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ENHANCED PHYSICAL METHOD OF REMEDIATING RICE MILL EFFLUENT

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ABSTRACT

As Chhattisgarh is known as "bowl of rice" thereby producing a variety of paddy crop. As it is producing a large portion of paddy variety thus to process it into rice grain a large number of mills are established thereby generating a lot of bio-waste which can be either solid or liquid form ultimately misbalancing the ecosystem. Liquid bio-waste are termed as effluents which is generated during parboiling process of rice. Near about 1 to 1.2 liters of effluents is generated on processing of one kg of paddy. The liquid waste produced during milling of paddy crop mainly consist of inorganic, organic substances contributing in aquatic pollution.This paper determine the efficacy of physical method used for treatment of effluent sample collected from Rice Mill.The physical method used here is separately treating the sample by adsorption as well as electrocoagulation method. Adsorption and electrocoagulationprocess was tested for color, pH, temperature, turbidity, electrical conductivity, TSS, TDS, DO, COD, BOD, total hardness, Nitrate, Phosphate, etc. The combined treatment method of adsorption and electrocoagulation shows significant reduction in turbidity (260 to 240NTU), electrical conductivity (10254.0 to 10024µS/cm), TSS (782.0 to 769.0 mg/l),TDS (990.0 to 986.0 mg/l) TS (3,300 to 3,117 mg/L), total alkalinity (2,124 to 2,014 mg/L as CaCO3), Total hardness (2,177 to 2,025 mg/L as CaCO3).COD (1498 to 1287 mg/l) While no change in rest all.Thus physical method is good for treating the above mentioned parameters.

Keywords: Adsorption, Effluents, Electrocoagulation, Rice, Rice Mill.

INTRODUCTION

When it comes to requirements for maintaining life, water is among the most fundamental. At present the global challenge facing by the human is scarcity of fresh clean water. In accordance with projections published by the United Nations (UN), the global population will be greater than 9 billion by the year 2045 (Naje*et al*., 2016). An alarming situation arises as a result of the corresponding increase in the total quantity of solid waste produced by both industrial and municipal sources, which is caused by the daily growth of the human population.

Consequently, it would have a straight effect on the availability of clean water, which may unsatisfied the requirements of an inhabitants that is continuously growing (Kuokkanen*et al*., 2013). In general, there are two types of wastewater that are produced by society. Sewage can come from several sources, such as houses, organizations, industries, rainfall, sludge, septic tanks, and internal production. Treatment stations include thickener and digester supernatants, sludge dewatering reject water, sludge drying bed drainage water, filter wash water, and equipment cleaning water. Water is used in a totally different way in industrial settings than it is in residential settings. The effluents that are found in the wastewater that is emitted from various businesses include a wide variety of complicated substances.

The technique of removing solid particles from wastewater is typically difficult since wastewater typically contains solid particles of varied sizes. In light of this, they are required to undergo treatment prior to being released as water on the surface or into sanitary sewers (Shahedi*et al*., 2020).Although it is a physical process, the separation of pollutants from wastewater does not have a significant impact on the chemical or biological features of the effluent. When certain contaminants are subjected to the chemical process, often referred to as the additive process, the chemicals are added to the contaminants in order to induce them to react, thereby reducing the concentrations of pollutants in the wastewater. One of the components of a biological unit process is the biodegradation of pollutants, which is accomplished through the use of microorganisms for minimization of organic matter suspected in wastewater (Moussa*et al.*, 2017).

About two third of global population's staple food is rice, and this is produced in mill by parboiling method. Generalizing over the capacities of rice processing facilities in India is challenging. Most of the smaller ones lack these gadgets, even if a few of the larger ones are fairly huge and contain automated utilities and pollution control equipment. Furthermore, a number of the minor mills is also rapidly growing resulting difficulty for treating generated. The hulling and milling properties of paddy are enhanced by using a hydrothermal treatment known as parboiling. The nutritional content of rice is not altered by this treatment. Globally parboiling of grains can be carried out in various ways. The basic steps involved in milling process of paddy crop is soaking, steaming, drying, and grinding (Asati, 2013). About 1.3 times of water is required for soaking process to the weight equivalent to the paddy crop. This process is responsible for tainting of various resource of water, by generating of effluent discharge to the nearby reservoir of water which is shown in **Figure 1**.

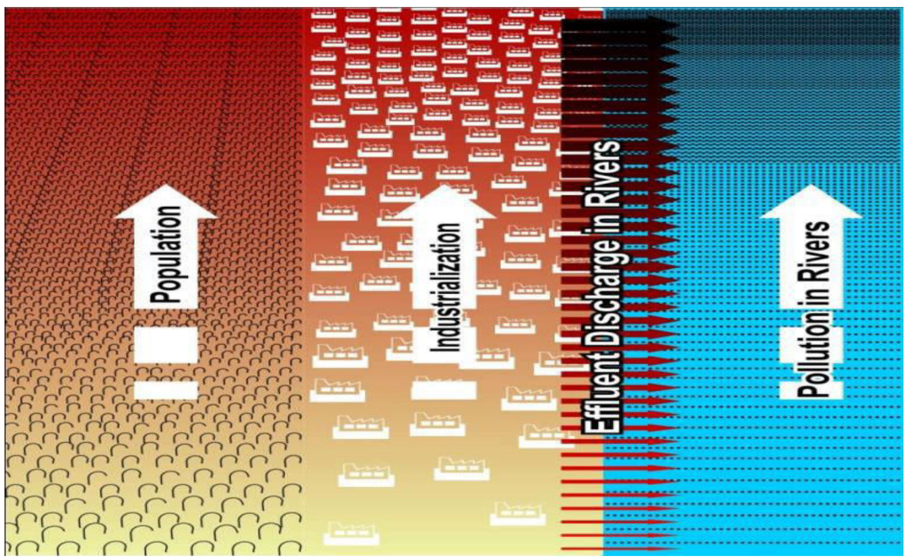

Figure 1: Contamination in rivers w.r.t. population and industrialization (Singh *et al.,* 2018)

In general, the water consignment necessary for drenching is around one third times the paddy's weight. Furthermore, in standard rice mill roughly 8 tons of paddy are soaked on a daily basis, making this activity the largest contributor to the outflow of wastewater (Roy *et al.,* 2011). Even though there are many different methods for treating water, although the most of it requires a substantial quantity of energy that comes from origin that do not replenish themselves, which results in increased levels of carbon dioxide emissions. Because of this, researchers have been motivated for producing new technologies that are not only economical but also efficient, low-impact on the environment, and must flexible enough to remediate effluents from a diversified business (Huo*et al.,* 2020). Consequently, electrochemical techniques including electro-flotation (EF), electro-kinetic treatment, the electrocoagulation process (EC), and electro-oxidation (EO) have received good recognition in the few decades. Due to its low chemical consumption and easy availability, they have gained a lot of appeal. To be more specific, electrochemical treatment, in contrast to other technologies, is a particularly dependable way for the elimination of pollutants from effluents (Naje*et al*., 2016). According to the findings of recent research, EC is capable of effectively removing pollutants from groundwater, including total dissolved solids (TDS), chlorides, sulphate, potassium, magnesium, calcium, and salt, particularly at higher concentrations.Over the past few years, technological advancements have made it possible for electrical equipment to be portable. This portable equipment can be adapted to fit the specific needs of many industries, and it also makes it possible to easily obtain data on voltage and current for the purpose of monitoring efficiency (Kuokkanen *et al*., 2013).

PRINCIPLE AND WORKING OF ELECTROCOAGULATION

Electrolysis is the primary principle from which EC is derived. In the process of breaking down chemicals, the phrase electrolysis refers to the utilisation of electricity (Sahu *et al.,* 2014). In its most basic form, the process of electrocoagulation is a method that involves the formation of a floc with the assistance of oxidised metal in wastewater that is in need of being cleansed through the electro-dissolution of soluble anode (Malakootian and Yousefi, 2009).

EC is a process that can also be defined as the elimination of suspended solids from effluents. This is accomplished through the utilisation of electricity by neutralizing the negatively ionic species by forming sodium hydroxide complexes in water. This process brings together the suspended solids, assists in bridging, binding, and strengthening the floc for the depositon due to the force of gravity (Fagnekar and Mane, 2015). This method collects the solid that is suspended in water without the need of a coagulant. The coagulation process took place when a direct current was applied, and it was able to remove small fragments and set them in motion (Koohestanian *et al*., 2011). By applying electricity to an anode and causing it to electro-oxidize, a process known as electrocoagulation can produce coagulants in situ. The coagulation of contaminants at the cathode is made possible by the simultaneous emission of hydrogen (Golder *et al.,* 2005).

When it comes to electrocoagulation, the following steps are typically involved:In electrolysis, surface of the electrodes is the place where electrolytic processes occur.Coagulation is the process of anodic metal hydroxides, or coagulants, forming in an aqueous phase. Through the process of adsorption, contaminants that are soluble or colloidal are absorbed by the surface of coagulants. Getting rid of it through electro-floatation, sedimentation, and adhering to bubbles respectively (Korczak *et al.,* 1991).

The electrocoagulation process's efficacy relies on various factors, such as the type of electrodes, the spacing between electrodes, the quantity of electrodes, the dimensions of the electrodes, the arrangement of the metals, the density of the current, the charge applied, the pH level of the sample, the inclusion of supporting electrolyte, and the duration of the process (Can *et al.,* 2006). Magnetite, aluminum, and stainless steel are the three types of electrodes that are typically utilized. The anode and the cathode are the names given to these two sets of metal sheets (Roopashree and Lokesh, 2014). As the cathode is oxidized (loses electrons) and the water is reduced (acquires electrons) during the electrocoagulation process, the end product is treated water and floc that is easier to settle (Fagnekar and Mane, 2015).

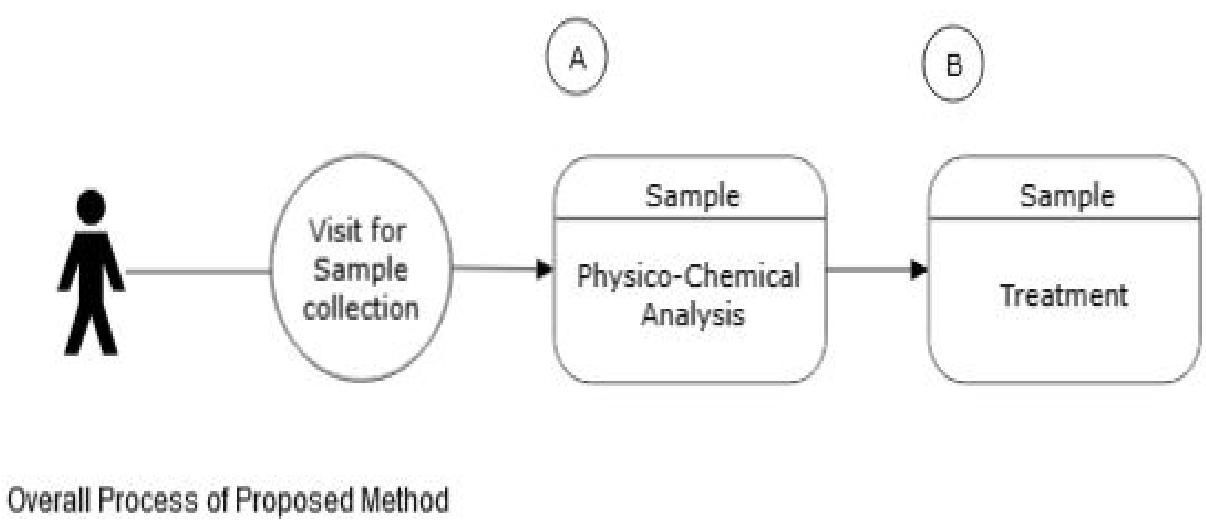

Figure 2: Research Methodology (Level 0 Diagram)

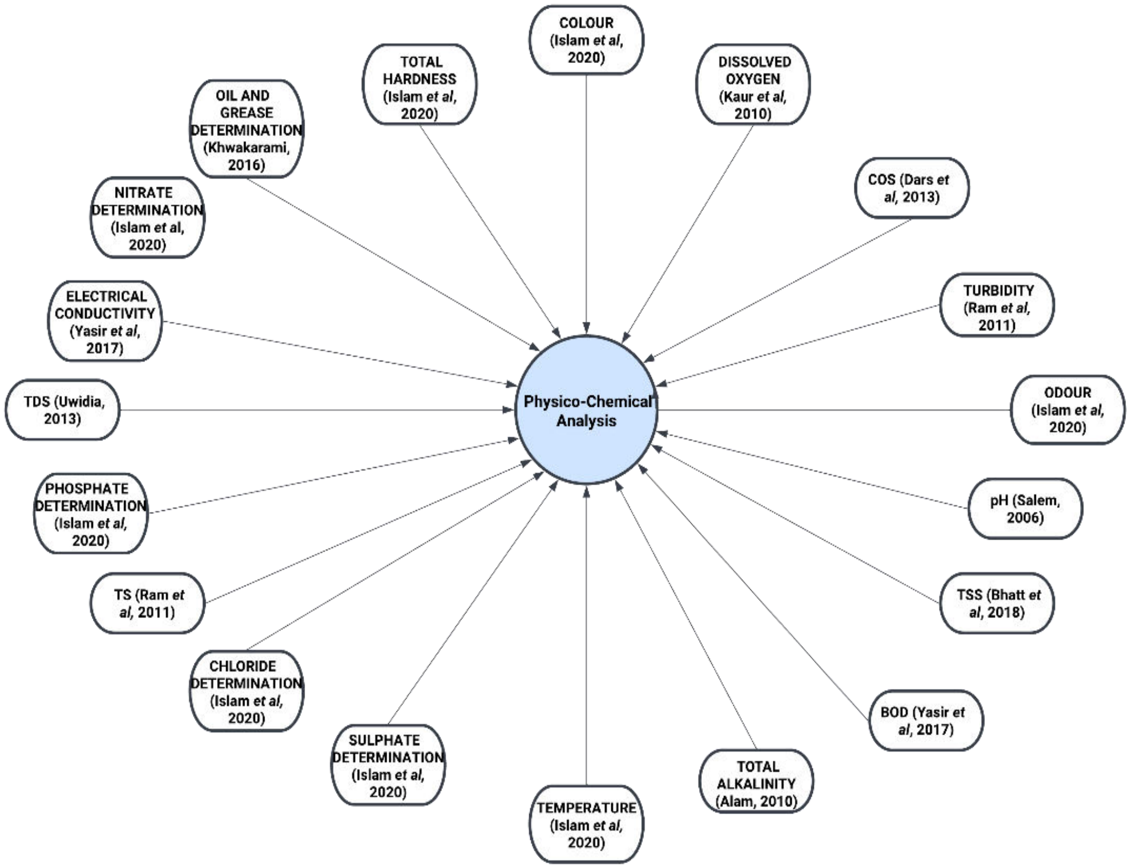

Figure 3: Research Methodology (Level 1 Diagram Part A)

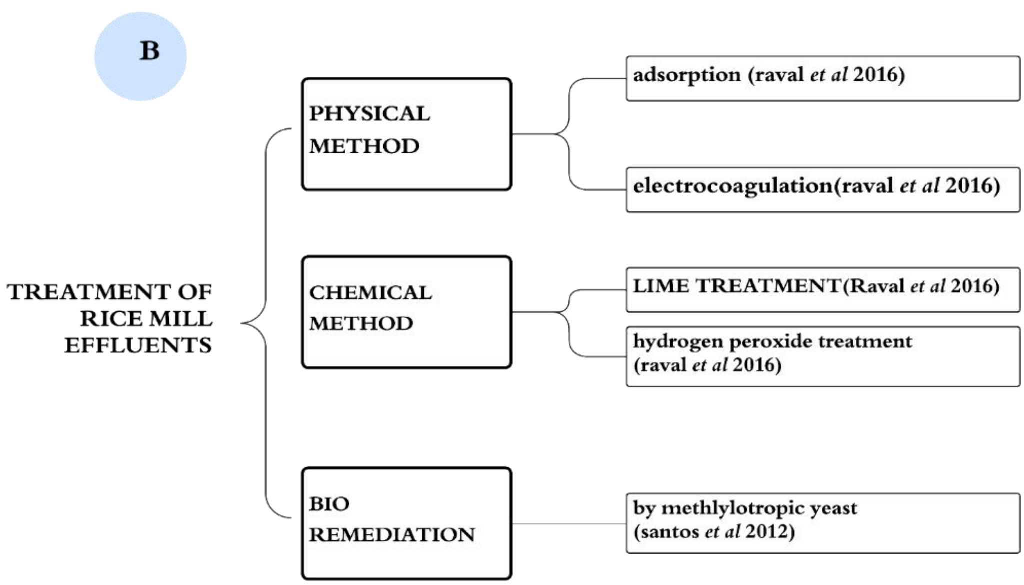

Figure 4: Research Methodology (Level 1 Diagram Part B)

MATERIALS AND METHODS

The research methodology is completed by three steps which is visit to sample site for collection of specimen, followed by analysis and remediation respectively (**Figure 2**). The present paper explains only about analysis of physical and chemical parameters **(Figure 3)** and physical treatment of effluent discharge (**Figure 4**).

Samples were collected from Rice Mill located at Raipur, Chhattisgarh. Standard methods recommended by APHA were applied to analyze the various chemical and physical parameters like as Colour, Odour, Temperature, pH, Turbidity, EC, Alkalinity **Total Dissolved Solids,** Total Suspended Solids, Total Solids, Dissolved Oxygen, Biological Oxygen Demand (BOD), Total Hardness, Phosphate Determination, Chloride Determination, Determination of Oil and Grease

Physical methods for Treatment of Rice Mill Effluent

Adsorption

The effluent generated by rice mill was treated by adding varying amounts of bottom ash collected from rice mill boiler. Quantities of bottom ash added per 100 ml of waste water from mill is ranged from 0.1 to 1 gm, and left to react for duration of 1 to 3 hours at room temperature. Following each peculiar time break, 40-micron Whattman filter paper was used to strain out the solution, and the resulting filtrate was assessed for turbidity and COD (Raval *et al.,* 2016).

Electrocoagulation

This process was hauled out in a 1-liter beaker followed by continuous mixing by a magnetic stirrer, setting rpm of 350 under room temperature. Rectangular electrodes of three different combinations were used, along with varying operation times and at two different current densities (**Figure 5**). The two electrodes were vertically positioned using spacers with intervals of 10 mm, 20 mm, 30 mm, and 40 mm is used to evaluate the spacing of electrode for its removal efficiency. Bakelite spacers were utilized to ensure effective insulation between the electrodesThe spacing between the electrodes was maintained at 25 mm in order to investigate the impact of other factors. The iron and aluminum plates of measurement 135 mm x 53 mm x 1.5 mm were utilized. A dual DC regulated power supply (HTC, with a maximum output of 30 V and 5 Amps) was used to provide the current. Sand paper was used for cleaning electrodes and distilled water to eliminate the oxide layer from the surface of electrode after each operation. The treatment time varied from 0-60 minutes. At different time intervals individual experiments was performed to ensure the sample homogenosity for analyzing each sample. No Chemical was added to increase pH as well as the conductivity of the solution (Raval et al., 2016).

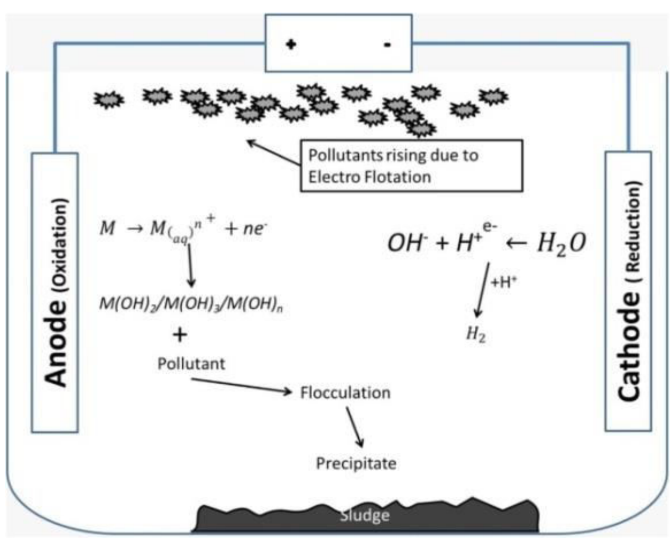

Figure 5: Electrocoagulation Process [Boinpally*et al.*,2023]

RESULTS

Table 1: Adsorption method of Sample

SN	Parameters	Before Treatment	After Treatment
1.	Color	Brown	Creamy
2.	Odor	Unpleasant or Foul	Unpleasant or Foul
3.	Temperature(0°C)	35	35
4.	pH	5.5	5.5
5.	Turbidity (NTU)	260	252
6.	Electrical conductivity (µS/cm.)	10254	10147
7.	Total Dissolved Solids (TDS) (mg/l)	990	987
8.	Total Suspended Solids (TSS) (mg/l)	782	779
9.	Total Solids (TS) (mg/l)	3,300	3,270
10.	Total Alkalinity(mg/l) as CaCO3	2,124	2,004
11.	Total Hardness(mg/l) as CaCO3	2,177	2,087
12.	Dissolved Oxygen (DO) (mg/l)	2.1	2.1
13.	Biological Oxygen Demand (BOD) (mg/l)	303	303
14.	Chemical Oxygen Demand (COD) (mg/l)	1498	1287
15.	Nitrate Determination (mg/l)	39	39
16.	Phosphate Determination (mg/l)	80	80
17.	Sulphate Determination (mg/l)	76	76
18.	Chloride Determination (mg/l)	880	880
19.	Oil and Grease (mg/l)	20	20

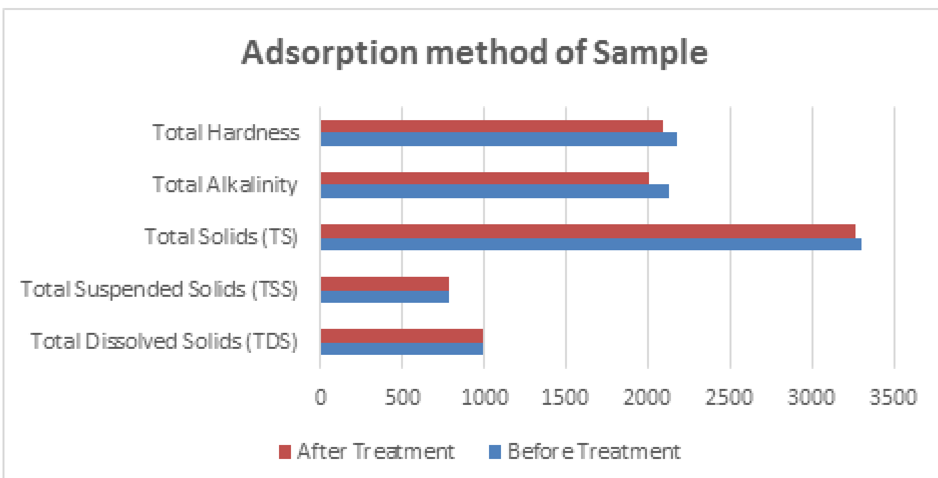

Figure 6: Comparative Analysis of before and after treatment through Adsorption Method

Table 2: Electrocoagulation method of Sample

SN	Parameters	Before Treatment	After Treatment
1.	Color	Brown	Creamy
2.	Odor	Unpleasant or Foul	Unpleasant or Foul
3.	Temperature(0°C)	35	34
4.	pH	5.5	5.5
5.	Turbidity (NTU)	260	248
6.	Electrical conductivity (µS/cm.)	10254	10140

7.	Total Dissolved Solids (TDS) (mg/l)	990	986
8.	Total Suspended Solids (TSS) (mg/l)	782	779
9.	Total Solids (TS) (mg/l)	3,300	3,277
10.	Total Alkalinity(mg/l) as CaCO3	2,124	2,014
11.	Total Hardness(mg/l) as CaCO3	2,177	2,095
12.	Dissolved Oxygen (DO) (mg/l)	2.1	2.1
13.	Biological Oxygen Demand (BOD) (mg/l)	303	303
14.	Chemical Oxygen Demand (COD) (mg/l)	1498	1287
15.	Nitrate Determination (mg/l)	39	39
16.	Phosphate Determination (mg/l)	80	80
17.	Sulphate Determination (mg/l)	76	76
18.	Chloride Determination (mg/l)	880	880
19.	Oil and Grease (mg/l)	20	20

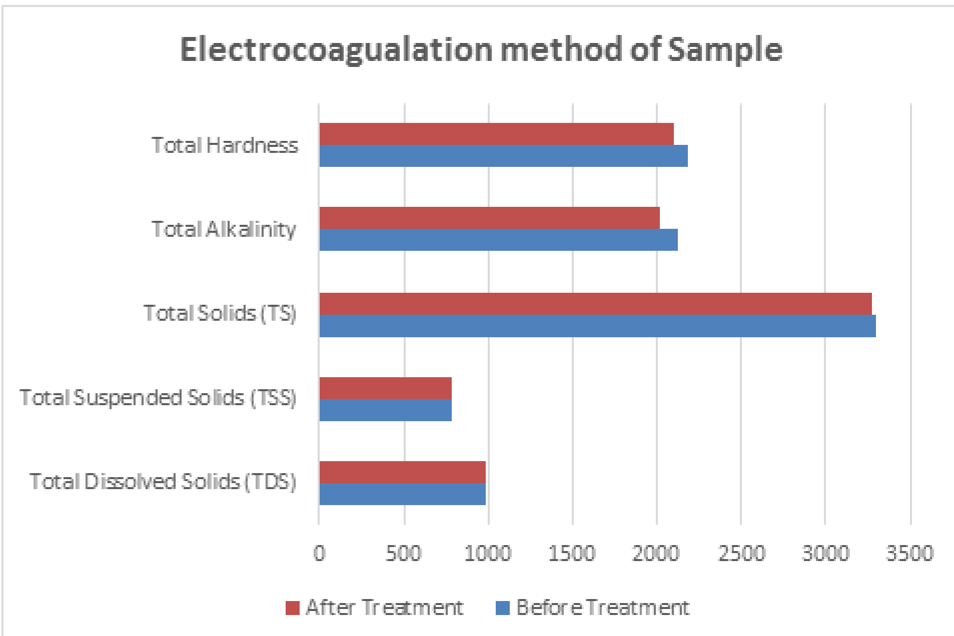

Figure 7: Comparative Analysis of before and after treatment through Electrocoagulation method

Table 3: Combination of Adsorption and Electrocoagulationmethod of Sample

SN	Parameters	Before Treatment	After Treatment
1.	Color	Brown	Creamy
2.	Odor	Unpleasant or Foul	Unpleasant or Foul
3.	Temperature(0°C)	35	34
4.	pH	5.5	5.8
5.	Turbidity (NTU)	260	240
6.	Electrical conductivity (µS/cm.)	10254	10024
7.	Total Dissolved Solids (TDS) (mg/l)	990	986
8.	Total Suspended Solids (TSS) (mg/l)	782	769
9.	Total Solids (TS) (mg/l)	3,300	3,117
10.	Total Alkalinity(mg/l) as CaCO3	2,124	2,014
11.	Total Hardness(mg/l) as CaCO3	2,177	2,025

12.	Dissolved Oxygen (DO) (mg/l)	2.1	2.2
13.	Biological Oxygen Demand (BOD) (mg/l)	303	303
14.	Chemical Oxygen Demand (COD) (mg/l)	1498	1287
15.	Nitrate Determination (mg/l)	39	39
16.	Phosphate Determination (mg/l)	80	80 mg/L
17.	Sulphate Determination (mg/l)	76	76
18.	Chloride Determination (mg/l)	880	880
19.	Oil and Grease (mg/l)	20	20

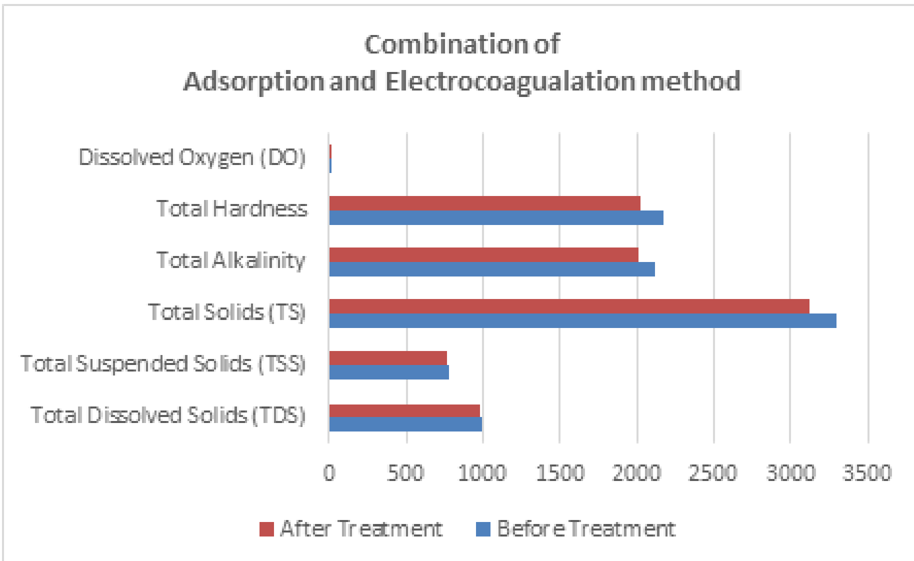

Figure 8: Comparative analysis of different parameters before and after treatment for Combination of Adsorption and Electrocoagualation method

DISCUSSION

The quantity of oxygen that is utilised in the process of chemically degrading the organic matter that is present in water is referred to as the COD. A total solid residue (TSS) is a solid residue that is held by a filter that has a particle size that is greater than or equal to the size of a colloidal particle, with a maximum of 2 µm. The table 1 is clearly depicting the treatment of sample by EC method. When it comes to the electrocoagulation process, the existence of colloids in solution was found to be related to the effects of distance and electrical voltage which influence the decrease in COD and TSS. It was stated by (Daneshvar*et al.,* 2007) that aluminium is a material that is more appropriate to be used as an electrode in electrocoagulation due to the fact that it generates Al (III) species. In addition, the method of electrocoagulation in solution demonstrates that colloids are considered to be stable in solutions when sedimentation occurs at such a slow rate that the motion of colloids becomes stable. At the present treatment facility, the electrode assembly is the most important component. Consequently, the selection of its materials in an appropriate manner is crucial for the proper operation of the system. Two different metal for electrode i.e Fe and Al are used most commonly in electrocoagulation, and both of these materials have been shown to be successful (Ugurlu*et al.,* 2008). Therefore, experiments were conducted using aluminium, iron, and a mixture of the two materials in conditions that were comparable to those of the experiments. This demonstrates that the iron electrodes were also very successful in reducing total dissolved solids (TDS) to 986.0 mg/l. (**Table 2**). while adsorption separately show decrement of 987 mg/L, (**Table 1)**and no decrement in the combined treatment (EC and Adsorption). The total dissolved solids (TDS) of the sample rose over the first fifteen minutes, instead of reduction while using Al-Al and Fe-Al electrodes. Al^{+3} has a standard decrease potential of -1.63V, while Fe^{+2} has a reduction potential of -0.41V. As Iron is having higher reduction potential, it is believed that why Fe-Fe electrodes have a higher removal efficiency as compared to Fe-Al electrodes and Al-Al. As a result of the absence of aluminium hydroxide formation in acidic conditions, the coagulation process is slowed down, this could be a reason for the initial rise in total dissolved solids (TDS) while using an Al-Al electrode. On account of the fact that the majority of the aluminium ions that are released into the solution do not participate in the process of coagulation, the amount of dissolved solids in the solution gradually increases.

$[Al(OH)_2]^+$ ion is not good at coagulating agent as compared to $Al(OH)_3$. This results significant decrease in initial rate of coagulation for Al-Al and Fe-Al electrodes. At a steady current density of 23.30 mA/cm2 for the Fe-Fe electrode, experiments were carried out over a period of thirty minutes at varying inter electrode distances of ten millimetres, twenty millimetres, thirty millimetres, and forty millimetres. For an electrode with a spacing of 10 millimetres, the maximum amount of COD that was removed was found to be 1287.0 mg/l. This remain same for combined method also. **(Table 1,2,3)**.Using solely Fe-anodes resulted in a removal effectiveness of 70.20% when maintained at the same current density. In other investigations, by using Al-electrodes at a pH of 9 the removal of 86.91% COD was achieved, while the removal of 5.04% was achieved at a pH of 3 (Sharma, 2014), and 60%–80% COD removal (Canizares*et al.*, 2007). According to paper Kamath (Kamath *et al.,* 2017), the use of Fe-electrodes resulted in a reduction of COD that was 69.4%, 78.9%, and 80.4% respectively. The removal of 48.14 percent and 90.12 percent of COD (Sadik, 2019) and 67.27 percent of COD (Hamada *et al.,* 2018) respectively. According to Chimenos (Chimenos*et al.,* 2006), the physicochemical procedures have the drawback of requiring the use of an expensive reagent, while the rates of soluble COD removal are rather low. Using Al-anodes at pH values of 5, 6, and 7 and electrolyzing them at 3 V for ten minutes, other investigations have reported NTU removal levels of 93.46 percent, 94 percent, and 86.7 percent, respectively (Shivayogimath and Naik, 2014) pH has a considerable impact on the efficiency of the EC process (Kobya*et al.,* 2003). On the other hand, very dismal removals are discovered either at a pH of ten or lower. As $Al(OH)_3$ is amphoteric in nature, it does not precipitate at pH less than 2.0. On the other hand, a high pH will enhance the solubility of $Al(OH)_3$, resulting in the creation of soluble $Al(OH)_4$, which is not useful for performing water treatment (Chakchouk*et al.,* 2017). Turbidity,TS, TSS, Total alkalinity, hardness, and EC show significant reduction of 1 to 14% in combined method **(Table 3,4),**while table 1, 2 also represent diminish of above mentioned parameters but not like as combined method. Figure 6,7, 8 also clearly depicting the difference.

Table 4: Percentage wise reduction comparison of hybrid method

S.No.	Parameters	Adsorption	Electrocoagulation	Combined EC and Adsorption
1	Color	-	-	-
2	Odor	-	-	-
3	Temperature(0°C)	-	-	-
4	pH	-	-	-
5	Turbidity (NTU)	3.08	4.62	7
6	Electrical conductivity (µS/cm.)	1.04	1.11	2.24
7	TDS (mg/l)	0.30	0.40	0.4
8	TSS (mg/l)	0.38	0.38	1.62
9	TS (mg/l)	0.91	0.70	5.54
10	Total Alkalinity(mg/l) as CaCO3	5.65	5.18	5.17
11	Total Hardness(mg/l) as CaCO3	4.13	3.77	6.98
12	DO (mg/l)	-	-	10
13	BOD (mg/l)	-	-	-
14	COD (mg/l)	14.09	14.09	14.09
15	Nitrate Determination (mg/l)	-	-	-

16	Phosphate Determination (mg/l)	-	-	-
17	Sulphate Determination (mg/l)	-	-	-
18	Chloride Determination (mg/l)	-	-	-
19	Oil and Grease (mg/l)	-	-	-

CONCLUSION

When it comes to the treatment of wastewater, there are a few different ways to eliminate pollutants. Because it is easy to use and has a number of benefits, including low cost, practice, and efficiency, coagulation and adsorption combined method is the procedure which show significant reduction of 1 to 14% in parameters like turbidity,TS, TSS, Total alkalinity, hardness, and EC instead of individual method (table 4). **Figure 8** is clearly showing the efficacy of this method. The removal of contaminants and the attainment of the quality of wastewater that is in accordance with standards are both accomplished successfully by this method. Based on the findings of this investigation, we are able to draw the conclusion that the Turbidity,TS, TSS, Total alkalinity, hardness, EC andCOD levels fall more rapidly when the electrode distance is closer together.

Conflict of Interest

All authors declare that we do not have any conflict between us.

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