INTEGRATED NUTRIENT MANAGEMENT FOR COMBATING SOIL POLLUTION

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Introduction

"Soil pollution" refers to the presence of a chemical or substance out of place and/ or present at a higher than normal concentration that has adverse effects on any non-targeted organism (FAO and ITPS, 2015). Soil pollution can be due to the presence of man- made chemicals or other alteration in the natural soil environment. The man-made soil pollution is usually caused by various industrial activities, chemicals used in agricultural activities, or improper disposal of waste materials. The diversity of contaminants is constantly evolving due to agrochemical and industrial developments. Modern agricultural practices often lead to soil pollution to a large extent. The different agricultural sources of soil pollutants include agrochemical sources, such as fertilizers and animal manure, and pesticides. Trace metals from these agrochemicals, such as, Cu, Cd, Pb and Hg, are also considered soil pollutants as they can impair plant metabolism and decrease crop productivity. The misuse of organic and synthetic fertilizers leads to nutrient imbalances in soils, alters soil biodiversity, and produces changes in soil acidification which contributes to the mobilization and bioavailability of other contaminants. In addition, excess nitrogen inputs contribute to the release of N_2O into the atmosphere, a greenhouse gas with a higher potential warming effect than CO_2. Excess N and P cannot be absorbed by plants and soils, and consequently these macro elements contaminate surface and groundwater bodies. Water sources for irrigation can also cause soil pollution if they consist of waste water and urban sewage. Excess N and heavy metals are not only a source of soil pollution, but also a threat to food security, water quality and human health, when they enter the food chain.

Integrated Nutrient Management (INM)

Integrated Nutrient Management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. Integrated nutrient management can play a great role in improving plant growth and productivity. Integrated Nutrient Managment (INM) plays a great role in maintaining organic carbon-rich soils, restoring and improving degraded agricultural lands and, in general terms, increasing the soil carbon content and play an important role in addressing the three-fold challenge of food security, adaptation of food systems and people to climate change, and the mitigation of

anthropogenic emissions. The main components of INM include fertilizers, organic manures, legumes, green manures, crop residues and biofertilizers.

Role of Integrated Nutrient Management (INM) in combating Soil Pollution

Reducing chemical inputs is an important element of pollution prevention. The less a potentially harmful substance is used in agriculture, the less likely it is to affect other parts of the environment. This applies most directly to fertilizers, manures and pesticides. A good nutrient management is the practice of a pplying fertilizers and manures only in the amounts that can be taken up by a crop. Applications in excess of these needs have the potential to enter surface and ground water. In the past emphasis was on increased use of chemical fertilizers, but INM approach aim on educating farmers to optimize the use of organic, inorganic and biological fertilizers in an integrated way. As a result there will be regular supply for optimum crop growth and higher productivity, improvement and maintenance of soil fertility and zero adverse effect on agro-ecosystem quality. The increased use of chemical fertilizers alone is a great concern because of the following reasons:

a. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity regardless of being supplied with sufficient nutrients

b. The decline in productivity can be attributed to the appearance of deficiency of secondary and micronutrients

c. The physical condition of the soil is deteriorated as result of long term use of chemical fertilizers

d. Excess N and P may lead to ground water and environmental pollution

The components of INM are helping to reduce the soil pollution by reducing the use of chemical fertilizers. Applications of commercial fertilizers or animal manures often add more N than that is taken up by crops during a year in systems. In general the amount of N added for production of many field crops is the quantities of N expected to be taken up by the crop plus additional N to compensate for losses of N expected to occur. Hence, application of nutrients according to the crop demand and estimating available nutrients supply in the soil are very important steps in INM for reducing potential N leaching. To improve the efficiency of nitrogen fertilizers it is recommended to give as many split doses as possible to the crops and hence avoid the wastage and loss permanently. Inclusion of both shallow rooted and deep rooted crops in the cropping system is also one of the recommended practice to avoid loss of nutrients in the surface and deeper layers of soil. Site specific application is another important strategy to avoid the excess use of nutrients and lead to soil pollution. INM also advise to use slow/controlled release fertilizers and nitrification inhibitors for reducing the

nitrogen loss by leaching and other ways and also helps to improve nitrogen use efficiency (NUE). Neem coated urea, sulfur coated urea, polymer coated urea, biochar coated urea are examples of slow/ controlled release nitrogen fertilizers. Also soil pH management through the addition of adequate lime/gypsum helps to avoid the loss of nitrogen by other means.

One of the most important components of INM is the legumes which fix atmospheric nitrogen and act as a nitrogen source in soil. This nitrogen supply helps to reduce the use of chemical nitrogen fertilizer application rates. This synergistic relationship between legumes and component crops are very much helpful in reducing the soil pollution by the use of nitrogenous fertilizers. Legume help in solubilizing insoluble P in soil, improving the soil physical environment, increasing soil microbial activity, and restoring organic matter, and also has smothering effect on weed and help in disease and pest control. The carryover of N derived from legume grown, either in crop sequence or in intercropping system for succeeding crops, is also important.

Organic manures as INM components help to improve soil quality by altering chemical and physical properties, increase organic matter content, water holding capacity, overall diversity of microorganisms, provide essential macro and micronutrients to plants and suppress diseases. Organic manures aid to reduce the use of chemical fertilizers to crops and hence reduce the pollution due to fertilizer chemicals. Manure management is a very important step to avoid environmental pollution due to the emission of green house gas methane. Methane is emitted during the anaerobic decomposition of manure. The amount of methane produced from manure depends on i) the quantity of manure, which depends on the number of animals, the quantity of feed consumed, and the digestibility of the feed ii) animal type, the condition of the digestive tract, and the quality of the feed consumed iii) the manure handling method - liquid versus solid storage (Liquid manure management systems, such as ponds, lagoons, and holding tanks lead to anaerobic conditions, which can emit up to 80 per cent of manure based methane emissions, while solid manure emits little or no methane) and iv) environmental conditions (temperature and moisture).

The things to be ensured during manure handling are

- Avoid adding straw to manure because straw acts as a food source for anaerobic bacteria, resulting in higher methane emissions.
- Apply manure to soil as soon as possible because storing manure for long periods can encourage anaerobic decomposition and result in increased methane emissions.
- Avoid manure application when the soil is extremely wet, as this leads to anaerobic conditions and increased methane emissions.

- apply manure shortly before crop growth to allow for the maximum amount of available nitrogen to be used by the crop
- Avoid applying manure in the cool seasons because it lead to high emission of nitrous oxide and high nitrogen loss in the summer.
- Avoid applying manure when the weather is hot and windy, or before a storm, because these conditions can increase nitrogen oxide emissions.
- Implement soil and water management practices such as: improving drainage, avoiding soil compaction, increasing soil aeration, and using nitrification inhibitors for nitrogen gas production instead of nitrogen oxide.
- Spread manure evenly around the crop field.
- Maintain healthy pastures by implementing beneficial management grazing practices to help increase the quality of forages.
- Avoid applying excess amounts of manure because nutrients can be lost to the environment. Testing both the soil and the manure before application ensures the proper nutrient balance for plant needs and can help reduce the loss of nutrients as GHGs.

Composting is another option in INM which helps to convert the agricultural and other wastes to enriched manures hence alleviate the soil pollution due to wastes generated in the farm. Composting also helps to reduce the pest and disease by suppressing the pathogens. Value addition also takes place by this process and nutrients in the unavailable condition will convert to easily available and ready to use form.

Biofertilizers are essential component of INM, which are preparations containing living cells or latent cells of efficient strains of beneficial microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. Beneficial microbes helps to reduce the need for the use of chemical fertilizers and thereby reduce environmental pollution caused by chemical fertilizers. Beneficial microbes are very important in increasing crop productivity, profitability and sustainability by releasing growth promoting substances and vitamins to maintain soil tilth and fertility and also by suppressing the incidence of pathogens. There are nitrogenous biofertilizers, phosphatic biofertilizer, potassic biofertilizers and arbuscular mycorrhizal fungi. Applications of organic manures such as animal manure, poultry manure, green manure, composts, farm yard manure, biochar, and ash increase the beneficial microbes in the soil and improve soil health and overall sustainability (Amanullah, 2015).

Controlling erosion and runoff is an important management strategy. Practices such as strip-cropping, shelterbelts and use of cover crops prevent erosion and reduce the movement of nutrients and pesticides from agricultural

land. Residue management through conservation tillage and continuous cropping is also effective in controlling erosion. A balance between erosion control and protection of water quality may have to be established to maximize conservation. Barriers and buffers can be planted to intercept and contain contaminants that are being carried from agricultural lands. In most cases, these are strips of vegetation that slow the velocity of runoff water enough for sediment to settle out, water to infiltrate into the ground and nutrients to be taken up by plants. Grassed waterways, vegetative strips and field borders are examples of buffers that can be used in annually cropped fields moving into the waterway from surrounding agricultural lands. The vegetation also stabilizes the banks and shores from the erosive action of the waterway itself.

Intercropping is another important option in INM which helps to reduce the loss of applied nutrients and increase the nutrient use efficiency within the system. The inclusion of annual and perennials in the system aid to explore the entire soil profile and utilizing the nutrients in surface and subsurface soil. This helps to reduce the excess retention of chemical fertilizers in the soil. Also the disease and pests will be suppressed by adding the trap crops as an intercrop. The pollution due to the application of pest control chemicals can be reduced by this way. The beneficial associations like mycorrhiza can be enhanced by including both tree spp as intercrop.

Crop residue management is a big problem when it is accumulated in the field. Proper management of residue ensures in INM and this may helps to reduce the pests and disease problems and also incorporation in the composting process helps to avoid loss of nutrients stored in the stubbles. Adequate measures to incorporate crop residues help to avoid leaching losses, help in improving water holding capacity, improve organic matter in the soil and help in microbial enrichment.

Conclusion

Sustainable agriculture requires that soil, water and air quality be maintained. Best management practice helps to reduce environmental pollution and retain more benefit to soil and crops. INM is one of the known and acceptable best management practice and if properly followed the INM approach can reduce the agricultural pollution to a great extent.

References

Amanullah. 2015. The Role of Beneficial Microbes (Biofertilizers) In Increasing Crop Productivity and Profitability. EC Agriculture 2.6: 504.

FAO & ITPS. 2015. Status of the World's Soil Resources (SWSR) - Main Report. Rome, Italy, ood and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils. (also available at http://www.fao.org/3/ a-i5199e.pdf).