Analysis of Aluminum Electrode-Based Electrochemical Treatment of DairyWastewater

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Abstract: When making milk products, a significant volume of water is utilized. This waste water has organic, biodegradable substances including dissolved sugar, protein, and lipids. Dairy waste water is therefore regarded as having a high organic matter concentration and a high Chemical-Oxygen-Demand (COD) level. According to estimates, the COD produced by the dairy business is higher than that of the sugarcane industry and varies from 1300 to 1800 mg/lit. The objective of this research is to identify the behaviors of several wastewater parameters. In order to figure out if recovered waste water was suitable for reuse, the effectiveness of the effluent treatment facility was also assessed. Wastewater produced by the cleaning and washing processes in the plant accounts for an important part of the water used in food processing. Dairy waste water was characterized high Biological-Oxygen-Demand (BOD), COD, and level of solids and their fraction such as total solids, total suspended solids, total dissolved solids, and concentration. The discharging of dairy waste water causes serious environmental problem. The execution findings include an evaluation of one of the Effluent Treatment Plants (ETP) offered for the treatment of wastewater produced by the dairy sector. One of the most advanced chemical methods is electrochemical treatment, which provides high removal efficiency in a small reactor with straightforward equipment for process control and operation. In this procedure, electrodes in a reactor tank receive an electric current that creates a coagulant agent.

Keywords: BOD and COD removal; Electrocoagulation; TDS; dairy plant; waste-water

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INTRODUCTION

Animal husbandry includes the dairy sector as an integral part. This includes raising milk, processing it for sale, and manufacturing dairy products.According to the Central Statistical Institute of the Government Statistics Office of India, the dairy sector belongs to the 20 major groups in the food industry. India is expected to produce 81 million tones of milk in 2001. It took India nearly 30 years to become self-sufficient in milk production. In 2010-11 and 2011-12, the country produced 123 million and 127.9 million tons of milk respectively. Compared to 2010-11, the annual growth rate of milk production increased by almost 5% in 2011-12. India maintained her third place among all Dairy wastewater contains soluble organics, suspended particles, and trace organics. High level of BOD and COD are primarily caused by all these factors. (cash on delivery). Dairy waste is typically white in color, slightly alkaline in composition, and rapidly acidified as a result of the fermentation of lactose to lactic acid. Milk waste has a significant airborne load, primarily due to the fine curds contained in cheese waste. The rapid and significant demand for oxygen is believed to be responsible for the detrimental environmental impact of dairy waste. The decomposition of casein produces a thick black sludge, the pungent odor of butyric acid, and other contaminants indicative of dairy waste contamination. Temperature, color, pH (6.5-8.0), DO, BOD, COD, suspended particles, chloride, sulfate, oil and grease are all characteristics of dairy wastewater. High levels of casein and other dairy components, as well as inorganic salts, detergents and disinfectants used for washing can be found in dairy wastewater. Because caustic soda is used to clean it, it contains a lot of sodium.

Dairy production are the most polluting

industries, both in terms of the quantity of wastewater and its overall composition. Each liter of processed milk produces from 0.2 to 10 liters of wastewater, an

average of 2.5 liters of wastewater. Quantity and composition of the waste-water produced in the dairy industry.

Figure 1: Field visit at Katraj Dairy, Pune

performed with Ti/TiO_2-RuO_2-IrO_2 electrode and

A new method of water treatment is electrochemical (EC) treatment. Electrical flotation, electrocoagulation and electrooxidation are major parts of the removed EC treatment. Electrical flotation is a simple process in which contaminant particles are transported to the surface of a liquid by the hydrogen and oxygen generated from the electrolysis of water as they move higher. The anode material is oxidized during electrocautery, resulting in the formation of various types of metal monomer and polymer hydrolysis. These metal hydroxides combine with colloidal particles present in the wastewater to form larger flocs, which are then removed by settling. These methods can be used to extract organic matter from wastewater.

BACKGROUND

Indra Deo Mall, et al., (2010) propose to use iron electrode for electrochemical treatment of simulated milk wastewater (SDW). To maximize the variables for more COD removal, design a factorial central complex with four factors, current density (J), sodium chloride (NaCl) (m), Electrolysis time (t) and pH - were used. D. Rajkumar1, K. Palanivelu, 2004, presents results of electrochemical treatment of wastewater containing phenolic chemicals from phenol-formaldehyde resin production, oil refinery and bulk drug production. Experiments were

undivided reactor at a fixed current density of 5.4 A/dm^2. But it was found that prolonging the electrolysis time reduced the AOX concentration. Calculations and presentations have been made on the energy consumption and current efficiency of the electrolysis. Yusuf Yavuz, et al., 2011, indicates an electrochemical treatment study for dairy sector wastewater (DW) was investigated utilizing a combined electrode system made of iron and aluminum, which is stainless steel (iron) as the cathode and aluminum as the sacrificial anode to remove soot, clay, and suspended particles. The impact of current density, starting pH, sodiumsulphate concentrations were investigated on the removal efficiency.

Guohua Chen, 2003, the processes of electrolocalization, electrocoagulation, electric flotation and electrooxidation have been highlighted. Colloidal particles, oils and greases can be effectively removed by electric flotation. Jai Prakash Kushwaha, et al., 2010, proposed electrochemical treatment of synthetic dairy wastewater using aluminum electrodes. Four operating parameters—current density (J, sodium chloride dosage (m), electrolysis time (t), and initial pH taken as input parameter and system response calculated as percentage of COD (Y1) and specific energy used (kWh per kg COD removed, Y2). K.Bensadok et al., 2011, proposes electro coagulation, causing indirect electrochemical destruction of dissolved pollutants. The removal of COD, phosphate and turbidity was examined under various operating parameters and the composition of the electrode material affected the removal efficiency. Serge Tchamango, et al. ,2009, calculated the efficiency of electrolytic treatment, electrocoagulation process is been used, using aluminium anode electrodes. It is convenient route foe treatment to get efficient parameters like turbidity, total phosphorus and nitrogen. The efficiency of COD removal has gained is upto 61%.

METHODOLOGY

The Katraj Dairy Company served as a collection source for wastewater samples used in the present investigation. It was founded in 1960 with the intention of offering country farmers in the Pune district a professional milk collecting service. During the first year of operation, Katraj Dairy collected about 30,000 liters of milk per day. Today, this has gradually increased to over 2.00 lakh liters per day, with the financial revenue of more than Rs. 250 crores. Milk and dairy products such as pasteurized or homogenized cow milk, fortified milk, two-tone milk, standardized milk, whole milk, butter and buffalo butter, flavored milk, buttermilk powder, soft cream and Pasteurized milk is manufactured and distributed by Katraj Milk and ifferent flavours of hard ice cream are available in various pack sizes.

The Methodology involves in collection of samples at different units. Effluent from ETP is collected with a total volume of two liters. To assess variations in plant operations, pH was monitored. The sample is kept cool until the required volume is obtained and analysis begins.

Stream Analysis:

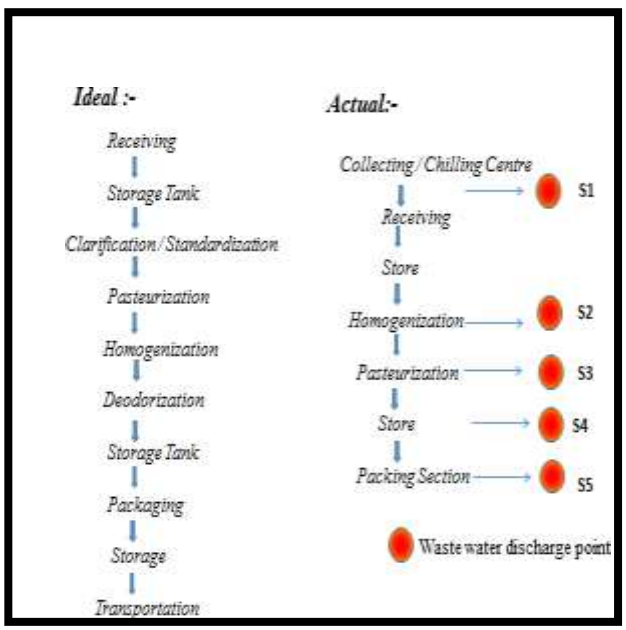

Figure 2: Comparison flow chart of Dairy IndustryStream characterizations are typically characterized by the following parameters,

High dissolved solids.
High suspended solid materials.
BOD and COD.
High sodium content due to the use of caustic soda for cleaning.

High proportion of nitrogen and phosphorus.

Sample Collection:

In this research first step is collection of data. For expected results we need to collect dairy waste water sample.

Figure 3: Dairy Wastewater Effluent

After sample collection it is necessary to find out psychochemical parameters for samereason we need to collect sample before treatment from source point. So we are calculating pH, dissolved solid, BOD, COD, TDS, content in sample.

On this basis of pre-treatment analysis data and literature survey making and developing of electrolysis reactor by considering various factor on laboratoryscale.

As the reactor used for the process of dairy waste water treatment the post characterization of sample is carried out.

To understand the study and performance of electrodes for better result the statisticalapproach carried out.

Experimental Setup:

In this research different parameters of dairy waste water or characterized waste waters such as the analysis of COD, BOD, level of solids and their fraction. The tests were performed forElectrocoagulation as follows;

Step 1:

Dairies handling milk are classified as receiving, pasteurization, bottling, condensing, Homogenization, Deodorization, Butter making, cheese making etc. these all have outlet underground connected to ETP.

Step 2:

The performance of the wastewater sample will be evaluated using different parameters and pretreatment methods. Parameters such as COD, BOD, TDS are calculated. To measure it's before and after change intreated parameters.

Step 3:

Electrolysis model was prepared by using three different electrodes such as aluminium, zinc, graphite having 15 cm length, 10-12 mm diameter of rods.

Figure 4: electrodes used for ElectrochemicalTreatment

The three reactor made by using plastic cane having capacity up to 3 liter. EC setup consists of two chambers Anode (anaerobic) and Cathode (aerobic).

Figure 5: Reactor Setup

Dairy waste water of 2 liter fed into plastic reactor and electrode was dip into the sample and connection was perpendicular type monopole and regulated DC dual power supply ofvoltage of 0.01A

Step 4:

Analyzing the change in Time and current as 4 hours,8 hours, 16 hour, 24 hour and 48 hour to maximize the removal efficiency COD. To get the maximum efficiency amongstthe change in time and current ofCOD removal.

Step 5:
Analysis of characteristics of waste water (Posttreatment characterization)

Figure 6: COD Procedure & Determination

4. RESULTS AND DISCUSSION:

The laboratory investigations provided the results showed as in figures 7-12. As the prime regulatory parameter is TDS, COD, BOD the emphasize has been given to regulate the same using different electrode materials with same current. The figures bellow indicates effect of electrode materials after 4 to 48 hours treatment on dairy wastewater.

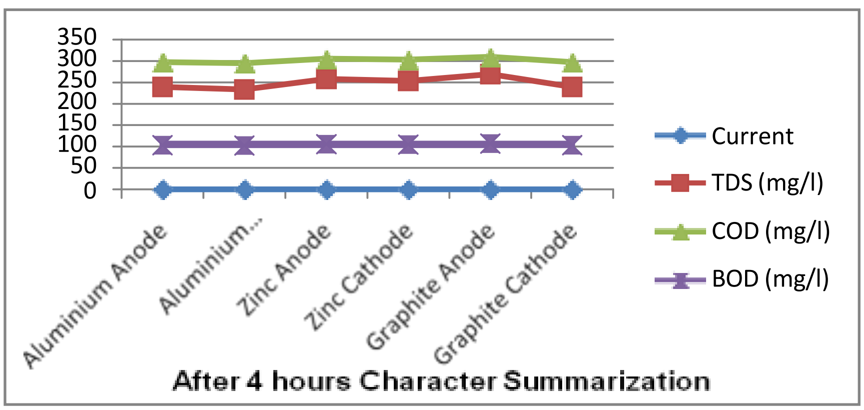

Figure 7: Character Summarization after 04 Hours

The figure 7 indicates the character summarization after 4 hours; the graph shows efficiency of COD is high in Aluminum, Zinc and Graphite having values approximately 300 and above. Whereas TDS shows low values in Aluminumand slightly increased in Zinc and Graphite respectively. Since the BOD removal for all the materials are same during the 4 hours process.

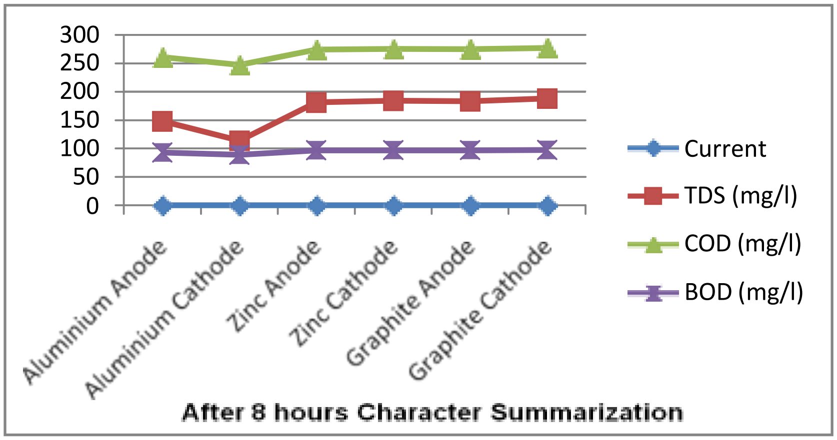

Figure 8: Character Summarization after 08 Hours

The figure 8 indicates the character summarization after 8 hours; the graph shows the COD and BOD in all materials are same i.e. they shows slightly low efficiency in Aluminium Cathode as compare to Aluminium Anode. Whereas removal efficiency is high in both Zinc and Graphite respectively. TDS value in Aluminium also shows lower value as compare to Zinc and Graphite.

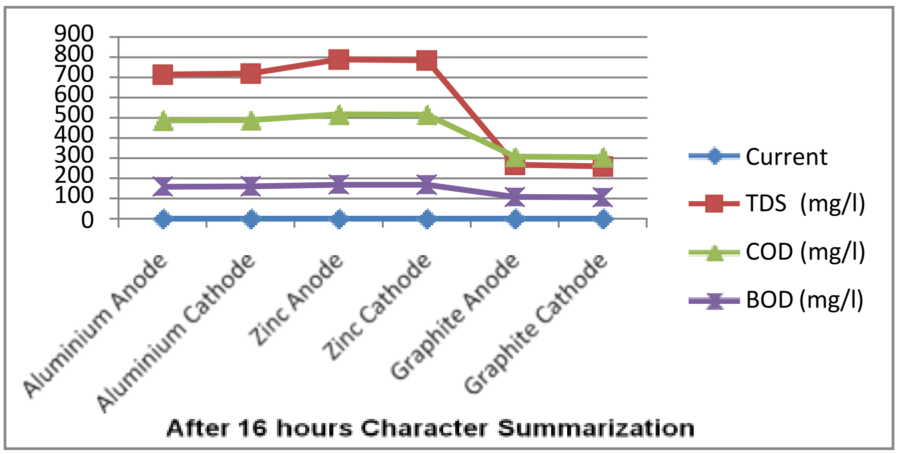

Figure 9: Character Summarization after 16 Hours

The figure 9 indicates the character summarization after 16 hours; the graph shows that the removal efficiency COD and BOD in Aluminum and Zinc goes on increasing after 16 hours reaching the value 500-550 mg/l but the removal in Graphite gets decreased. Also the TDS value for Zinc is higher as compare to Aluminum and Zinc respectively.

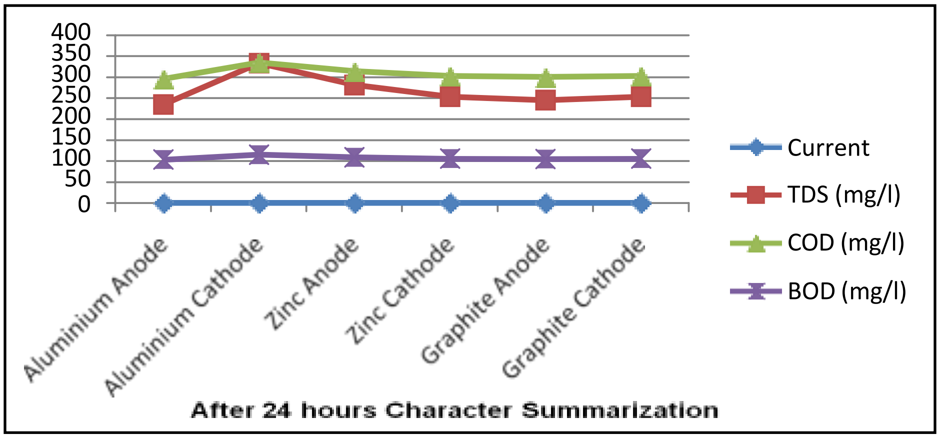

Figure 10: Character Summarization after 24 Hours

The figure 10 indicates the character summarization after 24 hours; the graph shows the COD is high in Aluminum cathode, having values approximately 350 and above. Whereas TDS shows low values in Zinc and Graphite and slightly increased in Aluminum respectively. Since the BOD removal for all the materials are same during the 24 hours process.

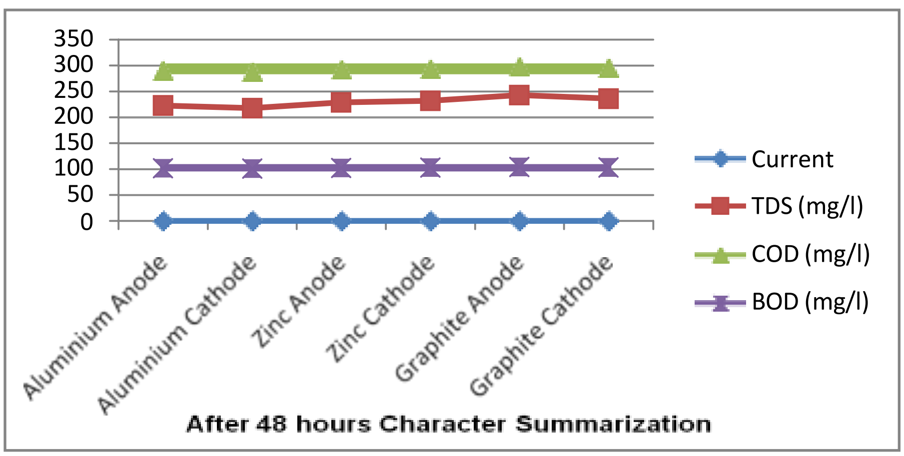

Figure 11: Character Summarization after 48 Hours

The figure 11 indicates the character summarization after 48 hours; the graph shows COD is same in all the materials, having values approximately 300 and above. Whereas TDS shows low values in Aluminum and slightly increased in Zinc and Graphite respectively. Since the BOD removal for all the materials are same during the 48 hours process.

The overall character summarization for the observation after 48 hours shows the removal efficiency of COD and BOD remains the same in all the materials and the values of TDS also remains thesame in Aluminum, Zinc and Graphite respectively.

Performance of various electrodes for TDS

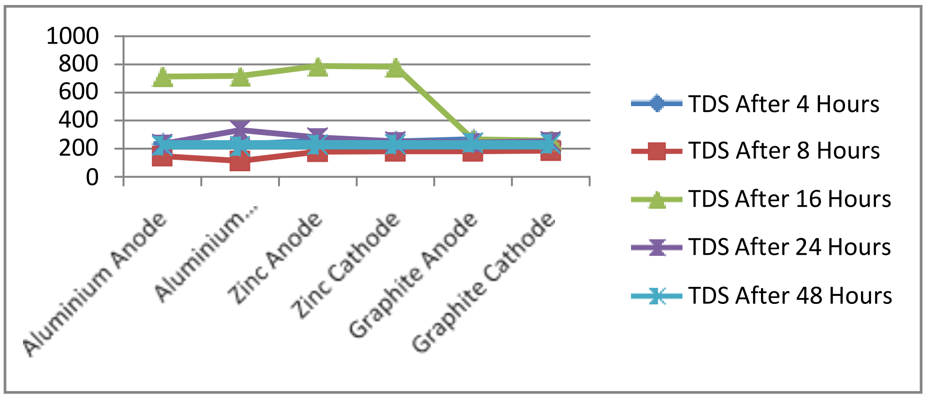

Figure 12: Performance of Electrodes for TDS

The above figure 12 indicates the performance of various electrodes for TDS; the graphshows the after 4, 8, 24, 48 hours the values of TDS remains the same for all the materials, whereas after

Performance of various electrodes for COD

16hrs the TDS value increases in Aluminum and Zincshows approximately 800 and above but the value remains the same in Graphite.

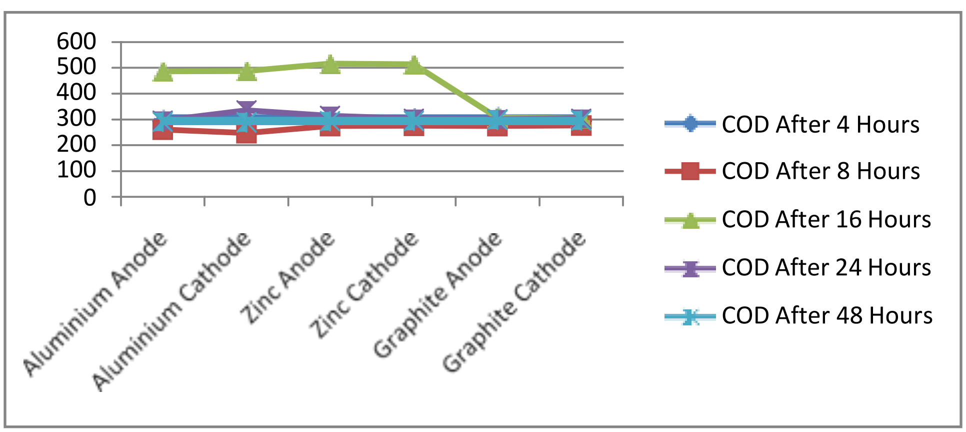

Figure 13: Performance of Electrodes for COD removal

The above figure 13 indicates the performance of various electrodes for COD; the graph after 8 hours the removal efficiency of COD

remains the same for Aluminum and Zinc, whereas after 16hrs the efficiency of COD increases for both Aluminum and Zinc but not observed in Graphite.

Performance of various electrodes for BOD

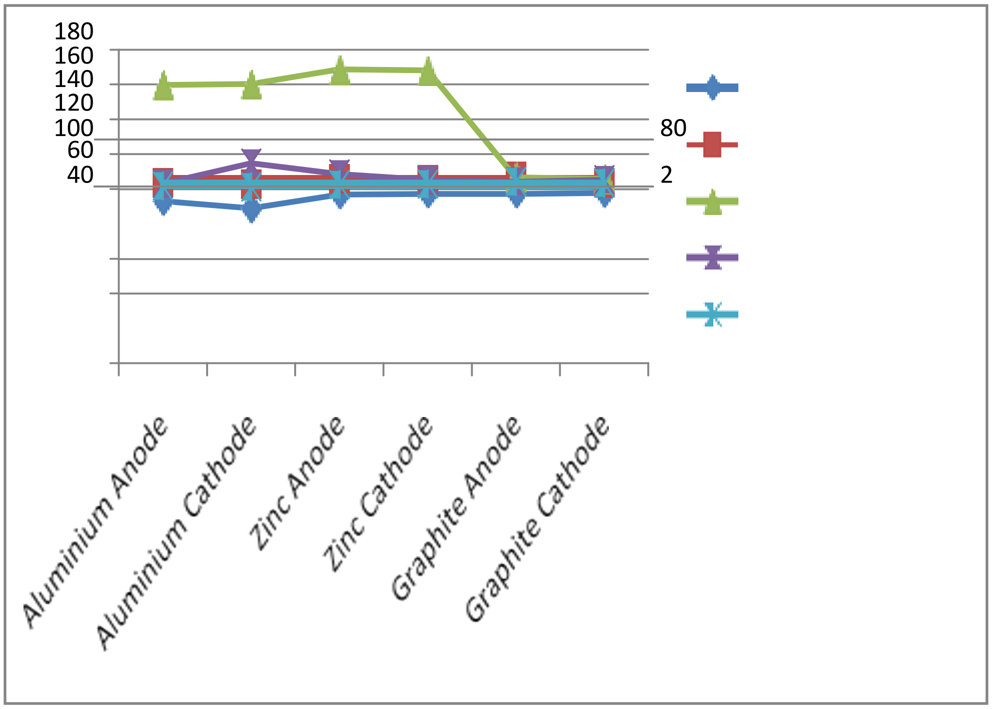

Figure 14: Performance of Electrodes for BOD removal

The above figure 14 indicates the performance of various electrodes for BOD; after a contact period of 4hrs removal efficiency of BOD increases for Aluminum, Zinc and Graphite remains the same, but after a 16hrs the removal efficiency increases but removal efficiency is not observed in Graphite.

From above all figure 12 – 14 the performances of TDS,COD and BOD shows that the value of all three parameter are increased after 16 hours of contact period having same flow of current and after 48 hours reaches to the certain values.

CONCLUSION

Dairy wastewater treatment is one the costlier affair for this industry. The study carried out for optimization of resources highlighted the need of systematic approach towards characterization and treatment. The study initially audited point sources of wastewater from the dairy processes. The quantification of the wastewater helped to optimize the treatment approaches as well as resource management. The characterization helped to identify strength of wastewater and further to decide the best possible strategy for treatment. The present practices need to be revised due to excessive pretreatment expenses and non recovery of commercial product. The sludge generation needs to be increased so as to reduce the strength in terms of COD. Electrochemical

treatment is most popular technology now a day, but need electricity as power. Its simple mechanism and less operation and maintenance cost will be helpful toreduce overall expenses. The electrochemical coagulation for dairy wastewater treatment hence found comparatively efficient approach. The attempt was carried out to select efficient electrode material when compared for aluminum zinc and graphite. As aluminum and zinc electrode are more popular; can be recommended. Further, considering economic factor, it would be better if aluminum electrode will be preferred. For the country like India, where Dairy industry is second largest industry and mostly operated on people cooperative venture, such optimization study will be better.

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