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***Research Paper***

# Effluent Generation by the Dairy Units: Characterization and Amelioration for Irrigation

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***Abstract-****A study was conducted to know the quality of effluent generated from the Mother Dairy, Yelahanka, Bangalore, Karnataka for the purpose of mitigating pollution. The methodology consists of collection of samples from the production unit and measuring the volume of effluent released out, per batch of processing of milk and also characterization of effluent was done as per the standard procedures. For amelioration, treatment methods like filtration through sand and clay filters, chemical coagulation and the combination of different treatments were followed. Results of the study revealed that, dairy units produce the effluent of exactly ten times of its production capacity (ten lakhs liters of effluent per day where the processing capacity is one lakh liters of milk per day). Dairy effluent was dark milky whitish in color, stringent smelling, which is slightly irritating and also contains fair amount oil. Dairy effluent posses all the characters of polluted water by having high pH, EC, BOD, COD, TSS, TDS and other plant nutrients. The effluent treated at dairy is also consist of huge amounts of pollutants. The methods followed for amelioration, improved the quality of effluent by reducing the pollutants present in it. Among different amelioration techniques physical filters followed by combination of different treatments are found to be most effective method in improving the quality of effluent. Among the different types of filters sand cum clay filter was found to be most effective filter in reducing the pH level to neutral, complete removal of oil, reduction of TDS and TSS by 68 and 74 per cent respectively, reduction of BOD and COD by 92 and 87 per cent respectively. From the study it was confirmed that treated effluent samples can be used safely for irrigation of crops as it meets the ISI standards.*

**Key words:** Dairy effluent, Characterization, Amelioration, Coagulation, Irrigation, Physical filters etc.

## Introduction

In the post independence era, an emphasis was given for establishment of industries, which has resulted in propelling India as the 7th largest nation of the world in terms of industries. Majority of the industries are agro-based and utilize large volume of good quality water and other raw materials. These industries generate almost entire quantity of water as effluent and appreciable quantity of solid wastes. Water pollution by industrial effluents has been one of the vital issues of the environmental concern in India. The effluents from almost all industries of the country are directly or in directly discharged into canals and rivers.

Due to continuous disposal of waste water into the water bodies, surface water quality throughout the country has deteriorated because of the mixing of various chemical pollutants of the effluent with water. The surface water quality has declined to such a level at which it will not be useful for any purpose. The use of industrial liquid effluent for agricultural irrigation has been in vogue in many countries of the world. This effluent contains various micro nutrients essential for growth of crop plant. However, many industrial wastes may have harmful effects and may cause soil fatigue.

Dairy industry is one of the most important agro-based industries in India and produces huge amounts of effluents through its processing units. The clean water is used in various stages of dairy operations, such as, milk processing, cleaning, packaging and cleaning of the milk tankers and releases the waste water which is known as dairy effluent. Water is used for processing in the ratio of 1:10 (water: milk) per liter of milk. Dairy effluent has high organic loads of milk as its basic constituent with high level of chemical oxygen demand, biological oxygen demand, oil and grease, total suspended matter, nitrogen and other plant nutrients. [13]

The effluent can supply greater input of minerals for the better growth of plants; in addition, the use of industrial effluent for agricultural irrigation purpose can reduce the water pollution and dependency of agricultural use of ground water. In view of the adverse effects, the dairy effluent need to be treated and discharged according to the standards procedures.

However, indiscriminate use of industrial effluents may cause pollution problems in the long run when they are not properly handled before and after their application to land. Protecting natural resources and their management for agricultural production is one of the key exercises of this study.

With view of all the side effects the dairy effluents is to be treated by using adequate treatment methods. Several approaches have been attempted which includes physical filters, chemical coagulation and combination of different treatments. These ameliorative techniques remove the pollutants from the effluent most effectively and are very effective in improving the quality of the effluent.

## Material and methods

**Collection of Dairy Effluent:** The dairy effluent samples were collected in dry plastic bottles which are rinsed with distilled water and then in effluent, from the Mother Dairy, Yelahanka, Bengaluru, in the month of November and December 2010. The combined sample of effluent was collected at the main drain pipe which is connected from washing tank to outside discharge unit.

**Characterization of Dairy Effluent:** The physico-chemical properties of dairy effluent samples were analyzed according to standard procedures. [11]

**Amelioration of Dairy effluent**

**Physical and chemical treatments**

**Filtration of dairy effluent:** The physical treatment trial includes: passing the effluent through filter containing 1. Sand alone 2. Clay alone 3. Sand+clay. The filtrate was collected and used independently for the analysis. [1]

**Coagulation of dairy effluent:** In order to reduce the colour, odour, pH, EC, suspended solids, BOD and COD and other pollutants of the biodiesel effluent, different chemical compounds were tried as coagulating agents. The coagulants used included potash alum, ferric chloride and calcium hydroxide in two different concentrations.

One liter of well mixed biodiesel effluent was taken in beakers and coagulants were added simultaneously to all the beakers. The suspension was stirred thoroughly to ensure dispersion of the coagulant in effluent and allowed to settle for two hours. The supernatant of the settled samples were used for testing the characteristics of biodiesel effluent.

***Experimental details***

The filtration and coagulation experiment consisted of seven different treatments as detailed below.

| Treatment symbols | Treatments |
|---|---|
| $\mathbf{T_1}$ | Raw effluent |
| $\mathbf{T_2}$ | Effluent treated at dairy |
| $\mathbf{F_1}$ | Sand filtrate |
| $\mathbf{F_2}$ | Clay filtrate |
| $\mathbf{F_3}$ | Sand + clay filtrate |
| $\mathbf{C_1}$ | Potash alum@ 100 mg/l |
| $\mathbf{C_2}$ | Ferric chloride @ 200 mg/l |

**Combination of different treatments**

Further, a set of treatments that combines both the physical and chemical treatments were tried for amelioration and the samples were used for analysis to know the effect of different treatments on physico chemical properties of dairy effluent.

**Experimental details**

*The experiment consists of eight different treatments. As shown below.*

| Treatment symbol | Treatments |
|---|---|
| $T_1$ | Raw effluent |
| $T_2$ | Effluent treated @ dairy |
| $T_3$ | Sand filtrate + Potassium alum |
| $T_4$ | Clay filtrate + Potassium alum |
| $T_5$ | Sand + Clay filtrate + Potassium alum |
| $T_6$ | Sand filtrate + Ferric chloride |
| $T_7$ | Clay filtrate + Ferric chloride |
| $T_8$ | Sand + Clay filtrate + Ferric chloride |

**Statistical analysis**

Fisher's method of analysis of variance was employed for the analysis and interpretation of the data. [12] The level of significance used in 'F' test was P=0.05 and the CD values were calculated.

## Results and discussion

**Physico-chemical analysis of Dairy Effluent**

The Dairy Effluent samples were collected from milk processing unit of Mother Dairy Yeahanka, Bengaluru, having the characters of polluted water and

the results are described in Table 1. The results obtained from the investigation showed that dairy effluent is white milky in colour with small amount of oil and having stringent odour which is slightly irritating. The dairy effluent is alkaline in nature, having high EC. This might be due to use of Calcium carbonate in cleaning and also due to use of milk as a raw material. Effluent posses the characters of polluted water by having high amount of oil, oxygen demanding waste and total suspended matter. The effluent also consists of fairly high amount of plant nutrients. [2]

**Effect of physical filters on physico-chemical characteristics of Dairy Effluent:**

The physical treatments improved the quality of dairy effluent. Results were presented in table 2 & plate 1. Sand, clay and sand cum clay filters improved the quality of dairy effluent by reducing the pH and EC, effectively removed the colour from the effluent and makes the effluent into a clear solution. Sand filters significantly removed the oil, reduced the total solids and organic waste present in the spent wash [3]. The concentration of nutrients present in the spentwash is also reduced significantly by sand filtration (Fig. 2). This could be due to the salts and other soluble materials present in the effluent that adhered to the minute sand and clay particles and thus reducing the concentration of salts. The microorganisms present on the surface of the sand filter could have decomposed the organic matter in the spentwash and reduced the organic waste from the effluent [4, 5 & 6].

Among the different physical treatments (sand filters, clay filters and sand cum clay filters), treatment $F_3$ (sand cum clay filters) followed by treatment $F_1$ (Sand filters) are found to be most effective in improving the quality of dairy effluent by reducing the pollutants present in it.

**Effect of chemical coagulation on physico-chemical characteristics of Dairy Effluent:**

Chemical precipitation of diary effluent was useful to remove particulate and colloidal materials which determine the quality of spentwash. The results were given in Table 2 & plate 1and figure 1.

Addition of coagulants improved the quality of diary effluent. The results are presented in Table 2. The addition of coagulants improved the quality of biodiesel spentwash by reducing the pollutants present in it. [9]

Among different types coagulants used, potash alum followed by ferric chloride are better coagulants in removal of colour and odour, reduction of pH and EC and removal of suspended salts, BOD, COD and other nutrients from the effluent. Potash alum and ferric chloride addition to dairy effluent formed insoluble alluminium hydroxide and ferric hydroxide respectively. They in turn must have facilitated the precipitation of colloids and increased the sedimentation rate of other particulate matter in the effluent. Thus it reduces the total suspended matter present in the effluent and also enhances the sedimentation rate of organic matter present in it [7].

**Effect of combination of different treatments on physico chemical properties of dairy effluent:**

The combination of different treatments effectively reduces the pollutants present in it. The results were presented in table 3, figure 2 & plate 3. Among the different treatments treatment $T_5$ (sand+ clay filtrate+ Potassium alum) was found to be most effective in reducing the pollutants load from the effluent. It might be due to reduction of pollutants from the sand cum clay filter and also in precipitation due to the addition of potash alum [9].

Among all the different ameliorative techniques sand cum clay filters are better in removal of pollutants from the effluent which is most effective in removal of pollutants and also economically cheap.

## Conclusion

The study infers that untreated effluent (Dairy Effluent) was unsuitable for irrigation and other purposes, as it contained high amounts of toxic substances. On the other hand the treated effluents free from colour, odour, pollutants and other toxic substances and can be used in agriculture for certain selected crops. Therefore the different ameliorative techniques like physical filtration (Sand, Clay and sand cum Clay filters), chemical precipitation and combination of different treatments can be used to reduce the toxic substances from the dairy effluent. The effluents treated by using different ameliorative techniques showed better results than the samples treated by dairy itself. Among the different ameliorative techniques sand cum clay filters are considered as one of the efficient method for reducing the toxic substances from the dairy effluent and can be used for treating the effluent.

## References

1. Achak, M., Mandi and Ouazzani., Removal of organic pollutants and nutrients from oil mill waste water by a sand filter. *J. Environ. Management,* **90**: 2771-2779 **(2009).**
2. Dhanam, S., Effect of dairy effluent on seed germination, seedling growth and biochemical parameter in Paddy. *Botanical Res. International,* **2(2)**:61-63 **(2009).**
3. Fayaza, A. Nasr., Hala, M. and El-Kamah., Chemico-Biological treatment of dairy waste water. *Environ. Management and Hlth*., **7(3)**: 22-27 **(1996).**
4. Kamalam, N. and Raj, D., Effect of tannery effluent on germination and nutrient uptake of ragi. *Madras Agric. J.,* **67(7)**: 441-444 **(1980).**
5. Rodgers, M., Healy, M. G. and Mulqueen, J., Organic carbon removal and nitrification of high strength wastewaters using stratified sand filters. *Water res.,* **39**(14): 3279-3286 **(2005).**

6. Buuren, J. C. L. Van., Abusam, A., Zeeman, G. And Lettinga, G., Primary effluent filtration in small scale installations. *Water sci. and Tech.*, **39(5)**: 195-202 **(1999).**
7. Upadyaya, J. S. and Singh, B., Decolorisation of effluents from pulp and paper industry. *Indian J. Environ. Hlth*, **33**(3): 350-356 **(1991).**
8. Tabatabaei Zahra., Mahvi Hossein Amir., Saeedi Reza., Khorshidi Rakhsh Ataolah and ali Sohrabi., Two-stage Sand Filtration of Secondary Effluent for Agricultural Reuse. *International J. Agri. Biol*, **9**(6): 889-892 **(2007).**
9. Mohana, V. S., Sinivasa murthy C.A., Prasanna K.T and Balakrishna Gowda.,Characterization of biodiesel spentwash and amelioration through chemical coagulation treatment for irrigation., *Envi. and Ecol.*, **29 (3A)**: 1274-1278 **(2011).**
10. Nemerow, N. L., Oxidation of cotton kier waste, *J. Wat. pollut. control Fed*, **25**:1060 (1963).
11. American Public Health Association (APHA)., 1998., Standard Methods for Examination of Water and Wastewater. 20th ed. Washington, DC **(1998).**
12. Gomez, K. A. and Gomez, A. A., Statistical procedure for agricultural research II. Edn., John Willey and sons, New York, P. 680 **(1976).**
13. MoEF (Ministry of Environment and Forest), 2003. Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003. Ministry of Environment and Forests, Government of India, New Delhi **(2003).**


**Table 1: Physico-chemical properties of untreated Dairy Effluent**

| Parameters | Values | ISI standards |
|---|---|---|
| Colour | Milky, turbid | Clear |
| Odour | Unpleasant | Odourless |
| pH | 8.33 | 5.5-9.00 |
| EC ($dSm^{-1}$) | 1.37 | <1.00 |
| Oil content (mg/l) | 138.33 | 10 |
| Total solids (mg/l) | 1182.69 | - |
| TSS (mg/l) | 448.29 | 100.00 |
| TDS (mg/l) | 734.40 | - |
| BOD (mg/l) | 634.06 | - |
| COD (mg/l) | 1171.82 | 250.00 |
| Nitrogen (mg/l) | 1.07 | 100.00 |
| Phosphorus (mg/l) | 1.01 | - |
| Potassium (mg/l) | 0.67 | |
| Sulphate (mg/l) | 0.33 | |
| Calcium (mg/l) | 1.23 | |
| Chloride (mg/l) | 19.83 | 600 |

**Table 2: Effect of physical and chemical treatment methods on physico-chemical properties of Dairy Effluent**

| Treatments | | Color | Odour | pH | EC | Oil content (mg/l) | TSS (mg/l) | TDS (mg/l) | Total solids (mg/l) | BOD (mg/l) | COD (mg/l) | N (mg/l) | P (mg/l) | K (mg/l) | S (mg/l) | Ca (mg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $T_1$ | Milky turbid | Unpleasant | 8.64 | 1.35 | 1089.44 | 447.93 | 740.30 | 1188.23 | 656.45 | 1160.51 | 1.36 | 1.04 | 0.74 | 0.44 | 1.27 | 21.41 |
| | $T_2$ | Turbid | Unpleasant | 8.17 | 0.86 | 250.50 | 173.73 | 638.20 | 811.93 | 126.60 | 245.07 | 1.44 | 0.94 | 0.41 | 0.26 | 0.65 | 12.78 |
| Physical | $F_1$ | clear | Odourless | 7.91 | 0.87 | 118.80 | 179.80 | 523.47 | 703.27 | 64.83 | 180.13 | 1.31 | 0.71 | 0.74 | 0.27 | 0.87 | 12.27 |
| | $F_2$ | slightly turbid | Odourless | 7.42 | 0.95 | 115.07 | 191.87 | 524.54 | 716.40 | 56.19 | 190.40 | 0.89 | 0.66 | 0.70 | 0.20 | 0.96 | 21.91 |
| | $F_3$ | Clear | Odourless | 7.70 | 0.88 | 52.03 | 114.80 | 369.30 | 484.10 | 36.61 | 150.78 | 0.45 | 0.51 | 0.29 | 0.20 | 0.89 | 21.42 |
| Chemical | $C_1$ | Slightly turbid | Odourless | 4.77 | 1.11 | 137.27 | 208.27 | 532.93 | 741.20 | 135.93 | 319.63 | 0.38 | 0.41 | 0.27 | 0.32 | 0.82 | 16.43 |
| | $C_2$ | Brownish turbid | Odourless | 4.27 | 1.13 | 180.60 | 247.83 | 450.40 | 698.23 | 159.60 | 326.23 | 0.77 | 0.83 | 0.45 | 0.42 | 0.74 | 18.80 |
| | | | | | | | | | | | | | | | | | |
| F | - | | - | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| CV | - | | - | 2.97 | 8.36 | 8.02 | 20.66 | 4.58 | 8.29 | 6.68 | 5.91 | 21.49 | 12.10 | 11.42 | 26.77 | 10.25 | 8.27 |
| S.Em ± | - | | - | 0.12 | 0.05 | 12.86 | 61.73 | 20.20 | 10.70 | 6.81 | 12.54 | 0.12 | 0.05 | 0.03 | 0.05 | 0.05 | 0.85 |
| CD@ 5% | - | | - | 0.36 | 0.15 | 39.01 | 187.25 | 61.26 | 32.45 | 20.66 | 38.05 | 0.35 | 0.15 | 0.10 | 0.15 | 0.16 | 2.59 |

*: Significant at 5%  NS: Not significant

**Legend:**

$T_1$: Raw effluent  $T_2$: Effluent treated @dairy  $F_1$: Sand filtrate  $F_2$: Clay filtrate

$F_3$: Sand+ Clay filtrate  $C_1$: Potassium alum @ 100 mg/l  $C_2$: Ferric chloride @ 200 mg/l

**Table 3: Effect of combination of different treatment methods on physico-chemical properties of Dairy Effluent**

| Treatments | Color | Odour | pH | EC | Oil content (mg/l) | TSS (mg/l) | TDS (mg/l) | Total solids (mg/l) | BOD (mg/l) | COD (mg/l) | N (mg/l) | P (mg/l) | K (mg/l) | S (mg/l) | Ca (mg/l) | Chloride (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | Milky turbid | Unpleasant | 8.64 | 1.35 | 1089.44 | 447.93 | 740.30 | 1188.23 | 656.45 | 1160.51 | 1.36 | 1.04 | 0.74 | 0.44 | 1.27 | 21.41 |
| $T_2$ | Turbid | Unpleasant | 8.17 | 0.86 | 250.50 | 173.73 | 638.20 | 811.93 | 126.60 | 245.07 | 1.44 | 0.94 | 0.41 | 0.26 | 0.65 | 12.78 |
| $T_3$ | slightly turbid | Odour less | 6.73 | 0.83 | 92.13 | 94.93 | 134.17 | 229.10 | 96.73 | 215.37 | 0.41 | 0.89 | 0.61 | 0.36 | 0.87 | 11.76 |
| $T_4$ | slightly turbid | Odour less | 6.77 | 0.84 | 82.07 | 88.80 | 119.53 | 208.33 | 86.53 | 192.93 | 0.43 | 0.82 | 0.56 | 0.26 | 0.27 | 12.76 |
| $T_5$ | slightly turbid | Odour less | 7.23 | 0.99 | 30.80 | 76.63 | 118.73 | 195.37 | 101.20 | 211.80 | 0.20 | 0.44 | 0.16 | 0.24 | 1.10 | 10.74 |
| $T_6$ | slightly turbid | Odour less | 5.81 | 0.84 | 93.20 | 100.83 | 141.20 | 242.03 | 106.93 | 199.93 | 0.35 | 0.51 | 0.38 | 0.26 | 1.30 | 10.83 |
| $T_7$ | Brownish turbid | Odour less | 5.89 | 1.07 | 95.87 | 74.30 | 109.80 | 184.10 | 86.47 | 193.13 | 0.79 | 0.33 | 0.22 | 0.26 | 0.79 | 12.15 |
| $T_8$ | Clear | Odour less | 6.15 | 0.92 | 75.67 | 72.53 | 114.27 | 186.80 | 80.90 | 180.20 | 0.81 | 0.62 | 0.25 | 0.35 | 0.76 | 21.41 |
| | | | | | | | | | | | | | | | | |
| **F** | - | - | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| **CV** | - | - | 2.69 | 4.95 | 9.62 | 3.51 | 5.26 | 12.06 | 6.90 | 5.37 | 24.02 | 6.22 | 12.58 | 18.13 | 14.18 | 10.31 |
| **S.Em ±** | - | - | 0.11 | 0.03 | 12.59 | 5.36 | 12.33 | 9.83 | 6.68 | 10.07 | 0.10 | 0.03 | 0.03 | 0.03 | 0.07 | 0.85 |
| **CD@ 5%** | - | - | 0.34 | 0.08 | 37.75 | 16.08 | 36.96 | 29.47 | 20.04 | 30.19 | 0.30 | 0.08 | 0.09 | 0.10 | 0.22 | 2.55 |

Note: *: Significant at 5%  NS: Not significant

**Legend:**

$T_1$: Raw effluent  $T_2$: Effluent treated @ dairy  $T_3$: Sand filtrate+ Potassium alum  $T_4$: Clay filtrate+ Potassium alum  $T_5$: sand+ clay filtrate+ Potassium alum  $T_6$: Sand filtrate+ Ferric chloride

$T_7$: Clay filtrate+ ferric chloride  $T_8$: Sand+ clay filtrate+ ferric chloride

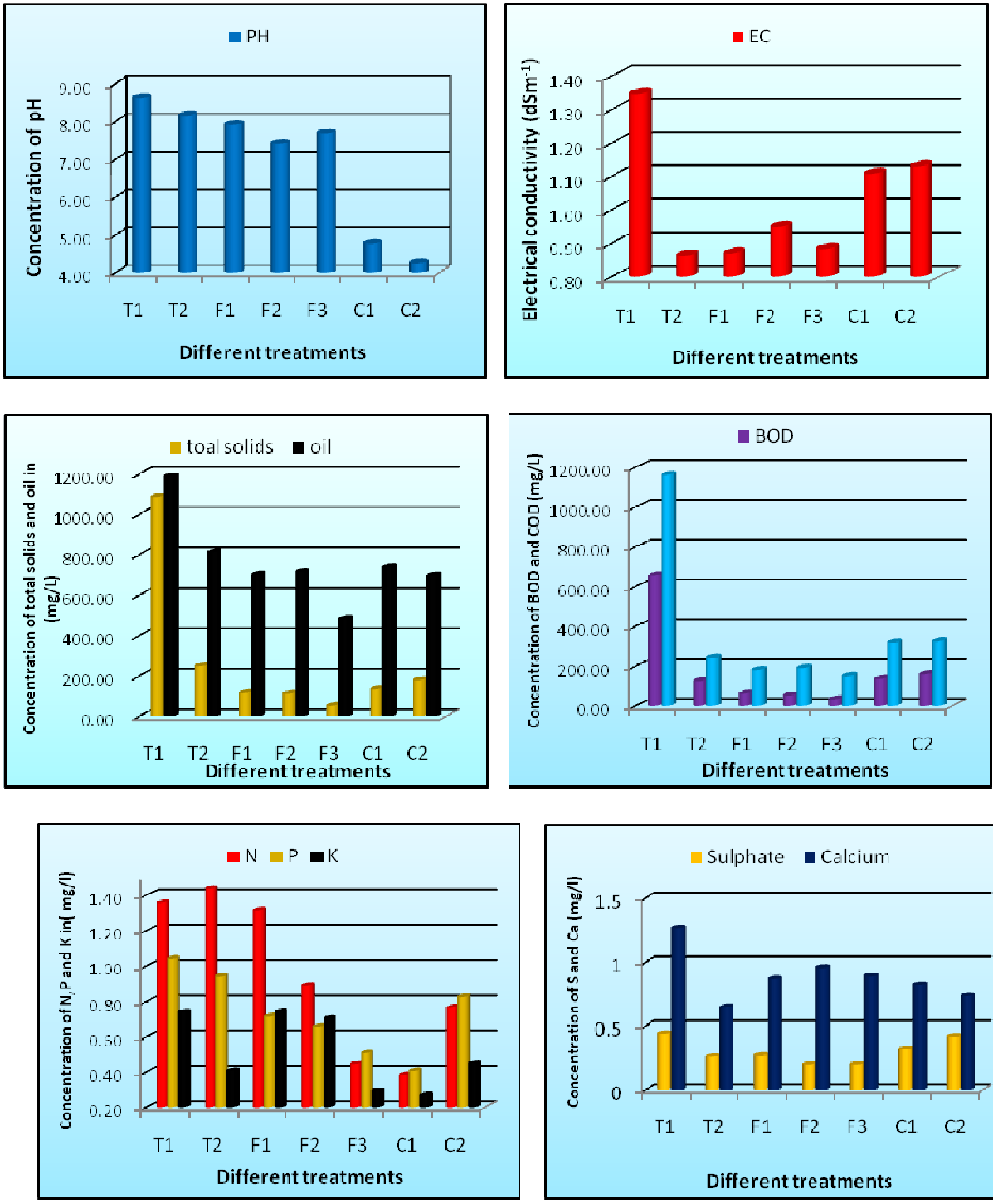


**Figure 1: Effect of physical and chemical ameliorative methods on pH, EC, Oil, Total solid, BOD, COD and nutrient content of dairy effluent**

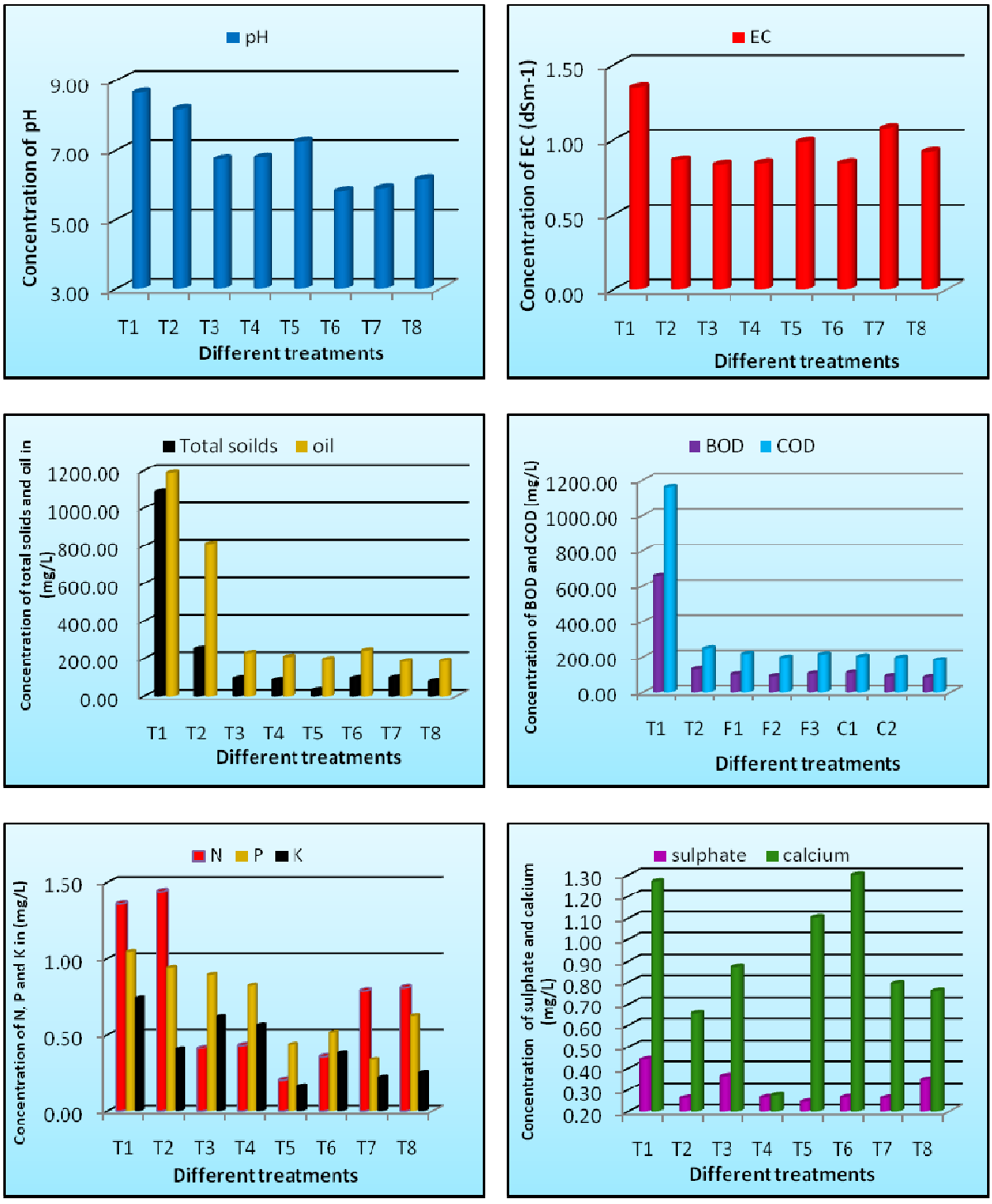


**Figure 1: Effect of combination of different treatments on pH, EC, Oil, Total solid, BOD, COD and nutrient content of dairy effluent**

**Plate 1: Raw Dairy Effluent**

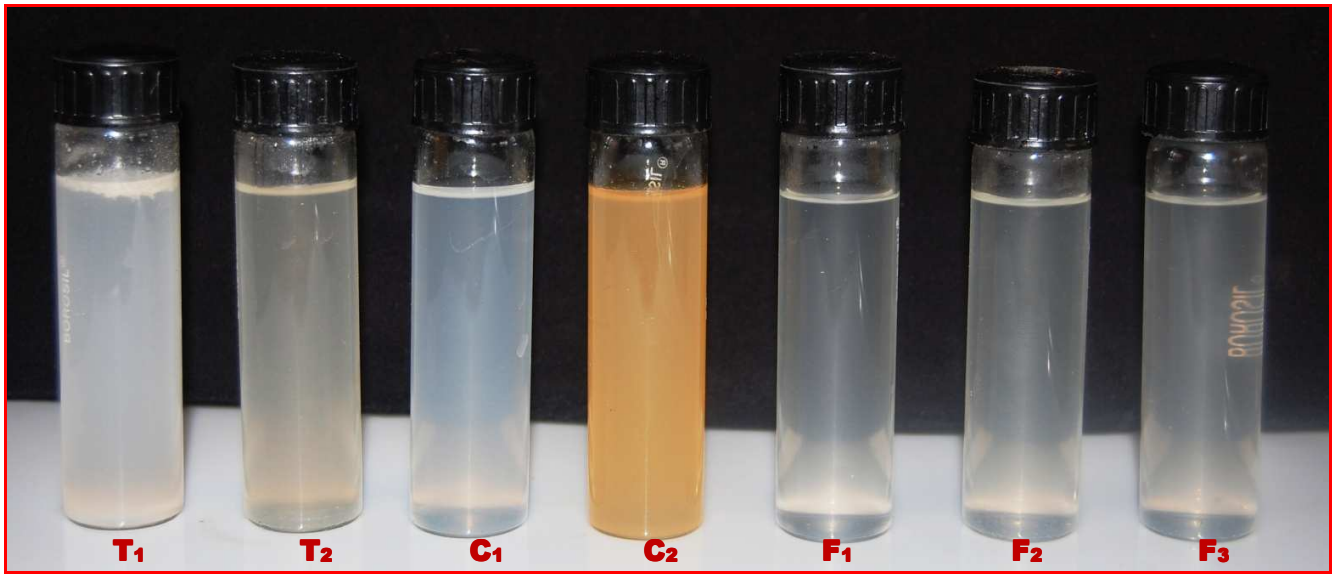


**Plate 2: Effect of physical and chemical amelioration on Dairy Effluent**

**Legend:**

$T_1$: Raw effluent
T2: Effluent treated @dairy
$F_1$: Sand filtrate
$C_2$: Ferric chloride @ 200 mg/l
$F_2$: Clay filtrate
$F_3$: Sand+ Clay filtrate
$C_1$: Potassium alum @ 100 mg/l


**Plate 3: Effect of combination of treatments on Dairy Effluent**

**Legend:**

$T_1$: Raw effluent
$T_2$: Effluent treated @ dairy
$T_3$: Sand filtrate+ Potassium alum
$T_4$: Clay filtrate+ Potassium alum
$T_5$: sand+ clay filtrate+ Potassium alum
$T_6$: Sand filtrate+ Ferric chloride
$T_7$: Clay filtrate+ Ferric chloride
$T_8$: Sand+ Clay filtrate+ Ferric chloride