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A review

Negative externalities of Synthetic Nitrogen Fertilizer on Human Civilization

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Abstract

The objective of this paper is to review the importance of synthetic nitrogen fertilizer on human civilization focusing on why synthetic nitrogen fertilizer cannot be used by certified organic farms and why does it matter whether the growers use synthetic nitrogen fertilizer or organic one in their farm? The review was under taken by referring the latest soil science researches combined with the actual many years of society member personal experience doing on no-till, organic and/or conventional farming and agro ecology. Previously available literatures on the importance of synthetic nitrogen fertilizer on human civilization related to human health, labor, water demand and supply, soil health and climate change were thoroughly reviewed. The review showed that synthetic nitrogen fertilizer becomes a great challenge for human development and agricultural production and productivity now and in the future. Due to the need to continuous application of synthetic N fertilizer in the world, people are exposed for accident damage and health infection as well as the production process enhances water pollution. In the same line synthetic nitrogen fertilizer have huge negative externalities on plant and animal nutrition, water supply, soil nutrient cycle and climate change. Therefore, despite synthetic nitrogen fertilizer will contribute for the harvest of some yield, by considering lots of its negative externalities on the human civilization, it should be supplemented by organic N fertilizers those are produced through lightening and microbial fixation.

Key words: Global warming; Human civilization; Organic farming; Synthetic fertilizer

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Introduction

Nitrogen is found in everywhere: in our bodies, the plants and animals we eat, and the soil under human feet. But avast amount of the planet's nitrogen is not in the soil; it is in the atmosphere. The atmospheric air encloses about 78% nitrogen (N_2), but atmospheric nitrogen is not in a form that plants can use.Without nitrogen, plants could not live and in turn human civilization would not be possible.Actually, over the years, humans have grown over 350 species of edible plants using no-till, organic methods that donot require chemical fertilizer or pesticide use(www.growjourney.com).

However, interestingly, anthropologists have shown that agricultural societies throughout history have distorted as a direct result of depleting their soil fertility, especially bio-available nitrogen (Jared 2005; Tobias, 2008). Once the soil could nolonger grow crops, food became scarce. Without food, the societies' socio-political structures inevitably collapsed. Post-collapse, whoever was left alive

would move on to areas with more fertile soil and start over. Otherwise in some cases, civilizations would anticipate this process by invading/conquering other lands, enslaving the indigenous populations, and sending their resources back home.

This is one of the reasons why advanced, modern societies do everything they can to make sure food is cheap and plentiful, even if the quality of that food is abysmal and they are rapidly degrading the soil in the process. Hungry people become revolutionaries, a threat to the stability of the state. Unfortunately, producers have been accomplishing the objective of feeding the growing global population largely through increasing the use of synthetic nitrogen fertilizer and other industrial farming methods that reward short-term results over long-term systemic impacts. But Chris (2017) disclosed that the compounding effects of this approach are catastrophic, and unless they change course or are able to colonize space in the near future, there is nowhere left on this planet to migrate once the soils can no longer grow the food, clean the air and water.

For any agriculturally linked human civilization that trusts on production of maximum nutritional yield and creation of sound environment, there is a need to knowing and understanding about the importance of synthetic fertilizers, and chemical pesticides on their health and environment as well as alternative options and requirements. As Nitrogen is the key element in the human, plant and animal nutrition, more attention should be paid for application of synthetic nitrogen fertilizer throughout human civilization and its impact on the environment. This meansScientists and Growers should answer or reflect the questions of whysynthetic nitrogen fertilizer cannotbe used by certified organic farms if it is used on conventional farms and why does it matter whether the growers use synthetic nitrogen fertilizer or organic one in their farm?

Therefore, the main objective of this review is to address those questions by referring the latest soil science researches combined with the actual many years of society member personal experience doing on no-till, organic and/or conventional farming andagro ecology.

Atmospheric Nitrogen conversion in to Plant Available form and Its Importance

The energy in lightning strikes to break N_2 bond of the nitrogen in the atmosphere. The resulting nitrogen oxides are then dissolved in the rain and converted to plant-available nitrates. On the other hand, certain types of bacteria in the soil are able to convert atmospheric N_2 into plant-available forms (Utah State University, 2016). Once the nitrogen is in a bioavailable form, it is cycled through the food chain via processes such as consumption, excretion, and decomposition. Some of this nitrogen is also respirated or volatilized back into the atmosphere. The other anthropogenic technic of N_2conversion is through Haber process which is called “Industrial Fixation”. In 1909, the German chemist Fritz Haber-Boschfigured out how to convert atmospheric nitrogen into ammonia ($N_2 + 3H_2 \rightarrow 2NH_3$). This process was ramped up for large scale production with the help of Carl Bosch.

Today, the synthetic nitrogen fertilizer made from the “Haber-Bosch” process is a key component of conventional farming. As a result, about 80% of the nitrogen in human’s body is from synthetic nitrogen fertilizer (unless who eat certified organic food).Moreover, recently, Researchers of Utah State Universityhave created a new light/solar-driven process to convert dinitrogen into ammonia, *(*Brown *et al.,* 2016). So there are now technically four ways that nitrogen moves from atmosphere to soil.

Influence of nitrogen fertilizer formation process on Plants, humans and environment

Duringthe 1930s-60s, the Green Revolution drastically increased global synthetic nitrogen fertilizer, pesticide, and hybrid seed use and increased yield per hectare. During that time, Norman (1914-2009), who was fierce defender of conventional agriculture, said that synthetic nitrogen fertilizer is not different than other forms of nitrogen and there are no nutritional benefits to eating organic food.

Conversely, in 2016, a meta-analyses of 263 peer reviewed research studies proved that organically-produced meat and dairy are significantly more nutritious than their conventionally produced counterparts (Średnicka *et al*., 2016ab). Similarly, a review of 343 peer-reviewed studies published in 2014 in the British Journal of Nutrition concluded that

organic produce is not only significantly more nutritious than conventional produce, but also has the added benefit of drastically reducing pesticide and heavy metal exposure (Barański *et al*., 2014). These advantages obtained from organic produces might result from Nitrogen fixation through lightening and biological activities.

The Haber-Bosch process is an extremely energy-intensive process that accounts for about 1-2% of total global energy consumption. It requires high pressure and high temperatures between 750-1200°F. It also requires hydrogen (H_2). The primary source for that hydrogen is methane from natural gas or petroleum which is increasingly comes from hydrolic fracturing. Additionally, there is concern over the possible adverse public health and Environmental impact implications of hydraulic fracturing activity (Broomfield and Lelland, 2013; Finkel and Hays, 2013). A review on shale gas production in the United States disclosed that with increasing numbers of drilling sites, more people are at risk from accidents and exposure to harmful substances used at fractured wells (Centner, 2013). A 2011 hazard assessment recommended full disclosure of chemicals used for hydraulic fracturing and drilling as many have immediate health effects, and many may have long-term health effects (Colborn *et al*., 2011).

Most evidence suggests that contamination of groundwater is most likely to be caused by leakage through the vertical borehole. Contamination of groundwater from the underground hydraulic fracturing process itself is unlikely. However, surface spills of hydraulic fracturing fluids or wastewater may affect groundwater, and emissions to air also have the potential to impact on health (Kibble *et al*., 2014). A report by Broomfield and Lelland (2013) also identified potential risks to humans from air pollution and ground water contamination posed by hydraulic fracturing. The potential environmental impacts of hydraulic fracturing also include air emissions and climate change, high water consumption, water contamination, land use, risk of earthquakes, noise pollution, and health effects on humans (Begley and McAllister,2013; Ellsworth, 2013; Kibble *et al*., 2014;Moran,2015).
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Impact of Synthetic Nitrogen Fertilizer on soil Carbon and Nitrogen Cycle

In nature soil is a massive biological recycling machine.Soil is a living system comprised of trillions of macro and microorganisms that works synergistically with plants to create a self-improving system. But this statement by conventional farmer or agricultural extension agent states that it does not apply to high-yield staple food crop production.The interpretation that seems to still be universal in conventional agricultural science is that soil is a sterile, inert substance that requires increasing quantities of annual fertilizer and pesticide applications in order to grow a food plant. And the only metric of import is yield: how much edible plant material can be extracted from a piece of dirt, while socializing the costs of the negative externalities (Elaine, 2015).

Researchers began measuring the effects of synthetic nitrogen fertilizer on soil health starting in 1967. However, the first study by Khan *et al.* (2007) found that synthetic nitrogen fertilizer use was rapidly depleting soil's carbon sequestration abilities.*"Intensive use of N fertilizers in agriculture is motivated by the economic value of high grain yields and is generally perceived to sequester soil organic C by increasing the input of crop residues. After 40 to 50 year of synthetic fertilization that exceeded grain N removal by 60 to 190%, a net decline occurred in soil C despite increasingly massive residue C incorporation".*

Similarly, the second study by Mulvaney *et al.* (2009) demonstrated that long-term use of synthetic nitrogen fertilizer was increasingly depleting the soil's nitrogen storage capacities, and therefore making continued crop production on those soils impossible:The authors asserted that the decline in soil Nitrogen in their study was in agreement with numerous long-term baseline data sets from chemical-based cropping systems involving a wide variety of soils, geographic regions, and tillage practices.Researchers also stated that the loss of organic N decreases soil productivity and the agronomic efficiency of fertilizer N and has been implicated in widespread reports of yield stagnation or even decline for grain production.

In short, the conventional thinking of conventional agriculture in regards to synthetic nitrogen fertilizer use is dangerously wrong. Synthetic nitrogen fertilizer is rapidly depleting the world's soil fertility, burning out

its carbon stores, and causing an increase in fertilizer use in order to continue getting a yield from the same land.This is why, in the past four decades, nitrogen fertilizer efficiency has decreased by two-thirds while nitrogen fertilizer use per hectare of land has increased sevenfold (Global average of 8.6 kg/ha in 1961 to 62.5 kg/ha in 2006)) (Pawel, 2015).

Effect of Synthetic Nitrogen Fertilizer on Water Supply

Healthy soil absorbs rainfall, retains and cycles the water, and eventually cleans the water on its way to the aquifers, streams, rivers, and oceans but the opposite does under unhealthy soil. As the more synthetic nitrogen fertilizer applied on the soils, the less those soils will be able to retain and cycle nitrogen, and other nutrients, the more nitrogen we have to input to continue getting a crop yield, and the more pollution willbe caused. For instance,according to NOAA(2015) and Pam (2016)the massive algae blooms shutting down beaches and rivers in Florida and the 6,500 square mile "dead zone" where the Mississippi River empties into the Gulf of Mexico were caused by mostly synthetic nitrogen fertilizer and phosphorus runoff from farms and lawns. These fertilizers stimulate rapid growth of phytoplankton, which then use up all the oxygen in the water, making it impossible for other organisms to breathe.

High concentrations of nitrates in our acidic stomachs form nitrosoamines**,** which are carcinogenic. This means that people consuming these nitrates have an increased risk of developing certain types of cancer. Another major concern with high nitrate concentrations in drinking water is infant methemoglobinemia .Infants fed water-added baby formulas are at high risk, especially if they live in agricultural areas (Frank *et al.*, 2005).

Importance of Synthetic N Fertilizer on Plant Pathogen and Insect Burden

Healthy soils grow healthy living plants. Conversely, plants grown in degraded soil without beneficial microorganisms present to protect and feed them will develop macro and micronutrient deficiencies, making them prime targets for pest insects. There are hundreds of species of predatory insects at Agricultural Farms. Healthy communities of below and above ground organisms keep pests and pathogens from becoming a problem for plants. According to SARE (2012) a review of 50 years of research identified 135 studies showing more plant damage and/or greater numbers of leaf-chewing insects or mites in nitrogen-fertilized crops, while fewer than 50 studies reported less pest damage in the nitrogen-fertilized crops.

Many researchers have demonstrated that high nitrogen levels in plant tissue can decrease resistance and increase susceptibility to pest attacksand the response of pests to nitrogen fertilizer has recognized dramatic expansion in pest numbers with increases in fertilizer rates (Chow *et al*., 2009, Daniela *et al.*, 2014).

Similarly, Altieri and Nicholls (2003*)* reported that crop fertilization can affect susceptibility of plants to insect pests by altering plant tissue nutrient levels. Their research shows that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical and mainly biological properties of soils. Soils with high organic matter and active soil biology generally exhibit good soil fertility and crop pest resistance. In contrast, farming practices, such as excessive use of inorganic fertilizers, can cause nutrient imbalances and lower pest resistance.

Impact of Synthetic Nitrogen Fertilizer on Global Warming

The synthetic nitrogen fertilizer that makes from industrial fixation is accelerating climate change largely because of the biological processes it generates in the soil. Climate scientists have long known that there was a sharp spike in N_2O (nitrous oxide) emissions corresponding with the increased synthetic nitrogen fertilizer usage of the Green Revolution. According to UC Berkeley (2012) report, increased fertilizer use over the past 50 years is responsible for a dramatic rise in atmospheric nitrous oxide, which is a major greenhouse gas contributing to global climate change. Climate scientists have assumed that the cause of the increased nitrous oxide was nitrogen-based fertilizer, which stimulates microbes in the soil to convert nitrogen to nitrous oxide at a faster rate than normal.

Park *et al.* (2012) concluded that limiting nitrous oxide emissions could be part of a first step toward reducing all greenhouse gases and lessening global warming, especially since immediately reducing global carbon dioxide emissions is proving difficult from a political standpoint. In particular, reducing nitrous oxide emissions can initially offset more than its fair share of greenhouse gas emissions overall, since N_2O traps heat at a different wavelength than CO_2 and clogs a window that allows Earth to cool off independent of CO_2levels.There is more carbon in the earth's soil than in the atmosphere and all plant life combined (2,500 billion tons of C in soil vs. 800 billion tons in atmosphere and life forms).The soil has lost somewhere between 50-70 percent of its carbon and cause global warming (Judith, 2014).

The related loss of soil nutrients means the foods that humans eat today have far less nutrition per calorie than the ones that parents and grandparents ate, we have to eat more calories to get the same nutrition.A mere 2 percent increase in the carbon content of the planet's soils could offset 100 percent of all greenhouse gas emissions going into the atmosphere (Rattan, 2015).

The researchers' message is that any agricultural practices must prevent the loss of nutrients and promote carbon sequestration in the soil system. Therefore synthetic N fertilizer application for crop production must be managed to reduce nutrient loss (soil carbon distraction) and thereby to reduce global warming.

Conclusion

In the human development, synthetic nitrogen fertilizer has compounding and accelerating power on the interrelated problems of soil degradation, water pollution, human health, and global warming. But Researchers have established a possible work that feeding a growing global population with sustainability goals in mind. Thepublished studies provide evidence that organic farming can produce sufficient yields, be profitable for farmers, protect and improve the environment and be safer for farm workers.However, the inverse is for conventional farming as synthetic chemicals including nitrogen fertilizer destroys soil carbon and undermines soil and human health.

Hence, instead of using synthetic nitrogen fertilizers and pesticides on theagricultural lands, it is better to use biological fertilizers that boost soil microbial communities, build soil organic carbon, and cycle nutrients.The researchers and scientists are suggesting the local, state, and national representatives to shape the public policies that shape the world agricultural production system and focusing on regenerative/organic agriculture. This review helps to think on the impacts of synthetic nitrogen fertilizer and the many benefits of organic farming methods.

Conflict of interest

The author didn't declare conflict of interest regarding to this work

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