQS	TDS		NEQS	TSS		NEQS
	Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)	
1	944	94	10	836	98	80	736	141	150	1056	938	3500	984	193	150
2	944	92	10	736	122	80	682	176	150	1049	925	3500	941	167	150
3	936	83	10	821	126	80	710	164	150	992	949	3500	947	214	150
Mean	**941.33**	**89.66**	**10**	**797.33**	**115.33**	**80**	**718.33**	**160.33**	**150**	**1032.3**	**937.33**	**3500**	**957.33**	**200.33**	**150**

Table 7. The mean of difference in sample of both untreated and treated waste water analyzed at different time

Sample	pH		NEQS	Temperature		NEQS	Fat%		NEQS	
	Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)		Before Treatment Result (Values)	After Treatment Result (Values)		
1	8.4	8.3	6-10	30°C	33°C	40°C	1.5	0.5	*N.M	
2	8.4	8.1	6-10	33°C	32°C	40°C	1.65	*0.57*	*N.M	
3	8.2	7.2	6-10	33°C	30°C	40°C	1.75	0.75	*N.M	
Mean	**8.33**	**7.86**	**6-10**	**32°C**	**31.66°C**	**40°C**	**1.63**	**0.61**	***N.M**	

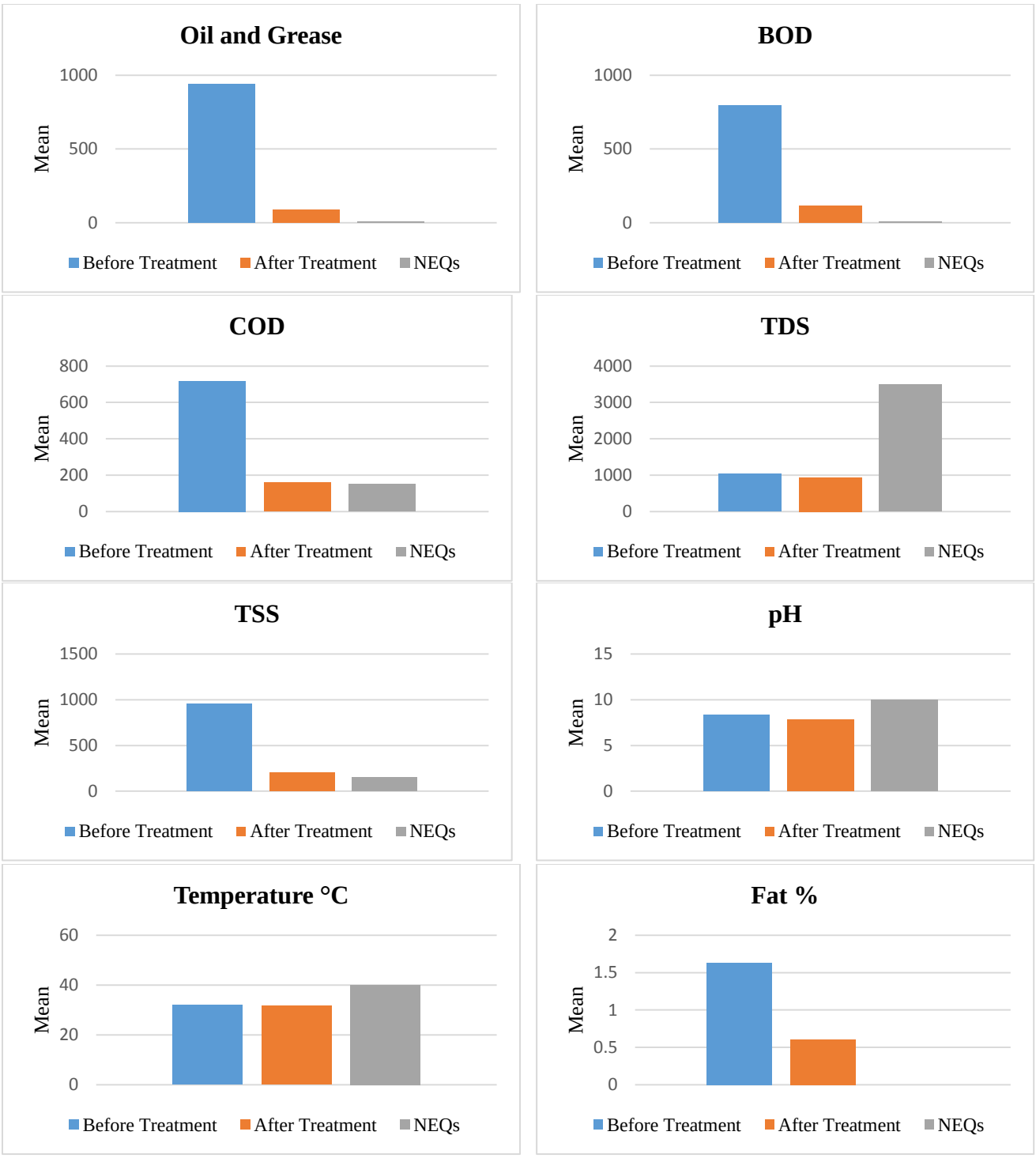

Fig 1. Mean of treated and untreated characteristics of wastewater taken from dairy industry

DISCUSSION

The study has been conducted to analyze the characteristics of wastewater of dairy industry. The main characteristics which were studied include colour, Temperature, pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Oil & grease. Dairy industries involve the processing of raw milk into different products. This raw milk is pasteurized, sterilized, skimmed, decreamed and then packed for marketing (Anjum *et al.,* 1989). Each division in the

dairy processing plant produces waste water (Patra and Duary, 2020). The water of dairy industry is turbid and whitish in color (Chakchouk *et al.,* 2017; Sarkar *et al.,* 2006; Shete *et al.,* 2013; Tikariha *et al.,* 2014; Qasim *et al.,* 2013). The waste water of dairy industry contains fat, oil and grease and residue of additive (Ahmad *et al.,* 2019; Bella *et al.,* 2021; Singh *et al.,* 2014). The waste water losses in dairy industry represent the loss of valuable products such as fat, oil and grease (Abomohra *et al*., 2020). The 350 ml of sample was taken in a separating flannel and 1:1 HC1 and diethyl ether was added and the amount of oil and grease in sample for untreated water and treated wastewater was measured. The waste water contains high organic load, salts, minerals which lead to high biochemical oxygen demand (BOD), Biochemical Oxygen Demand which was determined by taking 95 ml sample in ember bottle placed in BOD track chamber and incubated at 20C° for 5 days and values were calculated. Chemical Oxygen Demand was tested with the help of spectrophotometer by taking 0.2 ml effluent sample in a vial, the values for untreated and treated wastewater were obtained from the spectrophotometer. Calibrated Total Dissolved solid meter was taken and was dipped in the sample the values of Total Dissolve Solids obtained from untreated waste water and treated wastewater was studied. 25 ml sample was taken in sample cell and by using spectrophotometer (Hatch) the Total Suspended Solids were determined in (mg/L). The Total Suspended Solids in the untreated waste water and untreated was studied. The waste water of the dairy industry is basic in nature having a pH of nearly 8.3. The dairy waste water contains high value of BOD, COD, TSS, and TDS due to presence of high organic load as calculated by Asgharnejad *et al*., 2021 and Power *et al.,* 2023. There will always be greater accumulation of bacteria and other pathogens. These pathogens are harmful to the human and most important effect of this type of waste water in dairy industry was the environment damage. The high organic load affects the normal life of flora and fauna. If this water is discharged untreated then it would cause severe damage to both aquatic and land life so it must be treated before its disposal. This wastewater must be treated before its discharge and oil and grease must be removed to avoid pollution. The products that are being last must be handled carefully.

Conclusion: The waste water of dairy industry contains fat, oil &grease and high level of additive residue of additive. The BOD values of untreated wastewater is in the range of 738 mg/L - 83lmg/L and treated wastewater is in the range of 80 mg/L - 126 mg/L. COD values were in the range of 739 mg/L - 839 mg/L and 125mg/L - 134 mg/L. The TSS value is in the rage of 1038 mg/L - 1049 mg/L and 193mg/L to 214 mg/L respectively. The Total Dissolved Solids in the waste water is in the range of 992 mg/L and 1056 mg/L for untreated and between 938 mg/L- 949 mg/L to treated water. Oil and grease values for untreated wastewater are in the range of 936 mg/L-944 mg/L while the treated water values are in the range of 83 mg/L- 94mg/L. The pH of wastewater is in 8.3. The temperature of waste water varies. The fat is the most important constituent in the untreated wastewater contained about 1.5% fat in the given wastewater sample while the treated water contained about 0.5 % fat in the given sample. The values of BOD, COD and TSS in the treated waste water were higher than the standard values, while the values of TDS were less than the standard values. The wastewater after treatment still has high value of oil & grease, BOO, COD, TSS and TDS as compared to NEQS (Literature) this water because contains values of parameters which are still exceeding must be handled more carefully by treating it with suitable methods so it may be discharge to land without causing any severe damage to environment. The products that are being last must be handled carefully. The high value of BOD and COD cause the deficiency of oxygen in the waste stream. The high value of TDS and TSS lead to increase in the total dissolved solids and total suspended solids. The values of TDS are less than the value of NEQS this indicates that dissolved solids are not used in so much quantity. So, it is suggested to discharge wastewater from dairy industry after proper treatment in order to avoid any adverse environmental effects. This study will help the environmentalists and Environment Protection Department (EPD) to formulate policies for dairy industries to discharge treated wastewater.

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