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Assessment of toxicity in dairy waste: A Review

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Abstract: *Globally, the dairy sector is one of the most important sectors of the world. The milk processing industry is emerging during the last two decades due to enormous increase in the milk production and increase in demand for milk and milk products. The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization. The typical by-products of milk are buttermilk, whey, and their derivatives. The effluents are generated from milk processing through milk spillage, drippings, washing of cans, tankers bottles, utensil, and equipment's and floors. The dairy industry generate on an average 2.5-3.0 litres of wastewater per litre of milk processed. Generally this wastewater contains large quantities of fat, casein, lactose, and inorganic salts, besides detergents, sanitizers etc. used for washing. These all contribute largely towards their high biological oxygen demand (BOD), chemical oxygen demand (COD), oil and grease much higher than the permissible limits. Among the biological treatments trickling filter and activated sludge process involve more economy high power requirement, more chemical consumption and large area requirement. Use of a dairy wastewater for irrigation after primary treatment in an aerated may also be good for the disposal of dairy wastes. The waste water discharge form industries are major source of pollution and it affect the ecosystem. The degradation of environment results in adverse effect on living organism and agriculture. The present review focuses on the assessment of toxicity present in dairy waste and their characterization.*

Keywords: *Dairy waste, BOD, COD, toxicity, effluent.*

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I. Introduction

India has emerged as the largest milk producing country in the world with present level of annual milk production estimated as 94.5 million tonnes. It is estimated that about 2 % of the total milk processed is wasted into drains. Dairy waste waters are characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contain fats, nutrients, lactose, as well as detergents and sanitizing agents (Javed Iqbal Qazi *et al.*,2011). Dairy effluents decompose rapidly and deplete the dissolved oxygen level of the receiving streams immediately resulting in anaerobic conditions and release of strong foul odours 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 (Bharati *et al*., 2013). They decrease do, promote release of gases, cause taste and odour, impart colour or turbidity, promote eutrophication. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated wastewater cause serious environmental problems. (Tiwari, 1994). 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.

Characterization of dairy waste and Toxicity assessment:

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 (Muthusamy and Jayabalan, 2001). 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 (Tiwana, 1985). 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, 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. Detergents (Sodium hydroxide, Ethylene-diaminetetra-acetic acid) represent the biggest portion of chemicals used in dairies; it may be alkaline or acidic. Many Dairy industries have waste treatment facilities such as Effluent Treatment Plant (ETP). Outcome of Effluent Treatment Plant is sludge and scum, a huge problem occurs in disposal of such waste discharged from these industries. The high values of suspended solids and dissolved solids shows its high pollution potential. Discharge of such wastes into inland surface water will lead to depletion of oxygen in the water bodies, affecting aquatic life and creating unaesthetic anaerobic conditions. All these components contribute largely towards their high biological oxygen demand (BODS) and chemical oxygen demand (COD) (Marwaha *et al*., 2001). 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 impart color or turbidity, promote eutrophication. 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. Typical Characteristics of dairy industry wastewaters reported by various authors are given in table

Waste Type	**COD**	**BOD**	**PH**	**TSS**	**TS**	**REFERENCES**
Milk & Dairy Products factory	10251.2	4840.6	8.34	5802.6		Oneț 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*,2011
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 *et al* .,2008

Different categories of toxicity:

pH: - It is a term used to express the intensity of the acid or alkaline condition of a solution.It is a way of expressing the hydrogen-ion concentration or the hydrogen-ion activity. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline. The pH of untreated dairy effluent was between 4.5 to 9 and while in industry treated effluent it ranged from 7.0 to 8.5. Though the pH is alkaline in fresh conditions, the waste becomes acidic due to decomposition of lactose into lactic acid under anaerobic conditions and may cause corrosion of sewers (Joseph, 1995).

Colour and Turbidity*:* Wastewaters that are highly coloured are likely to alter the colour of receiving water. Dairy factory wastes probably contain little soluble colour, 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 (Bharati *et al.*,2013*).*

Oil and Grease- Dissolved or emulsified oil and grease is extracted from water by intimate contact with an extracting solvent. Some extractable, especially unsaturated fats and fatty acids oxidize readily; hence special precautions regarding temperature and solvent vapour displacement are included to minimize this effect. Organic solvents shaken with some samples may form an emulsion that is very difficult to break. This method includes a means for handling such emulsions. Analysis of dairy effluent from both sites showed the presence of oil and grease which was far below the permissible limits of CPCB (1995). Though oil and grease are found in negligible amount, its continuous discharge into an aquatic ecosystem could also destroy the nursery ground of a variety of fishes (Kumaraguru, 1995). Alkalinity was found to be high which is harmful to aquatic organism (Nemerow, 1978).

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 (Kolhe *et al*., 2009).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.

Sodium and Other Minerals*:* Sodium, potassium, calcium and magnesium are all immobilized by soils and occupy cation exchange sites on soil colloids and clays (Noorjahan *et al.* 2004).

BOD: BOD (Biochemical oxygen demand) is the pollution index of any water sample. One of the main factors influencing the estimation of BOD is the nature of microorganisms used as seeding material. In order to meet the variation in wastewater characteristics, one has to be specific in choosing the biological component that is the seeding material. Among the wastewater parameters, BOD is widely used as a primary indicator to gauge water pollution. BOD provides information about the amount of biodegradable substance present in wastewater (Nagarajan and Shasikumar, 2002).

The BOD_5 values of dairy wastewaters are often misleading since the normal seeding materials used for BOD_5 estimation are nonspecific bacteria that cannot biodegrade some of the nitrogenous compounds present in the effluent. Pepper et al. stated that the bioavailability of compounds in a given system is a very important factor determining the biodegradability of the system. Some of these compounds are refractory to biodegradation because of high molecular weight coupled with lesser bioavailability. The BOD analysis of dairy wastewater is problematic for many reasons; these include the heterogeneity of the samples at different times and nonspecific microorganism's present in general seeding material.

The aforementioned problems can be overcome by formulating a uniform microbial seed comprising selected bacterial isolates that are acclimatized to the dairy industrial wastewater. Further, these bacterial isolates must be specific for the biodegradation of the organic compounds present in dairy effluent(Singh *et.al*., 1998). Reproducible and reliable results may be obtained if a specifically designed formulated microbial consortium comprising selected bacterial strains is used as seed for the BOD_5 analysis. It is defined as the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The BOD test is widely used to determine the pollution strength of domestic and industrial wastes in terms of oxygen that they will require if discharged into natural water courses in which aerobic condition exist. It is not a precise quantitative test, although it is widely used as an indication of the organic quality of water. It is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 200C. The BOD is used for measuring the oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in waste water. In accordance with the work of Panneerselvam (1998) and Prabakar (1999) BOD levels of both untreated (260-490 mg/L) and industry treated (100-250 mg/L) dairy effluent surpassed the CPCB limit of 30 mg/L for effluent discharge into inland surface waters reflecting high organic load and pollution potential. Moreover the presence of organic matter will promote anaerobic processes leading to the accumulation of toxic compounds in water bodies.

COD: The COD test is widely used as a means of measuring the organic strength of effluents. This test allows measurement of waste of in terms of the total quantity of oxygen required for oxidation to CO2 and H2O. During the determination of COD, organic matter is converted to carbon dioxide and water regardless of the biological assimilability. The dichromate reflux method is preferred over procedures using other oxidants (e.g. potassium permanganate) because of its superior oxidizing ability, applicability to a wide variety of samples and ease of manipulation. The high levels of COD in both untreated and industry treated effluent which could render the aquatic body unsuitable for the existence of aquatic organism (Goel, 2000) due to the reduction in the dissolved oxygen content (Panneerselvam, 1998).

Total Suspended Solids (SS):- It refers to small solid particles which remain in suspension form in water as a colloid. It is used as one of the indicator of water quality. It is sometimes abbreviated TSS, but is not to be confused with settleable solids, which contribute to the blocking of sewer pipes. TSS levels in both untreated (20-700 mg/L) and industry treated (19-650mg/L) were found to be beyond the permissible limit (100 mg/L) of ISI (1979)for effluent discharge which could be due to various environmental factors, reducing the diversity of aquatic life and resulting in oxygen depletion(Thorat and Wagh (2000)

Heavy metals: Milk is an ideal source of macroelements such as Ca, K, P, in addition to microelements such as Mn, Cu, Fe, Se and Zn and even heavy metals can be found (Sikiric *et al.* 2003; Qin *et al*. 2009). The amount of metals in uncontaminated milk is minute, but their contents may be significantly altered through manufacturing and packaging as well as metals that may be contaminated from different cattle feeds and environment such as Pb, Cd, Cr, Ni and Co (Enb *et al*. 2009).

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