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# Biodegradation Of Synthetic Compounds By The Microorganisms Isolated From Different Regeions Of Telangana


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***Abstract***

The extensive use of synthetic compounds, including pesticides, has raised concerns about their environmental impact and potential risks to human health. Microbial biodegradation has emerged as a promising eco-friendly approach to mitigate the accumulation of these compounds in the environment. In this study, we investigated the biodegradation potential of found microorganisms isolated from pesticidetreated soils in different regions of Telangana State. 50 Soil samples were collected from agricultural areas in diverse regions, known for their significant pesticide usage. Enrichment cultures were prepared using these soil samples to isolate predominantly found 10 bacterial and 5 fungal genus capable of utilizing synthetic compounds as a carbon and energy source. The isolated microbial strains were characterized by morphological, physiological, and biochemical characteristics. Subsequently, the biodegradation potential of the isolated microorganisms was assessed through laboratory-scale degradation experiments. Commonly used pesticides were selected as model substrates for degradation studies. The degradation efficiency of the microorganisms was evaluated at different incubation periods (05, 10 and 15 days) to understand their ability to break down these synthetic compounds. The results demonstrated that the degradation of pesticides by bacteria and fungi was found significant after 15th day of incubation. The degradation of tested pesticides was initiated from the 5th day. At the end of 10th day there is an exponential degradation percentage. By 15th day the degradation percentage was approximately 1fold compared to 10th day degradation percentage. This investigation emphasizes the significance of harnessing the potential of bacteria and fungi to mitigate the environmental burden of synthetic compounds. The findings hold practical implications for developing eco-friendly and region-specific bioremediation strategies to combat pollution caused by synthetic compounds and promote environmental sustainability in the agricultural sector.



**Keywords:** Synthetic compounds, Bioremediation and Degradation percentage

## 1.0 INTRODUCTION

Pesticides are substances or mixtures of chemicals specifically designed to control, repel, or eliminate pests. Pests can include insects, weeds, fungi, bacteria, rodents, and other organisms that can cause harm or damage to crops, livestock, structures, or human health. Pesticides are commonly used in agriculture, forestry, public health, and residential settings to protect crops, control disease vectors, prevent the spread of invasive species, and manage pests that pose risks to human well-being. They play a crucial role in improving agricultural productivity. Pesticides can affect bacteria and fungi through various mechanisms, depending on the specific type of pesticide and its mode of action. Many pesticides act by targeting specific enzymes that are essential for the survival and growth of bacteria and fungi. These pesticides may bind to the active site of the enzyme, disrupting its normal function and inhibiting important metabolic processes. By interfering with critical enzyme activity, pesticides can disrupt cellular functions and ultimately lead to the death of the microorganisms. When microorganisms are exposed to Synthetic compounds, they can employ various counteraction mechanisms to mitigate the toxic effects and promote their survival. These mechanisms can involve both metabolic and genetic responses. The drastic rise in global population has increased the demand for food and fabric production throughout the world. It has become a need to achieve these demands which is possible by increasing the crop yield. To meet this increasing demand of food there is a need to increase crop production by adopting new methods. The use of synthetic compounds has shown negative impact on soil fertility and soil microflora Singh and Prasad, 1991; Bhuyan et al., 1992. Soil microorganisms and their secretions directly influence the rhizosphere region. This is the region where complex interactions between roots and microorganisms are observed. The extensive application of synthetic compounds causes pollution of the soil (Muñoz- Leoz et al., 2013). It has been reported that approximately three million tons of synthetic pesticide per year have been using globally (Pan UK, 2003). The amount of synthetic compounds that targets the insect or the pest is of about only 0.1% and the remaining 99.9% amount of synthetic compounds pollutes the soil environment (Carriger et al., 2006; Pimental, 1995; Harris and Sans, 1969; Alexander, 1961). It has been also reported that synthetic compounds at fento molar concentrations affect the biochemical properties of soil microorganisms (Cycon et al., 2006; Singh et al., 2008; Cycon et al., 2010; Schuster and Schroder, 1990). With reference to the counteraction mechanisms, the current investigation was carried out to determine the degradation of pesticides by soil microbes.

## 2.0 MATERIALS AND METHODS

The degradation of synthetic compounds in soil is a critical process for environmental remediation and the maintenance of soil health. Microorganisms play a crucial role in this process, as they possess the enzymatic machinery capable of breaking down a wide range of synthetic compounds. Understanding the materials and methods used to study the degradation of synthetic compounds by microorganisms in soil is essential for designing effective bioremediation strategies. The key materials and methods commonly employed in such studies include

### 2.1 SCREENING FOR SYNTHETIC COMPOUND DEGRADATION

Synthetic compounds for degradation studies were selected based on their prevalence and environmental significance. The synthetic compounds selected were (Parathion, Endosulfan, Mancozeb, Atrazine, Dicofol, Carbofuran, Monocrotophos, Phthalimide, Carbendazim). Stock solutions of synthetic compounds were prepared in appropriate solvents. Microorganisms were inoculated onto growth media supplemented with synthetic compounds as the sole carbon source. Microbial growth and degradation activity was monitored using Spectrophotometry or Turbidity measurements.

### 2.3 BIODEGRADATION OF SYNTHETIC COMPOUNDS

**E**nzymes produced by microorganisms are involved in the degradation of synthetic compounds. For this, 100ppm of the stock solution of all the synthetic compounds was prepared by dissolving 0.1mg of the synthetic compounds in the 1000ml of the respective solvents, from which 5ml of the stock solution was transferred to 500ml of the respective media to obtain 1ppm concentration. Respective microorganisms were inoculated on to growth media supplemented with synthetic compounds as the sole carbon source and incubated under optimal growth conditions for different time periods. After the respective time period, the % of degradation was calculated by extracting the synthetic compounds in the mixture of non polar solvents, mediate polar solvents and polar solvents (n- Hexane : Acetone : Methanol) in different ratios for different synthetic compounds. The % of degradation was calculated using the following formula.

% Degradation = ((Initial concentration - Concentration at time point) / Initial concentration) X 100

Where:

% Degradation is the percentage of pesticide degradation.
Initial concentration is the concentration of the pesticide at the start of the degradation process. Concentration at time point in hours is the concentration of the pesticide at the desired time point during degradation.

## 3.0 RESULTS

### 3.1 BIODEGRADATION OF PESTICIDES BY BACTERIA

In accordance to the results shown in tables 1.1, 1.2, 1.3, and Fig 1.1, 1.2, 1.3 the degradation of synthetic pesticides by bacterial strains was highly found significant after 15$^{th}$ day of incubation. The degradation of tested pesticides was initiated from the 5$^{th}$ day of incubation. At the end of the 7$^{th}$ day there is an exponential degradation percentage was noted. By 15$^{th}$ day the degradation percentage was approximately found 1 fold comparing to 7$^{th}$ day degradation percentage. (Table 1.1, 1.2, 1.3 and Fig 1.1, 1.2, 1.3). Among the bacteria isolated Pseudomonas and Bacillus noted significant degradation property against the tested synthetic pesticides. Using Pseudomonas highest degradation percentage 93% was achieved against Monocrotophos. Following, Mancozeb, Atrazine, Endosulfon were also significantly inhibited by Pesudomonas with degradation percentages 91%, 91%, 88% respectively. Moreover, Carbendazim and Paraoxon also degraded with significant degradation percentages 82% and82% respectively. The other pesticides are also highly degraded by pseudomonas (Table 1.3). Following to pseudomonas, Bacillus also exhibited significant degradation percentage against tested synthetic pesticides. Out of ten tested bacteria, five bacteria namely, Staphylococcus, Streptococcus, Azatobacter, Azosirillum and Rhizobium were exhibited poor degradation percentage against the tested pesticides (Table 1.1, 1.2, 1.3 and Fig 1.1, 1.2, 1.3). the degradation of synthetic pesticides by the remaining bacteria was shown in (Table 1.1, 1.2, 1.3 and Fig 1.1, 1.2, 1.3).

### 5.3.2 BIODEGRADATION OF PESTICIDES BY FUNGI

With reference to the results shown in tables 1.4, 1.5, 1.6, and Fig, 1.4, 1.5, 1.6 the degradation of synthetic pesticides by fungal strains was highly found significant after 15$^{th}$ day of incubation. The degradation of tested pesticides was initiated from the 5$^{th}$ day of incubation. At the end of the 7$^{th}$ day there is an exponential degradation percentage was noted. By 15$^{th}$ day the degradation percentage was approximately found 1 fold comparing to 7$^{th}$ day degradation percentage. (Table 1.4, 1.5, 1.6 and Fig 1.4, 1.5, 1.6).

Among the tested fungal strains Aspergillus and Thrichoderma were found significant tested synthetic pesticides. Aspergillus exhibited highest degradation percentage 81% and 84% against Mancozeb and Carbofuran respectively. Following, Thrichoderma also significantly degraded Carbofuran and Mancozeb with degradation percentages 80%, 79% respectively. Out of five tested fungi, Fusarium, Rhizopus and VAM exhibited average degradation percentage against all tested synthetic pesticides comparing to Aspergillus and Trichoderma. (Table 1.4, 1.5, 1.6 and Fig 1.4, 1.5, 1.6).

**Table 1.1 Degradation of pesticide at pH 7.0 after 05$^{th}$ day by the isolated bacterial strains**

| **Degradation (%)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Pseudomonas | 22 | 39 | 40 | 17 | 33 | 13 | 28 | 17 | 20 |
| Bacillus | 24 | 42 | 38 | 28 | 30 | 14 | 27 | 19 | 21 |
| Streptomyces | 26 | 34 | 30 | 31 | 19 | 20 | 19 | 13 | 14 |
| Rhizobium | 02 | 27 | 00 | 02 | 14 | 22 | 20 | 18 | 15 |
| Klebsiella | 27 | 32 | 00 | 10 | 22 | 17 | 21 | 19 | 19 |
| Staphylococcus | 00 | 05 | 06 | 00 | 03 | 00 | 02 | 00 | 06 |
| Streptococcus | 00 | 00 | 00 | 00 | 00 | 00 | 03 | 02 | 00 |
| Azatobacter | 00 | 42 | 00 | 00 | 10 | 00 | 04 | 00 | 00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Azosirillum | 03 | 00 | 00 | 02 | 11 | 02 | 00 | 03 | 02 |
| Actinomycetes | 17 | 30 | 08 | 12 | 13 | 13 | 05 | 17 | 00 |
| **PAR**- Paraoxon, **END**-Endosulfon, **MH**-Mancozeb, **ATR**- Atrazine, **DIC** - Dicofol, **CORB**- Carbofuran, **MON**- Monocrotophos, **PTHA** – Pthalimide, **CAR**- arbendazim. | | | | | | | | | |

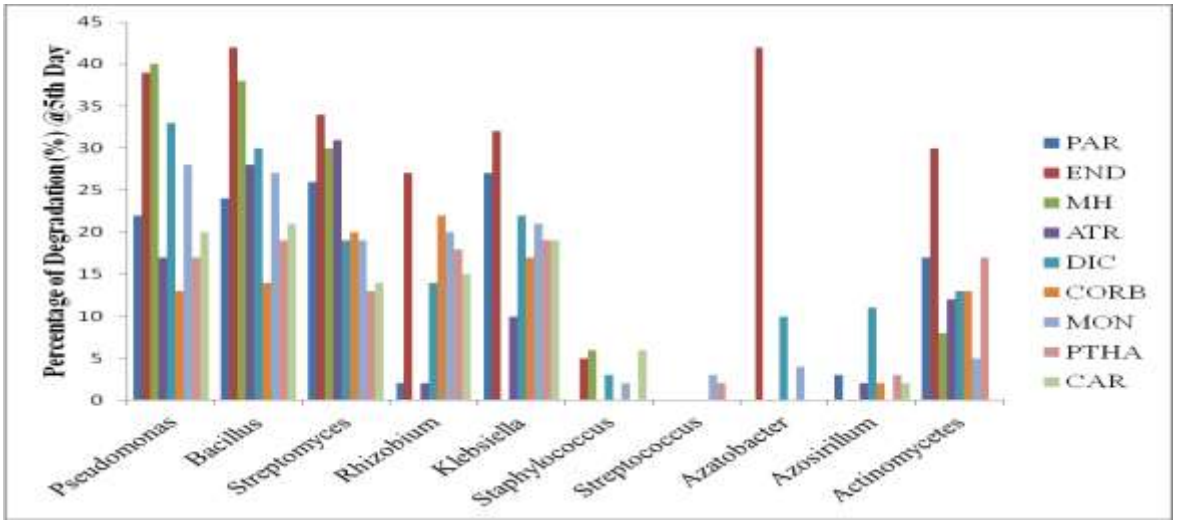


**Fig.1.1 Graphical representation of Degradation after 5th day of Incubation of pesticides by the isolated bacterial strains**

**Table 1.2 Degradation of pesticide at pH 7.0 after 10th day by the isolated bacterial strains**

| **Degradation (%)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Pseudomonas | 36 | 58 | 51 | 37 | 72 | 27 | 60 | 33 | 39 |
| Bacillus | 42 | 60 | 69 | 52 | 66 | 30 | 59 | 40 | 46 |
| Streptomyces | 38 | 44 | 51 | 63 | 36 | 46 | 40 | 26 | 26 |
| Rhizobium | 08 | 39 | 10 | 12 | 30 | 40 | 48 | 40 | 32 |
| Klebsiella | 33 | 40 | 06 | 24 | 45 | 35 | 42 | 39 | 40 |
| Staphylococcus | 05 | 15 | 15 | 05 | 12 | 06 | 10 | 02 | 15 |
| Streptococcus | 07 | 09 | 04 | 12 | 08 | 03 | 08 | 11 | 15 |
| Azatobacter | 05 | 42 | 03 | 03 | 22 | 07 | 13 | 06 | 08 |
| Azosirillum | 12 | 05 | 04 | 08 | 23 | 10 | 04 | 12 | 09 |
| Actinomycetes | 28 | 30 | 22 | 28 | 36 | 23 | 20 | 33 | 07 |
| **PAR**- Paraoxon, **END**-Endosulfon, **MH**-Mancozeb, **ATR**- Atrazine, **DIC** - Dicofol, **CORB**- Carbofuran, **MON**- Monocrotophos, **PTHA** – Pthalimide, **CAR**- Carbendazim. | | | | | | | | | |

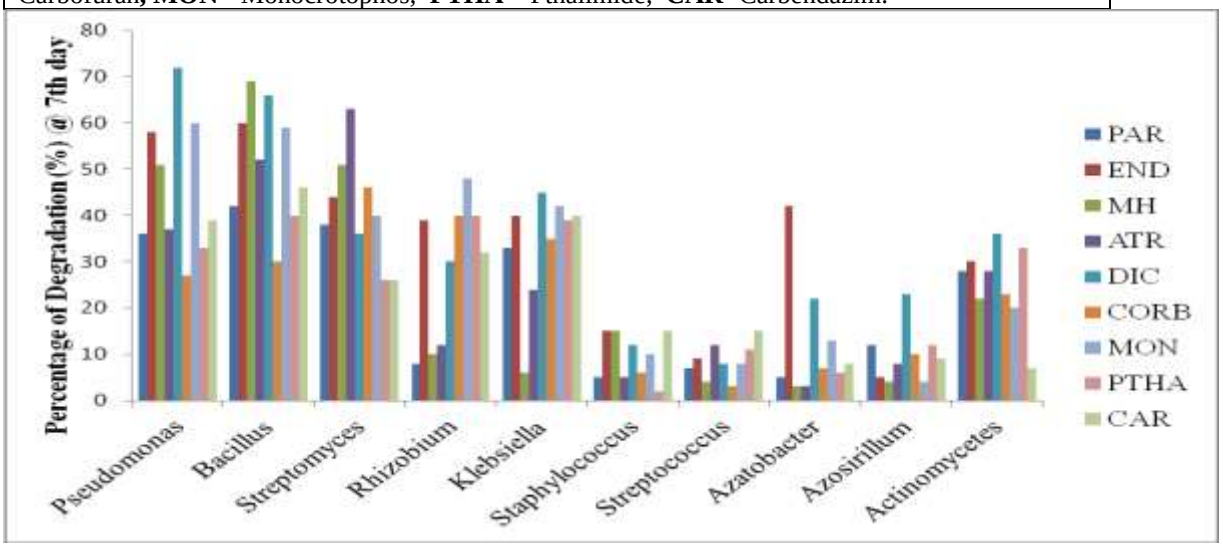


**Fig.1.2 Graphical representation of Degradation after 7th day of Incubation of pesticides by the isolated bacterial strains**

**Table 1.3 Degradation of pesticide at pH 7.0 after 15th day by the isolated bacterial strains**

| Degradation (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Pseudomonas | 82 | 88 | 91 | 77 | 91 | 58 | 93 | 68 | 82 |
| Bacillus | 79 | 90 | 89 | 85 | 80 | 76 | 89 | 83 | 90 |
| Streptomyces | 61 | 70 | 70 | 87 | 65 | 92 | 90 | 54 | 52 |
| Rhizobium | 19 | 75 | 21 | 22 | 59 | 66 | 77 | 79 | 65 |
| Klebsiella | 55 | 69 | 14 | 58 | 74 | 72 | 86 | 87 | 84 |
| Staphylococcus | 13 | 31 | 32 | 17 | 26 | 15 | 22 | 11 | 33 |
| Streptococcus | 18 | 22 | 12 | 30 | 20 | 10 | 14 | 23 | 28 |
| Azatobacter | 15 | 59 | 18 | 10 | 48 | 19 | 29 | 18 | 14 |
| Azosirillum | 21 | 15 | 12 | 19 | 51 | 25 | 10 | 25 | 20 |
| Actinomycetes | 54 | 66 | 45 | 63 | 78 | 56 | 49 | 68 | 17 |

**PAR-** Paraoxon**, END-**Endosulfon**, MH-**Mancozeb**, ATR-** Atrazine**, DIC** - Dicofol**, CORB-** Carbofuran**, MON-** Monocrotophos, **PTHA** – Pthalimide, **CAR-** Carbendazim.

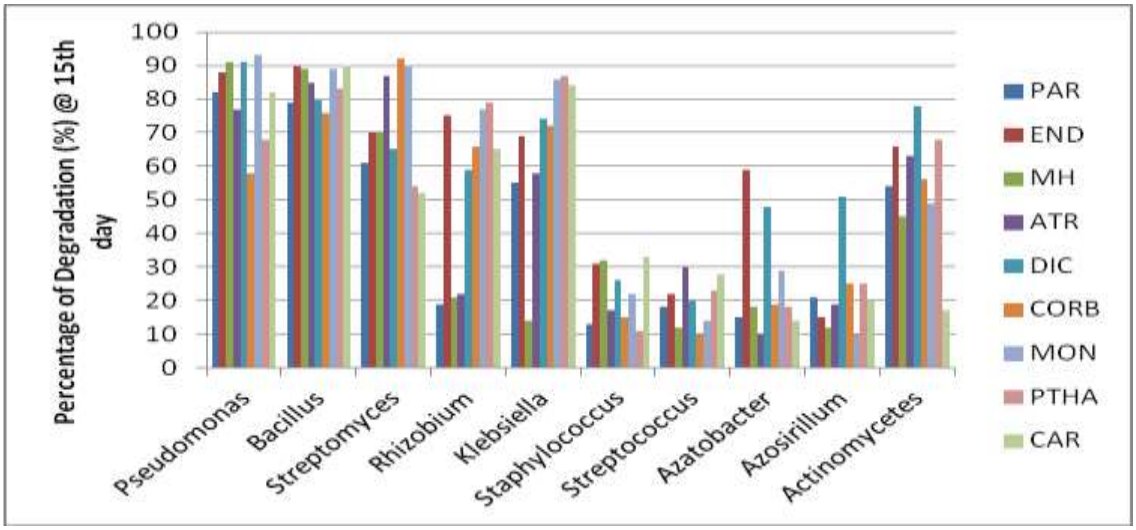


**Fig.1.3 Graphical representation of Degradation after 15th day of Incubation of pesticides by the isolated bacterial strains**

**Table 1.4 Degradation of pesticide at pH 7.0 after 05th day by the isolated fungal strains**

| Degradation (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Aspergillus | 18 | 10 | 15 | 10 | 08 | 19 | 15 | 12 | 11 |
| Trichoderma | 08 | 16 | 15 | 08 | 12 | 20 | 18 | 16 | 17 |
| Fusarium | 04 | 06 | 08 | 15 | 15 | 16 | 10 | 12 | 20 |
| Rhizopus | 02 | 03 | 15 | 12 | 17 | 19 | 14 | 13 | 15 |
| VAM | 04 | 03 | 10 | 16 | 13 | 13 | 08 | 14 | 17 |

**PAR-** Paraoxon**, END-**Endosulfon**, MH-**Mancozeb**, ATR-** Atrazine**, DIC** - Dicofol**, CORB-** Carbofuran**, MON-** Monocrotophos, **PTHA** – Pthalimide, **CAR-** Carbendazim.

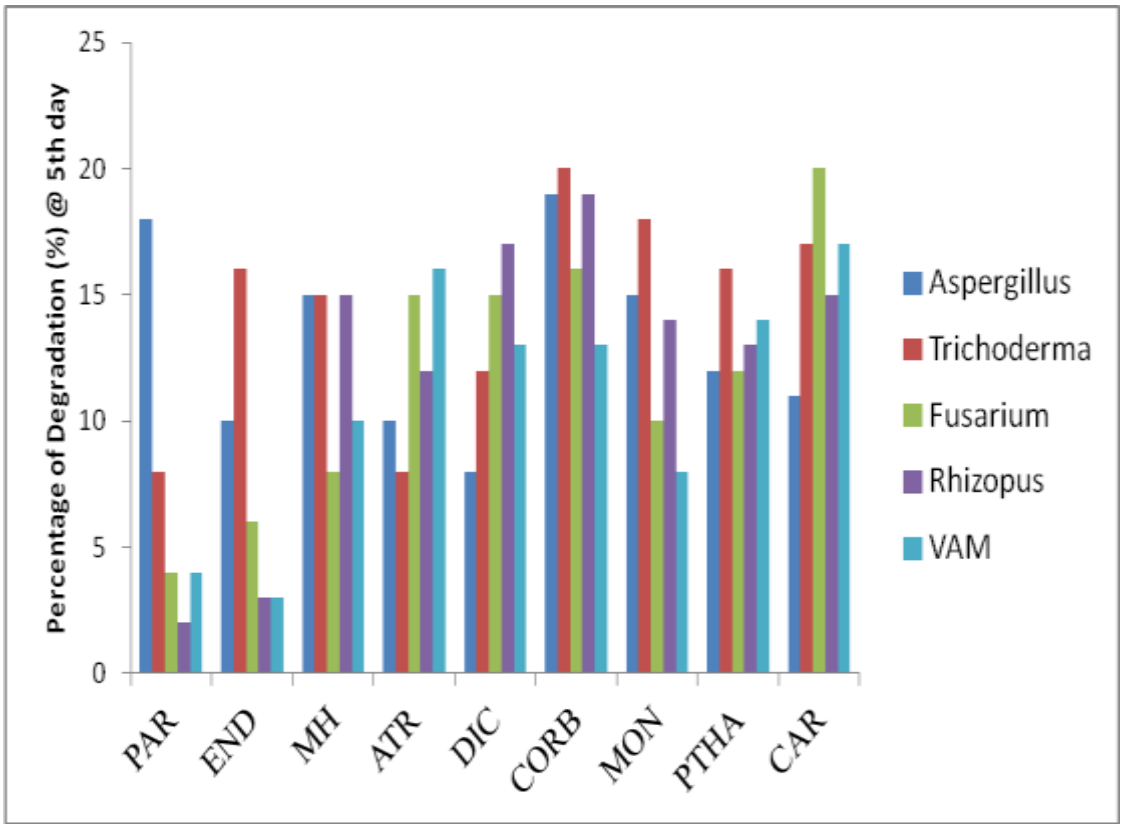


**Fig.1.4 Graphical representation of Degradation after 05th day of Incubation of pesticides by the isolated fungal strains**

**Table 1.5 Degradation of pesticide at pH 7.0 after 07th day by the isolated fungal strains**

| **Degradation (%)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Aspergillus | 34 | 41 | 49 | 38 | 22 | 51 | 37 | 30 | 24 |
| Trichoderma | 17 | 33 | 40 | 24 | 38 | 46 | 48 | 45 | 41 |
| Fusarium | 28 | 24 | 26 | 39 | 41 | 38 | 19 | 33 | 44 |
| Rhizopus | 12 | 19 | 32 | 27 | 40 | 44 | 29 | 29 | 32 |
| VAM | 28 | 22 | 28 | 35 | 36 | 28 | 17 | 31 | 40 |
| **PAR-** Paraoxon, **END**-Endosulfon, **MH**-Mancozeb, **ATR-** Atrazine, **DIC** - Dicofol, **CORB-** Carbofuran, **MON-** Monocrotophos, **PTHA** – Pthalimide, **CAR-** Carbendazim. | | | | | | | | | |

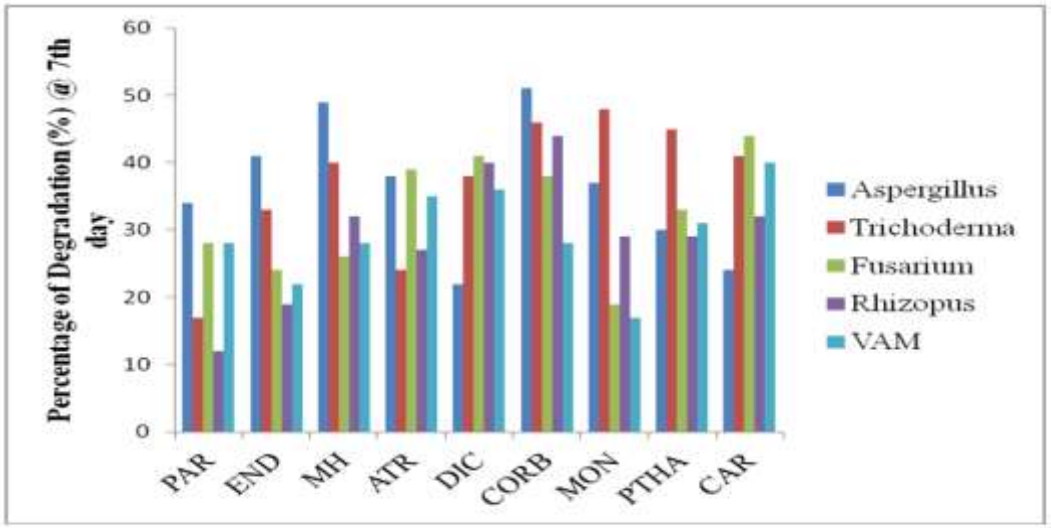


**Fig.1.5 Graphical representation of Degradation after 07th day of Incubation of pesticides by the isolated fungal strains**

**Table 1.6 Degradation of pesticide at pH 7.0 after 15th day by the isolated fungal strains**

| Degradation (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **BACTERIA** | **PAR** | **END** | **MH** | **ATR** | **DIC** | **CORB** | **MON** | **PTHA** | **CAR** |
| Aspergillus | 66 | 77 | 89 | 62 | 39 | 84 | 70 | 57 | 40 |
| Trichoderma | 41 | 68 | 75 | 48 | 58 | 80 | 79 | 76 | 74 |
| Fusarium | 50 | 51 | 55 | 70 | 77 | 72 | 40 | 64 | 77 |
| Rhizopus | 25 | 40 | 61 | 51 | 73 | 72 | 58 | 57 | 60 |
| VAM | 51 | 40 | 50 | 63 | 70 | 56 | 38 | 59 | 72 |

**PAR**- Paraoxon, **END**-Endosulfon, **MH**-Mancozeb, **ATR**- Atrazine, **DIC** - Dicofol, **CORB**-Carbofuran, **MON**- Monocrotophos, **PTHA** – Pthalimide, **CAR**- Carbendazim.

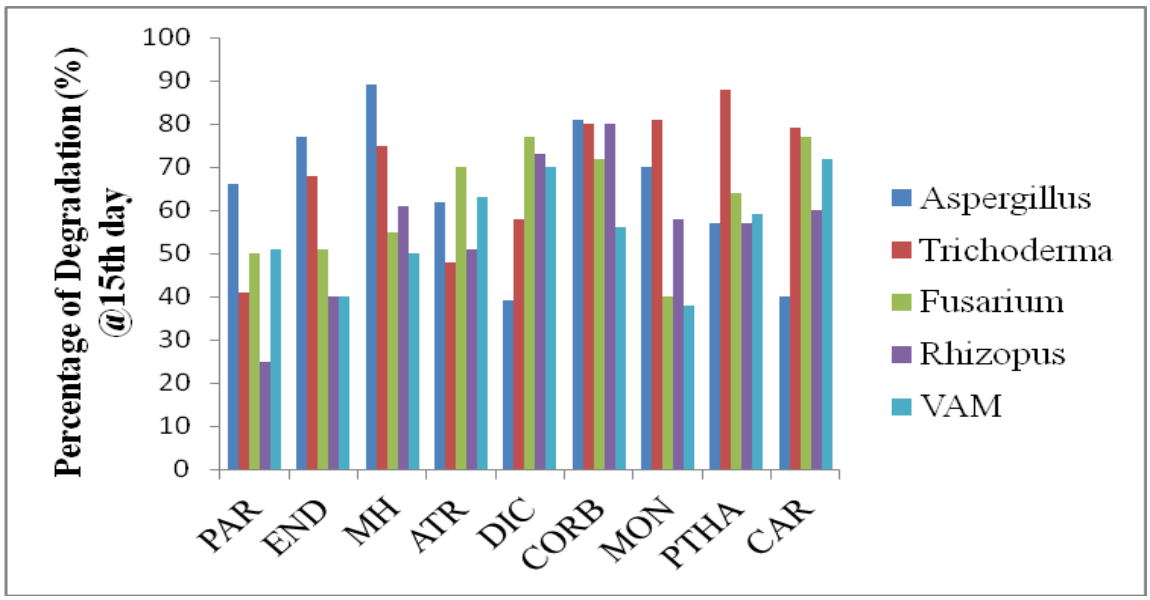


**Fig.1.6 Graphical representation of Degradation after 15th day of Incubation of pesticides by the isolated fungal strains**

## 3.0 DISCUSSION

Bacteria and fungi possess various counteraction mechanisms to cope with exposure to synthetic compounds or xenobiotics. These mechanisms enable them to survive and even degrade or transform these compounds. Bacteria and fungi have the ability to produce specific enzymes capable of degrading synthetic compounds. These enzymes, such as hydrolases, oxidases, dehalogenases, and monooxygenases, can break down the chemical bonds of the xenobiotic molecules, converting them into less toxic or more easily degradable forms. Microorganisms can adapt their metabolic pathways to utilize synthetic compounds as a carbon and energy source. Through genetic modifications or horizontal gene transfer, they can acquire genes encoding enzymes or regulatory proteins that enable them to metabolize and utilize the xenobiotics. Bacteria and fungi possess efflux pumps that actively transport toxic compounds out of their cells. These pumps can effectively remove synthetic compounds from the cell, reducing their intracellular concentration and toxicity. Bacteria and fungi can form biofilms, which are structured communities of microorganisms encased in a protective matrix. Biofilms provide a physical barrier that can reduce the penetration and toxicity of synthetic compounds, enabling the microorganisms to survive in their presence. Microorganisms have stress response systems that help them adapt to and tolerate exposure to toxic compounds. These systems include the activation of stress-related genes, production of protective proteins or chaperones, and the synthesis of antioxidant molecules that counteract the oxidative stress induced by the xenobiotics. Bacteria and fungi can modify synthetic compounds through detoxification reactions, such as reduction, oxidation, or conjugation with endogenous molecules. These reactions can make the compounds less toxic or more easily excreted from the cells. Bacteria and fungi have the ability to adapt genetically to synthetic compounds through mutation, selection, and evolution. Over time, they can develop improved mechanisms to cope with the toxic effects of xenobiotics, enabling their survival and proliferation in contaminated environments. It is important to note that the specific counteraction mechanisms exhibited by bacteria and fungi may vary depending on the

species, strain, and the nature of the synthetic compounds. The presence and effectiveness of these mechanisms can be influenced by factors such as concentration, exposure duration, environmental conditions, and the genetic makeup of the microorganisms. Understanding the counteraction mechanisms of bacteria and fungi toward synthetic compounds is not only important for environmental and public health considerations but also for the development of bioremediation strategies and the identification of potential biotechnological applications.

## 4.0 CONCLUSION

In conclusion, bacteria and fungi exhibit a range of counteraction mechanisms when exposed to synthetic compounds or xenobiotics. These mechanisms enable them to survive, tolerate, degrade, or transform these compounds, playing a crucial role in environmental detoxification and bioremediation. The key mechanisms include enzymatic degradation, metabolic pathway adaptation, efflux pumps, biofilm formation, stress response systems, detoxification reactions, and genetic adaptation. Through enzymatic degradation, microorganisms produce specific enzymes that break down synthetic compounds into less toxic or more easily degradable forms. They can also adapt their metabolic pathways to utilize xenobiotics as a carbon and energy source. Efflux pumps actively transport toxic compounds out of cells, while biofilm formation provides a protective barrier. Stress response systems help microorganisms cope with and tolerate the toxic effects of xenobiotics. Furthermore, bacteria and fungi can detoxify synthetic compounds through conjugation reactions or modify them through reduction, oxidation, or conjugation with endogenous molecules. Genetic adaptation and evolution allow microorganisms to develop improved mechanisms to cope with the toxic effects of synthetic compounds over time. Understanding these counteraction mechanisms is important for environmental and public health considerations. It aids in developing bioremediation strategies and identifying potential biotechnological applications for environmental detoxification. Further research in this field will continue to enhance our understanding of how microorganisms interact with and respond to synthetic compounds, ultimately contributing to the development of sustainable solutions for environmental pollution.

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## CONFLICT OF INTEREST

The authors disclose no conflict of financial or nonfinancial interest.

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