

Role of Balancing Sustainability and Safety in the Pharmaceutical Dilemma in Bio-Based Fertilizers

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DESCRIPTION

Bio-based fertilizers have gained popularity in recent years as sustainable alternatives to conventional chemical fertilizers. These fertilizers harness the power of beneficial microorganisms to enhance soil fertility and plant growth while minimizing the environmental impact. However, a growing concern is emerging regarding the presence of pharmaceuticals in bio-based fertilizers. This article explores the implications of pharmaceutical contamination in three types of bio-based fertilizers and the need for responsible practices in the agricultural industry. Bio-based fertilizers, also known as microbial or biologically derived fertilizers, are formulated using beneficial microorganisms that promote nutrient uptake by plants. These fertilizers are considered eco-friendly alternatives because they enhance soil health and reduce the need for chemical inputs. These fertilizers contain beneficial microorganisms, such as mycorrhizal fungi or nitrogen-fixing bacteria, which form symbiotic relationships with plants. These microorganisms improve nutrient absorption, increase drought resistance, and enhance plant growth. Compost and vermicompost are organic fertilizers created through the decomposition of organic matter by microorganisms and earthworms. They enrich the soil with organic carbon and essential nutrients, promoting soil structure and microbial activity. Biochar is a carbon-rich material produced through the pyrolysis of organic waste. Biochar-based fertilizers incorporate biochar with beneficial microbes and nutrients, offering a multifaceted approach to improving soil health and plant growth. Pharmaceuticals, including antibiotics, hormones, and other medications, are commonly found in wastewater due to their widespread use in human and veterinary medicine. These pharmaceutical compounds can enter the environment through various pathways, including the discharge of treated wastewater, agricultural runoff, and the application of sewage sludge on farmland. In recent years, studies have raised concerns about the presence of pharmaceutical residues in bio-based fertilizers, primarily due to the use of organic matter and wastewater-derived materials in their production. Some microbial inoculants are produced using organic materials or wastewater-derived components. If these materials contain pharmaceutical residues, they can transfer these compounds to the soil and, subsequently, to plants. Composting and vermicomposting processes can break

down pharmaceuticals, but under certain conditions, residues may persist in the final product. Pharmaceuticals can be introduced into these processes through the disposal of pharmaceutical waste or wastewater sludge containing pharmaceuticals. Biochar can adsorb various organic compounds, including pharmaceuticals. If biochar is produced from feedstock contaminated with pharmaceuticals or is exposed to wastewater containing these compounds, it may retain them and release them slowly into the soil. Pharmaceuticals can persist in soil and leach into groundwater, contaminating drinking water sources. Soil contamination can also affect the long-term health of ecosystems, disrupting microbial communities and impacting soil organisms. Some pharmaceuticals can be taken up by plants, leading to the presence of these compounds in crops intended for human consumption. While the levels are typically low, chronic exposure to pharmaceutical residues in food raises concerns about health effects. The presence of antibiotics in bio-based fertilizers can contribute to the development of antibiotic-resistant bacteria in soil. These resistant bacteria can pose a threat to human health if they spread to the food chain or through direct contact with contaminated soil. The regulation of pharmaceutical contamination in bio-based fertilizers is a complex issue. Existing regulations often focus on pharmaceuticals in water bodies rather than their presence in soil and fertilizers, creating a regulatory gap. Hospitals, pharmaceutical manufacturers, and wastewater treatment plants should implement effective measures to reduce the discharge of pharmaceuticals into wastewater, minimizing their entry into the environment. Manufacturers of bio-based fertilizers should implement quality control measures to ensure the absence of pharmaceutical contamination in their products. This includes testing the raw materials used in fertilizer production. Continued research is necessary to understand the fate and transport of pharmaceuticals in bio-based fertilizers. Monitoring programs can help assess the extent of pharmaceutical contamination in agricultural soils and crops. Governments and regulatory bodies should consider developing and enforcing regulations specific to pharmaceutical contamination in bio-based fertilizers, addressing this emerging environmental issue. Farmers and consumers should be aware of the risks associated with pharmaceutical contamination in bio-based fertilizers and make informed choices regarding

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their use. Bio-based fertilizers offer a sustainable approach to agriculture, promoting soil health and reducing reliance on chemical inputs. However, the presence of pharmaceuticals in these fertilizers raises concerns about their environmental and agricultural implications. To

ensure the responsible use of bio-based fertilizers, it is essential to implement source control measures, conduct quality assurance testing, invest in research and monitoring, establish a regulatory framework.