



Effect of Losing Nitrogen Fertilizers on Living Organism and Ecosystem, and Prevention Approaches of their Harmful Effect

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Authors' contributions

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ABSTRACT

The world's population is drastically increasing; therefore, an enormous amount of nitrogen and other fertilizers are used to produce enough food for their feeding. Furthermore, since the applied nitrogen amount is not completely absorbed by plants, its big proportion is released to the environment in different ways. The released nitrogen amount damages both humans' health and the environment. Some technical and agronomical techniques help to minimize the loss of this nitrogen. The fertilizer's loss not only affects farmers' economic condition, but their effects are integrated. Nitrogen fertilizers pollute water, soil, air, as well as our foods. Leaching nitrate can cause eutrophication in sea, lakes, and water bodies. This condition poses a big threat to the lives of fish and other aquatic organisms. It also causes various diseases in humans such as blue baby syndrome, carcinoma, and others. For instance, Nitrate-N ($\text{NO}_3\text{-N}$) leads to the blue baby syndrome, carcinoma, and other diseases in humans. $\text{NO}_3\text{-N}$ leaching stimulates the growth of blue-green algae and creates hypoxic zones in the water. Moreover, cyanobacteria produce toxins that affect the liver, kidney, brain, skin, and other parts of the human body, as well as cause complicated diseases. Ammonia and nitrogen oxides contribute to acid rains and have adverse effects on

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ecosystems. Nitrous oxides (N_2O) deplete the ozone layer, a layer that prevents harmful rays from reaching the earth. N_2O contributes extremely to global warming due to its potentiality. Although Nitrogen fertilizers have contributed to produce high yields in the world, their excessive application has created different problems in our environment. To reduce nitrogen leaching, some agronomical, technical, and other practices are required to be used in the large and small farming system.

Keywords: Fertilizers; leaching; denitrification; ammonia volatilization; eutrophication; nitrification inhibitor; urease inhibitors.

1. INTRODUCTION

Global food production has been increased due to agricultural intensification in the last few decades, but it has caused highly environmental costs. Generally, it leads to imbalance nutrients and increases the losses to the atmosphere, especially ammonia and greenhouse gases (nitrous oxide). Increasing production with the application of chemical fertilizers enhances soil erosion and salinization. Mineral fertilizers are the key factors in increasing global agricultural production. However, they have created an imbalanced situation in the world and caused environmental pollution. The increased application of fertilizers depletes soil organic carbon stock in the soil. Also, their losses through erosion and leaching, cause the global epidemic of eutrophication, reduce potable water resources, lose aquatic biodiversity, and create dead zones in oceans [1]. Nitrogen is a key driver of eutrophication that alters coastal ecology. It changes coastal productivity, nutrient cycles, water quality, biodiversity, and overall ecosystem health [2]. Nitrogen fertilizer is a major source of greenhouse gases due to increasing demand and usage. It also consumes fossil that contributes to global warming and pollution [3].

The water carries nitrogen from the soil-plant system to the river, lake, pond, ocean, and thus creating environmental problems. The accumulation of nitrogen in the water bodies stimulates algae and other organisms' growth, they sink to the bottom of water when they die. Their dead materials are decomposed by bacteria that use dissolved oxygen of water. As a result, they decrease oxygen in the water so that it could no longer sustain aquatic life. The fish and other aquatic species are suffocated; they either die or escape from the area. This condition of low oxygen (< 2-3mgO per liter) in the water is called hypoxia, the process that brings this status is known eutrophication [4,5]. Eutrophication degrades the function and health of an ecosystem, which leads to the loss of

biodiversity, ecosystem degradation, harmful algal blooms development, and oxygen deficiency deeper in the water [6]. The appropriate application aim of fertilizers is to absorb nutrients by the target plants. However, the plants cannot take all nutrients, therefore the major parts of applied fertilizers are lost in different ways from the field. A range of agronomics practices is implemented to improve the availability of nutrients to plants and prevent the losses of fertilizers [5,1]. This article aims to focus on nitrogen fertilizer losses, its effects on the environment, and ways to reduce leaching.

2. THE NITROGEN FERTILIZERS LOSSES

The fate of nitrogen fertilizers is affected by nitrogen absorption to plants, the amount of nitrogen in the soil residual, and its losses to the environment. This element is released to the environment through (1) leaching, (2) denitrification, (3) ammonia volatilizations, and (4) runoff. The fate of nitrogen is strongly influenced by soil and climate conditions, as well as agronomic management practices. Minimizing the nitrogen losses from fertilizers enhance nitrogen use efficiency and crop uptake, improve soil fertility, and reduce environmental risks [7]. The fertilizer application has increased plant yields in the world and combatted against hunger. However, if excessive fertilizer application does not improve crop yield, they have negative effects on the environment and public health [8]. Excessive nitrogen fertilization causes the accumulation of significant amounts of nitrogen in the soil. Except for absorption to plant, a large quantity in the form of nitrate is lost by leaching and denitrification. Such a situation for the environment and economy is undesirable [9]. The nitrogen uptake by plants and losses from soil depends on soil texture, soil mineralogy, crop type, tillage method, climate, irrigations, nitrogen fertilizer type, application timing, rate, and method [8], in addition to, nitrogen fertilizer losses also depend on the rate of application, pH, moisture, temperature,

reactions of nitrification and denitrification and soil microorganisms [10].

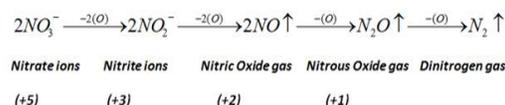
2.1 Leaching

The process of nitrate moving out from the plant roots zone is called leaching. $\text{NO}_3\text{-N}$ movement in the soil profile is influenced by the structure and texture of the soil, fertilizer amount, and irrigation intensity. The light soil textures, heavy rainfall, and irrigation, as well as free drainage help to increase nitrogen leaching [7]. The main form of nitrogen that is lost by leaching is nitrate. Ammonium (NH_4) is also dissolved in water, but it has a positive charge, which is easily absorbed by soils. Nitrate has a negative charge, which is not absorbed by the soil and moves downward freely with drainage water, so it is easily lost to the soil [4]. The leaching process occurs in irrigated land, humid climate, and coarse-textured soils. The applied nitrogen fertilizer loss range is 5-50% via leaching [11]. $\text{NO}_3\text{-N}$ leaching is a crucial part of the nitrogen cycle and causes a considerable financial loss to farmers and contaminates surface and groundwater [12]. Soil erosion, nutrients leaching, and soil fertility depletion are the most significant threats to the soil in developed and developing countries. The mentioned problems, increase minerals fertilizer application, and decrease organic materials such as farmyard manure and other organic wastes in arable lands [13]. Post-harvest soil that has a high level of soil minerals nitrogen, intensive rainfall, and permeable soil creates favorable conditions for nitrate leaching from the roots zones due to excessive drainage. Surplus of rainfalls on sandy soils during the autumn and winter increases nitrate leaching. Thus a large amount of nitrate is found in groundwater and then transported to the sea [14]. Nitrogen loss was increased by increasing nitrogen application rates in all irrigation treatments, as well as increasing water also enhances nitrate leaching from applied nitrogen fertilizer fields [15].

2.2 Denitrification

Denitrification happens in the anaerobic condition when nitrate is changed into nitrogen gas by denitrifying bacteria. The denitrifying microbes use nitrate rather than oxygen for respiration; therefore, nitrogen oxides are lost in this process from soil [11]. The organisms that perform this process are common and are found in large

numbers in the environment. These organisms are mainly facultative anaerobic bacteria and certain archaea and fungi also carry out denitrification. Generally, bacteria that belong to *Pseudomonas*, *Bacillus*, *Micrococcus*, and *Achromobacter* take part in this process. Most of these organisms are heterotrophs, that get their energy from the oxidation of organic compounds. The following formula describes the denitrification process [4].



A biological process such as nitrifier nitrification, nitrifier denitrification, denitrifier denitrification and coupled nitrification-denitrification play a significant role in nitrous oxide gas production. The application of nitrogen fertilizers and manure may increase the above processes and stimulate nitrous oxides emission to the atmosphere [7]. The atmospheric concentration of N_2O has steadily increased throughout the industrial era. The concentration of this gas in the atmosphere was 268 ppb in 1750 and reached to 329.9 ppb in 2017. The concentration of greenhouse gases has a close relationship to carbon and nitrogen cycles of the ecosystems, the three (CO_2 , CH_4 , and N_2O) greenhouse gas fluxes have become a significant cause of global climate change [16,17]. The fertilization rate, annual and perennial crops, cultivated mineral soils, soil moisture, temperature, and tillage affect nitrous oxide emission rate [18]. The N_2O important sources are automobile exhaust fumes, the release of nitrous oxide gas from the soil through the denitrification process, particularly in rice paddies, wetlands, and heavily fertilized or manured agricultural soil. It is estimated that 5-20% of nitrogen is lost from fertilizer through denitrification [4].

2.3 Ammonia Volatilization

Rice is cultivated over (165 million hectares) area and about 88% globally under flooded conditions [19]. The ammonia volatilization mostly occurs in paddy rice, moderate to slightly acid soil, the high losses occur in alkaline soil. Algae and other aquatic biota consume water carbon dioxide, so pH is increased that helps to release ammonia to the atmosphere from water [20].

Table 1. Environmental and soil conditions contribute to minimize or maximize the risk of ammonia volatilization from the soil to the atmosphere [23]

High-risk condition	Lower risk condition
Moist soil or heavy dew	Dry soil
High soil pH (>7.0)	Low soil pH (<6.0)
High soil temperature (>70°F) or frozen soil	Cool soil temperature
Crop residue, perennial thatch or sod	Bare soil
Low cation exchange capacity soil (sandy)	High cation exchange capacity soil (silt or clay-dominated)
Poorly buffered soils (low soil organic matter, low bicarbonate content, high sand content)	Highly buffered soils (high soil organic matter, high bicarbonate content, high clay content)

When ammonium-containing or urea fertilizers are applied to the calcareous and alkaline soil surface, ammonia (NH_3) volatilization is increased. Ammonia emission from fertilized land may be oxidized and turn into nitric acid, which creates acid rain after the chemical transformation [21]. Many factors affect ammonia volatilization including soil properties, meteorological conditions, fertilization practices, irrigation systems, and so on. Irrigation and rainfall help in moving nitrogen fertilizers below the soil surface and thus minimize ammonia volatilization. Additionally, the fertilizer application method also strongly influences on NH_3 emission, the surface broadcasting urea increase the volatilization rate of urea. The increasing soil temperature enhances the hydrolysis rate of urea and ammonia emission rate is increased to the atmosphere [7]. Livestock farming contributes about 70% of the total anthropogenic ammonia volatilization. It has been estimated that nitrogen is released 54 million tons annually to the atmosphere by NH_3 volatilization [17]. When nitrogen fertilizers are used, around 52 % of applied nitrogen is lost via ammonia volatilization, nitrous oxide emission, leaching, runoff, so on [22]. Some environmental and soil conditions contribute to minimize or maximize the risk of ammonia volatilization from the soil to the atmosphere, as shown in Table 1.

2.4 Fertilizers Losses by Soil Erosion

Soil erosion reduces nutrients from the soil, which has potentially negative effects on surface and groundwater quality, as well as on the air. Soil losses and nutrients can harm the environment; therefore, they lead siltation and eutrophication of waterways and inflict economic losses on farmers and society. It is reported that nitrogen fertilizers are lost greatly from tilled soil plots, and the intensity of the rains impact the soil losses quantity. The nitrogen fertilizers losses were less on untilled plots [24]. Soluble nutrients

such as nitrate and potassium can be lost in runoff and drainage water, whereas less soluble nutrients such as phosphorus can be lost with sediments moving in eroding soil and runoff water [25]. The nitrogen loss occurs by soil erosion in the sloping land, which depends on soil properties (texture, structure), length and steepness of the slope, conservation measures, amount of soil lost, nitrogen content, and climate condition. The annual nitrogen loss has been measured by water erosion usually amount to $<3\text{kg N ha}^{-1}\text{ yr}^{-1}$ [11]. Spontaneous vegetation cover reduces nitrogen effectively by runoff, and they added that effective management produces 3 times less runoff and 6 times less nitrate loss than conventional tillage. Conventional tillage causes higher mineral nitrogen loss because it produces more runoff and higher runoff nitrate concentrations [26].

3. THE FERTILIZER EFFECTS ON ECOSYSTEMS AND LIVING ORGANISMS

Fertilizer losses have adverse effects on (1) ecosystem productivity, (2) biological diversity, (3) eutrophication, (4) contamination of freshwater resources, (5) ozone depletion, (6) air quality degradation, and (7) climate change [10]. High levels of nitrogen fertilizer application may increase the amount of nitrate in drinking water that is harmful to humans and animals. High-level fertilization of nitrogen increases the amount of nitrogen in plants, especially in lettuce and spinach leaves which are edible. There is an accumulation of some carcinogenic substances such as nitrosamine, as well as nitrate, and nitrate accumulation are also harmful to humans [21]. Excessive Nitrogen fertilizer inputs in intensive agricultural ecosystems result in reducing nitrogen use efficiency. Furthermore, increased nitrogen loss to the environment pollutes air and water system via ammonia volatilization, surface runoff, leaching, and

denitrification.[27]. The great amount of nitrogen in the agroecosystem can increase concentration in surface and groundwater, which causes algal blooms, fish kills, and risk to public health. Moreover, nitrates in drinking water are harmful to infants, pregnant women, and a particular population with hereditary blood diseases [8]. Climate warming and acid deposition together may increase ultraviolet penetration in water. Consequently, their combined effects disrupt photosynthesis in algae and aquatic plants and cause sunburn damages in fish [28]. Weil and Brady [7] reported, when lakes, ponds, and other water sources enrich with nutrients, it stimulates the growth of aquatic organisms, which leads to the deficiency of oxygen in the water body. Increasing nitrogen in water bodies causes (1) hypoxia, (2) harmful algal blooms, (3) methemoglobinemia, (4) ozone layer depletion, and (5) acid rains.

3.1 Hypoxia

The depletion of oxygen in the water that cannot support aquatic life and does not provide enough oxygen to the extent and development of their life is called hypoxia. Hypoxia damages fish and other organisms over the large area in water and brings economic and environmental disasters in the world [29]. The nutrients enhance the growth of aquatic blue-green algae; therefore, organic materials are increased in the water bodies. These materials are decayed by biological activities during the times and they consume dissolved oxygen of water. Finally, oxygen is depleted by the degradation of aquatic rotten plants and create hypoxia condition [30]. Pure water has 8-9mg/L dissolved oxygen under the normal temperature condition. When it is dropped to 4mg/L, it will demolish significant aquatic life [31]. Below 2mg O/L is stressful for all aquatic organisms and dead zones occur when dissolved oxygen is completely consumed. A condition in which there is 0mg/L dissolved oxygen in water is called anoxia of water I. [32].

The Baltic Sea has been damaged by eutrophication and reduces the total economic benefits of approximately \$ 10 billion every year [33]. It is calculated that 383 million fish have lost their lives due to hypoxia along the Texas coast during the fifty years [34]. Over \$2.2 billion losses have been estimated by eutrophication-related practices every year [35] and 3000 tuna fish were killed by hypoxia in Kharan Bandar in Oman water in 2004 [36]. The United States Environmental Protection Agency [37] reported

that eutrophication damages tourism and recreation, commercial fishing, property values, and human health. Also, it increases the cost of drinking water treatment, mitigation costs in lakes, and restoration costs.

3.2 Harmful Algal Blooms

Cyanotoxins are released from blue-green algae. They are passed from one organism to another via the food chain and contaminate organisms when eaten by marine animals, seabirds, and humans. Illnesses and deaths have also happened in animals and humans through consumed shellfish that contained algal toxins [38]. They kill fish, directly and indirectly. Toxins kill fish directly, and algal bloom creates hypoxia and anoxia zones in the sea, which in turn kills fish indirectly [39]. The blue-green algae are decomposed by biological processes and release hazardous elements that threaten marine biodiversity and become a nuisance [40]. Cyanobacteria intoxicate animals when their contaminated cell are eaten by animals. The animal's tissues that contain cyanotoxins are also poisonous when they are consumed by animals [41]. These toxins cause liver, digestive, neurological, and skin diseases [42]. They also produce tumors and have carcinogenic effects [43]. Sufficient amount of cyanobacterial toxins in drinking water has poisonous properties and offer causes vomiting, diarrhea, abdominal pain, and headache [44].

3.3 Blue Baby Syndrome (Methemoglobinemia)

Increasing the usage of nitrogen fertilizers helps water contamination via nitrate [45]. Human and animal untreated wastes are also responsible for the contamination of water because they are the sources of nitrate [46]. When nitrate amount is increased in water and consumed by infants, the hemoglobin cannot carry oxygen to tissues, and thus the infant manifest clinical symptoms of cyanosis [47,48]. Nitrate itself is not toxic for humans, but it is converted to nitrite in the human body. Therefore, it causes methemoglobinemia in infants, who are more susceptible than adults. This disease is caused by the intake of water, vegetables, chemicals that have high nitrate. Of course, heredity is also a factor.[48].

3.4 Ozone Layer Depletion

The conversion of nitrates to NO, N₂O, and N₂ gases by anaerobic process and their release to

the atmosphere is called denitrification [49,50]. When nitrogen is released from the soil, plants show a deficiency of nitrogen, and its oxides harm to the environment. Dinitrogen gas is inert and harmless for the environment, but nitrogen oxides are very active gases and damage the environment potentially. Nitrogen oxides harm the environment in four ways. (1) The nitrous oxide (N_2O) rises to the upper layers of the atmosphere and contribute to the climate change and global warming, (2) nitrogen oxide gases in the ground level react with volatile organic pollutants and from ozone, it is caused photochemical smog that plagues for many urban areas, (3) Nitric and nitrous oxides are released by denitrification, contributing to the acid rain formation, (4) furthermore nitrous oxide gas destroys the ozone layer [4]. It is the third most significant anthropogenic greenhouse gas that its emission is a leading cause of the ozone layer depletion [50]. This gas has a global warming potential of around 300 times greater than carbon dioxides. It has an enormous effect on the ozone layer. Nowadays, it is considered to be the main ozone-depleting substance and will remain the greatest threat to the ozone layer throughout the 21st century if the current emission keeps going [49,10,51,52].

3.5 Acid Rains

Increasing levels of atmospheric nitrate and sulfate are produced by man-made sources, such as agriculture fertilizer applications, combustion fossil fuel, vehicle exhaust emission, and other sources. They may cause severe acid deposition [53]. It is a global environmental problem that has been started before the 1950s, and approximately 40% of China's land is affected by acid rain [54]. Acid rains help to acidify surface water. Acidification of surface waters has toxic effects on vegetation, fish, and other biotas. The release of ammonia and ammonium from the soil is a recognized contributor to acid rain and helps with eutrophication [55]. Qiu et al [54] reported that acid rains decrease soil pH significantly and leach toxic substances from soils. Acid rains cause extreme damage to buildings and car finishes, in addition to severe damage to fish and forests. The health of lakes and forests are impacted directly by acid rains. The rains leach aluminum, nitrate, and sulfate from the soil, lake, and river water and decreased their pH. The higher amount of aluminum is toxic for fish [4]. It dissolves toxic substances like aluminum and mercury that pollute water and poison plants and

humans. Lake, river, and wetlands become acidic that affects plant and animal life in aquatic ecosystems. Different aquatic species tolerate various acidity levels. When the water pH is decreased up to 6.0, high mortality happens in calms and mayflies. The frogs' population that feeds on clams and mayflies declined and terrestrial animals that depend on aquatic organisms are also impacted. Acid rain corrodes buildings, automobiles, materials, and other structures. For example, the Parthenon in Greece and the Taj Mahal in India have been affected by acid rain. Acid along with other substances in the air results in urban smog, which causes respiratory problems [56,57]. The greater amount of volatilized ammonia from rice fields is returned to earth by dry or wet deposits. It is an important air pollutant, contributing to acidification, eutrophication, and loss of biodiversity [27].

4. CURRENT APPROACHES TO PREVENT NITROGEN FERTILIZER LOSS

Many factors exist that result in plant abnormality, including, (a) Unsatisfactory environment, (b) Biological hazards, (c) Genetic deformity, (d) Nutritional starvation, (e) Nutritional and other toxicities, (f) Wrong or excess application of manures, fertilizers, and other soil amendments, and (g) Wrong or excess application of herbicides or pesticides. These factors help in the identification, diagnosis, and prevention of fertilizer pollution [58]. When nitrogen fertilizers are used in the fields, the four important points are considered for their efficiency: (a) right source, (b) right method, (c) right rate, and (d) right time [59,60]. The type of fertilizer, application methods, and source of fertilizers have a great influence on nitrogen fertilizer loss (Tables 2 and 3). Therefore, proper management and adequate techniques can minimize fertilizer loss. $(NH_4)_2SO_4$ and $CO(NH_2)_2$ applications on bare land, losses have been increased due to easily convert to Ammonia, but the loss in ammonium nitrate less compared to urea and ammonium sulfate, because, ammonium nitrate one part contains the form of nitrate [56]. Nitrate-related fertilizers are easily leached and lost by denitrification in paddy or wet soils. Ammonium containing fertilizers with nitrification inhibitors usage in the rice fields helps in increasing nitrogen efficiency. An equal amount of fertilizer is not used for all crops. Plant type, hunger signs, soil type, and plant tissue

tests are assessed during the requirement of fertilizers. also, plant types, soil, nutrient type, and moisture availability are looked during application time [60]. Deep-rooted crops, cover cropping, such as perennial grasses and synchronizing nitrogen application with crop nitrogen demand to increase nitrogen use efficiency, support to minimize soil residual nitrogen content, and nitrogen leaching. Fine-textured soil retains nitrogen and reduces nitrogen losses, compared to coarse-textured soils. Ammonium and ammonium producing sources such as urea are easily lost by volatilization; therefore, placing the fertilizer below the soil surface reduces volatilization losses [11]. Split and band application decreases ammonia emission compare to a single and surface application, in addition to, the use of urease inhibitors and controlled release fertilizers significantly decrease ammonia volatilization [61]. Shah et al [12] reported that cover crops reduce soil erosion; prevent nitrate and nutrient leaching, increase organic matter, improve soil biology, and suppress weeds. The EPA prescribed some techniques for farmers that can reduce nutrient losses from their operations such as (1) adopting nutrient management techniques, (2) using conservation drainage practices, (3) Ensuring year-round ground with plant cover that reduces erosion, (4) Planting field buffers to retain nutrients before they reach to the water body, (5) implementing conservation tillage that minimizes erosion, runoff, and compaction, (6) managing livestock access to streams, river, and lakes, (7) engaging in watershed efforts to reduce nutrient pollution from water and air. <https://www.epa.gov/nutrientpollution/sources-and-solutions-agriculture>.

Some important points that are necessary for nitrogen fertilizers are as follow:

- Split application of nitrogen fertilizers is better than a single large application during the planting and growing season, the split application is effective and increases nitrogen use efficiency [64].
- The proper amount of water in the soil is essential for the efficient use of fertilizers [65].
- On calcareous soils increase ammonia volatilization; therefore the fertilizers should be quickly incorporated by tillage or watered into the soil [60].
- Poorly drained soil increase denitrification, so heavy nitrate fertilizers should not be used. To avoid denitrification, the ammonium form is preferred [60].
- All crops do not need the same amount of fertilizers. Therefore, their requirements should be identified to use a suitable amount of fertilizers [65].
- Correct Timing, irrigation, and application of fertilizers enhance the efficiency of fertilizers and save money and time [66].
- The soil tests give a correct appraisal of fertility status and predict the right dose of fertilizers for crops [67].

Table 2. Percent of loss different nitrogen fertilizers have applied at 200 kg N ha⁻¹ at three various depths in clay soil at 16°C temperature [62,56]

Fertilizer	Depth (cm)	N Loss (%)
Ammonium sulfate	0	37
	2	3.8
	4	0.5
Ammonium nitrate	0	12
	2	1.3
	4	0.7
urea	0	31
	2	6.1
	4	0.6
UAN*	0	20
	2	3.9
	4	0.5

*urea ammonium nitrate solution

Table 3. Nitrogen different fertilizers have a potential risk to ammonia volatilization [63]

Fertilizer name	N %	Fertilizer type	The potential risk of NH ₃ volatilization
Urea	46	Dry granular	High
Anhydrous ammonia	82	Compressed gas	High
Ammonium nitrate	33	Dry granular	Low
Ammonium sulfate	21	Dry granular	intermediate
Urea ammonium nitrate (UAN)	28	liquid	intermediate

- Balanced fertilization increases crop productivity and enhances nitrogen efficiency [64].
- Use control released fertilizers that prevent nitrogen losses [49].
- Urea and nitrate are very soluble in water; excess application of fertilizers may leach by deep irrigation or heavy rainfall [21].
- Use urease and nitrite inhibitors to prevent nitrogen loss from fertilizers [68].
- Proper fertilizer management reduces the losses of nitrogen and increases its efficiency [69].
- Humic substances use with nitrogen fertilizers have synergetic effects, so humic acid along with urea increases the efficiency of fertilizers [70].
- In Northwestern China changing furrow irrigation and fertilize application to sprinkler fertigation in potato crop minimized the leaching of nitrate from the soil, it increased the efficiency of water and fertilizer use [71].

5. CONCLUSION

Chemical fertilizers especially nitrogen fertilizers are used to increase crop productivity in the world because the population growth and crop yields have links with each other. The intensive fertilizer application has played a significant role in crop production and combatted against hunger, but their extreme application damage biodiversity, ecosystems, soil, water, and air quality, as well as create imbalanced natural resources that have adverse effects on ecosystems. Nitrogen fertilizers are lost due to extreme usage, mismanagement, unfavorable climate conditions, chemical, physical and biological properties of soil. Nitrogen fertilizer leaching supports blue-green algae growth in

water bodies and creates eutrophication status. This condition in water bodies decreases soluble oxygen and contaminates water with toxins that are harmful to all living organisms. Contaminated water with nitrate intoxicates infants, breastfeeding mothers, and mammals. Hypoxic water kills aquatic life and creates dead zones in seas. Ammonia and other nitrogen oxides take formation in acid rains that devastate physical and biological assets. Nitrous oxides deplete ozone layers, as well as contribute to global warming. The technical and agronomical techniques and practices help to decrease fertilizer losses; therefore, it is important to improve crops, soil, water, and fertilizer management for better improvement. To improve crop productivity, enhance water and nutrients use efficiency and prevent ecological disorders, some important points should be considered about fertilizers application: (1) chose right (fertilizer, quantity, time, placement) for the specific crop, (2) divide fertilizers application timing according to climate, soil, and plant types, (3) cultivation methods change according to water resources, and plant species, (4) use urease and nitrite inhibitors increasing the quality of crops and enhancing environmental quality, (5) cover crops, and plant residues minimize nitrogen fertilizers usage, (6) prefer improving plant varieties increase the efficiency of fertilizers, (7) maintain the embankment of the field to store water, (8) proper cropping system and crop rotation sustain soil fertility, (9) construct infrastructures for store surplus water of rains to avoid probably damage, (10) and aware the farmers about harmful effects of fertilizers on living beings and ecosystems, and their recent and upcoming responsibilities for safe environment.

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