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Pollution Parameter Investigation of Waste Effluents of DDC and Kamdhenu Dairy Industries of Nepal

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ABSTRACT
The organic pollutants released from the milk processing units in dairy industries are considered a major source of environmental pollution which creates havoc in the human flora of the world. The dairy wastewater is rich in organic nutrients, fats and oils which becomes an appropriate medium for the growth of several microorganisms. So the direct discharge of dairy wastewater on the agricultural land and in drinking water streams is most problematic and is one of the major issues of global environmental pollution, gripping earth day by day. A huge volume of water is needed in the milk processing system in dairy industries and its release without proper treatment has a serious effect in the surrounding environment. The present study aims to describe the analysis of various physicochemical parameters like color, temperature, pH, DO, TDS, DS, TS, BOD, COD, chloride, turbidity, acidity, alkalinity and oil and grease content of the dairy wastewater of two different dairy industries located at the eastern part of Nepal. The study revealed slightly alkaline nature of the dairy effluents. The pollution indicator parameters are above of normal range and this research strongly recommends installing of the proper waste water treatment systems to reduce pollution level.

Keywords: *Dairy effluent, BOD, COD, DO, alkalinity*

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I. INTRODUCTION

Nepal is one of the least developed country ranking 18th position in the world. It lies in Asia continent with latitude and longitude, 27.9389° N and 84.9408° E respectively. Rapid population growth is the main cause of increasing poverty, unemployment and scarce of natural resources in Nepal. Here the vast majority of the population depends on natural resources. However, most of the resources are over-exploited. This causes environmental deprivation in the way of unplanned industrialization, vehicular pollution, deforestation, and unsustainable agriculture practices [1]. They offer the alteration of physical, chemical, and biological properties of air, water, and soil which is harmful to public health, livestock, wildlife, fish, and another biodiversity [2]. A dairy is a business enterprise established for the harvesting of animal milk mostly from cow and buffalo for human consumption. Most of the dairy plants in the government, cooperatives, and private sector produce almost similar dairy products like varieties of milk, butter, ghee, skimmed milk powder and whole milk powder [3]. Dairy waste water is released into the environment and is hazardous to human flora and fauna. It has high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contains fats, nutrients, lactose, detergents, sanitizing agents as well as milk constituents such as casein, lactose, fat and inorganic salts. A variety of liquids, gaseous and solid wastes are being generated from industries and disposed of directly without any treatment [4], [5]. The dairy industry is one of the most polluting industries, not in terms of volume of effluents generated, but also in terms of characteristics as well. In the dairy industry, some amount of wastewater gets produced during starting, equilibrating, stopping, and rinsing of the processing units [6]. However, a majority of wastewater get produced during the cleaning operation, especially between products changes when different types of products are produced in specific production unit and clean-up operations.

Due to highly biodegradable nature of dairy wastewater, its treatment requires urgent attention but such treatment is not a big issue. Biological treatment technologies can readily treat the dairy wastewater [7]. The final effluent can be readily used for irrigation and the sludge itself becomes a good fertilizer. If waste is disposed on water bodies, BOD becomes the major concern. It may lead to anaerobic conditions and related problems. In the present research work, the effluents of two dairy industries located at the eastern part of Nepal have focused to analyze their various physicochemical parameters and their impacts on the agriculture land that ultimately pollute the environment.

II. EXPERIMENTAL SECTION

Materials and Methods

Study Area

The study was conducted by sampling of the effluents from two dairy industries (Dairy Development Corporation (DDC), Biratnagar and Kamadhenu, Tarahara) outlet. Two samples from DDC and one sample from Kamadhenu dairy were taken for the study.

III. SAMPLE COLLECTION

The wastewater samples were collected from the outlets of dairy industries for physicochemical parameters test. The sample was collected in 1000 ml plastic bottles. Two samples were collected from two different sites of DDC, Biratnagar and one sample was collected from Kamdhenu dairy, Tarahara. Each bottle was rinsed three times with the appropriate amount of sample before final sample collection.

Table 1: Sampling sites with sample code in detail.

Sample ID	Sample Code	Sampling point details
1.	S_A	Outlet of DDC, Biratnagar
2.	S_B	Drain of DDC, Biratnagar
3.	S_C	Outlet of Kamdhenu Dairy, Tarhara

To provide necessary information about each sample, date of collection, location etc. were recorded in the note book and each sample collected in a plastic bottle was labeled separately with a unique identification number. Collected dairy effluents were analyzed for physicochemical characteristics. Effluent samples were then filtered through filter paper to remove undesirable solid and suspended materials. In the laboratory, the bottles were stored in a clean, cool, dark and dry place. The sampling point details are summarized in the Table 1.

Physico-chemical Measurements

All the chemicals used for the preparation of reagents and solvents were of the highest purity analytical reagent grade available. Triple distilled water was used throughout the analysis work. NPK analysis and soil texture were performed in the Regional Soil Test Laboratory, Sunsari, Nepal and remaining other parameters were analyzed in the Bio-inorganic and Materials Chemistry Research Laboratory of Mahendra Morang Adarsha Multiple Campus Biratnagar, Nepal. The investigated physico-chemical parameters of all the samples are reported in the Table 2.

IV. RESULTS AND DISCUSSION

4.1 Temperature

Surface water temperature has great influence on the aquatic environment. Temperature affects physical, chemical and biological processes in the water system. Temperature is known to influence the pH and alkalinity as well. The temperature has been found varying from 28°C to 32°C during sampling.

4.2 Color and Odor

At first, the color and odor of dairy effluents were observed visually. The observed color was champagne. Therefore, the waste water is totally unsuitable not only for aquaculture but also for agricultural purposes. The odor is an important physical parameter for determining the quality of effluent water. The investigation was found bad organic odor. The water at the dumping site emits noxious smell which ensures the significant pollution in water and dangerous for the survival of aquatic ecosystem and human health.

Table 2: physicochemical parameter of different dairy industry effluents

No.	Study Parameters	Dairy Development Corporation (DDC) Biratnagar		Kamdhenu Dairy, Tarahara
		S_A	S_B	S_C
1	pH	7.59	7.78	7.55
2	Conductivity	0.929 mS/cm	0.668 mS/cm	0.370 mS/cm
3	Temperature	28 ℃	31℃	32 ℃
4	Color	Champagne	Champagne	Champagne
5	Acidity	30 ppm	40 ppm	40 ppm
6	Alkalinity	50 ppm	48 ppm	45 ppm
7	Total solid	480 ppm	760 ppm	618 ppm
8	Dissolved solid	80 ppm	280 ppm	280 ppm
9	COD	91.2 ppm	84.8 ppm	46.4 ppm
10	DO	6.4 ppm	6.2 ppm	5 ppm
11	BOD	5.8 ppm	5.4 ppm	4.4 ppm
12	Chlorine	0	0	0
13	Oil and grease	81 ppm	38 ppm	19 ppm
14	Turbidity	414 NTU	89 NTU	165 NTU

4.3 Electrical conductivity (EC)

Electrical Conductivity is a measure of how much total salt is present in the water. More the ions present, higher will be the conductivity. Conductivity is linked directly to the total dissolved solids (T.D.S.) [8], [9].The electrical conductivity of dairy effluent was observed in the range of (0.370-0.929) mS/cm. The electrical conductivity of effluents of the samples S_A and S_B was 0.929 mS/cm and 0.688 mS/cm respectively. The electrical conductivity of the sample S_C was found 0.370 mS/cm. These data suggest that the Effluent of DDC Biratnagar contained more dissolved solid than that of Kamdhenu dairy, Tarahara (Figure 1a).

4.4 pH

pH is a measure of the acid balance of a solution. The pH of water affects the solubility of many toxic and nutritive chemicals. The pH of natural water bodies varies around 7, generally more than 7 (alkaline) due to the presence of carbonate. It increases during day time due to photosynthesis whereas decreases at night time due to respiration activity but it also depends upon many factors like air, temperature, disposal of waste. In this study, pH has been found varying from 7.55 to 7.78 (Table 1). It also has a key role in determining the speciation of metals in the system. Higher pH tends to precipitate the ionic species of heavy metals to the sediment [10], [11].

4.5 Turbidity

Turbidity affects aquatic life by interfering sunlight penetration. Water plants need light for photosynthesis. If suspended particles block out light, photosynthesis and the production of oxygen for fish and aquatic life will be reduced. If light levels get too low, photosynthesis may stop altogether and algae will die [12]. Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matters, plankton, and other microscopic organisms. In the present study, the turbidity values were measured 414 and 89 NTU for the samples S_A and S_B respectively and 165 NTU for the sample S_C. The high value of turbidity is probably due to the presence organic particulate matter in the effluents from this industry [13].

4.6 Acidity

Acidity in wastewater indicates its corrosive properties and can take a leading role in regulating biological processes as well as in chemical reactions. The acidity of dairy effluent is due to the CO_2 content. The mineral acidity of waste water of our study was observed as nil. In the present study, the acidity values were measured 30 and 40 ppm for the sample of S_A and S_B respectively and 40 ppm for the sample S_C.

4.7 Alkalinity

Phenolphthalein alkalinity was estimated nil and hence the value of total alkalinity was similar to the methyl orange alkalinity determined. Total alkalinity values have found varying in mg $CaCO_3$/L in wastewater. The carbonate and hydroxide alkalinity was calculated zero and the value of Bicarbonate alkalinity was similar to the total alkalinity value. The alkalinity values were measured 50 and 48 ppm for the samples S_A and S_B respectively and 45 ppm for the sample S_C (Figure 1b).

4.8 Total Solid

Total solid is the suspended solid materials, including organic and inorganic in the water sample. Total suspended solids play a major role in water and waste water treatment. High concentrations of suspended solids can lower water quality by absorbing light, hence causes depletion of oxygen level in the water sample. In the present study, the total solid values were measured 480 and 760 ppm for the samples S_A and S_B respectively and 618 ppm for the sample S_C.

4.9 Dissolved solid

The total solid concentration in the waste effluent represents the colloidal form and dissolved species. The probable reasons for the fluctuation of the value of total solid and subsequently, the value of dissolved solids are due to the collision of these colloidal particles. The rate of collision of aggregated process is also influenced by pH of these effluents. In the present study, the dissolved solid values were measured 30 and 40 ppm for the samples S_A and S_B respectively and 40 ppm for the sample S_C.

4.10 Oil and Grease

The effluent has the oil and grease present in the form of micro droplets or tiny suspended particles. In the present investigation, the oil and grease contents of the samples were found in the range of 19 ppm to 81 ppm. The dairy effluent of S_A contained 81 ppm, S_B contained 38 ppm and effluent of S_C contained 19 ppm of oil and grease.

4.11 Chlorine

Chlorides are generally present in natural water. The presence of chloride in the natural water can be attributed to dissolution of salts deposits, discharged from the chemical industries. In the present study, the value of chlorine content in all the dairy effluent samples was measured nil.

4.12 Chemical Oxygen Demand

The COD is widely used as a measure of the susceptibility of oxidation of organic and inorganic matter present in water bodies. The concentrations of

COD observed in surface waters is about 20 mg/L or less in unpolluted waters. In the present study, the chemical oxygen demand values were measured 91.2 and 84.8 ppm for the sample S_A and S_B respectively and 46.4 ppm for the sample S_C (Figure 1c).

4.13 Dissolved Oxygen

The amount of dissolved oxygen (DO) concentration of water points the degree of organic pollution. Oxygen content is essential to all forms of aquatic life. The higher water temperature lowers the solubility of oxygen in water [14]. In the present study, the dissolved oxygen values were measured 6.4 and 6.2 ppm for the samples S_A and S_B respectively and 5 ppm for the sample S_C.

4.14 Biological Oxygen Demand

BOD is defined as the amount of oxygen required by microorganism while stabilizing biological decomposable organic matter in waste aerobic conditions. The biological oxidation is a very slow process that occurs during the microbial oxidation of organic pollutants, using dissolved oxygen [15]. Hence lowering in dissolved oxygen value is the measure of BOD**.** In the present study, the BOD values were measured 5.8 and 5.4 ppm for the samples S_A and S_B respectively and 4.4 ppm for the sample S_C (Figure 1d).

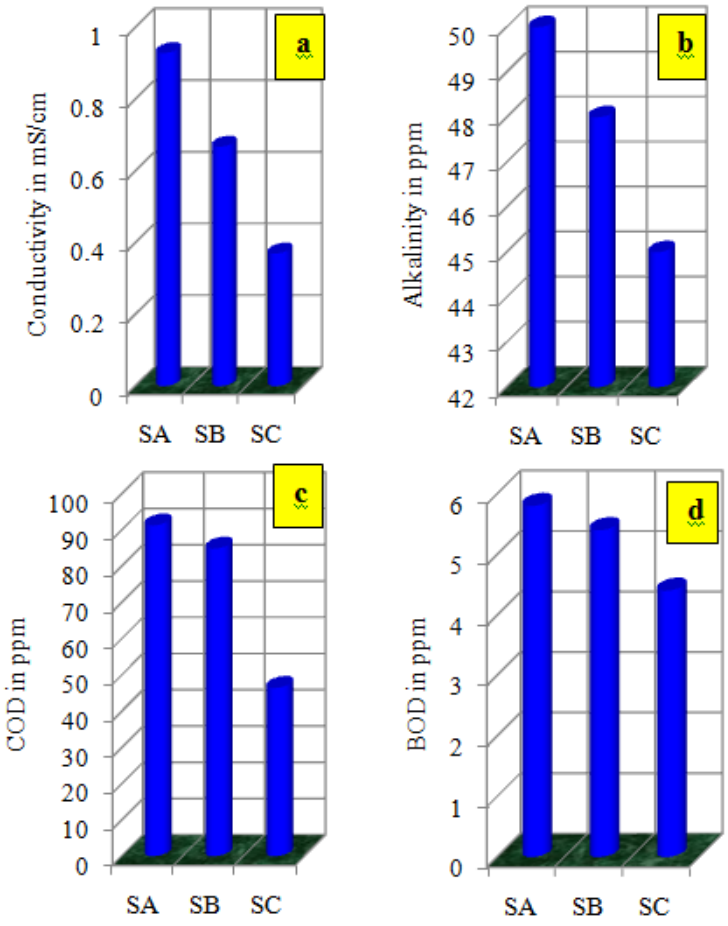

Figure 1: Bar graph illustrating (a) conductivity (b) alkalinity (c) COD & (d) BOD

V. CONCLUSION

The objective of this study was to investigate the main pollution parameters of dairy effluents. The waste water samples were tested for BOD, COD, DO, chloride, oil and grease, TS (Total solid), dissolved solid, turbidity, acidity, alkalinity, conductivity, and pH values. The results have shown the high pollution parameter levels of wastewater samples of dairy industry. Although the values in some cases were lower than the maximum allowable limits, the effluent discharge by DDC contained more oil and grease, turbidity, conductivity and COD than the effluent of Kamdhenu dairy. Thus, the comparative concentration of physicochemical parameter of effluents of DDC was found higher than effluents of Kamdhenu dairy. Overall, the study has shown that the effluents from dairy industries have a big impact on the water quality of the receiving

streams. To avoid the environmental pollution and to protect public health, waste water treatment systems are recommended for dairy industry. It is therefore recommended that careless disposal of the wastes should be discouraged and there is a need for the dairy industry to install a waste treatment plant with a view to treat wastes before being discharged into the streams.

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