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# Changes in water quality of Simle Khola by discharging dairy effluent from Sitaram Gokul Milk Industry inside Kathmandu Valley

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## ABSTRACT

Dairy industries convert raw milk into safe products for human consumption. Cleaning of all pipelines, equipments, machines, Cans; startup, products change, overhead shutdown, pasteurizers and loss in filling operations contribute wastewater generation in dairy industry. So the composition of waste water involves a substantial concentration of fat, milk, protein, lactose, lactic acid, minerals, detergents and sanitizers. The prime objective of this study is to analyze effects of such effluent on stream water discharging directly into it. The study has conducted on a stream which has been receiving dairy effluent from Sita Ram Gokul Milk Industry for years. Water samples at 200 m upstream from discharge point, at discharge point and 200 m downstream were collected in July of 2005, 2007, 2009 and 2011 A.D. All water quality parameters were negatively affected due to discharge of effluent. DO has depleted severely from its original concentration of 6 mg/l to 1 mg/l. BOD values i.e. 214 mg/l to 220 mg/l have in far more elevated level than national standard. COD, Nitrates and phosphates concentration are also in elevated level.

**Keywords**: Dairy industry, discharge, dilution, effluent, pollutants

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## INTRODUCTION

Dairy technology has been defined as that branch of diary science which deals with processing of milk and the manufacture of milk products on industrial scale. The dairy sector converts raw milk into safe products for human consumption. Products range from pasteurized and ultra-high temperature processing (UHT) milk to value-added dairy products such as yoghurt, butter and cheese. In the past, liquid milk and fresh dairy product plants tended to be located in or near urban centers. The modern trend is for plants to be situated close to the raw milk supply, especially those producing long life products (e.g. UHT, cheese, and milk powders). The current trend toward large processing plants has provided companies with more automated and efficient equipment. This development tends to increase the environmental impact in some areas, mainly due to high concentration of waste.

At present, pollution caused by industrial and dairy effluents has been a serious concern throughout the world (Braio and Granhem 2007). 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 (Vourch et al. 2008 cited in Kushwaha et al. 2011) with an average generation of about 2.5 liters of wastewater per liter of the milk processed (Ramasamy et al. 2004 cited in Kushwaha et al. 2011). Waste waters from dairy processing plants contain milk and milk product residues, as well as some additives from the specific dairy products and cleaning agents. They generally comprise high concentrations of organic materials such as proteins, carbohydrates and lipids, high concentrations of suspended solids, high Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), high nitrogen concentrations, high suspended oil and/or grease contents, and large variations in pH (Britz et al. 2004).

The unavoidable waste generation processes in dairy industry include washing, cleaning of all pipelines, pumps, equipment, tanks, filling machines, milk cans, bottles and floor; startup, products change, overhead shutdown, pasteurizers and loss in filling operations. So the composition of waste water involves a substantial concentration of fat, milk, protein, lactose, lactic acid, minerals, detergents and sanitizers. However, the degree varies depending upon the products and the home keeping practices. The majority of the pollutants are dissolved in either organic or inorganic form. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated wastewater cause serious environmental problems

(Montuelle et al. 1992). Thus the dairy effluent cannot be added to a water body without harm since they use up too much of oxygen in water.

A well-planned good management practice is needed to discourage the discharge of raw as well as partially treated effluent from dairy industry. Discharge of raw sewage and industrial effluents into the streams are not allowed in developed countries. Monitoring of treatment plants and effluent discharging has been taken as regular program. Even monitoring of farm dairy effluent as well as dairy factory effluent discharge has initiated in 1960s in developed part of the world. Initially such effluents were used to irrigate agricultural lands to remove direct discharge into the stream. When nitrate level in groundwater increased such effluent started to apply to grazed pasture. Later the factories started reducing amount of nitrogen containing acid use for cleaning in factory. Denitrifying trenches were developed to lower high nitrate levels flowing into the neighboring streams in 1990s(http://www.waikatoregion.govt.nz/Environment). These all monitoring system and processes are enriched by intensive scientific researches.

There are even very few researches on sewage and industrial effluent discharge into the river system in Nepal. Available (few) such researches are also ignorant to the dairy factory effluent because there are industries such as paper and pulp, tannery, soap, carpet, distillery, pharmaceuticals and others contributing heavy pollution to rivers (Green et al. 2003).

There is a standard developed by government of Nepal for the disposal of dairy waste into the surface water (MoEnv 2003). Almost all dairy industries in the country, however, have been discharging effluent into the nearby streams/rivers either treating, which do not meet the government set standard, or in its raw condition.

In this circumference, this study was designed to analyze the effect of dairy effluent to the water quality of the stream in suburb part of the Kathmandu Valley with a major objective of finding the changes in water quality in Simley Khola by the discharge of dairy effluent from Sita Ram Gokul Milk industry.

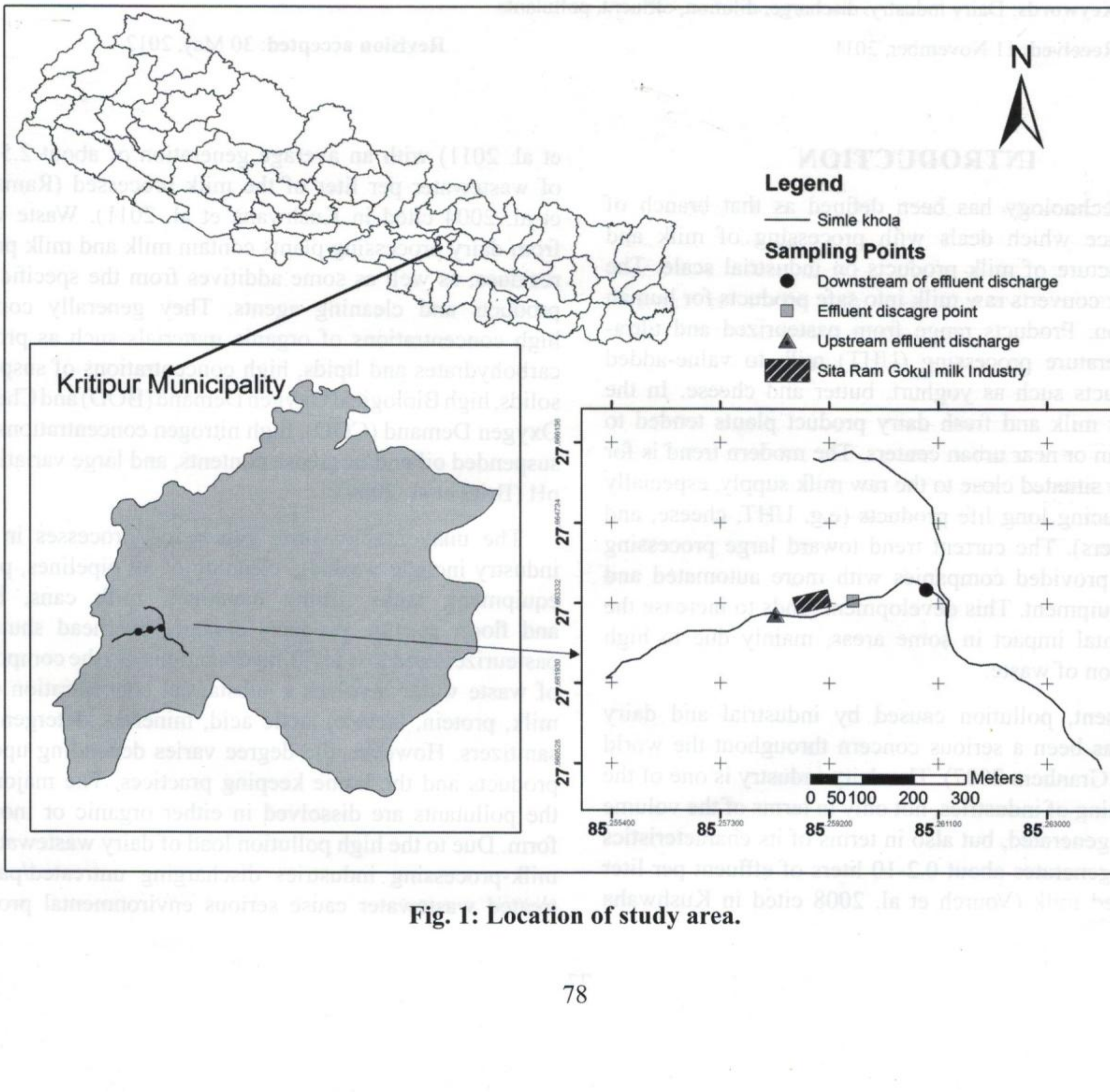


**Fig. 1: Location of study area.**

## METHODOLOGY

### Study area

Sita Ram Gokul Milk Kathmandu Limited located at ward no. 4, Kirtipur near Dudhpokhari (famous for water resources during Rana regime) named after water tastes like milk (Fig. 1).

This industry is near from Kathmandu. It was established in 2052 B.C. It has actual capacity of 35,000 Lt/day. It provides milk and various other milk products (Ghee, Yogurt, Butter, Peda etc.) by collecting raw milk mainly from Chitwan, Nawalparasi, Kavre and Rupendehi districts of Nepal. Its major market is Kathmandu city.

**Fig. 2: Oxidation pond of wastewater from Sita Ram Dairy Industry.**

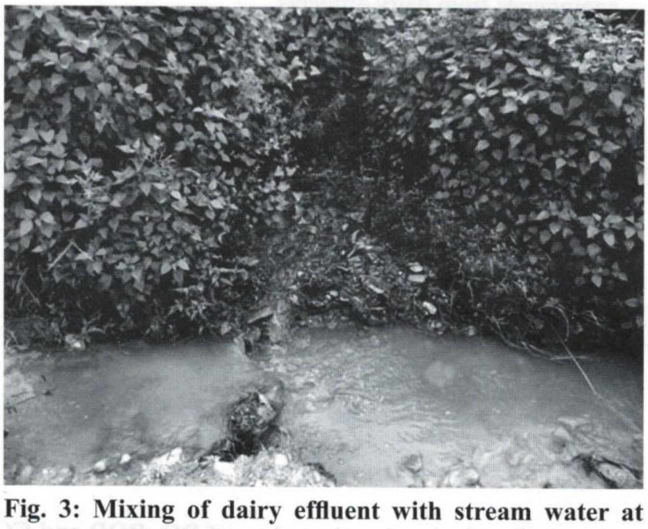

**Fig. 3: Mixing of dairy effluent with stream water at Champadevi, Kirtipur.**

It has occupied 20% of total dairy market share. It has an oxidation pond (Fig. 2) to pool the waste water before discharging into the stream. The study sites are along Simley Khola which is a small stream running from nearby southern hillock towards northeast from Kirtipur. It collects wastewater from Sita Ram Milk industry at Champadevi, Kirtipur (Fig. 3).

### Sample collection

Physicochemical parameters (temperature, pH, conductivity, hardness, alkalinity, chlorides, dissolved oxygen (DO), BOD, COD, nitrate and phosphate) were analyzed in this study. Water samples were collected from three different points from the stream, i.e., 200 m up and down from effluent discharge point and at the effluent mixing site of the stream in separate clean plastic bottles. The samples were collected in July 2005, 2007, 2009 and 2011. All samples were collected in the morning time.

### Laboratory analysis

Physicochemical parameters such as temperature and pH were recorded in the field (by using mercury thermometer and glass electrode pH meter) and other parameters such as Conductivity (conductivity meter), Hardness (EDTA titration), Alkalinity (titration), and Chlorides (potentiometric titration); DO (Winkler's iodometric titration), BOD (5 days incubation at $20^0$C), COD (Potassium dichromate closed refluxing), Nitrate (Colorimetric method) and Phosphate (Colorimetric method) were analyzed in the laboratory (APHA 1998; Trivedy and Goel 1984).

## RESULTS AND DISCUSSION

### Temperature

The value of temperature was higher (13.6-16.2)°C at the discharge point in every sample in comparison to the samples before (12.5-15.0)°C and after discharge (13.3-15.6) °C of effluents (Table1, Fig. 4). There is no national standard for temperature limit of dairy effluent to be discharge into river. However, the values obtained are far below (45°C) the temperature limit for industrial effluents to be discharged into the public sewerage network (MoEnv 2003).

### pH

The pH value indicates whether the water is acidic or alkaline. The wide variation in the pH value of effluent can

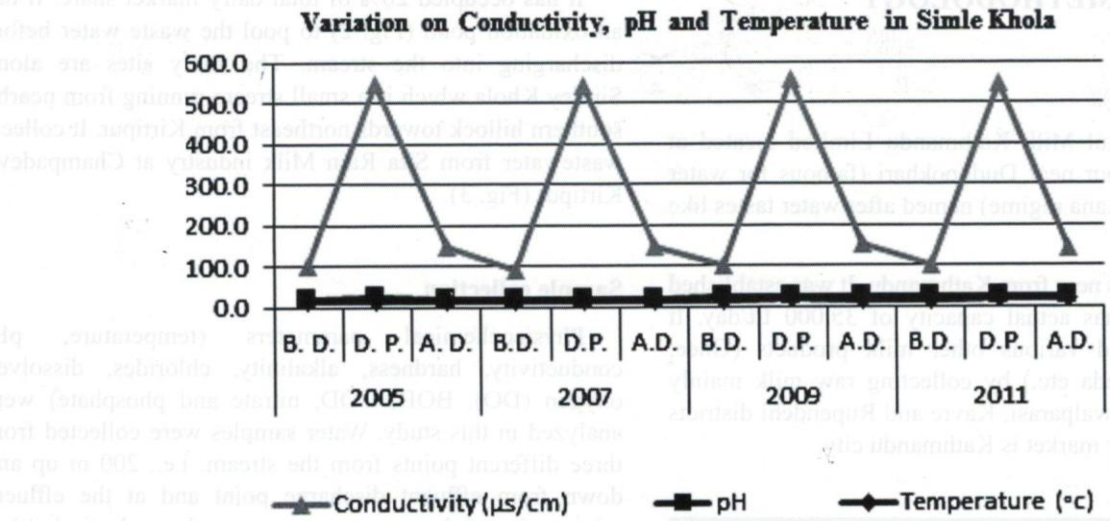


**Fig. 4: Graph showing variation in Temperature, pH and Conductivity in different sites.**

affect the rate of biological reaction and survival of various microorganisms. The pH values of all sites in all years of this study are within the range of standard for dairy industry set by Ministry of Environment (2003), i.e., 5.5 to 8.5. which is also somehow within the range (4.7-11) recorded by Passeggi et al. (2009) (Table 1).

### Conductivity

Conductivity value is high at the discharge point (519-525) µs/cm in all years relative to the sites before discharging and after dilution of the effluent (Fig. 4). This might be due to the higher amount of dissolved solids generated from Milk Industry since conductivity is a good and rapid measure of the total dissolved solids.

### Hardness

Hardness value is relatively high (79-83) mg/l at effluent discharge point in comparison with other two sites in all samples (Fig. 5). Hardness values at discharge point exceed 75 mg/l so it is moderately hard water and in other two sites water is soft since the values are below 75 mg/l (USEPA 1986).

### Chlorides

In this study, at all sites the chloride value is very low as compared to permissible limit. The chloride concentration is harmless up to 1500 mg/l though it produces salty taste at 200-250 mg/l (Trivedy and Goel 1984). Among the three sites highest value is observed at the discharge point (Table 1) which might be due to the mixing of different organic compounds from dairy effluents.

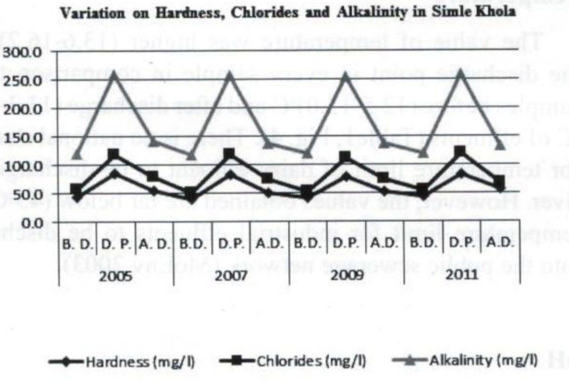


**Fig. 5: Graph showing variation in Hardness, Chlorides and Alkalinity in all sites.**

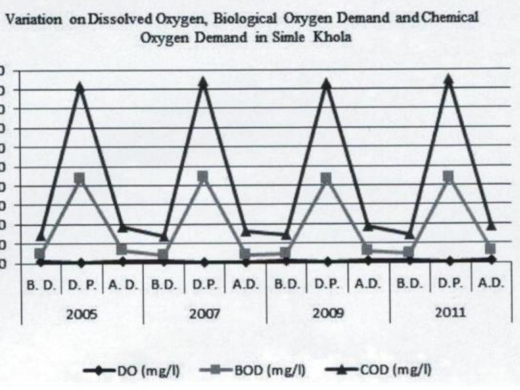


**Fig. 6: Graph showing the values of DO, BOD and COD in all sites.**

**Table 1: Water quality parameters of Simle Khola.**

| Parameter | 2005 | | | 2007 | | | 2009 | | | 2011 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B. D. | D. P. | A. D. | B.D. | D.P. | A.D. | B.D. | D.P. | A.D. | B.D. | D.P. | A.D. |
| Temperature (◦c) | 13.0 | 14.0 | 13.6 | 12.5 | 13.6 | 13.3 | 14.0 | 15.5 | 14.5 | 15.0 | 16.2 | 15.6 |
| pH | 6.8 | 7.0 | 6.9 | 6.7 | 6.9 | 6.8 | 6.7 | 7.0 | 6.9 | 6.8 | 7.0 | 6.9 |
| Conductivity (µs/cm) | 78.9 | 525.0 | 125.0 | 72.2 | 519.0 | 124.0 | 76.9 | 532.0 | 131.0 | 78.4 | 523.0 | 121.0 |
| Hardness (mg/l) | 44.0 | 84.0 | 55.0 | 38.0 | 82.0 | 51.0 | 41.0 | 79.0 | 52.0 | 43.0 | 83.0 | 56.0 |
| Chlorides (mg/l) | 11.4 | 34.0 | 23.9 | 12.1 | 35.7 | 22.1 | 11.6 | 32.5 | 21.2 | 12.3 | 36.3 | 11.9 |
| Alkalinity (mg/l) | 65.0 | 140.0 | 63.0 | 67.0 | 138.0 | 63.0 | 66.0 | 142.0 | 63.0 | 65.0 | 139.0 | 64.0 |
| DO (mg/l) | 6.1 | 1.2 | 3.4 | 5.9 | 1.1 | 3.2 | 5.7 | 1.2 | 3.8 | 5.6 | 1.2 | 3.5 |
| BOD (mg/l) | 17.0 | 217.0 | 28.0 | 15.0 | 220.0 | 17.0 | 16.0 | 214.0 | 26.0 | 17.0 | 218.0 | 27.0 |
| COD (mg/l) | 48.0 | 240.0 | 62.0 | 49.0 | 250.0 | 62.0 | 49.0 | 251.0 | 63.0 | 49.0 | 255.0 | 63.0 |
| Nitrate (mg/l) | 1.4 | 2.0 | 1.8 | 1.5 | 2.0 | 1.8 | 1.6 | 2.4 | 1.9 | 1.5 | 2.4 | 1.9 |
| Phosphate (mg/l) | 0.42 | 0.70 | 0.52 | 0.44 | 0.74 | 0.53 | 0.45 | 0.72 | 0.52 | 0.44 | 0.73 | 0.53 |

B.D= Before discharge, D.P.= Discharge point, A.D.= After discharge

**Alkalinity**

In this study there is abrupt increase in alkalinity at the discharge point in all samples i.e. 138 -142 mg/l (Fig. 5). It might be due to high use of alkaline cleansers in dairy industry.

**Dissolved Oxygen (DO)**

In the present study DO was in worsen condition at discharge points in all samples with the value of about 1 mg/l (Table 1). The DO before discharging effluent is in good condition with value of about 6 mg/l (Fig. 6) because the value of 5 mg/l is good for fishery and many natural aquatic habitat. However, dilution phenomenon of the stream was unable to recover the DO requirements for its life because at lower site the value is below 4 mg/l in all samples. So according to Miller (2002) the stream is in moderately polluted conditionn (DO = 4.5 to 6.7 mg/l) without discharge of dairy effluent; river went gravely pollution (DO>4 mg/l) when dairy effluent mixes.

**Biological Oxygen Demand (BOD)**

BOD values in this study has shown abrupt increase at effluent discharge point with value of 214mg/l to 220 mg/l (Table 1). 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 biological oxygen demand. The stream water has far more high value than the value of National Standard i.e.100 mg/l at 20$^0$C for Dairy Industry (MoEnv 2003) at discharge point. Other two sites have values within the standard (Fig. 6).

**Chemical Oxygen Demand (COD)**

The total COD of dairy wastewater is mainly influenced by the milk, cream, or whey (Wildbrett 1988 cited in Kushwaha et al. 2011). In the present study the value of COD is the highest, i.e., within the range of 240 mg/l to 255 mg/l at discharging point of the stream in comparision with other two sites (Table 1). According to National Standard for Dairy Industry Effluent given by MoEnv (2003) COD value is permissible upto 250 mg/l.

**Nitrate**

In present study nitrate was found relatively higher

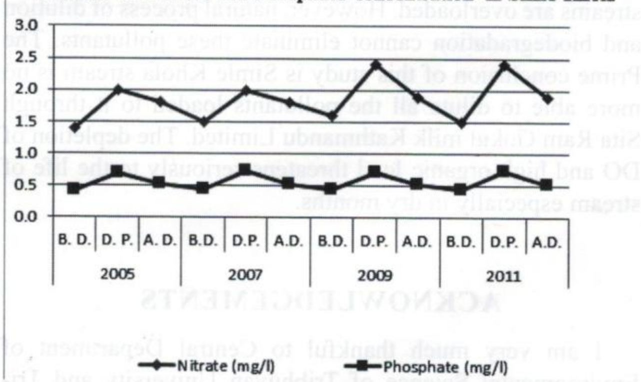


**Fig. 7: Graph showing variation of Nitrate and Phosphate concentration in all sites.**

(2.0 mg/l to 2.4 mg/l) at discharging point than sites before mixing (1.4 mg/l to 1.5 mg/l) and after dilution points (1.8 mg/l to 1.9 mg/l) (Fig. 7). This value is quite different than the findings of Skerman et al. (2006), i.e., 0.2 to 6.1 mg/l. However, it is the value of effluent pooled in the single as well as double pond system rather than of river water which received dairy effluents. The values lie within the permissible level given by Chapman (1992). Natural levels of nitrate in surface waters seldom exceed 0.1 mg/l as N, but waters influenced by human activity normally contain up to 5 mg/l as N with levels over 5 mg/l as N indicating pollution by animal or human waste or fertilizer runoff. The values are also within the range given in US EPA (1986), which adopted the 10 mg/l standard as the maximum contaminant level (MCL) for nitrate-nitrogen for regulated public water systems.

**Phosphate**

In present study the Phosphate concentration was high at discharging point (0.70-0.74 mg/l) compared to the value at the point before mixing (0.42-0.45 mg/l) and after dilution (0.52-0.53 mg/l). Concentration of phosphate in all sites is quite higher than permissible limit for stream which do not empty into reservoirs, i.e, not more than 0.1 mg/l (US EPA 1986); and it is within the range given by IFC and World Bank Group (2007) for dairy processing total phosphorus at effluent level (2 mg/l). However, it can be a serious threat to aquatic lives (e.g. algae and planktons) because the aforementioned values obtained are of river water not at effluent level.

## CONCLUSIONS

Flowing streams can recover sooner or later from pollutants such as degradable oxygen demanding wastes as well as excess heat by dilution and microbial decomposition. This natural recovery process can work efficiently till the streams are overloaded. However, natural process of dilution and biodegradation cannot eliminate these pollutants. The Prime conclusion of this study is Simle Khola stream is no more able to dilute all the pollutants loaded to it through Sita Ram Gokul milk Kathmandu Limited. The depletion of DO and high organic load threatens seriously to the life of stream especially in dry months.

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