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Physico-Chemical Analysis of Dairy Industrial Effluent

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A B S T R A C T

Milk has important place in human life. The dairy industry involves processing of raw milk into products like consumer milk, butter, cheese etc. The quantity of water required in a milk processing plant depends upon the size of the plant, generally expressed in terms of the maximum weight of milk handled in a single day, and the processes involved. The daily volume of water required may vary widely, depending mainly on the availability of water and the control of all water using operation in the plant. The operations where the process involves continuous flow, the amount of water needed for rinsing and washing is not necessarily proportional to the amount of product processed. Most of the waste water discharged into water bodies, disturbs the ecological balance and deteriorates the water quality. Effluent from milk processing unit contains soluble organics, suspended solids, trace organics which releases gases, causes taste and odor, impart colour and turbidity, and promote eutrophication. Which affect and disturb the environment in this regard's aimed to study the physicochemical characteristics of waste water generated from dairy industry with suitable treatment.

Introduction

India is the largest producer of milk and Rajasthan ranks II among milk producing states of the country. Among all industrial sectors, food processing units (including Dairy Industry) are major contributor of waste water generation. India, being largest producer of milk, huge amount of waste is also generated from these industries. The dairy industry in India on an average has been reported to generate 6-10 litres of waste water per litre of the milk processed. Milk-processing plants generate significant quantities of wastewater with relatively high organic matter concentrations on a daily basis. In addition to environmental damage that can result from the discharge of these wastewaters into the natural waterways, the presence of products such as milk solids into wastewater streams represents a loss of valuable product for the plants.

Wastewater from milk industries contains large quantities of fat, casein, lactose, and inorganic salts, besides detergents, sanitizers etc used for washing (Kolhe *et al.,* 2009). These all contribute largely towards their high biological oxygen demand (BOD), chemical oxygen demand (COD) and oil and grease are much higher than the permissible limits. Dairy raw wastewater was characterized by high concentrations and fluctuations of organic matter and nutrient loads (Farizoglu

and Uzuner, 2011). The composition varies depending on the operations and products (Khojare *et al.,* 2002).

The waste water discharge form industries are major source of pollution and affect the ecosystem (Anikwe and Nwobodo, 2006). The degradation of environment results by the adverse effect of industrial waste on living organism and agriculture (Danalewich *et al.*, 1998). Keeping all these points into consideration the study has been done to study physico – chemical properties of wastewater generated from dairy industry.

Materials and Method

Sample area and sample collection

Samples were collected from JAIPUR DAIRY directly from a discharge point in a clean plastic container, transferred to laboratory and stored at 4^{o}C until use for analysis. Sampling was done in the month of Jan. and July'12.

Physico-chemical analysis of effluent

Effluent samples were analyzed for physico-chemical parameters such as pH, temperature, salinity, conductivity and total dissolved solids (TDS) by water analyzer kit. Biological oxygen demand (BOD) was analyzed by membrane electrode method as given in American Public Health Association (APHA). All these parameters were analyzed within 24 hrs in each of three replicates. Results are shown in Table 1.

Results and Discussion

Temperature

Temperature is an important parameter and remarkably first one to be measured in physico-chemical analysis. It is important for its effects on the chemistry and biochemical reactions in the organisms; it also affects the efficiency of treatment units (Jayalakshmi *et al.,* 2011), for example, in cold temperature, the viscosity increases. This in turn, diminishes the efficiency of settling of the solids present in water because of the resistance offered by high viscosity to downward motion of the particles as they settle. Further, it is an important factor for calculating solubility of oxygen, carbon dioxide, bicarbonates and carbonates. It is an important factor and has its effect on certain chemical and biological reactions taking place in water and in organisms inhabiting aquatic media and will depend upon seasons and time of sampling. No specific limit for temperature is prescribed by WHO or ISI for the water quality use for the domestic purpose

In the present study, temperatures noted were 27±2.08 ^{o}C and 31±1.53 ^{o}C in months of January and July (tables 1). These slight changes in the values of temperature were due to seasonal variations. During the summer, water temperature is higher because of decrease in water level, clear atmosphere and great solar radiation, while in rainy and winter season can be explained on the basis of cloudy atmosphere, high percentage of humidity and high water levels.

Turbidity

Turbidity noted was within the range of 20 - 23 NTU for treated effluent in July and 23 ± 24 in months of Jan' 2012 (table - 1). A study reported turbidity varying from 35.9 – 97.1 NTU for dairy waste water by Ashish and Omprakash (2014), which is slightly on higher side.

Total dissolved solids

Usually TDS (total dissolved solids) is measured in ppt (part per trillion). In the present study, the total dissolved solid of treated effluent in the month of January'12

was found to be 1.2±0.25 ppt and in July'12 it was 1.28 ± 0.25 ppt. Kolhe *et al.,* 2011, studied dairy industrial effluent and recorded total dissolved solid value, which ranged from 1000 mg/l for untreated effluent and 480 mg/l for treated effluents.

The maximum concentration of total dissolved solids is in summer, which increased in rainy seasons, while the minimum value was found in winter probably because of stagnation. In summer most vegetation is decaying, so rise in the amount of dissolved solids was neutral as the products of decaying matter, which were settled in the water. The total solid concentration in waste effluent represents the colloidal form and dissolved species. The probable reason for the fluctuation of value of total solid and subsequent the value of dissolved solids due to content collision of these colloidal particles.

The rate of collision of aggregated process is also influenced by pH of these effluents. In the rainy season less concentration of total dissolved solids are obtained, due to the concentration of the dissolved solids are obtained due to the dilution of waste effluents with rain water. In present study TDS values for all effluent were found little higher than standard limits of 1ppt or 1000 mg/l (Tables 1). On the contrary, Shaikh *et al.*,(2009) obtained very high value of TDS i.e 1.9 ppt; similar higher values were obtained by other workers like Khojare *et al.,* (2005), Dharam (2009), and Gaiker *et al.,* (2010) for treated waste water from milk processing unit.

Salinity

Salinity values noted offinal dairy effluent was 1.4 ± 0.24 in month of January and 1.3 ± 0.40 in July' 12. Higher salinity values were due to increase in solubility of solids, while the values lowered after ETP due to decrease in solubility of solids.

Conductivity

Electrical conductivity of water is also an important parameter for determining the water quality. It is a measure of water's capacity for carrying electrical current and is directly related to the concentrations of ionized substance in the water. Conductivity of dairy effluents noted in year 2012 was 3.5 ± 0.36 mS and 3 ± 0.29 mS in months of January and July respectively for treated dairy effluent after ETP. No standards have been specified for conductivity and TDS in "General Indian Standards for Discharge of Environmental Pollutants IS: 10500".

pH

Hydrogen ion concentration is a largely studied ecological parameter, which gives an idea about the concentration of carbonate, bicarbonate and CO_2 in water. Slightly alkaline pH values noted in year 2012 for treated dairy effluent were 6.8±0.64 and 6 ±0.69 in months of January and July (Tables - 1). These results were similar to the findings by Carawan *et al.,* (1979); Monroy *et al.,* (1995); Dhanam (2009) and Shaikh *et al.,* (2009) for dairy industrial effluents.

Other studies conducted by Kolheand, Pawar (2011) also found pH of dairy effluents within 6 – 9.5 range, which was quite similar to the values obtained in present study. Alkaline pH of dairy effluent was also observed by Medhat and Usama (2004); Khojare *et al.,* (2005); Gaikar *et al.,* (2010). Presence of nutrients, high organic load and use of alkaline cleaning agents in dairy industry lead to its alkaline pH.

Biochemical oxygen demand (BOD)

Biochemical oxygen demand (BOD) is defined as amount of oxygen required by microorganisms, while stabilizing biological decomposable organic matter in a waste under

aerobic conditions. Since the test is mainly a bioassay procedure, involving measurement of oxygen consumed by bacteria. While stabilizing organic matter under the aerobic conditions, it is necessary to provide standard conditions of nutrient supply and pH. Absence of microbes because of the low solubility of oxygen in water and strong wastes are always diluted to ensure that the demand does not increase in available oxygen. Low value of BOD is comparatively in winter months may be due to lesser quantity of total solids, suspended solids in water as well as to the quantitative number of microbial population (Avasan and Rao, 2001).

In the present study the BOD of treated effluent range between 320 to 355 mg/l Waste water of dairy industry contain large quantities of milk constituents such as casein, lactose, Fat, inorganic salts. Besides detergents and sanitizers used for washing, all these components contribute largely towards their high biochemical oxygen demand. Trivedi *et al.,* (1986) observed the effluents of textile industry. From the different unit BOD value of mixed effluent ranged between 320 mg/l to 720 mg/l and final effluent 80 mg/l to 640 mg/l.

Chemical oxygen demand (COD)

The chemical oxygen demand test (COD) determines, the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of domestic and industrial waste. The waste is measure in terms of equality of oxygen required for oxidation of organic matter to produce CO2 and water. It is a fact that all organic compounds with a few exceptions can be oxidizing agents under the acidic condition. COD test is useful in pinpointing toxic condition and presence of biological resistant substances. Importance of organic matter in the ecology of bloom, firming cynobacteria has also reported by many workers. In the present study the value of treated effluent range from 954 - 982 mg/l. Trivedi *et al.,* (1986) observed COD value of textile industry ranges from 300 ppm to 2400 ppm. Similar, high BOD_5 570 mg/l and COD 1486.8 mg/l loads were also reported by Vishakha (2013) for dairy industry of Vijaynagar, Maharashtra. High values of BOD_5 and COD obtained in present study are in accordance with earlier studies. Emmanuel (2002) recorded a mean BOD_5 value as high as 603 mg/l and mean COD value as high as 1223 mg/l. The discharge of wastewater to the environment without any treatment plays significant risk for public health and environmental pollution.

Chloride

Chlorides are generally present in natural water. The presence of chloride in natural water attributed to dissolution of salt deposits discharge of effluents from chemical industry's oil well operations, sewage discharges initiation drainage, contamination from refuse leachates, and sea water intrusion in coastal area. The chloride content in the river water has been investigated by Hancock (1973) working on Vionis river pointed the significance of chlorides and stated that for this principle source is animal matter, sewage and drainage from refuse and animal matter. Chloride values ranged from 230 ± 0.2 mg/l to 241± 1 mg/l in months of January and July'12 treated dairy waste water. Chloride concentration in waste water had a random change in the value due to gradual increase/decrease in concentration as well as change in quality of water in fluxed. Kolhe *et al.,* (2008) observed that the effluent from sugar mill is having 205 mg/lit untreated effluent chloride and the treated effluent was 170-180 mg/lit.

Sulphate

Sulphate is one of the major cation occurring in natural water. Sulphate being a stable, highly oxidized, soluble form of sulphur and which is generally present in natural surface and ground waters. Sulphate itself has never been a limiting factor in aquatic systems. The normal levels of sulphate are more than adequate to meet plants need. When water is over loaded with organic waste to point that oxygen is removed then sulphate as an electron acceptor is often used for breakdown of organic matter to produce H2S and produce rotton egg smell (Welch, 1980). In the present study the values of sulphate for treated effluent was 81 ± 0.2 mg/l to 74 ± 1 mg/l in months of January, July'12. Kolhe *et al.*, (2008) observed the sugar mill effluent was having sulphate of untreated effluent is 660 mg/l and treated effluent showed 220 mg/l.

Table.1 Observed values of physico-chemical parameters for dairy industrial effluent samples after ETP collected in month of January and July in year 2012

Dairy Effluent	**January**	**July**	**Standards**
COLOUR	Colourless	Colourless	-
Temperature (^{O}C)	27 ±2.08	31 ±1.53	Shall not exceed 5°C above the receiving water temp
Turbidity (NTU)	23 ± 1	20 ±0.06	-
TDS (ppt)	1.2 ± 0.25	1.28 ±0.25	-
Salinity (ppt)	1.4 ± 0.24	1.3 ±0.40	-
Conductivity (mS)	3.5 ±0.36	3 ±0.29	-
pH	6.8 ± 0.64	6 ±0.69	6.5- 8.5
BOD	320 ± 26.76	**355 ± 78.99**	350[1]/100[2]
COD	**954±86.18**	**982±67.57**	250[3]
Chlorides	230±0.2 mg/l	241 ± 1 mg/l	600
Sulphate	81±0.2 mg/l	74±1 mg/l	Not above 100
Oil and grease	1.9 ± 0.1 mg/l	2.3 ± 0.2 mg/l	10

*Values in **Bold** are exceeding the limits of General Indian Standards for Discharge of Environmental Pollutants IS: 10500.

For effluent discharge into inland surface waters BOD limit shall be made stricter to 30 mg/l by the concerned State Pollution Control Board

Oil and grease

The oil and grease content of domestic and certain industrial waste water and of sludge's is an important in handling and treatment of this material for ultimate disposal. Oil and grease may influence waste-water system, if present in excessive amount. They may interfere with an aerobic and anaerobic biological process and lead t decreased waste water treatment efficiency. Knowledge of quantity of oil and grease present in effluent is helpful in proper design and operation of waste water. Industrial wastes contain high quantity of oil and grease which may cause a serious problem if discharged into water body without treatment. In the present study oil and grease of treated effluent was 1.9 ± 0.1 mg/l in January and 2.3 ± 0.2 mg/l in July'12. Trivedi *et al.*, (1986) reported oil and grease in textile industry effluent varies from 230 to 1897 mg/l.

In conclusion, the study has provided information about the waste water quality status released by Dairy Industries. Waste water quality can be maintained within safe limits better handling of plant. In Jaipur dairy, after ETP treatment wastewater discharged is within permissible limits. Construction of Effluent treatment plant in dairy industries should be encouraged. Waste water from dairies and cheese industries contain mainly organic and biodegradable materials that can disrupt aquatic and terrestrial ecosystems, hence the importance of carrying out a whey treatment as a starting point in order to optimize a simple and economic method to treat the whole dairy effluent. Watery effluent discharged can be used for gardening purposes, while a proper and usable alternative should be researched for oily and greasy sludge discharged.

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