



# Journal of Science Innovations and Nature of Earth

International, Double-Blind, Quarterly, Peer-Reviewed, Refereed,  
 Edited and Open Access Research Journal  
 Journal homepage: <https://jsiane.com/index.php/files>



## A Review on Impact of Chemical Fertilizers and Insecticides on Earthworm Species

Nida<sup>1</sup>, Vishan Kumar<sup>1</sup>, Anil Kumar<sup>1</sup>, Gauravi Yadav<sup>1</sup>, Neelam\*<sup>1</sup>, Hridayesh Arya<sup>1</sup>

<sup>1</sup>Department of Zoology, N.R.E.C. College, Khurja, Bulandshahr, Affiliated to Chaudhary Charan Singh University, Meerut, Uttar Pradesh, India

\* Corresponding author. E-mail- tyagineelamnrec@gmail.com

DOI- <https://doi.org/10.59436/jsiane.v6i1.19.2583-2093>

### ARTICLE INFO

#### Article history:

Received 15 December 2025

Received in revised form

17 January 2026

Accepted 1 March 2026

Available online 10 March 2026

#### Keywords:

Earthworm,  
 chemical fertilizers,  
 insecticides,  
 soil ecology,  
 agrochemicals,  
 toxicity,  
 biodiversity,  
 soil health

### ABSTRACT

Earthworms are important components of terrestrial ecosystems and play fundamental roles in maintaining soil fertility, nutrient cycling, decomposition of organic matter, and regulation of soil structure. Earthworms are frequently considered ecosystem engineers because their activities significantly influence soil biological, chemical, and physical properties. Modern agricultural systems increasingly rely upon chemical fertilizers and insecticides to improve crop productivity and reduce pest-related losses. Although these agrochemicals contribute substantially to agricultural development, excessive and prolonged use has raised ecological concerns because of their adverse effects on non-target soil organisms, particularly earthworms. Exposure to chemical fertilizers and insecticides may influence survival, growth, reproduction, burrowing behavior, enzyme activity, and physiological processes in earthworms. Several studies have demonstrated that agrochemical residues can induce oxidative stress, tissue damage, neurotoxicity, reproductive abnormalities, and alterations in population dynamics. Such impacts may subsequently influence soil ecosystem functioning and biodiversity. The present review summarizes available information regarding the influence of chemical fertilizers and insecticides on earthworm species with emphasis on diversity, physiological responses, ecological implications, and environmental consequences. The review further discusses sustainable alternatives and future perspectives for minimizing adverse impacts on soil ecosystems.

### Introduction

Earthworms represent an essential component of soil ecosystems and are widely recognized as ecological engineers because they modify soil characteristics through burrowing, feeding, and decomposition activities (Edwards & Bohlen, 1996; Lavelle *et al.*, 2006). Their activities improve soil aeration, nutrient availability, water infiltration, microbial activity, and organic matter decomposition. Earthworm species contribute significantly to maintaining agricultural productivity and ecosystem stability (Blouin *et al.*, 2013). Modern agricultural practices frequently depend on chemical fertilizers and insecticides to increase crop production and reduce losses caused by pests. Chemical fertilizers provide essential nutrients such as nitrogen, phosphorus, and potassium, whereas insecticides are used to control harmful insects affecting crop productivity (Pelosi *et al.*, 2014).

However, increasing evidence suggests that excessive application of agrochemicals may negatively affect non-target organisms including earthworms. Exposure to these compounds may alter survival, growth, reproduction, and physiological functions (Wang *et al.*, 2012). Long-term exposure may also influence ecological processes associated with soil biodiversity and ecosystem functioning.

### Review of Literature

Numerous investigations have documented the influence of agricultural chemicals on soil organisms. Edwards and Bohlen (1996) reported that earthworms contribute substantially to soil fertility and ecosystem functioning. Lavelle *et al.* (2006) emphasized the ecological role of soil organisms in nutrient cycling and agricultural productivity. Pelosi *et al.* (2014) suggested that pesticide exposure may alter earthworm physiology and behavior.

Wang *et al.* (2012) observed that chemical exposure can reduce growth and reproductive performance in earthworm species. Blouin *et al.* (2013) demonstrated that earthworms significantly influence ecosystem services and soil biological activity.

**3. Earthworm Diversity and Ecological Importance-** Earthworms belong to phylum Annelida and class Clitellata and represent one of the most important groups of soil macrofauna. More than 7,000 earthworm species have been described globally, occupying a wide range of terrestrial ecosystems including forests, grasslands, wetlands, and agricultural lands (Edwards & Bohlen, 1996; Lavelle *et al.*, 2006). Earthworms are generally classified according to ecological behavior into three groups:

**Epigeic earthworms-** These species inhabit soil surfaces and feed mainly on decomposing organic matter and leaf litter.

#### Examples:

- *Eisenia fetida*
- *Perionyx excavatus*
- *Endogeic earthworms*

These species inhabit subsurface soil layers and consume organic matter mixed with soil particles.

#### Examples:

- *Aporrectodea caliginosa*
- *Drawida species*
- *Anecic earthworms*

These species construct permanent vertical burrows and transport organic material from the surface into deeper soil layers.

#### Examples:

- *Lumbricus terrestris*

Earthworms perform several ecological functions including:

- Organic matter decomposition
- Nutrient recycling
- Soil aeration
- Improvement of soil structure
- Enhancement of microbial activity
- Maintenance of soil fertility

Blouin *et al.* (2013) suggested that earthworms significantly contribute to ecosystem services and agricultural productivity through modification of soil properties.

Table 1. Major Earthworm Species Frequently Used in Toxicological Studies

Species	Ecological Group	Common Application
<i>Eisenia fetida</i>	Epigeic	Toxicological studies
<i>Perionyx excavatus</i>	Epigeic	Vermicomposting studies
<i>Lumbricus terrestris</i>	Anecic	Soil ecological studies
<i>Aporrectodea caliginosa</i>	Endogeic	Agricultural soil studies

**4. Effects of Chemical Fertilizers on Earthworm Species**

Chemical fertilizers are extensively applied in modern agriculture to improve crop productivity through supplementation of essential nutrients including nitrogen, phosphorus, and potassium. Although fertilizers increase crop yield, excessive application may adversely affect soil organisms including earthworms (Lavelle *et al.*, 2006).

**Common fertilizer categories include:**

- Nitrogen fertilizers
- Phosphate fertilizers
- Potassium fertilizers
- Compound fertilizers (NPK)

Several studies indicate that long-term exposure to chemical fertilizers may influence:

**Growth and survival-** Excessive concentrations of fertilizers may reduce growth rates and survival of earthworms because of changes in soil chemical properties (Pelosi *et al.*, 2014).

**Reproductive performance-**Fertilizer exposure may decrease cocoon production and juvenile development (Wang *et al.*, 2012).

**Burrowing behavior-** Changes in soil chemistry may affect movement and burrowing activities, influencing soil aeration and nutrient distribution.

**Physiological stress**

Chemical exposure may induce:

- Oxidative stress
- Cellular damage
- Enzyme alterations
- Metabolic disturbances

**5. Effects of Insecticides on Earthworm Species**

Insecticides are commonly used in agriculture to control pests and improve productivity. However, earthworms frequently become exposed to insecticides through direct soil contact and ingestion of contaminated organic material (Pelosi *et al.*, 2014).

**Major classes of insecticides include:**

- Organophosphates
- Organochlorines
- Carbamates
- Pyrethroids
- Neonicotinoids

Toxic effects of insecticides on earthworms Mortality and population decline. High concentrations of insecticides may cause direct mortality and reduce earthworm population density (Wang *et al.*, 2012).

Reproductive abnormalities

Exposure may reduce:

- Cocoon production
- Hatching success
- Juvenile survival
- Neurotoxicity

Several insecticides interfere with nervous system function and may alter movement behavior.

**Oxidative stress-**Insecticide exposure may increase reactive oxygen species (ROS), leading to cellular damage and physiological stress.

**Behavioral changes**

Observed behavioral responses include:

- Reduced feeding activity
- Abnormal movement
- Surface avoidance behavior
- Reduced burrowing activity

**Materials and Methods**

The present study was conducted as a review-based investigation using previously published scientific literature related to the effects of chemical fertilizers and insecticides on earthworm species. Information was collected from peer-reviewed articles, books, reports, and online scientific databases, Google Scholar, PubMed, ResearchGate, Scopus, and Web of Science

**Results**

The literature survey demonstrated that earthworms are highly sensitive to excessive exposure to chemical fertilizers and insecticides. The reviewed studies indicated that agrochemicals may influence physiological, biochemical, reproductive, and behavioral characteristics. Long-term exposure was associated with reduced growth rates, lower cocoon production, altered enzyme activity, and decreased population density (Pelosi *et al.*, 2014; Wang *et al.*, 2012).

Table 2. Major Effects of Chemical Fertilizers on Earthworm Species

Parameter	Observed Effect
Growth rate	Reduced
Survival rate	Decreased
Cocoon production	Reduced
Burrowing activity	Altered
Enzymatic activity	Disturbed

Table 3. Major Effects of Insecticides on Earthworm Species

Parameter	Observed Effect
Mortality	Increased
Reproductive performance	Reduced
Feeding activity	Decreased
Oxidative stress	Increased
Population density	Reduced

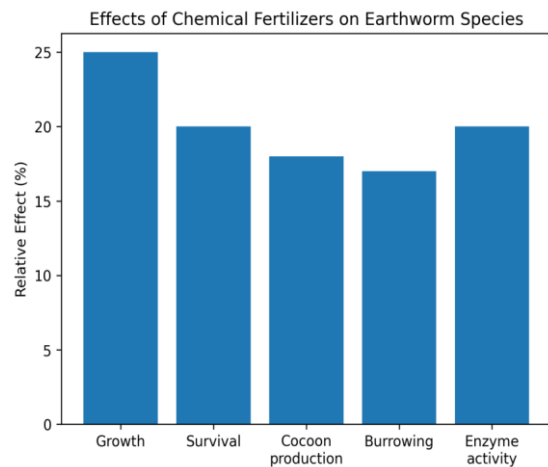


Fig. 1. Relative effects of chemical fertilizers on major physiological parameters of earthworm species.

Fig. 1. Relative effects of chemical fertilizers on earthworm species showing impacts on growth, survival, cocoon production, burrowing activity, and enzyme activity.

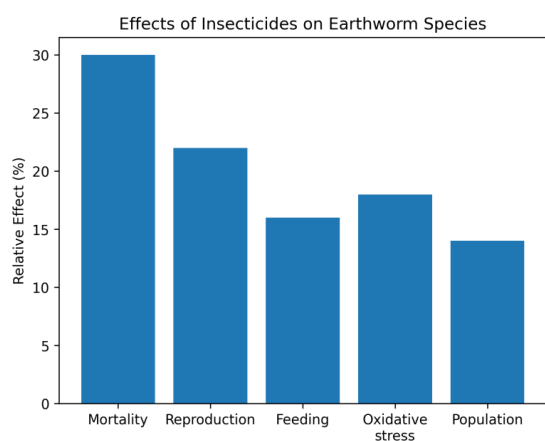


Fig. 2. Relative effects of insecticides on growth, reproduction, and survival of earthworms.

Fig. 2. Relative effects of insecticides on earthworm species showing increased mortality, reproductive impairment, oxidative stress, and population decline.

### Discussion

The present review indicates that chemical fertilizers and insecticides exert substantial impacts on earthworm species and soil ecological processes. Earthworms represent important soil organisms because they regulate nutrient cycling and maintain soil fertility (Edwards & Bohlen, 1996). Agricultural intensification has substantially increased use of fertilizers and pesticides worldwide. While these chemicals improve crop productivity, excessive use may create ecological disturbances that negatively affect non-target organisms (Lavelle *et al.*, 2006). Several investigations have demonstrated that fertilizer exposure can modify soil chemical properties including pH, nutrient concentration, and microbial composition. These changes may indirectly influence earthworm survival and physiological functioning (Blouin *et al.*, 2013). Insecticides appear to produce comparatively stronger toxic responses because many compounds interfere directly with nervous system activity and metabolic processes (Pelosi *et al.*, 2014). Neurotoxicity may reduce feeding behavior, locomotion, and reproductive efficiency. Reactive oxygen species (ROS) generation and oxidative stress have also been reported following exposure to various agrochemicals. Increased oxidative damage may affect cellular components including proteins, lipids, and DNA (Wang *et al.*, 2012). Long-term ecological consequences associated with declining earthworm populations may include:

- Reduced soil fertility
- Impaired nutrient cycling
- Reduced organic matter decomposition
- Altered microbial communities
- Reduced agricultural sustainability

Integrated management approaches emphasizing sustainable agricultural practices and reduced chemical dependency may help protect earthworm biodiversity.

### Conclusion

The present review demonstrates that earthworms are among the most important soil organisms and contribute significantly to ecosystem functioning through nutrient cycling, soil aeration, organic matter decomposition, and maintenance of soil fertility. Their activities support agricultural productivity and environmental sustainability. The findings of the present review indicate that excessive use of chemical fertilizers and insecticides may exert adverse effects on earthworm species through multiple physiological and ecological mechanisms. Exposure to agrochemicals may reduce survival, growth, reproductive

performance, burrowing behavior, and population density. Furthermore, several studies indicate that these chemicals may induce oxidative stress, neurotoxicity, metabolic disturbances, and alterations in enzyme activity.

Insecticides appear to produce comparatively stronger toxic effects because of their direct influence on nervous system functioning and physiological processes. Long-term exposure to chemical residues may subsequently affect soil biodiversity and ecosystem stability.

### Declines in earthworm populations may contribute to:

- Reduced soil fertility
- Altered nutrient cycling
- Reduced decomposition rates
- Changes in microbial communities
- Reduced agricultural sustainability

Therefore, sustainable agricultural strategies should be promoted to reduce ecological risks associated with excessive agrochemical use.

### Recommended approaches include:

- Reduction in excessive chemical use
- Adoption of organic farming practices
- Integrated pest management (IPM)
- Biological control methods
- Long-term soil biodiversity monitoring

Future studies integrating molecular techniques, biomarker analysis, and ecological assessment may provide improved understanding of agrochemical impacts on soil organisms.

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