Biological Forum – An International Journal **15(2): 1262-1268(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Repercussions of Chemical Fertilizers on the Environment and Safety Measures

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(Received: 02 January 2023; Revised: 18 February 2023; Accepted: 21 February 2023; Published: 23 February 2023)
(Published by Research Trend)

ABSTRACT: Agriculture in the twenty-first century faces numerous challenges, including the need to produce more food to feed a growing population. Chemical fertilizers are used to meet the needs of the population and to increase productivity. Chemical fertilizers improve plant growth and productivity, ensuring global food security, but they also prevent plants from developing desirable traits including a strong root system and nutritional traits, as well as giving them adequate time to develop and mature. Besides to this the chemical fertilizers are creating a lot of toxicity that impacts the environment adversely. Toxic compounds from chemically generated plants will build up in the human body and are extremely harmful and also several issues such as serious soil degradation, nitrogen leaching, soil compaction, soil organic matter loss, and soil carbon loss. To avoid this we must exchange chemical fertilizer with organic inputs like manure, bio-fertilizers, bio-pesticides, Nano fertilizers, and slow-release fertilizers, etc., which would improve the soil texture, allowing it to hold water longer, and increase the bacterial and fungal activity in the soil. A healthy natural environment and ecology will result from choosing organic farming for both the present and the coming generations.

Keywords: Environment, Ecosystem, Chemical fertilizers, Controlled released fertilizers, granulated fertilizer, Nano-fertilizer, Organic fertilizer.

INTRODUCTION

Due to urbanization, the area of land usage for food production has barely changed in a few decades and may have even declined in some areas of the world. However, the number of nutrients present per unit area is constantly rising (Kaarstad, 1997; Greidinger 1997). All of these factors imply that the production of food will need to be far more intensive and effective than it has ever been. Increases in crop productivity per unit area and the use of synthetic fertilizers in agriculture were both brought about by the green revolution, which met the food needs of the expanding population (Ayoub, 1999). To increase production, the global agricultural systems use a lot of chemicals, such as fertilizers, pesticides, and herbicides. However, using higher doses than the ideal of these chemicals and fertilizers causes several issues, including environmental pollution, decreased input efficiency, decreased quality of food, the emergence of pest and disease resistance, soil degradation, and a lack of micronutrients. Despite all of these issues, it is still difficult to meet the world's rising food demand. To create agricultural products that are high in nutrition and free of chemicals for human and animal use without depleting natural resources, the focus should be placed on the production of food that is both high in quality and quantity.

Chemical fertilizers play a significant role in the production of enough food for the entire population of the world, but their excessive use is posing serious problems for both the present and the next generation, including air, water, and soil pollution, degraded lands, depleted soils, and increased greenhouse gas emissions. These artificial fertilizers are not only posing a threat to our environment, but also to people, pets, and microbiological life. Everyone needs to act to reduce the use of chemical fertilizers and pesticides by replacing them with other organic amendments like organic manures, which not only provide vital nutrients to the plants but also maintain the soil's health for succeeding crops. It's time for everyone to realize the negative effects of using excessive amounts of chemical

fertilizers. Exploitation of chemical fertilizers and synthetic pesticides are serious problems for today's agriculture (Nanda *et al.,* 2021). The ailments like cancer, renal failure, stillborn babies and birth defects have been reported to be due to unabated use of fertilizers and pesticides to extract maximum yield and earning from the paddy-wheat cycle (Sharma *et al.,* 2019).

FERTILIZER AND TYPES

Photosynthesis is the process through which plants make their food. Plants use water, carbon dioxide, and sunlight throughout this process. Therefore, 95% of the plant's nutritional needs are met through photosynthesis. For respiration, plants too need oxygen, just like humans. Plants, however, require basic nutrition, supplemental nutrients, and micronutrients to remain healthy (Ashwini *et al.,* 2022).

- **Basic nutrients:** Nitrogen (N), Phosphorus (P), and Potassium (K) are three major essential nutrients that are provided via soil.
- **Supplementary nutrients:** Calcium, Magnesium & Sulphur are also essential nutrients, but are needed in the soil at a moderate level.
- **Micronutrients:** In extremely small amounts, the soil needs the mineral nutrients iron, boron, copper, zinc, molybdenum, and chlorine. These are essential for plant growth.

A fertilizer is any substance, whether natural or synthetic, that is added to soil or plant tissues to provide one or more nutrients necessary for plant growth or to make up for nutrient deficiencies.

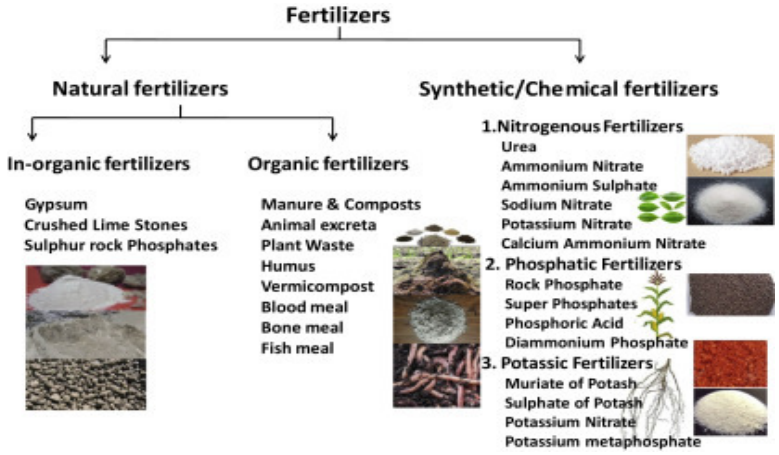

Fig. 1. Different types of fertilizers.

Table 1: Chemical composition of common inorganic fertilizers (adapted from US EPA, 2000).

Sr. No.	Chemical formula	Common Name	N (%)	P_2O_5 (%)	K_2O (%)
1	NH_4NO_3	Ammonium nitrate	34	0	0
2	$(NH_4)_2SO_4$	Ammonium Sulphate	21	0	0
3	$NH_4NO_3 + (NH_2)_2CO$	Ammonium nitrate-urea	32	0	0
4	NH_3	Ammonia (Anhydrous)	82	0	0
5	NH_4OH	Ammonia(aqueous)	20	0	0
6	$(NH_2)_2CO$	Urea	46	0	0
7	$Ca(H_2PO_4)_2$	Superphosphate	0	20-46	0
8	$NH_4H_2PO_4$	Mono ammonium phosphate	13	52	0
9	$(NH_4)_2HPO_4$	Di ammonium phosphate	18	46	0
10	$(NH_2)_2CO + (NH_4)_2HPO_4$	Urea-ammonium phosphate	28	28	0
11	KCl	Potassium chloride	0	0	60
12	KH_2PO_4	Monopotassium phosphate	0	50	40
13	KNO_3	Potassium nitrate	13	0	45
14	K_2SO_4	Potassium Sulphate	0	0	50

Dangerous poisonous substances created by chemically produced plants will build up in human bodies. Chemical fertilizer manufacturers, whose end products and by-products include some harmful chemicals or gases like NH_3, CO_2, CH_4, etc, will begin to harm the environment i.e. air pollution. Additionally, water pollution results from industrial waste being dumped into surrounding bodies of water without being treated. Eutrophication of the water is another aspect of it, which is the most harmful consequence of the

accumulation of chemical waste in water bodies. And when used continuously in soil, it destroys the health and quality of the soil, leading to soil pollution. It is therefore imperative that we acknowledge how our environment and ecology are being damaged by this crop production input. Numerous other technologies are in development, such as granulated fertilizers, nitrification inhibitors, slow-release fertilizers, Nano-fertilizers, and many others. These are all promising solutions that we can use to overcome these significant obstacles and preserve both the ecosystem and our environment. Let's learn about the various risks associated with the excessive use of chemical fertilizers for crop enhancement.

EFFECTS OF CHEMICAL FERTILIZERS

Chemical fertilizers are a major factor in the world's ability to produce enough food for everyone, but their excessive use is posing serious problems for both the present and the next generation in the form of polluted water, polluted air, polluted soil, increased greenhouse gas emissions, degraded lands, and depleted soils. These artificial fertilizers are increasingly dangerous not just for our environment it is also dangerous for people, animals, and microbiological life.

Effects of Chemical Fertilizers on Water Pollution. Leaching, drainage, and surface flow can occur as a result of the excessive use of chemical fertilizers intended to increase crop productivity. For instance, in the majority of cultivated highland soils, mineral N is likely to be oxidized to nitrate as a result of microbial activity. Because of this, significant amounts of the applied N may be removed or leached from the root zone and enter the surface and groundwater (Cooke, 1982). Even under ideal circumstances, when these chemicals are applied, plants only use up to 50% of the supplied N fertilizer, 2 to 20 % volatilize, 15 to 25 % react with organic molecules in the clay soil, and the remaining 2 to10 % interfere with ground and surface water (Feigin and Halevy 1989). The primary ingredient in fertilizer, nitrate, is one of the most significant indicators of water pollution. In groundwater or other bodies of water, dissolved nitrogen most frequently takes the form of nitrate. When nitrate concentration in drinking water exceeds 50 mg NO_3-/L or accumulation of high nitrate occurs, it may cause blue baby syndrome and in ruminants, gastric cancer, other diseases like goiter, birth defects, and heart disease and eutrophication of surface water (Feigin and Halevy 1989). Eutrophication of the water is a major negative result of the heavy use of fertilizers (mostly nitrogen and phosphorus). Phosphate is the main contributor to eutrophication. Phosphorus levels in surface waters should be under 50 g/L. When increased biomass growth occurs, nitrogen can potentially contribute to eutrophication (Neue, 1993). Due to a lack of oxygen in the water, eutrophication causes an increase in the growth of algae and aquatic plants that eventually cover the entire water body and cause the extinction of fish and other aquatic animals. Eutrophication can therefore result in the extinction of aquatic life, the spread of undesirable species, and a loss of recreational opportunities owing to dirty water, foul odors, etc.

Effects of Chemical Fertilizers on Air Pollution. To increase crop output, chemical fertilizer is applied at high rates, which produces several detrimental greenhouse gases, depletes the ozone layer, and exposes people to dangerous UV rays (Savci 2012). Agricultural soils are the main source of anthropogenic N_2O emissions, which account for 60% of all emissions (Shoji *et al.,* 2001). When nitrogenous fertilizer is made, greenhouse gases like CH_4, CO_2, and N_2O are created. The effects can be compounded into an equivalent volume of CO_2. By-products of nitrogen fertilizer, such as nitrous oxide, can be produced by soil microorganisms. Severe air pollution is caused by the overuse of nitrogen fertilizer, which releases nitrogen oxides (NO, N_2O, and NO_2) into the atmosphere (Cooper Julia *et al.,* 2017). After carbon dioxide and methane, nitrous oxide (N_2O) is now the third-largest greenhouse gas, it is 310 times more potent than CO_2 to cause global warming. The primary issue with nitrous oxide emissions is the impact of global warming and the part nitrous oxides play in ozone degradation, which results in atmospheric "holes" and exposes people and animals to too much UV radiation (Rutting *et al*., 2018). Acid rain is a result of ammonia that has been volatilized or released from fertilized land, which is then deposited in the atmosphere and oxidized to produce nitric acid and sulphuric acid. In addition to harming vegetation, and buildings, acid rain can also harm species that reside in lakes and reservoirs (Sharma and Chetani 2017). Water vapor, carbon dioxide, methane, hydrogen sulfide, and Chlorofluoro hydrocarbons are other gases that contribute to the ozone hole (Sharma and Chetani 2017). Since methane is a strong greenhouse gas and its concentration is boosted by the use of fertilizers containing ammonium, methane emissions from transplanted paddy fields are also a major concern. The effects of all these emissions on the climate are cumulative (Chen *et al*., 2006).

Effect of Chemical Fertilizer on Soil Pollution. The soil is the natural framework and a growing substrate for plants. The Soil serves as an ecosystem service provider, a habitat for soil organisms, and a method for recycling nutrients. Overuse of chemical fertilizers can cause soil acidification and soil crust, which decreases organic matter, humus, and beneficial organisms and stunts plant growth. It can also modify the pH of the soil, increase pests, and even help the atmosphere by releasing greenhouse gases. The soil acidity reduces the amount of phosphate that crops absorb, raises the concentration of harmful ions in the soil, and limits crop growth (Cooke, 1982). The soil's capacity to hold nutrients is decreased when humus levels are low.

Climate change is brought on by greenhouse gases produced by too much nitrogen fertilizer. Large amounts of nitrogen sprayed to fields over time disrupt the equilibrium among the three macronutrients N, P, and K, which would lead to a lack of micronutrients, it also degrades topsoil, which lowers crop yields. Sandy soils are significantly more likely than clay soils to become acidic. The impacts of excessive chemical fertilization can be masked by clay soils. Chemical fertilizer applications made repeatedly may cause the soil to become toxically contaminated with heavy metals like uranium, cadmium, and arsenic. In addition to degrading the soil, these dangerous heavy metals build up in grains, fruits, and vegetables. For instance, fertilizers like triple superphosphate include trace metals like cadmium and arsenic that build up in plants and may affect human health through food chains. Chemical fertilizers have significant and lasting negative impacts on soil (Sonmez and Sonmez 2007). The application of fertilizer without following the advice of soil testing can have effects such as soil deterioration, nutritional imbalance, damage to soil structure, and an increase in bulk density. Over-application of fertilizers results in the creation, accumulation, and concentration of mineral salts of fertilizers, which over time causes soil compaction and degradation.

Other Deleterious Effects of Chemical Fertilizers. Chemical fertilizer overuse, particularly N, can cause crop lodging, lower leaf yellowing, wilting, and crop tip browning. Roots that have been scorched by fertilizer may turn black and become limp. These symptoms are brought on by salt build-up in the soil, which makes it the soil harder to absorb water from the plants.

- Increased N fertilizer use in malt barley may have negative effects on the beer's quality.
- When plants receive excessive amounts of chemical fertilizer, the leaves may turn yellow or brown, harming the plant and lowering crop yield.
- It is expected to have the same negative effects as nitrate contamination of water sources when excessive nitrate or nitrite accumulation occurs in plant portions ingested by humans or animals (Bhattacharyya *et al.,* 2016).
- As a result of ammonia deposition in forests and streams, over-fertilization impacts reduce biodiversity (Nelson*,* 1984).
- Due to high N fertilization, they decrease the mycorrhizal root colonization and prevent rhizobia from fixing N symbiotically.
- The efficacy of fertilizers can be decreased because nutrients are quickly lost from soils by fixation, leaching, or gas emission (Trenkel 1997; Mohapatra *et al.,* 2022).

ALTERNATIVES BESIDES USING THE CHEMICAL FERTILIZERS

Long-term, excessive use of chemical fertilizers on the same soil can cause a variety of losses, including soil degradation, the loss of important soil microbes, and many others (Vitousek *et al*., 1997). Therefore, integrating the use of various nutrient supplements, such as slow or controlled released fertilizers, granulated fertilizer, nitrification inhibitors, organic fertilizer, Nano-fertilizer, etc. (Pandiselvi *et al.,* 2017), are the promising solutions we can use to overcome these significant challenges and save our ecosystem and environment.

Controlled Release Fertilizers and types. It involves a delayed release of nutrition than regular fertilizers. However, there is little control over the pace, pattern, and length of the release. However, controlled-release fertilizers are well known for their release rate, pattern, and longevity.

- Organic-N Low-Solubility Compounds, such as Isobutyledene-Diurea and Urea-Formaldehyde (UF) (IBDU).
- Fertilizers in Which a Physical Barrier Regulates the Release, such as those covered with inorganic materials like sulfur or mineral-based coatings, or those coated with organic polymer coatings that are either thermoplastic or resins.
- **Inorganic Low-Solubility Compounds:** Fertilizers like partially acidulated phosphate rock and metal ammonium phosphates (PAPR).

Nano Fertilizers. With the aid of nanotechnology, traditional fertilizers, bulk fertilizer components, or extracts from various vegetative or reproductive portions of the plant, Nano Fertilizers are manufactured or modified to increase soil fertility, crop productivity, and the quality of agricultural output. Fully bulk materials can be used to create nanoparticles. For instance, a seed-produced plant treated with nano-TiO_2 had higher dry weight, a faster photosynthetic rate, and more chlorophyll-a production than the control (Singh *et al*., 2017; Rajya Lakshmi *et al*., 2022; Dheerendra *et al*., 2022).

Organic Fertilizers. All organic fertilizers gradually & steadily release nutrients throughout time. For an assured constant supply of nutrients, organic fertilizers must be supplied in bulk or in higher volumes. They raise the humus content of the soil, keeping it moist and generally enhancing its health and quality. Comparatively to the addition of organic fertilizers alone, the use of organic fertilizers in conjunction with chemical fertilizers had a greater favorable impact on microbial biomass and consequently soil health (Usman *et al*., 2015; Popiha and Arunachalam 2022; Ummyiah *et al*., 2022; Amrutha *et al.,* 2022; Rizwan *et al*., 2022; Vijayalakshmi *et al.,* 2022; Nilima *et al*., 2022; Manjesh *et al*., 2022; Sudhir and Daksh 2022; Mukta *et al*., 2022; Pooja *et al*., 2022).

• **Cow Dung Manure:** India has the highest availability of organic fertilizer. Therefore, rotting cow dung should be used in place of fresh cow dung. The best type of cow dung is a wet, dark powder.

• **Bio-Compost:** Composting at the domestic or commercial level produces compost. Either a composter or a pit is used for this. Household green trash and farmyard brown waste are used to create compost.

• **Leaf Mould:** It is manure made possible by earthworms consuming organic waste and breaking it down. Vermicompost is a moist, dark, consistent manure that releases nutrients gradually and consistently.

• **Vermicompost:** It is a type of compost that is solely produced by the microbial and fungi breakdown of dry leaves. Leaf mold makes for high-quality humus. It serves as a pot filler for ferns and orchids as well as a rooting media for stem cuttings.

Fig. 2. Different types of Organic Fertilizers.

Advantages of using organic fertilizers for productive harvests. The following benefits are associated with organic fertilizers:

• Provide the best nutrients for efficient plant growth.
• Are much gentler than chemical fertilizers.
• Are less likely to overfeed your plants.
• Are not immediately absorbed by the plants.
• Can withstand heavy rainstorms and irrigation sessions that could wash away chemical fertilizer.
• Improve soil structure.
• Help soil retain nutrients and moisture.
• Long-term environmental benefits as they are less likely to contaminate lands and waters.
• Are significantly safer for humans.

CONCLUSIONS

Chemical fertilizers play a significant role in the production of enough food for the entire world's population, but their excessive use is posing serious problems for both the present and the next generation, including air, water, and soil pollution, degraded lands, depleted soils, and increased greenhouse gas emissions. These artificial fertilizers are increasingly dangerous not just for the environment but also for people, animals, and microbiological life. Long-term, excessive use of chemical fertilizers on the same soil can degrade the soil and cause the loss of beneficial soil microbes. Therefore, integrating the use of various nutrient supplements, such as controlled released fertilizers, granulated fertilizers, Nano-fertilizer, nitrification inhibitors, organic fertilizers, etc., are the promising solutions we can use to overcome these significant challenges and can save the environment. Organic fertilizers are readily available mineral sources that have a modest concentration of vital minerals for plants. They have the ability to reduce issues brought on by synthetic fertilizers. They lessen the requirement for recurrent synthetic fertilizer applications to maintain soil fertility. Using organic fertilizers has many advantages, including improved soil structure, a season-long supply of nutrients, and better water-holding capacity. In the foliar sector, organic fertilizer is now the most in-demand commodity. However, it's crucial to regularly do your homework and read labels before making a purchase. Growers must take the time to confirm that the fertilizer is natural, non-toxic, and prepared entirely with plant extracts from organic sources.

FUTURE SCOPE

Organic farming is a way of working and living that is in harmony with nature. As a result, healthy soil produces healthy plants, which produce healthy people. Organic farmers contribute to a better future for people, animals, and the environment by avoiding synthetic inputs and encouraging natural systems. Organic farming reduces public health risk by exposing children and the vulnerable population to fewer toxic chemicals and pesticides. By adapting Organic farming, we can serve as a significant producer of food in food-secure developed countries, and organic farming can also be a good fit in developing countries where fertilizers are too expensive, provided land is available for growing fertility-building crops.

Acknowledgement. It is a privilege to acknowledge the support and inspiration by Col. Prof. Dr. G. S. N. Raju garu Vice Chancellor, Centurion University of Technology and Management, Vizianagaram (Former Vice Chancellor of Andhra University, Visakhapatnam) to carry out the present work successfully.

Conflict of Interest. None.

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How to cite this article: Satheesh Ampolu, Santhi Priya Dalai, M.V.V. Ramanjaneyulu, Usha Hanumantu and Amit Kumar (2023). Repercussions of Chemical Fertilizers on the Environment and Safety Measures. *Biological Forum – An International Journal, 15*(2): 1262-1268.