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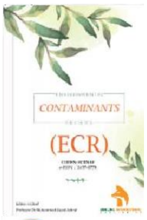

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REVIEW ARTICLE

A REVIEW: EFFECTS OF NITROGENOUS FERTILIZERS ON SOIL (PH, MICROBIAL COMMUNITY, GREENHOUSE GASES EMISSION AND CARBON POOL)

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ABSTRACT

With world population increasing at such fast rate and land available to cultivate decreasing substantially, it is of prime need to increase the productivity. This is the reason of increasing use of fertilizer in the world especially N fertilizer because of its direct influence on growth attributes. The main objective of this article is to review the existing literature regarding the effect of nitrogen fertilizer application in soil pH, microbial community, soil carbon pool and emission of Green House Gases. Most researches have shown urea to be the major source of anthropogenic N addition to soil. Studies have concluded that the unmanaged application of N fertilizers in excess amount than what crops utilize is the nerve center favoring pH change. In regards to their impact in microbial community, previous land management practice seemed pivotal. Also, abundance and diversity of greater fraction of microbes (fungi and bacteria) narrowed down with intensified application in cultivated soils in majority of trails studied. Increased efflux of CO_2 and N_2O was observed in soil fertilized with N however, CH_4 emission was limited as methanotrophs were replaced with nitrifiers. Acid rain was highly favored with such emissions. No changes in soil organic carbon pool were seen in short period but in due course of time, decomposition or turnover rate decreased increasing the stability of carbon under lignin rich root residues. Therefore, alterations varying with depth have been noticed in soils treated with N due to mineral association.

KEYWORDS

acidification, nitrification, urease, ureolytic bacteria, salinization

1. INTRODUCTION

Fertilizers are any organic or inorganic materials of natural or synthetic origin added to the soil to supply certain elements essential to the growth of plants. They play a key role in increasing crop production to feed the expanding world population. The global total nutrient capacity (N, P_2O_5, and K_2O) was 285.15 million tons in 2015 out of which the total supply was 245.77 million tons. The rate of production and capacity is expected to increase further (World Fertilizer Trends and Outlook To 2020, 2017). World nitrogen fertilizer demand is projected to increase steadily until a 2030 horizon undermining the income and population growth of the world (Patrick Heffer and Michel Prudhomme). Nitrogen is considered as the backbone of plants based on its functions, thus is required in greater amount. They are a key component of nucleic acid that forms genetic material, an essential element of amino acids, enhance chlorophyll and hold genetic codes in the plant nucleus (Tajer, 2016).

Since the 1950s, nitrogen fertilizers are used as a major input to increase net primary productivity (Geisseler and Scow, 2014). Fertilizers contain nitrogen combined in different compositions with other elements on the basis of which they are classified into 4 groups: *nitrate, ammonia, ammonium salts, and amide form.* Urea, diamide of carbonic acid, is popular among all the nitrogenous fertilizers across the globe, especially in Asian countries since it possesses proper solubility, non-polarity, less corrosiveness, less likely to explode, is less acidic in residual effects compared to $(NH_4)_2SO_4$ with high N2 content (46.7%) (Omar et. al, 1998; Omar and Ismail, 1999). Because of greater N content per pound, N application cost is minimized (Heilman, 1974). Excessive use of urea increases soil acidity and Al^{3+},Fe^{3+} and Mn^{2+} concentrations that result in crop failure (Schroder et al., 2011; Tian and Niu, 2015). Further, leaching and accumulation of nitrate acidify soil to a greater extent (Han et al., 2015). Under such condition's availability of exchangeable Ca, Mg and K are lowered (Zasoski et al., 1992).

During nitrification, NH_3 or NH_4^+ is oxidized to NO_3^- that lowered pH through H^+ generation (Han et al., 2015). Free protons are released by the hydrolysis of urea accompanied with urease activity produced by microbes especially bacteria of different taxa. In a study conducted in Shandong Province, China, 14.3-27.3 and 12.1-58.2 kmol H^+ ha^{-1} proton loading is reported from 600 kg N ha^{-1} and 1,200 kg N ha^{-1} respectively (Han et al., 2015). Absorption of bases accounted 0.3-4.5% of nitrification for proton loading. Groundwater contamination through leached nitrate is a potential nonpoint source of pollution (Komatsuzaki and Wagger, 2015). Nitrates circulating across the food chain are harmful to human health (Huang et al., 2012). Excessive nitrogen application and low recovery rate promote soil salinization under greenhouse conditions. Leaching is impossible and also with the capillary rise of water in the soil, deposition of plenty of salt on the surface (Na^+, K^+, Ca^{2+}, Mg^{2+}, and NO^{3-}) occurred (Han et al., 2015).

Microbes are the key component present in soil involved with biogeochemical nutrient and energy recycling. They are ubiquitous helping to form, maintain and evaluate the soil ecosystem. Their abundance and diversity are widely mediated by physical, chemical and anthropogenic factors. Different methods were accessed to understand microbial diversity: the molecular ecology method, the traditional plate

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count of cultivation method, BIOLOG method, and Phospholipids fatty acid (PLFA) analysis. All the mentioned aspects were found less in tea orchards than in wasteland and forest land (Ge et al., 2010). Community Level Physiological Profiles (CLPP) of soil microbes relates to nitrate concentration. With increasing nitrate levels, decreased microbial diversity and microbial carbon source utilization, such as carbohydrates, amino acids, polymers, and miscellaneous, have been observed.

Dominance, richness, and evenness were found to be decreased among the microbial community (Huang et al., 2012). Additionally, the secondary salinization, soil salinized as a result of human activities, due to nitrates affects the microbial population (Huang et al., 2012; Fitzpatrick et al., 2000; Dehaan and Taylor, 2002). However, a group researchers reported a similar ratio of ureolytic bacteria (24%) in control soils to the soils with urea application for 10 years (Sun et al., 2019). Methanotrophs are replaced by nitrifying bacteria under increased N fertilization resulting in reduced oxidation of CH_4 (Serrano-Silva et al., 2011). Atmosphere contains half the amount of organic C stored than present in soil ($1.5*10^{18}$ g C) worldwide (Schlesinger, 1997). Similarly, soils have C3 times as much as terrestrial vegetation (Neff et al., 2002). Process of humification contributes its formation and is highly affected by any minor change in them. It can be said that this entity has all physical, chemical and biological control. Application of N_2 fertilizer supplements the growth attributes leading to increased productivity along with stimulation of soil heterotrophs that aids in Soil Organic Carbon (SOC) decomposition.

Therefore, limiting the addition of plant residues to soil decreases the level of SOC (C loss in the form of CO_2) via mineralization aided by fertilization (Kuzyakov, 2000). However, SOC pool size increase when residues are returned to the soil (Smith, 1999). Greenhouse Gases (GHGs) emitted from nitrogenous fertilizer include N_2O, CO_2, CH_4, etc. that absorb the outgoing terrestrial long-wave radiation (4-100µ). N_20, obtained as products of the microbial process via nitrification and denitrification (Bange, 2000). $CO_2$is heavily produced by photosynthesis and decomposition of organic residues. N_2O have warming capability of 298 times than of CO_2 (IPCC, 2007). NH_3 produced from NH_4^+ in alkaline soil is a precursor of particle matter (PM2.5) and contributes to acid rain (Liu et al., 2017; Serrano-Silva et al., 2011). The phenomena of nitrification and denitrification contribute to the production of nitrous oxide (N_2O) as an intermediate product.

The emission factor ranges between 0.1% - 2% of nitrogen fertilization that significantly contributes to ozone layer depletion(Luo et al., 2007)N_20 emissions from sugarcane fields in Brazil after 50 days of urea application @ 60-180kg/ha showed an emission of 2.6-8.9 N_20-N/ha (Signor et al., 2013). The elemental carbon content of urea (20%) is converted to CO_2 during hydrolysis resulting in increased CO_2 emissions in the early incubation period (Serrano-Silva et al., 2011). However, their emission is also highly affected by land management practices, weather conditions esp. rainfall, soil moisture and O2 parameters, etc (Cardenus et al, 2010). Ammonia volatilization accounts for about 40% of N_2 loss globally from different environments and edaphic conditions (SIngh, 2013). A previous study in China showed 64.3% of total ammonia emissions from urea application (Zhang, 2011). CH_4 emission is multiplex and paradoxical, obtained chiefly via methanogenesis of organic matter in an anaerobic environment (Lindau, 1994). Their oxidation might be anaerobic or aerobic (Miyashita and Conrad, 2009). It possesses 25 times more warming potential than CO2 (IPCC, 2007).

2. DISCUSSIONS

2.1 Effects Of Nitrogenous Ferilization On

2.1.1 Soil pH

Different experiments concluded that it is not the application of N fertilizer that cause acidification, the application in excess amount than utilized by plant depose N in soil being the ultimate cause unless it is immobilized by microbes or denitrified or volatized or leached from the soil (Wallace 1994; Stoddard 1994; Barak et al., 1997). Nitrogen uptake by plants takes place in 2 forms: NH_4^+ ion and NO_3^- ion from soil (Bloom et al., 2003). They either leave acid, neutral or basic residues in the soil. Level of acidification which is the major concern of world today varies between different ecosystem simply because of different N forms, their application rates and experiment time (Lu et al., 2011). This is however, also dependent on pH buffering capacity since soils low in these acidify greatly in short period (Bolan et al., 1991, Helyar et al., 1990).

Fertilizers supplying N as ammonium ion undergo ammonification and nitrification resulting the release of proton (H+) ion which is the main cause of acidification.

Urea Urease ⟶ NH3 + CO2

1. $NH_3 + 2O_2 = H^+ + NO_3^- + H_2O$
2. $NH_4NO_3 + 2O_2 = 2H^+ + 2NO_3^- + CO_2$
3. $CO(NH_2)_2 + 4O_2 = 2H^+ + 2NO_3^- + H_2O + CO_2$
4. $(NH_4)_2SO_4 + 4O_2 = 4H^+ + 2NO_3^- + 2H_2O$

However, some researchers claimed this proton to help for biological fixation of N as amines in plants (Barak et al., 1997). The degree of acidification via nitrification relies on source of N used (Pierre, 1928a,1928b). Nitrification being pH, is limited by low pH sensitive (Kyveryga et al., 2004; Kemmitt et al., 2006; Shen et al., 2010). Despite nitrogen application numerated as kg per hectare, the acidity is expressed as mol per hectare. Based on mole per hectare, soil acidity produced via application of ammonium sulphate (AS) must be double of Ammonium nitrate (AN) and Urea (U) since half of N in AN present as nitrate is non-nitrifying and half acidity from urea is balanced by itself as carbonate is produced intermediately. Experiment carried out in greenhouse for 3 years with wheat-maize-wheat-maize- wheat cropping showed AS to produce more acidity than AN and U. Acidity by AN and U had no signifying difference. The Relative Lime Requirement (RLR) of AS as supposed to be 2 times of AN and U was found close as well (Mahli et al., 1991; 2000; Chien et al., 2008). In contrast to this, no statistical difference in the acidity developed was stated in the finding (Schroder et al., 2011)

Furthermore, the nitrate leaching into layers of subsoil by rain that promotes acid build up immensely on surface since this is accompanied with the basic cations Ca^{2+}, Mg^{2+}, K^+ and leached sites eventually gap filled by H^+ (Bolan and Hedley, 2003; Xu et al., 2002).

Ca saturation (%) = (Ca^{2+}/ CEC) × 100, where CEC is Cation Exchange Capacity in cmolkg^{-1} = [Σ (Ca^{2+}, Mg^{2+}, K^+, H^+, Al^{3+})]

Mg saturation (%) = (Mg^{2+} / CEC) × 100

Base saturation (%) = [Σ (Ca^{2+}, Mg^2, K^+) / (CEC)] × 100

Al saturation (%) = [(Al)/ Σ (Ca^{2+}, Mg^2,K^+, Al^{3+})] ×100

Acidity saturation (%) = (H^+ + Al^{3+}/CEC) × 100

Also, acidification is promoted by plant-N interaction for cation-anion exchange (Jarvis and Robson, 1983). To gain NH_4^+ ion, H^+ ion has to be exchanged to maintain electroneutrality. This definitely results in acid build up. Similarly, when fertilizers supply nitrogen as nitrate ion, for uptake OH^- ion is lost to maintain electroneutrality thereby studies show use of calcium ammonium nitrate (CAN) to promote alkalinity.

The increased acidity favored solubility of Al ion causing toxicity to plants and declining the yield (Pintro et al., 2004; Kariuki et al., 2007). pH was found inversely related to Al saturation (Schroder et al., 2011; Karuiki et al., 2007). Acidification with loss in basic cations not only create their deficiencies but also intensify the toxicity of H^+ and Al^{3+}. Cu and Zn were also noticed to not increase in such affected soils causing grain loss (Zhang et al., 2007).

A group researchers used the concept of excess base/ nitrogen (EB/N) ratio to evaluate effect of plant on soil reaction (Pierre et al., 1970; Pierre and Banwart, 1973). They claimed plants with the ratio less than 1 decreased acidity while greater than 1 increased acidity. Values for several crops were found to support this as well. However, another greenhouse experiment done concluded this to be true only when fertilizers supplying nitrogen as nitrate were used (KIEHL Jorge de Castro et al., 1995).

A study conducted via CRD with three factors and two levels of N source, application rate and soil (rhizospheric/bulk) in maize concluded that theoretically N fertilization in soil especially at high dose exaggerates its impact on acidification and also decrease in soil pH (increase in exchangeable acidity) was observed in bulk soil remaining in pot after maize was removed due to interaction source * rhizospheric effect (Rodriguez, et al., 2008; PIERRE et al., 1970). Acidification in bulk soil was seen to be greater at lower depths and was linked with the variation in water regime which regulated this process. Rhizospheric soils with about same pH as bulk soil showed greater exchangeable bases, organic C content and less obtainable acidity (Zasoki et al., 2008). The root extension and mass of maize seedlings were high under availability of NH_4^+ than NO_3^- ion (Bloom et al., 2003). This is reasoned by the maize experiment mentioned above as less energy is required for assimilation of NH_4^+, plants focus more in elongation and biomass accumulation.

Another long-term fertility trial carried out in South Central Wisconsin; USA deduced that exchangeable acidity increased in soils via N fertilization. With this, reduction in cation exchange capacity (CEC) due to mineral weathering and formation of non-exchangeable Al-hydroxy complexes in inter layer region of clays often termed chloritization; saturation of bases and exchangeable Ca^{2+} and Mg^{2+} ions were noticed (Sposito, 1989). In sum, they concluded acidification rate via N addition to be about 25 times quicker than by acid rain (Barak et al., 1997). Linear decrease in base saturation with N fertilization (Fageria et al., 2010).

Pot experiment carried out in 5 different soils in greenhouse conditions with different N fertilization rate showed the influence in salinization as well. A portion of salts brought by the fertilizers used and major contribution of nitrification process via release of protons helping for base cation to be available in soil solution. Also, they concluded with the results that free land soil when used in greenhouse conditions, nitrification and acidification boosts up (Han et al., 2014).

Moreover, some researcher in their meta-analysis of 106 studies regarding N addition on acidification showed experiments conducted for period less than 20 years showed promising acidification while above 20 years showed non-significant impact on acidification (Tian and Niu, 2015). This might be due to change in community to N demanding plants or base cations lost may get regenerated within the ecosystem (Stevens et al. 2004, Bai et al. 2010; Perakis et al., 2013).

3. SOIL MICROBIAL COMMUNITY

Studies show soil microbial community to depend on pattern of land use (sustainable or not) and thus are an indicator of change in soil quality and chemical properties (Beck et al., 1995; Xue et al., 2006). Another study concluded primarily land use and secondarily management practice of soil is influential to microbial biomass and diversity (Ge et al., 2010). Upon fertilization of previously unmanaged (wasteland and forest) soil, microbial community were stimulated however, the opposite situation withheld for soil (tea orchards of 8, 50 and 90 years old) being fertilized in previous years. Soil enzyme (sucrase, proteinase, acid phosphatase) activities and Average well-color development (AWCD), taken as measures of microbial activities, also exhibited the same response as above with larger impact on young tea orchards reasoned to be due to microbial adaptability. In contrast to this, fungal PLFA increased in three tree orchards while decreased in wasteland and forest.

The availability of all fungal groups except the cellulolytic ones were found lower in soils treated with either urea or urea with inorganic salts at 0.2 and 0.5mg N/g of soil than in untreated soil. Minutely, the population of bacteria was found more in soil treated by urea with the inorganic salts among the two but it was just reverse for fungi meaning more in soil treated with urea only (Omar and Ismail, 1998). Viral abundance was found to decrease, and community is diverged in soils under urea application for long term in fallow period (Li et al., 2019). Nitrate contamination via excess N fertilizer addition has caused serious secondary salinization problem today. A study conducted to evaluate relation between secondary salinization and microbial biomass and diversity showed AWCD to decrease with increasing nitrate concentration proving activity of microorganisms preferring mainly Carbohydrates, Miscellaneous, Amino acids and Polymers as carbon source degraded (Huang et al., 2011). More the salinization, lower the abundance, regularity and authority of microorganisms was concluded.

A study regarding urease activity and ureolytic bacterial community in 3 different layers of soil (0-10, 10-20 and 20-30cm) showed under prolonged urea application showed urease activity and bacterial abundance to be more in surface soil and increased with fertilization dose in above two layers but regarding the diversity of bacterial community, more influence in lower layer was seen rather than the upper two surface layers since notable effects in vertical distribution of roots and exudates were seen via fertilization (Coskun et al., 2017; Sun et al., 2019; Coolon et al., 2013; Sun et al., 2015b). Urease and nitrate reductase seemed to work inefficiently with incorporation of sulphate and chloride to soil (Hemida, 1997; Omar et.al, 1994). In an experiment carried out with Stimulated Acid Rain (SAR) in Paleudalfs soil incubated for 30 days with or without application of urea@ 200mg N/kg soil showed for same pH of SAR applied, total phospholipid fatty acid (PLFA) was contradictorily high in urea treated soils signifying positive effect of urea to increase microbial activity (Liu et al., 2014).

4. SOIL GREEN HOUSE GASES

With the addition of inorganic N fertilizer into the soil, microbial activity starts thereby increasing the outflow of CO_2 (Mendoza et. al, 2007; Aarnio and Martikainen, 1996). Thereafter, the fertilizer is hydrolyzed to NH_4^+ which in turn is acted upon by nitrifiers/denitrifiers to produce N_2O via nitrification/denitrification process respectively (Wrage et.al, 2001). A laboratory experiment was conducted in an agricultural soil constrained or not for 7 days, applied with or without 200 mg urea-N kg^{-1} soil and C_2H_2, an inhibitor of ammonium monooxygenase. Evaluation for emission of 3 GHGs was made.CO_2emissions were influenced by rainfall after the application since the organic matter was liberated thereby increasing microbial activities contributing its emission. When no urea was added, its emission was higher in the unconstrained soil than in the constrained soil, but the opposite was found when urea was added.

Upon its addition, CO_2 emissions increased significantly, but acetylene had no effect on it (Nancy Serrano-Silvaa et al., 2010). Independent of C_2H_2 or urea application, the emission of N_2O was significantly higher from unconstrained soil than from soil constrained for 7 days particularly when the soil is dry (Nancy Serrano-Silvaa et al., 2010). Also, micro-anaerobic spots may form since the 0_2 consumption boosts up via C mineralization resulting denitrification therefore the N_2O emission (Sanchez-Martin et al., 2008). Methanotrophs on the other hand get replaced by nitrifiers after the addition of nitrogen fertilizer since nitrifiers get promoted. Thereafter, application of urea in soil had no effect in CH_4 emission in unconstrained soil however, increased the formation in soil not supplied with acetylene than when supplied (Sanchez-Martin et al., 2008).

Another laboratory experiment carried out by to see CO_2emission in soil with 0, 175, 350, and 700 mg N/kg soil application showed cumulative CO_2 to increase linearly with the application rate (Lee et al., 2011). The urea hydrolysis generates a major part of the cumulative emission, which is very rapid, about 3days in the soil used (Khalil et al., 2007; Choi et al., 2007). Despite the boost in fertility, the fertilizer application favors the soil heterotrophs for Soil Organic Carbon (SOC) decomposition when enough bio residues aren't returned to soil. Therefore, increased mineralizable SOC pool and mineralization rate contributes the remaining portion of cumulative emission. Experiment carried out via closed soil chamber technique with either no (control) or 50kg N/ha (as urea) during different seasons in between 2003-5 showed the effect of season in the increased emission of GHG (N_2O) during the 30 days period.

Higher outflow during winter and spring was observed. This is because the soil water filled pore space was above the field capacity conducive for denitrification process to occur and emit N_2O (Lindsey, 2007). Moreover, during winter, nitrate leached from the nitrogen fertilizer added can act as non-point N_2O emitting source. A study done analyzed the effects of different N fertilizer treatments on the greenhouse gas emissions of wheat in silt loam soil of Cancienne. The treatment options included conventional urea, polymer-coated urea, ammonium sulfate, urease inhibitor (NBPT, N-(n-butyl) thiophosphoric triamide)-treated urea, and nitrification inhibitors (DCD, dicyandiamide)-treated urea. Urea application yielded the highest N_2O-N emissions regardless of the time period or split method. The effects of the split method on the nitrogen content of the soil were minimal or no different from the one-time application of urea however, split application of ammonium sulfate showed remarkable effect on bothN_2O-N and NH_3-N emissions than single urea application (Liu, et al., 2017).

Acid rain, a result of increased GHG emission, help for cation mobilization, leaching and toxic metal availability thereby reducing soil fertility and promoting deterioration all by replacing H^+ at binding sites in soil (Liu et al., 2014). Research carried out in sugarcane fields of Brazil showed nitrification inhibitors added to urea decreased N_2O emission, but the opposite was seen for polymer and Sulphur coated urea (Soares et al., 2015). Effectiveness of these modified fertilizers to enhance efficiency have been found to depend on climatic conditions, soil type, use, management practices and application rates (Wang et al., 2016). Regarding NH_3-N emissions, results show greatest reduction by coated urea and for N_2O-N emissions, DCD-treated urea was most effective over conventional urea (Liu, et al., 2017). Similarly, a 2-yearexperiment carried out in rice regarding the placement method of urea showed tremendous reduction in N_2O and NO emissions when placed 10-15cm below the soil with significant increase in yield (Yao et al., 2017).

5. SOIL CARBON POOL

Simply, conversion of a natural land to a cropping field seems to decrease SOC pool (Schrabel et al., 2000; Schuman et al., 2000). Quantity and quality (dissolved organic C, DOC; microbial biomass C, MBC; and particulate organic matter C; POC) of SOC is key component in sustainable land use. This doesn't change over a short time and depend for management practices over a course of time (Saviozzi et al., 2001; Xu et al., 2011). However, anthropogenic addition of N in soils have resulted to slow humus decomposition and enhance the genesis and stability of refractory soil C in fields grown with plants supplying rich root lignin litter inputs as N reacts abiotically with the phenolic compounds giving the products that withstand microbial decay (Berg and Matzner 1997; Matzner 2002; Hagedorn et al., 2003, Zech and Kogel-Knabner 1994). Investigation done in S.E. China in 0-100 cm of soil profile regarding fertilization impact on SOC and SOC fractions displayed no increase in SOC content over long term via N fertilization.

In compared to unfertilized soil, C input was increased but no improvement in C concentration or storage (Liu et al., 2013). Presently, we believe SOC levels under control and treated soil to be on par simply because of lower root biomass accumulation and known importance of other nutrients (P and K) to microbial synthesis. Evidence from 5-year grassland field experiment in Minnesota showed high N and root lignin inputs to the soil improved the stability of C in light soil fraction, however, for low lignin deposits, the decomposition rate was increased (Dijkstra et al., 2004; Hobbie, 2000). Another study deducted N fertilization has its effect on Soil organic Carbon (SOC), the physical and biological (microbial biomass C) properties, however, this is influenced by tillage regime (conventional/ no) and also may be depended upon cropping intensity or rotation (Franzluebbers et al., 1994).

A study of ^{14}C measurements on soil sample with light and heavy SOM fractions under N fertilization showed varying result. For light soil fraction, the fertilization led to its reduction directly or indirectly justified likely due to enhanced decomposition by priming effect or stimulation of microbial organisms. On the other hand, further stabilizing effect was noticed in heavier fraction (Neff et al., 2002). In Iowa, USA two experimental sites at 0-15cm layer for 2 years regarding carbon balance under different schemes of N fertilization used organic carbon (OC) input (Net Primary Productivity, NPP) and decay to explain the relation. They suggested 3 ways by which N fertilization alone influenced carbon balance: Influence in NPP, its partitioning above and below ground or the change in crop tissue chemistry to alter their decay rate. A group researcher's found initial N to mediate decomposition rate but the above experiment conducted showed decrease in C:N ratio after N fertilizer addition and enhancing the rate of decay of litter (Parton et al., 2007; Johnson et al., 2005; Russell et al., 2009).

Conclusively, some ecosystems showed positive influence of N addition on sequestration (at least for annual crops) while some showed negative impact on C balance indicating some other factors influence this process as well (Hyvönen et al., 2008; Pregitzer et al., 2008; Mack et al., 2004; Khan et al., 2007). An experiment in switchgrass to see response of soil N and C towards N fertilization showed no fertilizer addition yielded more C and N stocks. Addition of N affected dense fraction of SOC at depths >15cm which contributes the major portion of C in soil ecosystem. Therefore, long term sequestration potential may be affected by N treatment due to alterations in depth and mineral associations of C and N (Valdez et al., 2017). Another effort done to understand influence of N treatment to SOC concluded minor stimulation (increase) occurred due to treatment in agricultural soils even though the C input given to soil was increased notably and non-significant change in non-agricultural lands indicating treatment influence plant pool but not to soil pools. Also, this is justified with decrease in microbial C seen after N addition resulting decreased turnover rate (Lu et al., 2010).

6. CONCLUSION

It can be concluded from the information presented in this review that N fertilizer application has significant effects in soil physical, chemical and biological properties thereby leading to soil degradation. Detrimental effects caused due to fluctuations in soil pH, microbial community, GHG emission and SOC pool reduce plant yield directly as well as indirectly and render the land to be un-cultivable in due course of time. Findings unfold the key role of addition of organic residues to the soil to mediate this process for control of quality change. Also, application of N fertilizers in correct form in appropriate amounts at suitable stage of crop growth seems the easy correction measure to apply. Correct method of harvesting of plants with suitable crop rotation and intensity is shown to help immensely for righting this wrong.

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