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BIODEGRADATION OF LAMBDACYHALOTHRIN BY *RHODOCOCCUS ERYTHROPOLIS*

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ABSTRACT: Based on the enrichment method, actinobacteria isolated from the Lambdacyhalothrin exposed paddy field soil designated as JMCTTKA11. The Mineral medium spiked with 0.05% of Lambdacyhalothrin showed good growth on which indirectly proved its capacity to degrade. JMCTTKA11 colonies showed abundant growth in ISP2, ISP4, ISP6 and ISP7 whereas good growth observed in ISP1, ISP5, BA and CM. The isolate strongly utilized the 1.0% D-mannitol, fructose, maltose, glycerol, sucrose and dextrin used as a sole carbon and energy source. SEM images clearly revealed the external morphology (10000x) as filamentous with single coccoid (0.0.364µm x 1.153µm) as well as rod shaped (0.392µm x 0.663µm) cells. At 30000x, beautiful rod shaped cells (411.7nm x 996.0nm; 356.3nm x 1419.2nm) were observed. The 16S rDNA sequence analysis identified JMCTTKA11 as *R. erythropolis* and also highly efficient in degrading Lambdacyhalothrin. Two degraded compound peaks at 22.160 and 23.522 Rt with peak area 20.739 and 26.097% whereas 65.100 and 55.773% of peak height (15th day intervals) observed. From these results, it is clearly confirmed that the 0.1% of commercial Lambdacyhalothrin was degraded and converted into non toxic compound used as a sole energy source of carbon and nitrogen for the growth and metabolism. Therefore, the strain *Rhodococcus erythropolis* is suitable for the efficient and rapid bioremediation of Lambdacyhalothrin pesticide contaminated environment.

KEYWORDS: Lambdacyhalothrin, 16S rDNA, *Rhodococcus erythropolis*, FTIR, HPLC.

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1.INTRODUCTION

Generally, the synthetic pyrethroid (SP) insecticides are produced from the flower extracts of *Chrysanthemum cinerariaefolium* [1]. One of the widely used pyrethroid insecticide to paddy fields was Lambdacyhalothrin [(RS)-a-Cyano-3-phenoxybenzyl-(Z)-(1RS,3RS)-(2-chloro-3,3,3-trifluoro propenyl)-2,2-dimethylcyclopropanecarboxylate], to control aphids, Coleopterous and Lepidopterous pests in cotton, cereals, hops, ornamentals, potatoes, vegetables and flowers in agriculture and domestic (gardens, homes) fields [2, 3]. It also used to control various pests like cockroaches, mosquitoes, ticks, and flies [4]. Lambdacyhalothrin is applied as a broad spectrum pyrethroid insecticide to control foliar insects on a large scale in rice fields of Tamil Nadu, India. Excessive usage of Lambdacyhalothrin has posed a great threat to human health and also for ecosystems [5, 6]. When it reaches the soil surface and accumulates nearly up to 15 cm of top soil layer [7]. Top soil layer acts as a vital site which maintains the soil fertility by various microbial activities [8]. It leads to the unsystematic hazards to the beneficial microorganisms in the paddy field [9]. Slow and non degradable properties of some pesticides persist for longer duration in the environment which not only prone ecological damage to crops [10], through aquatic ecosystem it enters into the other organisms *via* food chain. Lambdacyhalothrin is highly toxic to aquatic invertebrates and fish [11] by disturbing its neuroendocrinal activities [12] and its half-life in water varies from 17-110 days [13]. The pesticide enters humans *via* many ways like ingestion of food, contaminated drinking water, inhalation, dermal contact [14]. Therefore, it is necessary to develop remediation strategies to degrade and eliminate Lambdacyhalothrin from the environment. Biodegradation involves the use of living microorganisms to detoxify and degrade hazardous materials and generally considered to be an effective and safe way to remove contaminants from environment. Microbial metabolisms play a significant role in the degradation or detoxification of pyrethroid residues in the environment. Currently, a few pyrethroid biodegradation mechanisms have been studied such as pyrethroid-degrading strains *Serratia sp*. JCN13 [15], *Streptomyces parvulus* HU-S-01 [16], *Brevibacterium aureum*DG-12 [17], pyrethroid-hydrolyzing carboxylesterases from *Klebsiella* sp. ZD112 [18], *Sphingobium* sp. JZ-1 [19], *Streptomyces* sp [20] and *Ochrobactrum anthropi* YZ-1 [21]. Actinobacteria, a group of bacteria that were formerly classified as actinomycetes, constitute a significant fraction of the microbial population in soils (>1million/gm) [22, 23]. These microorganisms have been recognized as having great potential for the biodegradation of certain organic compounds such as pesticides [24].To overcome the synthetic pesticide hazards, the biodegradation plays an alternative approach to control pesticide residues because of its cost-effective and ecofriendly properties. A few reports are available the degradation of Lambdacyhalothrin by actinobacterial isolates. Therefore, there is an urgent need for effective strategies to remove Lambdacyhalothrin from environment. So, the present work mainly focused on the Lambdacyhalothrin degradation with the following objectives as Isolation of actinobacterial

strains from pesticide exposed paddy field soil samples by enrichment method, Morphological, biochemical and molecular characterization of the isolated actinobacterial strain and their efficiency in the biodegradation of Lambdacyhalothrin.

2. MATERIALS AND METHODS

2.1. Sample collection and preparation

Soil samples were collected in an aseptic manner (depth 5-10cm) according to the 'V' shaped method at different sites of paddy field at Paithur, Attur, Salem district, Tamil Nadu (India) due to its continuous application of Lambdacyhalothrin for more than 17 years, within six hours samples were brought to the laboratory. The collected samples were dried in clean aluminum trays at room temperature and sieved in a mesh (<2mm) and stored at 4°C [25].Commercial grade pesticide Lambdacyhalothrin 5% EC w/v named KARATE® (Syngenta Agrochemicals, India Private Limited) procured from the local market Attur Taluk, Salem District, Tamil Nadu (India). All other chemicals and reagents used were of analytical grade and purchased from Hi-Media Pvt. Ltd, Mumbai (India).

2.2. Isolation and enumeration of Actinobacteria by enrichment method

For the isolation of Actinobacteria, 10g of soil added to 100ml of sterilized Mineral medium (MM pH 6.8–7.0) containing Na_2HPO_4-5.8g/L, KH_2PO_4-3.0g/L, NaCl-0.5g/L, NH_4Cl-1g/L; $MgSO_4$-0.25g/L spiked with 0.05% pesticide (Lambdacyhalothrin) in 250ml Erlenmeyer flask and placed on a rotary shaker, incubated in 28±2°C, 121rpm for 25 days. After twenty five days, 1ml aliquots of treated samples was taken and mixed in 9ml of sterile deionized water, serially diluted upto 10^{-8} dilutions. The serially diluted sample (0.1ml) from 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} was taken and spread over the petridish containing Starch-Casein Nitrate (SCN) media [26] supplemented with cycloheximide (50µgm/L) for the enumeration of Actinobacteria and uninoculated plate was used as control. All the plates were incubated at 28°C for up to 15 days and observed daily from the third day onwards for the growth and characteristics.

2.3. Morphological and Cultural Characteristics

Morphologically different actinobacteria colonies were appeared and their spores were picked from the isolated plates [27] and streaked on ISP4 medium supplemented with Lambdacyhalothrin (0.05%) and incubated at 28°C for 7 days. The colour of spore mass of the matured aerial mycelium of the isolates JMCTTKA11 were determined by naked eye examinations of 15 days old cultures grown on various International Streptomycetes Project (ISP) media [27] ISP1 to ISP7, Bennet's agar and Calcium Malate (CM) agar. The intermediated colour of the substrate mycelium was also recorded.

2.4. Biochemical characterization

2.4.1. Utilization of Carbon sources

Different types of carbon sources (1.0%) such as arabinose, xylose, meso-inositol, D-mannitol, fructose, rhamnose, raffinose, galactose, maltose, glycerol, sucrose, lactose, D-mannose, D-sorbitol,

dextrin and dulcitol were sterilized with diethyl ether overnight and added separately on the molten basal medium. The isolates streaked on various slant tubes and incubated for 15 days at 28°C. Basal medium + 1.0% glucose for positive control and basal medium alone for negative control were used. The selective JMCTTKA11 isolates were streaked on various sugars and incubated for 15 days at 28°C [27].

2.4.2. Utilization of Nitrogen sources

The ability of selected JMCTTKA11 isolates in utilizing various nitrogen compounds as a source of energy was studied following the method recommended by ISP [27]. L-Proline + Basal medium (positive control), Basal medium alone (negative control), Basal medium with 0.1% L-Glutamine, L-Methionine, L-Valine and L-Alanine used for nitrogen sources and the inoculate growth observed from the 5th day onwards. For each of the nitrogen sources, utilization is expressed as positive (+), negative (-), on doubtful (+ or -). In the doubtful strains, there was only a trace of growth which was slightly higher than that of the controls.

2.5. Scanning Electron Microscope

The strain JMCTTKA11 grown on ISP4 medium selected and 2 to 3 sterilized small disc inserted at 45°, incubated for 5 days at 28°C. After 5 days, disc from cultures were washed twice with PBS (0.1M) and fixed in 2% Glutaraldehyde at 4°C for 2hr [16]. After fixation, the samples were dehydrated with 30%, 40%, 50%, 60%, 70%, 80%, 90% ethanol series at one time each and then dehydrated with 100% ethanol by three times for 10min. The dehydrated samples were kept overnight in desiccators and thereafter gold coated by sputtering. The samples were then analyzed by HR-FE-SEM (JEOL, JSM-670IF) at 30kV.

2.6. Molecular Characterization

Genomic DNA was prepared according to standard methods [28]. PCR amplification was performed for the respective samples of purified DNA using Actino-F (5'-CGCGGCCTATCAGCTTGTTTG-3') and Actino-R (5'-CCGTACTCCCAGGCGGGG-3') primers [29]. The polymerase chain reactions conditions include initial denaturation of template DNA was achieved at 94°C for 6min. Further denaturation was carried out 94°C for 1min; annealing at 52°C for 1min, extension at 72°C for 30sec and a final extension at 72°C for 10min for 35 cycles. Amplified products were isolated by electrophoresis on 1.2% agarose gel using 1×TAE buffer at a constant supply of 60V for 30min. The resulting sequences were compared with the genes available in the GenBank nucleotide library by a BLAST search through the National Center for Biotechnology Information (NCBI) and phylogeny was analyzed using MEGA 7.0 [30]. An unrooted tree was built using the neighbor-joining method. Based on the expressed phenotypic characters, the potential of actinobacteria strain was tentatively identified with the help of the keys of Nonomura [31].

2.7. Biodegradation assay: Inoculum Preparation

The actinobacterial strain JMCTTKA11 were thawed and grown individually in 250ml Erlenmeyer

flask containing 100ml of sterile mineral medium with 0.1% glucose as a sole carbon and energy sources and the flasks were kept in a shaker at 120rpm, 28°C for 3 days. The strain was harvested in the early log phase by centrifuging (10min, 8000rpm, 4°C) and washed twice in sterile mineral medium and once again washed with sterile deionized water. The 0.1% of the pure suspension was used as inocula for further biodegradation assay [32].

2.7.1. Biodegradation of Lambdacyhalothrin

The 0.1% of actinobacterial strain JMCTTKA11 was inoculated on the sterilized mineral medium spiked with 0.1% of commercial Lambdacyhalothrin and the flasks were kept in a shaker at 28°C, 120rpm for 15 days. Uninoculated flasks with mineral medium containing 0.1% of commercial Lambdacyhalothrin served as control. At 15^{th} day intervals, the 20ml of sample was aseptically recovered from the control as well as treated sample and centrifuged at 8000rpm for 10min to obtain the cell free medium. For the determination of residual pesticide concentration and its functional groups, equal volume of Ethyl acetate was added on the respective cell free medium in a separating funnel was allowed to settle. The organic layer of ethyl acetate was collected individually, then aspirated, pooled and evaporated at room temperature. The remaining residual pesticide concentration was determined by HPLC and their functional groups were analysed by UV and FTIR analysis [33].

2.7.2. Silicagel cleanup

Three grams of silicagel (60-120mesh) baked at 200°C for 12h was stirred with ethyl acetate to form slurry and poured into a glass column (16×1.5cm), then Na_2SO_4 was layered (~1cm) above the silica gel and finally, conditioned with 15ml of ethyl acetate. The concentrated extract of control and treated sample transferred individually to the column and eluted with 15ml of ethyl acetate. Elute was collected at evaporated at room temperature. The residue was further subjected to find out the functional group as well as the pesticide residual concentrations through the UV, FTIR and HPLC [34].

2.7.3. UV-Vis Spectral analysis

The absorption maxima (λ_{max}) of pure Lambdacyhalothrin, commercial grade Lambdacyhalothrin and treated samples were analysed by UV Spectrophotometer coupled with DAD detector (Alignment Technologies, Cork, Ireland) [35].

2.7.4. Fourier Transform Infra-Red Spectra analysis

IR spectra of the 0.1% concentration of the parent compound Lambdacyhalothrin as well as treated samples were recorded at room temperature in the frequency range of 4000-400cm^{-1} with a Fourier Transform Infrared (FTIR) spectrophometer IR affinity-1 Perkin Elmer 2000 model FTIR spectrometer (Thermo Fisher Scientific Inc., MA and USA) with a helium-neon laser lamp as a source of IR-Radiation. Pressed pellets were prepared by grinding the extracted samples with potassium bromide in a mortar with 1:100 ratio and immediately analyzed in the region of 4000-

400cm^{-1} at a resolution of 4cm^{-1} [25].

2.7.5. High Performance Liquid Chromatography Conditions and analysis

Extracted samples of control and also treated samples were analyzed on a various HPLC equipped with a binary pump programmable variable wavelength UV detector and ODS2 C18 reversed phase column. The pesticide residue analyses were conducted using a gradient mobile phase of Methanol:Water (80:20). Sample injection volume was 20µl and the mobile phase was programmed at a flow rate of 1ml/min. Lambdacyhalothrin was detected at 232nm wavelength. The retention time for Lambdacyhalothrin was 23.291 min. These values are fixed to compare the wavelength and retention time of the treated samples [33].

3. RESULTS AND DISCUSSION

3.1. Isolation and enumeration of Actinobacteria by enrichment method

10g of pesticide exposed soil sample collected from paddy field was inoculated on sterilized mineral medium spiked with 0.05% of commercial Lambdacyhalothrin pesticide and incubated in 28±2°C, 121rpm for 25days. After 25days, 1ml of treated sample was taken and mixed in 9ml of sterilized deionized water and serially diluted upto 10^{-8} dilutions. From the dilution factor 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} were used to isolate the actinobacteria by spread plate method on SCN media. The strain JMCTTKA11 exhibited a good growth by degrades 0.05% of commercial Lambdacyhalothrin.

3.2. Characterization of JMCTTKA11

JMCTTKA11 colonies showed abundant growth, Gram positive, aerobic, non motile characters were observed in ISP2, ISP4, ISP6 and ISP7. Pinkish ash coloured, smooth glistening and wavary outgrowth of colonies with dark brown reversed side pigment was noted in ISP2 medium. Smooth, waxy, glistening, pale yellow coloured colonies were observed in ISP4 medium (Table 1).

Table 1. Morphological characteristics of JMCTTKA11 in various ISP media

Medium	Growth	Colour of the aerial mycelium	Colour of the substrate mycelium	Soluble pigment	Melanin pigment
ISP1	+++	Creamy	Pale yellow	0	0
ISP2	++++	Pinkish ash	Dark brown	0	0
ISP3	+	Pale white	Pale whitish	0	0
ISP4	++++	Pale yellow	Ash in colour	0	0
ISP5	+++	Pale yellow	Pale whitish	0	0
ISP6	++++	Pale yellowish	Pale brownish	0	0
ISP7	++++	Milky ash	Pale ash in colour	0	0
BA	+++	Pale whitish	Pale yellowish	0	0
CM	+++	Pale whitish	Pale whitish ash	0	0

No growth; +: Poor growth; ++: Moderate growth; +++: Good growth; ++++: Very good growth; x: Not determined; 1: Produced; 0: Not produced

In ISP6 medium, the colonies exhibited as pale yellowish colour with smooth, waxy, glistening pale brownish reversed side pigment. Milky ash colloidal, waxy, wavaryout growth of the young colonies in the peripheral region was recorded in the ISP7 medium with pale ash reverse side pigment. Good growth was recorded in ISP1, ISP5, BA and CM whereas the colour ranges from creamy, pale yellow and pale whitish colour, the reverse side pigment exhibited as pale yellow and pale white colour. At the sametime, poor growth was observed on ISP3 media. No soluble and melanin pigments were recorded.

3.3. Utilization of Carbon sources

The isolate strongly utilized the 1.0% of the following sugar such as D-mannitol, fructose, maltose, glycerol, sucrose and dextrin and also the positive control (1% of glucose in Basal medium). A moderate level of growth was observed in raffinose, galactose, D-mannose and D-sorbitol used as a sole carbon and energy source. However, the isolate fails to growth the following carbon sources such as arabinose, xylose, meso-inositol, rhamnose, lactose, dulcitol and also in negative control (Table 2).

Table 2. Utilization of Carbon source by JMCTTKA11 actinobacterial strain

Sr. No.	Carbon Source	Growth	Result
A	Basal medium (Positive control)	++	Strongly positive
B	Basal medium with glucose (negative control)	-	Negative
1	Arabinose	-	Negative
2	Xylose	-	Negative
3	Meso-inositol	-	Negative
4	D–mannitol	++	Strongly positive
5	Fructose	++	Strongly positive
6	Rhamnose	-	Negative
7	Raffinose	+	Positive
8	Galactose	+	Positive
9	Maltose	++	Strongly positive
10	Glycerol	++	Strongly positive
11	Sucrose	++	Strongly positive
12	Lactose	-	Negative
13	D–mannose	+	Positive
14	D–sorbitol	+	Positive
15	Dextrin	++	Strongly positive
16	Dulicitol	-	Negative

(++) strongly positive; (+) Positive; (-) Negative

3.4. Utilization of Nitrogen sources

The 0.1% of positive control, L-glutamine, L-valine and L-alanine was highly utilized by the isolate as a sole nitrogen and energy source. However, the isolate moderately utilized L-methionine as an energy source and the growth was totally absent in negative control (Table 3).

Table 3. Utilization of Nitrogen sources by JMCTTKA11 actinobacterial strain

Sr.No.	Nitrogen Source	Growth	Result
1	Basal medium+L–Proline (Positive control)	++	Strongly positive
2	Basal medium (Negative control)	-	Negative
3	L–Glutamine	++	Strongly positive
4	L–Methionine	+	Positive
5	L–Valine	++	Strongly positive
6	L-Alanine	++	Strongly positive

(++) Strongly positive; (+) Positive; (-) Negative

3.5. Scanning Electron Microscope

SEM image clearly revealed the external characters of the isolate as a very thin filamentous and the cells are arranged in a linear fashion. At 10,000x magnification, filamentous single cells observed with coccoid as well as rod shaped cell with the diameter of 0.0.364µm and length of 1.153µm, 0.392µm diameter and 0.663µm length was noted. At 30,000x magnification beautiful rod shaped cells with diameter of 411.7nm and length of 996.0nm, 356.3nm and length of 1419.2nm was observed **(Figure 1)**.

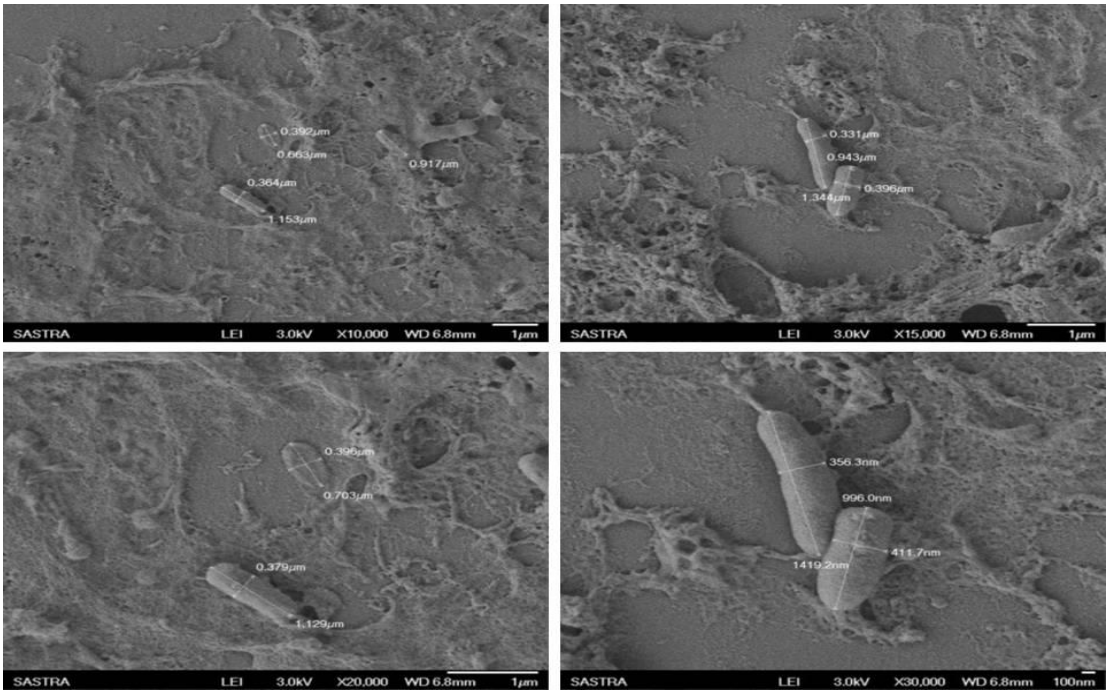


Figure 1: Scanning electron microscopic images showing the rod- to coccoid-shaped cells of JMCTTKA11

3.6. Molecular characterization

According to BLAST analysis, the 16S rDNA of strain JMCTTKA11 sequence had high similarity to the 16S rDNA gene sequence of genus belongs to *Rhodococcus erythropolis* group. The phylogenetic tree based on the 16S rDNA gene sequence and related strains indicated that the isolate was closely clustered with *Rhodococcus qingshengii* (GenBank accession No. MF929191.1) and *Rhodococus erythropolis* (GenBank accession No. HF558425.1) with 100% sequence identity respectively. The JMCTTKA11 16S rDNA gene sequence deposited in the GenBank database with the accession number MG208090.Based on the morphological, biochemical characteristics and 16S rDNA sequence analysis, the potential strain JMCTTKA11 was identified as *Rhodococcus erythropolis* **(Figure 2).**

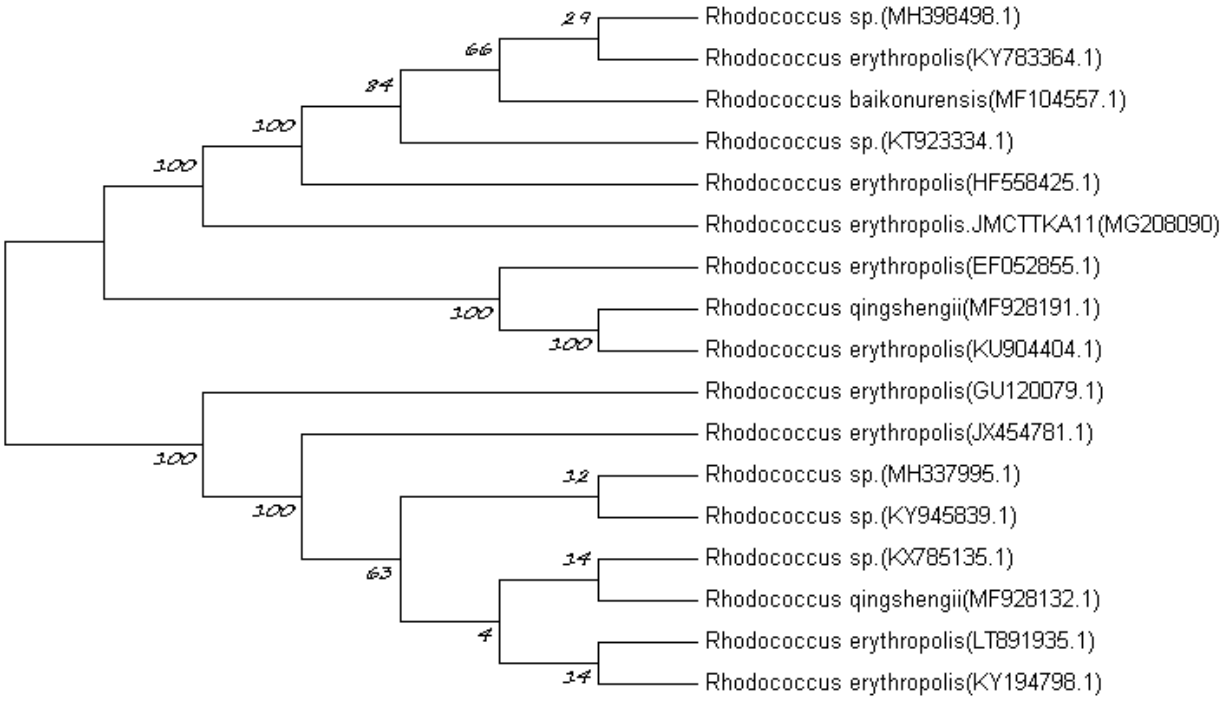


Figure 2: The phylogenetic tree based on the 16S rDNA sequence of strain JMCTTKA11 and related strains

3.7. Biodegradation of Lambdacyhalothrin

3.7.1. Spectral analysis of Lambdacyhalothrin through UV-Vis spectrophotometer

The absorption maxima of 0.1% commercial Lambdacyhalothrin control sample exhibited at 237.0 nm as a sharp peak with broad peak area along with it shoulder at the λmax of 276.6 nm (Figure 3). In JMCTTKAA11 treated sample, totally four different peaks were observed at the λmax of 217.01, 222.17, 217.01 and 272.31nm. At the sametime, other shifted functional groups were recorded (Figure 4).

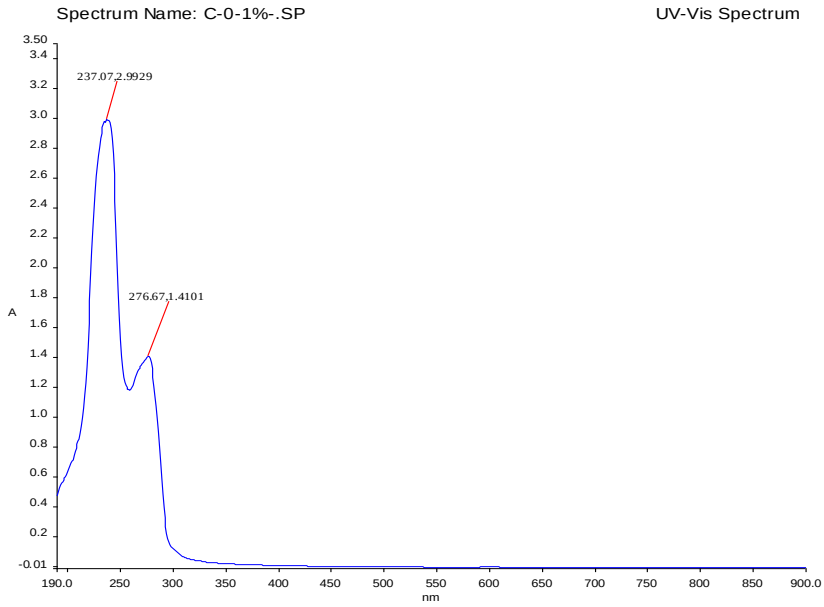


Figure 3: UV-Vis spectra of commercial Lambdacyhalothrin 0.1% control

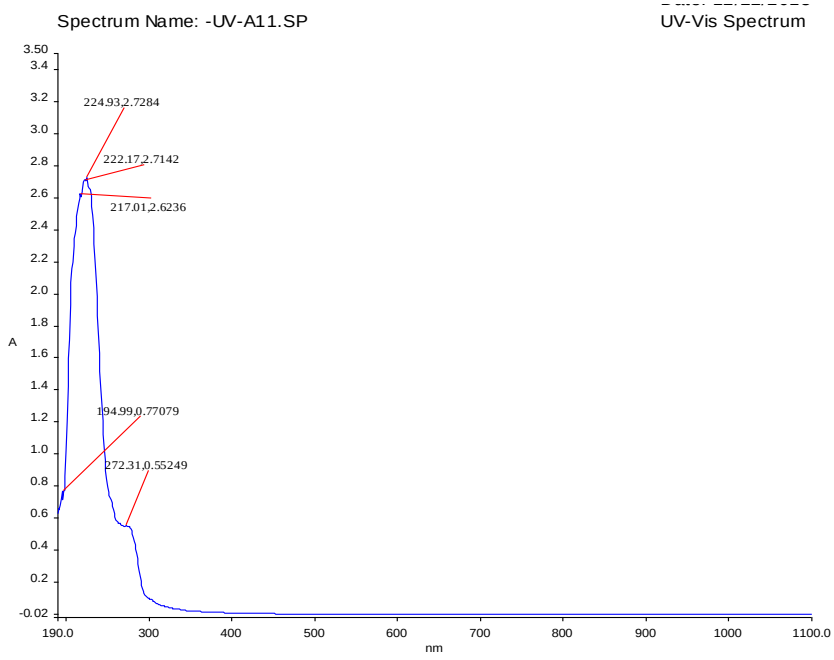


Figure 4: UV-Vis spectra of commercial Lambdacyhalothrin 0.1% treated with JMCTTKA11

3.7.2. Spectral analysis of the Lambdacyhalothrin through FTIR

In the IR spectrum of the control commercial Lambdacyhalothrin 0.1% five functional groups were identified, which fall in between the particular frequency range cm^{-1}, the functional groups such as 51% of transmittance and 49% absorbance in C-H aliphatic group, 93% transmittance and 7% absorbance in C≡N nitrile group, 61% transmittance and 39% absorbance in C=O carbonyl group, 44% transmittance and 56% absorbance in C-F fluorine group and 73% transmittance and 27% absorbance in C-Cl chlorine group was recorded (Figure 5).After 15 days of intervals, JMCTTKA11 treated samples showed 29% transmittance and 71% absorbance in C-H aliphatic group, 89% transmittance and 11% absorbance in C≡N nitrile group, 63% transmittance and 37% absorbance in

C=O carbonyl group, 15% transmittance and 80% absorbance in C-F fluorine group and 63% transmittance and 77% absorbance in C-Cl chlorine group (Figure 6).

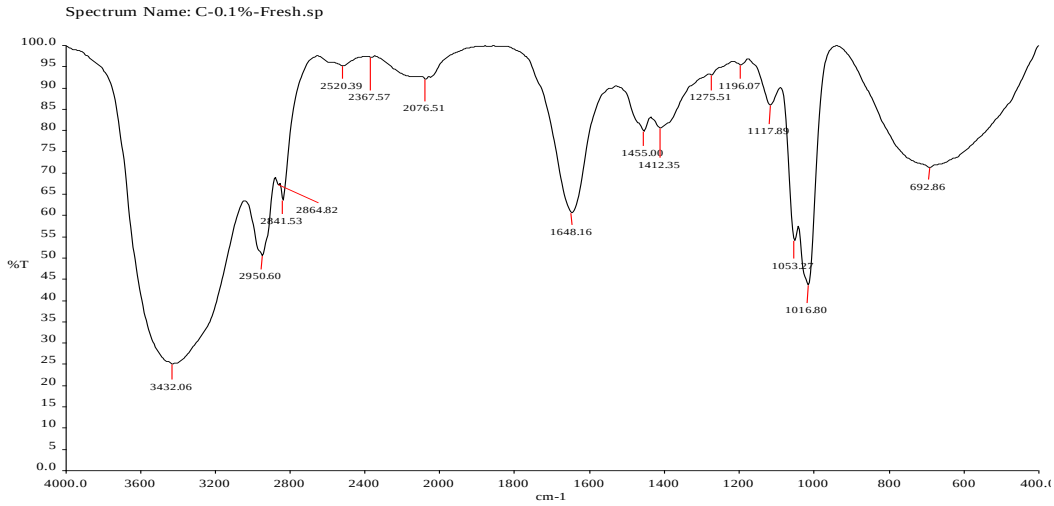


Figure 5: FTIR spectra of commercial Lambdacyhalothrin 0.1% control

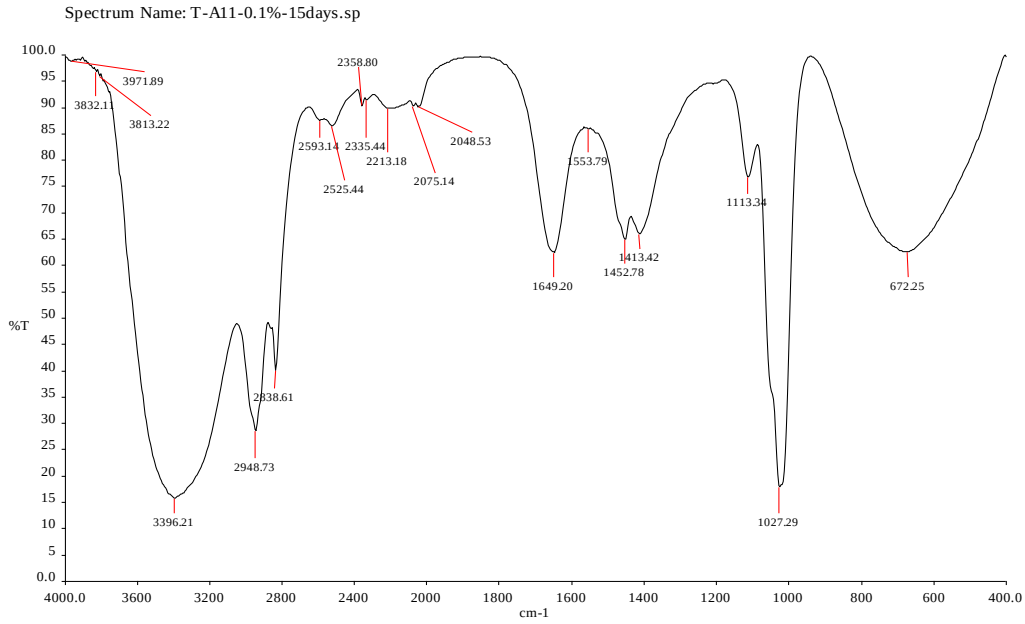
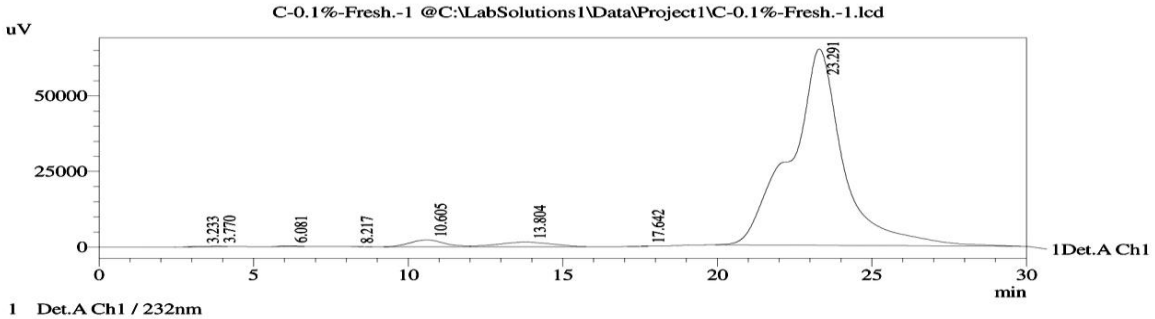


Figure 6: FTIR spectra of commercial Lambdacyhalothrin 0.1% treated with JMCTTKA11

3.7.3. Residual quantification analysis of Lambdacyhalothrin by HPLC

A single sharp peak with high concentration of broad peak was observed in 0.1% concentration commercial Lambdacyhalothrin pesticide at the retention time 23.291 with 95.234% of peak area and 93.337% of peak height was observed. Being the highest concentration of pesticide, the degradation level was studied at 15th day intervals (Figure 7). In 15th day intervals, JMCTTKA11 treated sample exhibited two degraded compound peaks at 22.160 and 23.522 Rt with 20.739 and 26.097, 65.100 and 55.773% of peak area and peak height respectively. From these results, it is clearly confirmed that the 0.1% of commercial Lambdacyhalothrin was degraded and converted as

a minerals in the treated samples **(Figure 8).**

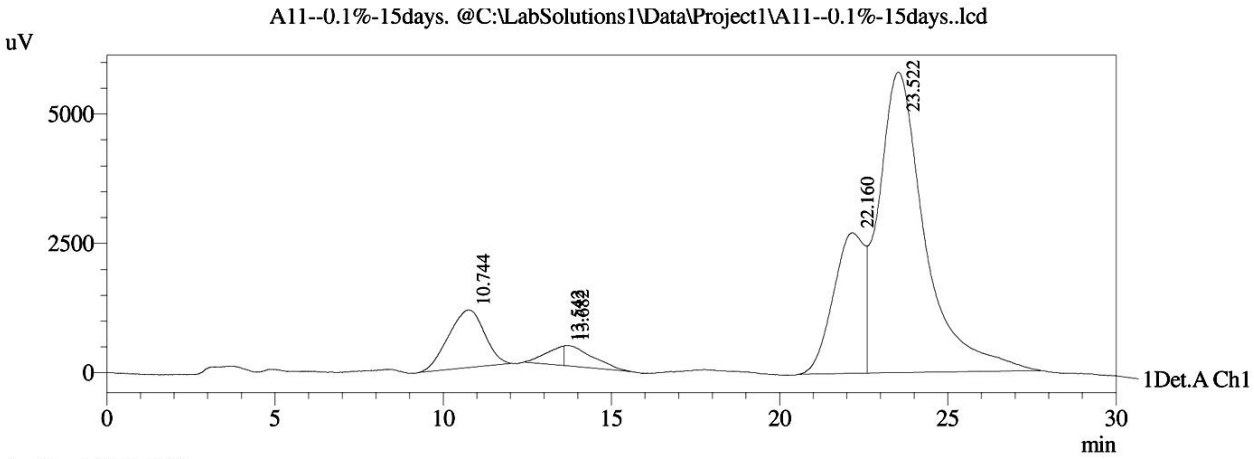


PeakTable

Detector A Ch1 232nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	3.233	5339	176	0.066	0.252
2	3.770	7650	198	0.094	0.285
3	6.081	10017	238	0.123	0.342
4	8.217	2048	63	0.025	0.091
5	10.605	176396	2304	2.164	3.307
6	13.804	185654	1620	2.278	2.325
7	17.642	1348	43	0.017	0.062
8	23.291	7761697	65027	95.234	93.337
Total		8150148	69669	100.000	100.000

Figure 7. HPLC chromatograms of commercial Lambdacyhalothrin 0.1% control



PeakTable

Detector A Ch1 232nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	10.744	83329	1115	9.841	10.713
2	13.542	13592	375	1.605	3.601
3	13.682	22989	397	2.715	3.816
4	22.160	175621	2717	20.739	26.097
5	23.522	551263	5806	65.100	55.773
Total		846793	10411	100.000	100.000

Figure 8. HPLC chromatograms of commercial Lambdacyhalothrin 0.1% treated with JMCTTKA11

The degradation of high level of pesticide concentration (0.1%) is evident by the enzymatic activity of the actinobacterial isolate JMCTTKA11. The Lambdacyhalothrin, highly toxic pesticide compound converted into non toxic as well as mineral compound used as a sole energy source of carbon and nitrogen for the growth and metabolism of the inoculated cultures. In the present investigation, *Rhodococcus erythropolis* strain JMCTTKA11 was isolated from a pesticide exposed paddy field soil by using enrichment culture technique and found to be highly effective in degrading Lambdacyhalothrin. Using enrichment culture techniques, several bacterial and fungal species

belonging to various genera have been isolated from pyrethroid-contaminated soils [36-40]. Pyrethroid-degrading microorganisms utilizes the metabolites formed from the parental compounds degradation studies reported by various researches such as fenvalerate-degrading *Stenotrophomonas* sp. strain ZS-S-01 [41], deltamethrin-degrading *Streptomyces aureus* strain HP-S-01 [42] were also capable of degrading pyrethroids such as fenpropathrin, bifenthrin, b-cypermethrin, cyhalothrin, or permethrin with a wide range of efficacies.In most studies, strains completely degraded pyrethroids (50 mg/L) within 5 days of incubation were also reported. Moreover, strains ZS-S-01 and HP-S-01 also eliminated 3- phenoxybenzoic acid and 3-phenoxybenzaldehyde from liquid media, respectively [41, 42]. Chen et al. [43] also demonstrated that *B. thuringiensis* strain ZS-19, when inoculated into an organic medium, degraded only 86% of cyhalothrin (100 mg/L) within 72 h of incubation, whereas 100% of cyhalothrin was removed by ZS-19 strain (72h) cultured in a mineral medium. Xiao et al. [44] demonstrated the influence of pyrethroid concentration on the degradation rate in *B. subtilis* strain BSF01. About 94, 89, and 85% of cypermethrin at concentrations of 25, 50, and 100mg/L were degraded within seven days reported by several researchers respectively. Approximately 80% of degradation was achieved at of 200, 300 and 400mg/L concentration with a longer lag phase observed. Biodegradation results revealed that strain JZ-2 utilized 100% of fenpropathrin, nearly 90% of cypermethrin, permethrin, fenvalerate, and deltamethrin and about 70% of cyhalothrin within 5 days of incubation. *O. tritici* strain pyd-1 has the ability to utilize seven pyrethroids with different efficiencies [36]. Among the pyrethroids tested, the fastest degradation occurred in the case of permethrin 100% of the initial concentration (100mg/L) was removed by strain pyd-1 after 72 h. The ability to degrade more than one pyrethroid compound was also reported for *Bacillus* sp. DG-02 [45], *Bacillus subtilis* BSF01 [44] and *Brevibacillus parabrevis* FCm9 [38].

4. CONCLUSION

The Lambdacyhalothrin degrading actinobacterial strain isolated from the pesticide exposed paddy field soil sample. Based on its morphological, biochemical and analysis of 16S rDNA gene sequence strain JMCTTKA11 identified as *Rhodoccoccus erythropolis* which was highly efficient in commercial Lambdacyhalothrin degradation and tolerate high concentrations (0.1%). Therefore, the information presented here indicated that potential strain JMCTTKA11 was proficient for biodegradation and implied for development of a bioremediation strategy of pyrethroid-contaminated environment.

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CONFLICT OF INTEREST

No conflict of interest

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