DAIRY WASTEWATER AND ITS POTENTIAL WASTE MANAGEMENT

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Abstract

Rapid urbanization, increase in population, industrialization generates a large amount of waste. Presently, waste management requires more attention as it is in critical situation. In recent days one of the most polluting industries in India is dairy industry. Due to the rise of milk demand, dairy industry has grown swiftly. An initiative has been taken to characterize the dairy wastewater. Study found the presence of high concentrations of chemical oxygen demand (COD), biochemical oxygen demand (BOD), fatty acids and inorganic pollutants in dairy wastewater. The FTIR spectra analysis showed the presence of C=O bond of protein (1625.96cm^{-1}), C-O polymer of carbohydrate (1547.60cm^{-1}–1242.61cm^{-1}) or C-O stretch of fatty acid (1092cm^{-1}), C-N stretch of amino acid in protein (1547.60cm^{-1}–1242.61cm^{-1}). Dairy wastewater contains fatty acids group which can be used for further production of biodiesel. Also, it contains many nutrients such as nitrogen and phosphorus compounds which can be reused in application of agricultural purposes. This study discusses on characterization of dairy wastewater and their impact on environment and the management of dairy waste.

Keywords: *dairy, extraction, management, reuse, waste*

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1.0 Introduction

The dairy processing industry is mainly associated with the large volume of wastewater generated from industry containing high levels of organics. The wastewater that contains high organic waste requires treatment before discharge, as they causes problem for environment. The generation of dairy wastewater is increasing day by day because the industry demand huge amount of water of its processing, which is about 8 times the total amount of milk [1], [2]. The dairy effluent contain both inorganic and organic pollutants, which affect the surrounding environment, human and aquatic life [3], [4]. The organic pollutant includes oil, fat, grease, protein, lactose, etc. whereas inorganic pollutant includes hydrogen peroxide, chlorine, quaternary ammonia compounds etc.

In spite of pollutant causes adverse effect to the environment, and hence can be utilized as resource for various valuable products such as lipid, carbohydrate, protein. For example, the extraction of lipid from dairy effluent can be used for production of biodiesel. In this regards, many studies [5], [6], [7] have been centered on lipids extraction from wastewater sludge for biodiesel production. Generally few studies utilized some biological agents and fresh dairy wastewater for extraction of lipids and some other utilized activated sludge obtained from effluent treatment plant to extract lipid from solvent extraction.

The pollution caused by petroleum-based diesel and limited fossil fuel, the interest for sustainable bio-resources has been expanding around the world. Many other sources for biodiesel have been started and used in different parts of country [8], [9]. The advantages of using biodiesel production over petroleum based diesel such as reduction in emission, non-toxic, biodegradability, superior lubrication [10]. The absence of sulphur, aromatic compounds of hydrocarbon, metals which enhance the property of non-toxic in biodiesel. But biodiesel is also called as fatty acid methyl ester (FAME) because it is an esterified fatty acid. The fatty acid esterification is done with the help of alcohol in presence of a base/acid/enzyme catalyst. Mainly lipids from animal fats and vegetable oil are the basic material for biodiesel production [11].

2.0 Experimental section

2.1 Source of dairy effluent

The raw effluents of dairy industry were obtained from OMFED, Bhubaneswar, Odisha. Samples were collected in bottles for characterization of various parameters and stored at 4^0c for further analysis. Different physicochemical parameters were analyzed such as pH, BOD, COD, TDS, TSS, TP, and Phosphate with appropriate reagent.

2.2 Preparation of sample and extraction

Dairy effluent and hexane was homogenized in the ratio 1:1 for 15min in separating funnel. For complete separation and clarification immiscible liquid was allowed to settle for 20min. The layers which contain organic were removed and same process was repeated for 5 times to extract maximum amount of lipids from dairy effluent. The organics were separated and then dried by using sodium sulphate. By the use of rotary evaporator hexane was allowed to evaporate. The final sample was kept on vacuum desiccator for 3days for complete dry.

2.3 Detail instrumentation

To analyze various compounds and their functional group FTIR technique was used. For detection of functional group present in raw effluent of dairy industry Fourier Transform Infrared spectrum was used (Shimadzu IR Prestige 21). The spectral data were observed in the range 4000 to 500 cm^{-1}. Nearly 4-5mg of extracted sample was used for analysis. Also to confirm the compounds NMR (Bruker, Avance III) was used. In this analysis extracted lipids with $CDCL_3$ was taken.

3.0 Result and discussion

3.1 Characterization of wastewater

The samples were characterized 6 times for different physicochemical properties. The standard [12] was followed for the analyses of different parameter. The dairy effluent pH is found to be acidic in nature i.e. 5.83(±0.57). It is may be due to decomposition of lactose to lactic acid under anaerobic condition. BOD and COD of dairy wastewater is also very high i.e. 730(±66.62) mg/l, 900(±76.94) mg/l. The presence of TSS, TDS in effluent is summarized in table 1. Dairy wastewater also contain protein, amino acid, nutrients, all these also may increase the concentration of BOD, COD in wastewater. Table1 shows the presence of acids in dairy effluent. The high COD and BOD along with acidic pH confirm acid presence in wastewater. Total nitrogen is an essential compound which helps in the recovery process of protein as it is a polymer of amino acid containing nitrogen. The presence of phosphorus in wastewater increases the risk of eutrophication in water bodies.

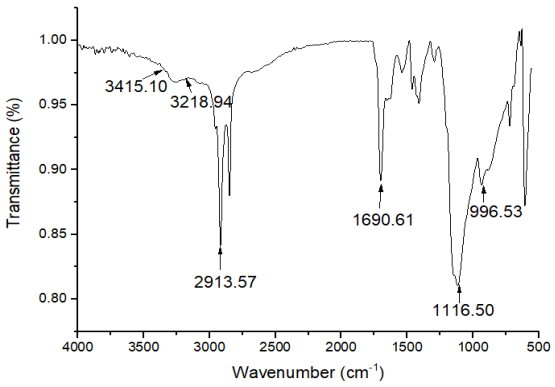
Table I: Characterization of dairy effluent

Sl.no.	Parameter	Average concentration	Tolerance limit IS:2490 Inland surface water
1	pH	5.83(±0.57)	5.5-9
2	TSS(mg/l)	1344(±20.93)	100
3	TDS(mg/l)	984(±43.20)	2100
4	BOD(mg/l)	730(±66.62)	30
5	COD(mg/l)	900(±76.94)	250
6	Turbidity (NTU)	97(±8.68)	-
7	TP(mg/l)	30(±1.41)	-
8	TN(mg/l)	83(±1.44)	100
9	Phosphate(mg/l)	37(±1.32)	-
10	Protein (mg/l)	1562(±65.85)	-

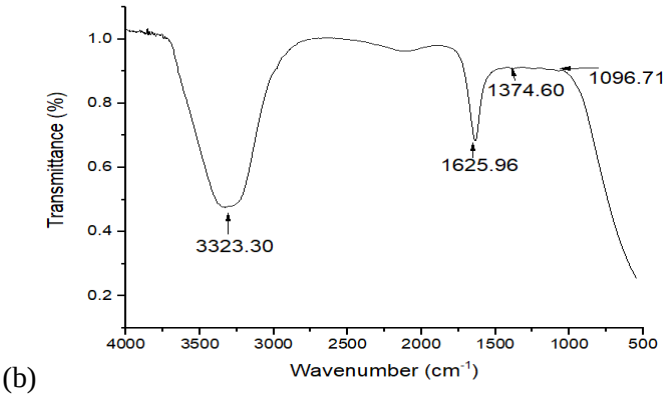
3.2 Spectral analysis

3.2.1 FTIR analysis

The dairy effluent contains dissolved solid and suspended solid, organic and inorganic components, lactose, fats, nutrients etc. It can be used as raw material in manufacturing different material such as such as feed for animal, biomedicine, bioplastic, biofuel. The presence of lipids, proteins, fatty acids, carbohydrate has been identified by FTIR technique as summarized in figure 1.



(a)



(b)

Figure1: (a) FT IR spectra of extracted solid sample and (b) raw liquid sample of dairy wastewater

The broad peak found between 3415.10-3218.94cm^{-1} which signifies the presence of lipid, protein, carbohydrate in wastewater. Also the peak signifies the presence of stretching vibration of –OH, -NH, -NH_2. The stretching of –OH is may be due to water or presence of carbohydrate in dairy effluent. The stretching vibration of –NH may be due to peptide bond of protein [13]. The strong peak of 2913.57cm^{-1} is due to C-H group in wastewater as carbon chain of fats, carbohydrate and protein. The peak of 1690.61cm^{-1} -1625.96cm^{-1} attribute the bond of protein (-CO-NH) i.e. peptide (C=O). The band at 1116.50cm^{-1} represents either C-O bond in fatty acid [14] or C-N of protein as amino acid 1547.60cm^{-1}–1242.61cm^{-1} [15]or 1547.60cm^{-1}–1242.61cm^{-1} C-O bond in carbohydrate as polymer linkage [16]. The peak of 1092cm^{-}1-996.53cm^{-1} signifies the stretching vibration of C-O bond in glycerol. This provides confirmation about the presence of fats and fatty acid in dairy wastewater [17].

3.2.2 NMR analysis

^{1}H NMR spectra does not provide confirmation of presence of compound in wastewater, but it gives the skeleton structure of carbon in organic compound present in dairy effluent. The lipophilic compounds were analyzed in NMR using $CDCL_3$ as shown in figure 2.

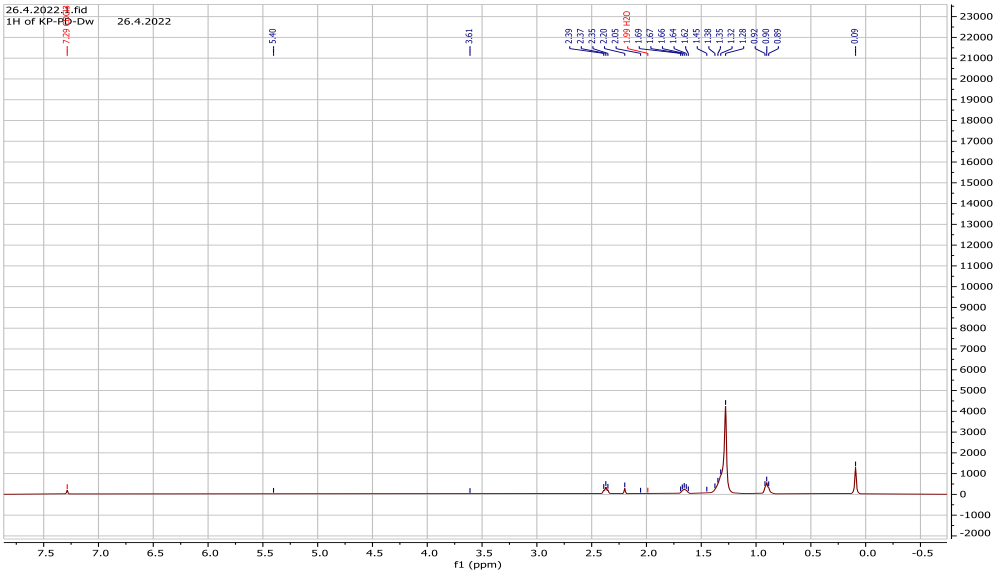


Figure 2: ^{1}H NMR of extracted sample with $CDCL_3$

The extracted lipid from dairy wastewater using hexane was analyzed on NMR spectra. It contain compounds such as aromatic (7.285ppm), it may be due to presence of some detergent e.g. n-alkyl dimethyl benzyl

ammonium chloride, which is a surface active element in dairy wastewater [18], [19]. Also oxidized fats are confirmed in the range (5.402-5.291ppm).

4.0 Conclusion

Biodiesel has many merits over petroleum-based diesel such as toxicity, biodegradability, chemical emission etc. The conversion of lipid to biodiesel is viable commercially. However the lipid cost specially from vegetable or animal source does not allow the conversion process to biodiesel. The best and economic method in dairy wastewater or sludge (solid) from municipal treatment plant. As per literature, the extraction of lipid by solvent extraction method is high as compared to lipid in sludge. By NMR and FTIR analysis presence of protein, lipid, different organic acid, carbohydrate is confirmed. Therefore dairy wastewater can be used for the conversion of lipid to biodiesel. Hence, further research should be done on the quantification of fatty acid for production of biodiesel.

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