APPLICATIONS OF LA DOPED COPPER OXIDE NANOPARTICLES AS PHOTOCATALYST FOR THE DECONTAMINATION OF AZOXYSTROBIN 23% SC RESIDUES IN SOIL

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ABSTRACT

Lanthanum doped with copper oxide nanoparticles with size ranging from 20 to 100 nm and 2 μm in length were prepared by reacting copper nitrate with Lanthanum oxide. The structure of the nanoparticles was confirmed by scanning electron microscope (SEM) analysis. Photocatalytic activity of the fungicide azoxystrobin was investigated. Four different types of soil (sandy loam, loamy sand, sandy clay, and clay soil) were investigated for the decontamination effect of catalyst on the azoxystrobin residues in the soil. Under direct sunlight, the catalytic process was monitored at two different azoxystrobin concentration levels. The optimum concentration of catalyst (lanthanum doped copper-oxide) required for the decontamination was found to be 0.05 g/kg. Residues were quantified by ultra-fast High-Performance liquid chromatography method (UHPLC-PDA). Parameters, DT_{50} and DT_{90} were calculated from the dissipation data. In four soils, the reaction's pace displayed first order kinetics. The addition of Lanthanum doped with copper oxide nanoparticles contributed to significant photocatalytic dissipation of residues. Complete dissipation of the residues was confirmed by the ultra-fast high-performance liquid chromatography. The method maximum allowable Limit in soil is 0.01 mg/kg.

Keywords: UHPLC, SEM, La doped CuO nanoparticles and DT_{50} and DT_{90}.

INTRODUCTION

Many insecticides are utilized in crop farming today. Most pesticides have a harmful nature and are stable in the environment, the method's maximum allowable measurement in soil is 0.01 mg/kg. As a result, environmental experts are now concentrating their research on employing catalytic nanomaterials to remove pesticide contamination from soil, the environment, and food goods. The physical and chemical properties of the soil system, which are represented by organic matter, sand, silt, clay, moisture, and pH, as well as the pesticides' vaporization, adsorption, and deterioration characteristics, as well as the accessibility to all soil resources, all affect how agricultural pesticides behave in the environment. Pesticide residues infiltrate water reservoirs because to the compound's prolonged persistence or the production of bound residue in soil, which affects the microbial community of the soil and is harmful to subsequent crops.

Leukaemia, lymphoma, and other cancers, as well as Parkinson's disease and developmental anomalies in farmers, sprayers, and production workers have all been linked to pesticide exposure. It has an immediate effect on an ecosystem's fauna as well as its biodiversity and human population. Many different applications of nanoparticles have been documented, including those in advanced materials, electronics, magnetism, and photonics, biomedicine, pharmaceuticals, cosmetics, energy, catalysis, and environmental detection and monitoring. Azoxystrobin photocatalytic degradation in soil under UV and direct sunlight was assessed. Both heterogeneous and homogeneous catalysis were used. The photocatalytic degradation of pesticide residues from organophosphates is found to be best accomplished by semiconductor oxides. Numerous studies have documented the catalytic activity of ferrous, zinc oxide, and copper oxide on many pesticides and other environmental pollutants. The copper oxide (group II–VI) exhibits optical characteristics and behaves like a semiconductor. According to reports[1–20], copper oxide nanoparticles are useful in gas sensors, magnetic storage, photo conductivity, and photocatalytic processes. In the current study, the photocatalytic activity of lanthanum-doped copper oxide nanoparticles was assessed on pesticide residues (Azoxystrobin).

EXPERIMENITAL

Material and Methods

Chemicals and reagents

Analytical reference standard of azoxystrobin purity 99.90% was purchased from Sigma Aldrich, Bangalore, India. The Suspension concentrate (SC) formulation of fungicide was purchased. Acetonitrile, copper nitrate, ammonia solution and triethyl amine, hydrochloric acid, acetone, hydrogen peroxide, Ammonium chloride, Ammonium hydroxide, sodium hydroxide, potassium dichromate, Sulfuric acid, orthophosphoric acid, diphenyl amine, chloroform, and potassium sulphate supplied by Merck life sciences private limited. The other chemicals used are analytical grade reagents.The Milli Q water purification system (Millipore SAS) was used to collect the water.

Analytical Instruments:

Azoxystrobin residues were identified and quantified using the Agilent-1260 Infinity II, Ultra High-Performance Liquid Chromatography (UHPLC) system with a PDA detector. The chromatographic conditions are Zorbax C8, 250 mm in length, 4.6 mm in diameter, and 5 mL of injection volume with a flow rate of 1.0 mL/min for the mobile phase mixture. The column oven is 40 °C in temperature. 3.0 minutes was the observed Azoxystrobin retention time.
Fourier transform infrared spectroscopy (FT-IR) for the prepared La-doped CuO nanoparticles were recorded using Perkin Elmer Spectrum.
VU-VIS spectrum were recorded using Shimadzu UV-1800.
The nanoparticles morphology was determined using a field emission scanning electron microscope (FESEM). The other analytical instruments Hot air oven and muffle furnace were used for the Physico chemical characteristics.

General Procedures

Preparation of lanthanum doped with copper oxide nanoparticles

Chemical precipitation was used to create la doped copper oxide nanoparticles. Three separate burette were used to administer the lanthanum oxide, copper nitrate, and ammonia

solutions. In order to create the precipitate, the solutions were allowed to drop steadily into a conical flask that contained 100 mL of distilled water and was mounted on a magnetic stirrer with a magnetic bead. The precipitate that was so produced was removed, filtered using a Buckner funnel, and then three times washed with distilled water. For neutralization, a few drops of triethyl amine were utilized. The precipitate was then cleaned with acetone and transferred to a silica crucible that had been cleaned and dried before being heated to 80 °C for an hour. Later, it spent two hours in a muffle furnace that had been preheated to 250 °C. At the conclusion of the process, coffee-brown coloured powder was formed, demonstrating the completion of lanthanum doped copper oxide nanoparticles. SEM (scanning electron microscope), EDS (energy dispersive spectroscopy), FT-IR, and UV spectra were used to confirm it.

Physico - Chemical Properties of Soils

Collection and Preparation of Soil:

Field soil samples were collected at Kalyani, West Bengal, India. 22.975084 and 88.434509 are the location's latitude and longitude (DMS Lat: 22° 58' 30.3024" N, DMS Long: 88° 26' 4.2324" E). Each test soil was passed through a 2 mm mesh filter before being used. The soils were kept in an aerobic environment at a temperature at 4 °C.

Moisture content:

The moisture content of each soil was estimated by drying an aliquot of the soil overnight in an oven at approximately 110˚C. The following calculation was used to calculate the dry weight equivalent for each soil:

Moisture Content % = [(Before drying soil weight-After drying soil weight)/After drying soil weight] x 100

Soil Texture:

In a 1 litter beaker with a weight of 20.0 g of dried soil, 50 mL of hydrogen peroxide (30% w/v) was poured and stirred. The beaker was immersed for 30 minutes in an 80 °C water bath after 5 minutes. Following the addition of 20 mL of hydrogen peroxide, the same beaker was heated in a water bath to 50 °C for 20 minutes. Then, the content was diluted to 150 mL with water and boiled. The technique using H_2O_2 was intended to speed up the oxidation of the organic materials in the soil. After the beaker's contents had cooled, 25 mL of 2 N HCl was added. After that, it was diluted to 250 mL. The reaction was then continued for a further hour using 10 mL of 0.1 M NH_4Cl, 30% NH_4OH, and 1 N NaOH, respectively.

Calculating clay and silt:

The mixture was placed into a graduated cylinder with a 1000 mL capacity, and the volume was increased to 1000 mL with a stopper before being well shaken. After taking out the stopper and waiting for five minutes, 20 mL of the content was pipetted into a porcelain bowl, where it was weighed. The liquid was evaporated, the residue dried at 105 °C, the content cooled, and the weight was once again measured. Finally, the percentage of clay and silt was calculated from the results.

Calculation of Clay Content:

The heterogeneous mixture was left unattended for 6 hours before 20 mL were pipetted out and evaporated. At 105 °C, the residue was dried, then it cooled, was weighed. Based on the findings, the proportion of clay was calculated.

Estimating coarse and fine sand

The deposit was transferred to a beaker that was 10 cm from the bottom and filled with distilled water after the majority of the supernatant liquid had been drained from the cylinder. The cloudy suspension was drained after it had been thoroughly mixed and set aside for 5 minutes. Once the liquid was clear, the procedure was repeated with a new beaker and the necessary amount of water. The residue was placed to a porcelain basin that had already been pre-weighed, dried at 105 °C, chilled, and weighed. The entire sand (coarse and fine) was used to calculate the percentage.).

pH:

A 100 mL beaker was filled with 20 g of soil and 75 mL of distilled water after being weighed and transferred. A mixture was thoroughly mixed with a glass rod. After 5 minutes, the solution was transferred into a 100 mL beaker. The electrode was immersed into solution and immediately start the stopwatch to record the pH.

pH (1:2 soil water extract):

20 mL of distilled water was added to 10 g of soil in a 100 mL beaker (1:2 soil water suspension ratio), and the mixture was thoroughly stirred for 5 minutes before being left for 30 minutes to allow the soil to settle. The electrode was placed in the solution, and the timer was immediately started to record the pH.

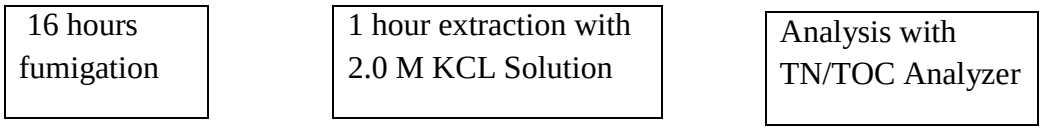
Total organic carbon content:

The 500 mL Erlenmeyer flask was filled with 1.0 g of soil, 10 mL of 1 N $K_2Cr_2O_7$, and swirled. 20 mL of H_2SO_4 were gradually added to the flask after 30 minutes. In order to stop further oxidation, 200 ml of distilled water, 10 mL of H_3PO_4, and 1 mL of diphenylamine indicator were added after that. With 0.5 N $FeH_8N_2O_8S_2$ solutions, the mixture was adjusted until the blue colour changed to green. For calculations, the blank titration was also calculated.

Microbial Bio mass:

The microbial biomass of each soil was determined by using a fumigation-extraction method just prior to test item application (in acclimatized, untreated samples) and at the time of the final sampling interval in samples treated with the same volume of solvent used to treat the test samples and incubated along with the treated test samples.
Chloroform fumigation lyses soil microbial cells, resulting in an increased organic carbon, which is extractable with 0.5 M potassium sulphate. The total organic carbon measurement by titrimetric dichromate-oxidation procedure provides an estimate of the amount of microbial biomass carbon in soil samples.
For each soil with 100 g of soil (oven dry weight) for biomass determination. A known weight of the soil sample in triplicate was extracted with 0.5 M potassium sulphate for 30 minutes. A known volume of extract was refluxed for 30 minutes with potassium dichromate and an acid mixture (sulphuric acid/ perchloric acid, 2/1). The residual dichromate was

measured by titrating with ferrous ammonium sulphate solution with ferroin indicator. A known weight of a second set of soil samples in triplicate was fumigated with chloroform and then incubated for 24 hours. These samples were later extracted with 0.5 M potassium sulphate for 30 minutes. A known volume of extract was refluxed for 30 minutes with potassium dichromate and an acid mixture (sulphuric acid /perchloric acid, 2/1). The residual dichromate was measured by titrating with ferrous ammonium sulphate solution with ferroin indicator. The difference between the organic carbon extracted from fumigated and unfumigated soil was expressed as the biomass carbon from the microbial population.



Estimation of Cation Exchange Capacity (CEC):

A 250 mL beaker containing 10 g of soil was weighed, then 50 mL of $C_2H_7NO_2$ solution was added. The beaker was capped, and the solution was left in for the night. The subsequent step involved passing the solution through Whatman filter paper that had been eight times leached with a 30 mL solution of $C_2H_7NO_2$. To determine the concentration of each exchangeable cation, the filtrate was poured into a 250 mL volumetric flask, filled to the proper level, and kept. Using 250 mL of distilled water, a minor amount of ammonium chloride that had remained on the filter paper was removed. After passing the filtrate completely through the filter paper with 60% alcohol in the beaker, the soil was thoroughly rinsed with alcohol until the filtrate was chloride-free. Carefully removing the soil filter paper, it was put in a distillation flask. A 500 mL ice tumbler was filled with 25 mL of 0.1 N H_2SO_4 and two drops of methyl red indicator after the flask had been filled with around 400 mL of distilled water. Once the feed pipe was in touch with the 0.1 N H_2SO_4 surface and the tumbler was placed underneath it, 10 mL of 40% NaOH was added to the flask containing the dirt. As soon as the flask was sealed, distillation started while the ammonia level was monitored. Until the distillate was ammonia-free, the feed hose was cleaned in the same tumbler with distilled water. Following the removal of the tumbler, titrate with 0.1 N KOH. The result was crimson turning into a straw yellow.

Photocatalysis

The photocatalytic effect of La-doped copper-oxide NPs on residues of azoxystrobin fungicide in soils were evaluated on two different concentrations of azoxystrobin formulation (Azoxystrobin 23% (w/w) SC) at 1.0 and 2.0 mg/kg. The experiment was carried out under direct sunlight in four different soil types (sandy loam, loamy sand, sandy clay, and clay soil) both with and without a catalyst (Lanthanum doped copper oxide nanoparticles). The temperature of the soil samples during the study period was found between 24 and 41 °C. The intensity of sunlight was measured during the exposure. At designated time intervals, the samples were collected and stored in the amber-colored bottles. All the samples were stored in dark (~ 4 °C) before injecting into UHPLC. The concentration of La-doped copper-oxide used was 0.05 g/L.

Validation Methodology

The procedure was optimized by a number of trials, and the final circumstances were examined for validation. Zorbax C8 stationary phase column, stainless steel column, 250 mm length, 4.6 mm i.d., and 5 µm. With a flow rate of 1.0 ml/min, a 30:70 ratio of 0.1% orthophosphoric acid in water in Pump A and Acetonitrile in Pump B made up the mobile phase. The validation parameters in UHPLC are set at 30 °C for the column, 15 °C for the cooler, 5 L for the injection volume, and 254 nm for the detection wavelength. Acetonitrile and water were mixed in a 1:2 ratio to dilute the column. Specificity, limit of detection and limit of quantification, precision, linearity, and accuracy are among the metrics used to validate the method.

RESULTS AND DISCUSSION

Characterization using SEM

Figure 1 shows the SEM of nanoparticles of copper oxide doped with lanthanum that were produced in an aqueous solution. Below is a high-magnification SEM image of CuO: La nanoparticles. The micrograph of CuO: La, Figure 1, shows a spherical-shaped morphology. The SEM images exhibit self-aligned prismatic nanoparticles and a distinctive spherical shape. CuO nanopowder's morphology as revealed by FESEM revealed nanoparticles with dimensions of 20–100 nm and 2 µm length.

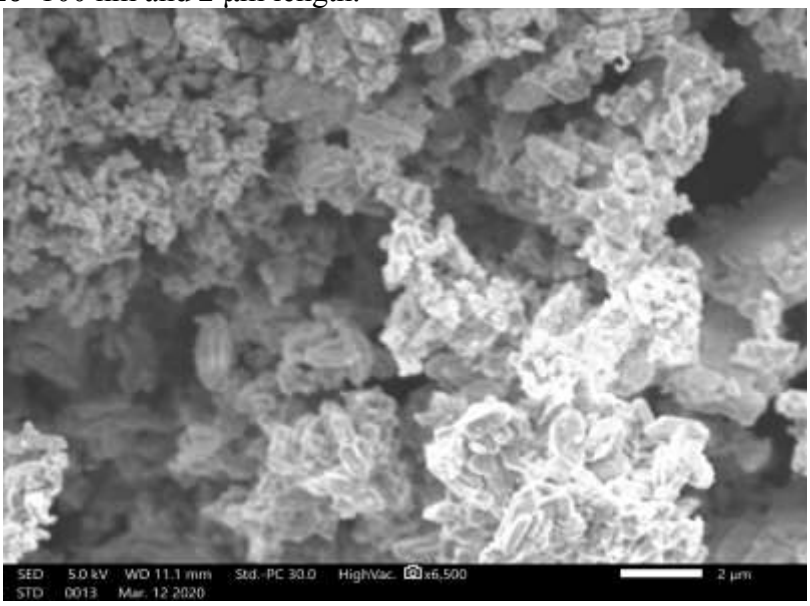


Fig.-1: SEM image of copper oxide nanoparticles doped with La (20–100 nm)

Analysis of EDS spectra of La doped copper oxide nanoparticles

Energy Dispersive Spectrum Analysis (EDS) was used to analyse the sample's dried powder. The peaks have verified the atoms of Lanthanum, Oxygen, and Copper. The Fig. 2 EDS spectrum of La-doped copper oxide nanoparticles shows that each peak not only corresponds to a specific element but also to a certain type of X-ray. The concentration of an element in a

spectrum is indicated by the peak's height. The micrograph of CuO: La reveals a spherical-shaped morphology.

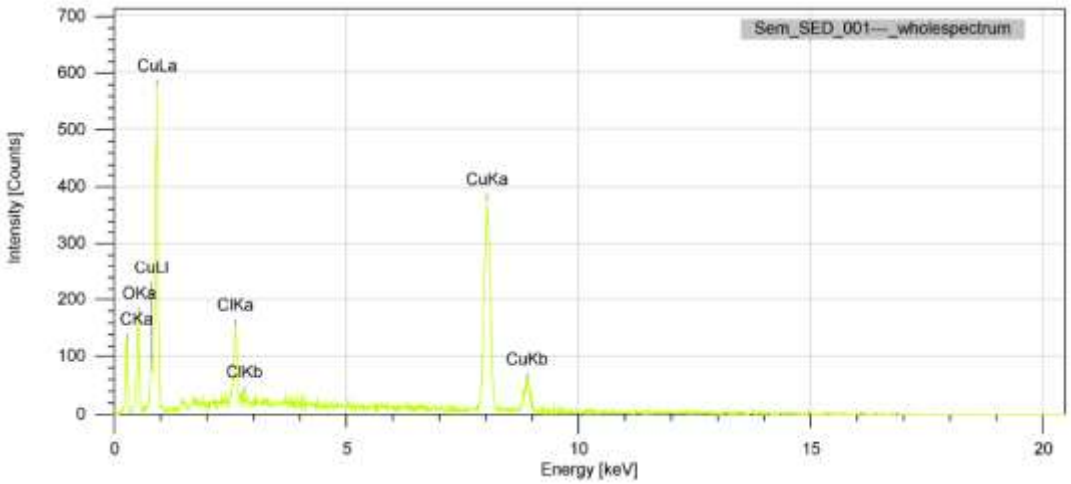


Fig.-2: Energy dispersive spectrum analysis of La doped copper oxide nanoparticles

FT-IR Spectrum of La doped copper oxide nanoparticles

The spectra of CuO: La scanned by FT-IR spectroscopy is depicted in Figure 3. It has been demonstrated that bond frequency reduces in nanoparticles as particle size increases. The stretching vibrations of Cu-O are attributed to the bands at 447.12 cm^{-1} and 535.71 cm^{-1}. Bulk CuO has a stretching frequency of 447.12 cm^{-1}. The stretching vibrations of the C = O, C = C, and C-H groups are observed at that frequency, which is the frequency caused by quantum confinement. Three intense bands were centred at 849.5 cm^{-1}, 993.34 cm^{-1}, and 1640.60 cm^{-1}. Water can be found on the surface of nanoparticles because of the large absorption peak centred at 3444.85 cm^{-1} and 1640.60 cm^{-1}, which correspond to the O-H stretching and bending frequencies of H_2O.

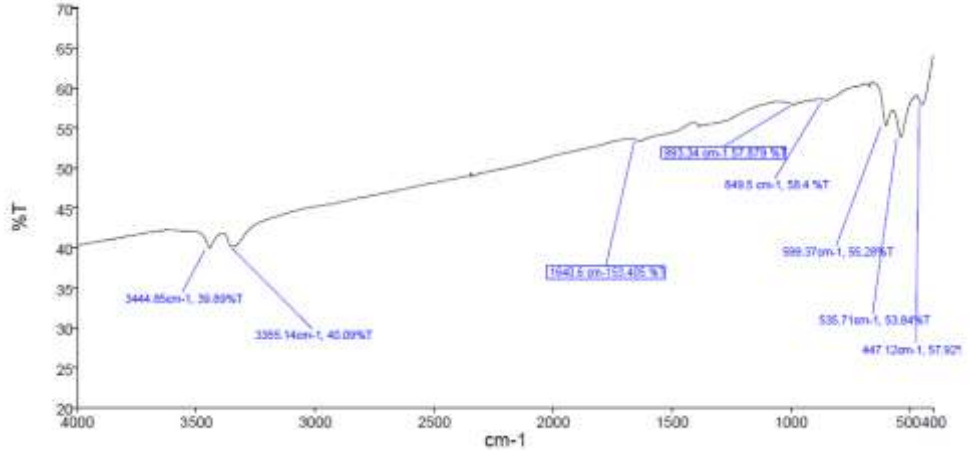


Fig.-3: FT-IR spectrum of La doped copper oxide nanoparticles

UV Absorption Analysis

The band gap and the type of electronic transitions were identified from the investigation of the optical characteristics of the La-doped CuO nanoparticles using the absorption spectrum. The optical absorption spectrum of CuO:La nanopowder produced under aqueous conditions

is shown in Fig. 4. The excitonic absorption peak was evident in the UV visible spectrum at 232 nm.

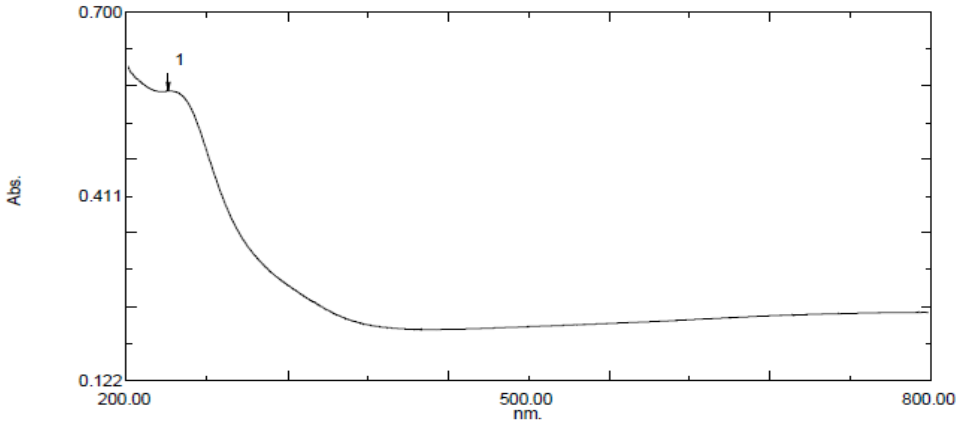


Fig.-4: UV-Vis spectrum of La doped copper oxide nanoparticles

Physico-chemical Properties of Soils

Table 1 shows the results of the computation of the physico-chemical characteristics of soil.

Physico Chemical Parameters						
S.No	**Parameters**	**Units**	**Sandy loam**	**Loamy sand**	**Sandy clay**	**Clay**
1	Soil Texture	-	Fine	Medium	Fine	Very Fine
2	pH	-	6.86	7.07	7.64	7.58
3	pH (1:2 Soil water extract)	-	5.54	5.74	6.56	6.39
4	Total Organic Carbon	%	1.16	0.31	1.29	0.48
5	Microbial Bio mass	%	2.04	0.49	2.2	0.83
6	NH_4-N	mg/kg	3.01	0.36	3.33	3.93
7	(as NO_3)-N	mg/kg	2.35	7.62	1.52	1.76
8	CEC	meQ/100 g	10.50	6.80	16.10	23.40
9	WHC	%	23.90	37.20	63.20	51.90
10	Clay	%	18	30	46	70
11	Silt	%	30	22	32	18
12	Sand	%	52	45	22	11
13	Porosity	%	27.06	52.81	79.41	77.60

Photolysis of pesticides without catalyst

Azoxystrobin fungicide photolysis in various soils under the influence of direct sunlight was evaluated without the use of a catalyst. According to the study, the chemicals in sandy loam, loamy sand, and sandy clay soil deteriorated to below detectable levels in less than 90 days. Azoxystrobin was shown to degrade quickly in clay soil, with below detectable levels (BLOQ) appearing within 60 days. The details are presented in (Table 2) and dissipation details presented in Figure 5.

Table 2: Photolysis of azoxystrobin in sandy loam, loamy sand, sandy clay and clay soil (Without catalyst)

Without catalyst					
Tested Dose	**Azoxystrobin**		**Tested Dose**	**Azoxystrobin**	
	T1- 1.0 mg/kg	**T2 - 2.0 mg/kg**		**T1- 1.0 mg/kg**	**T2 - 2.0 mg/kg**
Sampling Occasions (Days)	**Dissipation of Residues in Sandy Loam (mg/Kg)**		**Sampling Occasions Days**	**Dissipation of Residues in Loamy Sand (mg/Kg)**	
0	0.99	1.98	0	0.99	1.98
1	0.92	1.93	1	0.93	1.94
3	0.81	1.82	3	0.8	1.81
5	0.73	1.75	5	0.74	1.77
7	0.65	1.61	7	0.62	1.59
15	0.31	0.87	15	0.33	0.89
30	0.12	0.34	30	0.14	0.36
60	0.05	0.11	60	0.06	0.14
90	BLOQ	BLOQ	90	BLOQ	BLOQ
120	BLOQ	BLOQ	120	BLOQ	BLOQ
Dissipation of Residues in Sandy Clay (mg/Kg)			**Dissipation of Residues in Clay Soil (mg/Kg)**		
0	0.98	1.97	0	0.96	1.93
1	0.91	1.89	1	0.87	1.77
3	0.79	1.77	3	0.71	1.67
5	0.71	1.64	5	0.65	1.52
7	0.62	1.32	7	0.51	1.27
15	0.27	0.76	15	0.22	0.68
30	0.09	0.30	30	0.05	0.21
60	BLOQ	0.07	60	BLOQ	0.06
90	BLOQ	BLOQ	90	BLOQ	BLOQ
120	BLOQ	BLOQ	120	BLOQ	BLOQ

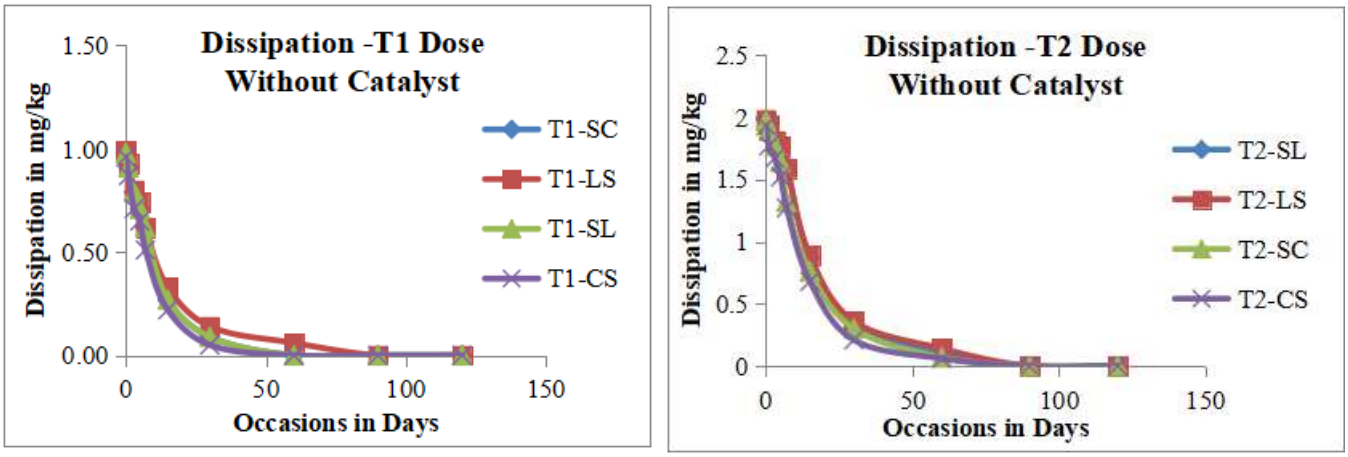


Fig.-5: Dissipation curve of Azoxystrobin influenced in soils

Photolysis of pesticides with catalyst

The photolysis of Azoxystrobin fungicide in the presence of La-doped copper oxide under the influence of direct sunlight and different soils was evaluated. The details are presented in Table 3. The adsorption of fungicide on the catalyst was quantified in soils at designated time intervals. The degradation of pesticide residues was accelerated by the addition of more catalyst (tested concentrations varied from 0.02 to 0.2 g/L), with equilibrium being reached at 0.05 g/L. As determined from the fungicide's dissipation statistics, the DT_{50} and DT_{90} values. From the study, it was observed that the reaction was influenced by changes in different soils. The reaction was found slow at sandy loam and loamy sand, while dissipation was found rapid with clay soil. Further, it was observed that the different soils after the addition of La-doped copper oxide nanoparticles as catalyst enhanced the degradation of fungicide. The influence of the aeration in decontamination of residues was presented in (Table 4). The Dissipation details are presented in the Figure 6. The following formula was used to calculate the DT_{50} and DT_{90} values:

$DT_{50} = \ln 2/(k)$ and $DT_{90} = \ln 10/(k)$

Where "k" is the slope of the curve obtained from the dissipation data.

Table 3: Photolysis of azoxystrobin in sandy loam, loamy sand, sandy clay and clay soil (with-catalyst)

Withcatalyst					
Tested Dose	**Azoxystrobin**		**Tested Dose**	**Azoxystrobin**	
	T1- 1.0 mg/kg	**T2 - 2.0 mg/kg**		**T1- 1.0 mg/kg**	**T2 - 2.0 mg/kg**
Sampling Occasions hours	Dissipation of Residues in Sandy Loam (mg/Kg)		Sampling Occasions hours	Dissipation of Residues in Loamy Sand (mg/Kg)	
0	0.99	1.98	0	0.98	1.96
1	0.85	1.83	1	0.83	1.79
3	0.72	1.69	3	0.70	1.66
6	0.60	1.41	6	0.58	1.39
12	0.47	1.22	12	0.44	1.20
18	0.29	0.76	18	0.26	0.77
24	0.07	0.31	24	0.08	0.28
36	BLOQ	0.09	36	BLOQ	0.08
48	BLOQ	BLOQ	48	BLOQ	BLOQ
72	BLOQ	BLOQ	72	BLOQ	BLOQ
Dissipation of Residues in Sandy Clay (mg/Kg)			**Dissipation of Residues in Clay Soil (mg/Kg)**		
0	0.96	1.94	0	0.95	1.93
1	0.80	1.72	1	0.80	1.69
3	0.68	1.62	3	0.65	1.55
6	0.52	1.34	6	0.50	1.29

12	0.37	1.17	12	0.33	1.02
18	0.19	0.65	18	BLOQ	0.40
24	BLOQ	0.15	24	BLOQ	BLOQ
36	BLOQ	BLOQ	36	BLOQ	BLOQ
48	BLOQ	BLOQ	48	BLOQ	BLOQ
72	BLOQ	BLOQ	72	BLOQ	BLOQ

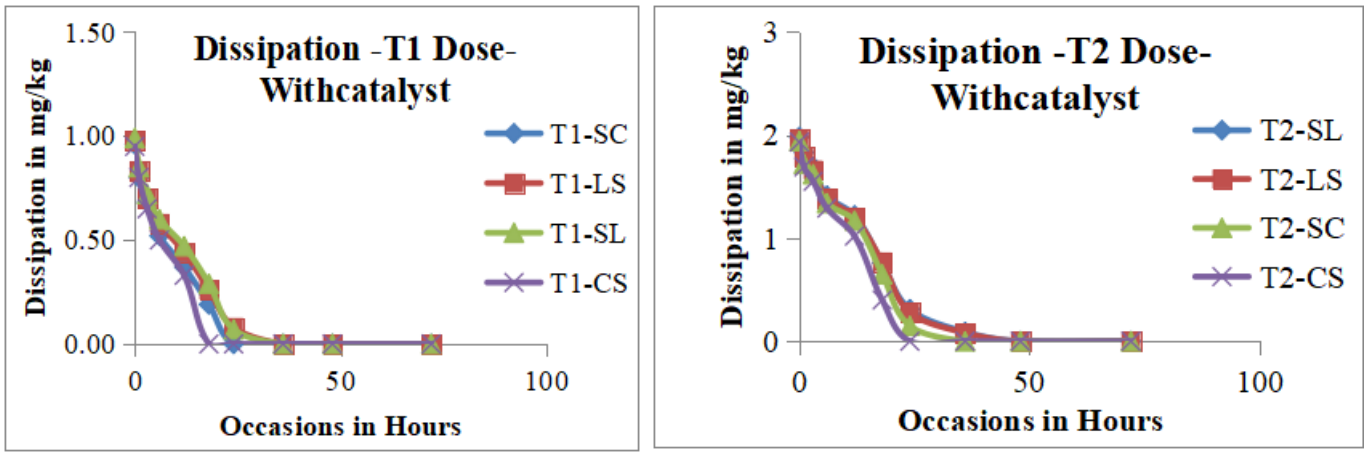


Fig.-6: Dissipation curve of Azoxystrobin influenced in soils

Table 4: Azoxystrobin DT_{50} and DT_{90} values in various soils with and without catalyst

Azoxystrobin							
Sandy loam		**Loamy sand**		**Sandy clay**		**Clay**	
DT_{50} in days (Without Catalyst)							
T1	T2	T1	T2	T1	T2	T1	T2
13.30	12.10	14.28	14.76	8.52	12.10	6.99	11.48
DT_{90} in days (Without Catalyst)							
44.18	45.28	47.45	49.05	28.29	40.20	23.23	38.14
Sandy loam		**Loamy sand**		**Sandy clay**		**Clay**	
DT_{50} in hours (With Catalyst)							
T1	T2	T1	T2	T1	T2	T1	T2
7.35	8.34	7.57	8.07	8.27	7.62	8.13	8.83
DT_{90} in hours (With Catalyst)							
24.43	27.72	25.16	26.80	27.46	25.32	27.00	29.34

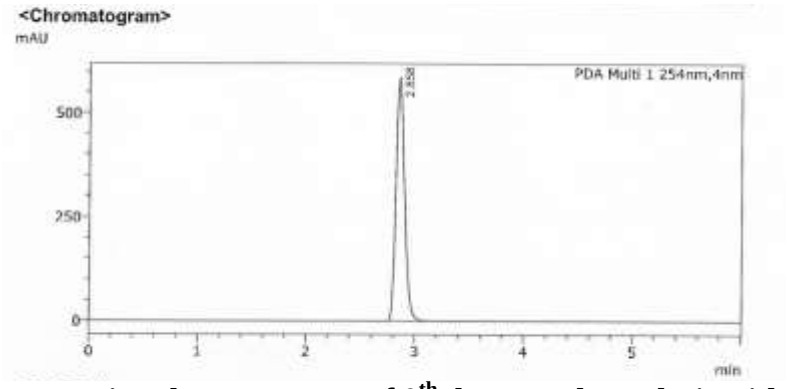


Fig.-7: Representative chromatogram of 0th day sample analysis without catalyst

CONCLUSION

In the present study, La-doped CuO was synthesized through a chemical process and characterization has been carried out by using UV-Vis, FT-IR, and FE-SEM, EDS. The data that doping of La-doped with Cu-O reduces the size of the particle, and decrease crystalline size and band gap, which ultimately leads to the efficiency of Photocatalytic activity. The photocatalytic degradation of azoxystrobin residues clearly shows that the inclusion of lanthanum-doped copper oxide nanoparticles as a catalyst affected sunlight photolysis. In several soil samples, the La doped CuO nanoparticles were found to be an efficient decontaminating catalyst. The breakdown of insecticides was greatly accelerated by the clay soil. By using UV-Vis, FT-IR, FE-SEM, and EDS, the lanthanum doped copper oxide nanoparticles were characterised. UHPLC-PDA detection was used to identify and quantify the chemical. La doped CuO nanoparticles were shown to be an efficient catalyst in photocatalytic degradation in the current investigation.

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