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Potential Environmental Impacts of Uncomposted Organic Materials, Composts and Manures

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Abstract

Soil health is central to organic farming and organic inputs are applied to improve it so as to get higher economic yields on sustainable basis. A lot of work has been done around the world to support this fact. But there are environmental concerns related to the use of inputs which include the losses of nutrients from the farming systems to the open ecosystems causing damage to the water bodies including underground water contamination. Gaseous nitrogen losses tend to be lower from composted than fresh organic materials. There is a need to investigate trade-offs between different gaseous and leaching forms of pollutants following compost application. The environmental impacts of organic materials including uncomposted and composted manures applied to the soil to get higher production and productive of crops, have not been studied by many. This review paper is an attempt to summarize the same.

Keywords: Compost, Manures, Pollution, Environmental impact

Introduction

Soil health is central to organic farming, but its potential has not been fully explored. Soil is a living dynamic system that functions in a holistic way depending upon its condition or state. Its reflection can be seen in terms of our own health. And phrases such as soil sickness, feeding the soil etc take on a real meaning when soil is managed and treated as a vital living system.

Soil health has been formally defined as "the capacity of a specific kind of soil to function as a vital living system, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation."

Organic farming systems are dependent upon the management of soil organic matter which enhances the chemical, biological, and physical properties of the soil, in order to optimise crop production. This subject has been reviewed by Watson et al. [1]. Soil management has a bearing on the supply of nutrients to crops, and inturn to livestock and humans. In addition to symbiotic N fixation and atmosphericdeposition, nutrients may be brought in to the organic system in the form of off-farm animal feeds, manures, composts and permitted fertilisers, such as rock phosphate [2]. Soil type and its inherent nutrient supplying capacity will decide the type and quality of fertilizers to be supplied. Watson et al. [3] highlighted that horticultural systems are dependent upon purchased manures and other organic inputs.

Though there is a vast literature available which indicates the positive effects of the organic materials including compost and manures on soil health; there is meagre work reported showing the environmental impacts of use of undecomposed organic materials, decomposed organic manures and compost. Here, it has been tried to review the literature regarding potential environmental impacts from the use of organic materials.

Nitrate Leaching

Generally, nitrate nitrogen leaching begins immediately after its level in soil exceeds the demand by the crops when enough drainage volume is present. In organic farming systems nitrate accumulates from both added organic matter and mineralization of soil organic matter. Initial N content of the organic material does not always indicate the potential for leaching as the nitrogen content in mineral and organic forms varies tremendously. As reported by Di & Cameron [4] the mineral nitrogen contents (% total N) ranged from 15% in anaerobic dairy sludge to 60-85% in pig slurry.

Leaching loss depends a lot on the time of application of manures. Application of dairy waste in four splits resulted in lesser leaching of nitrogen when same amount was applied in two splits, because there was more synchronisation between supply nitrogen and demand of nitrogen by the pasture [4]. Method of application is also important as far as the environmental contamination from the use of organic inputs is concerned. Application of fresh and composted biosolids increased the risk of P and metal leaching, But, had no effect on nitrate leaching as observed by Gove et al. [5].

Not much work has been reported, comparing leaching loss from composted and fresh material. lysimeter experiment conducted by Leclerc et al. [6], in which the concept of leaching/supply ratio was used to study the effects of different organic amendments across a rotation, revealed that the ratio was lower for composted manure than for urban compost. Vervoort et al. [7] reported lesser nitrate leaching from composted than fresh chicken manure. There may be the possibility that the capacity to immobilize nitrogen from high C:N ratio wastes is responsible for its lower leaching. For example, Vinten et al. [8] demonstrated a drop in leaching from 177 to 94kg N ha-1yr-1 in vegetable production system when 40tha-1 dry matter of paper mill waste was applied.

Runoff and Erosion

Use of municipal solid waste compost can reduce degradation of surface structure, thus decreasing losses by runoff and erosion [9]. Composted as well as non-composted municipal wastes have the ability to reduce runoff and erosion as proved by Ros et al. [10]. Though, both treatments reduced runoff in amended soils as compared with unamended soil, but compost has an edge in reducing soil loss over less stable material.

Loss of phosphorus in runoff from applied manures is determined by the type of manure and crop. Sharpley and Rekolainen [11] quoted losses of from 1.9 and 17.1% of applied P in manure lost in run-off. The main hurdle in minimising this loss is the inability of the farmer to apply at right time which is due to the lack of adequate storage facilities with the farmer. No difference in the levels of soluble phosphorus in runoff from composted and fresh chicken manure was observed by Vervoort et al. [12], inferring that runoff is directly correlated with the amount of phosphorus applied to soil. Sharpley and Moyer [12] recorded the release of dissolved organic and inorganic phosphorus from simulated rainfall events from a range of slurries and manures applied at the equivalent of 10Mgha-1.

Gaseous Losses

About 10% of ammonia emissions in Europe is due to the emission of ammonia from field applied manures [13]. A complex relationship exists between ammonia emission rates from slurry and soil conditions, slurry composition and climate Sommer and Hutchings [14]. Meagre research work is available on solid or poultry manure. Aerobically stored manures when applied to field cause more ammonia losses as compared to anaerobically stored ones [15]. Ammonia loss from slurry is directly proportional to the dry matter content [16]. A comparison was made between ammonia volatilization from surface applied fresh and composted poultry manure under laboratory conditions. Total ammonia loss for a 21day period varied from 17-31% from fresh material compared with 0-0.24% from composted material. Method of application such as slurry application to ploughed land and manures incorporation into cultiviable land have been proved to decrease ammonia loss over surface application [14].

Annual nitrous oxide emissions are directly proportional to manure application rate [17]. Kaiser et al. [18] reported an inverse relationship between nitrous oxide emission and dry matter to N ratio of incorporated crop residues. However, few studies have compared annual nitrous oxide losses from field application of different organic materials. Mogge et al. [19] compared losses from slurry and FYM application to maize. About 5.7% of applied nitrogen (equivalent to 5.3kgha-1) was lost as nitrous oxide in the FYM treatment as compared to compared only 0.6% of applied nitrogen in the slurry treatment (equivalent to 2.1kgha-1). No significant effect was recorded with the addition of 30Mgha-1 household compost on cumulative nitrous oxide production as compared with an unamended soil, in a laboratory incubation experiment done by De Wever et al. [20]. Further it was concluded that the use of compost as a fertilizer at normal agronomic rates would not have much effect on nitrous oxide production. Contrasting results have been observed for sewage sludge in field trials. A cumulative loss of 23kg nitrogen ha-1 along with high carbon dioxide losses of 5.1MgCha-1 from incorporated sewage sludge was recorded by Scott et al. [21].

Human Pathogens

Some scientists like Stephenson [22] have suggested that the use of manures and organic food without preservatives may mean a high level of microbial contamination of organic food. The organic standards, however, prevent the use of fresh manure and require good management practices in the storage and handling of manures and composts. Both composting of farmyard manure [23,24] and anaerobic digestion of slurry [25] have been reported to decrease pathogen viability. There have been a number of claims of E. coli (O157:H7) outbreaks being associated with organic food [26] but none of these claims have ever been proven. There is no concrete evidence in the form of research reviews which prove that certified organic food contains any traces of E. Coli as compared to the conventionally produced food. Advanced research should be carried out to standardize the microbiological risks associated with different production systems.

Mawdsley et al. [27] reported that 11 bacteria, 3 viruses and 4 protozoa/parasites were present in livestock waste which may cause human disease. Contamination of ground and surface waters with pathogenic organisms can be caused by application of animal wastes on land [28]. These contaminats from ground water can be transmitted to both humans and livestock. E.

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coli, and especially verocytotoxin producing E. coli, including serogroup O157 is excreted by as much as 15.7% cattle in the UK [29].

Very high concentration E. coli in field drains were recorded after application of slurry, but low-level contamination persisted for 3 months only [30,31] quotes a review by Sorber & Moore [32] summarising data on survival of microorganisms from biosolids applied to soil. The median die-off rate (days, 99%) was 155 for total coliforms in the top 5 cm of soil, and 22 and 30 days for Salmonella in the 0-5cm and 5-15cm soil layers.

Potentially toxic elements (PTE's)

Urban wastes are fully of heavy metal contaminants. This problem is also with animal manures where metals are present in their feed e.g. Cu in pig and poultry feeds. Many fungicides contain Cu, Zn or Mg and their residues may remain on composted organic matter [33]. The level of potential toxicity increases exponentially in a hierarchical manner in a food chain which must be considered in perspective of human and animal health. The pattern of release of plant available metals from decomposition of organic materials cannot be predicted from laboratory extractions. For example, Arnesen & Singh [34] observed that application of compost increased plant Cu levels but not DTPA extractable Cu but the reverse was true for Zn. Type of soil will determine the pattern of release of available heavy metals and nutrients elements, which depends upon the leaching/adsorption properties of the soil which in turn depends on pH, texture and organic matter content of soil. Plots treated with organic manures showed less available copper than control plots in spite of having high levels of copper in manures, thus demonstrating moderating effect of soil [35].

From a review of 96 articles on phytotoxicity caused by metals from municipal solid wastes, from a review it was concluded that plant uptake of Cu, Ni, Zn, As and Pb was less although municipal solid wastes were used as source of nutrients [36]. It was further inferred that boron levels would have no deleterious effect inspite of its increasing levels in soil. Modern manufacturing processes have changed the compositions of waste materials and thus, the old literature may not give the correct picture about the toxicity effects of waste materials. Regulation also limits the application rate of potentially toxic elements from sewage and sludge. Giusquiani et al. [37] observed that total heavy metals accumulation in soil is directly proportional to the rate of application of urban waste compost. Application of mixed compost of paper sludge and chicken manure increased the available Mn and Zn content in soil Baziramakenga et al. [38].

In acid soils, additions of organic residues decreased exchangeable Al in the order poultry manure>filter cake>household compost>grass residues when same number of residues were applied Mokolabate & Haynes [39]. It was suggested that this may be due to the high $CaCO_3$ content in the case of poultry manure and filter cake, the proton consumption capacity of humic material present in the household waste and decarboxylation of organic acid anions during decomposition of the grass residues.

Conclusion

Gaseous nitrogen losses tend to be lower from composted than fresh organic materials, but management options to minimise these losses need further development. There is a need to investigate trade-offs between different gaseous and leaching forms of pollutants following compost application. This should include methane and carbon dioxide. There is little information on pathogen persistence and movement in soils/water following spreading. Gaseous and leaching losses from the use of compost need to be assessed in the context of the farming system rather than for individual crops.

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