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Mini Review

Agriculture and the Dark Side of Chemical Fertilizers

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Abstract

Agricultural pollution is a significant problem in our present system of food production. The interminable use of chemical fertilizers is accelerating many interrelated problems like soil pollution, water pollution and air pollution, thus affecting the future of our planet and humanity. Besides maintaining the long term productivity to feed an ever increasing world population, measures must be taken to address the environmental and economic concerns associated with the chemical intensive farming practices. Soil is vital for survival of all forms of life on earth and it should be preserved and treated respectfully. In this article, the dark side of chemical fertilizers use is discussed briefly.

Introduction

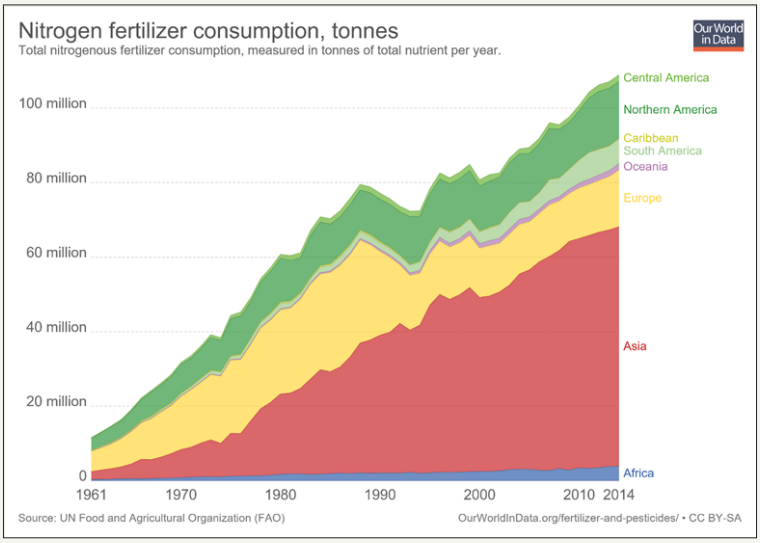

Figure 1: Continued use of Nitrogen fertilizers since its introduction in the agriculture system.

Agriculture is inextricably linked to nature, and many aspects of nature are deeply influenced by human actions directly or indirectly, and the modern agriculture is an extreme example of this. The exponential increase in world population and growth in food consumption are placing unprecedented demands on agriculture and natural resources. In its unsustainable form, besides consuming the nonrenewable resources, it is eroding the natural resources faster than the environment can regenerate or replenish them. Agriculture's deep connections to the world economy, human societies and biodiversity in ecosystems, further makes it as one of the most important frontiers for conservation around the globe and it is a critical part of any movement towards sustainability. Agriculture is only considered as sustainable when it is ecologically sound, economically viable, socially just, culturally appropriate, and based on a holistic scientific approach [1]. With the advent of Green Revolution in the second half of the 20th century, our agriculture system relied more on chemical fertilizers use. Professor Norman Borlaug, the leader of the Green Revolution,

and other plant breeders contributed towards developing dwarf, high-yielding varieties of cereals which were totally dependent on chemical fertilizers to exhibit their high yield performance. Thus, in order to boost the crop yields, this chemical fertilizers' addiction was embraced globally and got deeply rooted in our main agriculture system. No doubt, Haber's major discovery (industrial method to synthesize ammonia from nitrogen gas and hydrogen gas) revolutionized the agriculture world by averting the global famine and definitely solved the food problem for an overgrowing population during all these years (Figure 2) but it has a dark side too. This modern agriculture system with its reliance on monoculture, mechanization, chemical fertilizers and pesticides is detrimental to our ecosystem. Adopting management practices that protect water quality and conserve soils, combined with efficient use of fertilizers, will help reduce the negative impact of the current agriculture system towards meeting the needs of the present and projected future population growth.

Negative Impact of the Chemical Fertilizers on the Enviornment

Environment, the sum total of water, air and land interrelationships among themselves and also with the human beings, other living organisms has been severely affected by the continued and overuse of the chemical fertilizers, especially by the nitrogen fertilizers (Figure 1). The adverse impact on soil, water and air is discussed briefly here.

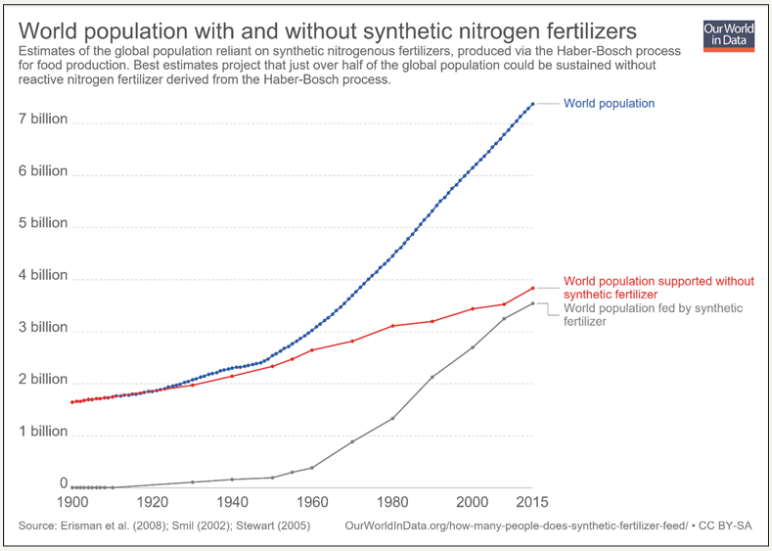

Figure 2: World population reliance on synthetic nitrogenous fertilizers.

Soil pollution

Soils are fundamental to life on Earth and play a critical role towards delivering ecosystem services but human pressures on soil resources are reaching critical limits. Careful soil management is one essential element of sustainable agriculture and also provides a valuable lever for climate regulation and a pathway for safeguarding ecosystem services and biodiversity [2]. Better stewardship of the soil is of prime importance since managing its chemical, biological, and physical properties directly contributes towards its fertility. The deterioration of soils is one of the most serious challenges encountered while using chemical fertilizers since their use gradually increase the acidity of the soil and it impedes the plant growth. Soils around the world have lost, on an average, at least 1 to 2 percentage points of organic matter in the top 30 cm since the adoption of chemical fertilizers use in the agriculture system. It takes 500- 1000 years to build one inch of topsoil and 24 billion tonnes of fertile soil is washed away annually making soil degradation a major threat to humanity [3]. Besides the chemical fertilizers use, the industrial agriculture also endangers the soil health since the heavy machinery compacts the soil, destroying soil structure and also killing the beneficial organisms in the soil food web. These soil organisms (beneficial bacteria, fungi, nematodes and protozoa) are vital for maintaining the soil fertility and productivity. With excess and repeated use of chemical fertilizers, the soil becomes infertile and barren thus limiting the crop production. Educating and making farmers more aware around the globe to apply the precise amounts of fertilizers can combat this issue.

Water pollution

The use of nitrogenous fertilizers has resulted in unacceptable levels of water pollution (increasing concentrations of toxic nitrates in drinking water supplies) and the eutrophication of lakes and rivers [4]. The nitrogen present in fertilizers breaks down into nitrates and reaches the groundwater. Since it is water-soluble and can remain in groundwater for decades, the addition of more nitrogen over the years has an accumulative effect. A recent study showed that the maximum NO_3– contaminant level of 10mg L^{-1} was exceeded in 22% of domestic wells in agricultural areas [5]. Fertilizers contain substances including nitrates and phosphorus that are flooded into lakes and oceans through rains and sewage which can lead to harmful algae blooms or hypoxia-reduced levels of oxygen and its deprivation leads to death of fish and other aquatic fauna and flora, often with disastrous consequences. Indirectly, it contributes to an imbalance in the food chain as the different kinds

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of fishes in the water bodies tend to be the main food source of various birds and animals in the environment. For example, the Chesapeake Bay, the nation's largest estuary, considered once the site of a highly productive fishery and renowned for its oysters, crabs, and clams, today represents an extreme example of the ecological ruin caused by the chemical fertilizers. This type of reactive nutrient pollution is now so common that the dead zones, acidified lakes, and major habitat degradation it can cause are occurring with greater frequency, not just in the Chesapeake Bay, but in other parts of the United States and around the world. The US EPA agency reports that the runoff of chemicals, silt, and animal waste from U.S. farmland has polluted more than 173,000 miles of waterways [6].

Air pollution

Air has physical properties and a chemical composition that are vital parameters of life for both plants and animals. Air pollution is a major concern, the large amounts of nitrogen being pumped into the environment from heavily fertilized fields and livestock waste are contributing to air pollution and to global warming. Agricultural air pollution comes mainly in the form of ammonia, which enters the air as a gas, besides the emissions of Nr (reactive Nitrogen) released into the atmosphere from agriculture, industry, and urban areas contributing to high levels of fine particulate matter (PM2.5), ground-level O3, and NO x in the air we breathe thus leading to premature death and other serious health effects [7]. Animal agriculture is responsible for more than half of the total greenhouse gas emissions and it contributes to 30-40% of all global NO x pollution and also the highest share of direct greenhouse gas emissions, equal to some 2.1 billion tons of CO2 annually. Excess fertilizer use also results in the emission of the gas nitrous oxide (N2O), which is 300 times more harmful than carbon dioxide. The changing dietary preferences, with a move towards meat and animal products rather than plant foods is also a big concern as revealed by an analysis that 75% of all agricultural land, including crop and pasture land, is dedicated to animal production [8]. It is projected that by 2030, emissions of ammonia and methane from the livestock sector of developing countries could be at least 60 percent higher than at present, if no serious measures are taken to combat this unintended air pollution. Reduction in meat consumption and shifting the allocation of crops from animal feed to directly feeding the human population would substantially reduce the burden on natural resources, besides contributing to significant health benefits like lowering heart disease, cancers and other chronic diseases.

Conclusion

Since agriculture has such profound effects on the environment and ecosystems functioning, it is extremely important to understand agriculture from ecological perspective. A new reconciliation of agriculture with nature is necessary. Agricultural operations should be sustainably managed, and a multifaceted approach is needed which not only preserve and protect the ecosystems in terms of soil health, water quality, and air quality but also feed our planet efficiently, nutritionally and in an environmentally responsible way. We should work with nature not against her. More awareness about the negative impact of chemical fertilizers, government participation towards better policy making and then successful implementation of these measures is much needed to combat this menace. Consideration should be given to long -term interests (preserving topsoil, biodiversity, water bodies) rather than focusing on short-term interests (profit and yield gains). Individual as well as collective efforts are must to hasten the shift towards a more sustainable agriculture where humans and the nature coexist in productive harmony.

Acknowledgements

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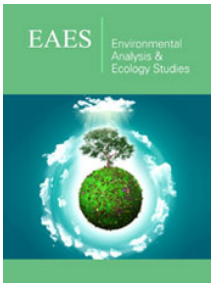

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