https://doi.org/10.31674/book.2022macbs.008

Human Impacts on Nitrogen Cycle

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ABSTRACT

Human beings have played the role of a major force in bringing about a significant change in our global ecosystems. In fact, among the various attributes of our ecosystems, anthropogenic activities have been crucially affecting the biogeochemical cycles. The human-mediated alterations of the earth's nitrogen cycle are having a very perturbed impact upon the world's ecosystems as the nitrogen element is key to living beings and its attainability plays a critical part in maintaining the balanced performance of the biotic and abiotic components of our ecosystem. Human activities such as the use of fossil fuels, the use of nitrogen-based fertilizers, and nitrogen-producing industrial and agricultural pursuits have significantly increased the nitrogen content of our ecosystem. The pollution caused due to the addition of excess nitrogen to the different constituents of the ecosystems alters both their ecological operations as well as the living communities they support. Other than the increase in the supply of nitrogen by human activities, the global intensification of the drifting of nitrogen in its various forms in the environment has also been observed. Because of this increased mobility, excess nitrogen introduced to the ecosystem initiates serious and long-term environmental consequences. The data obtained from the latest research studies indicates that the huge amount of nitrogen introduced on account of human activities also contributes to climate change. However, such environmental desecration can be minimized by the adoption of time-honored sustainable practices. Therefore, it is high time that state and global decision-making should strive to bring down these detrimental effects through the growth and extensive distribution of more well-planned and effective management practices of human activities that reduce them.

Keywords: *Nitrogen Cycle; Nitrogen Fixation; Nitrogen Saturation; Acidification of Water; Eutrophication of Water*

INTRODUCTION

Nitrogen (N_2) forms one of the chief and primary nutrients present in our ecosystem, which is extremely necessary for the continuity of life. Nitrogen forms the essential constituent of many biological molecules in the living world, including proteins, DNA, and chlorophyll. The intricate interplay of the biological and geochemical processes (like the other nutrient elements: carbon, sulphur, phosphorus) maintains the continuous circulation of nitrogen through all the components of the ecosystem for the sustenance of life and the environment. Nitrogen, like any other nutrient element, also moves from one component to the other in the environment in a closed loop of "cycle", which is termed the Nitrogen Cycle. The cycle has been in operation on Earth for billions of years, converting the non-biological form of nitrogen in the atmosphere into various biologically useful forms used by living organisms. This particular conversion is called Nitrogen Fixation. According to the information from the Science paper, the nitrogen cycle has undergone several major changes since pre-biotic times. The geological processes like volcanic processes and lightening were the key factors in regulating the cycle, and then gradually the anaerobic organisms also took over, as the biological activities commenced. It was about 2.5 billion years ago that the appearance of molecular oxygen (O_2) on the earth, as a result of microbial processes, led to the evolution of the modern nitrogen cycle.

The supply of nitrogen in the terrestrial and aquatic ecosystems forms the essential factor in controlling the character and variety of autotrophic plants, the biological processes of heterotrophic consumers and the indispensable ecological processes. On account of heavy amounts of nitrogen addition, the ecosystems get polluted, altering both the operation of ecological processes and the living communities they sustain.

With the advent of the 20th century, anthropogenic activities and their effects on the nitrogen cycle started to rise extremely high, driven by extensive industrialization, farming, and agricultural practises to meet the demands of global production, consumerism, and Gross Domestic Production (GDP). Among the various pursuits of humans, the chief culprit has been the burning of fossil fuels-which brings about the release of nitrogen oxides into the atmosphere, which in turn combines with other elements of the atmosphere to form smog and acid rain-effecting the nitrogen cycle. The massive effect of human activities on the global nitrogen cycle started to be felt and observed from the mid-1900s onwards. Along with the burning of fossil fuels, the making of fertilizers by humans has significantly contributed to altering the fixed nitrogen present in the ecosystems of the earth. The prediction of some environmental scientists is that by 2030, the nitrogen fixation brought about by human activities would surpass the amount of nitrogen that is fixed by microbes. The unprecedented surge in nitrogen that remains available has altered the ecosystems by augmenting primary production, carbon shortage and eutrophication. Ecologists and environmentalists have focused their attention on the importance of nitrogen in ecosystems and the significant impact of human activities on nitrogen and its transformations, emphasising the development of technology and management to pave the way for sustainable living and the protection of our ecosystems and environment (Bernhard, 2010).

Local human activities are chiefly responsible for the augmentation of global nitrogen on a large scale. Besides, human activities mediated increased supplies of nitrogen have also enhanced the flow of nitrogen in its various forms globally through the different constituents of the environment. The increased mobility of surplus nitrogen resulting from human activities has a grave and long-term environmental consequence. It is truly a painful lesson to realize that the things human beings depend on to make their lives more comfortable can also kill them. Human addiction towards fossil fuels is the obvious example, but at the same time, they are addicted to nitrogen too, and it now appears that the combination of climate change and nitrogen pollution is multiplying the possibility of wrecking the world around them. (Bernhard, 2010).

LITERATURE REVIEW

What is nitrogen cycle?

Nitrogen plays a very vital role in the lives of every living creature. It forms the most abundant element in our atmosphere, existing as dinitrogen gas (N_2). But nitrogen remains mostly unreachable to the living components of the ecosystems in this particular form, often limiting its primary productivity. It is only the conversion from the dinitrogen gas form of nitrogen to ammonia (NH_3) that makes the availability of nitrogen to primary producers possible. The inorganic form exists freely in the environment and the organic form exists in living beings as the transfer of nitrogen takes place through the food chain from one organism to another by the process of eating and being eaten. Thus, the nitrogen cycle brings about the various transformations of nitrogen in the ecosystem, making it available to all the living organisms. The major processes of nitrogen transfer involve nitrogen fixation, nitrification, denitrification, and ammonification. The conversion of nitrogen takes many forms through the biogeochemical cycle called the Nitrogen Cycle, with nitrogen being sequentially transferred from the atmosphere to the soil, then to organisms, and again back into the atmosphere. The transformation of nitrogen into its various forms takes place in the environment, which helps to maintain a balance in the ecosystem (Bernhard, 2010).

Three major steps of Nitrogen cycle:

Nitrogen Fixation – Nitrogen is made available to living organisms for the building of proteins, DNA, and other key biological compounds. In this way, N_2 is converted into a biologically available form, and this process is called "nitrogen fixation." This particular process is carried out by a selected group of prokaryotes that carry out this energy demanding process. Although the maximum amount of nitrogen is fixed by the prokaryotes, some nitrogen can be fixed abiotically by lightning, which supplies energy for mediating the reaction of N_2 with oxygen, producing oxides of nitrogen (NO, NO_2). These nitrogen oxides enter the soil through rain and snow. Some of the prokaryotes that bring about nitrogen fixation are free-living, while others live symbiotically (Rhizobium) in close association with the host plant to carry out the process. Though the prokaryotes manifest a diversity of phylogenetic and physiological differences, they all have a similar enzyme complex called Nitrogenase that catalyzes the reaction, bringing about the reduction of N_2 to NH_3 (ammonia). Due to its high sensitivity to oxygen, the enzyme gets deactivated in the presence of oxygen. Symbiotic bacteria make this nitrogen available to their host plants by converting the inert nitrogen to its usable form – such as nitrites and nitrates.

Nitrification – This particular step occurs in the soil, which involves the conversion of ammonia to nitrites (NO^{2-}) and nitrates (No^{3-}). Some of the soil prokaryotes (nitrobacter) convert the nitrites into nitrates and others (nitrosomonas) convert ammonia into nitrites. Both these prokaryotes can act only in the presence of oxygen. Nitrate is a more stable molecule than nitrite and is the chief source of nitrogen for primary producers. The nitrate form is mainly absorbed and assimilated by plants and animals directly.

Denitrification - In this particular stage of the nitrogen cycle occurring in soil and aquatic habitats, the nitrate is converted into nitrogen gas. Denitrification is carried out with the aid of diverse groups of prokaryotes (*genera Bacillus, Paracoccus*, and *Pseudomonas*). This particular step is important because it takes out nitrogen (nitrate) that had remained fixed within the living biomass of the ecosystem, returning it back to the air in the biologically inert form (N_2). Dinitrogen (N_2) gas, which forms the end product of denitrification, also exists with the other forms of nitrogen. Among those forms is nitrous oxide (N_2O), which acts as an important greenhouse gas, undergoing reaction with ozone and causing air pollution.

Ammonification – Here, the nitrogen present in the organic form (amino acids, DNA) of the biotic organisms is released back into the ecosystem as ammonia. Generally, when the living organisms die or excrete their organic wastes, the various fungi and prokaryotes of the detritus food chain start decomposing and breaking down the organic nitrogen, transforming it into ammonia, which finally becomes available to the plants and microorganisms for growth.

- **Significance of Nitrogen cycle-**

Nitrogen is a critical component for the survival of life on Earth. cycling is very essential for maintaining a productive and healthy ecosystem, keeping it in a stringently regulated manner. Nitrogen forms the significant component of many cells and biological operations, playing a very significant part in the sustenance of life in our ecosystem (Bernhard, 2010).

Quantity of nitrogen in normal environment:

Nitrogen, as it comes in many forms in our environment, is significant to primary producers for their survival. Plants cannot use the Di-nitrogen (N_2) or atmospheric form of nitrogen, but it can be found in significant quantities in various organic and inorganic forms on the earth's crust. Nitrogen present in its organic configurations constitutes a very huge share of the total nitrogen content present on land. The amount of nitrogen produced by the nitrogen fixing bacteria approximately stands to 32-53 Tg/year (Galloway *et al.*, 1995).

- **Environmental issues of surplus nitrogen levels**

Nitrogen entering in huge amounts to our environment – generally resulting out of diverse human activities –pollute the atmosphere and water bodies extensively. The impact of nutrient mediated pollution has also been manifested in many water bodies like - streams, rivers, lakes, bays and coastal waters for the past several decades, creating a detrimental impact on our environment, health and economy.

The introduction of unwanted and excess quantity of nitrogen triggers the burgeoning of aquatic plants and algae, which in turn causes the clogging of water intakes, utilization of dissolved oxygen on account of their decomposition and obstructing the entry of light to the bottom levels of water. Eutrophication of water bodies produces dense formations of algae on the surface of water bodies, which on certain instances causes the killing of aquatic animals of the water bodies, and can even proceed to the "killing" a lake by causing oxygen deprivation. The effect on the efficiency of respiration of aquatic organisms is also observed, having a massive effect in the reduction of diversity of aquatic organisms (Galloway *et al.*, 1995).

- **Human mediated fixation of nitrogen**

Human activities since the past century have considerably augmented the fixation of terrestrial nitrogen at a significant rate, pragmatically causing the annual transfer of nitrogen to be doubled, converting the vast but unavailable pool of nitrogen present in the atmosphere to the forms that have been made available biologically. The major sources causing such a magnified supply include the manufacturing of nitrogen fertilizers by industrial processes, the kindling of fossil fuels; and the raising of agricultural crops like soybeans and peas that host nitrogen-fixing bacteria by forming a symbiotic relationship with them. Besides, anthropogenic activities are speeding up the process of liberation of nitrogen from sources like soils and organics where it has remained locked up for a very long term. Different human activities continue to increase the amount of nitrogen oscillating between the biotic and abiotic components of the ecosystem. The excessive amount of nitrogen pollutes the ecosystem and alters the ecologically functioning processes and the living communities supported by them.

The primary human activities blamed for the increase in nitrogen on the planet are on a local scale, ranging from the production and use of nitrogen fertilizers to the combustion of fossil fuels. However, it is not only the increase in supply that has been achieved by the effect of human activities, but they have also magnified the mobilization of nitrogen in its various forms through the different constituents of the ecosystem. Because of this increased mobility, the huge amount of nitrogen injected into our ecosystem through the activities mediated by human beings has grave and extended environmental consequences for large realms of the Earth. Global nitrogen fixation contributes to about 413 Tg of nitrogen (N) to ecosystems sustained in terrestrial and marine environments per year, of which human affairs account for about 210 Tg of N, which amounts to almost half of the global nitrogen fixation.

According to graphical data from a report published in Issues in Ecology in 1997, the research work carried out by professor Peter Vitousek and his colleagues, the human activities contributing to the generation of nitrogen like burning of biomass and organic matters mediate the transfer of more than 40 Tg annually; the conversion of forests and grasslands into agricultural lands adds about 20 Tg per year. In fact, human activities inject approximately 140Tg of nitrogen into the global nitrogen cycle each year (Erisman *et al.*, 2013).

RESULTS

Human activities impacting the Nitrogen cycle:

- **Production and utilization of Nitrogen Fertilizer**

The human mediated fixation of nitrogen by industrial processes to apply as fertilizer currently amounts to approximately 80 Tg per year and represents the largest share of the contribution made by humans of newly added nitrogen to the global cycle. This quantum excludes organic nitrogen fertilizers and manures, which are the transfer of nitrogen which has already been fixed, from one place to another rather than the fixation of new nitrogen. The industrial method of nitrogen fixation was first developed for the first time in Germany during World War I, and since the 1940s its growth has been taking place enormously. In recent years, the tremendous expansion of production has been found to be remarkable to meet the demand of a growing capitalist economy. The application of the quantity of fixed nitrogen produced by industrial methods to the crops from 1980 to 1990 has surpassed all the industrial fertilizer that has been applied in human history. The fertilizer produced industrially during the late 1970s was mostly utilized in developed countries. In the present scenario, the use of fertilizer among the developed countries has been brought under control, but its application in the developing countries has been observed to rise greatly. The increase in human population growth and an increasing trend of urbanization have created an ever-increasing demand for food production to satiate hunger, ensuring a parallel increase in industrial fertilizer production to continue for decades (Erisman *et al.*, 2013).

- **Propagation of Crops**

About one third of the Earth's terrestrial surface is dedicated to the utilities of agriculture and pastoralism, as a result of which diverse natural vegetation with monocultures of leguminous crops (soybeans, peas, beans, lentils) has replaced large extents of land comprising of natural vegetation manifesting huge diversities and forages has been brought about by humans because of the demand for protein-rich food. Since these plants house symbiotic nitrogen-fixers, a good amount of the nitrogen is obtained from the atmosphere directly by them, which greatly enhances the rate of nitrogen fixation that had been occurring earlier on those lands. Substantially, a good amount of fixation of nitrogen also occurs in the cultivation of some non-legume plants, like rice. All of these represent the newly introduced stocks of biologically available nitrogen generated as a consequence of human activities. The quantum of nitrogen that the crops fix is more difficult to analyze than the production of nitrogen mediated by the industries. The estimates have ranged from 32 to 53 Tg per year (Erisman *et al.*, 2013).

- **Fossil Fuel Burning**

Humans have endeavored for the production of goods and commodities to cater to the call of consumerism and economic growth by the burning of fossil fuels, as a result of which the nitrogen that remained locked in the geological sources got released into the atmosphere in the form of its gases. The release of nitric oxide gas into the atmosphere as a result of the combustion of fossil fuels causes smog and acid rain, as well as contributing to the global reactive nitrogen load. Nitrous oxide (N_2O) is also the primary greenhouse gas, causing the greenhouse effect and climate change. The combustion activities occurring at high temperatures even fix a trifling amount of atmospheric nitrogen directly. The functioning of automobiles, factories, industries, power plants, and other combustion processes causes the emission and introduction of fixed nitrogen to our environment. That amounts to more than 20 Tg per year in the atmosphere. All of these are considered newly fixed nitrogen since they have remained locked up for millions of years under the influence of geologically high temperature and pressure, and would continue to remain locked up indefinitely if human actions don't allow their liberation (Erisman *et al.*, 2013).

- **Mobilization of Stored Nitrogen**

Other than increasing fixation and release of nitrogen from geological reservoirs, nitrogen liberation from long-term biological storage pools like terrestrial organic matter contributes further to the enhancement of biologically available nitrogen. The draining of wetlands also mediates mobilization of 10 Tg per year or more of nitrogen by facilitating the oxidation of organic matter present in the soil; land clearing for crops also mobilizes 20 Tg per year from soils. Taken together, these human activities cause significant changes in the earth's nitrogen cycle (Galloway *et al.*, 1995).

Human versus Natural Nitrogen Fixation:

The terrestrial ecosystems experience the introduction of approximately 140 Tg of new nitrogen each year due to the production of legume crops and fertilizer and also fossil fuel burning, which is equated to the upper estimates of nitrogen naturally fixed by ecosystem organisms. Various other human activities also liberate half that much nitrogen and make it available to our environment. All the ground level studies point to the conclusion that the transfer of nitrogen from the atmosphere into the terrestrial biological nitrogen cycle has been doubled by human activities. This amount of excess nitrogen is distributed in an uneven manner across the Earth's surface, where the northern hemisphere gets profoundly affected while the southern hemisphere receives a very small amount of direct input of human generated nitrogen (Erisman *et al.*, 2013).

Ecological consequences of human mediated changes of nitrogen cycle:

Human activities have significantly influenced the nitrogen cycle. The burning of fossil fuels, the application of nitrogen-based fertilizers, and other activities dramatically increase the amount of nitrogen that remains available biologically in an ecosystem. Huge changes in the amount of nitrogen available bring about severe changes in the nitrogen cycle in both aquatic and terrestrial ecosystems. The exponential increase of industrial nitrogen fixation and other human activities has been found to double the amount of global nitrogen fixation since the 1940s.

The introduction of nitrogen in the terrestrial ecosystem can lead to a number of alterations in our environmental components, like nutrient imbalance in trees, forest health degradation, and the diminishing of biodiversity. A change in carbon storage has also been experienced with an increase in nitrogen availability, thus ramifying the impacts upon other processes than just the nitrogen cycle. The extensive application of fertilizers in agricultural systems to achieve the increment of plant production, generally in the nitrate forms, leaches the soil out, which enters the water bodies, and ultimately makes its presence in our drinking water.

Nitrogen applied to agricultural and urban areas ultimately makes its way to the water bodies (rivers and near shore coastal systems). An increase in the amount of nitrogen in coastal marine ecosystems often leads to the condition of anoxia (no oxygen) or hypoxia (low oxygen), creating alterations in the biodiversity, changes in the food web structure, and general habitat degradation. A common consequence of nitrogen getting elevated is a rise in harmful algal blooms. Certain types of dinoflagellates (algal blooms) have been associated with a high level of mortality in fish and shellfish due to their toxicity. Even without any catastrophic effects on the ecosystem, nitrogen addition may lead to overall changes in ecosystem function. Results of many field studies have also indicated that changes in the nitrogen cycle can also bring about a higher risk of parasitic and infectious diseases among humans and wildlife. Furthermore, increased nitrogen levels in aquatic systems cause acidification of freshwater ecosystems (Hu, 2018).

Nitrogen saturation and ecosystem functioning:

The natural deficiencies of nitrogen in an ecosystem at a particular point are fully relieved, but still growth of the plants get restricted due to the shortage of other resources such as phosphorus, calcium, or water. When no further response from the vegetation are manifested towards further inclusions of nitrogen, it clearly indicates that the ecosystem has reached the complete nitrogen saturation stage. Theoretically, completely nitrogen-saturated ecosystems and its components are unable to utilize or hold the new nitrogen deposits anymore, as a result of which the excess nitrogen gets dispersed to streams, groundwater, and the atmosphere. Many harmful consequences for the ecosystem's health and functioning has been accounted for nitrogen saturation. The impacts of such consequences became apparent for the first time in Europe about two decades ago when observation by the scientists in some lakes and streams found that as a result of significant increase in nitrogen concentration extensive yellowing and loss of needles in spruce and other conifer forests was seen. In a similar manner a number of field experiments conducted in the U.S. and Europe have come up with the revelation of a complex outpouring of effects brought about by the excess nitrogen in forests soils. Due to the building up of ammonium in the soil, it gets converted to nitrate by bacterial action, a process that causes the release of hydrogen ions causing the acidification of soil. The building up of nitrate enhances the emission of nitrous oxides from the soil and also enhances draining away of highly water-soluble nitrate into terrestrial and ground water bodies. The swiping away of the negatively charged nitrates also results in the carrying of positively charged alkaline minerals such as calcium, magnesium, and potassium. Therefore, the modifications of the nitrogen cycle caused due to the impact of human activities decreases the fertility of soil by greatly accelerating the loss of calcium and other nutrients which are vital for the growth of plants. Trees growing in soils well-stocked with nitrogen but deficient in calcium, magnesium, and potassium expresses nutrient imbalances in their roots and leaves. This also leads to the reduction of their photosynthetic rate and efficiency, resulting in abnormalities in their growth and development and even deaths (Hu, 2018).

Impacts on the atmosphere:

Alterations in the nitrogen cycle have been the major outcome of human-driven sources, like the increased emissions of nitrogen-based trace gases such as nitrous oxide, nitric oxide, and ammonia (NH_3), mediating its significant effect on the chemistry of the atmosphere at the regional and global level. The trace amounts of nitrogen gases both in the airborne and in the deposited form cause environmental effects, like the nitrous oxide, which remains sustained for a long time in the atmosphere and contributes to the human-driven rise of the greenhouse effect, which adds to the warming of the Earth's climate. Nitric oxide also forms an important precursor of acid rain and photochemical smog. Essentially all of the more than 20 Tg per year of fixed nitrogen released from automobile exhausts and other emissions from fossil fuel burning is released into the atmosphere as nitric oxide. Intensive fertilization of agricultural soils also increases the rate at which nitrogen in the form of ammonia is released into the atmosphere. The speeding up of the breakdown of ammonium and nitrates by the microbes in the soil escalates the release of nitrous oxide (National Science Foundation, 2010).

- **Nitrous Oxide**

Nitrous oxide plays a significant role in heat-trapping in the atmosphere. It does so by partly absorbing the departing radiant heat energy from the Earth's surface in the form of infrared wavelengths, which goes uncaptured by other major greenhouse gases, like water vapour and carbon dioxide. The contribution of nitrous oxide remains to a small extent to the overall greenhouse warming, by absorbing and reflecting this leftover heat back to the earth's surface. Besides remaining unreactive, the nitrous oxide remains sustained for a long period of time in the lower atmosphere. More importantly, its ascent into the stratosphere triggers the reactions that deplete and thin the stratospheric ozone layer, which forms a protective covering surrounding the Earth, shielding it from the incoming harmful ultraviolet radiation. The present concentration of nitrous oxide in the atmosphere is increasing at a rate of two-to three tenths of a percent per year. Fossil fuel burning and agricultural fertilization have been considered to be the major sources of such an increase. A consensus has been reached, clearly indicating that a wide array of human-driven sources has been systematically contributing to enhancing the terrestrial nitrogen cycle (Hu, 2018).

- **Nitric Oxide and Ammonia**

Both nitric oxide and ammonia are extremely reactive in nature, unlike nitrous oxide and therefore they are much short lived. On account of this the detection of changes in their atmospheric concentrations can be only be manifested at regional scales only. Varied critical roles are played by Nitric oxide in atmospheric chemical interactions, including catalysis of the formation of photochemical (or brown) smog. The nitric oxide and oxygen react with hydrocarbons emitted from the automobile exhausts, in the presence of sunlight, leading to the formation of ozone, the most dangerous component of smog. The ozone present in the ground level causes serious detrimental effects on human health and the health and productivity of crops and forests. The oxides of nitrogen and sulphur gets transformed into nitric acid and sulfuric acid in the atmosphere, forming the major components of acid rain. Among the different sources contributing to the nitric oxide emissions, the Combustion is the dominant one. Fossil fuel burning alone contributes the amount of more than 20 Tg per year of nitric oxide. Forest burning by humans add about 10 Tg and global emissions of nitric oxide from soils, amounts to a total 5 to 20 Tg per year. The worldwide nitric oxide emissions produced on account of the human activities stands to about 80% or more, which is manifested in many regions with increased smog and acid rain. Compared to nitric oxide, ammonia functions as the chief acid-neutralizing agent in the atmosphere, with its antagonistic effect on the acidity of aerosols, cloud water, and rainfall. The proportion of global ammonia emissions caused by human activities stands to about 70%. The volatilized ammonia emanating from fertilized fields contributes an estimated quantum of 10Tg per year; ammonia released from domestic animal wastes forms about 32 Tg; and forest burning to some 5 Tg (National Science Foundation, 2010).

Effects on the carbon cycle:

The elevation of atmospheric nitrogen emissions has increased the deposition of nitrogen on terrestrial and aquatic bodies. The fertilizer effect of nitrogen chiefly triggers the growth of plants, but the deposition may be influencing the atmosphere indirectly, causing a change in the global carbon cycle. The overgrowth of plants and the accumulation of plant material over the earth's crust have been effectively limited historically by a very limited supply of nitrogen, particularly in the regions experiencing temperate and boreal conditions. The activities of human beings have also expanded nitrogen deposition over much of the earth's surface area. Carbon dioxide emissions on account of human activities such as fossil fuel burning and deforestation have exceeded by more than 1000Tg, which stands to be equivalent to the amount of carbon dioxide accumulating in the atmosphere each year. Empirical studies in Europe and America indicate that a greater extent of the extra nitrogen retained by natural ecosystems like forests, wetlands, and tundra stimulates the absorption and storage of carbon. On the other hand, this nitrogen also stimulates microbial decomposition, thus releasing carbon from the organic matter of the soil. During the balanced condition, however, the uptake of carbon by the new plant growth appears to exceed the carbon losses, especially in forest ecosystems. Numerous attempts made by many research institutes to calculate the amount of carbon that can be stored in terrestrial vegetation have come up with estimates ranging from 100 to 1300 Tg per year. However, the number has shown a gradual increase in more recent analyses as the magnitude of human-driven changes in the nitrogen cycle has become more prominent (National Science Foundation, 2010).

Effects on biodiversity:

Limitations in the supply of biologically available nitrogen in the natural ecosystems mediate the best functioning and adaptation of many native plant species. The introduction of a new supply of nitrogen into the ecosystems causes a major deviation in the composition of dominant species and also a marked depletion in overall species diversity. From the various empirical studies, it has been deduced that quite a number of plant species experience a decline of more than fivefold as a result of the highest fertilization rate. Besides, the rich species composition of the earth and the biological diversity of the landscape get reduced because of the resemble of the plant communities occupying more fertile soils by the modified plant communities. The distinctive species composition adapted to sandy, nitrogen-poor soils is also getting lost from the region. Biodiversity loss caused by nitrogen accumulation also has an impact on other ecological processes (Vitousek, 1997).

Effects on the aquatic ecosystem:

The various responses observed in aquatic ecosystems lead to nitrogen enrichment, which involves No_3^- loading from N-saturated terrestrial ecosystems, resulting in acidification and eutrophication of downstream fresh and marine water systems. The acidified freshwater also causes mortality of pH-sensitive fish species on account of aluminium toxicity. Since there is a limitation of nitrogen in marine systems, the unrestricted N inputs can result in the degradation of water quality due to the blooming of toxic algae, deficiency of oxygen, decrease in biodiversity, loss of biodiversity and fisheries.

- **Acidification of freshwaters**

The deposition of N_2 from the atmosphere in terrestrial landscapes undergoes microbial transformations through the soil, which results in surface water acidification and biodiversity loss. The NO_3^- and NH_4+ that pass from terrestrial and atmospheric systems acidify freshwater systems when the buffering capacity is insufficient due to soil acidification. The introduction of reactive nitrogen from agricultural activities, animal raising, fertilizer application, and other sources has raised the nitrate concentration in the waterways of most industrialized nations. Recent empirical studies report that the concentration of nitrate in 1000 Norwegian lakes and land has doubled in less than a decade. In the United States alone, 20% of groundwater sources were found to exceed the World Health Organization's limit of nitrate concentration in fresh water. Such high concentrations cause "blue baby disease," where nitrate ions weaken the capacity of the blood to carry oxygen. Exposure of reproductive tissues to high concentrations of nitrates augments the chances of some cancers like Saturday bladder and Ovarian cancer (Vitousek, 1997).

- **Eutrophication of marine ecosystems**

Anthropological activities like urbanization, deforestation, and agriculture have significantly contributed to the sedimentation and introduction of nutrients to coastal waters via rivers. A high increase in the primary production of estuarine and coastal systems has been manifested on account of high nutrient inputs. The increased primary production leads to increased carbon flow to the bottom waters as the decaying organic matter is absorbed and consumed by aerobic bacteria. As a result, the oxygen consumption in water is greater compared to the dissemination of oxygen from the surface waters. In addition, the toxins produced by certain algae blooms can act as neuromuscular or organdamaging compounds. These algal blooms can be detrimental to humans as well as other marine life (Vitousek, 1997).

- **Impact on water quality**

The conversion of nitrogen to the nitrate form in the soil provides an extreme concern for water quality, as the mobile attribute of nitrate makes it move and flow easily along with water. The effect of nitrates on water quality has been mostly observed in ground water, but sometimes they make their way into the surface water too, such as ponds, streams, and rivers. Besides the formation of nitrate in the soil by natural biological processes, the nitrates may also arrive from animal manure and nitrogen fertilizers. The underlying soil as well as the depth of groundwater determine the entry of nitrates into the ground water.

High levels of nitrates also cause serious health problems in humans, such as anoxia or internal suffocation in newborns. The most commonly observed symptom of nitrate poisoning in babies is the appearance of a bluish colour on the skin, particularly around the baby's eyes and mouth. These symptoms of nitrate toxicity are commonly referred to as the "blue baby" syndrome (Vitousek, 1997).

DISCUSSION

Nitrogen (N_2), goes through the environmental metabolism which involves the conversion of N_2 into chemically diverse reactive forms. Some of them play a crucial role for life itself and some are responsible for dangerous nitrogen pollution. The reporting from 2018-2019 Frontiers alerts that the human activities have been creating diverse forms of nitrogen species which are creating a concerned effect on living beings, ecosystems and climate (de Vries, 2021). The chief concern over the problem still goes unacknowledged to a wide extent outside scientific borders. The degradation of water and air quality, greenhouse-gas alterations, decline in ecosystems and biodiversity has been significantly recognized by The European Nitrogen Assessment as the most significant threat of nitrogen to the environment (Mellilo, 2021). Accelerating demand of human needs in agriculture, transport, industry and energy sectors have led to a high level of nitrogen pollution and related greenhouse gas emissions. It is high time that a well-managed and proper steps have to be taken in our society from individual to governmental and administrative levels for a healthy maintenance of N_2 balance in our ecosystems, so that a balanced sustained life forms can be perpetuated with organized preservation of our environment (National Science Foundation, 2010).

CONCLUSION

Since the past century the human activities have increased twice than the natural annual rate of nitrogen fixation and its entry into the terrestrial and soil nitrogen cycle, and it is going on accelerating substantially. Very concerned environmental circumstances have already started to emerge empirically. The levels of the nitrous oxide (greenhouse gas) and the nitrogen precursors of smog and acid rain are significantly augmenting in the atmosphere. The acidification of soil in many regions have resulted in its stripping of nutrients that are essential for continued fertility. Besides, the water bodies present in these regions are also getting acidified, resulting in the transportation and delivery of excess nitrogen into the estuaries and coastal waters.

ACKNOWLEDGEMENT

The author is very thankful to his colleagues, publisher and reviewer for helping him in writing this review paper.

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