

REMOVAL OF CARBAMATE INSECTICIDE FROM WASTEWATER USING UV/TiO₂ AND UV/ZnO

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ABSTRACT

Pesticides are widely used in agriculture to ensure good yields and proper harvesting as well as minimal storage losses. Most pesticides are resistant to chemical and/or photochemical degradation under typical environmental conditions. The presence of pesticides residues in water and food-chains may have a harmful effect on human health and on the equilibrium of ecosystems. Carbamates is a group in which having a very huge family used as insecticides, herbicides and fungicides. These are commonly used as insecticides similar to organophosphates and contains carbofuran compound which is highly toxic in nature. Zinc oxide (ZnO), Titanium dioxide (TiO₂) considered as a catalyst of choice for such surface reactions as it has good chemical stability, low cost, and high UV/solar photo activity. Photo catalytic degradation of this insecticide with help of semiconductors like TiO₂ and ZnO in presence of UV or solar light is an environmentally friendly and ecological process. ZnO and TiO₂ considered as a catalyst of choice for such surface reactions as it has good chemical stability, low cost, and high UV/solar photo activity. Photo catalytic degradation of carbamate insecticide by using TiO₂ and ZnO in presence of UV light the parameter that impact on rate of reduction are contact time, concentration of insecticide, pH of solution and mass of catalyst. As Carbamate is colorless so we need to add some reagents before measurement of absorbance. NaOH, add the mixture of HCl and Sodium Nitrite, and finally add coupling agent Sulfonic acid or Nitro aniline. Finally add these all mixture of reagents in above distilled water solution of Carbamate. The maximum reduction of Carbamate is 90%, and 92 % for 10 ppm solution resp. at 120 min. using ZnO/UV and TiO₂/UV process with 1.5 Gms/lit of ZnO and TiO₂ catalyst amounts. Both the processes are economical and having same efficiency for Carbamate reduction.

KEYWORDS: AOPs, Photo Catalytic Degradation, UV/TiO₂, UV/ZnO, Insecticide, Carbamate

1. INTRODUCTION

Photo catalytic degradation of the Carbamate insecticide using the ZnO and TiO₂ catalysts and polychromatic light. Initial concentration of insecticide can affect on the photo chemical process. A decrease in insecticide photo degradation with increasing initial concentration. The concentration in all photo catalytic degradation considers as a major factor which affected on the process. Reduction of insecticide by photochemical process can analysed by absorbance or concentration changes.[2] The efficiency of photo catalytic degradation of pollutants is known to be a complex process, which depends type and intensity of irradiation, structure and concentration of pollutant, temperature, pH, the duration of pollutant exposure to a light source, the type and concentration of an applied catalyst, surface area, surface properties, doping, etc. [3] The rate of population growth day to day increases and requirement of food also increases, hence needs to increase the yield of crops and for this purpose the use of insecticides for agricultural purposes increases. Insecticides mixed with the water and creates the lot of amounts of wastewater. Carbamate groups insecticides use much in amounts for control of insects. Wastewater treatment for insecticidal industry and agriculture becomes an important task for environmental as well as human being. The conventional methods for treatment of such types of wastewater dose not gives better results for removal of pollutants. AOPs are economical and ecofriendly processes giving high removal rate of pollutants. Treatment process by catalyst ZnO and TiO₂ in presence of UV or Solar light gives the high removal of pollutants from the waste water. [3, 4] The requirement for water increases but the natural source of water which is useful for domestic and industrial uses is very limited. High quantity of wastewater come out from the industrial processes and treatment of this waste is necessary to protect the environment and human beings from harmful effects. The search for additional water sources or even in recycling wastewater treatment plant effluents is becomes necessary for fulfilment of requirement. The goal of biological wastewater treatment is stepwise oxidation of organic pollutants aiming to achieve complete mineralization. [5] Pesticides are major organic pollutants, and their random extensive applications threaten human health and ecosystems. Reduction of toxic insecticides from the aquatic system remains a global priority. A zinc oxide Nano catalyst was synthesized with suitable properties to achieve complete degradation of some insecticides (dimethoate and methomyl) from aqueous media. In normal and in nano-size as a part of an advanced oxidation process ZnO used in the presence of H₂O₂ and UV rays. [6] Water pollution due to pesticide emerges as the serious environmental concern.

Removal of such pesticide contaminants has become the key concern of scientific community. Pesticide pollution due to the excessive use of pesticide, by-products and intermediated form during the degradation. Pollution mainly arises due to incomplete degradation by the conventional techniques, because of their high chemical stability and low biodegradability and high persistence in the atmosphere. [10] Highly reactive hydroxyl radicals from UV/hydrogen peroxide (H₂O₂) and UV/titanium dioxide (TiO₂) advanced oxidation processes can decompose organic contaminants efficiently. Decomposition of 3, 5-dinitrobenzamide in aqueous solution can be possible using photo catalytic degradation with UV/H₂O₂ and UV/TiO₂. [18] Organic pesticide, degradation in the presence of modified ZnO metal composites ZnO/MgO and ZnO/SnO₂ studied at normal pH in the presence of sunlight. Both the synthesized nanocomposites characterized by different spectral techniques. Pesticide concentration, catalyst dosage, and pH affected on the photocatalytic degradation efficiency. [24]

Sources of Carbamate

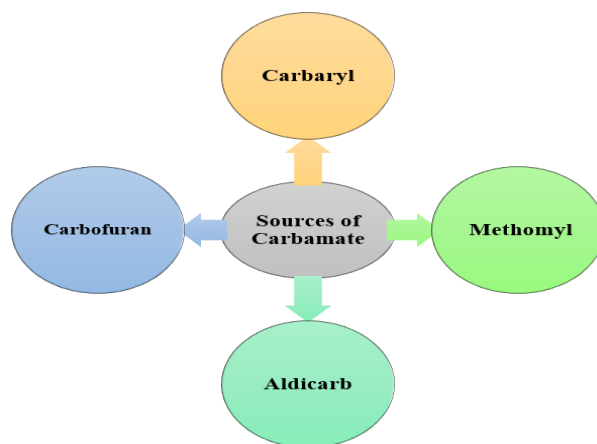


Fig. 1 Sources of Carbamate

Classification Pesticides

1. Insecticides include organophosphates parathion, trimesters of phosphates and phosphoric acids, Carbamate, organ chlorines, and botanical insecticides.
2. Herbicides are used to destroy other invasive weeds by inhibiting of photosynthesis.
3. Fungicides prevent fungus growth and include several structurally different chemicals.
4. Rodenticides include chlorophacinone, brometalin, diphacinone, zinc phosphide, and strychnine.
5. Algaecides prevent and control the growth of algae in crops. Copper sulphates, copper chelates, and copper citrates are important algaecides.
6. Bactericides kill bacteria. An important example includes sodium di-acetate.

Methods for Removal Carbamate from wastewater [7]



Fig. 2 Methods for Removal Carbamate from wastewater

1. **Adsorption**- Activated charcoal, metal oxide compound, synthetic zeolites and silica widely used adsorbent for removal of insecticide like carbamate.
2. **Biological Treatment** - Activated sludge treatment used for removal of carbamate insecticide in which mixed microbial culture for treatment.

- 3. Chlorination and Ozonation** - Electrophilic attack by hypochlorous acid and electrophilic attack by ozone use for treatment of carbamate.
- 4. Membrane Technologies** - Nano filtration can be separate and removal of carbamate. UF and RO process can also use for removal of Carbamate.
- 5. Physical Treatment** - Filtration is a used to remove the pesticide from water, and the type of membrane depends on the targeted pesticides. Filter containing membranes with an average size between 10-2 and 10-3 μm are ideal for removing bacteria's and organic molecules.
- 6. Advanced Oxygen Process** - Photochemical oxidation like UV/TiO₂, UV/ZnO types of processes are used for removal of carbamate from wastewater.

LITERATURE REVIEWS

In 2019 studied by Adela Tomasevic, Dusan Mijin, degradation of the carbamate insecticide carbofuran in water using polychromatic light and ZnO and TiO₂ catalysts. Reaction time and initial carbofuran concentration affected on photo catalytic degradation. An almost complete removal of 88.4 mg L⁻¹ of carbofuran occurred within 2 h under optimized conditions. The photo catalytic efficiencies of ZnO and TiO₂ compared under the same reaction conditions. [2] UV light and visible light used to remove chlorpyrifos pesticide in presence of semiconductors TiO₂ and ZnO. pH, amount of adsorbent, and irradiation time, on the amount of pesticide removal are the major factors affecting on reduction of pollutants from wastewater. Efficiency of chlorpyrifos removal at pH 2, irradiation time of 80 min, and photo catalyst amount of 0.2 g for UV light and visible light, equal to 91.4 % and 78.25 %, respectively. As best choice efficiency described the chlorpyrifos degradation process according to Langmuir-Hinshelwood kinetic with rate constants equal to 0.0301 and 0.0177 min⁻¹ vicinity of UV light and visible light respectively. [3] Beneficial photochemical process for removal of pesticides from wastewater is advanced oxidation process using semiconductors like TiO₂ and ZnO with UV or solar light. Photochemical reactions having large contributions for waste water treatment processes of various types of industrial. [4] In 2022 studied by Mahmoud Samy, Mohamed Gar Alalm, Eman Ezeldean et al, photo degradation performance of ZnO and ZnO/Fe using various catalyst doses in a constructed parabolic solar collector reactor. ZnO catalyst dose and reaction time 1.0 g/L and 135 min. Removal of various insecticides OX, MA, and LM increased from 38%, 30%, and 24% in pristine ZnO to 55%, 70%, and 46.9% in the case of the addition of BC with ZnO (ZnO/BC), respectively. [8] In 2019 studied by B. Saritha, Fabian Ramthansanga, Lalroliana Tochhawng et al, concentration of catalyst TiO₂ optimized at 4 gm/l in presence of UV light where 61 % degradation of insecticide.[9] The ZnO exhibit good photo catalytic efficiency under UV light irradiation but when combine with membrane filtration; degradation rate increases several times as compared to ZnO mediated photo catalysis. At 5 ppm, maximum degradation achieved in 60 minutes and further degradation is achieved after membrane filtration. The Membrane filtration combined with photo catalytic degradation is efficient and time savvy technique for the degradation of pesticide compounds. [10] Photo catalytic degradation of pesticide by using ZnO/MgO Nano composite is at 4 mg/L of the catalyst in 20 ppm of the quinalphos solution to achieve 98% degradation in forty minutes.[11] Treatment of insecticide by using photo catalytic degradation in the presence of modified ZnO metal composites at normal pH in the presence of sunlight. Pesticide concentration, catalyst dosage, and pH affected on the photo catalytic degradation efficiency. Photo catalytic efficiency of ZnO/SnO₂ Nano composite efficient than the ZnO/MgO Nano composite for the treatment of pesticide effluent, achieving 98 % and 95 % of total organic carbon (TOC) and chemical oxygen demand (COD) removals. The ZnO/SnO₂ Nano composite was the more stable and well-organized composite.[13] Removal of pesticide of methyl parathion using photo catalytic process is 48.5% in 30 minutes and at 45 minutes of treatment, the removal efficiency of methyl parathion 90%, being completely mineralized at the end of treatment. Removal of the metabolite methyl paraoxon observed during the photo catalytic process. The complete mineralization of insecticide by using Photo catalytic degradation in presence of catalyst TiO₂ and ZnO is possible. [15] Total detoxification of insecticides after treatment with the most effective system (TiO₂(s)/H₂O₂/UV) through exploring the biochemical alterations and histopathological changes in the liver and kidneys of the treated rats. Degradation rates of the examined insecticides were faster using the TiO₂ catalyst of nano size. The tested insecticides 100% achieved under the TiO₂(s)/H₂O₂/UV system after 320 min of irradiation. [17] The parameters affected on degradation of insecticides are catalyst amount, pH, concentration of pesticides, light intensity and contact time. Pesticides reviewed, namely insecticides, herbicides and fungicides. The photo catalytic processes could remove pesticides with an average acceptable degradation efficiency of 93.36%. Photo catalytic processes for the degradation of insecticides, herbicides and fungicides 93.35%, 90.73% and 100% respectively. [21] Fenamiphos, an insecticide from organophosphorus class of pesticides, in aqueous solution using UV light in absence and in presence of slurry titanium dioxide (TiO₂) or supported on borosilicate glass plates. Photolysis of Fenamiphos, two photoproducts identified and characterized using High Performance Liquid Chromatography/mass spectrometry. Photolysis involved is oxidation of sulphonamide group. Photo catalyst, Degussa P25 shows a good photo catalytic activity and a complete degradation observed after 180 min. [22] By using a facile precipitation method SO₄-Ag₃PO₄ was prepared to enhance the photocatalytic activity of the catalyst and degrade neonicotinoid insecticides under visible light irradiation. The sulphate doping reduces the band gap; hence, it could reduce the energy required for photoactivation and improve the charge transfer efficiency compared with the pristine Ag₃PO₄. [23] ZnO/SnO₂ nanocomposite more efficient than the ZnO/MgO nanocomposite for the treatment of pesticide effluent, achieving 98 % and 95 % of total organic carbon (TOC) and chemical oxygen demand (COD) removals. ZnO/SnO₂ nanocomposite more stable and well-organized composite could be preferred treatment of industrial and agricultural wastewater containing organic contaminants within a short span of time. [24] The five most abundant pesticides studied in the presence and absence of 1% TiO₂ or ZnO photocatalysts under UV irradiation at a wavelength of 306 nm. Pesticides were Atrazine (OCP), Chlorpyrifos methyl (OPP), Dimethoate (OPP), Heptachlor (OCP), and Methomyl (Carb). Photolysis of all pesticides was complete under UV radiation for

irradiation times between 64–100 h. Photocatalysts enhanced photocatalytic degradation of the pesticides in comparison with photolysis. Photo catalytically degraded completely within 20–24 h of irradiation. Photocatalyst with TiO₂ higher activity compared to ZnO. [27] An efficient photocatalytic method for the degradation of the aquatic pollutant, emamectin benzoate, coupled with a novel electrochemical monitoring method is reported for the first time. In a slurry-based reactor containing either a ZnO or TiO₂ photocatalyst irradiated with 365 nm UV-LEDs. Initial pollutant concentration, solution pH and photocatalyst dosage, to optimize the process. ZnO provided a higher initial rate of degradation than TiO₂ at all concentrations investigated. A large range of parameters to be rapidly and effectively scrutinized using electrochemical monitoring of the degradation. [29]

MATERIALS AND METHODOLOGY

Materials

1. Carbamate (Carbofuran) - Chem. Name-2,3 dihydro -2,2-dimethyl -7-benzofurynyl methyl Carbamate. Molecular Wt. 221.25 gm/mol. Solubility in water 0.7 gm/l. CAS No. 1533-66-2.
2. TiO₂ - Molecular Wt. 78.86. Insoluble in water, organic solvent. CAS No. 13463-67-7, pure 99%.
3. ZnO - Molecular Wt. 81.38. Insoluble in water, organic solvent. CAS No. 1314-13-2, pure 99%.
4. NaOH (Sodium hydroxide) to break down the Carbamate which is alkaline solution.
5. HCl
6. Sodium Nitrite.
6. Sulfanilic acid or Nitro aniline.

Methodology

Photo catalytic degradation pharmaceutical waste water using UV/ZnO/TiO₂ is the one of the of advanced oxidation process. This method is suitable for treatment of various types of waste water. Pharmaceutical industry produces lot of waste water and treatment of such wastewater necessary to fulfilment of environment and water needs. Catalyst and water reactions produces highly reactive OH radical. This highly reactive OH radicals decompose the complex compound presents in wastewater.

Photo catalytic Degradation of Pollutants in presence of UV and semiconductors TiO₂ and ZnO

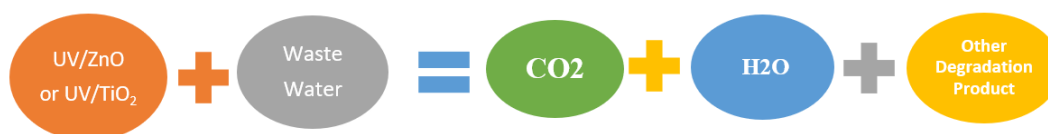


Photo catalysts (TiO₂/ZnO) + $h\nu \rightarrow e^- + h^+$

$h^+ + H_2O \rightarrow H^+ + OH^\bullet$

$h^+ + OH^- \rightarrow OH^\bullet$ (3)

$e^- + O_2 \rightarrow O_2^-$ (4)

$2e^- + O_2 + 2H^+ \rightarrow H_2O_2$ (5)

$e^- + H_2O_2 \rightarrow OH^\bullet + OH^-$ (6)

Organic pollutants + $OH^\bullet + O_2 \rightarrow CO_2 + H_2O + \text{other degradation product}$

Synthetic wastewater preparation for selected Insecticide

1. Take 1L of distilled water.
2. Select the insecticide which will be treat.
3. Take 0.01 to 1 ml of insecticide for preparation of various concentrations solution.
4. Add the amount of insecticide in 1 L distilled water.
5. Stir the solution for 10-15 min for complete mixing of insecticide in distilled water.
6. Take NaOH, add the mixture of HCl and Sodium Nitrite, and finally add coupling agent Sulfanilic acid or Nitro aniline.
7. Add these all mixture of reagents in above distilled water solution of Carbamate.

Sample for various concentrations solution

- 1 ppm solution = [1 mg or 0.001 ml/liter of distilled water]
 10 ppm solution = [10 mg or 0.01 ml/liter of distilled water]
 100 ppm solution = [100 mg or 0.1 ml/liter of distilled water]
 1000 ppm solution = [1 gm or 1 ml/liter of distilled water]

Measurement of absorbance of Carbamate solution by Colorimeter

As Carbamate is colourless so we need to add some reagents before measurement of absorbance. We take NaOH, add the mixture of HCl and Sodium Nitrite, and finally add coupling agent Sulfanilic acid or Nitro aniline. Finally add these all mixture of reagents in above distilled water solution of Carbamate. Then Measurement of initial absorbance and absorbance after treatment of Carbamate solution by using colorimeter. Finally, we calculate the % reduction of the Carbamate at various parameters and conditions as shows in experimental analysis below.

Analysis

Analysis carried out using colorimeter. With the help of colorimeter, we measure the absorbance of solution. % reduction of pollutant calculated using initial and final absorbance of solution. Analysis carried out at various contact time, concentration, pH and mass of catalyst. The EQ-650A is a microcontroller-based digital colorimeter designed for precise and efficient colorimetric analyses. It features disc-mounted filters and is suitable for various laboratory applications. % Transmittance (%T) and Optical Density (OD), 8 disc-mounted German glass filters at 400, 420, 470, 500, 530, 620, 660, and 700 nm, 3-digit LED display, 10 mm path length square cuvette with optical glass window, LED with infinite life and Photocell detector is there.

Experimental Analysis

1. Procedure for various Contact Time

Take known 10 ppm insecticidal wastewater solution and measure absorbance using colorimeter. Put the solution photo chemical reactor and add 1-2 gm/ L of ZnO/TiO₂ catalyst in beaker and start UV light. Stirred the solution for 10 min. For various time of interval 30, 60, 90, 120 and 150-min withdrawal of sample. Check absorbance unit for each sample with help of colorimeter. Calculate % reduction of various for insecticides by comparing initial and final absorbance unit taken using colorimeter. Calculate the % reduction for the insecticide.

2. Procedure for various Concentrations

Take known 10 ppm insecticidal wastewater solution and measure absorbance using colorimeter. Put the solution photo chemical reactor and add 1-2 gm/ L of ZnO/TiO₂ catalyst in beaker and start UV light. Withdraw sample after 30-120 min of contact time. Check absorbance unit for each sample with help of colorimeter. Calculate % reduction of various for insecticides by comparing initial and final absorbance unit taken using colorimeter. Calculate the % reduction for the insecticide. Repeat the procedure for various concentrations.

3. Procedure for various Amount of Catalyst

Take known 10 ppm insecticidal wastewater solution and measure absorbance using colorimeter. Put the solution photo chemical reactor and add 0.5 gm/ L of ZnO/TiO₂ catalyst in beaker and start UV light. Withdraw sample after 30-120 min of contact time. Check absorbance unit for each sample with help of colorimeter. Calculate % reduction of various for insecticides by comparing initial and final absorbance unit taken using colorimeter. Calculate the % reduction for the insecticide. Repeat the procedure for various amount of catalyst used.

% Reduction of Pollutant = [(Initial absorbance – Final Absorbance)/ Initial Absorbance] * 100

4. Stepwise Procedure

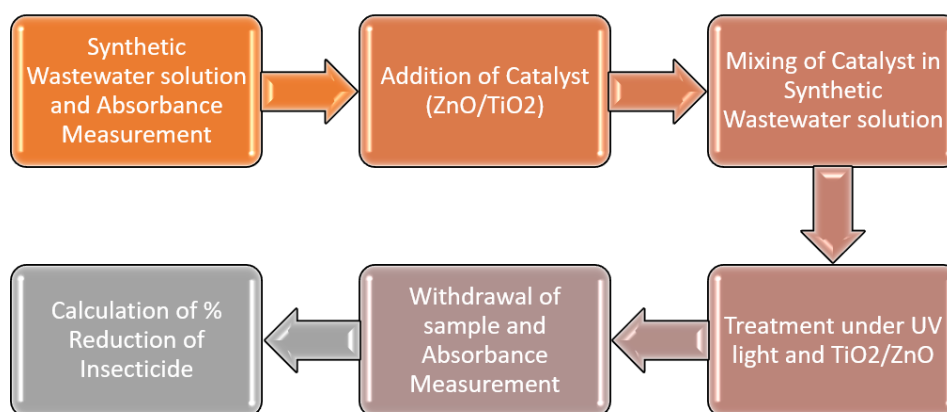


Fig. 2 Stepwise Treatment Process

RESULTS AND DISCUSSIONS

1. Reduction of Carbamate for various Contact Time

Table No.1 Shows the effect of contact time on % reduction of Carbamate using ZnO/UV and TiO₂/UV process. For various contact time 30,60,90,120,150 and 180 min. shows the % reduction of Carbamate using ZnO/UV process are 45,72,82, 88,85,82, resp. and using TiO₂/UV process are 52,78,85,90,88, and 86 resp. As per observation as the as contact time increase the rate of reduction also increase. For both process 120 min. is the optimum value of contact time in which highest reduction of Carbamate. After 120 min there is little bit changes in the reduction of Carbamate.

Contact Time in Min.	% Removal of Carbamate for ZnO/UV Process	% Removal of Carbamate for TiO ₂ /UV Process
30	45	52
60	72	78
90	82	85
120	88	90

150	85	88
180	82	86

Table 1 for % Reduction of Carbamate for various Contact Time

2. Reduction of Carbamate at various concentrations

Table shows the effect of concentration on % reduction of Carbamate using ZnO/UV and TiO₂/UV process. For 10,20,30,40 and 50 ppm solutions % reduction of Carbamate using ZnO/UV process are 90, 88, 84, 72 and 68 using TiO₂/UV process are 92, 90, 86, 74 and 70 resp. at 120 mins. As per observation as the concentration of Carbamate increase, rate of reduction decrease. As per observations both the processes are economical and having same efficiency for Carbamate reduction.

Concentration In ppm	% Removal of Carbamate for ZnO/UV	% Removal of Carbamate for TiO ₂ /UV
10	90	92
20	88	90
30	84	86
40	72	74
50	68	70

Table 2 for % Reduction of Carbamate at various concentrations using ZnO/UV and TiO₂/UV

3. Reduction of Carbamate for various amount of catalyst TiO₂ and ZnO

Amount of Catalyst grams/lit	For ZnO/UV Process	For TiO ₂ /UV Process
0.5	60	64
1	72	78
1.5	88	90
2	78	82
2.5	72	76

Table 3 for % Reduction of Carbamate for various amount of catalyst (TiO₂ and ZnO)

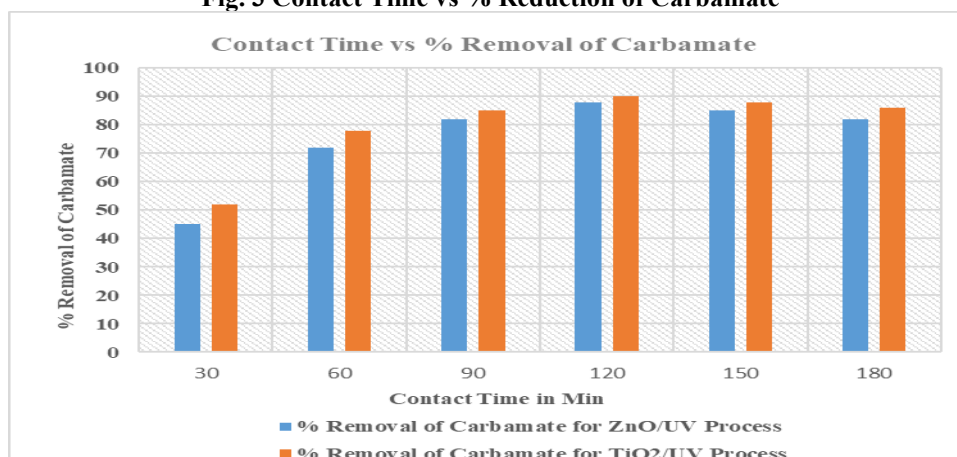
Table shows the effect of mass of catalyst on % reduction of Carbamate using ZnO/UV and TiO₂/UV process. For amount 0.5,1,1.5 and 2 gms of ZnO catalyst shows the % reduction of Carbamate using ZnO/UV process are 60, 72, 88, 78 and 72 resp. and using TiO₂/UV process are 64, 78, 90, 82 and 76 resp. and at 120 mins. As per observation as the amount of catalyst increase rate of reduction also increase. For both process 1.5 gm/l is the optimum value of catalyst which gives highest reduction of Carbamate. As the amount of catalyst increase more than 1.5 g/l the turbidity of solution increase and the rate of reduction decreases.

Effect of Various Parameters

1. Effect of Contact Time

The effect contact time on % reduction of Carbamate using ZnO/UV and TiO₂/UV process for various contact time 30, 60, 90, 120, 150, and 180 minutes shown in fig. for 10 ppm solution of Carbamate. As per study reduction rate reduce with increase in concentration of Carbamate and reduction of Carbamate removal increase with contact time for ZnO/UV and TiO₂/UV process. After 120 min rate of removal of Carbamate is constant or little bit change.

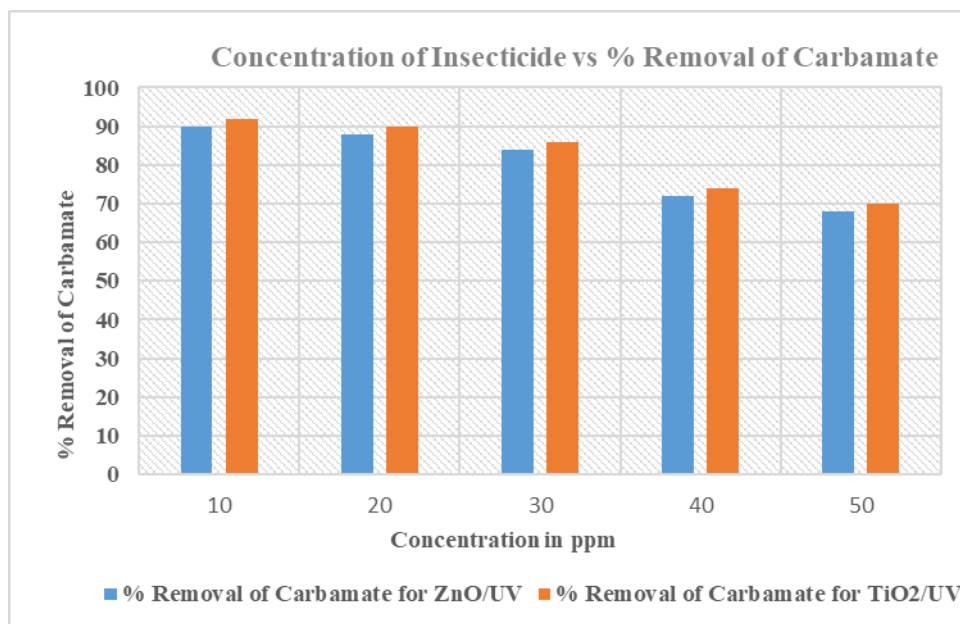
Fig. 3 Contact Time vs % Reduction of Carbamate



2. Effect of Concentration of Carbamate

The effect of concentration of Carbamate using TiO₂/UV and ZnO/UV process for various concentrations 10,20,30,40, and 50 ppm. As per study % reduction of Carbamate decreases with increase in concentration of Carbamate and % reduction of Carbamate increases with contact time for TiO₂/UV and ZnO/UV.

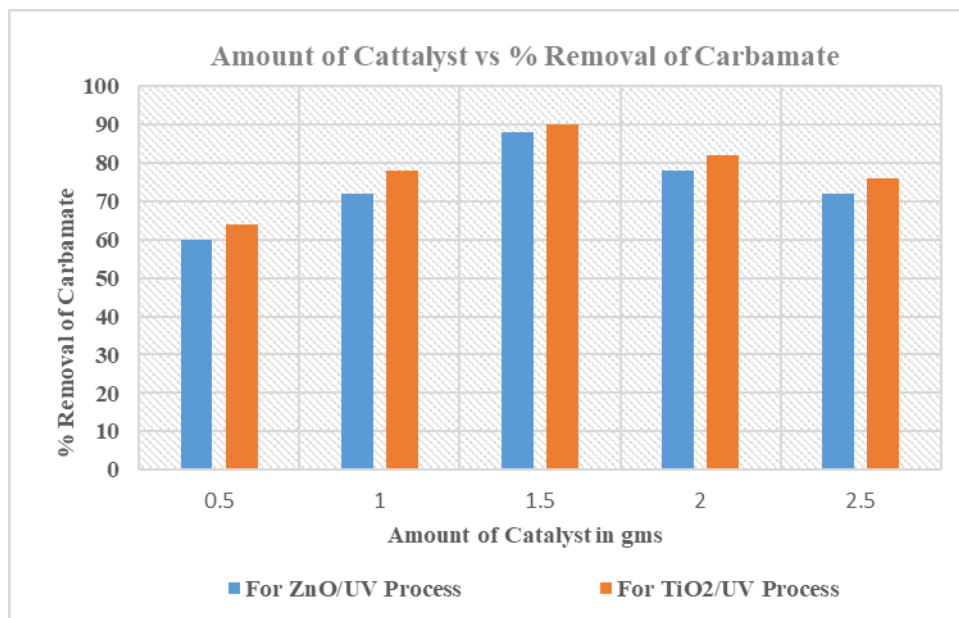
Fig. 4 Concentration vs % Reduction of Carbamate



3. Effect of amount of catalyst

The effect of amount of catalyst ZnO and TiO₂ on % reduction of Carbamate using TiO₂/UV and ZnO/UV process analysed by the study. The % reduction of Carbamate for various amount of catalyst 1 to 5 gm/liter. As per study the 1.5 gm/Lit catalyst amount is sufficient for the more than 90% reduction of Carbamate.

Fig. 5 Amount of Catalyst vs % Reduction of Carbamate



CONCLUSION

Insecticidal waste water contains highly toxic pollutants which has the serious environmental concern. Removal of such types of pesticide from the wastewater is necessary on environmental as well as living life. The high use of pesticide for crop growth creates the environmental issues. Removal of such type's insecticidal pollutants with TiO₂ and ZnO catalyst in presence of solar light or UV light is most powerful and economical methods as comparing with conventional methods. For treatment of insecticidal waste water with UV/TiO₂ and UV/ZnO the parameters like contact time, concentration of pollutants, pH, and amount of catalyst consider as the important parameters which directly affected on the removal of

insecticidal pollutants from wastewater. There are needs of optimization of such parameters for high removal of pollutants from the insecticidal waste water. A per analysis the high removal of insecticidal pollutants like Carbamate for UV/TiO₂ and UV/ZnO this process is more than 90% at 120 minutes contact time, at 1.5 gms/lit of catalyst TiO₂ or ZnO, and 10 ppm concentrations solutions. Both the processes are ecological and ecofriendly and capable to removal of any types of pollutants from wastewater and make it reusable.

FUTURE SCOPE AND BENEFITS

Photo catalytic oxidation is the one of the strongest advanced wastewater treatment methods that can adopted for various types of wastewater treatments, removal of targeted pollutants from wastewater. This treatment method can couple with any type of conventional method for high scale industrial waste water treatment. There are numbers of semiconductor are available for these methods like TiO₂, ZnO, H₂O₂ that can use in presence of UV and solar light for treating various types of wastewaters. In future there is large scope for these types of waste water treatment methods due to increase in the populations and rapid industrialization. Industry needs of lot of amounts of water for processes and produces the large amount of waste water. There is limited source of clean water available on earth so treatment and recycling of water become necessary. In such views there are needs of advanced treatment that can make water reusable and ecological processes, also needs ecofriendly processes. Photo catalytic processes are economical, ecofriendly and that can make water recyclable and reuseable. Hence, these processes have importance for waste water treatment in presence and will be in future.

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