ISSN 2664-4169 (Print) & ISSN 2664-7923 (Online)
South Asian Research Journal of Biology and Applied Biosciences
Abbreviated Key Title: South Asian Res J Bio Appl Biosci

| Volume-7 | Issue-2 | Mar-Apr -2025 | **DOI: https://doi.org/10.36346/sarjbab.2025.v07i02.004**

Review Article

The Negative Relationship between Earthworms and Pesticides

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Article History
Received: 16.02.2025
Accepted: 24.03.2025
Published: 27.03.2025

Abstract: Degradation of soil quality is an inevitable consequence of modifications to the characteristics of the soil that contribute to a decrease in ecosystem services. Numerous stressors, including chemical, biological, and physical ones, as well as those originating from both natural and artificial sources. The most prevalent kind of soil contamination that contaminates soil biota is agrochemicals. Soil is the most common place for xenobiotic dumping, which makes it the most probable source of other natural resources' pollution, such as surface and ground waters, based on the results of several studies. The danger to the environment posed by polluted soils is influenced by a variety of biological and physicochemical mechanisms that regulate the mobility and transformation of pesticides. However, species that are both above and below ground and are vital to the functioning of soil are seriously threatened by the insecticides' ability to linger in soil. Using living soil biota selectively is one of the effective ways to clean soil. This procedure is known as. In the past, chemical residues in soil have been removed or their toxicity decreased by the use of bioremediation. Even though microbes are frequently used in bioremediation, some well-known soil fauna, such as earthworms, contribute significantly to the disintegration and purification of substances. Because they change the state of the People consider earthworms to be soil engineers. Earthworms are capable of soil, help break down pesticide residues in one of two ways: directly by releasing detoxifying enzymes into their digestive tracts or indirectly by favorably influencing microbial communities that have the ability to break down pesticides. The earthworm-supported breakdown of pesticides is mostly limited to the worms' processed soil and gut milieu. Histological alterations brought on by pollutants are believed to be a sensitive method of determining the test organism's direct exposure to certain chemical contaminants. This study's objective was to ascertain how the pesticide methiocarb affected earthworms. After ten days of exposure to sublethal dosages (200 and 400 mg/kg), earthworms underwent several histological changes. such as villi fusion, tearing of the body wall, as well as the breakdown of the cuticle and circular muscle layer. They also become less able to dig in the ground.

Keywords: Soil, Earth worm, pesticide, bioremediation, Relationship.

INTRODUCTION

Earthworms are important components of the soil system mainly because of their positive effects on soil structure and function. Their digging and feeding practices greatly enhance aggregate stabilization, water infiltration and soil aeration. Additionally, by producing a topsoil layer of organic compounds, earthworms help to create more productive soil. Earthworms have gained popularity as excellent bioindicators of soil contamination due to these and other traits. Large amounts of soil or specific soil fractions are consumed by these organisms. As a result, their gut surfaces expose them to toxins continuously [1]. Furthermore, several studies have shown that the epidermis of earthworms is a key route for the absorption of pollutants. mainly by consuming organic materials, decomposing them, and fully Mixing it with earth mineral particles to produce aggregates that are soluble in water. Specifically, earthworms' capacity for bioaccumulation is crucial for a bio-monitoring organism [2]. Consequently, earthworms are probably an excellent organism to employ for this. Notwithstanding its potential and utility, this approach has numerous drawbacks because of its accessibility and sensitivity for unidentified metabolites [3]. Because only a specific combination of substances and living creatures may be able to reach it. Therefore, Selecting suitable live organisms for bioremediation is crucial for every kind of assessment [4]. Certain earthworm species, like Eisenia fetida and E. andrei, have been the focus of toxicological testing and are acknowledged as a valuable bio-monitor for determining the chemical toxicity of the soil [5]. The closeness of this species to the soil pollutants in [6, 7] aids in the analysis. In order to explore the possible use of earthworms as bioremediation organisms for soil pollutants, we provide a brief summary of our previous research [8] as well as those of other scientists. Long-term research, have unequivocally demonstrated that ecosystem services are greatly diminished when soil quality declines. use of insecticides for Protecting agricultural crops is a common activity. However, because the majority of these chemicals have a long half-life, residual accumulation is always a possibility [9]. It may have an impact on agricultural soil fertility by altering the soil biota. Many biological and physicochemical mechanisms are involved in the environmental damage caused by contaminated soils that control the flow and modification of insecticides Both above-ground and subterranean species that are vital to a range of soil processes are seriously threatened by the accumulation of soil-borne pesticide residues. In an effort to lessen the detrimental effects on soil organisms, pesticide residues have recently been removed from soil using bioremediation [10]. The pollutants are immobilized or degraded throughout this procedure. Bioremediation is a practical, affordable, and environmentally beneficial substitute for traditional chemical and mechanical techniques Cummings. Fungi and bacteria are the remediating organisms used in the vast majority of bioremediation techniques. Numerous variables, including the bacteria's metabolic adaptability to specific pollutants, including organophosphate insecticides, hinder this process. The hydrolysis of the organophosphate chlorpyriphos and its exposure to microorganisms results in the production of substances such as 3,5,6-trichloro-2-pyridinol. Microorganisms in the soil may suffer from these substances [11]. Similarly, certain soil physicochemical characteristics, such as pH, may prevent bacteria from adapting metabolically to break down pesticides.

On occasion, several groups of organic materials are introduced as nutrients to polluted soils. sources and biostimulants. However, introducing organic materials into contaminated soils may result in pesticides adhering to dissolved organic materials and increasing their mobility. Competition and predation among microbial populations may have a negative impact on bioremediation effectiveness [12]. The utilization of Utilizing pure forms of microorganism-derived detoxifying enzymes provides a new way to circumvent ecological interactions' detrimental consequences on bioremediation. However, there are a number of disadvantages to this approach, such as the high expense of developing cell free enzymes, the deterioration of enzymes, and the ease with which pesticides can reach the active region where enzymes are located. The bioremediation of contaminated soils has been systematically studied by many authors from a variety of perspectives, ranging from innovative and technological to more ecological. However, Vermiremediation using earthworms has not been thoroughly studied. Therefore, the goal of this research is to investigate and provide comprehensive information regarding earthworms' eligibility as viable candidates for bioremediation of soils contaminated by pesticides. Pesticides' detrimental effects on earthworms.

2-Usage of pesticides:

The Organization for Development and Economic Cooperation reports that over the past ten years, a number of countries have used a lot of pesticides. Some EU countries, Poland, France, Italy, Spain, Germany, and other countries have the highest rates of pesticide use. The use of pesticides has dramatically increased in some of these nations. declined since 2011, while in others, it has remained consistent [13]. In agriculture, organophosphate (OP) pesticides are widely used [2]. Between 2010 and 2014, the use of pesticides rose sharply in Sudan, Malawi, Togo, and Rwanda, whereas it declined in African nations such as Congo and Mauritius. The Pesticide Risk Reduction Programme reports that active ingredients were present in 160 of the 302 pesticides that were registered in Ethiopia. That were categorized as WHO class II. chemicals with a moderate level of danger [14]. Herbicides that are classified as risky by the WHO are being used because of ignorance. Environmental Science Frontiers 02 In Africa, DDT was created subsequent to benzene hexachloride, which signaled the start of pesticide manufacturing in India in 1952 [12]. Since then, there has been a notable growth in the manufacture of pesticides. About 5,000 metric tons of insecticides were manufactured in India in 1958; by the mid-1990s, that number had increased to 85,000 metric tons, with 145 compounds registered. Insecticides were the most widely produced pesticides. One of Asia's biggest manufacturers is India of pesticides, with 90,000 tons produced year, placing it 12th in the world. In 2018, 549,280 tons of pesticides were used in Brazil. Sugar cane, corn, and soybeans are the three most pesticide-intensive crops that are produced extensively in India. OPs are also widely consumed in China and India. In 1954, Pakistan started utilizing insecticides for the first time when 250 metric tons of pesticides were brought into the nation. Approximately 55.8 metric tons of pesticides are used annually by the Department of Agriculture's Plant Protection Division in Nepal, according to the primary application of pesticides in Sri Lanka is in the agriculture sector. According to a study, the US accounts for 16–18% of global pesticide spending [7, 8]. Sri Lanka was the first nation to use DDT as a pesticide following World War II. At an annual cost of $10 billion, the United States utilizes 500 million kilograms of pesticides.

They examined the pesticide content of 172 banana samples, of which 8.1% were from South America, 32.5% were from Asia, and 59.3% were from Europe. According to Brazilian, European, and Codex standards, pesticide residues were found in 79.1%, 32.4%, and 42.6% of the samples, respectively. Brazil is the world's second-largest producer of soybeans. output and is a major producer and exporter of several other commodities. Due to the significant increase in pesticide use and the noticeable increase in grain output, Brazil is now among the US, EU, and China, as well as The top four nations in the world of pesticides use. In 1996, 56.1% of all pesticide sales were herbicides, with insecticides coming in second at 26% and fungicides at 15.4%.

3-Soil health and pesticide contamination:

Pesticides have become a hazard for the environment since they are challenging to properly store and dispose of. Larger-scale usage of these damages microbiota and microfauna, pollutes soil and water, and stops plants from absorbing vital minerals. nutrients. Leaching of pesticides is another element that contaminates water bodies. Pesticides damage leak into groundwater and drinking water. According to a US survey, the herbicides atrazine, simazine, prometon, and metolachlor were the most often used pesticides (53% of 2,542 samples). The herbicides diuron, atrazine, and simazine were the most often found pesticides, according a different research from a similar survey carried out in Catalonia, Spain. 51%, 10%, 3%, and 7% of groundwater samples contained the organic phosphorus dimethoate (0.24–2,277 ng/l), fenitrothion (8.15–19.5 ng/l), diazinon (0.32–30.8 ng/l, min–max concentrations), and malathion (2.57–86.6 ng/l). respectively. Pesticides have the ability to harm the soil's natural microorganisms, disturb the ecology of the soil, taint the food chain and jeopardize people's health. Nowadays, the majority of people concur that pesticides seriously endanger non-target organisms in agroecosystems, including earthworms, pollinators (bees), and natural enemies of pests [15].

4- The influence of pesticides and the functional significance of soil invertebrates:

Invertebrates found in soil offer a variety of ecological crucial services to agriculture's survival. Soil biodiversity supports specialized processes that support self-sustaining ecological services, including disease and insect control, soil structure preservation, nutrient cycling, and carbon transformation The soil's porosity is altered by soil animal burrowing, which also increases aeration, retains water, and reduces compaction. In addition to increasing soil fertility and cycling nutrients, Additionally, woodlice, millipedes, earthworms, nematodes, and springtails convert degraded materials and materials into shapes. that are beneficial. Enchytraeid (pot worm) behavioral behavior, including respiration, activity, digging, casting, litter decomposition, feeding rate, and avoidance; and biological indicators, such as DNA damage, metabolism, gene expression, membrane stability, enzyme activity, general oxidative stress, survival, and reproduction. Fungicides and pesticides were found to have a significantly negative impact. There are numerous transformation products (TPs) from different insecticides. Just a handful of the most plausible TPs are pesticides that have been discovered in dirt, indicating the need for additional study in this field. Pesticides that are hydrophobic, persistent, and bioaccumulable are closely linked to soil [16]. The organochlorine DDT, endosulfan, endrin, heptachlor, lindane, and their TPs are among the insecticides that have this tendency. Their leftovers are commonly used in farming., despite the fact that most of them are already illegal. Although carelessly administered chemicals may be effective for a few years, they can harm beneficial creatures. According to certain investigations, these pesticides have a clear detrimental impact on soil microbes [17].

5- A remedy for pesticide pollution is bioremediation:

A greater number of xenobiotic compounds are being discharged into the environment due to the expansion of industrial and agriculture. Too much Crop productivity has been impacted by soil disturbances and a lack of clean water brought on by the loading of hazardous waste. Bioremediation uses biological agents, mainly microbes, to clean up contaminated soil. bacteria, fungus, or yeast. The foundation of This strategy promotes the development of specific microorganisms or microbial communities that are indigenous to contaminated areas and have the ability to carry out particular tasks. Using live organisms, primarily bacteria, this technique breaks down the biodegradation of pesticides involves the participation of microbes, plants, and earthworms. technology for bioremediation of pesticide-polluted agricultural soil. pollutants from the environment into less dangerous forms. It removes harmful pollutants from the atmosphere. These techniques may employ microorganisms that are native toa hazardous area, or they may be isolated from another area and then sent there [18]. Contaminating chemicals are altered by the metabolic reactions of living organisms. A substance's biodegradation frequently happens when multiple species work together for bioremediation to be effective, pollutants must be attacked by microorganisms enzymatically and transformed into innocuous compounds. successful. For bioremediation to be successful, the conditions must be conducive to Microbial development and activity Consequently, environmental conditions may need to be altered to speed up microbial growth and destruction. Bioremediation operations are frequently less costly than more conventional techniques like incineration. On-site treatment of some contaminants can reduce the risk of exposure for cleaning personnel and possibly improve visibility in the event of a transportation accident. Because bioremediation relies on natural attenuation, it is more well-known than other methods. While the majority of bioremediation systems function in aerobic settings, anaerobic conditions could enable microorganisms to degrade materials that may not otherwise be amenable to decomposition. Pathogen tolerance may develop as a result of contaminated environments. Screening for specific either plants or microbes that exhibit hyperaccumulative or highly degradable characteristics of specific. It will be simpler to deal with contaminants. However, it will always be difficult to get the hyperaccumulative plants or miraculous bacteria required for, bioremediation techniques in a hygienic setting. From the perspective of biological evolution specific bacteria and plants that accumulate can be identified from polluted ecosystems an economical and environmentally friendly substitute for intricate engineering-based methods is bioremediation [19]. But employing microbes like fungus and bacteria the adaptability of metabolism of bacteria to the intended pollutants is one of the many challenges in bioremediation. An illustration of this is the organophosphorus pesticide chlorpyrifos trichloro-2-pyridinol 3,5,6 and its metabolites and chlorpyrifos ox on are created When this pesticide is hydrolyzed chemically and by microbiological activity. These byproducts, however, have the potential to be hazardous since they might prevent microorganisms from mineralizing and biodegrading the parent chemical. To help sustain the germs over time, or even to accelerate the breakdown of the pollutants, bioremediation employing microorganisms typically requires some kind of bio stimulation in addition to metabolic adaption Competition and predation are examples of ecological interactions between microbial populations that may compromise the effectiveness in bioremediation. Making application of detoxification remedies that are pure Using enzymes that have been isolated from bacteria is one novel way to stop ecological interactions from negatively impacting bioremediation. Some drawbacks of this strategy include the expensive cost of creating cell-free enzymes, the breakdown of enzymes, and the ease with which pesticides can reach the area where enzymes are active. Together. These disadvantages and possible bioremediation remedies suggest a comprehensive strategy in which the contaminated area is simultaneously treated with multiple biological pollutant degradation vectors. If extracellular enzymes, microorganisms, plants, and the best strategy to increase Bio accessibility, dispersion, absorption, and metabolism of pesticides would be to combine these biological entities with other possible soil decomposers, such as springtails and earthworms, which are necessary regarding pesticides destruction [20].

6- Earthworms as potential:

The reason People consider earthworms to be soil engineers. is because they way they affect the biological and physicochemical characteristics of dirt. Their unwavering digging Proper feeding practices are a significant factor in the development and improvement of microhabitats in soil, which has a big impact on both above-ground and below-ground systems. The most obvious physical alterat ions brought about by earthworms are improved plant root development, soil aeration, water infiltration, and soil porosity. As they scuttle through the soil, earthworms dig burrows. These burrows have a very lengthy lifespan in the ground. Earthworms are the reason why soil rises. holes growing soil permeability. Moreover, increased Porosity encourages root growth and lowers bulk density [21]. Earthworm casts, which are rich in nitrogen, phosphorus, Magnesium and potassium increase soil fertility. The quantity of microbes in earthworms' castings is increased by the breakdown of organic waste in their abdomens. Microbe growth promotes the growth of plants, and the recycling of nutrients from organic waste. By promoting the growth of plant roots and shoots, earthworms can increase plant productivity. For example, nutrient mineralization and soil texture changes caused by earthworms resulted in a 20% increase in plant growth. These mammals increase plant resilience to pests by strengthening plant chemical defenses. The main objective of earthworm activity is the microorganisms in the soil. The growth and dissemination of microorganisms depend on earthworms. High levels of microbial activity and biomass are generally observed in soil that has been impacted by earthworms. Earthworms can degrade pesticides in two ways: directly by releasing digestive enzymes that detoxify the chemicals, or indirectly by encouraging and dispersing pesticide-degrading bacteria [22]. Therefore, depending on the ecological categories of earthworms, different species will have varied effects on the breakdown of pesticides. Anecic and endogeic earthworms will be larger impact on the breakdown of pesticides since they consume more soil and burrow more than epigeic earthworms. When considering earthworms' functions in pesticide breakdown, two drilosphere compartments are considered: the external (or burrow wall) microenvironment and the internal or microenvironment of the luminal digestive canal. The drilosphere includes the earthworm's body, burrows, and diapause chambers. Earthworm-induced bioremediation employs both internal and external mechanisms [23].

7- Internal procedures for detoxifying pesticides:

Alterations changes soil properties such microbial activity, dissolved organic carbon, and pH development are the main causes of earthworm-induced metal alterations. speciation. However, the exact role earthworms play in restoring metal-contaminated soils remains unknown. Regarding organic pollutants, Microorganisms and earthworms must cooperate for them to decompose. Symbiotic bacteria found in the earthworm's digestive tract have the ability to break down organic contaminants such polychlorinated biphenyls, crude oils, pesticides, and polycyclic aromatic hydrocarbons [24]. Rhodococcus MTCC, a bacterial strain isolated from Metaphire posthuma's gastrointestinal system, degraded the organochlorine pesticide endosulfan. Both gut symbiont-generated and glycolytic digestive enzymes, which facilitate food digestion, can be created in the digestive tracts of earthworms. natural materials. validated earlier discoveries in L. terrestris and emphasized the importance secreted from the gastrointestinal tract as enzymes that detoxify pesticides. About carboxylesterases Carboxylesterase activity is essential for the metabolism of xenobiotic chemicals. To help with their detoxification, These esterases have interactions with carbamates, Both synthetic pyrethroid insecticides and organophosphorus [25]. When carboxylesterases hydrolyze synthetic pyrethroid insecticides, they create carboxylic acid and alcohol. Carboxylesterases render the "oxon" oxidized An organophosphorus metabolite pesticides inactive. through permanently connecting the oxon molecule to the enzyme's active site. The enzyme won't function and the hazardous metabolite will stay dormant. Consequently, this detoxification of organophosphorus process is thought to be noncatalytic and is largely dependent on how well the herbicide binds to the active site of the enzyme as well as the number of molecules of carboxylesterase that are able to interact with it. Although the level of inhibition differs significantly according on the pesticide and species, carboxylesterases have a similar interaction with carbamate pesticides as they do with organophosphorus pesticides. It has been shown that the activity of earthworm luminal carboxylesterase can be impacted by the oxon metabolites of organophosphorus insecticides. Detoxification outside of cells lowers intestinal absorption of these harmful chemicals. found that If the hazardous metabolite of the organophosphorus pesticide has been generated, luminal carboxylesterases are effective molecular scavengers of chlorpyrifos. chlorpyrifosoxon. Nevertheless, a number of studies have shown that earthworm activity has minimal impact on the soil's ability to retain pesticides. Pesticide absorption may be hampered by modifications to soil aggregates and an increase in the amount of organic carbon found in burrow walls and casts. Even though numerous studies demonstrate that earthworms significantly contribute to the deterioration of chemicals like atrazine, with chlorpyrifos with lindane, their real ability to digest pesticides in the field has not been determined yet [26].

8- Detoxification of external pesticides procedures:

Earthworm burrows and castings are examples of dilosphere components that show significant enzymatic and microbiological activity.glucosidase, alkaline phosphatase, dehydrogenase, and protease. Extracellular enzymes become stable and active when they attach to soil organomineral complexes. This most likely also holds true for earthworm casts. However, food loss and antagonistic microbial interactions may be the cause of the apparent decrease in extracellular enzyme activity in older casts. demonstrated shows the type pH, K and Mg concentrations, and total N content are among the physicochemical characteristics that are significantly impacted by the soil and earthworm species, particularly Lumbricus. Terrestris is more important than Aporrectodea rosea and Allolobophora chlorotica. Despite the fact that these researchers did not look at any microbiological characteristics, it can be said that castings with different physicochemical characteristics support various microbial activity types and community configurations. Earthworms that are anecic construct middens by gathering castings and plant litter near the entrance to their burrows. Microfauna and mesofauna decomposers use these structures as microhabitats to break down organic compounds. Middens ought to be regarded as local hotspots for the breakdown of pollutants due to the high microbial activity that are observed there. The microbial populations in the soil are actually impacted by L. terrestris's burrowing activity, which increases their biomass and activity as well as the extracellular enzyme activities that accompany it. Mucus and castings are released by the earthworms as they move through the tunnels, and these materials mix with broken litter to create the linings [13] of the burrows. The buildup of organic matter in the burrow linings facilitates insecticide absorption. Pesticide mobility is influenced by the chemical makeup of earthworm burrows through Two processes that work in tandem: biodegradation and sorption on ligands that are organic sorption on organic ligands. L. terrestris's existence in the soil reduced the likelihood of metabolite and atrazine leakage. It was shown that this earthworm species' feeding habits and the tunnel walls' increased organic carbon content in contrast to bulk soil were important variables in reducing vertical transfer of atrazine and raising the herbicide's nonextractable portion [2]. Earthworm castings Burrow walls and middens have metabolically active microenvironments that could accelerate insecticide degradation and immobilization. The main processes may have a significant role in the way pesticides find their way into the environment., Hydrophobic insecticides initially attach to organic ligands as organic matter builds up in these microsites. increasing their persistence and. reducing their microorganism-accessible bioavailability (biodegradation). Second, the growth of indigenous soil bacteria that can degrade pesticides may be encouraged by earthworm activity. Extracellular enzymes with a range of chemical structures, including laccases, peroxidases, and carboxylesterases, can metabolize. It has been investigated how stable and reactive carboxylesterases are in earthworm-contaminated soils. Compared to soils without earthworms, L. terrestris enhanced the activity of soil carboxylesterase. For a long period, the esterase activity remained constant even after the earthworms were removed from the soil Attachment of the extracellular enzyme to soil organomineral complexes is most likely the source of this, which made it stable. It's interesting to note that By acting as an organophosphorus pesticide molecular scavenger, earthworm-induced carboxylesterase activity rendered the lethal metabolites inactive. One of the few instances that shows how pesticides and soil enzymes interact directly is this one [5].

9- The effect of pesticide on earthworms:

To ascertain the optimal response to the acetylcholine enzyme, the internal effects of three pesticides—methomyl (from the carbamate group), dimethoate, and malathion (from the organophosphorus group)—as well as a fungicide that contains the element copper (sulfur hydroxide)—were evaluated. Earthworms' esterase of field chemicals. The four compounds that were calculated from bio-evaluation tests to evaluate their effect on enzyme activity were given three concentrations of doses that kill 50% of worms (LC50), one-half, and one-tenth of this dose. These pesticides, at the three dosages employed and analyzed, led to the suppression of the activity of the acetylcholinesterase enzyme, and the severity of inhibition with increasing the concentration of the first three pesticides mentioned above. The findings also demonstrated that the enzyme was most inhibited at the concentration that killed half of the earthworms seven days after they were exposed to soil tainted with methomyl insecticide (98.9%). The acetylcholinesterase enzyme was activated at all three tested levels of LC50 values by the fungicide capric hydroxide (Dacoside), which includes the element copper. Half the LC50 dose produced the maximum activation, followed by a tenth of the LC50 value and then the LC50 value (27.7%, 20.3%, and 6.8). This is contrasted with the control, respectively [27]. The concentration determines the level of exposure to methiocarb or any other pollutant. The exposure time and the contaminant. After being subjected to a pesticide, a histological analysis of a worm's body wall revealed notable variations in wall thickness between the several treatments.

The cuticle layer dissolved 200 mg/g of methiocarb, while the pesticide had no effect on the muscle layer. The cuticle layers and the wall's circular muscle layer were found to be damaged during exposure to a 400 mg/g concentration. The histology study also displayed the body. When they applied the herbicide profenose to earthworms, they saw that the subterranean fluid was not well regulated, causing the earthworms to break apart and the muscles in their body walls to deteriorate [6].

10- Impacts on Development:

The common worm Eisenia fetida/andrei has been the subject of numerous investigations. Earthworms' reactions to pesticide exposures below the deadly threshold have shown that when it came to detecting the harmful effects of acetochlor, the earthworms' weight was a more sensitive indicator than their mortality. as well as methamidophos. Eisenia fetida was treated with the organophosphate pesticide malathion, while the impact of exposure to commercial parathion on Eisenia fetida was investigated by [3]. Both studies noted a reduction in the body weight of treated worms. Intoxication with organochlorine pesticides has also been linked to weight loss. Also for the effects of herbicides and fungicides on Lumbricus terrestris. When treated to soil at a regular application rate in both the field and the lab, endosulfan dramatically decreased the weight of young Aporrectodea trapezoides within 5 weeks, but fenamiphos only did so in the field. Methiocarb and fenamiphos both decreased weight of earthworms in the lab at a regular rate of 10×. Losing weight seems to be a useful sign of physiological stress that is connected to the level of drunkenness and exposure duration [22]. Another symptom that is present in all worms treated with Parathion is coiling, which is linked to weight loss and is thought to be the result of a change in muscle function brought on by organophosphoric pesticides. This could account for the worms' difficulty moving around and relative incapacity to feed themselves [7]. Numerous researches have documented that pesticides have a detrimental effect on earthworm growth. According [5], growth can be thought of as a sensitive metric. to assess acetochlor's toxicity to earthworms [12] examined the effects of carbendazim, glyphosate, and dimethoate on Eisenia fetida and discovered a significant decrease in earthworm development in a dosedependent manner, while Helling *et al*., [36] assessed the effect of copper oxychloride in a lab setting. [27] claim that parathion has an impact on Eisenia andrei growth. Booth and others. examined the effects of diazinon and chlorpyrifos, two organophosphates, whereas [13] looked into the toxicity of aldicarb, cypermethrin, The earthworm Aporrectodea caliginosa was exposed to profenofos, chlorfluazuron, atrazine, and metalaxyl; all worms treated with these pesticides showed a decrease in growth rate. Growth rate has been proposed as a key biomarker for endosulfan and aldicarb contamination by [8], who investigated the effects of these substances on Lumbricus terrestris. Zhou and associates evaluated and discovered that after eight weeks, earthworms exposed to 5 mg/kg of chlorpyrifos had a negative impact on their growth. According to certain research, Earthworm growth seemed to be more negatively impacted during the juvenile stage as opposed to the adult stage [6].

11- Repercussions for Reproduction:

In earthworms exposed to different xenobiotics, a number of reproductive characteristics have been investigated, including the creation of cocoons and hatchlings, the survivability of the worms produced as well as sexual development The most sensitive parameter for paraquat, benomyl, phenmedipham, carbaryl, copper oxychloride, and dieldrin was determined to be cocoon formation [18], whereas the most sensitive parameter for cocoon hatchability was pentachlorophenol, parathion, and carbendazim, copper oxychloride [3] investigated how exposure to commercial parathion affected reproductive characteristics such sperm and revealed that changes in reproductive parameters were noticeable in terms of the quantity of sperm, cocoons, and worms produced, as well as the genotoxicity and cocoon formation on male Eisenia fetida germ cells. According [23] the number of juveniles per cocoon can be thought of as a sensitive metric o assess the toxicity of acetochlor on earthworms. Also discovered that methiocarb at 10× normal rate and endosulfan and fenamiphos at normal application rates decreased cocoon development in Aporrectodea trapezoides. When [21] applied the organophosphate insecticide malathion to Eisenia fetida, they discovered that it reduced the spermatic viability in spermatheca, changing the spermatogonia's DNA structure and cell growth. Malathion may have an impact on sperm count, but its metabolites may also have an impact According to several experts, pesticides affect reproduction (producing fewer cocoons, having fewer hatchlings overall, and having a longer duration of incubation) of worms in a dose-dependent fashion, with a larger effect at higher chemical concentrations [15]. The effects of carbaryl, an Nmethyl carbamate pesticide, on the reproductive characteristics of the earthworm Metaphire posthuma were investigated by [16]. They discovered abnormalities in the sperm heads even at the lowest test dosage of 0.125 mg/kg. At 0.125 mg/kg carbaryl, wavy head abnormalities were seen; however, at 0.25 mg/kg and 0.5 mg/kg, the spermheads went amorphous and the head nucleus transformed into granules that were deposited inside the wavy head. on sperm quality [28]. Sperm count also appears to be a highly sensitive metric [14]. Acetochlor had no long-term effect on Eisenia fetida reproduction at field doses of 5–10 mg/kg^{-1}, according to in greater quantities, acetochlor showed sublethal toxicity to Eisenia fetida at doses ranging from 20 to 80 mg/kg. After eight weeks [29], evaluated and discovered that earthworms exposed to 5 mg/kg of chlorpyrifos had a negative impact on fecundity [30] reported that cypermethrin seems to have a more detrimental effect on earthworm reproduction during the juvenile stage as opposed to the adult stage. When 20 mg/kg of cypermethrin was applied, it had a major detrimental influence on worm reproduction. Worms treated with parathion exhibit coiling, which hinders reproduction as well since it makes it harder for the worms to find a mate and causes incorrect mating posture during copulation. As discussed by [31], despite a marked effect on sperm production under parathion therapy, a substantial number of spermatozoa are discovered in inebriated worms because ejection of sperm appears to be hampered as well (claim that malathion also directly causes cytotoxicity, resulting in tail coiling, increased chromatin metachromasia in spermatozoa, and changes in sperm count [32].

CONCLUSION

Notwithstanding certain limitations brought on by their physical, chemical, and biological effects, In bioremediation processes, earthworms can be utilized directly to accelerate the biodegradation of pollutants such as pesticides. Earthworms have been linked to bioremediation because they have been demonstrated to increase nutrient availability, aerate soils, and promote microbal activity. Furthermore, it has been demonstrated that earthworms release toxins that were previously bound to the soil, slow down the breakdown and binding of organic contaminants to soils, and encourage and disperse organic microorganisms that degrade contaminants. The purpose of this review is to draw attention to the effects of earthworms on the environment of pesticide-contaminated soil in order to encourage bioremediation. potential. The ability of organics and agrochemicals to bind and be transported by organisms may be evaluated by molecular docking experiments. The bioremediation of polluted soils and soil restoration are more possible uses for earthworms. composition the state of nutrition. To create sustainable and site-specific earthworm-based bioremediation, more study is required. techniques in order to enhance outcomes.

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