World Wide Journal of Multidisciplinary Research and Development

WWJMRD 2018; 4(1): 253-257
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
UGC Approved Journal
Impact Factor MJIF: 4.25
e-ISSN: 2454-6615

AjaySharma
Guru Kashi University,
Talwandi Sabo, India

Ashutosh Pathak
GuruKashiUniversity,
Talwandi Sabo, India

Correspondence:
AjaySharma
Guru Kashi University,
Talwandi Sabo, India

Dairy Industry and Sewage Wastewater & its Effects on Environment

AjaySharma, Ashutosh Pathak

Abstract
In this paper, it is shortly discussed that what are the units involved in the dairy industry, what processes are involved in it; the work done in these processes; from what processes we can obtain the wastewater and what are the sources of wastewater in these units and the effect of this wastewater on the environment. These industries discharge wastewater which is characterized by high chemical oxygen demand, biological oxygen demand, nutrients, and organic and inorganic contents. Such wastewaters, if discharged without proper treatment, severely pollute receiving water bodies and disrupts complete ecosystem. Moreover, the Indian government has imposed very strict rules and regulations for the effluent discharge to protect the environment. Thus, appropriate treatment methods are required so as to meet the effluent discharge standards.

Keywords: Dairy, Wastewater, processes, sources, effluent, characteristics, effect

Introduction
Milk
The milk is one of the most important commodity entering trades and it is required in everyday life as an article of food. Since the milk is highly perishable, basic public health and economic consideration is required that consumer should be provided with the product which is of good quality, pure, free from pathogenic bacteria. To maintain quality standard, quality control operation have to be performed at all the stages of production of milk which includes maintenances of sanitary conditions at milking place, storage, transportation and handling the milk at reception docks, processing and packing etc. till the milk is delivered to consumer. The rural areas were identified for milk production; the urban centers were collected for the location of milk processing plants and product manufacturing factories. As the rapid industrialization taking place all over the country, the number of dairies and allied industries are sharply rising. So it's necessary to know the processes involved in these industries; these processes are as given below

Dairy Technology (Milk Process Technique)
Milk treatment is the preparation of raw milk including heat treatment as a precondition for milk processing. The treatment of milk is done in the preparation room. It is a first process in any dairy plant. The milk processing is thequality oriented activity of manufacturing, packing of dairy based products on the basis of treated milk.

1.1.1 Product and process involved in dairy: Many dairies restrict themselves bottling pasteurized milk and making ghee from scoured milk. The dairy industry is characterized by the multitude of products and therefore production lines. Plants can have as few as one or two production lines or all of them (pasteurized milk, cheese, butter, etc.). In few dairies where supply of milk is larger, butter, condensed milk, powdered milk, ice cream, panner, shrikhand, milk powder, yoghurt, cheese etc. are also produced. However the production of skimmed and toned milk and cheese making has the increasing demand in India.

Milk Processes
A chain of operations involving receiving and storing of raw materials, processing of raw materials into finished products, packaging and storing of finished products, and a group of

other ancillary operations (e.g., heat transfer and cleaning) are examples of some of the great variety of operations performed in the dairy industries. The initial operations such as homogenization, standardization, clarification, separation, and pasteurization are common to most plants and products. Clarification (removal of suspended matter) and separation (removal of cream for milk standardization to desired butterfat content), generally, are accomplished by specially designed large centrifuges. Drying, condensing, etc. are also used in dairy industries for the production of various products. The details of operations involved are as given below, (Dr. A.S. Kolhe et al 2008-09)
Milk Receiving Station: The milk cans are unloaded at the receiving station and emptied into a receiving tank, after testing for fitness and freshness.
Pasteurization: Pasteurization is accomplished by heating either to 620C for 30 min. of at 710C for 15 seconds, followed by chilling to 40C. The milk is then bottled for distribution.
Cheese Making: Cheese is made from milk in which fat to protein ratio is adjusted when the proper degree of settling of curd has been reached, it is cut into pieces and after further adjustment to temperature, is then allowed to settle.
Butter, Butter Milk and Skim Milk: Milk is first passed through centrifugal machines to separate cream and skim milk. Cream is then churned until butter separates from the liquid and butter milk is left over. Ghee is prepared from the butter, sour milk is separated to remove fat and skim milk thus obtained is fed into large vats and treated with the acid to precipitate casein which is washed and dehydrated.
Products of milk-raw milk storage: Storage is an activity in which milk is kept between receptions and processing. Storage helps in balancing the different capacities and timings between reception and processing. The total volume of storage silos can be very different and can vary from 20 to 100% of the dairy reception volume, usually storage vessels are installed individually on the outside of the buildings, are made of stainless steel or fibre glass and may have avolume of 20,000 to 2,00,000 L. In the dairy industry, some amount of wastewater gets produced during starting, equilibrating, stopping, and rinsing of the processing units (flushing water, first rinse water, etc.). However, a majority of wastewater gets produced during cleaning operations, especially between products changes when different types of products are produced in a specific production unit and clean-up operations (Fig. 1). Figure 1 explains in detail the units involved in milk processing industries and shows the flowchart of effluent sources from various units. (Jai prakash Kushwaha et.al., 2011)

Characteristics of the Effluent

Dairy effluent contains soluble organics, suspended solids, trace organics. All these components contribute largely towards their high biological oxygen demand (BODS) and chemical oxygen demand (COD). Dairy wastes are white in colour and usually slightly alkaline in nature and become acidic quite rapidly due to the fermentation of milk sugar to lactic acid. The suspended matter content of milk waste is considerable mainly due to fine curd found in cheese waste. The pollution effect of dairy waste is attributed to the immediate and high oxygen demand. Decomposition of casein leading to the formation of heavy black sludge's and strong butyric acid odors and characterize milk waste pollution.
The characteristics of a dairy effluent contain Temperature, Color, PH (6.5-8.0), DO, BOD, COD, Dissolved solids, suspended solids, chlorides, sulphate, oil & grease. It depends largely on the quantity of milk processed and type of product manufactured. The waste water of dairy contains large quantities of milk constituents such as casein, inorganic salts, besides detergents and sanitizers used for washing. It has high sodium content from the use of caustic soda for cleaning. Typical Characteristics of dairy industry wastewaters reported by various authors are given in table1.

Effects of Effluents: Environmental Effects

The dairy industry is one of the most polluting of industries, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well. It generates about 0.2–10 liters of effluent per liter of processed milk with an average generation of about 2.5 liters of wastewater per liter of the milk processed. Dairy processing effluents are generated in an intermittent way and the flow rates of these effluents change significantly. The volume, concentration, and composition of the effluents arising in dairy industry are dependent on the type of product being processed, the production program, operating methods, design of the processing plant, the degree of water management being applied, and subsequently the amount of water being conserved. These dairy industries generate different types of waste including: wastewater from the production line (cleaning of equipment and pipes) cooling water, domestic wastewater,

Table. 1: Characteristics of dairy industry wastewaters (composition in mg/l, except pH)

Waste Type	COD	BOD	PH	TSS	TS	References
Milk & Dairy Products factory	10251.2	4840.6	8.34	5802.6		Oneţ Cristian,2010
Dairy effluent	1900-2700	1200-1800	7.2-8.8	500-740	900-1350	U. B. Deshannavar, et al 2012
Arab Dairy Factory	3383 ± 1345	1941± 864	7.9 ± 1.2	831 ± 392		A. Tawfik et. al,2007
Dairy waste water	2,500- 3,000	1,300-1,600	7.2-7.5	72,000-80,000	8,000-10,000	Javed Iqbal Qazi et. al,
Dairy effluent (CPCB 1993)	1120-3360	320-1750	5.6-8	28-1900		Kusum Lata, et. al, Biogas forum,1999
Whey	71526	20000	4.1	22050	56782	Deshpande D.P. et. al, 2012
Bhandara Co-operative dairy industry wastewater	1400 to 2500	800 to 1000	7.1-8.2	1045 to 1800	1100 to 1600	Monali Gotmare* et al.,2011
Cheese Whey pressed	80,000-90,000	120,000-135,000	6	8000-11000		Rana Kabbout, et al.,2011
Aavin dairy industry washwater	2500-3300		6.4 -7.1	630-730	1300-1400	Sathyamoorthy G.L, et al.,2012
Dairy industry wastewater	2100	1040	7-8	1200	2500	A. Arumugam

the acid whey and sweet. Due to this the quality and quantity of the product content in the dairy wastewater at a given time changes with the application of another technological cycle in the processing line. The sweet whey form the most polluting effluent by its biochemical composition rich in organic matter (lactose, protein, phosphorus, nitrates, nitrogen) and is from 60 to 80 times more polluting than domestic sewage.

The waste water of dairy contains large quantities of milk constituents such as casein, inorganic salts, besides detergents and sanitizers used for washing. All these components contribute largely towards their high biological oxygen demand (BODS) and chemical oxygen demand (COD). Which is much higher than the specified limits of Indian standard institute (ISI), now Bureau of Indian standard (BIS), for the discharge of industrial effluents; As these wastes are generally released to the nearby stream or land without any prior treatment are reported to cause serious pollution problems.

Dairy effluents decompose rapidly and deplete the dissolved oxygen level of the receiving streams immediately resulting in anaerobic conditions and release of strong foul odors due to nuisance conditions. The receiving water becomes breeding place for flies and mosquitoes carrying malaria and other dangerous diseases like dengue fever, yellow fever, chicken guniya. It is also reported that higher concentration of dairy wastes are toxic to certain varieties of fish and algae. The casein precipitation from waste which decomposes further into a highly odorous black sludge at certain dilutions the dairy waste is found to be toxic to fish also. Dairy effluent contains soluble organics, suspended solids, trace organics. They decrease do, promote release of gases, cause taste and odor, impart color or turbidity, promote eutrophication.

The main environmental problems related to milk production affect the pollution of water, air and biodiversity. They often cause a growth of algae and bacteria that consume oxygen in the water and eventually suffocate the rivers leading to the gradual disappearance of fish. Hence the need to treat dairy effluents by various processes.

Effects of effluents on water

The Organic Components: The organic components of the wastewater from dairy processing operations can be classified as proteins, lactose and fat. These will affect the environment in different ways depending on their biodegradability and their solubility.

River Oxygen Levels and BOD5

The concentration of oxygen in a river depends on both the rate at which oxygen is consumed by microorganisms and the rate of reaeration from the atmosphere. It is usual to perform a series of river surveys to obtain a best fit of the oxygen depletion / reaeration equations to the actual river conditions. Oxygen is very important in rivers, primarily because it supports fish and other aquatic organisms. The usual lower limit for oxygen concentrations in rivers is usually about 6 g/m3. This level is based on the ability of sensitive fish species (usually trout and salmon) to survive.

Fully aerated rivers at temperatures of 15 to 25oC contain oxygen concentrations of at least 8 g/m3. It is therefore essential that discharges to rivers maintain an oxygen concentration of at least 6 g/m3. In order for this to be the case the discharge to the river must not increase the river BOD5 by more than about 3 g m-3 (depending on the reaeration characteristics of the river).

Measures of the amount of oxygen that are consumed by bacteria are the Biochemical oxygen demand (BOD5) and the chemical oxygen demand (COD). BOD5 is measured as the amount of oxygen that is consumed by bacteria in decomposing the waste over a 5 day period at 20oC. The COD is measured by digesting the waste with boiling sulphuric acid and potassium dichromate in the presence of a catalyst, and the result is expressed as oxygen equivalents. In both cases the organic material is converted to carbon dioxide and water, but with the BOD5 test some of the organic matter is converted to new bacterial cells.

The organic components in dairy processing wastewater are highly biodegradable. In waterways, bacteria will consume the organic components of the waste. The process of biodegradation in waterways consumes oxygen according to the following equation: Organic Material + O2 → CO2 + H2O + Bacteria (J. W. Barnett et.al.)

Sewage Fungus: Low molecular weight organic compounds promote the growth of certain filamentous slimes in waterways. These bacterial colonies are collectively known as sewage fungus. The most common bacterial species in this category is Sphaerotilus natans. One of the major constituents of dairy factory wastewaters is lactose, a low molecular weight sugar that is known to promote sewage fungus growth. Sewage fungus growth has been related to lactose concentrations in rivers by the equation:

Growth/g/m2 = 0.333 + 2.479 m(lactose)/g/m3

and this equation can be used to predict the extent of sewage fungus growth in a receiving waterway.

Colour and Turbidity: Wastewaters that are highly coloured are likely to alter the colour of receiving water. Dairy factory wastes probably contain little soluble color, although after various forms of treatment true colour may result. Colloidal and particulate components in the waste reflect light back to an observer. This is known as apparent colour. The concept of turbidity is closely related to this phenomenon. Milk wastes contain significant quantities of material that will result in turbidity of discharges.

The Inorganic Components (Mainly Nitrogen and Phosphorus): One of the industry's main aims is to recover the protein (organic nitrogen component) of the waste and convert it to saleable products. Nitrogen is, therefore, a very important component of the dairy factory wastewaters. Some protein will be lost to the waste streams. Bacteria convert the nitrogen in proteins to the inorganic forms including ammonia, and the ammonium, nitrite and nitrate ions. Each of these inorganic forms of nitrogen has different environmental effects.

Nitrate ions are toxic in high concentrations to both humans and livestock. In young infants, nitrate can be converted to the nitrite form, absorbed into the bloodstream and convert haemoglobin to methaemoglobin. Methaemoglobin cannot transport oxygen. The condition of methaemoglobinaemia affects infants less than six months in age because they lack the necessary enzyme to reconvert the methaemoglobin back to haemoglobin. To protect humans the usual limit placed on drinking water supplies is 10 g m-3 of nitrate-nitrogen. Livestock can also suffer from methaemoglobinaemia. Since ruminants have a more neutral stomach pH and rumen bacteria that reduce nitrates

to nitrite, deaths from methaemoglobinaemia can occur. This usually results from the consumption of nitrate rich feed, although a limit of 30 g/m3 nitrate-nitrogen on drinking water for stock has been suggested.
Inorganic forms of nitrogen (nitrate, nitrite and ammonium ions) and inorganic phosphates act as plant nutrients in waterways. To protect receiving waters from undesirable growths it has been suggested that total inorganic nitrogen concentrations in receiving waters are limited to less than about 30-100 mg m-3 or that dissolved reactive phosphorus (inorganic phosphorus) concentrations are less than about 15-30 mg m-3.

Effects of effluents on land

Wastewater application to soils is a common method of waste treatment in the dairy industry. Nutrients (nitrogen and phosphorus): The major mechanisms for nutrient removal in soil based treatment systems are:

- plant uptake and incorporation in animal products
- adsorption and immobilization in the soil
- losses to the atmosphere
- losses to groundwater (leaching)

Plant uptake of nitrogen amounts to up to 500 kg ha-1 year -1. For phosphorus, the amount is about 30 kg of phosphorus. If animals subsequently consume the pasture, up to 90% of the nitrogen and phosphorus is recycled to the pasture.
Losses of nitrogen to the atmosphere occur through volatilization of ammonia from urine and dung patches, and through the process of denitrification. Denitrification is the process where microorganisms reduce nitrate to either nitrous oxide or dinitrogen gas. This occurs under anoxic conditions (i.e. a lack of oxygen) and when a suitable organic carbon supply is available for energy. Denitrification rates can be quite high at wastewater irrigation sites. Losses of nitrogen (principally in the nitrate form) to groundwater can occur at some irrigation sites depending on the amounts of nitrogen removed by other means. The factor usually limiting the disposal of nitrogen containing wastes to soils is nitrate contamination of ground waters that are subsequently used as water supplies for humans or stock. It is usual to apply normal drinking water guidelines under these circumstances. Phosphorus does not usually cause a problem by leaching to groundwater because of the high retention and immobilization of phosphates in soils.
Sodium and Other Minerals: Sodium, potassium, calcium and magnesium are all immobilized by soils and occupy cation exchange sites on soil colloids and clays.

Effects on the atmosphere

Gaseous Emissions: Manufacturing operations can result in a number of emissions to the atmosphere.
Boiler stacks result in emissions of carbon dioxide, sulphur oxides and nitrogen oxides to the atmosphere. Methane may be emitted from anaerobic waste treatment systems and nitrous oxide (N2O) is emitted from the soil at wastewater irrigation sites. Carbon dioxide, methane and nitrous oxide are very important greenhouse gases, and it is likely that the consequences of these emissions will need to be considered in the future.
Dust/Odours: Particulate materials can be emitted from boiler stacks, powder driers etc. Losses of particulate material may also occur from other factory processes. If particulate emissions are high then surrounding buildings are coated with dust and powder which, as well as being undesirable, can also be corrosive. Smoke and steam plumes from factories may also be regarded as a form of visual pollution. The emission of objectionable odours must be considered at industrial processing sites. Many waste treatment plants can produce undesirable odours.

Need to treat the Wastewater

Wastewater from dairies and cheese industries contain mainly organic and biodegradable materials that can disrupt aquatic and terrestrial ecosystems. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated wastewater cause serious environmental problems. 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. Moreover, the Indian government has imposed very strict rules and regulations for the effluent discharge to protect the environment (Table2).

Table. 2: Minimal standards for discharge of effluents from the dairy industry

Parameter	Maximum Value (mg/l)	
	World bank report	**CPCB, India**
pH	06-Sep	6.5-8.5
BOD_5	50	100 (based on BOD_5)
COD	250	-
Total Suspended Solids	50	150
Oil & Grease	10	10
Total Nitrogen	10	-
Total Phosphoruus	2	-
Temperature Increase	< = 3^0 C	-
Coliform Bacteria	400 Most Probable Number/100ml	-

Thus, appropriate treatment methods are required so as to meet the effluent discharge standards.
The wastewater treatment which does not give any monetary benefit to dairy industry owners they release it directly to nearby water streams or on land (i.e. in nature) by giving only some of the primary treatment; due to lack of awareness in this regard and lack of funds.
In my research work, I wish to minimize the cost of the treatment plant using coir as a media in a fixed film fixed bed reactor developing anaerobic digestion process which releases methane gas. To characterize the wastewater at various stages, I shall use the standard methods given by APHA.

Conclusion

If we devise such a method which reduces the cost of treatment and provide some of the byproduct, in line. The owners themselves think of applying the same in the industry, ultimately minimize the losses to be developed to the ecosystem which is helpful in protecting the environment. Thereby I propose of using coir as a media the cheapest and readily available material in a fixed film fixed bed reactor.

References

1. Jai prakash Kushwaha, Vimal Chandra srivastava, & Indra deo mall (2011), An Overview of various technologies for the Treatment of Dairy Wastewaters Critical Reviews in Food Science and Nutrition, 51:442–452.
2. A S. Kolhe, S. R. Ingale, Dr. R. V. Bhole (Nov-Jan 2009), Effluent of Dairy Technology Shodh, Samiksha aur Mulyankan (International Research Journal)—ISSN-0974-2832 Vol. II, Issue-5
3. J. W. Barnett, S. L. Robertson and J. M. Russell, Environment Portfolio, New Zealand Dairy Research Institute, Private Bag 11029, Palmerston North, Environmental Issues in Dairy Processing
4. Oneţ Cristian (2010), Characteristics of the untreated wastewater produced by food industry Analele Universităţii din Oradea, Vol. XV.
5. U. B. Deshannavar, Basavaraj. R. K and Nandini M. Naik (2012), High rate digestion of dairy industry effluent by upflow anaerobic fixed-bed reactor, Journal of Chemical and Pharmaceutical Research, 4(6):2895-2899
6. A Tawfika, M. Sobheyb, M. Badawya (2008) ,Treatment of a combined dairy and domestic wastewater in an up-flow anaerobic sludge blanket (UASB) reactor followed by activated sludge (AS system) Desalination 227, 167– 177
7. Javed Iqbal Qazi, Muhammad Nadeem, Shagufta S. Baig, Shahjahan Baig and Quratulain Syed (2011), Anaerobic Fixed Film Biotreatment of Dairy Wastewater Middle-East Journal of Scientific Research 8 (3): 590-593, 2011, ISSN 1990-9233,© IDOSI Publications.
8. Kusum Lata, Arun Kansal, Malini Balakrishnan, K V Rajeshwari and V V N Kishore (1998/99)Tata Energy Research Institute, Biogas Users Survey in Nepal, Evaluation of Biomethanation Potential of Selected Industrial Organic Effluents in India
9. Deshpande D.P., Patil P.J. and Anekar S.V. (April 2012), Biomethanation of Dairy Waste, Research Journal of Chemical Sciences, ISSN 2231-606X Vol. 2(4), 35-39.
10. Monali Gotmare, R.M.Dhoble, A.P.Pittule Biomethanation of Dairy Waste Water Through UASB at Mesophilic Temperature Range (IJAEST @ 2011, Vol.8 Issue 1, 001-009
11. Rana Kabbout, Moemen Baroudi, Fouad Dabboussi, Jalal Halwani, Samir Taha (2011), Characterization, Physicochemical and Biological Treatment of Sweet Whey (Major Pollutant in Dairy Effluent), 2011 International Conference on Biology, Environment and Chemistry IPCBEE vol.2 , IACSIT Press, Singapoore