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Physiological Analysis of Dairy Effluent

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Abstract

The paper is a review based of the study done on the dairy effluents in Rohtak Dairy "Vita Milk Plant". It talks about the industrialization that serves as the backone of the country, The effluent treatment plant is used for the reduction or control of pollutants. This process is operable under the 4 treatment levels which are stated as Preliminary, Primary, Secondary, Tertiary/ Advanced treatment of the wastewater which contains various steps for their completion. In the introduction part the presentation of work is given which remarks about the dairy industry and the effluent production. In the literature review portion, a review of the work performed by earlier researchers on dairy waste and characteristics of dairy waste is included. The materials and methods portion constitutes the materials required for the analysis. The methodology used for the analysis of different characteristics of dairy waste is also covered up with conclusion and references.

Keywords: APHA (American Public Health Association), BIS (Bureau of Indian Standards), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen)

1. Introduction

Industrialization leads to the enhancement level of productivity with a consequence of toxic production These waste are potential pollutants which cause harmful impact on the environment. This upsurge in pollutants has culminated into disruptions in normal functioning of flora and fauna due to rise of potential health hazards. Dairy effluent are highly organic and their direct discharge into river or water stream leads to a spike in biological oxygen demand due to increased organic pollutants in water. This wastewater has highly pungent smell and biological activity. Majority of wastewater released from dairy industry is from cleaning operations like cleaning of soils, homogenizers, tanks, pipes, heat exchangers and other equipments. Therefore waste from effluent treatment plant in the arid and semi-arid area is used for irrigation or any other agro-forestry practices.

In the lime lightening the above study was performed in "Vita Milk Plant" area. A milk processing unit was selected for the study of its wastewater. it has a total production capacity of about 400MT/Day having 4 chilling sections with daily water consumption of 262.22m^3 per day in milk processing operations. 5.0m^3 per day in cooling processes and 6.62m^3per day in domestic operations. waste discharge lies in lower areas.

1.1 Objective of the study:

To study the physiochemical properties of the effluent of Vita Milk Plant.

To compare the studied parameters with BIS.

1.2 Operating Dairy Industry and the Generation of Effluents:

This involves the bioprocessing of milk.

Fig.1. Brief Description of Dairy Process

1.3 Waste Water and its Source:

Waste from milk industry containing milk solution in more or less diluted condition, but the concentration varies. The entry of solid particles from waste of all the operations. Generation of Waste by milk based food industry.

Table1. Details of Source of Wastewater generation in Dairy Process.

Dairy Process	Source of Waste	
Storage and Receiving of Milk	Tankers of poor drainage Leaked pipes and hoses Storage tanks are spilled	Foaming Cleaning Operations
Pasteurization/ Treatment with Ultra Heat	Liquid loses/leaks Downgrading product is recovered Cleaning Operations	Production and Deposition of foams onto the surface of pasteurization and on the equipments used for heating purposes
Homogenization	Leaking and Loss of Liquid	Operation for cleansing
Centrifugation, Separation, Reverse Osmosis	Production of foams Operation for cleansing	Leaking of Pipes
Processing Stage of Product		
Chessy milk	Vats are overfilled Whey is incompletely separated from curd Using salt for the processing of cheese	Spills and Leaks Cleaning Operations
Making of Butter	Cleaning operation Product Washing	Reduction in pressure used in process of pasteurization via salt usage and steaming
Manufacturing of Power	Power handling of spills Losses in Start-ups and Shut-down Malfuctioning of plants	Losses in Stack Cleansing of Driers and Evaporators Losses in Bagging

1.4 Mechanism and Treatment Level of Dairy Effluent Treatment Plant:

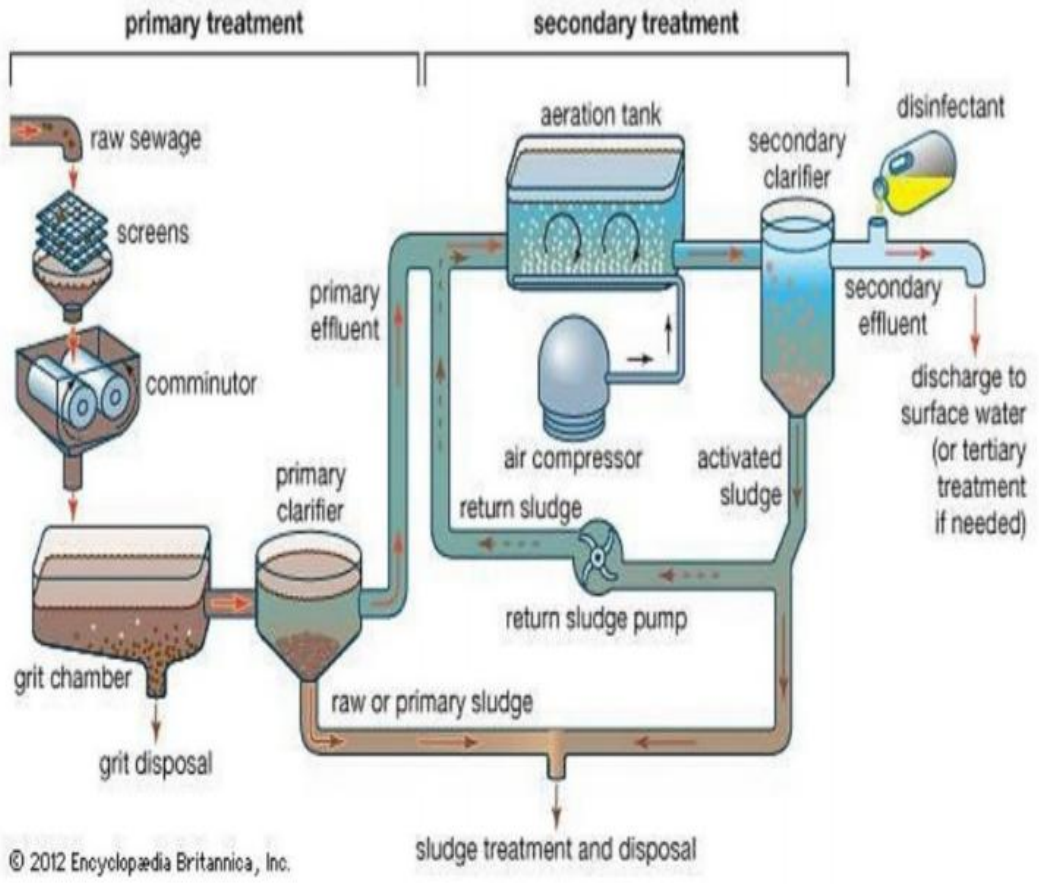
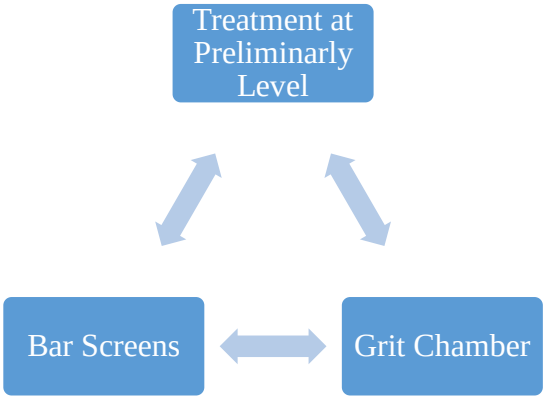
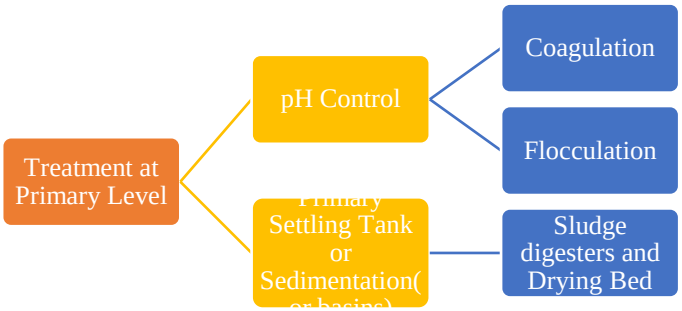


Fig.2. Treatment level of Dairy Effluent Treatment Plant

1.) Treatment at Preliminary Level:





2.) Treatment at Secondary Level:

This process is explained as follows:

A) Suspended Growth Treatment: The micro-organisms are suspended in the water then move with the water.

b) Activated Sludge: unit of a multichamber reactor , uses aerobic micro-organisms to degrade organics in wastewater and to produce a high quality effluent. To maintain aerobic conditions and to keep the active biomass suspended, a constant and well timed supply of oxygen is

required. Activated Sludge Process can be employed to ensure that the wastewater is mixed and aerated in the aeration tank. The microorganisms oxidized the organic carbon in the wastewater and to produce new call, carbon dioxide and water. Aerobic Bacteria are the most common organisms that can be present along with higher organisms. During aeration and mixing, the bacteria form small clusters of flocs.

Continuously diffusion of compressed air is done into the sewage as it flows through the tank that is used for aeration. It is helpful for the the flocs of aerobic bacteria that grows in the tank for bringing out of the turbidity to remove the waste and for the bacterial contact. Bacteria's which are aerobic in nature attacks the solids that are finely divided and unable to remove by primary sedimentation. Removal of flocs is done with the sewage from the aeration then proceeds for treatment at secondary settling tank where the flocs are being settled to the tank's bottom then pumping is done to get back in the tank used for aeration. The flowing of liquid is done over a weir after chlorination and releasing it to a stream. For gaining the desirable goals towards BOD phosphorous, nitrogen alongwith different adaptations and modifications are made for the designing of activated sludge. Aerobic conditions, nutrient specific organisms, design for recycling and dosing of carbon are successfully allowed. ASP is achievable with high treatment efficiencies.

Organic Nitrogen Converted into NH^{4+}/NO^{3-}

Organic Sulphur Converted into SO_4^{2-}

Organic Phosphorous converted into H_2PO^{4-}/HPO^{4-}

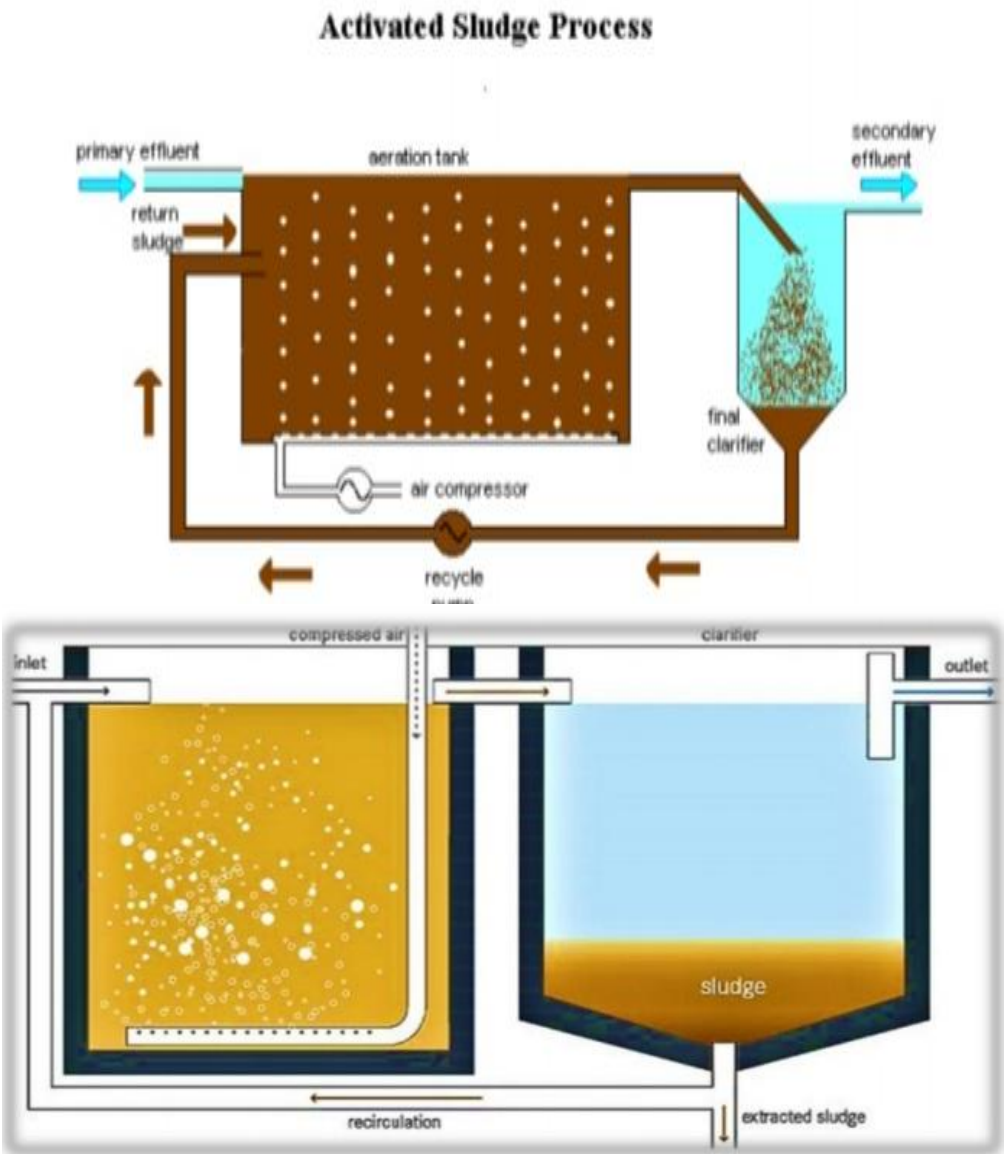


Fig.3. Activated Sludge System

C) Membrane Bioreactors:

In this water form mixed liquor is separated through the hollow fiber membrane submerged in the activated sludge aeration tank. Thus, avoiding the need for secondary settling tank. The microfiltration fibers have for size of about 0.2um.

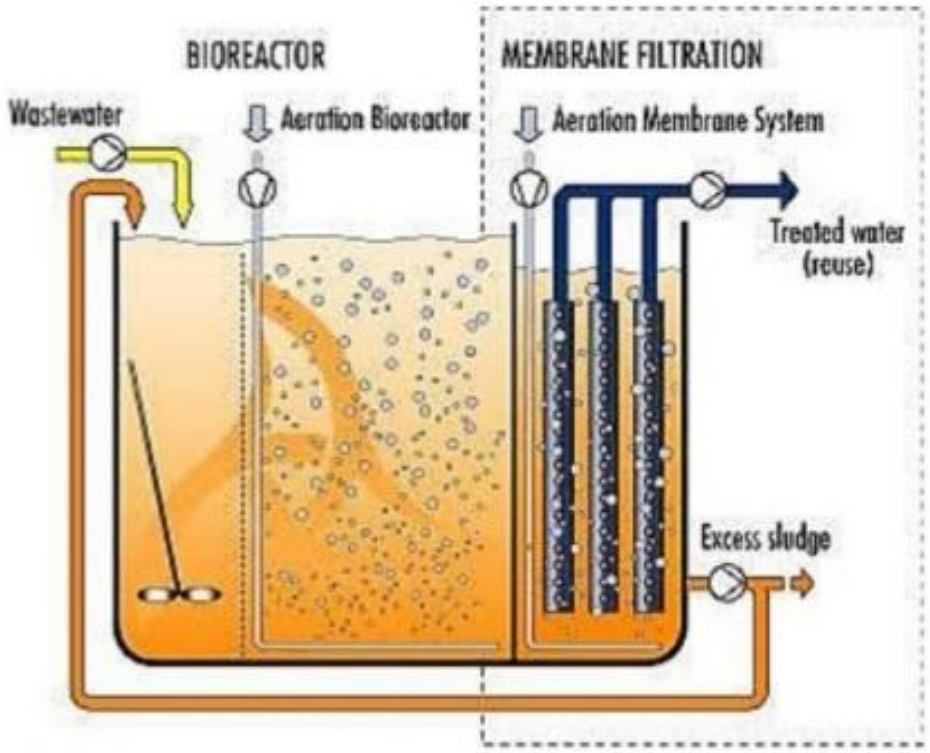


Fig.4. Bioreactor Membrane

4) Treatment at Tertiary Level/ Advanced level:

This is used for the final cleansing process which is helpful in the improvement of wastewater quality for reusing and discharging it into the environment.

Disinfection	**Chlorination**
Helpful in the reduction of microbial quantity in the water before using it for various chaos.	Disinfecting agent for water Use of chlorine is done in the liquid form as a bleaching powder. $Cl_2 + H_2 \longrightarrow HOCl + HCl$ $HOCl \longrightarrow HCl + (O)$ Both HOCl (Hypochlorous acid) and (O) are strongly powerful germicides. $2CaOCl_2 + 2H_2O \longrightarrow CaCl_2 + Ca(OH)_2 + HOCl$ (Chlorinated lime)) $NaOCl_2 + H_2CO_3 \longrightarrow 2NaHCO_3 + HOCl$ (Sodium hypochlorite) Disadvantages: Generation of chlorinated organic compounds which are cancer causing agents as well as harmful for the environment.

2. Literature review:

2.1) Dairy Industry:

Talks about all the positive and negative effects of this industry on a large scale like production of products as well as creation of pollution on a large scale.

2.2) Characteristics of Dairy Effluents:

Milk constitutes of proteins, carbohydrates and fats. It categorization is done and buttermilk, Whey, Skimmed Milk which varies according to their parts per million.

Investigated the BOD and COD permissible limit of dairy waste and also stimulation of pollution level.

The organic compounds are present in the dairy effluent is high which is suitable for the micro-organisms growth whose identifications is done via presence of minerals, vitamins and other Biomolecules like proteins and carbohydrates in the dairy's wastewater.

Concentration of BOD:

Upto 30mg/l for fresh water bodies, source for the supply of drinking water.

Of 350mg/l for chilling the effluents in plants and operated as a secondary treatment. After the treatment it is satisfactory to a limit of 30mg/l of biological oxygen demand and 10mg/l for nitrate.

Table.2. Effluents Standard of Dairy Wastewater.

Parameters	Concentration in mg/l, no units for pH	Quantum per product processed
pH	6.5-8.5	-
Biological Oxygen Demand at 27^0C for 3 days	100	-
Suspended solids	150	-
Oil and grease	10	-
Wastewater generation	-	-

3. Materials and methods:

3.1) Physiochemical Analysis of Wastewater of Milk Processing Unit

Physical Parameters: Color, odor, pH

Chemical Parameters: COD, BOD, TSS, TDS

Instruments used for measurement of different parameters:

Table.3. Instrument Used For Measurement of Dairy Parameters

Parameters Measured	Instrument
pH	pH comparator
TDS	Drying oven
TSS	Drying oven
COD	Closed reflux method
BOD	Closed reflux method
OIL & Grease	Partition –gravimetric method

1. **Color/Appearance:** observable with naked eyes.
2. Odor: Odors of the effluent is judge by sniffing
3. pH: For the measurement of basicity and acidity of the given solution.
4. Total solid: They are determined as the residue left after complete evaporation of well mixed sample (APHA, 2017). Total solid measured by the gravimetric method by using porcelain evaporating dishes and weighing on electronic balance and it is expressable in mg/l unit.
5. Total Dissolved Solids:
Total Dissolved Solid mainly represents the various kind of mineral present in water and their determination is done via evaporation, drying the known values of the filteres sample.
Procedure:

- Filtering of sample via the Whatmann filter paper.
- Evaporation of clear filtrates in water bath until their constant weight is not gained.
- After gaining of the crucible weight the difference is noted down.
- Calculation;

TDS (mg/l)= (X_1-X_2)*1000/Volume of sample in ml
Where,
X_1=Dried Residue weight+ Crucible
X_2=Crucible's weight
Total Suspended Solids:
It is an indication for the measurement of all kind of solids that are soluble in nature.
Procedure:

- Filtration of sample via Whattman Filter Paperz
- Drying of the sample at 150^0C for approximately 8 hours after that the sample is taken out.
- Calculation

TSS (mg/l)= (X_1-X_2)*1000/ Volume of sample in ml
Where,
X_1= Filter paper weight+ Dried Residue
X_2= individually weight of filter paper
Oil and Grease:

- Taking up of 5ml of effluent from the extraction of fat.
- Adding up of 50ml Petroleum Ether
- Mixing and untouched till 15 minutes.
- Decanation off the ethereal layer from the mixture in clean and dried previously weighed, aluminium flat dish.
- Adding up of 5ml ethanol
- Mixing is done and untouched till 5 minutes.
- Decenation of the top layer into the dish extract
- Drying up in the hot plate
- Cooling is done in dessiccator
- Measurement of weight.

Calculation;
% of grease and oil=2X
Where,
X is the weight of dried extract
3.2) Dissolved Oxygen:
It is dependent on the physically, chemically and biochemically occurring activities to the water bodies.
3.3) BOD (Biological Oxygen Demand):
The BOD was measured according to the method described in (APHA, 2017). The BOD is performed using the dissolved oxygen. There is a differencre between the two levels of BOD which is a representation to to the required amount of oxygen for decomposing the organic material into the sample with a good approximation in the level of BOD.
Required Reagents:

- **Magnesium Sulphate Solution:**
  22.5 $MgSO_4.7H_2O$ dissolved in 1 liter of distilled water, filtered dilution in 100ml should not give any color with starch.
- **Calcium Chloride:**
  27.5g of calcium chloride dissolved in 1 liter of distilled water.
- **Concentrated H_2SO_4**
- **Starch Indicator:** Soluble powder of starch was dissolved in 80ml of distilled water and its dilution is done in 100 ml.

Procedure:

- Collection of fresh waste water sample
- Dilution is done for about 1000 times
- Incubation in done for 5 days at 20^0Cto get the measurable amount of oxygen.
- Filling of sample into 4 bottles

- After incubation determination of oxygen concentration is done.

BOD in mg/l= DO_i-DO_f

Where,

DO_i= Dissolution of Oxygen value at initial level

DO_f= Value of Oxygen after 5 days of Incubation

3.4) COD (Chemical Oxygen Demand):

The test of COD determines the requirement of oxygen for the process of chemical oxidation of the organic matter with the help of strong oxidizing agent $K_2Cr_2O_7$ (Potassium Dichromate). It is the measurement according to the dichromate reflux method describe in APHA-AWWA-WPCFC (2017).

Advantage:

- Results in a short time period.

Required Reagents:

- Mercuric Sulphate
- Silver Sulphate Crystals
- Concentrated Sulphuric Acid
- Potassium Dichromate (0.25N): dissolved in distilled water in a quantity of 1000ml in a volumetric flaskof 1.0ml of 0.025N $K_2Cr_20_7$
- Ferroin Indicator (39.29g): Dissolution is made in 20ml of cooled concentrated H_2SO_4 and a solution of upto 1000ml is made in a volumetric flask.
- Silver Sulpate: Addition of 5.5g of $AgSO_4$ to the 1l of H_2SO_4 and the mixture is allowed to stand for one day to dissolve in $AgSO_4$

Standarization against Potassium Dichromate:

- Dissolution of 19.6g of ferrous sulphate in distilled water
- Addition of 20ml of concentrated H_2SO_4 to the solution
- Cooling is done
- Dilution in done in 1 liter
- Completion of standardization is done by the mixing of 30ml of H_2SO_4 in the above solution and titered against $K_2Cr_2O_7$ solution using ferroin as an indicator.

Procedure:

- Dilution of wastewater is done in 10ml wastewater that is taken in 250ml of refluxing flask.
- Addition of 0.2g of HgSO4 and H2SO4 reagent is added.
- Cooling of solution is done.
- Addition of 5ml of 0.2N$K_2Cr_2O_7$.
- Refluxing of solution for 2 hours.
- Cooling of solution.
- Dilution to final volume of 70ml with distilled water.
- Excess of refluxed solution was titred against the ferrous ammonium sulphate in the presence of 2-3 drops of ferroin indicator.
- Indication for the end point of titration is observed via change in color from blue green to reddish brown.

COD (mg/l)= (X1-X2)N*8000/sample in ml

Where,

X_1= ml ferrous ammonium sulfate titrant used for blank

X_2= ml ferrous ammonium sulfate titrant used for sample

N= Normality of ferrous ammonium sulfate

4. Results and Discussions:

Table.4. Result of Physiochemical Analysis of Water Effluent

Parameter	Result	Specification EPA,1986(in land surface0 water
Color	Light Yellow	-
Odour	Odorless	-
pH	7.83	5.5to9.0
COD(mg/l)	47.0	250max
BOD(mg/l)	5.6	30max
TSS	23.0	100max.
TDS	926.0	-
Oil and Grease	1.2	10 max

Color:

Color is a vital element for sustainability of aquatic life in water bodies. The crucial process of photosynthesis forms the basis of sustaining life and colour. The turbidity of water affects this process. In present study the color of untreated effluents was found to be dark yellow to brownish, whereas, after treatment effluent appeared to be Yellowish.

Odor:

Presence of excessive odour in effluent indicates towards high biological and chemical activity in effluent due to inadequacy in treatment processes. In present study the treated effluents released from the milk plant were found to be odorless..

pH:

In the present study the value of pH was found to be 7.83.

COD (Chemical Oxygen Demand):

The oxygen that is required for the chemical oxidation of organic matter via using the chemicals that are strong oxidizing agents like $KMNO_4$. The measurement of COD is done for the production of CO_2 and H_2O after oxidizing the organic matter. Except few all the organic compounds are oxidising agents in acidic environment. It is useful for accessing the toxicity In the current study the value of treated effluent was found to be 47mg/l. as per as the Indian Standards (EPA,1986) a value of 250mg/l for COD is found to be acceptable.

BOD (Bio logical Oxygen Demand):

It is an interpretation for the quantity of oxygen required by aerobic micro-organisms in water bodies to disintegrate organic matter. It is one of the most vital parameters for the strength of determination for wastewater in creation of pollution. The current study for the treatment of BOD effluent was found to be 5.4mg/l. as per as the Indian Standards (EPA,1986) a value of 250mg/l for COD is found to be acceptable and the results of this study was also within the acceptable limits.

- Factors that increases the level of Biological Oxygen Demand majorly constitutes milk products.
- Factors that decreases the level of Biological Oxygen Demand is the lesser quantity of suspendesd solids and observable in the season of winter.

Total Solids:

Total Dissolved Solids:

The present study shows about 926mg/l of TDS which is high for the untreated effluent due to the attribution towards the climatic conditions during the study period, which provided ideal conditions for increased TDS values in treated effluent.

Values for TDS:

- 1000 mg/l to the untreated effluent
- 480 mg/l to the treated effluent.

Total Suspended Solids:

- The TSS of the untreated effluent was studied of 23.0mg/l.

Oil and Grease:

Excessive amount of it leads to interference with aerobic and anaerobic biological processes leading to the reduction of wastewater treatment efficiency. In the current study it was 1.2mg/l.

As per as the Indian Standards (EPA), 1986, a value of 10mg/l for oil and grease is found to be acceptable and it was under that formality.

Consequences:

- Creation of humus.
- Decreased soil fertility.

Advantages:

- Helpful for the designation and handling of the wastewater system.

Conclusion:

The current physiochemical scenario for wastewater is done in Haryana dairy for which various physical and chemical parameters came into considerations for determining the water quality of effluent water. Wastewater quality can be maintained within safe limit by all physical and chemical parameters meets up to the limit of specification EPA, 1986,(in land) surface. The dairy industry has the highest consumption of freshwater in each unit. The current study revealing the quality of water of the dairy effluent seems suitable for irrigation purpose but not suitable for drinking purpose because in “vita milk plant” Effluent treatment plant process does not involve tertiary/advanced process.

Dairy waste:

- Non-toxic.
- No harmful chemicals are used.

- Consists of mainly biodegradable and organic matter.

Remedy:

- Whey treatment.

Advantages:

- Simple.
- Economically affordable.

The effluents from water can be used for gardening after the treatment of dairy waste treatment process.

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