



EFFECT OF INTENSITY OF LIGHT AND DISTANCE FOR DECOLONIZATION IN DIRECT RED WASTEWATER BY PHOTO FENTON OXIDATION

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ABSTRACT

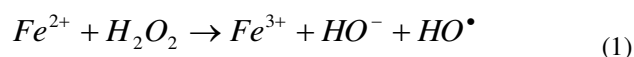
In this paper, the decolonization of direct red wastewater, by photo-Fenton oxidation designed aimed at decontamination of industrial wastewater. The experimentations be situated designed by a response surface method comprising the effect of the irradiation time (30-120 min.), hydrogen peroxide (20-100 ppm), ferrous sulphate (4-20 ppm), Temperature (25-60 °C) and pH (3-9). Then and at the optimum values of these conditions (120 min, 60 ppm of H₂O₂, 13 ppm of ferrous sulphate, temperature 25 °C and pH 6) was 98.5% organic removal from simulated wastewater, and studied belongings of Intensity and Distance from UV Light on simulated wastewater. The results show that the increase in the Intensity of UV light increases the removal and the proximity of the pollutant to the UV light increases the removal.

Keywords: dye wastewater, wastewater treatment, photo-Fenton process, CCD; optimization.

1. INTRODUCTION

One of the main subjects which researchers had been concentrating on stands the undesirable influence of diseased and poisonous wastewater on environment. Organic colours are nonetheless one prominent contaminant of manufacturing wastewater [1]. The dye wastewater reasons thoughtful ecological problems by way of it covers poisonous water contaminants for instance xylenes, colours, bumpers, phenols, peroxides and scrubbing agents, water bribes, surfactants, caustic mixes and acids etc. Water ecological pollution through artificial dyes is the greatest contaminating amongst all the manufacturing sectors and is a thoughtful quandary because of the high water and soil perseverance [2], [3]. The wilds discharged from these manufactures are often powerfully coloured, and the direct statement of the wastewater into receiving water body will aim wound to composed humanoid and water life beings owing to their high solubility, artificial colours remain common water contaminants that are similarly poisonous and oncogenic [4], [5]. Traditional wastewater action arrangements were not envisioned aimed at this emerging Mixes, so they can Living the treatment disadvantaged of squalor and get into the environment [6], [7], [8]. Altogether the lime approaches remain foreseeable toward minimize possessions that give to environmental problems and very influence energy well-organized, a cost real and eco-benign [9], [10], [11]. Wastewater treatment had remained specified aimed at the removal of organic in wastewater [12], [13]. However, no one of these action methods is vigorous toward treat the wastewater. Advanced oxidation processes (AOPs) are additional treatment stage is elective to remove waste of wastewater [14]. AOPs is fundamentally physicochemical action in nature that type very oxidizing class, primarily free radicals () by a redox potential of around $E_0 = 2.8 \text{ V}$ (Subsequently 3.06 eV for fluorine) [15]. These action can completely destroy the organic pollutants into innocuous inorganic resources aimed at instance CO₂ and H₂O underneath sensible

conditions [16]. Photo-Fenton treatment is one of advanced oxidation processes is combination of Fenton reagents and UV-vis. energy that stretches toward free radical [17] as showing in equation (1):



Numerous parameters affect the Fenton process, in specific the original concentration of the component to deteriorate, pH solution, the ferrous ions concentration, the hydrogen peroxide concentration, the solution volume, temperature, and irradiation time. Studying of the result of each and every issue is fairly tedious and time overwhelming [18]. The chief aim of this teaching absorbed on organic elimination from direct red through using photo Fenton oxidation processes. Firstly, find the finest value of H₂O₂, iron (Fe²⁺), temperature, pH and irradiation time aimed at batch technical, then studying the belongings of UV intensity and distance from UV source.

2. MATERIALS AND METHODS

2.1 Materials

All substances rummage-sale in this effort were of logical grade and rummage-sale deprived of extra cleansing; distilled water remained second-hand aimed at preparing the simulated dye wastewater, H₂O₂ (45% wt./wt., Germany), Ferrate sulphate (99 % purity, India), HCl (98 % purity) and NaOH were bought from India. The Direct red dye with molecular weight 571.5 g/mol and wavelength 508 nm, is full from Al-Hilla textile factory south of Baghdad. Figure-1 brings direct red (DR) chemical structure, a stock solution of 1000 ppm is prepared through dissolving 0.25 g of direct red in 250 mL of distilled water, a UV spectrophotometer (UV-1800 Shimadzu, Japan) remained rummage-sale toward measure the organic concentration in direct red throughout the photo Fenton oxidation. The consequences had been



rehabilitated into the consistent concentrations (B). The dye elimination competence was assessed by equation (2):

$$Y_{\text{OCRE}} = \frac{B_0 - B_t}{B_0} \times 100 \% \quad (2)$$

Where: YOCRE is the percentage of organic elimination; B_0 , initial concentration before the treatment process (ppm), and B_t is the organic concentration after the treatment process (ppm).

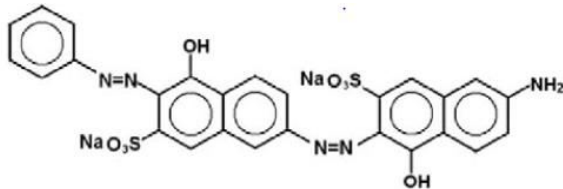


Figure-1. Chemical structure of direct red wastewater.

2.2 Batch Oxidation Reactor

The photo Fenton procedure was emotional to 200 mL of direct red solution and the postponement was irradiated underneath UV box equipped with eight UV tubes (6 W of each overwhelming a wavelength of 365 nm). A magnetic stirrer was second-hand to protection unchanging mixing of the solution in the ampule. After 20 min, the solution separated and a UV-VIS Spectrophotometer was rummage-sale to measure the final organic concentrations in simulated wastewater, the pH

solutions remained measured through WTW pH-720 digital pH meter.

2.3 Experimental Design

The optimization of untried circumstances aimed at direct red decolonization finished photo-Fenton treatment aimed at batch scheme was displayed through the Box Behnken design (BBD) method beneath response surface method. The software Design Skilled Minitab-17 was used aimed at the untried design, data examination, quadratic model removal, and graph plotting. The autonomous variables of pH (X_1), H_2O_2 concentration (X_2) (X_3), Temperature (X_4) and ferrous sulphate (X_5). They were coded finished low and high levels in the BBD as exposed in Table-1.

Table-1. Working parameters.

Parameters	Ranges
X_1 : pH	3-9
X_2 : H_2O_2 concentration (ppm)	20-100
X_3 : Irradiation time (min)	30-120
X_4 : Temperature ($^{\circ}C$)	25-60
X_5 : Ferrous Sulphate (ppm)	4-20

3. RESULTS AND DISCUSSIONS

Table-2 clarifies the values of the working variables and the replies of the final organic removal efficiency for each run.

**Table-2.** Results of batch photo-Fenton oxidation experiments.

Run	Std Order	Run Order	Pt Type	Blocks	X ₁ : pH	X ₂ : Hydrogen Peroxide	X ₃ Time	X ₄ Temperature	X ₅ Ferrous Sulphate	TOC removal (%)
1	1	1	2	1	3	20	75	42.5	12	5.4375
2	2	2	2	1	9	20	75	42.5	12	6.6875
3	3	3	2	1	3	100	75	42.5	12	9.8125
4	4	4	2	1	9	100	75	42.5	12	22.3125
5	5	5	2	1	6	60	30	25	12	94.8125
6	6	6	2	1	6	60	120	25	12	98.4375
7	7	7	2	1	6	60	30	60	12	10.4375
8	8	8	2	1	6	60	120	60	12	16.0625
9	9	9	2	1	6	20	75	42.5	4	15.4375
10	10	10	2	1	6	100	75	42.5	4	34.1875
11	11	11	2	1	6	20	75	42.5	20	5.4375
12	12	12	2	1	6	100	75	42.5	20	12.3125
13	13	13	2	1	3	60	30	42.5	12	16.6875
14	14	14	2	1	9	60	30	42.5	12	22.9375
15	15	15	2	1	3	60	120	42.5	12	21.6875
16	16	16	2	1	9	60	120	42.5	12	58.5625
17	17	17	2	1	6	60	75	25	4	94.1875
18	18	18	2	1	6	60	75	60	4	10.4375
19	19	19	2	1	6	60	75	25	20	98.5625
20	20	20	2	1	6	60	75	60	20	15.4375
21	21	21	2	1	6	20	30	42.5	12	17.3125
22	22	22	2	1	6	100	30	42.5	12	5.4375
23	23	23	2	1	6	20	120	42.5	12	45.4375
24	24	24	2	1	6	100	120	42.5	12	53.5625
25	25	25	2	1	3	60	75	25	12	91.6875
26	26	26	2	1	9	60	75	25	12	97.9375
27	27	27	2	1	3	60	75	60	12	10.4375
28	28	28	2	1	9	60	75	60	12	22.9375
29	29	29	2	1	6	60	30	42.5	4	35.4375
30	30	30	2	1	6	60	120	42.5	4	49.8125
31	31	31	2	1	6	60	30	42.5	20	10.4375
32	32	32	2	1	6	60	120	42.5	20	56.0625
33	33	33	2	1	3	60	75	42.5	4	9.1875
34	34	34	2	1	9	60	75	42.5	4	19.1875
35	35	35	2	1	3	60	75	42.5	20	16.6875
36	36	36	2	1	9	60	75	42.5	20	31.6875
37	37	37	2	1	6	20	75	25	12	81.0625
38	38	38	2	1	6	100	75	25	12	89.8125
39	39	39	2	1	6	20	75	60	12	11.6875
40	40	40	2	1	6	100	75	60	12	29.1875
41	41	41	0	1	6	60	75	42.5	12	31.0625
42	42	42	0	1	6	60	75	42.5	12	30.4375
43	43	43	0	1	6	60	75	42.5	12	29.8125
44	44	44	0	1	6	60	75	42.5	12	30.1875
45	45	45	0	1	6	60	75	42.5	12	30.75
46	46	46	0	1	6	60	75	42.5	12	29.9375



3.1 Mathematical Correlation of the Studied Reply

Founded scheduled untested penalties, the mathematical equation (3) was developed in relations of actual subjects concerning the organic elimination reply to the occupied variables revealing the relations between these variables:

$$\begin{aligned} \text{DR Removal} = & 293.6 + 3.66 X1 + 0.366 X2 - 0.951 X3 - \\ & 10.21 X4 - 0.62 X5 - 0.760 X12 - 0.00525 X22 + 0.00277 \\ & X32 + 0.0890 X42 - 0.0409 X52 + 0.0234 X1X2 + 0.0567 \\ & X1X3 + 0.0298 X1X4 + 0.052 X1X5 + 0.00278 X2X3 + \\ & 0.00313 X2X4 - 0.0093 X2X5 + 0.00063 X3X4 + 0.0217 \\ & X3X5 + 0.0011 X4X5 \end{aligned} \quad (3)$$

3.1.1 The effect of hydrogen peroxide

Hydrogen peroxide (H_2O_2) is oxidizing reagent use to urgency the organic decomposition process. Figure 2 protests the comparative between the aptitude of organic removal and the different of under the H_2O_2 constant conditions, it's clear that the squalor of organic increased by way of the is H_2O_2 augmented from 20 to 100 (mg/L) accomplishment a maximum elimination of 41% at 67 (mg/L) of H_2O_2 then 90 min, the reaction rate was dramatically amplified when hydrogen peroxide was extra to the direct red solution that was exposed to UV radiation. These clarifications are agreed with that touched through Tony *et al.*, 2009 [19]. Then adding of hydrogen peroxide directly overhead this value had a negative consequence on organic competence in direct red, 28% at 100 ppm of H_2O_2 . Consequently, a balance necessity be preserved between extra and low levels of hydrogen peroxide [20], [21].

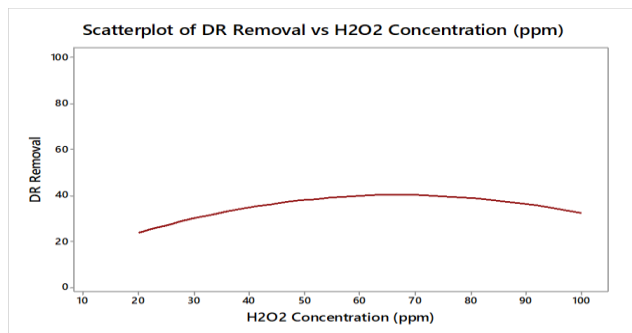


Figure-2. Effect of hydrogen peroxide on DR elimination.

3.1.2 Effect of Ferrous Sulphate

Toward determine the finest ferrous sulphate concentration aimed at the mineralization of the direct red wastewater, the direct red was treated with ferrous sulphate in the variety of 4 to 20 ppm as demonstrated in Figure-3, the finest ferrous concentration was originated to be 13 mg/L which caused in 38 % elimination afterward about 90 min irradiation time. Alike observations were made in earlier studies by Tony *et al.*, 2012 [22].

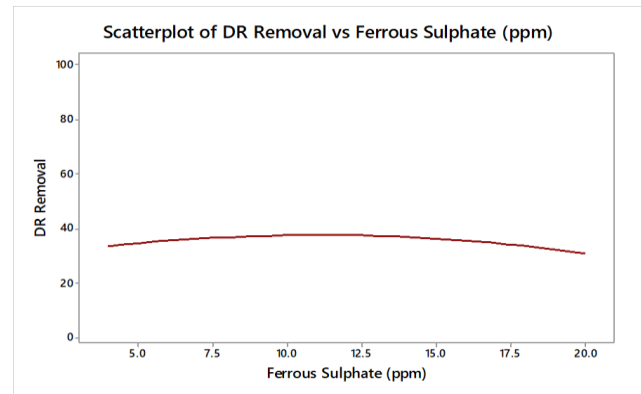


Figure-3. Effect of ferrous sulphate on DR elimination.

3.1.3 Effect of irradiation time

The photo- Fenton process time need remain by way of short as probable to evade a high electricity consumption, which indicates about 60% of the whole working cost afterward by means of electric light sources [23], [24]. The hydrogen peroxide is not compulsory aimed at all the photochemical treatment however, whenever exploited it has to be detached beforehand the biological stage if it will be practical afterward the photo Fenton oxidation step. Figure-4 designate that elimination upsurge was comparative and slow afterward, upsurge of organic removal can remain associated to chemical oxidation of organic elimination through free radical. A number of revisions stated that the upsurge of irradiation time upsurses the competence of the process [25].

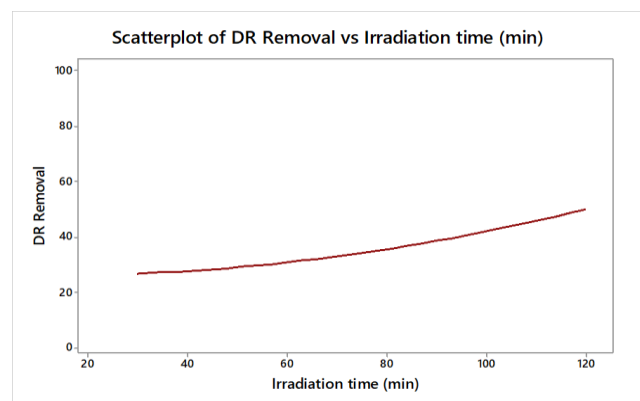


Figure-4. Effect of irradiation time on DR elimination.

3.1.4 Effect of temperature

Figure-5 demonstrations the elimination of organic in the direct red aimed at trials conducted through different temperatures. The positive result of temperature can remain empirical. Upsurge of temperature from 25 to 60°C has abridged the obligatory time meant aimed at the pollutant's elimination. The photo-Fenton squalor is preferred aimed at most cases finished increasing temperature. The temperature rises from 25 to 60 °C that the organic elimination upsurses from 89 % at 20 °C to 24% at 60 °C. The upsurge in the temperature value quickens the decay of H_2O_2 so decreasing the generation of free radicals which discounts the degradation



competence and this significance is similar to Filiz Ay *et al.*, 2010 [26].

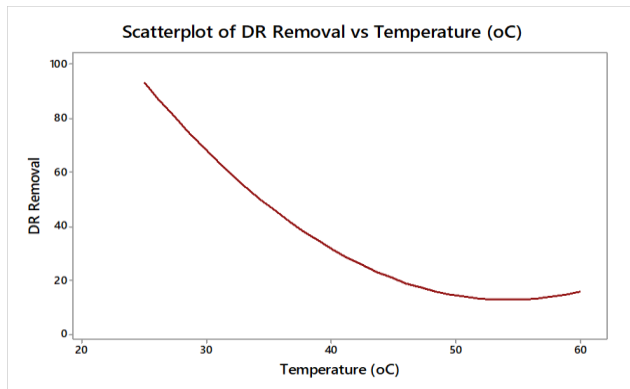


Figure-5. Effect of temperature on DR elimination.

3.1.5 Effect of pH

The pH value has a conclusive consequence on the oxidation potential of free radicals owing to the mutual relative of the oxidation potential to the pH value. Too, the inorganic carbon concentration and the hydrolytic speciation of Fe^{2+} species are powerfully pretentious thru the pH value. Consequently, the pH role in the photo-Fenton reaction necessity be strong-minded. The pH value belongings the generation of free radicals and then the oxidation efficiency. Aimed at pH values above 6 the degradation muscularly reductions since iron precipitates by way of hydroxide derivate, plummeting the Fe^{2+} obtainability and the radiation transmission. [1]. Figure-6 demonstrations the result of the pH value throughout the use of the photo-fenton treatment, all-out organic elimination of 42 % was got with the system UV/ H_2O_2 /

Fe^{2+} at a pH =6.8 and within irradiation time of 90 min [27].

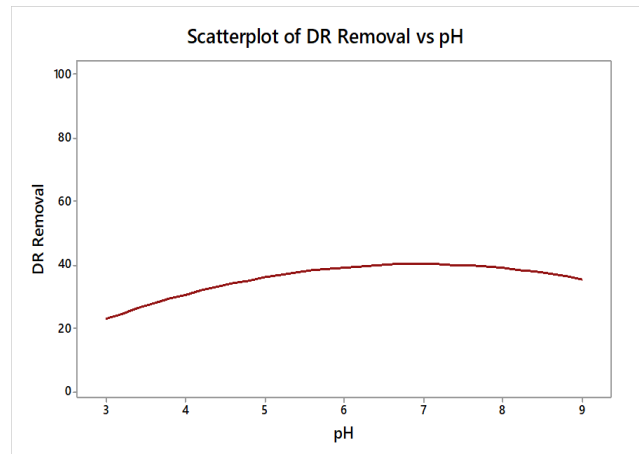


Figure-6. Effect of pH on DR removal.

3.2 Analysis of Variance Test

The Analysis of variance is an implement of examination aimed at fitting the function toward the data that might attitude misguiding consequences then the obligatory replicas cannot remain labelled sufficiently. Table-3 delivers the analysis of variance aimed at organic elimination where the values of Prob (P) was less than 0.001 and the F-value was 61.32 which means that the assessed perfect is important. Furthermore, the high value of the regression constant ($R^2=0.9454$) intended for DR elimination response implies that this model is important.

**Table-3.** Analysis of variance.

Source	DOF	Seq. SS	Adj. MS	Fisher Value	P-test Value
1-Model	20	38248.9	1912.4	21.62	0.000
Linear	5	27131.6	5426.3	61.36	0.000
X ₁	1	632.8	632.8	7.16	0.013
X ₂	1	290.1	290.1	3.28	0.082
X ₃	1	2165.2	2165.2	24.48	0.000
X ₄	1	24015.3	24015.3	271.55	0.000
X ₅	1	28.2	28.2	0.32	0.577
Square	5	10435.5	407.8	23.60	0.000
X ₁ ²	1	407.8	615.6	4.61	0.42
X ₂ ²	1	615.6	615.6	6.96	0.014
X ₃ ²	1	273.8	273.8	3.10	0.091
X ₄ ²	1	6489.2	6489.2	73.38	0.000
X ₅ ²	1	59.8	59.8	0.68	0.419
2-Way Interaction	10	681.8	68.2	0.77	0.655
X ₁ *X ₂	1	31.6	31.6	0.36	0.555
X ₁ *X ₃	1	234.5	234.5	2.65	0.116
X ₁ *X ₄	1	9.8	9.8	0.11	0.742
X ₁ *X ₅	1	6.3	6.3	0.07	0.793
X ₂ *X ₃	1	100.0	100.0	1.13	0.298
X ₂ *X ₄	1	19.1	19.1	0.22	0.646
X ₂ *X ₅	1	35.3	35.3	0.4	0.534
X ₃ *X ₄	1	1.0	1.0	0.01	0.916
X ₃ *X ₅	1	244.1	244.1	2.76	0.109
X ₄ *X ₅	1	0.1	0.1	0.00	0.974
Error	25	2211.0	88.4		
Lack-of-Fit	20	2209.8	110.5	476.45	0.000
Pure error	5	1.2	0.2		
Total	45	40459.8			

3.3 Optimization of Working Variables

The finest values of H₂O₂, Fe²⁺, irradiation time, temperature and pH were got through by means of a Statistical software program (Minitab-17). Figure-7

explains the penalties of the D-optimization measurement. The best values of the competences of dye were more than 98 %.

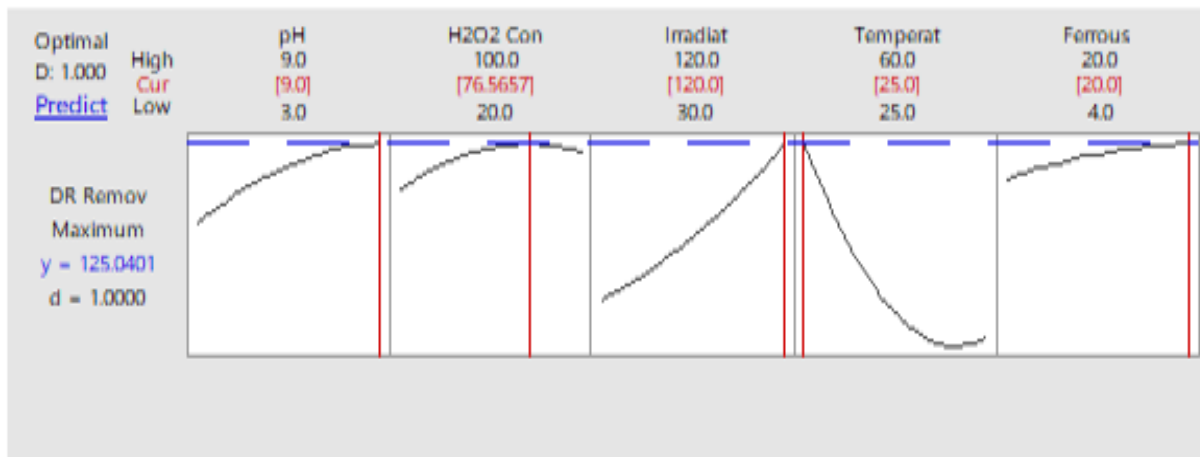


Figure-7. The best values of the working variables for organic removal.

3.4 Effects of Intensity of Light and Distance from UV Source

The result of the UV radiation intensity on the discoloration competence was too deliberate, through treating the samples in (6, 12, 18, 24 W) UV box. The consequences have exposed that UV radiation intensity improved the dye degradation non significantly which might remain due the inaccessibility of free radicals. The result of ultraviolet light power on organic removal was also investigated. Ultraviolet light irradiates H_2O_2 to damage colour very fast since the concentration of OH radical augmented. The organic elimination rate augmented with incrementing ultraviolet light power which might be the reason that ultraviolet light resulted higher free radical generation. The squalor of organic was experiential greatly faster through upsurge of ultraviolet intensity, representative that ultraviolet light had an significant influence on the squalor of dye [28]. Too has been set Distance of UV lamps from direct red wastewater was adjusted to 15, 30, and 50 cm. The consequences of the effects of intensity of UV source are exposed in Figure- 8. The organic removal through Photo Fenton was straight line reduced with the rising of UV lamps from glass reactor. By way of in Figure 8, it appeared that best distance in which concentration reduction happens most fast was 15 cm from surface of direct red wastewater. The aim for this may be because of lower light intensity and reduction of surface Photo Fenton activities. This is the same results founded by [29].

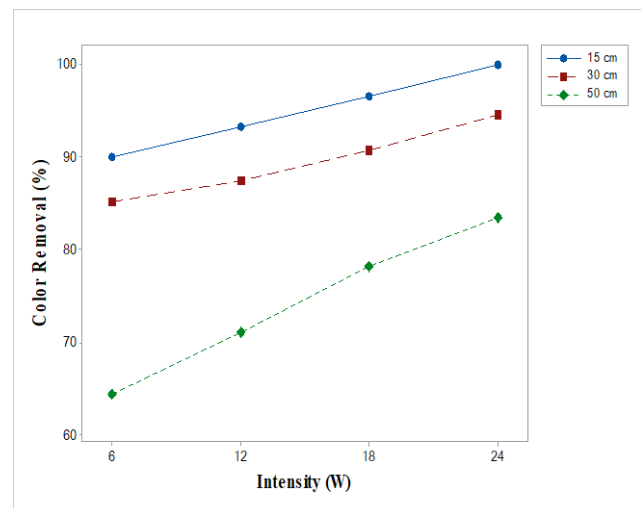


Figure-8. Effects of intensity of light and distance on organic elimination.

4. CONCLUSIONS

This education presents significant findings aimed at future growth of large-scale photo-Fenton oxidation reactors. We have deliberated that batch system configurations might be a appropriate excellent aimed at direct red wastewater. Too, the studies of the effect of the different variables in batch system on the squalor presentation are vital for organic in direct red wastewater, all the organic content was removed. According to the results, photo-Fenton is talented treatment options aimed at these highly organic wastewaters. Future investigations must emphasis on optimizing action processes and assessing toxic effects those residual contaminants.

Declaration of Interests

The authors declare that they have no known competing monetary interests or personal relations that might have appeared to effect the work stated in this paper.



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