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Treatment of dairy wastewater using the Electrocoagulation process

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Abstract: Dairy wastewater is a major source of environmental pollution due to its high content of organic matter, nutrients, and suspended solids. Electrocoagulation (EC) process is an efficient and sustainable technology that can be used for the treatment of dairy wastewater. This paper presents a review of recent studies on the treatment of dairy wastewater using the EC process. The paper discusses the operating parameters, such as current density, pH, and reaction time, that influence the efficiency of the EC process. The paper also highlights the advantages and limitations of the EC process and compares it with other conventional treatment methods. The results of recent studies indicate that the EC process can effectively remove the pollutants from dairy wastewater and produce a treated effluent that meets regulatory standards. The paper concludes by recommending further research to optimize the EC process for the treatment of dairy wastewater..

Keywords: Dairy wastewater, Electrocoagulation, Current density, pH, Reaction time

INTRODUCTION

The dairy industry is considered to be the largest source of wastewater in many countries to be the largest source of wastewater in many countries among the food processing Industries. In India, the dairy industry is one of the major industries causing water pollution. Dairy wastewater is enriched in organic matter and also contains biodegradable carbohydrates. The organic substances present in wastes come directly in the same or degraded form. The dairy wastewater is generated at receiving stations, sanitization, boiling plants, cheese plants, butter and dried milk plant as well as can washing plants etc. The treatment of dairy wastewater is of critical importance both from the environmental point of view, also for recycling water for use in industrial purposes. In dairy wastewater biological oxygen demand (BOD), chemical oxygen demand (COD) and nutrients are higher than disposal standards. Discharging wastewater without any treatment affects the whole environmental system. Therefore, the treatment of dairy wastewater is very important to protect the environment for future generations and avoid scarcity of water for the dairy and other industries' requirements. Dairy effluents are generally treated with physic-chemical and biological processes. The physic-chemical processes suffer the disadvantage that the reagent costs are high and soluble COD removal is low. Further, chemical treatment could induce secondary pollution due to the addition of chemical coagulants which may contaminate the treated water. The biological treatment process requires more space and a long time for treatment along with the generation of a high amount of sludge as well as high energy costs. Electrocoagulation can be another way to treat wastewater. Recently, the electrocoagulation process is emerging as a cost-effective treatment method for the treatment of varieties of wastewater. The Electrocoagulation (EC) process is a simple and compact reactor, with minimum operations and maintenance that gives maximum removal for the varieties of wastewater.

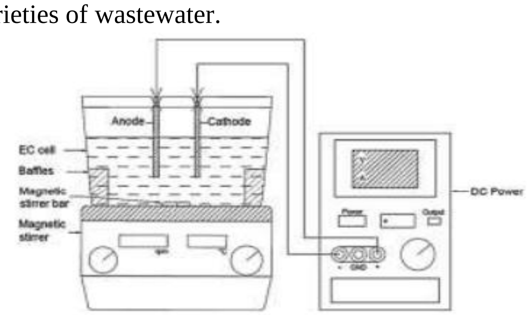


Fig:- set up of electro-coagulation

METHODOLOGY

Conductive metal plates are often referred to as "sacrificial electrodes". The sacrificial anode reduces the potential of the anode and reduces the passivation of the cathode. Battery-powered monopolar electrodes are arranged in series. In the cell process, there must be a greater difference from the current supplied, as the cells connected in series are stronger. During electrolysis, the positive side undergoes anodic reaction, while on the negative side, the cathode reaction is encountered. The coagulation process will be initiated by neutralizing charges of particles by released ions. The released ions remove undesirable contaminants rather by chemical reaction and precipitation or by causing the colloidal materials to coalesce, which can then be removed by flotation. Water containing colloidal particulates, oils, or other contaminants moves through the applied electric field, there may be ionization, electrolysis, hydrolysis, and free-radical formation which can alter the physical and chemical properties of water and contaminants. The active and excited state causes pollutants to leave the water and become damaged or deteriorate.

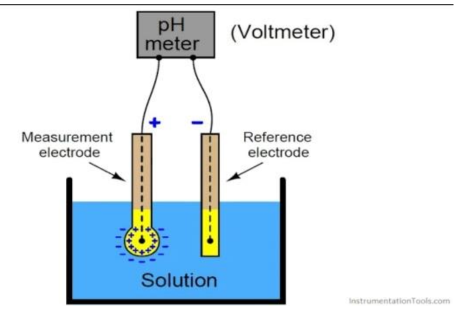
ANALYSIS

Materials

- Aluminium electrodes.
- Magnetic Stirrer.
- Stop Watching.
- pH meter.
- Ammeter
- Glass awesome glass wares were used in this work such as 500ml beakers, volumetric flasks and others.
- Filter paper

Testing on dairy wastewater

1. pH: The pH of a substance is defined as the negative logarithm of its hydrogen ion concentration [pH = -log(H+)]. When the dissociation products of water are in equilibrium, the pH of water is 7, which is considered neutral as it does not show any reaction with acid or alkali. However, as the concentration of hydrogen ions (H+) increases, water becomes acidic, and when it decreases, water becomes alkaline. The pH ranges from 0 to 14, with 0 being acidic, 7 neutral and 14 alkaline.



PROCEDURE Electrometric method:

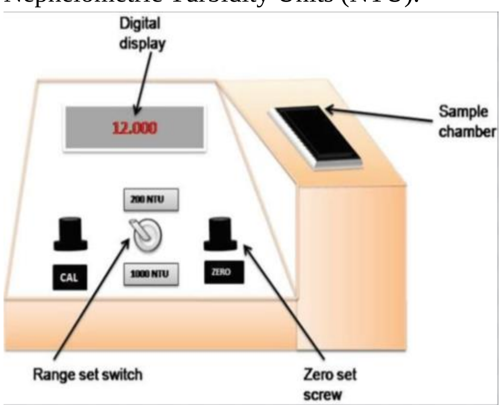
1. Wash the combined electrode of the pH meter with distilled water and clean the same with distilled water. 2. Dip the combined electrode in the buffer solution of pH value 4. 24 3. Adjust the temperature by the adjustment knob to an ambient (room) temperature. 4. If the instrument shows the reading as 4 then it is in order if not, adjust the reading to 4.0 with the calibration adjustment knob. 5. Wash the electrode of the pH meter with distilled water and clean the same with distilled water and dip it into the buffer solution of pH value 9.2. 6. Note the reading if the instrument shows the reading as 9.2, then it is in order otherwise use the calibration adjustment knob and bring the reading to 9.2. 7. Repeat the above procedure until the meter shows a reading of 4 when the electrode is dipped in a buffer solution of pH 4 and shows a reading of 9.2 when the electrode is dipped in a buffer solution of pH value 9.2. 8. Now the instrument is calibrated. 9. After cleaning the electrode dip in the sample for which the pH value is to be found. 10. Directly record the reading from the meter without doing any adjustments.

2. Turbidity:

Turbidity is the result of suspended materials that absorb and scatter light. These materials are colloidal and finely dispersed, which means they won't settle under calm conditions and are difficult to remove by sedimentation. In water supply engineering, turbidity is a critical parameter because it makes water aesthetically unpleasant and causes issues in water treatment processes such as filtration and disinfection. Turbidity measurements using Nephelometric instruments are expressed in Nephelometric Turbidity Units (NTU) and are often used as an indicator of possible bacterial presence. The Nephelometric apparatus is specifically designed to measure the forward scattering of light at a 90-

degree angle to the path of an incandescent light beam. Suspended particles in a water sample reflect a portion of the incident light off the surface of the particle. A photoelectric detector measures the light reflected at 90 degrees and compares it to light reflected by a reference standard. The turbidity test is not subject to interference.

Procedure:
• Switch on the nephelometric turbidity meter • Fill the sample cell up to the given mark with the provided sample and insert it into the cell holder in the turbidity meter. • Ensure that the sample cell is clean, dry, and free from any fingerprints. Use tissue paper to wipe the outside of the cell. • Make sure that the cell is fully inserted and held securely in place. • Cover the sample with the light shield or cover lid. • The digital reading is displayed in Nephelometric Turbidity Units (NTU).



3. CHEMICAL OXYGEN DEMAND:

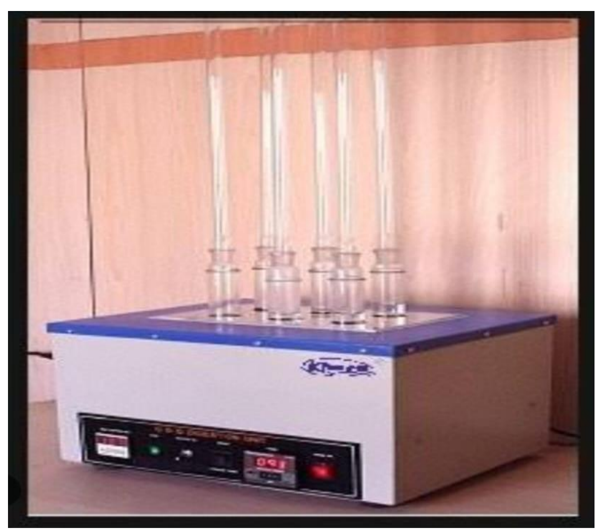
The COD test is employed to determine the amount of organic matter in a sample that can be oxidized by a potent chemical oxidant and is measured in terms of oxygen equivalence. This method is particularly useful for specific sources and can be correlated empirically to BOD, organic carbon, or organic matter. Once a correlation has been established, the test can be employed for monitoring and control purposes. The dichromate reflux method is the preferred approach compared to other oxidants due to its superior oxidizing ability, wide applicability to various samples, and the fact that it achieves 95 to 100% of the theoretical value in oxidizing most organic compounds.

Reagents: i) Standard potassium dichromate 0.25 N ii) Conc. H_2SO_4 (A.R. Grade) iii) Ferroin Indicator – Dissolve 1.485gm 1-10 phenanthroline monohydrate together with0.695 gm ferrous sulphate ($FeSO_4$, $7H_2O$) in distilled water and dilute to 100 ml. Catalyst – Silver Sulphate (for 8 straight chain sulphatic compounds) mercuric sulphate (for Cl^-). iv) Sulphomic acid – Required only if the interference of NO_2 is to be eliminated. Add 10 mg sulphamic acid/mg NO_2 – N if present, in the refluxing flask. (Do not forget to add in a blank also in this case).

PROCEDURE:
• Take a 50 ml sample or an aliquot that has been diluted to 50 ml with distilled water and place it in a round bottom refluxing flask with a ground glass joint of 300 ml capacity. 27 • Add 25 ml of $K_2Cr_2O_7$ and 75 ml of concentrated H_2SO_4 to the flask. Gently shake the mixture and attach the refluxing condenser. Reflux the mixture for a period of 2 hours. • After refluxing, wash the condenser with distilled water to remove any residue. • Allow the mixture to cool and then dilute it with distilled water. • Titrate the mixture with ferrous ammonium sulphate (0.25 N) using a ferroin indicator until the red colour appears after the intermediary reddish brick colour.

Calculation: -

COD Formula: - COD (mg/lit) = $\frac{(\mathbf{A-B}) \times \mathbf{N} \times \mathbf{8000}}{\textbf{ml of sample taken}}$ Where, A = ml of FAS required for the blank sample. B = ml of FAS required for a sample of dairy waste. N = Normality of FAS = 0.1



Dissolved Oxygen:

For standardization of sodium thiosulphate solution, take NaSO solution in the burette. In a conical flask, take 2 ml (or Smi) of 0.IN KIO, Potassium Iodate. Dilute it by adding 8-10 mi distilled water. Add approximately 1 ml of 3% acetic acid solution. Add about 0.5 gm Kl crystals. Mix well. The solution is after completely dissolved. titrate with NaSO, immediately. Add NaSO till pale yellow colour appears. Then add 2-3 drops of starch indicator and titrate till blue to colourless. Find out the normality of NaSO by using the formula, NV settle.Do not remove the faucets.

Fill the BOD Bottle (300 ml capacity) with the sample up to the rim. Tap the bottle from the sides to remove air bubbles inside the bottle and stopper the bottle. Then take out the stopper and add 2 ml of MnSO, solution followed by 2 ml of alkali-iodide-azide reagent (D the additions by dipping a pipette inside the boule. Use separate pipettes for each reagent). Stopper the bottle carefully to remove the air bubbles and mix by inverting the bottle a few times. When the precipitate has settled sufficiently, add 2 ml of Cone H.SO, way Mayr stopper the bottle and mix by inverting several times until the precipitate goes into the solution. Take 200 ml of the solution in a conical flask and add Na,5,0, titrant till pale yellow colour appears. Then add starch indicator and titrate till blue to colourless.

Reactions:

MnSO, +2 KOH → Mn(OH), K_2SO_4 White ppt

$2Mn(OH)_2 + 0_2$ (DO) → $2MnO(OH)_2$ Brown ppt

Basic manganese oxide

$2Mn(OH)_2 + 2KI + 2H_2SO_4 \rightarrow 2MnSO_4 + 4H_2O + I_2 + 2KOH$

Where $I_2 = O_2$

$2\ Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2\ Nal$

Calculations:

DO in sample mg/L =[A x F x 1000]/ml sample (200 ml) Where A = ml of $Na_2\ SO_2\ O_2$ solution required

F = Factor

As 1 ml of 1N Na_2,S_2O_3= 8 mg of oxygen

1 ml of x N $Na_2S_2O_3$ =8 x mg of oxygen

F = 8 x

Where x is the actual normality of $Na_2S_2O_3$

Electrical sConductivity:

Electrical conductivity (EC) is a measure of the ability of a solution to conduct electrical current transported by ions in solution, and conductivity increases as the concentration of ions increases; EC value is used to substitute measure of TDS concentration; EC of water important parameter to determine its suitability for irrigation. The salinity of treated wastewater to be used for irrigation is estimated by its EC;

SI units: milli siemens per meter (mS/m)

Estimation of TDS of water sample based on measured EC value: TDS (mg/L) EC (ds/m) x (0.55-0.70)

RESULT

Parameters	Initial Values	Final Value	Permissive levels
pH	7.50	8.42	6.5-9.0
Turbidity (NTU)	128(NTU)	09(NTU)	Below 10
Conductivity(s/m)	1.29 (s/cm)	1.03c(s/cm)	-
COD (mg/lit)	564 (mg/L)	120 (mg/L)	Below 125
Dissolved Oxygen(mg/lit)	1.3 (mg/L)	5.1 (mg/L)	4.0-9.2
Colour	Yellowish	Transparent in colour	Clearly visible to the naked eyes

CONCLUSIONS

In this study the removal of pollutants from dairy wastewater by electrocoagulation technique using aluminium electrodes was investigated also the various process parameters such as electrolysis time, Voltage, stirring speed, and spacing between the electrodes on removal efficiency were investigated.

The main conclusions made on the work are

- The electrocoagulation process was successful in removing pollutants, Turbidity from dairy wastewater and turbidity removal efficiency was dependent on Process parameters such as electrolysis time, Voltage, Stirring Speed, and Spacing Between the Electrodes.
- The results showed that electrolysis time, Voltage, and Stirring Speed, were all in direct proportion to turbidity Removal Efficiency whereas electrode distance was found to be in inverse proportion to pollutants removal Efficiency.
- Based on the experimental results obtained the optimum parameters for dairy wastewater with Aluminium as Electrode are
    - Electrolysis time = 60 minutes

- Voltage = 15 volts
- Stirring speed = 50 rpm
- Spacing of electrodes = 3.5 cm

- Comparatively higher efficient turbidity removal was obtained by Al electrodes.
- Colour removal was 100% and treated effluent looked like clear water.
- The various parameters of treated dairy effluent meet the disposal standards.
- Hence from the project work it can be concluded that for EC technology with Aluminium Electrodes with obtained optimum parameters is efficient and economical for dairy wastewater.

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