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Treatment of Coalgasifier Effluent using Dual Chamber Microbial Fuel Cell

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Abstract: This study was designed a waste water treatment plant with an aim at minimizing and removing of COD, BOD, dissolved solids, and toxic compounds, before it releases into a water body. In the present study efficiency of Microbial Fuel Cells (MFC) in removing contaminants was determined. It was found that MFC is much effective and cheaper method for treating waste water and for the removal of TDS, TSS, BOD, COD, Sulphates and Chlorides, Oil and Grease. Batch type aerobic biological treatment plant was constructed and operated for Coalgasifier industry waste water treatment. The hydraulic retention time was 12 days. The treated water samples were collected for every 72 hours and tested for its pH, TSS, TDS, COD, BOD, Sulphates and Chlorides, Oil and Grease to evaluate the efficiency of the plant. Experiments are performed in batch reactor in optimized condition. The degradation of waste water has been investigated in terms of reduction in COD. Various process parameters like pH, TSS, TDS, BOD, Sulphates, Chlorides and Oil and Grease were varied and their effects on MFC of Coalgasifier industry waste water have been analysed. The results obtained were quite appreciable as it reduced COD to 94% and a small amount of 129mV has also been produced.

Keywords: BOD, Coal Gasifier Effluent, *Lactobacillus*, COD, MFC.

INTRODUCTION

The coal gasification industry in India has been rapidly developed and played an important role in new clean and renewable energy market in recent years [1]. However, the arbitrary discharge of coal

gasification wastewater (CGW) would cause a serious environmental problem, due to the presence of complicated and considerable amounts of toxic compounds such as sulphates and chlorides compounds [2]. Conventional treatment of CGW includes a series of biological treatment (mostly anoxic–toxic process and activated sludge process) [3] after a physical-chemical, pre-treatment to reduce the concentrations sulphates and chlorides, The biologically pre-treated CGW still contains a large number of toxic and refractory compounds as well as their derivatives, with lower biodegradability than the raw wastewater. Meanwhile, Great attention has been given to the anaerobic digestion method, due to its capability to increase the degradation rate of refractory compounds and improve degradation of CGW [4]. However, the removal efficiency of phenolic compounds was still less than 65% even at a prolonged HRT of 48 h in two-continuous thermophilic anaerobic UASB process. As regards nitrogen compounds, which exhibited poor removal efficiency in an aerobic process needed to be removed by the followed aerobic treatment in order to meet the requirement of concerned standard. Therefore, there is a need for an improved process with the merits of anaerobic that is more practical in terms of investment costs and efficient removal nitrogen for advanced treatment of real biologically pre-treated CGW. Microbial Fuel Cells have the potential to simultaneously treat wastewater for reuse and to generate electricity; thereby producing two increasingly scarce resources. While the Microbial Fuel Cell has generated interest in the wastewater treatment field, knowledge is still limited and many fundamental and technical problems remain to be solved [5]. Microbial fuel cell technology represents a new form of renewable energy by generating electricity from what would otherwise be considered waste, such as industrial wastes or waste water etc. A microbial fuel cell is a biological reactor that turns chemical energy present in the bonds of organic compounds into electric energy, through the reactions of microorganism in aerobic conditions [6]. The study was under taken with following objectives are Characterization of waste water, Microbial Fuel Cell treatment of Coalgasifier industry waste water and Effect of MFC to reduce the impurities for various parameters [7].

MATERIALS AND METHODS

Treatment Procedure: The present study was carried out to investigate the capability of biological process for the treatment of Coalgasifier industry effluent. The experimental work was carried out to reduce the parameters like pH, TSS, TDS, BOD, COD, Sulphates, Chlorides and Oil and Grease. Microbial Fuel Cell is used for the treatment of waste water sample continuously for a span of 12 days taking samples at regular intervals of 72 hours [8].

Microorganisms, media and inoculum development: The effluent from Coal Gasifier was used for isolating microorganism capable of degrading varying substrates. The isolated microorganism was characterized as lactobacillus Spices from morphological and biochemical test results. The slants were incubated for 18 to 24 hr at 30^0 C and then stored in a refrigerator. Inoculums for physiological experiments was obtained by cultivation for 18 to 24 hr in the following liquid medium: glucose,10 g; $(NH_4)2SO_4$, 2.64 g; KH_2PO_4, 2.38 g;K_2HPO_4, 5.65 g; $MgSO_4p7H_20$, 1.0 g; $FeSO_47H_20$, 1.1 mg; $MnCl_2$ $4H_20$, 7.9 mg; $ZnSO_4'7H_20$, 1.5 mg; yeast extract, 0.25 g; precipitated $CaCO_3$, 1.0 g; deionizer water,1 L. The glucose and the $CaCO_3$ were sterilized separately, and then added to the medium. Most experiments were carried out in 250- or 500-ml conical flasks containing 50 or 100 ml of medium. 2 per cent 18-hr liquid inoculums were used. Liquid cultures were incubated on a mechanical shaker. Accumulation of glutamic acid and residual sulphate in the medium lowered the pH to the point of inhibition of further growth of the lactobacillus, in spite of the presence of $CaCO_3$. Inhibition of growth as noticeable at about pH 5.5 and was marked at about pH 4.8. Cultures were, therefore, periodically adjusted to pH 6.0 to 6.5 by addition of 10 per cent Na0H.Bacterial growth was measured turbid metrically on a UV-spectrophotometer after eliminating the $CaCO_3$ with a drop of HCl.

Microbial Fuel cell using a Salt bridge: Dual chambered MFC was constructed using air-tight plastic bottles of 1 liter volume each (anode and cathode chamber) [9, 10]. A side opening of 1 cm radius was made at a height of 12.5 cm from the bottom of the bottle (approximately at the center) on each bottle and was connected with a PVC pipe(length=20cm; diameter=2cm). Agar of 2gms along with 2gms of sodium chloride (NaCl) salt was prepared by heating it in a water-bath of 100ml and the molten agar was allowed to cool down and poured into the PVC pipe and sealed at one end using cello-tape. The agar was left undisturbed to solidify. The PVC pipe containing the salt-agar mixture was fixed between the two bottles using epoxy material and behaved like the salt-bridge assisting in the proton transfer mechanism during the MFC operation [11],Carbon rods (height= 12cm; diameter = 0.75 cm) were used as electrodes. The distance between the two electrodes was maintained at distance of 20 cm in the MFC setup. Copper wires were used to connect the electrodes to the circuit [12]. An external resistance (R) of 100Ω was connected and the readings were measured using a digital multimeter. Constructed salt bridge MFC is shown in **Figure 1**.

Figure 1: Microbial Fuel Cell for the treatment of waste water.

RESULTS AND DISCUSSION

Waste water characteristics: Sample was taken from Coalgasifier industry waste water to determine its various parameters. The values of various parameters like pH, temperature, Dissolved oxygen, COD, BOD, TSS, TDS, Chlorides, Sulphates, Oil and Grease before the treatment of sample effluent are as shown in **Table-1**.

Table-1: Characteristics of Coalgasifier effluent. (All units mg/L, except pH).

S. No	Parameter	Untreated effluent before treatment
1	pH	7.93
2	TSS	1160
3	TDS	6000
4	DO	14.8
5	BOD	75
6	COD	17840
7	Sulphates	1896
8	Chlorides	1000
9	Oil & Grease	17
10	Temperature	40

Effect of Microbial Fuel Cells: Sample taken from the Coalgasifier industry waste water is treated by Microbial Fuel Cells. In the process, two bottles, one having the waste water sample and the other having the tap water is taken. Carbon electrodes are dipped into each bottle and a salt bridge is attached between two bottles through which flow of electrons takes place. Moreover, an aerator is also placed in the bottle having waste water. During the treatment samples were taken at constant intervals of 72 hours to determine its various parameters i.e. pH, Total Suspended Solids, Total Dissolved Solids, Chemical Oxygen Demand, Biological Oxygen Demand, Sulphates, chlorides, Oil and Grease. MFC is known to be one of the cheapest methods for reducing COD values in waste water [13]. In the present operation, the value of COD has reduced from 17840 mg/lit to 400mg/lt. Besides reducing the toxicity MFC also produces Voltage. The voltage produced can be checked by connecting electrodes to the Multi-meter. The maximum voltage found out to be 129mV (1.29V).The **Figure 2** shows the maximum Voltage could be recorded over a period of 12days.

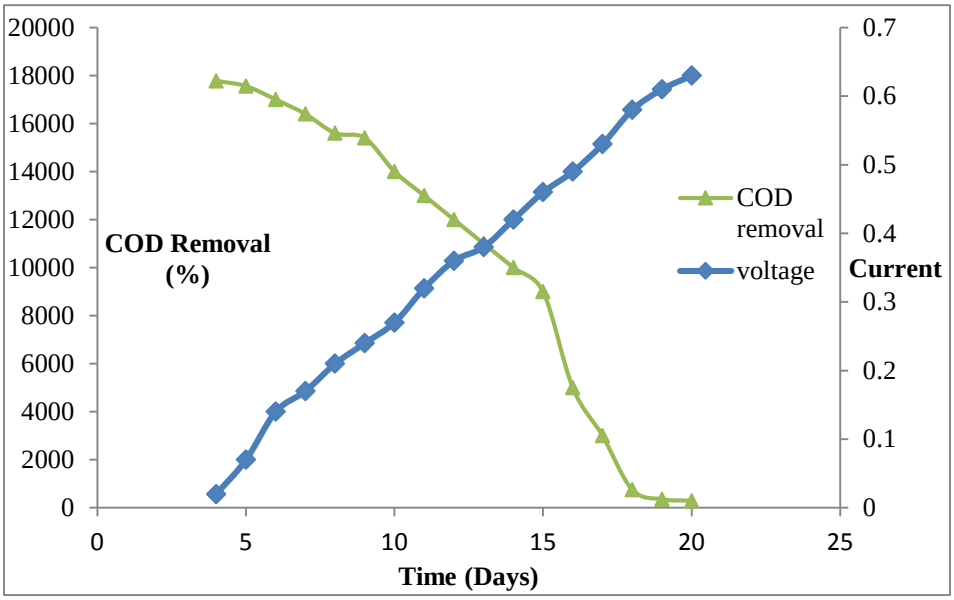

Figure 2: Shows the maximum Voltage could be recorded over a period of 12days.

EFFECT OF MFC ON VARIOUS PARAMETERS

Effect of Temperature: The effluent temperature plays an important role in making an effect on certain chemical and biological reactions taking place in water which affects organism and inhabitation of aquatic media. It depends upon season, time sampling etc. The water discharged from the industry which has generally high temperature, affects the land adversely. The temperature of untreated effluent was recorded 40°C and treated effluent was recorded 38°C. The temperature of the discharge should not exceed 35 °C. The high tem i.e. 40°C of the untreated effluent has adversely affected the germination process.

Effect of pH: In the present investigation the pH value of treated and untreated were recorded as 7.9 respectively. According BIS standards the pH of the effluents should be in range 6.5 to 8.0. pH is one of the important biotic factor that serves as index for pollution. If such water is used for irrigation for a longer period the soil becomes acidic resulting in poor crops growth and yield. The factors like photosynthetic exposure to air, disposal of industrial effluent and domestic sewage also affect the pH of the soil.

Effect of Dissolved Oxygen: The analysis of DO is very important in water pollution control as well as waste water control. Aquatic ecosystem totally depends on DO, various biochemical changes and its effects on metabolic activities of microorganism were very well documented. Its presence was essential to maintain variety of forming of biological life in water and effect of water discharge in water body are largely determined by oxygen balance of the system. According to the BIS standard the DO of the effluent should be within the range 4 to 6 mg/lit. In the present investigation the DO of the untreated and treated effluent sample was recorded 14.8 mg/lit and after treatment it is 4.5mg/lit respectively which is sufficiently low than the BIS Indian standard (3) values.

Effect of BOD: Biochemical Oxygen Demand (BOD) is defined as amount of oxygen required by microorganism while stabilizing biological decomposable organic matter in water under aerobic conditions. The biological oxidation is very slow process during oxidation; organic pollutants are oxidized by certain microorganism into carbon dioxide and water using dissolved Oxygen. Hence lowering in dissolved oxygen value is the measure of BOD relation. In the present investigation the BOD of the untreated effluent was 75 mg/l while the treated effluent recorded 51 mg/l. According to BIS Indian3 standard the BOD should not exceed the 50 mg/l.

Effect of COD: The chemical Oxygen demand test determines the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of domestic and industrial waste. The effluent is measured in term of quality of oxygen required for oxidation of organic matter to produce carbon dioxide and water. It is a fact of all organic compounds with few exceptions that they can be oxidized by the action of strong oxidizing agents under acidic conditions. COD is useful in pinpointing toxic condition and presence of biological matters. In the present investigation the COD of the untreated effluents was 17840 mg/l while treated effluent was recorded 400 mg/l. In untreated effluent it is appreciably high compared to BIS standard (200-300 mg/L). This indicated high organic pollutants in the sample.

Effect of TDS: The total dissolved solids concentration in the effluent represent the colloidal form and dissolved specters. The probable reason for the fluctuation or value of total solids and subsequent the value of dissolved solid due to convent collision of the colliding particles. The rate of collision aggregated process is also influenced by pH of this effluent. In the rainy season less concentration of total dissolved solids are obtain due to dilution of waste effluent with rain water. In the present investigation the total solids in untreated effluent was 6000 mg/l and 2150 mg/l in treated effluent. In both the samples in TDS values are much higher compared to BIS Indian Standards (2100 mg/L).

Effect of TSS: The total suspended solids affect the light intensity of water; suspended solids are the cause of suspended particle inside the water body influencing turbidity and transparency. According the present investigation the suspended solids of untreated effluent were 1160 mg/l and 700 mg/l respectively.

Effect of Chlorides: The presence of chloride in natural water is attributed to dissolution of salt deposit, discharge of effluents from chemical industries oil well operations. In the present study chlorides of untreated was 1000 mg/l and in treated effluent was recorded 650 mg/l. This is well within the limits of BIS Indian Standard.

Effect of Sulphate: In the present investigation sulphate in untreated effluent was 1896 mg/l and treated effluent was recorded 1100 mg/l according BIS Indian standard the sulphate should not exceed the 1000 mg/l. High SO42- amount in both the effluents is attributed to the use of sulphur during crystallization

Effect of Oil and grease: In the present investigation oil and grease present in untreated and treated effluent showed 17 mg/l and 10 mg/l respectively this is almost in accordance with the BIS Indian Standard.

S. No	Parameter	Untreated effluent before treatment	treated effluent
1	pH	7.93	7.9
2	TSS	1160	700
3	TDS	6000	2150
4	DO	14.8	4.5
5	BOD	75	51
6	COD	17840	400
7	Sulphates	1896	1100
8	Chlorides	1000	650
9	Oil & Grease	17	10
10	Temperature	40	35

CONCLUSION

The focus of the present study was to review biological method involved in the treatment of waste water. In this physical study, Microbial Fuel Cell was selected to improve the waste water quality. The amount of TSS, TDS, BOD, COD, Sulphates and Chlorides, Oil and Grease are decreased when compared to initial characteristics of waste water. The MFC was effective, cheaper, easy to maintain and does not require any skilled worker. They undoubtedly have potential in terms of energy recovery during wastewater treatment. They may occupy a market niche in terms of a stand-alone power source and also in the direct treatment of wastewater .It was observed that the basic principle guiding for the removal of toxicity and the production of electricity is the availability of bio-degradable compounds present in the waste water sample. The COD removal denotes the function of microbes, present in wastewaters in metabolizing the carbon source as electron donors. It was observed that MFC has succeeded in achieving the COD removal efficiency of 94% and also in generation of 129mV. The study demonstrated that microbial fuel cell technology was able to treat Coalgasifiier industry wastewater successfully, and microorganisms present in the wastewater are for removal of COD, BOD and other parameters. MFC technology may provide a new method to offset wastewater treatment plant operating cost, making wastewater treatment more affordable for developing and developed nations. Thus, the combination of wastewater treatment along with electricity production may help in saving money as a cost of wastewater.

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