INTRODUCTION:

Pollution caused by industrial and dairy effluents is a serious concern in throughout the world (Braio and Granhem, 2007). Of all industrial activities, the food sector has one of the highest consumptions of water and is one of the biggest producers of effluent per unit of production in addition to generating, besides to generate a large volume of sludge in biological treatment (Ramjeawon, 2000). The dairy industry is an example of this sector. Dairy industry is one of the major food industries in India, and India ranks first among the maximum major milk producing nation (Tripathi et. al. 2003). Dairy is an industry where milk is processed and various milk products are manufactured. Dairy, in which the cleaning silos, tanks, heat exchangers, homogenizers, pipes and other equipment, engenders a large amount of effluent with a high organic load. This organic load is basically constituted by milk (raw material and dairy products), inorganic salts, detergents, sanitizers used for washing reflecting an effluent with high levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), oils and grease, nitrogen and phosphorus than the specified limits of ISI. The characteristics of effluent like temperature, colour, pH, DO, BOD, COD, dissolved solids, suspended solids, chloride, sulfate, oil and grease largely depends on quantity of milk processed and type of product manufactured.

Waste water discharged from the milk processing unit is white in colour, slightly alkaline in nature due to the alkalis and detergents used and become acidic due to the fermentation of the milk sugar to lactic acid. The resulting low pH leads to the precipitation of casein. The suspended matter content of milk waste is considerably due to fine curd. The pollution effect of dairy wastes 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 odor characterizes milk waste pollution.

Liquid effluent from milk processing unit pose environmental problem like water and soil pollution as these wastes are generally released to the near by stream or land without any prior treatment are reported to cause serious pollution problems (Sethi et. al. 1981). An effluent from milk processing unit decomposes rapidly and depletes the
dissolved oxygen level of the receiving streams immediately resulting in an anaerobic condition and release of strong foul odour of butyric acid. The receiving water becomes breeding place for fleas, and mosquitoes carrying malaria and other dangerous diseases like dengue fever, yellow fever, and chicken gunia. It is also reported that higher concentration of wastes are toxic to certain varieties of fish and algae. (Inamdar and Singh 2008, Kolhe et. al. 2009). The higher concentration of effluent is toxic to the plant growth. It is recommended that only after the treatment and dilution of dairy effluent be used for irrigation purpose (Dhanam, 2009, Gaikar et. al. 2010).

Most of the waste water discharged into water bodies, disturbs the ecological balance and deteriorates the water quality. The casein precipitation from waste decomposes further into highly odorous black sludge. Effluent from milk processing unit contains soluble organics, suspended solids, trace organics which releases gases, causes taste and odor, impart colour and turbidity, and promote eutrophication.

The milk processing plant involves processing of raw milk into products like consumer milk, butter, cheese etc. using processes such as pasteurization, bottling, filling in cans etc. The quantity of water required in a milk processing plant depends upon the size of the plant, generally expressed in terms of the maximum weight of milk handled in a single day, and the processes involved. The daily volume of water required may vary widely, depending mainly on the availability of water and the control of all water using operation in the plant. The operations where the process involves continuous flow, the amount of water needed for rinsing and washing is not necessarily proportional to the amount of product processed.

The Dairy factory is a major source of food processing waste water (Britz et. al. 2006). The milk industry generates between 3.739 and 11.217 million m³ of waste per year (i.e. 1 to 3 times the volume of milk processed) (Monroy et. al. 1995). Waste water is generated in milk processing unit, mostly in pasteurization, homogenization of fluid milk and the production of dairy products such as butter, cheese, milk powder etc.

Most of the milk processing unit use “clean in place” (CIP) system which pumps cleaning solutions through all equipment in this order water rinse; caustic solution (sodium hydroxide) wash, water rinse, acid solution (phosphoric or Nitric acid) wash, water rinse, and sodium hypo-chlorite disinfectant. These chemicals eventually become a part of waste water (Thompson and George 1998). Large amount of water is used to clean
dairy processing plants; hence, the resulting waste water can contain detergent, sanitizers, base, salts and organic matter, depending upon source. (Floor spills vs regular equipment cleaning) (Belyea et. al. 1990).

Waste water volume and strength fluctuated widely from day to day due to partly differences in production, therefore, data of effluent or waste water volume per unit of product processed (liters waste water/kg product), waste water concentration (mg/litre) and weight of waste generated per unit of product processed (g waste/kg product) also changes (Carawan et. al. 1979). Climate of the area and production of the dairy plant are two major reasons, responsible for changing waste water character. This variation is not only from one industry to another dairy industry but also from season to season and even hour to hour.

In land received waste water affect the soil quality and soil structure and part of waste water can also leach is to underlying groundwater and affect its quality. The problem is more serious, when it concerns waste water discharge before treatment from dairy or milk processing industry. It is one of the largest sources of industrial effluents in many countries like (Europe and India). A typical European dairy factory generates approximately 50m³ waste water daily with considerable concentration of organic matter (fat, protein and carbohydrates) and nutrients mainly (Nitrogen and phosphorous) originating from the milk and the milk products (Omil et. al. 2003, Demirel et. al. 2005). The annual cost of treatment and disposal for the typical plant appears to be in the order of a million dollars as a whole is many millions of dollars. Disposal of untreated water is rapidly becoming a major economic and societal problem faced by the dairy processing industry in many respects (Belyea et. al. 1990).

Almost all the dairy factories are facing the problem of water treatment, disposal and utilization of the waste water. Disposal of waste water into rivers, land, fields and other aquatic bodies, without or with partial treatment, in crude tanks, will soon offer a serious problem to health and hygiene.

In recent times, development of newer membranes with high flux/rejection characteristics have increased the probability of water reuse and recycling up to a great extent. For recycling the waste water it is essential to know the inorganic and organic matter present. The waste is inevitable consequence of industrial process generally released in the form of solids, liquid effluent and slurries containing a spectrum of
organic and inorganic chemicals, produces harmful effects on environment. Thus pollution is necessary evil of all development. To combat the plethora of environmental evils of present day society, efficient and environmentally safe organic waste treatment and utilization technologies are needed.

In arid and semi arid regions of the country, where shortage of water becomes limiting factor, the effluent is being used for irrigational purposes by the farmers in agriculture and agro forestry practices. Since the production of waste water is a continuous process, hence it can be utilize for substantial irrigation requirements. This alternative use of waste water not only prevents the waste from becoming an environment hazard but also will serve as a potential source of fertilizer, if used rationally and at appropriate concentration.

There are so many investigations underway to finding solution for cheaper treatment, easy disposal and utilization of waste water from milk processing unit, in India as well as in abroad. Dairy factory sludge characterized by low heavy metal content and high amounts of degradable carbon can prevent the depletion of soil nutrients that results intensive harvesting in forest plantation studied by (Omil et. al. 2007). Anaerobic bi hydrogen production as a source of energy from dairy waste water treatment in sequencing batch reactor was investigated by (Venkata Mohan et. al. 2007). Dairy industry sewage sludge as a fertilizer for an acid soil was investigated by (Suarez et. al. 2004). The utilization of dairy waste effluent provides nutrients and water for crop growth was studied by (Macoon et. al. 2002). 5% dairy waste solids in feeding diet of sheep and swine is an alternative means for combating solid disposal problem of dairy industry (Belyea et.al., 1990).

To cater to increased water demand due to urbanization and industrialization, reduced rainfall, increase in standard of living, depletion in natural water resources, water recycling is necessary, which is known as zero effluent discharge. Photocatalytic detoxification method for zero effluent discharge in dairy industry was studied by (Inamdar and Singh, 2008). Reed bed treatment method can be used for the treatment of dairy waste water and microbe was demonstrated by (Mantovi and Piccinini, 2002).

In light of above knowledge, present study was conducted in waste water discharged from “Raipur Sahakari Dugdh Utpadak Sangh Limited”, a milk processing
unit. A huge amount of water is used in this unit, hence equally yield waste water. Waste water is discharged with partial treatment, however no proper treatment facility is available with the industry and waste water is simply discharged into low lying area. Beside that, industry doesn’t have any means of recycling the water as well as any means for utilization.

In such a situation, finding of present research on study of waste water quality may become very useful for milk processing industry to plan its proper disposal, recycling and utilization strategy in order to avoid pollution as well as keeping environment clean. Simultaneously, the waste water utilization study in irrigation purpose for promoting biomass production of vegetables may become very useful for milk industry as well as for farmers of the area to have a potential use of waste water.

**OBJECTIVES:**

1. To find out the quality of waste water is produced by the milk processing unit.
2. To investigate physical characteristics of waste water discharged by the milk processing unit.
3. To determine quantity of inorganic & organic nutrients in waste water discharged by the milk processing unit.
4. To study the biological property of waste water disposed from milk processing unit.
5. To investigate the utilization of waste water for irrigation purpose.
6. To find out the effect of waste water on Net Primary Production of leafy vegetables.
7. To study the suitability of vegetable for growing in waste water.
8. To compare the NPP of vegetables grown in waste water treated soil with control.
9. To find out the best dilution of waste water for the cultivation of vegetables.
10. To find out the comparative ability of plants to grow in waste water.
MATERIAL AND METHODS:

(A) STUDY OF WASTE WATER QUALITY OF MILK PROCESSING UNIT:

Waste water quality was determined by estimating physical, chemical and biological characteristics of waste water in monthly interval for the period of year 2008. Waste water sample was collected by fabricated water sampler of 1L capacity and transported to lab, where analysis was done during the period of 2 days. Preservation of waste water sample and methodology of analysis was referred from APHA-AWWA-WPCF (1980).

The physical parameters viz. Temperature, Hydrogen ion concentration (pH), Turbidity, Electrical conductivity and Total dissolved solids, Fats % were analyzed instrumentally, while Alkalinity, Free CO₂, Chloride, Dissolved oxygen, Chemical oxygen demand, Total hardness and Calcium were determined Titrimetrically. Nitrogen was estimated in Ammonical, Nitrite and Nitrate form and Phosphorus was estimated as Ortho, Acid hydrolyzable and total phosphate, Protein and Carbohydrate Spectrophotometrically. Total carbon dioxide, Magnesium and Organic phosphate were estimated indirectly by different method following APHA-AWWA-WPCF (1980). MPN test was done by following method of Aneja (2001) and APHA-AWWA-WPCF (1980).

(B) UTILIZATION OF WASTE WATER FROM MILK PROCESSING UNIT IN CULTIVATION OF PLANTS:

Net primary productivity (NPP) of three plants *Trigonella foenum-graecum* L., *Spinacea oleracea* L. and *Coriandrum sativum* L. were determined in gm m⁻² day⁻¹ for the period of 30, 40 and 45 days respectively, during the year 2007-2009 by Harvest method in control and treated field.

200 seeds of each vegetable were used for the cultivation. The weight of 200 seeds was referred as initial biomass. Production was determined by drying the cultivated plants at 105°C in hot air oven. This biomass was referred as final biomass. The values of final and initial biomass were computed along with the number of days of culture in a formula adopted for Net primary productivity determination.
In statistical analysis Pearson Correlation was performed on the data of Physico-chemical parameters recorded in the year of investigation 2008.

RESULTS:

(A) STUDY OF WASTE WATER QUALITY OF MILK PROCESSING UNIT:

Physico-chemical Characteristics of waste water

Water quality of waste water from milk processing unit was assessed by analyzing Physico-chemical characteristics of wastewater in monthly interval, during the year 2008.

(a) PHYSICAL CHARACTERISTICS:

(1) TEMPERATURE:

Temperature of waste water was ranged from 26.2-35.4°C. The observed temperature of waste water had a general conformity with atmospheric temperature; hence higher temperature was recorded in the summer months and lower in the winter months.

(2) HYDROGEN ION CONCENTRATION (pH):

The pH value of waste water was varied from 6.2-7.6. The pH of waste water indicated the acidic nature of effluent in most of the months of investigation. Acidic nature of waste water was due to break down of milk lactose in to lactic acid.

(3) TURBIDITY:

Turbidity was varying form 35.9-97.1 NTU in waste water. The difference between the minimum and maximum value was more than the double. The turbidity depends up on the strength of waste water. The stronger or more concentrated the waste, the higher is the turbidity.
4) **SALINITY:**
Salinity value had ranged from 0.254-0.639 ppm in waste water. Higher salinity values were due to increase in solubility of solids, while the value lowered due to decrease in temperature which lowered the solubility of solids.

5) **ELECTRICAL CONDUCTIVITY:**
Electrical Conductivity values were varying from 352.7-954.0 μmhos/cm in waste water. Higher value of electrical conductivity was obtained during the rainy months due to increase in concentration of solids, while the value lowered in winter months due to less discharge of solids from milk processing plant.

6) **TOTAL DISSOLVED SOLIDS (TDS):**
Total dissolved solid values were varying from 180.2-445.4 ppm in waste water. Increase in concentration of TDS was due to greater input of dissolved solids in water, while the minimum TDS value was noted in the month of October and November due to lower dissolution of solids in water in lower temperature.

(b) **CHEMICAL CHARACTERISTICS:**

7) **ALKALINITY:**
Phenolphthalein alkalinity (PA), Methyl orange alkalinity (MOA) and Total alkalinity (TA):
Phenolphthalein alkalinity was estimated nil, throughout the study period, hence, the value of total alkalinity was similar to the methyl orange alkalinity determined Total alkalinity values were varying from 198.45-376.80 mg CaCO₃/L in wastewater. Higher values of total alkalinity was obtained during rainy months due to addition of buffering material by surface runoff.

Carbonate, bicarbonate and hydroxide alkalinity:
As Phenolphthalein alkalinity was absent in the waste water therefore, following the formula prescribed in APHA-AWWA-WPCF (1980). The Carbonate and
Hydroxide alkalinity was calculated zero and the value of Bicarbonate alkalinity was similar to the total alkalinity value. The reason for variation was similar as registered for Total alkalinity.

(8) FREE CARBON DIOXIDE:

Free CO₂ values were ranging from 22.00-108.41 mg/L for waste water. The higher values of free CO₂ was due to higher rate of addition of organic matter in to waste water, while the reduced value was due to addition of lower quantity of organic matter in to waste water.

(9) TOTAL CARBON DIOXIDE:

Total CO₂ values were ranging from 196.63-398.95 mg/L for waste water. Total CO₂ was comparatively higher in rainy months due to addition of higher concentration of bicarbonate ions, while lowered during the winter months due to less concentration of bicarbonates in waste water.

(10) CHLORIDE:

Chloride values ranged from 24.85-92.91 mg/L in waste water. Chloride concentration in waste water had a random change in the value due to gradual increase/decrease in concentration as well as change in quality of water in fluxed.

(11) DISSOLVED OXYGEN (DO):

Dissolved oxygen values were varying from 0.38-1.42 mg/L in waste water. The lower value of dissolved oxygen in waste water was due to higher biological and chemical oxygen demand and presence of greater quantity of organic matter in waste water.

(12) BIOCHEMICAL OXYGEN DEMAND (BOD):

In 1%> dilution the range of BOD value as prescribed by Trivedy and Goel, (1984) is 400-1200mg/L as obtained in present investigation.
(13) CHEMICAL OXYGEN DEMAND (COD):  
The chemical oxygen demand values were fluctuated from 216.0-904 mg/L for the waste water. COD values were higher during the winter months and lower in rainy months. These results were obtained because of input of higher concentration of organic matter during winter, while the value lowered in the rainy months due to dilution of wastewater by rainwater.

(14) TOTAL HARDNESS:  
Total hardness was found to vary from 145.50-293.40 mg CaCO₃/L for the waste water. Higher value of total hardness recorded in the month of April in the waste water was because of more evaporation in the month of April due to increase in temperature, while the value lowered in the month of December due to lower temperature.

(15) CALCIUM HARDNESS:  
Calcium hardness was ranged from 100.80-208.06 mg CaCO₃/L for the waste water. Explanation for higher and lower value was found same as reported for the Total hardness.

(16) CALCIUM:  
Calcium values were fluctuated from 40.40-83.39 mg/L for waste water. Higher and lower value was due to the same reasons as described for the fluctuation of calcium hardness value.

(17) MAGNESIUM:  
The Magnesium value in waste water was found to range from 10.01- 19.11 mg/L. Comparatively Magnesium value was ¼ of the Calcium value. Higher and lower value was due to the same reasons as described for the fluctuation of calcium hardness value.
(18) AMMONICAL NITROGEN (NH₄ - N):

Ammonical form of nitrogen values were varying from 2.10-6.50 mg/L in waste water. Lower values in August was obtained due to dilution of waste water by rain water, while, higher concentration of waste water in April was responsible for higher concentration of Ammonical nitrogen.

(19) NITRITE NITROGEN (NO₂ - N):

Nitrite nitrogen was ranged from 0.0375-0.7000 mg/L in waste water. Value indicated random fluctuation due to different in oxidation - reduction potential of waste water.

(20) NITRATE NITROGEN (NO₃ - N):

Nitrate nitrogen ranged from 10.24-15.52 mg/L in waste water. The higher values were obtained due to greater rate of oxidation, while lower value was obtained due to lowering in oxygen, which reduced the rate of the oxidation.

(21) TOTAL ORTHO PHOSPHATE (TOP):

Total ortho phosphate values were varying from 2.00-7.42 mg/L in waste water. Higher and lower value of ortho phosphate was dependent on the amount of discharge and the temperature suitability for breakdown.

(22) ACID HYDROLYZABLE PHOSPHATE (AHP):

Acid hydrolyzable phosphate values were varying from 5.14-9.00 mg/L in waste water. Higher values of acid hydrolysable phosphate was noted because of less settlement of condensed phosphate, while lower values were obtained due to more settlement of condensed phosphate at the bottom.

(23) TOTAL PHOSPHATE (TP):

Total phosphate value had a variation in values from 18.00-26.42 mg/L in waste water. Total phosphate value exhibited a random monthly variation in values,
which could not be explained but probably was due to variation in the influx of phosphate.

(24) ORGANIC PHOSPHATE (OP):

Organic phosphate value had ranged from 7.00-11.72 mg/L in waste water. Lower values were obtained in rainy months due lower rate of breakdown and greater dilution of waste water; nevertheless, higher values were obtained both in summer and winter, dependent on rate of breakdown of organic matter in waste water.

(25) PROTEIN:

Protein value determined in mg/L was ranging from 13.78-72.12 in waste water of milk processing unit. Lower value of protein was observed in rainy months due to dilution of waste water, while, higher value was obtained in winter as well as in summer, because of difference in influx of protein in to waste water as well as difference in the rate of decomposition.

(26) CARBOHYDRATE:

Carbohydrate value determined was varying from 0.1007-0.2958 mg/L in waste water of milk processing unit. Lower value of carbohydrate was observed in June due to dilution of waste water, while, higher value was obtained in winter, because of difference in influx of carbohydrate and its rate of breakdown.

(27) FATS:

Fats value determined in % was changing from 0.01-0.06 in waste water of milk processing unit. Lower value of Fat was observed in rainy months due to dilution of waste water, while, higher value was obtained in winter month November. because of difference in influx of milk in to waste water.

(28) SULFATE:

Sulfate value determined in mg/L was ranging from 124.0-186.0, in waste water of milk processing unit. Higher value of sulfate was noted during rainy months July
and August due to influx of sulfate from surface runoff water during rains, while, random variation was observed in the value, when there was no contribution of surface runoff sulfate.

(29) SODIUM:
Sodium value was varying from 21.0-83.0 ppm in waste water of milk processing unit. Higher value of sodium was obtained in the month of October and lower value in the summer months. Lower value was obtained due to lower influx of sodium in water used in milk industry for various works.

(30) POTASSIUM:
Potassium value was ranging from 5.0-16.0 ppm in waste water of milk processing unit. Higher value was obtained due to higher influx of Potassium in water used in milk industry for various works.

(31) MOST PROBABLE NUMBER (MPN):
MPN value obtained was >2400 for most of the months from March to November, while in 03 winter months of December, January and February value recorded (1600) was comparatively low. Higher MPN value reflects greater presence of bacteria as well as higher rate of growth and breakdown of organic matter present in the waste water of Milk Processing Unit.

(B) UTILIZATION OF WASTE WATER FROM MILK PROCESSING UNIT IN CULTIVATION OF PLANTS:
Net primary productivity (NPP) of three plants *Trigonella foenum-graecum* L., *Spinacea oleracea* L. and *Coriandrum sativum* L. were determined in gm m$^{-2}$ day$^{-1}$ for the period of 30, 40 and, 45 days respectively, during the year 2007-2009. Net primary productivity of all the three plants was found higher in the field treated with waste water of milk processing unit in comparison to control, where field was irrigated with tap water. Amongst all the three plants *Spinacea oleracea* L. had recorded higher NPP value throughout the period of investigation. The reason of higher net primary
productivity was the nature of plant which is comparatively broad leaves and its suitability of growth in waste water due to higher rate of nutrients from treated soil. Lowest NPP value was noted for *Coriandrum sativum* L. having decomound leaf, while moderate NPP value was recorded for *Trigonella foenum-graecum* L. NPP value of all the three plants cultivated in field irrigated with waste water suggested that waste water of milk processing unit had a very good amount of organic matter, which on decomposition yield nutrients available in the field, hence can be used for cultivation of variety of vegetables. Utilization of waste water for irrigating fields may become useful in promoting NPP for large scale cultivation of vegetables.

**CONCLUSION:**

1. Waste water discharged from milk processing unit is white, acidic with higher Turbidity, Salinity, Electrical conductivity and total dissolved solids.
2. Alkalinity recorded was due to Bicarbonate alkalinity. Higher values of carbon dioxide and lower value of Chloride was noted for the waste water.
3. Dissolved oxygen in waste water was recorded low value due to higher organic matter and BOD and COD.
4. BOD and COD value were quite higher in the waste water indicates its polluted nature.
5. Higher quantity of inorganic nutrients like nitrogen & phosphorus was found present in the waste water.
6. Waste water was rich in Protein and Fat content, which can be used as a feed for animals.
7. MPN value was higher again indicates the polluted nature of waste water.
8. All the studied physico-chemical and Biological parameter proved that the water discharged from milk processing unit is of polluted nature. Its disposal without any treatment in to fresh water body may impose the danger of eutrophication as well as serious problems of health and hygiene.
9. Long term leaching of waste water may alter the soil quality as well as may influence the quality of ground water.
10. Diluted Waste water enriched with vital nutrients like nitrogen and Phosphorus can be utilized for cultivation of vegetables.
11. Study revealed an increase in biomass probably due to more availability of growth promoting macronutrients like nitrogen and phosphorus in waste water.

Present study may proved to be a very useful for the Milk Processing Unit of India, as it demonstrates an economical method of waste water utilization in cultivation of vegetables, simultaneously it solves the problem of waste water disposal and treatment.

This Technique has multifold benefits, as on the one hand it provides a cheaper method of waste water utilization and on the other hand it adds the biomass, which may have usefulness as vegetables.

References:


Summary and Conclusion


Pollution level (BOD and COD) of dairy plant effluent”, Int. conf. on systems, theory and application, held at PAV: 651-655.


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