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*Full Length Research Paper*

# Techniques for minimizing the excess sludge of wastewater treatment in various industrial sectors

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**Determination of COD and BOD in waste water from sludge can be reduced by using low cost adsorbent like Wooden Based Activated Charcoal (WBAC) and Laterite in a column used as a stationary phase. The parameters like specific gravity, viscosity, total suspended solids and pH are reduced with great effect by using WBAC and Laterite as a permanent adsorbent. The fixed bed efficiencies can be compared by changing the bed ration of adsorbent. The whole study of optimizing parameters has been done in column chromatography to compare the result of after treatment and before treatment. The fixed bed of WBAC and Laterite reduces COD and BOD value to 70 and 75% respectively. The ration of WBAC and Larerite in 2:3, 2:1, 1:3, 1:2 and 1:1 reduces the COD percentage as 66, 67, 71, 75 and 65% respectively and the BOD value is reduced as 71, 72, 73, 74 and 67% respectively. This is the maximum value of minimization of COD and BOD from waste water of dairy industry. Thus, it is a cheaper method for minimizing the excess sludge of wastewater treatment in various sectors.**

**Key words:** Dairy industry, COD, BOD, wooden based activated charcoal (WBAC), laterite, waste water.

## INTRODUCTION

Dairy plants are found all over the world, but because their sizes and the types of manufactured products vary tremendously, it is hard to give general characteristics. The dairy industry can be divided into several production sectors. Each division produces wastewater of a characteristic composition, depending on the kind of product that is produced. Wastewater from dairy industry may originate from the following sources:

1. Milk receiving: Wastewater results from tank, truck and storage tank washing, pipe line washing and sanitizing. It contains milk solids, detergents, sanitizers and milk wastes.
2. Whole milk products: Wastewater is mainly produced during cleaning operations. Particularly when different types of products are produced in a specific production unit, clean-up operations between product changes are necessary. In developing countries, the main problem is pollution through spoilage of milk.
3. Cheese/whey/curd: Waste results mainly from the production of whey, wash water, curd particles, etc. Cottage cheese curd for example is more fragile than rennet curd which is used for other types of cheese. Thus the whey and wash water from cottage cheese may contain appreciably more fine curd particles than that from other cheeses. The amount of fine particles in the wash water increases if mechanical washing processes are used.
4. Butter/ghee: Butter washing steps produced wash water containing butter milk. Skim milk and butter milk can be used to produce skim milk powder in the factory itself or these materials may be shipped to another dairy food plant by tank truck.
5. Milk powder: Environmental problems are caused by high energy consumption (= emission of $CO_2$, CO, etc.),

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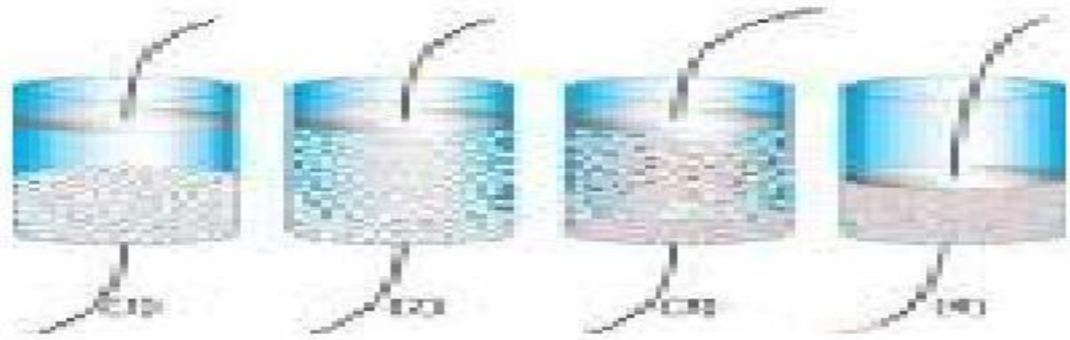

**Figure 1.** Adsorption column.

by cleaning and by emission of fine dust during the drying process.

(a) Condensed milk/cream/khoa: Environmental problems related to the production of condensate and khoa are mainly caused by the high energy consumption during the evaporation process. The main suspended solids mentioned in the literature are coagulated milk and fine particles of cheese curd.

Activated carbon is a carbon material mostly derived from charcoal. The unique structure of activated carbon produces a very large surface area: 1 lb of granular activated carbon typically provides a surface area of 125 acres (1 Kg = 1,000,000 $m^2$). The activated carbon surface is non-polar which results in an affinity for non-polar adsorbents such as organics. Activated carbon is very effective in applications requiring air or water purification as well as precious metal recovery or removal.

## MATERIALS AND METHODS

### Experimental setup

For the minimization of sludge from dairy industry, an adsorption study with wooden based activated charcoal is done on wastewater to maintain the conditions in dairy industry.

For the separating column of the column chromatography experimentation, the following experiment set up was used: an acrylic pipe with a height of 70 cm and diameter of 6.4 cm was used as the top inlet tap for the entry of wastewater in the following ratios: for ratio 1:1 of wooden based activated charcoal to laterite, there is 5 min interval of five run; for ratio 1:2 of wooden based activated charcoal to laterite, there is 5 min interval for five run; for ratio 1:3 of wooden based activated charcoal to laterite, there is 5 min interval for five run; for ratio 2:1 of wooden based activated charcoal to laterite, there is 5 min interval for five run; and finally for ratio 2:3 of wooden based activated charcoal to laterite, there is 5 min interval of five run. However, there was a bottom outlet tap used to collect treated wastewater as shown in Figure 1.

### Selection of adsorbent

The adsorbent particle size must be spherical and uniform; it should be pure and does not react with waste water.

### Material used

In the study, the following two materials were used as adsorbents: 1. Wooden based activated carbon (WBAC) and 2. Laterite. For dairy wastewater treatment, wooden based activated carbon and laterite were used as “low cost adsorbents”.

### Preparation of activated carbon from wood

Powder activated carbon is produced by steam activation of wood. This wood based activated carbon has high porosity and purity. Majority is being used in the water and wastewater treatment, decolonization and vapor phase injection systems. It has advantages compared to the material because of its ability to adsorb colour or aroma (Figure 2).

### Available wood based activated carbon types

Table 1 shows the different types of available wood based activated carbon.

### Preparation of laterite

Laterites are a source of aluminum ore; the ore exists largely in clay minerals and the hydroxides, gibbsite, boehmite, and diaspore, which resembles the composition of bauxite. In Northern Ireland, they once provided a major source of iron and aluminum ores. Laterite ores also were the early major source of nickel.

The soil containing laterite (Figure 3) is collected and washed with tap water to remove the impurities. The soil particles are dried in sunlight for 24 to 48 h then crushed

**Figure 2.** Wooden based activated charcoal.

**Table 1.** Powder wood based activated carbon.

| Product unit description | Product range available |
|---|---|
| Mesh size (US sieve) | Passing 100 mesh (99%)<br>Passing 200 mesh (95%)<br>Passing 300 mesh (90%) |
| Surface area ($m^2/g$) minimum | 1000 |
| Iodine (mg/g) minimum | 1000 |
| Methylene blue (ml) minimum | 180 |
| Moisture (%) | 10 |
| Fe (%) maximum | 0.07 - 0.1 |
| Cl (%) maximum | 0.1 |

to make different sizes of particles. Afterwards, it is washed with water to remove red colorization. Finally, the powder is dried in an oven at 110°C, after which the powder is used for acidic adsorption.

## Sampling and preservation of effluent

The sample is collected in a clean air tight plastic barrel having a capacity of five liters. For analysis, fresh samples are required so the sample are collected twice in a week and sometimes preserved samples (preserved in refrigerator at 4°C) are used for analysis. The wastewater from the dairy industry is first filtered to remove the soil particles, after which this filtered wastewater is used for further analysis.

## Optimization of various operating parameters

### *Optimization of surface area*

Fine powder of activated charcoal and laterite having 1 and 2 mm size are used in preparation of adsorbent in column.

### *Optimization of ratio*

For the analysis, the adsorbent used in the ratio of 1:1,

Figure2: Wooden Based Activated Charcoal

**Figure 3.** Laterite soil.

Figure 3: Laterite Soil

1:2, 1:3, 2:1 and 2:3 respectively for WBAC: laterite, to maintain the flow rate of effluent is 5 min; at the same time, there is effective removal of suspended particles from waste water. Thus, the most suitable size of adsorbent is used for the preparation of adsorbent in column chromatography.

***Optimization of contact B time***

For the study of the effect of contact time of 1000 ml of wastewater from dairy in column chromatography, there is variation in flow time and it is found to be 60 sec/5 min approximately. In this column chromatography, the effective treatment is obtained from 1:2 (WBAC: laterite) ratio. The chemicals used are LOBA samples which are out at ambient temperature in column chromatography method.

**Analytical methods**

For the analysis of various parameters, standard methods of water and waste water analysis are as follows:

**Procedure**

The adsorbent materials namely Wooden Based Activated Carbon (WBAC) and laterite are taken in different ratios by weight of WBAC which is less compared to that of laterite. Number of particles in half of the kilogram of WBAC is much more compared to that of laterite, that is, surface area for adsorption by WBAC is more than that by laterite. However, all the experiments were carried out at room temperature of 27.5°C±2.5°C. The column chromatography is conducted in 5 different columns of 100 cm height and 6.5 cm diameter. Columns are run in different ratios of WBAC and laterite as a stationary phase for all the experimental conditions like pH, viscosity, COD, specific gravity, and total suspended solids of solution. The influences of various operating parameters are studied by varying ratios of adsorbents such as WBAC and laterite. Surface area of adsorbents namely WBAC and laterite are chosen, considering the rate of flow of waste water. When the weight ratio is 2:3 (WBAC: Laterite), the size of WBAC and laterite particle is 1 mm, which gave satisfactory outflow of wastewater at a rate of 0.215 m/min. The column was prepared using mixed bed material and wastewater samples collected at different intervals of time. Thus, the filter water was analyzed for the different parameters mentioned above and the results are given subsequently.

**RESULTS AND DISCUSSION**

The column was prepared using mixed bed materials and wastewater samples collected at different intervals of time. Thus, the results obtained from the analysis of the different parameters mentioned in the foregoing are given in Tables 2 to 4 and Figures 4 to 9.

**Conclusion**

By the experimental data, WBAC and laterite are the low cost, easily available adsorbents used for the minimization of the sludge from the dairy industry. Laterite is acidic in nature and WBAC have good adsorbing ability to absorb neutral as well as basic components in the wastewater. The WBAC and laterite are mainly available materials for the preparation of mixed bed in adsorption column and is obtained from

**Table 2.** Production of wastewater as highly influenced by management practices.

| Type of product | Wastewater volume | | BOD | |
|---|---|---|---|---|
| | Average | Range | Average | Range |
| **(1)** | | | | |
| Milk | 3250 | 100 - 5400 | 4.2 | 0.20 - 7.8 |
| Condensed milk | 2100 | 1000 - 3000 | 7.6 | 0.20 - 13.3 |
| Butter | 800 | | 0.85 | |
| Milkpowder | 3700 | 1500 - 5900 | 2.2 | 0.02 - 4.6 |
| Cottage cheese | 6000 | 800 - 12400 | 34.0 | 1.30 - 71.2 |
| **(2)** | | | | |
| Milk (canned) | | 320 - 1870 | | 0.02 - 1.13 |
| Condensed milk | | 800 - 7290 | | 0.17 - 1.48 |
| Butter | | 800 - 6550 | | 0.19 - 1.91 |
| Natural cheese | | 200 - 5850 | | 0.30 - 4.04 |
| Cottage cheese | | 830 - 12540 | | 1.30 - 42 |
| **(3)** | | | | |
| Milk | | | | 0.2- 4.0 |
| Cheese | | | 0.9 | |
| Butter/milkpowder | | | 0.3 | |
| Total | 4000 | | | |

**Table 3.** Management attitude towards waste control.

| Product | Milk processed (kg/day) | BOD (kg/ton) | Wastewater (kg/kg) | Management level |
|---|---|---|---|---|
| Milk | 181,600 | 0.3 | 0.4 | Excellent: 19, 25, 26 |
| | 227,000 | 0.2 | 0.1 | Excellent: 19, 21, 26, 27 |
| | 113,500 | 0.7 | 1.0 | Good: 8, 10, 18, 20 |
| | 68,100 | 7.8 | 5.2 | Poor: 1 |
| Cottage cheese | 272,400 | 2.0 | 0.8 | Good: 8, 15, 16 |
| | 135,200 | 1.3 | 4.7 | Good: 8, 17 |
| | 295,100 | 71 | 12.4 | Poor: 2 |
| Milk, cottage cheese | 454,000 | 4.1 | 1.2 | Good: 2, 19 |
| | 211,110 | 1.8 | 1.1 | Good: 21, 22 |
| | 408,600 | 3.3 | 1.1 | Fair: 8, 9 |
| | 454,000 | 8.6 | 2.0 | Poor: 8, 3, 4 |
| Milk, butter | 135,200 | 0.9 | 0.8 | Good: 23, 24, 28 |
| Whey powder | 227,000 | 0.2 | 5.9 | Good-fair: 11, 12, 13 |
| Milk powder, butter | 90,800 | 3.0 | 2.5 | Fair: 14, 7, 3 |

agricultural by-products. The ratio of 1:2 (WBAC and Laterite) is more effective than other ratios in this ration that adsorbed all acidic and basic impurities particle from wastewater. It also helped to reduce the COD and BOD up to 75.75 and 74.51% respectively. The other parameters like pH, viscosity and total suspended solids also effectively reduced these techniques used in various industries for the treatment of waste water.

**Table 4.** Observation for average row waste water and treated waste water.

| S/N | Parameter | Row waste water | Treated waste water | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1:1 | 1:2 | 1:3 | 2:1 | 2:3 |
| 1 | Colour | Light milky | Transparent | Transparent | Transparent | Transparent | Transparent |
| 2 | Odour | Milky smell | No test | No test | No Test | No Test | No Test |
| 3 | Total suspended solid | 370 | 85 | 80 | 75 | 70 | 65 |
| 4 | COD | 1320 | 452 | 320 | 374 | 423 | 439 |
| 5 | Viscosity | 6.2 | 9.1 | 9.75 | 9.40 | 9.34 | 9.26 |
| 6 | Specific gravity | 0.63 | 0.85 | 0.87 | 0.89 | 0.95 | 0.97 |
| 7 | pH | 4.8 | 5.1 | 6.9 | 7.6 | 7.2 | 7.1 |
| 8 | BOD | 467 | 153 | 119 | 127 | 131 | 135 |

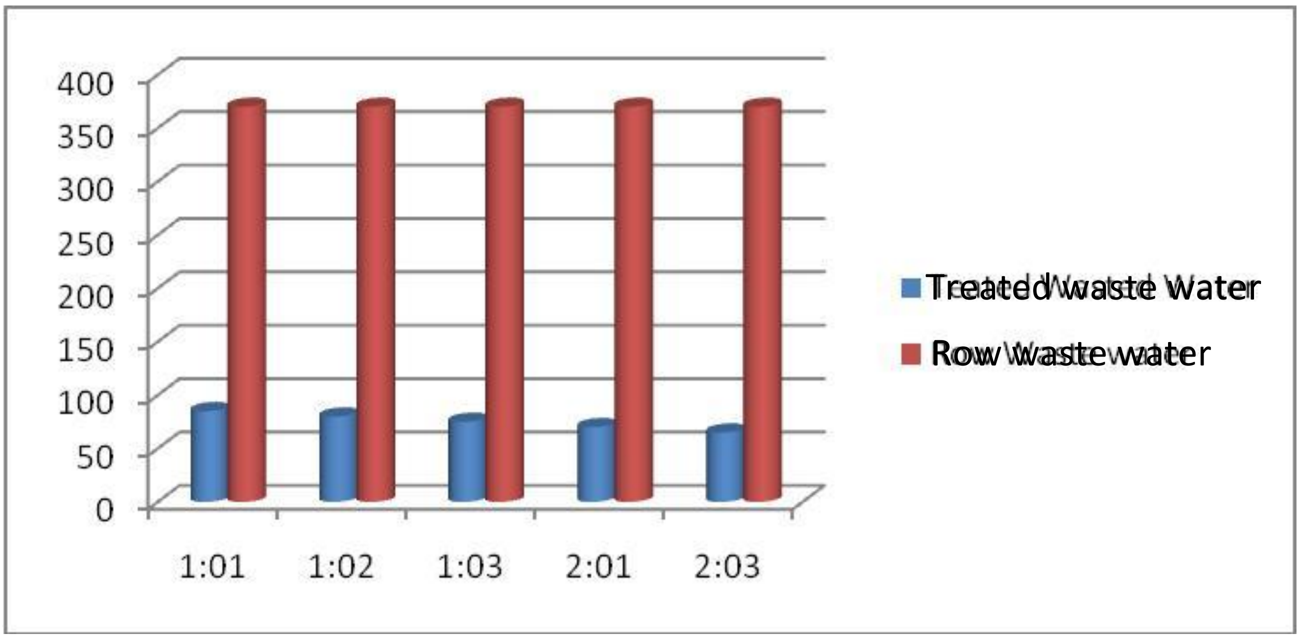


**Figure 4.** Total suspended solid.

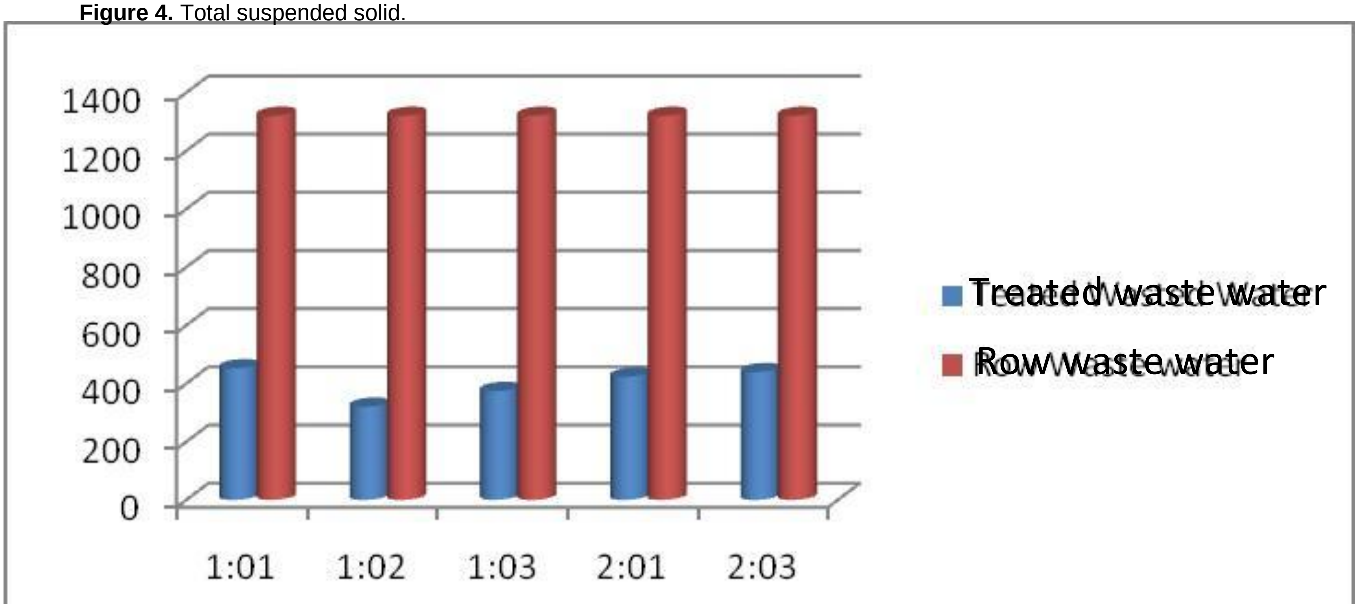


**Figure 5.** Chemical oxygen demand (COD).

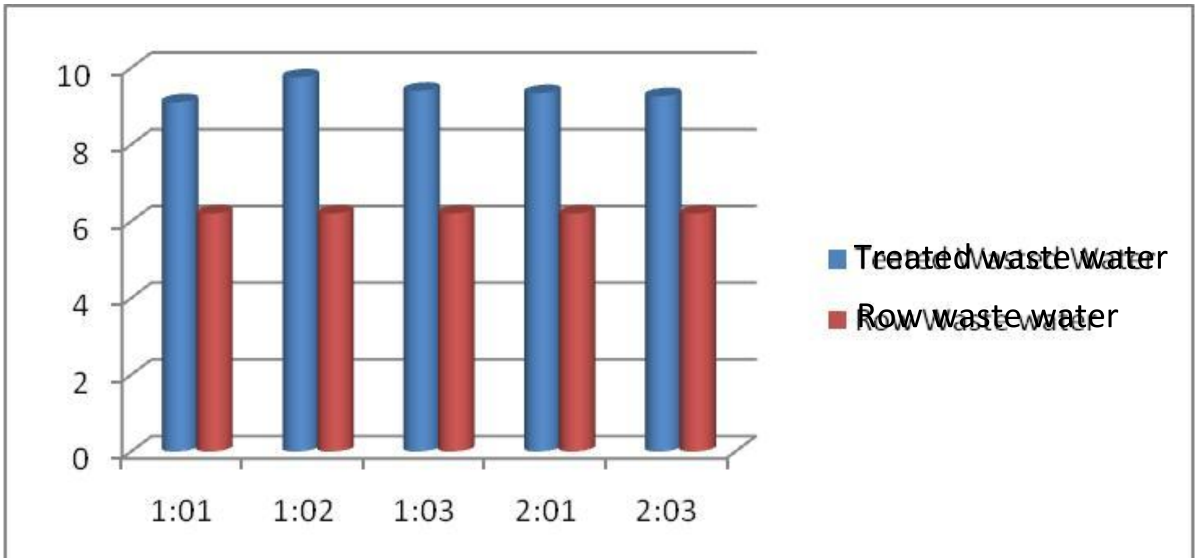


**Figure 6.** Viscosity.

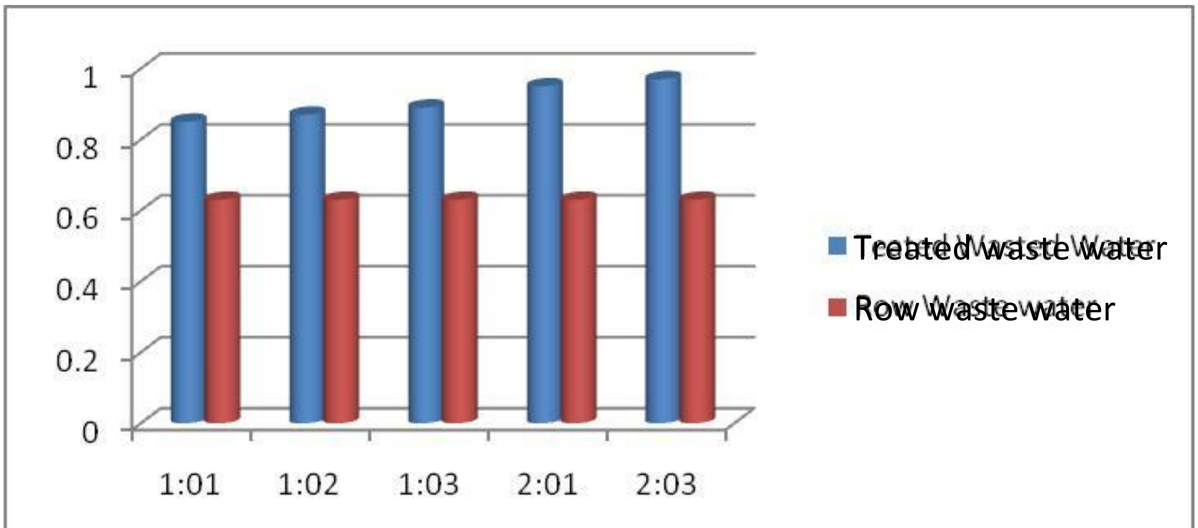


**Figure 7.** Specific gravity.

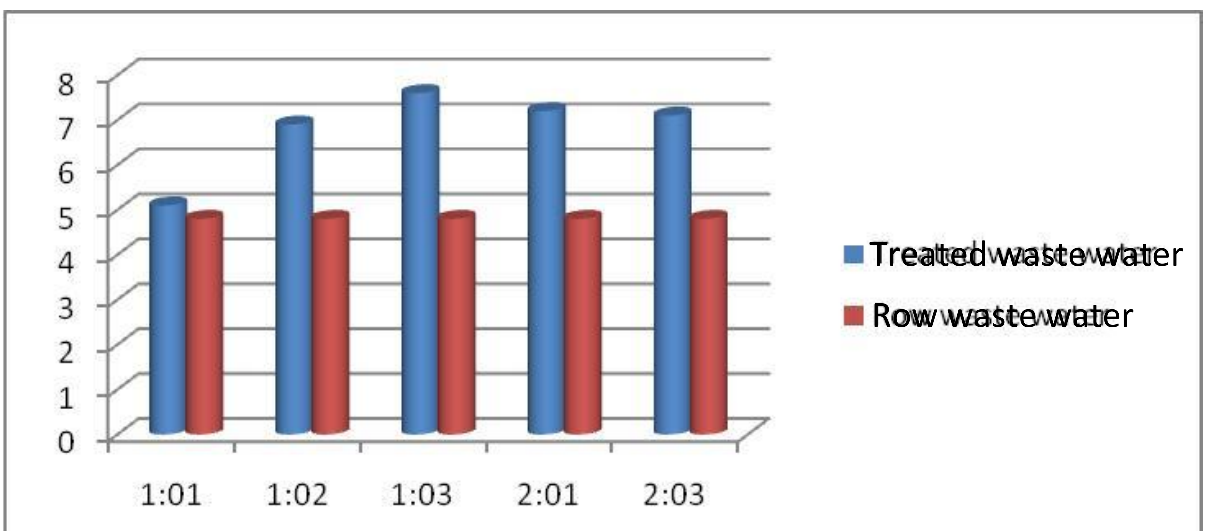


**Figure 8.** pH.

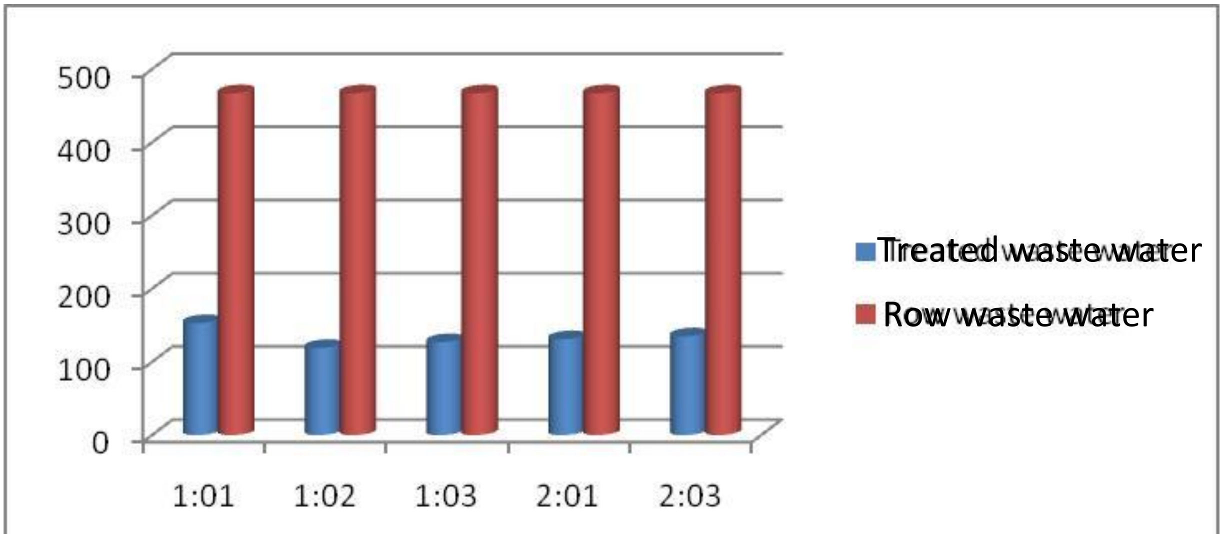


**Figure 9.** Biological oxygen demand (BOD).

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