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Spectrophotometer Method for Removal of Paraben by Using UV/H_2O_2 Process

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Abstract:

Parabens are esters of para-hydroxybenzoic acid, with an alkyl (methyl, ethyl, propyl, or butyl) or benzyl group. They are mainly used as preservatives in foodstuffs, cosmetics, and pharmaceutical drugs. Parabens are present at low concentration levels in effluents of the wastewater treatment plant. These parabens have continuously entered the environment and cause serious threats to aquatic and humans. So, the elimination of parabens is important in wastewater. The study aims to remove the paraben from an aqueous solution using the UV/H_2O_2 process. The parameters vary such as pH, H_2O_2, pollutant concentration, and time. The simple, rapid and sensitive UV spectroscopy method was used for the determination of paraben. Paraben was observed maximum at the absorbance of 254 nm. The results show that the maximum removal will be observed at the optimum conditions. The removal efficiency of paraben will be noted and reported in the study.

Keywords: Cosmetics, Aqueous solution, paraben, UV/H_2O_2, spectrophotometer

1. Introduction:

The deterioration of cosmetics, medications, and food brought on by the action of microbes is stopped or delayed by the use of parabens. A class of preservatives called parabens is frequently utilized in pharmaceutical and cosmetic products. Many goods, including moisturizers, hair care items, shaving creams, and makeup, contain parabens. When parabens are used in personal care items, they may find their way into aquatic ecosystems and the environment through wastewater. Parabens can linger in the water for a very long period and have the potential to harm aquatic life. Particularly in the case of parabens, a class of purportedly harmless preservatives that has been linked to breast cancer, some allergies, skin and eye irritation, a decline in male fertility, and other side effects over time recent years. Studies indicate that methyl paraben may harm the skin by causing cancer. Recently, reports have also been made about the discovery of parabens in human tissues as a result of environmental exposure. Parabens are permitted in a variety of pharmaceutical goods as preservatives at maximum quantities that rarely reach 0.1%. All parabens have a limited solubility in water, however they

dissolve in the majority of systems as the temperature rises above 60°C. Methyl-paraben (MP), ethyl-paraben (EP), propyl-paraben (PP), and butyl-paraben (BP) are the parabens that are most frequently found in natural waters. Only a small number of research had examined the possible harm that parabens could do to both humans and the environment before the late 1990s. But today, there are a strikingly greater number of scientific publications alerting the public to the dangers parabens pose to both human health and the environment.

Methodology:

First, we take a closed box that has been interior lined entirely with aluminium foil. Fix the 11W UV lamp within the box so that it is precisely next to the sample beaker, then connect it to the UV adaptor choke so that it may receive electricity. Aluminium foil serves as a barrier to prevent UV light from inside the box from losing its intensity. Only inside the confined box is the full paraben elimination procedure carried out.

Fig 1 - Reactor Setup

- Initially we prepare the solution with a concentration of 0.1g/l and from that we prepare required samples using formulae

$$N_1V_1=N_2V_2$$

N_1= Concentration of initial sample (100 mg/l).

V_1= Volume of paraben sample required for preparing sample solution.

N_2= Concentration of required sample (2, 4, 6, 8 and 10 µg/l).

V_2= Volume of sample solution (200 ml).

- We prepare NaOH and H_2S0_4 samples of different concentration for balancing pH.
- We prepare $Na_2S_2O_3$ sample for stopping the reaction of paraben and H_2O_2 after every 30 minutes.

- In this study in order to remove paraben from solution some parameters are required (pH, H_2O_2 and paraben concentrations).

- In order to identify optimal pH we maintain initially other two parameters are constant (H_2O_2 (50 mg/l) and paraben Concentration (6 µg/ml) and varying the pH between 2 to 11.
- After finding the optimal pH we need to fix that pH as constant and paraben Concentration (6 µg/l) for finding optimal H_2O_2.
- After finding the optimal H_2O_2 we need to maintain pH and H_2O_2 at optimal conditions for finding optimal paraben concentration
- In above all for every 30 minutes we need to identify absorbance of sample using spectrophotometer and every 15 minutes we need blend the solution using stirrer.

After identifying the absorbance values of samples before and after reactions using spectrophotometer we need to analyse and interpretate those values to understanding better and identify the removal efficiency.

$$\text{Removal Efficiency \%} = \left[\frac{a1-a2}{a1}\right] * 100$$

$a1$ = Initial absorbance of paraben (before treatment).

$a2$ = Final absorbance of paraben (after treatment)

3. Analysis:

The concentrations of paraben in the water samples were measured at the Laboratory in Aditya Engineering College of Environmental Engineering using a UV-vis spectrophotometer.

Following is a list of the analysis steps:

The desired concentration of methyl paraben (2 to 10 µg/ml) was prepared accurately. The maximum wave length (nm) for each Paraben was measured using a spectrophotometer, using a survey scan at wavelengths 200 to 400 nm, as seen in Figure

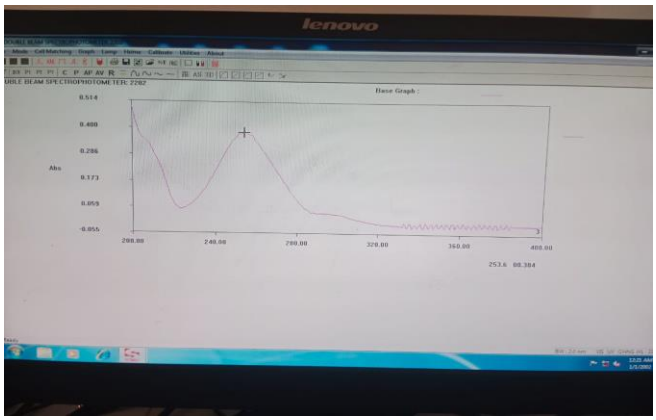

Fig 2 -Maximum wavelength for Methyl Paraben

Five solutions of Methyl paraben at concentrations 2, 4, 6, 8, and 10 µg/ml were prepared. Absorbance at the maximum wavelength (254 nm) was determined using a spectrophotometer. A linear relationship was plotted between absorbance (at the

maximum wavelength of the paraben) and each paraben concentration, in order to estimate unknown concentrations of paraben, as seen in below table-1 and fig-3.

Table 1- Absorbance Values of Different Paraben Concentration

S. No	Paraben Concentration (µg/l)	Absorbance
1	0	0
2	2	0.242
3	4	0.396
4	6	0.504
5	8	0.681
6	10	0.823

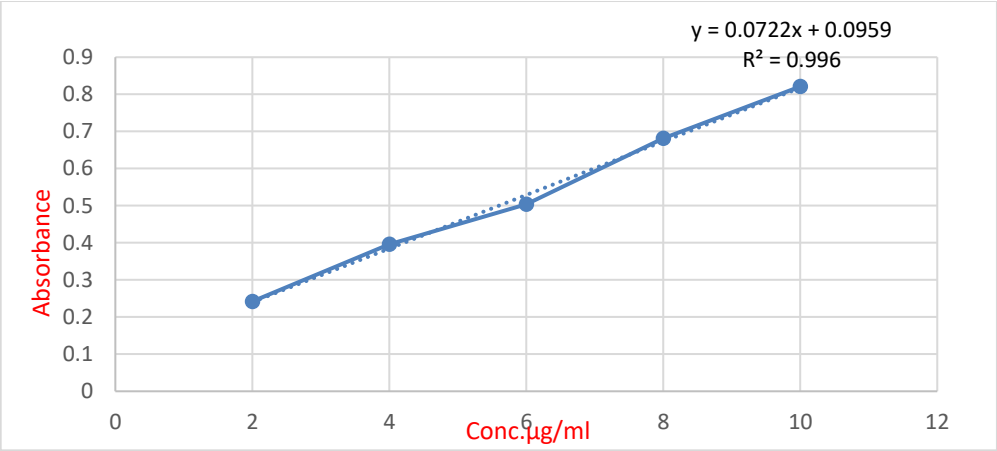

Fig 3- Calibration curve for Methyl Paraben

4. Result and Discussion:

4.1 Effect of pH:

In order to determine the pH needed to destroy the paraben most efficiently, the effects of pH on the UV/H_2O_2 process were investigated. In this series of tests, the H_2O_2 concentration (50 mg/L) and paraben concentration (6 µg/ml) were fixed in order to achieve the ideal pH at various intervals. The study's ideal pH for pH removal is 3. Each result is listed in the tables below and plotted in figure 4.

Table-2 Effect of pH = 2 on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, H_2O_2 conc. =50mg/l

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.449	10.91
2	60	0.398	21.03
3	90	0.245	51.38
4	120	0.198	60.74

Table-3 Effect of pH = 3 on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, H_2O_2 conc. =50mg/l

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.438	13.09
2	60	0.383	24.00
3	90	0.213	57.73
4	120	0.179	64.48

Table-4 Effect of pH = 5 on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, H_2O_2 conc. =50mg/l

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.417	17.26
2	60	0.383	24.00
3	90	0.274	45.63
4	120	0.226	55.15

Table-5 Effect of pH = 9 on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, H_2O_2 conc. =50mg/l

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.435	13.69
2	60	0.410	18.65
3	90	0.289	42.65
4	120	0.246	51.19

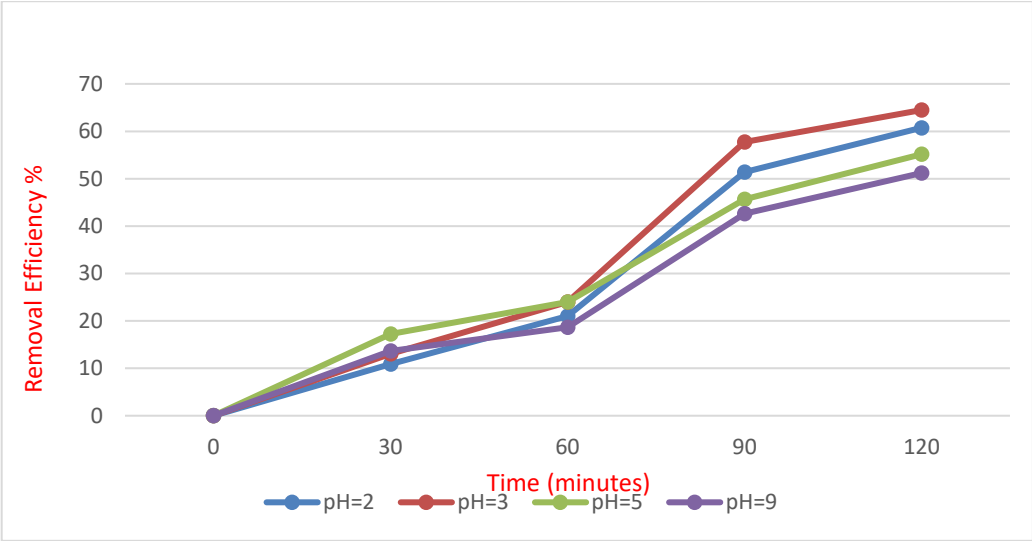

Fig-3: Effect of pH on degradation of paraben by UV/H_2O_2 process at paraben conc. = 6µg/ml, H_2O_2 conc. =50mg/ml

4.2 Effect of H_2O_2 Concentration:

The effect of initial concentration of H_2O_2 on the UV/ H_2O_2 process was explored by performing experiments with various concentrations of H_2O_2 (50, 80, 110, 140, and 170 mg/L). The optimum pH = 3 from the previous investigation stage was applied in these tests. The paraben concentration of 6 µg/L and they were also preserved. The results are shown in fig-4. Below figures demonstrate that the removal efficiency of paraben distinctly increases with increasing quantities of H_2O_2 till it reaches its ultimate value (71.23% removal) at 80 mg/L after about 120 min ; it then starts to decrease gradually, and the addition of further H_2O_2 above this amount had a negative result, reaching only 65.67% removal at110 mg/L H_2O_2. The optimal H_2O_2 for paraben removal is 80 mg/l. All the outcomes are noted in below Tables and fig-4.

Table-6 Effect of H_2O_2 concentration=50 mg/l on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH =3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.438	13.09
2	60	0.383	24.00
3	90	0.213	57.73
4	120	0.179	64.48

Table-7 Effect of H_2O_2 concentration=80 mg/l on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH =3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.376	25.39
2	60	0.288	42.85
3	90	0.198	60.71
4	120	0.145	71.23

Table-8 Effect of H_2O_2 concentration=110 mg/l on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH =3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.445	11.70
2	60	0.375	25.59
3	90	0.229	54.56
4	120	0.173	65.67

Table-9 Effect of H_2O_2 concentration=140 mg/l on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH =3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.449	10.91
2	60	0.383	24.00
3	90	0.237	52.97
4	120	0.184	63.49

Table-10 Effect of H_2O_2 concentration=170 mg/l on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH =3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.473	8.13
2	60	0.395	21.62
3	90	0.245	51.38
4	120	0.206	59.12

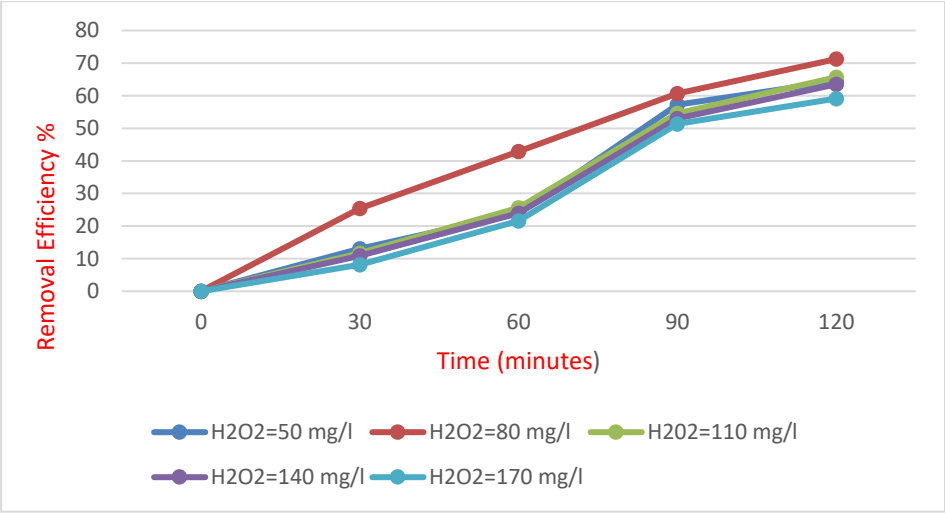

Fig 4: Effect of H_2O_2 conc. on the degradation of paraben by UV/ H_2O_2 process at paraben conc. =6µg/ml, pH=3

4.3 Effect of Paraben Concentration:

Different concentrations of paraben (2, 4, 6, 8, and 10) µg/L were used at H_2O_2 concentration = 80mg/L, pH= 3. The results are plotted in below fig-5. From the fig-5 it can be seen that the removal efficiency increases from 47% to 82% as the concentration of paraben increases from 2 to 8 µg/ml and the concentration further increase to 10µg/ml the removal efficiency reduces to 62%. This can be attributed to the reduction of light photon penetration, which leads to a lowering of hydroxyl radical concentrations. The optimal paraben concentration value is 8 µg/l. All the outcomes are noted in below tables and fig-5.

Table -11 Effect of paraben conc. = 2µgm/l on the degradation of paraben by UV/H_2O_2 process at H_2O_2 conc. =80 mg/l, pH=3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.212	12.39
2	60	0.184	23.98
3	90	0.143	40.90
4	120	0.126	47.93

Table -12 Effect of paraben conc. = 4µg/ml on the degradation of paraben by UV/H_2O_2 process at H_2O_2 conc. =80 mg/l, pH=3

S.No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.325	17.92
2	60	0.316	20.20
3	90	0.178	55.05
4	120	0.138	65.15

Table -13 Effect of paraben conc. = 6µg/ml on the degradation of paraben by UV/H_2O_2 process at H_2O_2 conc. =80 mg/l, pH=3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.376	25.39
2	60	0.288	42.85
3	90	0.198	60.71
4	120	0.145	71.23

Table -14 Effect of paraben conc. = 8µg/ml on the degradation of paraben by UV/H_2O_2 process at H_2O_2 conc. =80 mg/l, pH=3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.48	29.41
2	60	0.35	48.5
3	90	0.24	64.70
4	120	0.12	82.35

Table -15 Effect of paraben conc. = 10µg/ml on the degradation of paraben by UV/H_2O_2 process at H_2O_2 conc. =80 mg/l, pH=3

S. No	Time (minutes)	Absorbance	Removal Efficiency (%)
1	30	0.65	20.73
2	60	0.52	36.58
3	90	0.46	43.96
4	120	0.31	62.19

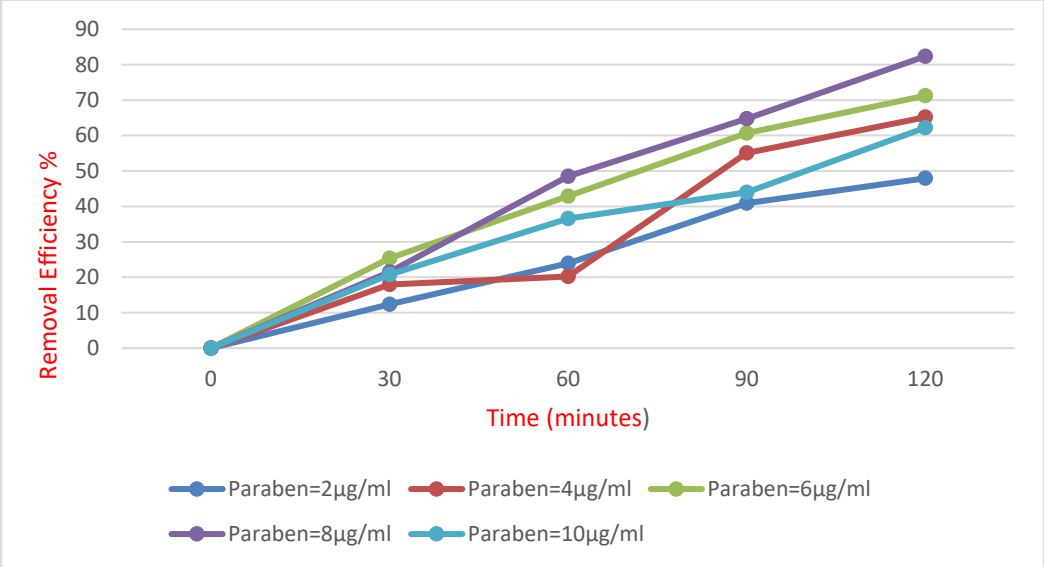

Fig 5: Effect of paraben conc. on the degradation of paraben by UV/ H_2O_2 process at H_2O_2 conc. =80mg/l, pH=3

5. Conclusion and Future Scope:

This study investigated the treatment of water contaminated with Methyl Paraben using a UV/H_2O_2 process. The reaction was influenced by the input concentration of hydrogen peroxide H_2O_2, pH, temperature, and the concentration of Paraben in the wastewater. The removal efficiency of the UV/ H_2O_2 process at optimal conditions and dosage (H_2O_2 = 80 mg/L, pH=3, for 8 µg/ml paraben concentration) were found to be 29.41%, 48.5% , 64.70%, and 82.35% at 30 min, 60 min, 90 min, and 120 min.

The aim of the study is to remove the paraben from the aqueous solution using UV/H_2O_2 process. But along with paraben there may be a chance of the existence of several compounds and metals in the aqueous solution. To remove such types of components further improvement must be developed in terms of the techniques and materials. In future, we should focus on removal of different kinds of heavy metals and several compounds such as dyes, harmful pathogens, toxic ions etc. with developed techniques and materials with greater stability and capacity to remove multiple contaminants simultaneously.

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