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Optimization of Grey Water Characteristics Using Electrocoagulation and Response Surface Methodology

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Abstract

Water crisis restricts availability to safe water, due to unsustainable practices leading to excessive aquifer consumption. In this study, the Grey water was collected from household kitchen sink and was treated by Electro-coagulation (EC) (60 A/m^2) method using aluminium (Al), copper (Cu), stainless steel (SS) electrodes along with banana bract activated through three different agents (H_3PO_4, $CaCo_3$, KOH) as adsorbent by varying the operating parameters (time, electrode and activation agent). Initial characteristics of Grey water were determined using experimental methods. The surface response design is based on Box-Behnken which has been used to optimize parameters by quadratic model, with independent variables assessed by analysis of variance (ANOVA). Cu-Cu electrode with $CaCo_3$ adsorbent (0.5g dosage) at 60 minutes of contact time exhibited higher efficiency of 82% achieved under optimum parametric conditions. With Response Surface Methodology (RSM) the wastage of water to find the suitable adsorbent and contact time has been reduced with minimal runs. This study shows that the EC process along with RSM is an effective tool to improve characteristics of Grey water under different operating parameters.

Article History

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Keywords

Adsorbent;

Box- Behnken;

Electro-Coagulation;

Response Surface Methodology.

Introduction

Grey water describes the relatively clean, researchers like Pushparaj, Shubhi Gupta and Prasenjit Mondal,[1] emphasize that wastewater which comes from sinks, bath tubs and washing machines and other kitchen appliances, compared to black water (which includes toilet waste), it usually has fewer impurities and makes up a sizable amount of household waste water. Given its makeup, grey water has a substantial opportunity exists for product recycling and restage

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functions,[2] as well as for meeting water demands in areas with limited supplies. The grey water from home waste sullage, can be processed and used as a ground water recharge mechanism. In order to address water scarcity by another investigation[3] reusing of recycled water sources must be taken to raise the dried-up riverine zones.

Need for this Study

Grey water constitutes approximately 30- 50% of the waste water that is released into sewer systems. Although treated grey water is unlikely to be safe for consumption, its recycling can lead to substantial reductions in water expenses for businesses. The release of untreated grey water contributes to groundwater contamination through the introduction of nutrients and micro-pollutants, as well as causing eutrophication in surface water bodies. The conversion of agricultural byproducts into activated carbon presents both economic and environmental benefits.[4-5] the grey water can be reused by electrocoagulation method by using suitable adsorbent.

Materials and Methods

Collection of Raw Material

Plantain fruit bracts were collected from local community market at Coimbatore which is considered as a waste material.

Electrocoagulation Unit

The unit simply comprises of the choice electrode placed within a distance of 5 cm using a thermocol or cardboard sheet where it is placed in a container filled with grey water and the ends of the electrode is kept immersed in the water such that to remove the contaminants during the process.[6]

Preparation

Researchers washed bracts with distilled water to eliminate dust and maintained them under 37°C sun exposure for four days of drying.[7] The Grey water is filtered as pre-treatment before actual coagulation.

Synthesis and Activation

The obtained charcoal is cooled down and divided into three parts, mixed with Phosphoric acid, Potassium hydroxide, Calcium Carbonate.

The obtained charcoal is cooled down and divided into three parts, the ratio of 1:2 (1g: carbon substitute (Banana Bract); 2g:1+1 distilled water + acid (say Phosphoric acid and respectively))

The activation is done using,

- H_3PO_4 (Phosphoric Acid) Phosphorous is chosen due to excellent synthesis process lead to high pore volume and increase in diameter for perfect adsorption.
- $CaCo_3$ (Calcium Carbonate) is chosen for pore structure development, the decomposition of $CaO+Co_2$ this release creates pores in carbon structure extreme area.
- KOH (potassium hydroxide) is chosen for adsorption capacity and reduced activating temperature and high pore formation (reaction between KOH and carbon generates gases that creates and expand pore network. A crucible received 1-hour exposure at 400 °C within the muffle furnace. The device was left to cool before being transferred into an air-tight package for subsequent testing.

Treatment by Electro-Coagulation

- 500ml of sample in filled accurately in two beakers and 0.5g (since it's the threshold for effective coagulation) of activated carbon (AC) is added respectively in separate beakers.
- Mixed uniformly by using a Magnetic stirrer for approximately 3 minutes.
- The positive and negative electrodes were connected to 2 Aluminum (Al) strips (say for first process) with a spacing of 5cm from each electrode and a supply of 12.9v DC power source.
- The supplication is maintained undisturbed for 30 minutes and simultaneously for 60 and 90 minutes. after the period of time the metal ions get trapped on electrode surface and suspended particles form flocs and can be removed by simple filtration process. This process is repeated for different electrodes and adsorbent likewise.

Electrode Selection

Aluminum is Best for removing turbidity and color. Copper can be used For pH greater than 7, copper ions produce $Cu(OH)_2$ and CuO, which can act as coagulants. Stainless steel is Best for removing total chromium in waste water source.

Selection of Activation Agent Calcium Carbonate

- Flexible porous structure and functional group modification increases the pore space in adsorbent.

Phosphoric Acid

- Creates the porous structure, protects the carbon skeleton, creates enriched functional groups in adsorbents.
- It causes less equipment corrosion.

Potassium Hydroxide

- Creates large surface area narrow porosity distribution in adsorbents.

Results

The physio chemical analysis of effluent showed that the effluent is slightly alkaline in nature with less Dissolved oxygen and has high turbidity. If this water is discharged without treatment, it will pose a threat to Ground water. Though turbidity levels were high as compared to standards, their levels were not so much high. (Refer Table 1). Therefore, it's safe to discharge into ground and can help to increase ground water table and reduce scarcity of water and can be used in some industrial purposes (oil refineries, coolants, etc.,).

Table 1: Initial Physico-chemical parameters of Grey water

Sl. No	Parameters	Effluent Sample	Standard of EPA*
1	pH	8.28	6.5-8.5 mg/l
2	Temperature	28° C	20-35o C
3	Turbidity	49.8 NTU	< 5 NTU
4	COD	1250 mg/l	<100 mg/l
5	Dissolved oxygen	4.2 mg /l	2.7-5.2 mg/l
6	Hardness	310 mg /l	50-150 mg /l
7	Total dissolved solids	1850 mg /l	500-1000mg/l

*These ranges are based on general standards and guidelines from the EPA and state/local regulations this confirms that the post-treatment range should be within the mentioned range from standard of EPA. The third column represents the initial concentration of pollutants present in the sample.

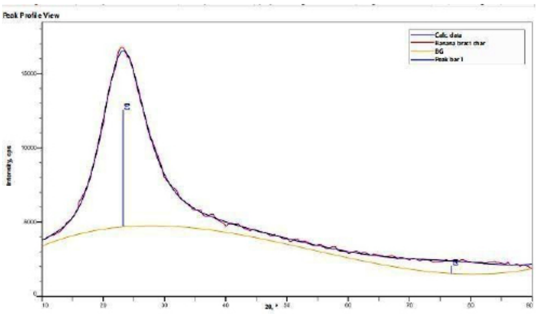


Fig. 1: peak Profile View of Phosphoric Acid

Characteristics of Adsorbent X-Ray Diffraction Phosphoric Acid

Peak is observed at 23.22 with miller index (1 0 1) shown in figure 1. The XRD peak with 2θ values 23.22 corresponds to the miller index (1 0 1) The prepared crystalline structure was estimated as, D=16.95 nm. using Braggs's law, d=0.382 nm Inner planar spacing is calculated.

Potassium Hydroxide

Peak is observed at 28.48. In the observed pattern its depicted in figure 2,The XRD peak with 2θ values 28.48 is The prepared crystalline structure was estimated as, D=17.13 nm. Inner planar spacing is calculated using Braggs's law, d=0.31 nm.

Calcium Carbonate

Peak is observed at 31.73. In the observed pattern, The XRD peak with 2θ value 31.73 has The prepared crystalline structure was estimated as, D=17.26 nm, Inner planar spacing is calculated Braggs's law, d=0.28 nm. The peak is shown in figure 3.

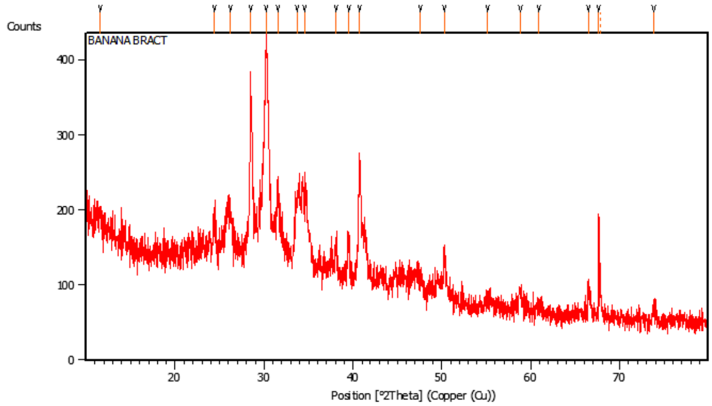


Fig. 2: Peak profile view of Potassium Hydroxide

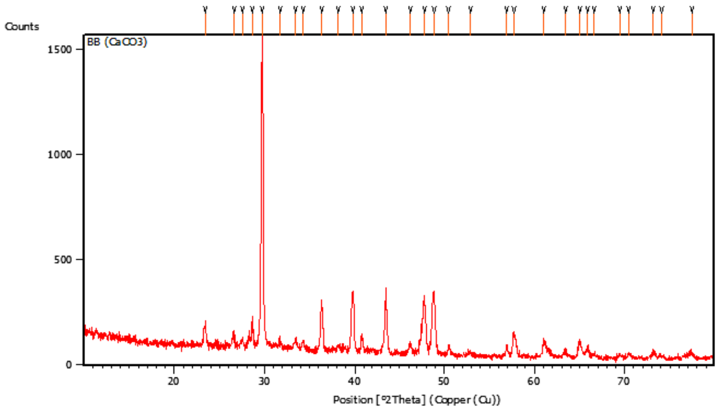


Fig. 3: Peak profile view of Calcium Carbonate

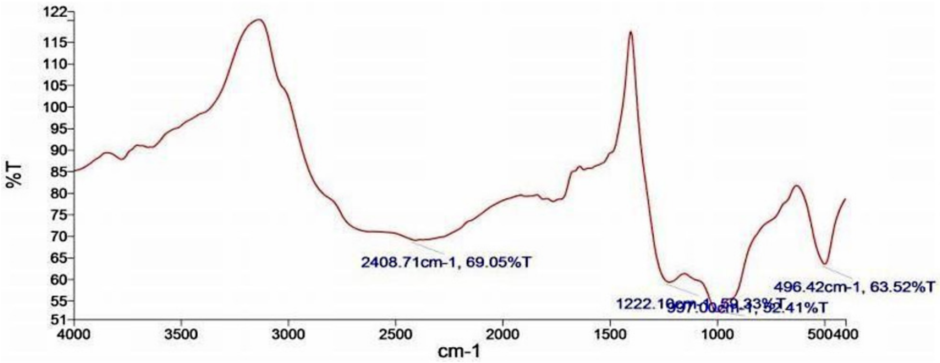


Fig. 4: Spectrum result of Phosphoric Acid

Fourier Transform Infra Red Spectroscopy Phosphoric Acid

The highest at 1222 cm^{-1} as represented in figure 4, indicates the C-O-C and C- OH, S=O,P=O, C-F bending vibration of ethers, alcohol, sugars, Sulphur, phosphorus and fluorine compounds. The peak at 997.00cm^{-1} corresponds to the Si-O, P-O stretching[8] vibration of the organo silicon and phosphorus compounds, 496.42cm^{-1} corresponds to the c-halogen and aromatic rings revealing halogen and aromatic compounds.

Potassium Hydroxide

The FTIR spectrum of the broad peak at 3628.58 cm^{-1} which is depicted in figure 5 corresponds to the O-H stretching vibration of the alcohol group. (medium, sharp peak).[9] The peak at 2560.06 cm^{-1} corresponds to the O-H stretching carboxylic acid class with strong, broad peak.

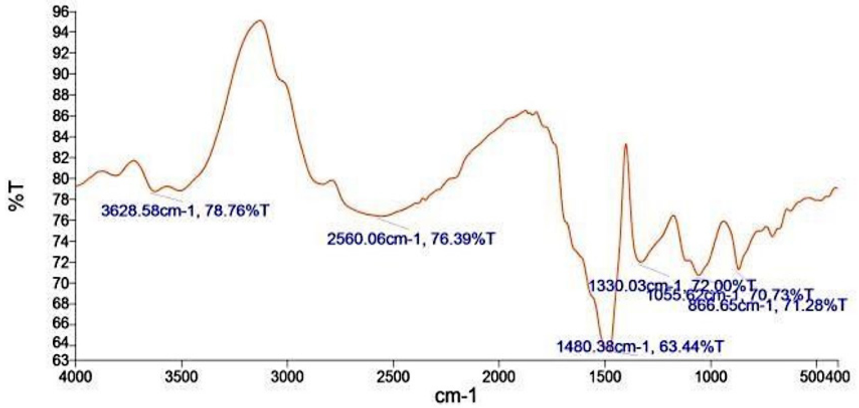


Fig. 5: Spectrum result of Potassium Hydroxide

Calcium Carbonate

The FTIR spectrum of the broad peak at 3520 cm^{-1} which is depicted in figure 6 corresponds to the primary amine.[11] (Medium peak). The peak at 2515.32 cm^{-1} corresponds to the O- H stretching carboxylic acid class with strong, broad peak.The peak at 1493.03 cm^{-1} corresponds to the nitro compound group with strong peak.[11] The peak at 709. 71 cm^{-1} corresponds to the C=C bending alkene with strong peak.[11]

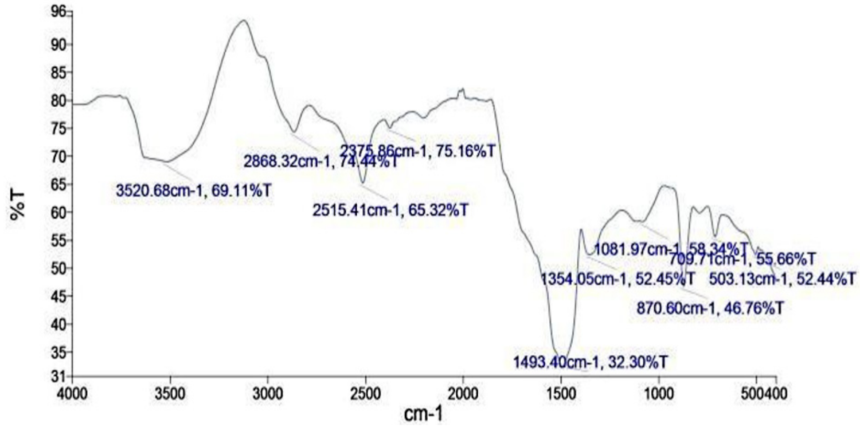


Fig. 6: Spectrum result of Calcium Hydroxide

Scanning Electron Microscope

Morphological Analysis of Activated Carbon (Calcium Carbonate)

Morphological analysis was performed in order to study the structure, elemental composition, thickness, grain size of sample material. SEM and EDAX were performed. SEM analysis was done using TESCAN MIRA3 Fe-SEM equipment. From SEM images, it was found that obtained activated carbon is smooth with glossy surface but irregular in shape. The fibrous structure may be due to helically wound cellulose microfibrils in an amorphous matrix of lignin and cellulose. Large pores were created due to the thermal decomposition of these phloem fibers. Such this structure provides high adsorption property to the adsorbent. EDAX mainly done to find the elemental composition of adsorbent. EDAM was done using EDAX-APEX software. From EDAX image, it was observed that adsorbent contains major element of carbon, potassium and calcium around 88% from figure 9. along with that a negligible number of other elements are present. Is shown in figure 7 and 8. Particle size of the adsorbent varied from 133 µm to 19.5µm with a surface area. This clearly shows that the pores are of sufficient size to adsorb contaminants.

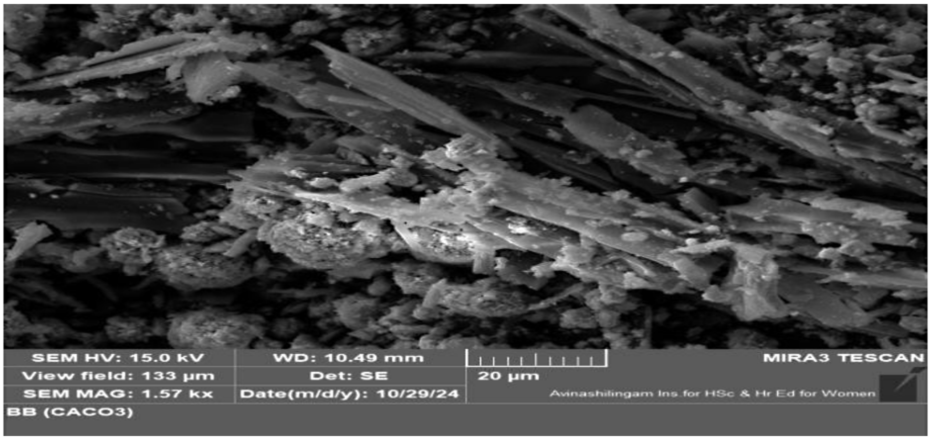


Fig. 7: SEM image of Calcium Carbonate

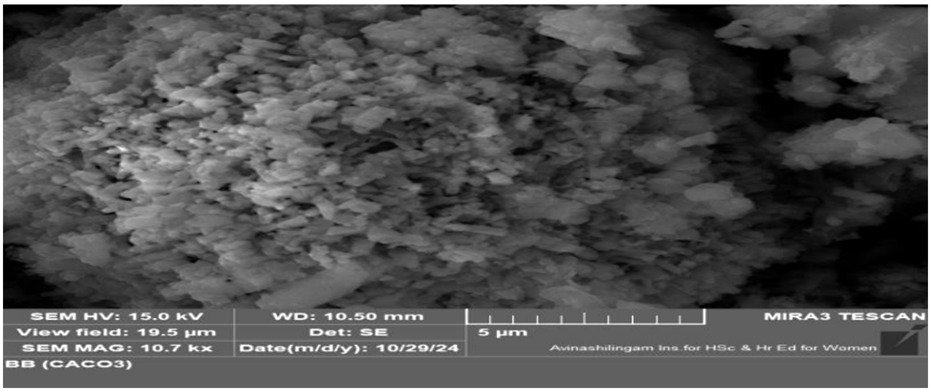


Fig. 8: SEM image of Calcium Carbonate with pores

Element	Weight %	Atomic %	Error %
C K	24.57	37.27	7.35
O K	40.39	46.00	10.34
Mg K	1.65	1.24	9.21
Si K	0.83	0.54	8.54
Cl K	1.17	0.60	12.45
K K	7.26	3.38	3.99
Ca K	24.13	10.97	2.78

Fig. 9: composition percentage of elements present in Calcium Carbonate

Optimization Using RSM

The RSM optimizes the results within a limited runs given in figure 10, the build information is mentioned in table 2.

Table 2: Build Information of RSM

File Version	23.1.6.0
Design Type	Response Surface
Study Type	Box Behnken
Sub Type	Randomized
Runs	17
Design Model	Quadratic
Build Time	89.00

Significance of Box-Benkhen Type

By employing Box-Benkhen designs manufacturers generate complex response surfaces through fewer experimental runs than standard factorial approaches require. The final and actual values obtained are given in table 3 and 4, the confirmation run is stipulated in figure 17. The A,B,C represents time, electrode and activated carbon respectively.

Table 3: Equations in terms of Coded

EQUATIONS IN TERMS OF CODED	
Turbidity	12.70+0.8250XA+0.3125XB+1.21XC+1.45XAB-1.25XAC+2.07XBC+12.59XA2+9.26XB2+14.31XC2
TDS	940+5XA+0XB+10XC+32.50XAB-12.50 XAC+32.50XBC+121.25XA2+76.25XB2+136.25XC2
Hardness	110+2.50XA+7.50XB+10XC+20XAB-10XAC+35XBC+77.50XA2+32.50XB2+82.50XC2
DO	2.80+0.05XA+0.025XB-0.025XC+0.05XAB+0.05XAC+0XBC+0.55XA2+0.60XB2+0.70XC2
COD	750+28.75XA-3.50XB+25.25XC+57.50XAB-25XAC+49.50XBC+184XA2+108.50XB2+241XC2
pH	2.65+0.0443XA-0.0443XB-0.0429XC+0.0457XAB-0.0429XAC+0.0429XBC+0.0685XA2+0.0685XB2+0.157XC2

Table 4: Equations in actual factors

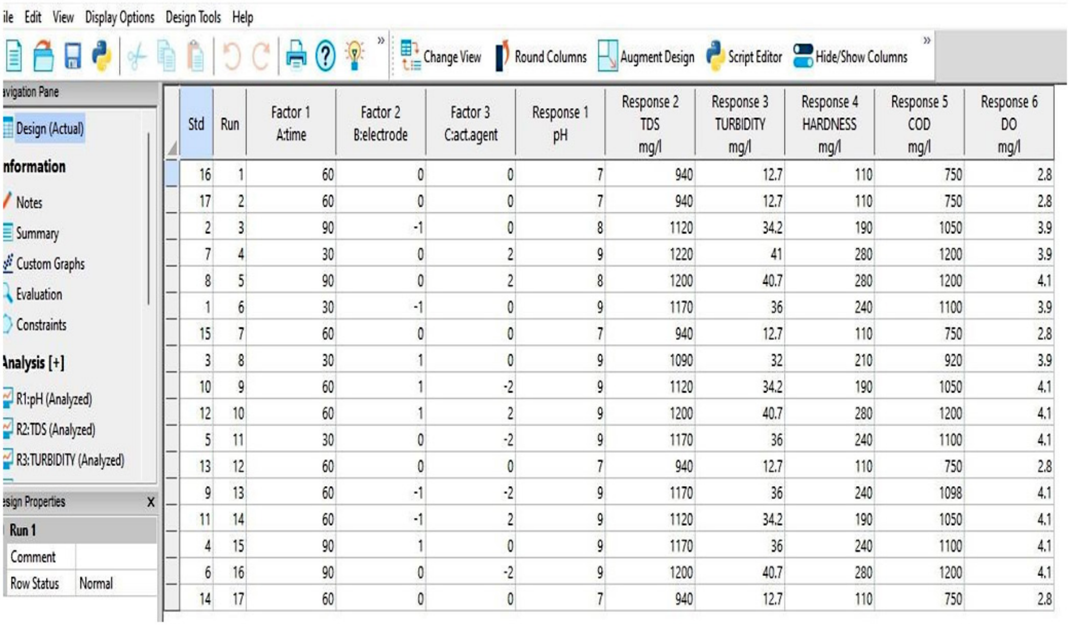
EQUATIONS IN TERMS OF ACTUAL FACTORS	
Turbidity	+61.4-1.65 time-2.58 electrode +1.85 activation agent+0.048 time*electrode-0.02 time* activation agent +1.03 electrode *activation agent +0.013 time2 +0.013 electrode2 +34.06 activation agent 2
TDS	+1415-16 time-65 electrode +17.5 activation agent +1.083 time*electrode-0.2083 time* activation agent + 16.25 electrode *activation agent +0.134722 time2 + 9.26 electrode 2 +3.57 activation agent 2
Hardness	+415-10.25 time-32.5 electrode +15activation agent +0.6 time*electrode-0.16 time* activation agent +17.5 electrode *activation agent + 0.086 time2 + 32.5 electrode2 +20.62 activation agent 2
DO	+4.9-0.07 time-0.075 electrode -0.062activation agent +0.001 time*electrode +0.00083 time* activation agent -2.07 electrode *activation agent + 0.0006 time2 + 0.6 electrode 2 +0.175 activation agent 2
COD	+1428.5-23.57 time- 118.5 electrode +37.62activation agent +1.91 time*electrode-0.41 time* activation agent +24.75 electrode *activation agent + 0.20 time2 + 108.5 electrode 2 +60.25 activation agent2
pH	+2.83-0.007 time-0.135 electrode +0.02 activation agent +0.001 time*electrode-0.0007 time* activation agent +0.02 electrode *activation agent + 0.000076 time2 + 0.068 electrode 2 +0.039 activation agent2

pH

The predicted R^2 of 0.9978 matches the adjusted R^2 of 0.9997 within a margin of less than 0.2. Figure 11 illustrates the relationship between environmental parameters and pH.

TDS

A difference of less than 0.2 separates the predicted R2 value of 0.9514 from the adjusted R^2 value of 0.9997. Figure 12 shows the connection between environmental parameters and TDS.



Std	Run	Factor 1 A:time	Factor 2 B:electrode	Factor 3 C:act.agent	Response 1 pH	Response 2 TDS mg/l	Response 3 TURBIDITY mg/l	Response 4 HARDNESS mg/l	Response 5 COD mg/l	Response 6 DO mg/l
16	1	60	0	0	7	940	12.7	110	750	2.8
17	2	60	0	0	7	940	12.7	110	750	2.8
2	3	90	-1	0	8	1120	34.2	190	1050	3.9
7	4	30	0	2	9	1220	41	280	1200	3.9
8	5	90	0	2	8	1200	40.7	280	1200	4.1
1	6	30	-1	0	9	1170	36	240	1100	3.9
15	7	60	0	0	7	940	12.7	110	750	2.8
3	8	30	1	0	9	1090	32	210	920	3.9
10	9	60	1	-2	9	1120	34.2	190	1050	4.1
12	10	60	1	2	9	1200	40.7	280	1200	4.1
5	11	30	0	-2	9	1170	36	240	1100	4.1
13	12	60	0	0	7	940	12.7	110	750	2.8
9	13	60	-1	-2	9	1170	36	240	1098	4.1
11	14	60	-1	2	9	1120	34.2	190	1050	4.1
4	15	90	1	0	9	1170	36	240	1100	4.1
6	16	90	0	-2	9	1200	40.7	280	1200	4.1
14	17	60	0	0	7	940	12.7	110	750	2.8

Fig 10: The tests to be conducted according with RSM

Turbidity

The predicted R^2 value of 0.9514 shows acceptable correlation when compared against the adjusted R^2 value of 0.9931. Figure 13 illustrates the relationship of environmental variables with Turbidity since the difference remains below 0.2.

Hardness

The model predicts an R^2 value of 0.8903 which stays within reasonable limits compared to the adjusted R^2 value of 0.9843. However, the predicted values remains below 0.2 , as figure 14 illustrates the interaction of environmental factors with Hardness measurements.

COD

The predicted R^2 of 0.7919 exhibits a compatible relationship with the adjusted R^2 value of 0.9703 which constitutes a difference of less than 0.2. Figure 15 shows a depiction of the environmental parameter-CPM interaction.

DO

The predicted R^2 of 0.9708 shows as match with the adjusted R^2 of 0.9958. Figure 16 illustrates DO variation according to environmental parameters and the differences remain less than 0.2.

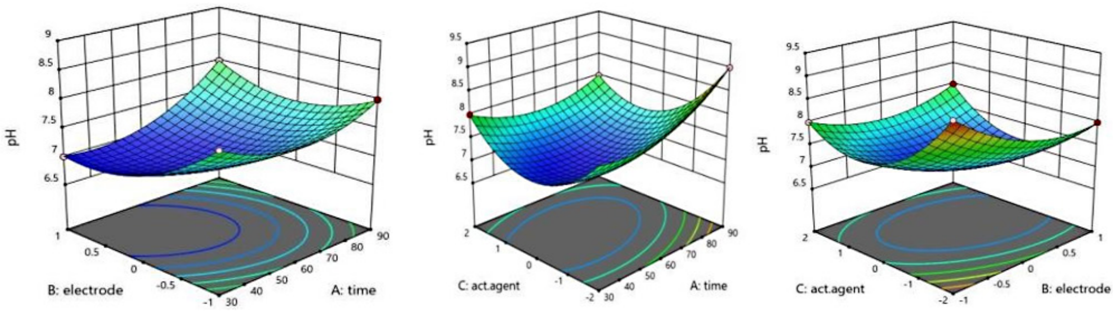


Fig. 11: Interaction between environmental parameter of pH

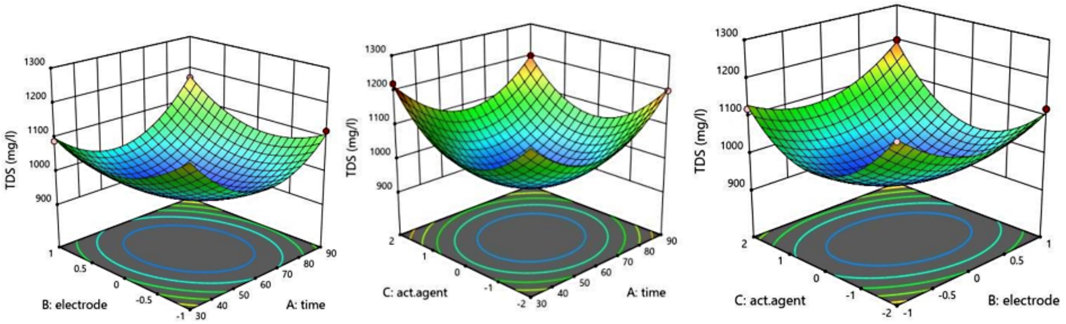


Fig. 12: Interaction between environmental parameter of TDS

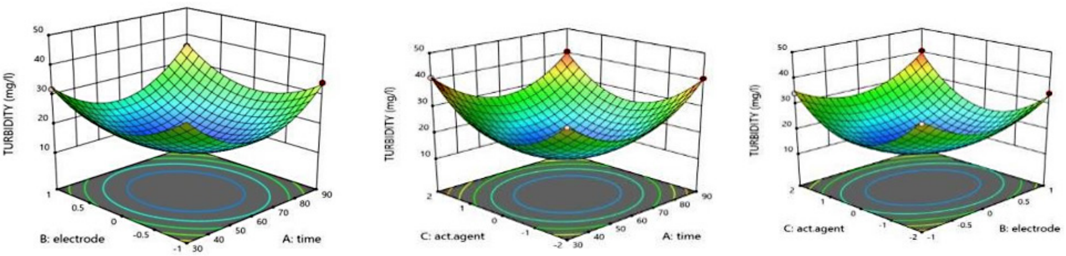


Fig. 13: Interaction between environmental parameter of Turbidity

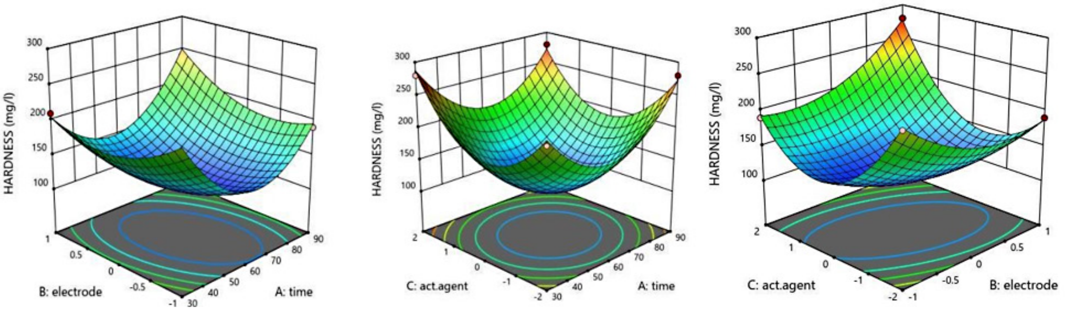


Fig. 14: Interaction between environmental parameter of Hardness

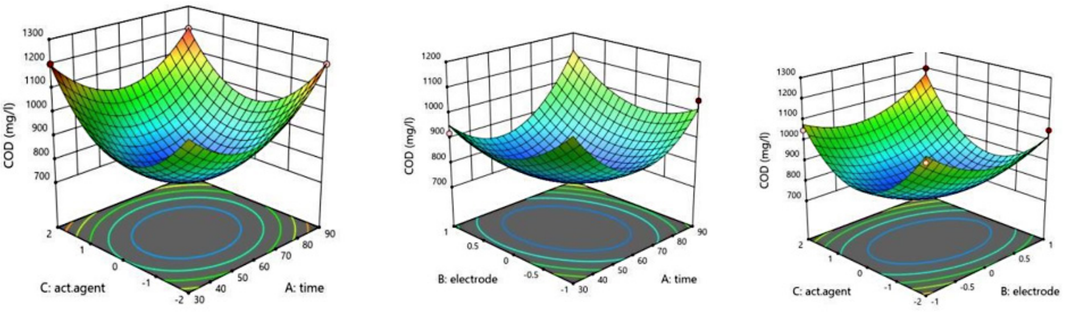


Fig. 15: Interaction between environmental parameter of COD

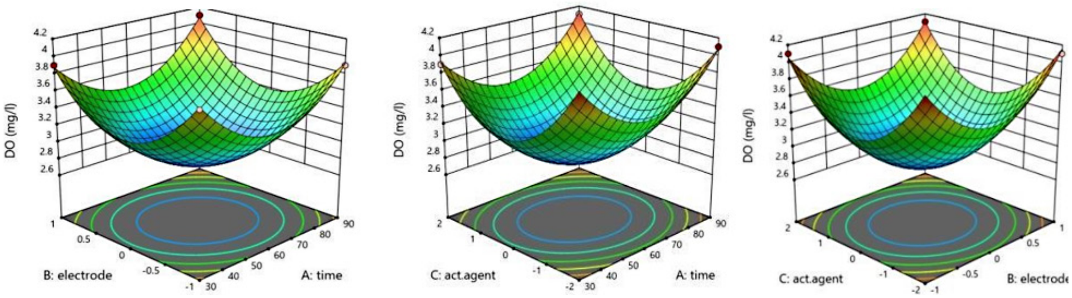


Fig. 16: Interaction between environmental parameter of DO

Coefficient of R^2, in this study shows that the values reached nearly 1 that interprets better fit that shows excellent variability in response. The table 5 shows the significance about the tests and estimate quadratic model parameters, detect lack of fit and to build sequential designs and Table 6 depicts the Fit Statistics of the variability in response.

Table 5 : ANOVA result and adequacy of the quadratic model

pH	source	Sum of squares	df	Mean squares	F-value	P-value	
	model	0.225	9	0.025	5696.5	<0.0001	significant
	A-time	0.015	1	0.015	3562.9	<0.0001	-
	B-electrode	0.015	1	0.015	3562.9	<0.0001	-
	C-act.agent	0.01	1	0.014	3343.1	<0.0001	-
	AB	0.0083	1	0.0083	1894.89	< 0.0001	-
	AC	0.0074	1	0.0074	1671.55	< 0.0001	-
	BC	0.0074	1	0.0074	1671.55	< 0.0001	-
	A2	0.0198	1	0.0198	4487.90	< 0.0001	-
	B2	0.0198	1	0.0198	4487.90	< 0.0001	-
	C2	0.1039	1	0.1039	23592.8	< 0.0001	-
	Residual	0.000	7	4.403	-	-	-
	Lack of fit	0.000	3	0.0000	-	-	-
	Pure error	0.000	4	0.0000	-	-	-
	Cor total	0.2258	16	-	-	-	-
TURBIDITY	model	2153.92	9	239.32	255.08	<0.0001	significant
	A-time	5.44	1	5.44	5.80	0.0468	-
	B-electrode	0.7812	1	0.7812	0.8327	0.3918	-
	C-act.agent	11.76	1	11.76	12.54	0.0095	-
	AB	8.41	1	8.41	8.96	0.0201	-
	AC	6.25	1	6.25	6.66	0.0364	-
	BC	17.22	1	17.22	18.36	0.0036	--
	A2	667.14	1	667.14	711.07	<0.0001	-
	B2	361.24	1	361.24	385.03	<0.0001	-
	C2	862.52	1	862.52	919.32	<0.0001	-
	Residual	6.57	7	0.9382	-	-	-
	Lack of fit	6.57	3	2.19	-	-	-
	Pure error	0.0000	4	0.0000	-	-	-
	Cor total	-	-	-	-	-	-

HARDNESS	Model	72394.12	9	8043.79	112.61	<0.0001	significant
	A-time	50.00	1	50.00	0.7000	0.4304	-
	B-electrode	450.00	1	450.00	6.30	0.0404	--
	C-act.agent	800.00	1	800.00	11.20	0.0123	-
	AB	1600.00	1	1600.00	22.40	0.0021	-
	AC	400.00	1	400.00	5.60	0.0499	-
	BC	4900.00	1	4900.00	68.60	<0.0001	-
	A^2	25289.47	1	25289.47	354.05	<0.0001	-
	B^2	4447.37	1	4447.37	62.26	<0.0001	-
	C^2	28657.89	1	28657.89	401.21	<0.0001	-
	Residual	500.00	7	71.43	-	-	-
	Lack of Fit	500.00	3	166.67	-	-	-
	Pure Error	0.0000	4	0.0000	-	-	-
	Cor Total	72894.12	16	-	-	-	-
	Model	5.191	9	57682.66	59.02	<0.0001	significant
	A-time	6612.50	1	6612.50	6.77	0.0354	-
COD	B-electrode	98.00	1	98.00	0.1003	0.7607	-
	C-act.agent	5100.50	1	5100.50	5.22	0.0563	-
	AB	13225.00	1	13225.00	13.53	0.0079	-
	AC	2500.00	1	2500.00	2.56	0.1538	-
	BC	9801.00	1	9801.00	10.03	0.0158	-
	A^2	1.426E+05	1	1.426E+0	145.86	<0.0001	-
	B^2	49567.37	1	49567.37	50.72	0.0002	-
	C^2	2.446E+05	1	2.446E+0	250.24	<0.0001	-
	Residual	6841.00	7	977.29	-	-	-
	Lack of Fit	6841.00	3	2280.33	-	-	-
	Pure Error	0.0000	4	0.0000	-	-	-
	Cor Total	5.260	16	-	-	-	-
DO	Model	5.47	9	0.6073	425.08	<0.0001	significant
	A-time	0.0200	1	0.0200	14.00	0.0072	-
	B-electrode	0.0050	1	0.0050	3.50	0.1036	-
	C-act.agent	0.0050	1	0.0050	3.50	0.1036	-
	AB	0.0100	1	0.0100	7.00	0.0331	-
	AC	0.0100	1	0.0100	7.00	0.0331	-
	BC	0.0000	1	0.0000	0.0000	1.0000	-
	A^2	1.27	1	1.27	891.58	<0.0001	-
	B^2	1.52	1	1.52	1061.05	<0.0001	-
	C^2	2.06	1	2.06	1444.21	<0.0001	-
	Residual	0.0100	7	0.0014	-	-	-
	Lack of Fit	0.0100	3	0.0033	-	-	-
	Pure Error	0.0000	4	0.0000	-	-	-
	Cor Total	5.48	16	-	-	-	-
TDS	Model	1.926E+05	9	21400.33	272.37	< 0.0001	significant
	A-time	200.00	1	200.00	2.55	0.1546	-
	B-electrode	0.0000	1	0.0000	0.0000	1.0000	-
	C-act.agent	800.00	1	800.00	10.18	0.0153	-
	AB	4225.00	1	4225.00	53.77	0.0002	-
	AC	625.00	1	625.00	7.95	0.0258	-
	BC	4225.00	1	4225.00	53.77	0.0002	-
	A^2	61901.32	1	61901.32	787.83	< 0.0001	-

B^2	24480.26	1	24480.26	311.57	< 0.0001	-
C^2	78164.47	1	78164.47	994.82	< 0.0001	-
Residual	550.00	7	78.57	-	-	-
Lack of Fit	550.00	3	183.33	-	-	-
Pure Error	0.0000	4	0.0000	-	-	-
Cor Total	1.93	16	-	-	-	-

Table 6: Fit Statistics

pH	Std.dev	0.0021	R^2	0.9999
	mean	2.78	Adjusted R^2	0.9997
	C.V%	0.0574	Predicted R^2	0.9978
		1	Adeq Precision	220.9897
	Std.dev	0.9686	R^2	0.9970
TDS	mean	29.72	Adjusted R^2	0.9931
	C.V%	3.26	Predicted R^2	0.9514
			Adeq Precision	38.4140
TURBIDITY	Std.dev	0.9686	R^2	0.9970
	mean	29.72	Adjusted R^2	0.9931
	C.V%	3.26	Predicted R^2	0.9514
			Adeq Precision	38.4140
HARDNESS	Std.dev	8.45	R^2	0.9931
	mean	200.59	Adjusted R^2	0.9843
	C.V%	4.21	Predicted R^2	0.8903
			Adeq Precision	27.3834
COD	Std.dev	31.26	R^2	0.9870
	mean	1001.06	AdjustedR^2	0.9703
	C.V%	3.12	Predicted R^2	0.7919
			Adeq Precision	18.9352
DO	Std.dev	0.0378	R^2	0.9982
	mean	3.676	Adjusted R^2	0.9958
	C.V%	1.03	Predicted R^2	0.9708
			Adeq Precision	46.5701

The confirmation point is adhered as 60,0,0 which indicates calcium carbonate adsorbent works good in grey water improvement with copper electrode at 60 minutes.

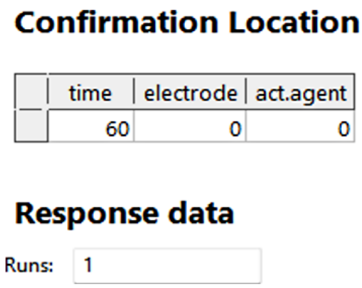


Fig 17: Confirmation Location

Discussion

The procured results is observed that the optimum condition for electro- coagulation of grey water is at 60 minutes with calcium carbonate activated banana bract by using copper electrode, and can be concluded by an efficiency strategy of runs where on this particular conditions the pH, TDS, Turbidity, Hardness, COD, DO as 84%, 85%, 74%, 75%,85%,80% and the total efficiency is attained as 82% is attained in improving grey water.

Conclusion

The Electro coagulation is simple treatment process using aluminum, copper and stainless-steel electrodes with different adsorbents. The effect of process was examined in removal of pH, TDS, Turbidity, COD, etc. Results showed that optimum removal of contaminants are achieved at 60 minutes by Cu-Cu electrode with $CaCo_3$ as adsorbent with a total efficiency of 82%. A 3D surface plot constructed by RSM shows the optimal confirmation points that require minimal testing runs. The analysis shows the developed quadratic model successfully matches experimental data through 95% assessment of variance model optimization. The future studies may be conducted to analyze the wetland cultivation viability on plant growth and yield or can be used to recharge ground water. This study indicates that grey effluent is let into environment without affecting the quality of nature and can be utilized as a revival resource in replenishing the riverine areas and can be used as industrial coolants.

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Conflicts of Interest

The authors do not have any conflict of interest.

Data Availability Statement

The manuscript incorporates all datasets produced or examined throughout this research study.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Permission to Reproduce Material from other Sources

Not Applicable

Author Contributions

- **Charlotte Mashiya Rajesh:** Conceived methodology and writing original draft.
- **Ravathi Mohanadhas Chandrika:** Data collection and manuscript critical revision
- **Revathi Sampath Kumar:** Contributed in data analysis

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