



ECOLOGICAL IMPACTS OF FERTILIZER MANAGEMENT PRACTICES

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Introduction

Natural or synthetic fertilizers are applied to soils to supply essential plant nutrients. They have been instrumental in boosting crop yields and meeting global food demands. In the mid-20th century, most nutrients for grain production came from natural soil fertility and manure. Over time, fertilizer use increased significantly to support higher productivity, but its environmental implications cannot be ignored. For instance, during 2021-22, the consumption of nitrogen (N), phosphorus (P₂O₅), and potassium (K₂O) fertilizers declined by 4.7%, 12.8%, and 19.8%, respectively, compared to 2020-21, underscoring the importance of sustainable management practices.

Need for Fertilizer Management Practices

With growing food demands and limited arable land, fertilizers are vital for higher productivity. However, excessive reliance on mineral fertilizers has led to environmental challenges such as eutrophication, groundwater nitrate pollution, soil degradation, and atmospheric pollution. Mismanagement results in nutrient losses through leaching, runoff, and volatilization, polluting vital resources like soil, water, and air. Implementing Best Fertilizer Management Practices (BFMPs) is crucial to optimize nutrient use efficiency (NUE) and minimize environmental harm.

Environmental Benefits of Fertilizers

Proper fertilizer use enhances crop yields on existing farmland, reducing the pressure to clear additional land. This conserves natural vegetation and supports biodiversity. Fertilized crops can improve soil stability, reduce erosion, and enhance air quality, contributing to ecological preservation.

Constraints Due to Fertilizers

Despite their benefits, fertilizers have adverse environmental effects due to inefficient nutrient use. Overapplication leads to pollution of soil, water, and air. Nitrogen and phosphorus are especially problematic, as they are heavily utilized but prone to loss, impacting water quality and contributing to eutrophication.

Environmental Consequences of NPK Fertilizer Use

Fertilizer nutrients undergo transformations that influence their environmental impact:

- **Nitrogen (N):** Susceptible to losses via leaching, volatilization, and denitrification. These processes contribute to nitrate pollution in groundwater, ammonia volatilization, and greenhouse gas emissions.
- **Phosphorus (P):** Often fixed in soil, its use efficiency is low (~20%). Losses through runoff contribute to eutrophication of water bodies.
- **Potassium (K):** Though abundant and mobile in soil, its environmental concerns are minimal compared to N and P.

Major Environmental Consequences

1. **Nitrate Pollution of Groundwater:** Nitrate leaching contaminates groundwater, posing health risks such as "blue baby syndrome" and potential cancer. Factors like soil type, fertilizer application rate, and rainfall affect the extent of leaching.
2. **Eutrophication:** Nutrient runoff, particularly of N and P, promotes excessive algal growth in water bodies,

depleting oxygen and harming aquatic life.

3. **Ammonia Volatilization:** Loss of ammonia not only wastes N but also contributes to air pollution, greenhouse gas emissions, and acid rain.
4. **Acid Rain:** Emissions of ammonia and nitrogen oxides from fertilizers contribute to acid rain, affecting ecosystems and soil quality.
5. **Greenhouse Gas Emissions:** Fertilizer use contributes to emissions of methane (CH₄) and nitrous oxide (N₂O), potent greenhouse gases. Efficient fertilizers and site-specific practices can mitigate these emissions.

Effect on Environment and Human Health

Chemical fertilizers contribute to pollution during their production, use, and disposal. Manufacturing emits greenhouse gases, while improper disposal leads to water and soil pollution. Continuous use depletes soil health, affects water bodies through eutrophication, and poses health risks through nitrate contamination.

Fertilizer Management Practices

Adopting sustainable practices enhances NUE and minimizes environmental harm:

1. **Integrated Nutrient Management (INM):** INM combines organic and inorganic nutrient sources to maintain soil fertility and sustain productivity while protecting the environment.
2. **Balanced Fertilization:** Supplying all essential nutrients in appropriate ratios ensures optimal crop growth and improves soil health.
3. **Slow and Controlled Release Fertilizers (SRF & CRF):** These fertilizers release nutrients gradually, reducing losses and improving NUE. They can reduce application rates by 20-30% without compromising yields.
4. **Site-Specific Nutrient Management (SSNM):** SSNM tailors nutrient application to specific crop and field conditions, optimizing yield and reducing

nutrient losses. It integrates indigenous nutrient sources and minimizes greenhouse gas emissions.

Conclusion

Efficient fertilizer management is vital to balance agricultural productivity with environmental sustainability. Practices like INM, balanced fertilization, and site-specific management offer solutions to minimize nutrient losses and mitigate pollution. Promoting these practices will ensure long-term agricultural and ecological health.