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Review Paper

A Review on Microbiological and Nutritional properties of Livestock Manure and its Impacts on Soil Physical, Chemical and Biological parameters with special reference to Indian Himalayas

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Abstract
The present review is aimed to summarize the literature and the current status on the effect of live-stock compost manure on soil agro-ecosystem. Reviewed literature confirms the potential of composted manure to enhance soil physical, chemical and biological properties. Livestock compost system was found to promote the diversity of microbes (bacteria and fungi) by providing diverse nutrient sources, tolerable temperature range, proper aeration and acceptable pH for the growth of a wide group of microorganisms. The concentration of total dissolve salt (in terms of available nutrients) and macro nutrients are also reported higher in manure amended soil. In addition, due to its multiple positive impacts on soil health, live-stock manure also contributes to increase crop yields and its quality. Researchers reported that compost shows positive impacts on water holding capacity and moisture content along with lowering the bulk density of soil. However, the availability of nutrients varies with soil profile (different depths) and incubation time after manure amendments due to the microbial transformation and water mediated movement of ions through soil profile. Thus, for sustainability of agro-ecosystem; use of homemade livestock manure can be a good option for developing countries like India, composted manure not only sustains soil health by maintaining nutritional status but also promote microbial activity in soil. In India, the farmers of rural area use less synthetic fertilizers as compare to plain area due to unavailability and economic problems, in context of low land holding farmers and importance of open heap compost used traditionally in the Indian Himalayas, present review is aimed to compile the nutritional properties of the compost as well biological properties along with its impact on the farm land in order to validate this traditional agriculture practice.

Key words: *Live-stock compost, Soil microbiota, Plant nutrients, Soil physico-chemical property, Compost nutrients, Electric conductance, Succession.*

Introduction

Organic farming is a productive system which avoids or largely excludes, the use of chemical- synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. The objectives of environmental, social, and economic sustainability are the basics of organic farming (Stockdale *et al.*, 2001**).** The key characteristics include maintaining the long-term fertility of soils with the aid of organic matter levels, fostering soil biological activity, careful mechanical intervention, nitrogen self-sufficiency through the use of legumes and effective recycling of organic materials including livestock wastes or crop residues. India is one of the agricultural based nations with more than 58% of the population out of 1200 million, pertaining to agricultural sector. Before 1960, in India only OF (Organic Farming) practice was followed without chemical fertilizers and pesticides. In recent time, Government of India has entered collaboration with USA for reforming farming practices by adding chemical products for cultivation, diseases and weed management. After 40-50 years, production and productivity declined through time with abnormal input costs, resulting farming sector turned to be unfavourable occupation to all concerned. Soil degradation, more diseases, uncontrollable weeds, high water consumption, unfavourable price and with several natural and anthropogenic issues, conventional farming turned to be unworthy for farmers. Organic agriculture is now being practiced in more than 130 countries with a total area of 30.4 million hectare, about 0.65% of total agricultural land of the world (Willer *et al*., 2008). With respect to the area under organic agriculture, Australia occupies the top position followed by China, Argentina, USA, Italy and many other countries. Today, the growing population pressure forced many countries to use synthetic-fertilizers to increase the productivity for meeting their increasing food requirements. The prolonged and over usage of chemicals has, however, resulted in human and soil health hazards along with environmental pollution. Farmers in the developed countries are, therefore, being encouraged to convert their existing farms into organic farm. A great emphasis is placed to maintain the soil fertility by returning all the wastes to it chiefly through live stock waste to minimize the gap between N, P, K addition and removal from the soil (Chhonkar, 2002). Soil organic matter is considered as a major component of soil quality because it contributes directly or indirectly to its physical, chemical and biological properties. Thus, soil amendment with composts is an agricultural practice commonly used to improve soil quality and also to manage organic wastes. Beside the soil nutrient profile, manure can greatly effects the physical properties of soil *i.e.* Bulk density, moisture content, water holding capacity and pH. In general, the application of organic manure lowers the bulk density, increase water holding capacity and moisture content of soil which ultimately make it favourable for better crop production. In this context, Bonde *et al.* (2004) observed that the application of organic residues significantly lowered the bulk density in manure amended soil over control. Among different residues, live-stock manure resulted in greater availability of nitrogen, phosphorus and potassium in soil compared to other treatments (wheat straw compost) including control in cotton-soybean cropping system. Furthermore, some researcher reported that the application of organic manure lowers the bulk density with increased in OC content of soil (Rajshree *et al.,* 2005).

Applying livestock manure locally called as 'Mole' is one of the most useful and significant indigenous methods practiced almost in all villages of Uttrakhand hills of India. Application of livestock manure is a practice which involves using of fully decomposed organic matter of livestock excreta mixed with bedding material (straw, grasses, leaves) of live-stock. The type of bedding material used for cattle depends upon the availability of resources in nearby forests (Mishra *et al*., 2008).

Sustaining soil organic carbon (SOC) is of primary importance in terms of cycling plant nutrients and improving the soil physical, chemical and biological properties. SOC is an important index of soil quality because of its relationship with crop productivity (Lal, 1997). A decrease in SOC leads to a decrease in soil's structural stability (Le Bissonnais and Arrouays, 1997) and also restoration of SOC in arable lands represents a potential sink for atmospheric CO_2 (Lal and Kimble, 1997). Agricultural utilization of organic materials, particularly farmyard manure (FYM) has been a rather common traditional practice (Shen *et al.,* 1997). As it enhance the soil organic C level, which has direct and indirect effects on soil physical properties. The application of inorganic fertilizers has been widely observed to increase the crop yields. The inorganic fertilizers affect soil physical environment by increasing the above ground and root biomass due to immediate supply of plant nutrients in sufficient quantities (Bostick *et al.,* 2007).

In India, declining of soil fertility is a major issue to agricultural productivity and economic growth. Although the traditional live-stock composting process is being practiced in India for long time ago, but a very few data is available on its quality, impacts on soil health (Physical, chemical and biological properties) and sustainability of cropping system in north-western Himalayas of India. This motivated the present review; we evaluated the significance of compost and its impacts on soil properties (Physical, chemical and biological)

Compost Characteristics

Use of homemade live-stock compost for sustainability of soil health and crop productivity is being practiced in Indian Himalayas since time immemorial. It refers to the decomposed mixture of excreta of farm animal along with leaf litter (bedding material) and left over material from fodder fed to the cattle. Manure collected daily consists mainly of dung and part of urine soaked in the refuse, which is allowed to decompose for a sufficient period of time in a form of open heap. This open heap composting involves the microbial decomposition of live stock waste and litter under aerobic conditions to produce a humus-like nutrient rich end product. Typically, Live-stock manure contains 0.70-1.30 % nitrogen (N), 0.30-0.90 % Phosphorus (P), 0.40-1.00 % Potassium (K) and 24-40 % organic carbon (OC) depending upon the type of animals and nature of material used (Chhonkar, 2003). Moreover, urine part of excreta contains more percentage of nitrogen and potash compared to the dung portion.

This traditional practices followed by the farmers in central Himalayas of India, reveals rich reservoir of Indigenous Technical Knowledge (ITK) available. The experimental findings of Subramanyeswari in 2007 revealed that there is abundant knowledge and practices that have been used from generation to generation and local practices is much favourable for organic livestock production. From the soil fertility point of view, the excreta of various farm animals is important for supply of three major nutrients mainly, N, P_2O_5, K_2O along with organic matter and found to contribute significantly not only for soil quality but better crop yield by increasing soil OC, total N, P and K (Poul *et al.,* 2004)**.**

The farmers of rural area use less synthetic fertilizers as compare to plain area in India, due to unavailability or economic problems (Singh and Rachel*,* 2010) and routinely apply livestock compost and vermicompost to the crop fields either alone or in combination with some available mineral fertilizers. Live-stock manure act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of microbiota in soil, which ultimately influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Albiach *et al*., 2000). It contains organic matter in large quantities and makes a slow but steady supply of nutrients to plants. This is a bio-oxidative process involving the nutrient mineralization through microbial metabolism and humification of the organic material, leading to a stable end product that is free of phytotoxicity and pathogens and with certain humic properties, which can be used to sustain soil quality and fertility (Zucconi and Bertoldi, 1987). Traditional practice is followed by the farmers for better handling, transport and management (Bernal *et al*., 2009).

Frequently, the live stock waste is heaped up and attention is not paid to the process conditions (aeration, temperature, ammonia loss, etc.) and using rudimentary methodology; while, the benefit of a range of organic material applications (livestock manures, composts, biosolids, etc.) for SOC and quality has been widely documented and reviewed (Johnston *et al*., 2009). Knowledge about the micro-organisms present in composts, their coexistence and the successional pattern during the entire degradation process should help to ensure a high quality of the final compost product (Miller, 1993). The stability of final composted material is strongly related to microbial activities during the composting process; therefore, several authors have suggested that microbiological parameters can serve as indicators of compost maturity (Tiquia, 2005).

Significance of live stock manure
Traditionally in hilly areas of India, the process of Live-stock manure commence with the collection of forest litter of the adjacent area and used as bedding of live-stock over night. When cattle pass on excreta over it and next day this mixture is transferred to outside of the house. This compost from the base of the heap is transferred to fields followed by scattering of manure and ploughing.

Typically the composting process can be divided into four phases: (1) First mesophilic phase (15-40 °C), which may last for a couple of weeks; (2) Thermophilic phase (temperature up to 60-65 °C), lasting for months; (3) Second mesophilic phase (4) The stabilization phase which can last for several months (Hoitink and Boehm, 1999). In latter phases, the microbes often similar to those of the previous ones (That has ability to survive in harsh environments *viz.* Spore forming microbes) that recolonize the substrates. The nature and population size of microorganisms in any composting heap directly reflects the quality of manure through microbial nutrient bio-transformation and depend on a number of factors, one of which is temperature. The open heap compost system consist greater microbial activity due to proper aeration, suitable temperature and moisture as compare to close pit compost system (Francis *et al.*, 2003). Comparatively, homemade composts also contain higher counts of heterotrophic bacteria, and fungi then that of close pit compost system (Ivon *et al.,* 2007). These results may be because of both the milder conditions of home composting where temperatures do not exceed 45–50ºC and the similarity of the pH of these composts and of the culture media used, which presumably favoured the microbial recovery. This is previously reported that the temperature can also affects the degradability and microbial mediated nutrients dynamics because it is a key limiting factor for microbial growth. The highest degradation rate reported at 50ºC, while degradation was to some extent lower at 28-65ºC and at 75ºC it was reported at least level, but helps to solubilize as a result of the high temperature and alkaline reaction of the compost (Waksman *et al.*, 1939). The temperature in aerated composting process do not goes very high up to thermophilic phase as it promote the enormous growth of microbes, that's why it is more useful as compare to other composting processes (Taiwo *et al.,* 2004)

Chemical properties
Live stock manure contain considerable amount of macro and micro-nutrients which are converted to their available form through microbial mediated nutrient bio-transformation. Electrical conductivity is a measure of total cations and anions in solution and was usually determined largely by Mg and Ca ions (Clark *et al.*, 1998). The EC value of manure reflects the amount of total dissolved salt present and directly related to the availability of nutrients for plants.. The availability of nutrients, in terms of electric conductance also exhibited variation with composting time; the mineralization of nutrients was thought to be the microbiologically mediated which depends on various biotic and abiotic factors.

Fluctuation in electrical conductivity after such a period of composting indicated the loss of nutrients reduced salt content of the manure (Eghball *et al.,* 1997). The higher EC values in composted manures could be attributed to the release of salts from the manure with the passage of time. Simple correlation study shows that manure P and K2O was positively correlated with EC, might be due to the conversion of these nutrients to plant available form (Irshad *et al.,* 2013). The application of manure also improves total soluble salts and Na adsorption ratio in the soil (Chang *et al*., 1990). The previously reported nutritional profile of live stock manure shows that it may contains 0.70-1.30 per cent nitrogen (N), 0.30-0.90 per cent Phosphorus (P) and 0.40-1.00 per cent Potassium (K) and 24.00-40.00 per cent organic carbon (OC) depending upon the type of animals and nature of feed (Chhonkar, 2003). Among different residues, live stock manure has been reported in greater availability of nitrogen, phosphorus and potassium in soil as compared to other amendments (wheat straw and pressmud compost etc.) including control in cotton-soybean cropping system (Bonde *et al.,* 2004). However, the nutritional profile of organic manure varies widely with animal species, age, ration and feed consumed, as well as with type of process, temperature and moisture content. Typically, manure contains nitrogen, phosphorus and potassium (NPK) as major nutreints, as well as many trace nutrients such as Mg, Ca, S, Zn, Cu, B, Mn etc. (Fulhage, 2000). Overcash *et al.* (1983), have reported in their study that live-stock manure contains, 31, 42, 27, and 19 g kg^{-1} (3.1, 4.2, 2.7 and 1.9%) N, of total solids when collected from scraping under slotted floors, in pits or tanks, in bedded units, and in earthen feedlots, respectively. Fresh and scraped beef manure had phosphorus (P) contents of 11 and 7 g kg-1 (1.1 and 0.7%) of dry weight, and potassium (K) contents of 25 and 20 g kg-1 (2.5 and 2.0%), respectively (Westerman *et al*., 1985). About 58% of N is in the urine, mostly as urea (Overcash *et al*., 1983). About 96% of P is contained in feces, while 73% of K is excreted in urine (Safley *et al*., 1985). Additionally, Live-stock manure is source of macro and micro nutrients essential for normal growth of plants (Eghball and Power, 1994), but not all of the secondary and micronutrients in manure are plant-available. The loss of nutrients from developing manure is the second major concern, some previous research conducted in controlled environments to evaluate the loss of nutrients from manure through various factors indicated that aerobic composting of manures can lead to significant gaseous and leachate losses of N and other nutrients, with the greatest losses, up to 77% of the initial N, in gaseous forms, and this could be a drawback of high microbial metabolism in open system (Martins and Dewes, 1992). Nonetheless, the changes in nutritional status and nutrients mineralization of compost during time interval depend on the composting system and conditions; characteristics of both the bedding material and environmental conditions of the season (Parkinson *et al*., 2004). This factor also affects the rate of decomposition process. Sometimes the concentration of P and Potassium K in developing manure showed decreasing pattern as in case of N, but runoff loss is the main mechanism of P loss during composting process. The decrease in P and K concentration is thought to be due to runoff and leachate from the compost with number of rainfall event (Eghball *et al.,* 1997). Tiquia *et al.* (2002), reported P and K losses 23 to 39% and 20 to 52% of the initial P and K respectively. Substantial losses of P and K could be attributed to run-off and leaching from the manure, however, in case of open heap system the available forms of these elements are not volatile but the loss is attributed to runoff (Reddy *et al.,* 2010). The mineralization of phosphate during the degradation process is might be due to the formation of ammonium phosphate as ammonia decomposes phosphates get converted to some other insoluble form and hence the amount of phosphate decreases in available form.

Biological properties

The biological properties (*viz*. Types and numbers of bacteria and fungus populations) were earlier reviewed by Ryckeboer *et al.* (2003), somewhat depends on the organic residues and type of bulking agents used in composting process which are mainly derived from locally available plants material. The foremost requirement for microbial growth is a C source, beside the C source; macronutrients *i.e.* N, P, and K with some trace elements are required for proper growth and metabolism (Tuomela *et al*., 2000). The ability of nutrients assimilation from complex substrates is depends on types of microbes present and their metabolic enzymes machinery for degrading that particular substrate (Tuomela *et al*., 2000). The availability and loss of these nutrients from manure heap are summarised in our previous topic under chemical properties of manure. Under Open heap system as it promote aerobic growth of microbes, temperature is a key selective factor for growths and optimum metabolic performance (Miller, 1993)

TABLE. Numbers of microbes in composting process

Organism	Number
Bacteria in mesophilic stage	10^9 - 10^{13} g^{-1} substrate.
Bacteria in thermophilic stage	10^8 - 10^{12} g^{-1} substrate
Actinomycetes in thermophilic stage	10^7 - 10^9 g^{-1} substrate
Actinomycetes in meshophilic stage	10^8 - 10^{12} g^{-1} substrate
Fungi*, average value	10^5 - 10^8 g^{-1} substrate

(Source: Miller, 1993)

As earlier stated, that composting is a dynamic process and governed by a large number of biotic and abiotic factors. Change in any of these factors does not only alter the quality of compost but also change the time required for composting. Once the microbial consumption of substrate has been stimulated to a certain level, the faunal effect will become quantitatively important (Tian *et al.,* 1995). Adequate knowledge of microbial flora associated with it is very important in any chosen composting method. Various studies have been carried out to identify the major microbiological agents responsible for biodegradation. For example, Macdonald *et al.* (1981) noted that composting process was brought about by several organisms such as bacteria, fungi, actinomycetes and protozoa and may also involve invertebrates such as nematodes, potworms, earthworms mites and various other organisms. Singh (1987), however, noted that the sole agents of decomposition of carbonaceous materials are the heterotrophic microorganisms.

Sawant *et al.* (2007), while working on microflora associated with cow dung manure, isolated different bacterial genera *i.e., Citrobacter koseri, Enterobacter aerogenes, Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, Kluyvera* sp., *Morgarella morganii, Pasteurella* sp., *Providencia alcaligenes, Providencia stuartii* and *Pseudomonas* sp. The succession and diversity of microbial communities during the various composting phases plays a key role in the organic matter transformation and reflects the particular environment being established in the compost (Ryckeboer *et al*., 2003). The population density or diversity of bacterial or fungal-flora associated with manure decomposition, throughout the process is directly linked to the temperature reached in the compost heap.

The microbial load during the early phase of decomposition remain high as compare to mid thermophilic phase due to the availability of plenty of substrates in initial mixture (Golueke *et al.,* 1992; Hargerty *et al*., 1999); however, in some researches it was observed that primary decomposers create a adoptable conditions for secondary organisms, which cannot attack the initial substrates, while metabolites produced by the one group can be utilized by the other (crossfeeding), this leads to the succession of microorganisms in decomposing manure through time (Davis *et al*., 1992; Golueke, 1992; Ryckeboer *et al*., 2003). The decreasing density of bacterial population could be due to the unavailability of nutrients and adverse growing conditions *i.e.* desiccation and temperature of compost at maturation phase of composting process (Chandna *et al.*, 2013). This increase in bacterial density is thought be due to the favourable growing conditions for a wide range of microorganisms such as moderate temperature, partially decomposed substrate, pH and other factors (Rebollido *et al.,* 2008). Microbial competition and antagonistic behaviour also affects the type of microorganisms present at any time, the enormous growth of fungi in mesophilic or cooling phase could suppress the growth of fungi due to antagonistic behaviour or secretory secondary metabolites in surrounding environments (Cecilia, 2006).Fungi play a vital role in organic matter decomposition some author reported that the population of fungi is higher as compare to other microbes in during the decomposition of manure. Ashraf *et al*. (2007) reported majority (38%) of the total number of isolates were members of the genus *Aspergillus* while *Bacillus* was found to be the second largest genus comprising 20% of the total microbial isolates during compost decomposition. The isolated fungi were belongs to the genus *viz*., *Aspergillus, Trichoderma, Mucor, Penicillium, Alternaria, Cladosporium, Monilia, Helminthosporium, Coccidioides, Scedosporium,* actinomycete. The population density of fungal species is depends on temperature profile and available substrates in manure. Most of the fungi are sensitive to heat and can't grow at thermophilic stage of manure decomposition, thus heat is a major limiting factor for fungal growth in compost process (Adegunloye *et al*., 2007) , very few fungi can tolerate the moderate thermophilic range of temperature including . Among fungi, substrate is initially colonised by pioneer saprophytic species followed by more specialised polymer degraders, which utilise cellulose, hemicellulose or chitin. In later stage, the fungal flora comprises species able to break down recalcitrant compounds. In similar patteren bacteria showed successional changes during organic matter decomposition (Dilly and Irmler, 1998). *Aspergillus, Penicillium* etc. The presence of the *i.e Aspergillus, Fusarium* and *Alternaria* in live-stock waste can be attributed to high content of cellulose and hemicellulose as these are responsible for lignin decomposition (Reza, 2008). The main cellulose utilizing species are the aerobic and anaerobic filamentous fungi (Wright, 2003). Edesi *et al*. (2012), have reported the higher abundance of cellulose decomposer cattle manure.

Due to the heterogeneity of substrates, little is known about original composition of the waste microbial community. Only few researchers reported on microbial diversity present in organic waste material. Von Klopotek (1962), isolated few mesophilic fungi from fresh municipal solid waste at a temperature of 36ºC. Ryckeboer *et al*. (2003a), found neumerous mesophilic and thermophilic fungi in source-separated household waste. Beside the harmless fungal populations, some pathogenic fungi *i.e. Alternaria, Fusarium, Crynespora, Cladosporium* were also isolated from compost during study period.

The live-stock manure compost contain beneficial micro and mycoflora which can potentially soulubilize phosphate and also produce indole acitic acid which helps in plants growth. Swain *et al.* (2012), in their study recovered thermotolerant *Baillus subtilis* form Cow dung with effective phosphate solubilisation potential. The isolated strain also shows antagonistic activities against plant pathogens along with production of growth regulators.

Uniyal *et. al.* (2016), while working on beneficial mycoflora associated with decomposing livestock manure, isolated two species of fungi (*Aspergillus* and *Penicillium*) which were observed to have strong phosphate solubilization and indole acitic acid producing potential, quantitatively as well as qualitatively. In terms of beneficial microbes researchers also reported pollutant degrading microbes in cattle manure such as *Acinetobacter, Bacillus, Pseudomonas, Serratia* and *Alcaligenes* sp. (Umanu *et al*., 2013). Beside phosphate solubilization by fungal components, many researchers also reported phosphate solubilising bacteria from developing manure. Atekan and Handayanto (2014) set an experiment using Pikovskaya method qualitatively followed by quantitatively, to isolate bacterial species from developing compost manure, and to test ability of the isolated bacteria to dissolve phosphate. Hameeda *et al*. (2008), isolated 207 species of bacteria using different compost waste. Out of these 5 species were found to solubilise rock phosphate with highest efficiency, *Serratia marcescens* and *Pseudomonas* sp. Solubilized P in buffered roch phosphate (RP) medium. Solubilization of di- and tri-calcium phosphate solubilisation by bacteria and fungi from chromite, iron and magnese mines were reported by Gupta *et al*. (2007). They also reported that fungi are better solubilizers than bacteria. Different species of fungi namely *Aspergillus, Penicillium* and *fusarium* were isolated and their phosphate solubilisation efficiency has been worked by some researchers (Wakelin *et al*., 2004). It is clear that several fungal strains, mostly belonging to the genara of *Penicillium* and *Aspergillus*, have been reported as plant growth promoters by their phosphate solubilising activities.

Impacts on soil health

Various researchers focused their study on nutritional status of live-stock manure and its effects on soil physico-chemical properties, crop quality and quantity. The literature showed that organic practices are the key of long term sustainability of agricultural land and having no adverse effect on soil in comparison to chemical fertilizers. Farmers in the Indian Himalayas routinely apply composted livestock manure to their soil, either alone or in combination with mineral fertilizers. However, there is limited research on the effects of these organic amendments on yield of crops and on soil properties, particularly during the period of transition to organic production. We chose to review the impact of traditional livestock manure amendments on physico-chemical and biological properties of soil.

Soil Physical properties

Manure can greatly effects the physical properties of soil *i.e.* Bulk density, moisture, water holding capacity. In general, application of organic manure lower the bulk density, increase water holding capacity and moisture content of soil. The manure was observed to decrease the bulk density of soil (Bonde *et al.,* 2004) with increasing its water holding capacity and total organic content (Rajshree *et al.,* 2005). Similarly, Ghuman and Sur (2006), come out with same findings, reported that application of manure increase soil total organic carbon content, lower bulk density and lower pH besides increasing yield of crops. However, some of previous research stated that use of recommended dose of fertilizers along with organic input also helps to reduce the soil bulk density (Bandyopadhyay *et al.,* 2010). The bulk density of soil may vary with the quantity of organic manure applied to the soil. Soil amended with high organic input showed lowest bulk density observed by Gopinath *et al*. (2008). Additionally, the soil texture is somewhat responsible for the bulk density of soil. Islam *et al.* (2011), reported that soil treated with organic matter decreased bulk density from 1.52 to 1.40 g cm^3.

Past investigations demonstrated that application of livestock manure greatly affects soil water content in terms of water holding capacity and moisture content due its high organic matter fraction which is thought to be responsible for increased moisture content and water holding capacity of soil (Bouajila and Sanaa, 2011). Soil water holding capacity increased instantly with the application of manure, however the texture of soil is the primary factor followed by increased organic C input (Brown and Cotton, 2011). The live stock manure showed positive impacts on infiltration rate and runoff volume by up to 20% (Ramos and Marttinez-Casasnovas, 2006) The water retention power of soil might be decreased gradually after application of live stock manure in soil reported by some researchers (Saxton, 2003). Previous work by Korodjouma *et al.* (2006), suggested that the mixing of organic matter content in soil can affect the soil moisture content by changing the soil structure and porosity. Furthermore, the role of soil texture in soil moisture content and water holding capacity is well defined as evident from the positive relationship between soil fine particles content and water holding capacity. The water holding capacity is proportional to clay content and inversely proportional to the sand content of soil. Many workers have observed these correlations between soil texture and moisture contents of soils (Saxton, 2003).

The addition of organic matter increase root biomass in soil which subsequently helped in soil microbial growth that cause beneficial effects on water holding capacity and hydraulic conductivity (Katkar *et al.,* 2012).

Soil chemical properties

Increased in soil pH in manure amended soil is regarded as a major advantage when compost manure is used (Mkhabela and Warman, 2005). Research data in this regard shown to that manure significantly improves soil pH and helpful to sustain the soil as a adoptable habitat for microbes. Increases in soil pH after addition of organic manure from 6.1 to 7.6 (Hernando *et al.*, 1989), 5.8 to 6.4 (Maynard, 1995), 5.9 to 6.3, and 5.4 to 5.8 (Mkhabela and Warman, 2005), 5.3 to 6.6, and 6.0 to 6.6 (Zheljazkov and Warman, 2004), 4.9 to 5.8 and 5.1 to 5.9 (Shanmugam, 2005), and 5.8 to 6.7 and 6.1 to 6.5 (Zhang *et al.*, 2006) have been reported earlier. Although, these increase were usually proportional to the application rate. The increase in the pH of soil may be due to the mineralization of carbon and the subsequent production of OH ions (Mkhabela and Warman, 2005).

The main reason for manure to raise soil pH is due to the lime like materials such as calcium and magnesium in the manure. Therefore, applying manure to soils not only supply much needed nutrients and organic matter for plant growth but also reduce soil acidity, thus improving nutrients availability and reducing toxicity (Zhang, 1998). In contrast to this, the decreasing trend of pH in manure amended soil through time may be due to the controlled microbial mediated metabolism and organic matter depletion. These findings are in line with the findings of Roy and Kashem (2014). They also observed the decreasing trend in pH of manure treated soil and the amount of reduction was about 1 unit within 60 days of incubation.

Similar to that of pH, soil electrical conductance (EC) is also improved with the application of livestock manure. Soil EC directly reflects the amount of dissolved salt (Plant available form of nutrients), high organic input in soil enhance the microbial mediated mineralization and solubilisation of insoluble nutrients to soluble form. In support of this assumption, Eghball (2002) showed that the manure/compost application enhances soil EC. Soil EC is also directly proportional to the rate of manure application. The effect of the manures in increasing the EC is a reflection of the amount of dissolve salt (DS) in the manures. As mentioned earlier, the salts in the manures are usually sourced from the feed additives (Goff, 2006). Nevertheless, salinity of animal manure and potential secondary soil salinization induced by its application is greater in manure treated soil. The addition of such manures to the soil in large amounts increased the soil EC and salt content. Manure-induced salinity in soil has also been reported erliear by Pratt (1984) after 4 years of livestock manure application. However, the loss of soluble nutrients from soil results the decreasing value of EC, furthermore the less retainable soluble salts can move through different soil profile from surface to bottom soil (Santillan, 2014; Roy and Kashem, 2014). Inputs in organic cultivation to soil were higher in C, P, K, Ca and Mg as a result of manure applications than inorganic fertilization (Clark *et al*., 1998). Nutrient levels in the soil also varied accordingly. Higher levels of total organic C, total N, and soluble P were reported for organic soils (Poudel *et al*., 2002), whereas Mader *et al*. (2002), reported small differences for soil chemical parameters like organic C and P. Availability of soil N was most important in limiting the yield in organic systems, though mineral N levels varied by crop farming system and the amount and source of N fertilization (Poudel *et al*., 2002).

Investigators demonstrated the significant effects of manure in soil nutrient dynamics. Previous observation showed that total N and total organic carbon (OC) of manure treated soil were significantly higher as compare to manure untreated soil with respect to depths. Most of the nitrogen in livestock manure originated from plant material used in bedding and excreta. Studies showed that about 70–80% of the nitrogen (N), 60–85% of the phosphate (P_2O_5), and 80% of the potassium (K_2O) fed to animals are excreted in the manure (Klausner *et al*., 1984). Hao *et al.* (2003), observed that the value of total N in soil amended with manure gradually increased to some extent after manure amendments, this could be attributed to the continuous microbial mediated mineralization in soil and then decreases. The decreased value of N in soil could be associated with the volatilization, and conversion in available form (Roy and Kashem, 2014). It is well documented that application of livestock manure in soil increases total organic carbon content, its different fractions as well as soil microbial activity (Marschner *et al*., 2003). Findings of Bastida *et al*. (2008), showed that manure treated soils have a significantly higher OC throughout the experiment than the untreated soil. The quantity of soil P is greatly influenced by the manure application. Composted livestock manure is a rich source of available phosphorus and this further increase the concentration of available phosphorus in amended soil due to microbial metabolism (Eghball and Power, 1997; Irshad *et al*., 2013). In contrast to this, the more soluble form of P are subject to leachate loss or movement to bottom soil from upper soil surface, which is a major concern in manure amended soils which subsequently deplete the P from soil (Santillan, 2014). Low mineralization rates of P were seen immediately after application, but after a residence time of 3 months, the concentration of P is sufficient for plant growth (Iglesias-Jimenez *et al.*, 1993). Soumare *et al.* (2003), conclude in his study that, 10–50% of total P in compost is available both in the first and second year after application. Plant uptake of P is increased with the addition of compost and uptake increased with application rate (Shanmugam, 2005). Livestock manure is considered to be a rich source of available K; about 90-100% K in manure is available to plant as synthetic fertilizer reported by Hao and Chang (2003a) and Schoenau and Davis (2006). The concentration of mobilized and solubilised form of K increased gradually in manure amended soil via microbial mediated production of organic acids (Uroz *et al*., 2009). Live-stock manure itself contain a heavy fraction of K, a soil microbe undergoes partial decomposition of this organic material which subsequently releases available-K in soil. The organic and inorganic acids convert insoluble K to the soluble form of K with the net result increasing the availability of the nutrients to the plants. The various types of organic acid produced by K-solubilising microbes differed with different organisms. Total pool of soil K is extremely complex and this can be solubilised by the microorganisms through production of acids and it will be available for plant, most of the total soil K available to plants is usually located in the topsoil due to high microbial activity (Basak and Biswas, 2012).

Regarding the secondary and micronutrients dynamics in soil; the concentration of Ca, Na, Zn, Cu, Fe and Mn was found significant in manure treated soil in previous studies. It is well documented that livestock manure is a plenty source of available micronutrients. Eghball (2002), reported greater than 55% of calcium (Ca) and magnesium (Mg) and less than 40% of zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), sulfur (S), and boron (B) is remain in plant-available form in livestock manure. Nevertheless, the salt content of manure is highly variable, depending on the livestock species, diet formulation and salt content of the livestock drinking water. Furthermore, the concentration of these nutrients in manure amended soil is influenced by the rate of manure application, mineralization and immobilization.

The heavy fraction of livestock manure supports the growth and activity of a wide range of microbial population; which further responsible for the mineralization of organic content and subsequent release of micronutrients in soil (Kumar *et al*., 2004). The concentration of Zn, Mn, Fe and Cu was reported significant by condition and interaction with incubation time. Livestock manure contributing to increase soil Zn concentration with incubation time and this significant increase of soil Zn with incubation time and interaction with depths might be due to the slow microbial transformation and mobility of Zn through soil profile (Ayten, 2004).
Zhang *et al*. (2006), in his work reported an increased Cu concentration in manure amended soil and concluded that the Cu has greater mobility potential from surface to bottom soil. The higher concentration of Cu in bottom soil is probably due to its high mobility potential also reported by Cerqueira *et al*. (2011).

The concentration of Fe and Mn is also affected by the application of manure, it is well documented that about 40% Fe and Mn of livestock manure is plant available (Eghball, 2002). The application of such amendments in soil directly enhances the quantity of available micronutrients. However, the concentration of these nutrients in soil is somewhat depends on the incubation period, probably due to microbial mediated enzymatic decomposition of organic amendment.

Warman *et al*. (2004), in their work reported a significant increase in soil Fe after manure application. The higher concentration of soil Mn after the application of livestock manure could be attributed due to the soluble organic matters which increase the Mn availability by providing a strong buffer for free Mn (Businelli *et al*., 2009). Ano and Ubochi (2007) while working with compost prepared from different sources. The positive correlation among pH and Ca, Mg concentration of soil indicating the subsequent releasing of these salts from organic material due to microbial metabolism (Azeez and Averbeke, 2012). Researchers observed a lower level of available Ca with incubation time due to antagonistic effect of increased K concentrations on Ca uptake and formation of Ca-P precipitates that reduces Ca solubility on amended soils (Leytem *et al*., 2011). Beside all of these trace-nutrients, the concentration of Na was reported highly significant in manure amended soil which subsequently increases DS (Dissolve salt) concentration in soil. The increasing concentration of sodium in livestock manure treated soil is responsible for the increasing salinity of soil. This is the major advantage of Na in controlling the soil salinity in case of acidic soil. The concentration of Na in composted manure is directly proportional to the EC value (Hicklenton *et al*., 2001). The concentration of Na in manure is directly related to Na concentration in diet or in excreta (Hicklenton *et al*., 2001).

Soil Biological properties
Beside the physico-chemical properties of soil affected by livestock residue, the addition of compost may increase microbial population along with microbial biomass and enhance soil enzyme activity (Debosz *et al*., 2002), but little is known about the specific modifications received by the home made livestock manure of the microbial communities (Chander and Joergensen, 2002). The livestock manure along with synthetic fertilizer as a soil amendment in low-input intensive farming has been well documented as a major agricultural practice to improve soil quality and productivity (Kravchenko *et al*., 2017) Previous studies also suggested that live stock manure either alone or with synthetic fertilizers improved soil enzymatic activity and microbial population density (Zhang *et al*., 2015). Sun *et al*. (2015), reported that application of chemical fertilizers caused reduction in microbial diversity, whereas use of live-stock amendments restores the lost diversity. However, some researchers also suggested that the combined use of organic and synthetic fertilizers not only increased soil organic C but also enhanced the bacterial community which is associated with decomposition of complex organic matter and soil nutrients transformations (Li *et al*., 2017) . One of the most important impacts of

composted manure is the promotion of soil biology. Soil contains a great variety of microbes and these microbes perform a wide range of functions, which are major contributions to what we consider a healthy soil. The supply of C source play a key role in maintaining the balance of microbial population, in this regard, compost has a stimulation effect on soil-born micro-biota. Study reported by Brown and Cotton (2011), showed that compost amended soil has 2 times higher microbial count as compare to control soil due to plenty supply of organic substrates. The manure application to the soil increase soil micro-biota, and the population size of any microbial community is directly depends on the quantity and quality of substrate present. It may initially increase up to the plenty of substrates available and then gradually declined due to depletion of resources, which may be further increases with the re-addition of organic inputs, due to carbon addition and changes in physico-chemical properties of soil (Meena *et al*., 2015). In this regard, Zhen *et al.* (2014), suggested that the amount of humus in cattle manure treated soil is positively correlated with microbial population related parameters. Typically, soil treated with cattle manure contain indigenous population of microbes present in bovine excreta, viz. Enterobacteriaceae (*Enterobacter*, *Serratia*, *Yershinia*, *Citrobacter*) and Pseudomonadaceae etc. (Freitas *et al.,* 2003).

Live-stock manure not only enhances the population of bacteria but also improves the fungal density as well as diversity in soil. Mostly reported and dominated genera of fungi in manure amended soil are *Aspergillus*, *Penicillium*, *Fusarium, Trichoderma* and *Teleromyces.* Organic manures when applied to the soil supply readily available substrate to the cellulose decomposing fungi; this could be one explanation for the dominance of Deuteromycotina species in livestock manure amended soils (Swer *et al.,* 2011). Furthermore, Abawi and Widmer (2000), showed an increase in pathogenic fungi with organic fertiliser application. However, these pathogenic fungi did not cause any severity to the crop plants (Swer *et al.*, 2011). The occurrence and dominance of antagonist fungal species *i.e. Trichoderma, Penicillium* and *Aspergillus* sp. might have aid in antagonising the pathogenic species and reduce the disease severity which these fungi can inflict on the crop plants studied. As these species were largely isolated from the organically managed soils, enhancing the use of organic manures in a long run may perhaps prove crucial for large scale control of many soil-borne fungal diseases. This is of paramount importance in organic farming systems where soil fungus itself acts as a biological agent which can help in excluding the use of synthetic fungicides (Swer *et al.*, 2011).

Microbial biomass

Accumulation of organic carbon as a result of manure additions not only affects microbial community structure and functional diversity but has also has linked with increased microbial biomass (Zhen *et al*., 2014). The microbial biomass is linked with the decomposition of organic materials and thus, the cycling of nutrients through immobilization and their subsequent mineralization in soils. It is also frequently used as an early indicator of changes in chemical and physical properties of soil. Although, the soil microbial biomass carbon (MBC) constitutes only 1-3% of total soil C (Jenkinson and Ladd, 1981) but increased microbial biomass and diversity are beneficial for soil quality because soil microorganisms play a key role in soil nutrient cycling. They accelerate the breakdown of organic substances and mineralize the organic nitrogen and phosphorus contained in manures into plant-available forms. Non-viable microbial cells affect the turnover of macronutrients as a source of easily available substrates. All these parts of total microbial biomass are crucial for evaluating soil functions, however, only viable organisms take parts in the ongoing processes and consequently, all processes should be related to the mass of live microbes that drives biogeochemical cycling in soil.

The total microbial biomass includes all viable and nonviable microorganisms which are smaller than 150-200 µm. The total amount of microbial biomass is relatively small and it averages at 2-3% and usually does not exceed 4.5% of organic C content (Anderson, 2003). Non-viable mass of cells acts as a secondary pool of substrate but do not contribute to any microbial-mediated metabolic processes. Observations of Das *et al*. (2017), revealed that composted live stock cattle manure contributes significantly to increase availability of nutrients, improve soil pH along with high microbial biomass in treated soil, as compare to swine manure treated soil. These changes eventually responsible for enhanced aboveground biomass and grain yield under cattle manure amendment compared to swine manure amendment in a flooded rice cropping system. It is well documented that total organic input in soil is the key factor which stimulates the increasing microbial biomass and microbial activity reviewed by various researchers through time to time using different substrates, as such as cattle manure compost and rice husk compost (Chowdhury *et al*., 2000), shed effluent (Zaman *et al*., 1999), dairy and cow manure (Peacock *et al*., 2001), farmyard manure (Goyal *et al*., 1999). The qualitiy of organic substrates may differentially effects the soil microbiology since substrate composition has profound impacts on C use by microbial populations (Martens, 2000). Soil microbial biomass is affected by numbers of factor, one of which is the types of substrate available, thereby affecting soil quality. Hongli *et al*. (2003), concluded in his experiment that red bean straw can increase soil microbial biomass, may be because the main component of the straw, including cellulose, hemicelluloses, etc.

Microorganisms play a major role in decomposition, nutrient bio-transformations in soil (Sinegani *et al*., 2009). Microorganisms also immobilize the significant amounts of C and other nutrients within their cells. The total mass of living microorganisms (microbial biomass) therefore has a central role as a source, sink, and regulator of the transformations of energy and nutrients in the soil. In agricultural systems, soil fauna can be important in organic matter decomposition, nutrient cycling, and SOM dynamics. In this regard, bacteria and fungi are mostly responsible for 90–95% of the total heterotrophic metabolism occurring in most soils (Sinegani *et al*., 2009). The microbial community and its diversity have been significantly positively correlated with a wide range of environmental variables such as soil pH, C:N ratio etc. Previous studies, suggested that an increase of soil microbial biomass results in immobilization of nutrients, whereas decrease in microbial biomass results in mineralization of nutrients (Yang *et al*., 2010). Moreover, Soil microbial biomass is directly connected with the total organic carbon (TOC) content of soil, in this regards, Wang and

Wang (2007) while working on the microbial biomass related parameters, reported a linear correlation between TOC and soil microbial biomass. Recent study on impacts of types of substrate and their relation to microbial biomass C, N and respiration rate in soil by Zhen *et al*. (2014), indicates that live-stock manure amended soil have greater potential to produce higher microbial biomass, and microbial population density (*i.e.* bacteria, fungi and actinomycetes) as compare to soil amended with manure along with bacterial fertilizer. These findings support the hypothesis of live-stock manure contains a sufficient carbon source that enhanced the microorganism biomass. Furthermore, the value of microbial biomass for any cropland soil system does not remain same throughout the time, but gradually declined as due to transformation of soil nutrients and the enhanced competitiveness of crops (Inselsbacher *et al*., 2010)

Conclusion

Cultivation at larger scale using chemical fertilizers for fulfilment the required need of food, may lead to soil become infertile due to loss of soil organic matter that also shows unfavourable impacts on environment and can even threaten human as well as animal health and food safety. For this purpose organic inputs such as live-stock manure can consider as affordable for low land holder farmers, environmentally non-hazardous and a rich source of nutrients. Composted manure sustains soil health, increase soil microbiota and enzymatic activity in a long term scale. Homemade livestock compost system is a prominent practice to promote the diversity of microbes (bacteria and fungi) by providing diverse nutrient sources, moderate temperature, aeration and acceptable pH range for the growth of a wide range of microorganisms in a soil ecosystem. The proper aeration and adoptable temperature of compost during decomposition process plays a crucial role to maintain the diversity of bacteria as well as fungi. As a nutritional point of view the concentration of nutrients is also high as compare to other method of manure preparation. The manure also shows to have greater potential to improve soil physico-chemical properties, total salt concentration, pH and total organic carbon content. The community diversity of microorganisms and biomass C content is also high. The homemade livestock manure not only sustains soil health by maintaining nutritional status but also promote microbial activity in soil. It can be successfully used for sustainability of soil and better organic production. Furthermore, it will be interesting to find out the successional pattern and role of microbes in organic matter bio-transformation during the decomposition process of an open heap compost system, with some recent techniques.

References

Abawi, G.S. and Widmer, T.L., 2000. Impact of soil health management practices on soil-borne pathogens, nematodes and root diseases of vegetable crops. *Appl. Soil Eco*. 15:37-47.

Adegunloye, D.V., Adetuyi, F.C., Akinyosoye, F.A. and Doyeni, M.O., 2007. Microbial analysis of compost using cowdung as booster. *Pak. Jr. of Nutri.* 6(5):506-510.

Albiach, R., Cancet, R., Pomares, F. and Ingelmo, F., 2000. Microbial biomass content and enzymatic activities after the application of organic amendments to a horticultural soil. *Biors. Tech. Jr*. 75:43-48.

Anderson, TH., 2003. Microbial eco-physiological indicators to asses soil quality. *Agri.. Ecos. Environ*. 98:285-293.

Ano, A.O. and Ubochi, C.I., 2007. Neutralization of soil acidity by animal manures: mechanism of reaction. *Afri. Jr. Biotech*. 6(4):364-368

Ashraf, R., shahid, F. and Ali, A.T., 2007. Association of fungi, bacteria and actinomycetes with different composts. *Pak. Jr. Bot*. 39(6):2141-2151.

Atekan, Y. N. and Handayanto, E.S., 2014. The potential of phosphate solubilizing bacteria isolated from sugarcane wastes for solubilizing phosphate. *Jr. of degr. Mini. lands Manag*. 1:175-182.

Ayten, K., 2004. Effect of organic wastes on the extractability of cadmium, copper, nickel, and zinc in soil. *Geoderma*. 122:297 – 303.

Azeez, J.O. and Averbeke, W.V., 2012. Dynamics of soil ph and electrical conductivity with the application of three animal manures. *Commu. in Soil Sci. and Plant Analy*. 43:865-874.

Bandyopadhyay, K.K., Mishra, A.K., Ghosh, P.K., Hati, K.M., 2010. Effect of Integrated Use of Farmyard Manure and Chemical Fertilizers on Soil Physical Properties and Productivity of Soybean. *Soil & Til. Res.* 110:115-125.

Basak, B.B., Biswas, D.R., 2012. Modification of waste mica for alternative source of potassium: evaluation of potassium release in soil from waste mica treated with potassium solubilizing bacteria (KSB Germany: *Lambert Academic Publishing*. ISBN 978-3-659-29842-4.

Bastida, F., Kandeler, E., Moreno, J.L., Ros, M., Garcıa, C. and Hernandez, T., 2008. Application of fresh and composted organic wastes modifies structure, size and activity of soil microbial community under semiarid climate. *Appl. Soil ecol.* 40:318-329.

Bernal, M.P, Alburquerque, J.A. and Moral, R., 2009. Composting of Animal Manures and Chemical Criteria for Compost Maturity Assessment. A Review. *Biors. Tech*. 100: 5444-5453.

Bonde, A.N., Karle, B.G., Deshmukh, M.S., Tekale, K.U. and Patil, N.P., 2004. Effect of different organic residues on physico-chemical properties of soil in cotton soybean intercropping in Vertisol. *Jr. of Soils and Crops.* 14(1):112-115

Bostick, WMN., Bado, VB., Bationo, A., Solar, CT., 2007. Hoogenboom G, Jones JW. Soil carbon dynamics and crop residue yields of cropping systems in the Northern Guinea Savanna of Burkina Faso. *Soil Till. Res.*93:138-151.

Bouajila, K., Sanaa, M., 2011. Effects of organic amendments on soil physico-chemical and biological properties. *Jr. Mater. Environ. Sci.* 2: 485-490.

Brown, S., Cotton, M., 2011. Changes in Soil Properties and Carbon Content Following Compost Application: Results of On-farm Sampling. *Compost Sci. Utiliz.* 19:88-97.

Businelli, D., Massaccesi, L., Said-Pullicino, D., and Gigliotti, G., 2009. Long-term distribution, mobility and plant availability of compostderived heavy metals in a landfill covering soil. *Sci. Total. Environ*. 407:1426-1435.

Cecilia, M.L., Helmut, F. and Lars, J.T., 2006. Antagonism between bacteria and fungi: substrate competition and a possible tradeoff between fungal growth and tolerance towards bacteria. *OIKOS*. 113(2):233-242.

Cerqueira, B., Covelo, E.F., Andrade, M.L. and Vega, F.A., 2011. Retention and Mobility of Copper and Lead in Soils as Influenced by Soil Horizon Properties. *Pedosphere*. 21(5):603-614.

Chander, K. and Joergensen, R.G., 2002. Decomposition of 14C labelled glucose in a Pb-contaminated soil remediated with synthetic zeolite and other amendments. *Soil. Bio. Bioch.* 34:643-649.

Chandna, P., Nain, L., Singh, S. and Chander, R.K., 2013. Assessment of bacterial diversity during composting of agricultural byproducts. *BMC Microbio*. 13:99.

Chang, C., Sommerfeldt, T.G. and Entz, T., 1990. Rates of Soil Chemical Changes with Eleven Annual. Applications of Cattle Feedlot Manure. *Canad. Jr. Soil. Sci*. 70:673-681.

Chhonkar, P.K., 2002. Organic farmingmyth and reality, in *Proceedings of the FAI Seminar on Fertilizer and AgricultureMeeting the Challenges*, New Delhi, India, December.

Chhonkar, P.K., 2003. Organic farming : Science and belief. *Jr. Indian Soc. Soil Sci.* 51(4):365-377.

Chowdhury, M.A.H., Kouno, K., Ando, T., Nagaoka, T., 2000. Microbial biomass, S mineralization and S uptake by African millet from soil amended with various composts. Soil Biology & Biochemistry 32: 845–852.

Clark, M.S., Horwath, W.R., Shennan, C. and Scow, K.M., 1998. Changes in soil chemical properties resulting from organic and low-input farming practices. *Agron. Jr.* 90:662-671.

Das, S., Jeong, ST., Das, S., Kim, PJ., 2017. Composted cattle manure increases microbial activity and soil fertility more than composted swine manure in a submerged rice paddy. *Front. Microbiol.* 8-1702.

Davis C.L., Donkin C.J., Hinch S.A. and Germishuizen P., 1992. The microbiology of pine bark composting: an electron-microscope and physiological study. *Biores. Tech*. 40:195-204.

Debosz, K., Petersen, S.O., Kure, L.K. and Ambus, P., 2002. Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties. *Applied. Soil. Eco.* 19:237-248.

Dilly, O. and Irmler, U., 1998. Succession in the food web during the decomposition of leaf litter in the black alder (Alnus glutinosa L.) forest. *Predobiologia*. 42:109-123.

Edesi, L., Jarvan, M., Noormets, M., Lauringson, E., Adamson, A. and Akk, E., 2012. The importance of solid cattle manure application on soil microorganisms in organic and conventional cultivation. *Acta Agriculturae Scandinavica*: *Soil. Plant Sci*. 62(7):583-594.

Eghball, B. and Power, 1994. Beef cattle feedlot manuremanagement. *Jr. of Soil and Water Conser*. 49: 113-122.

Eghball, B., 2002. Soil properties as influenced by phosphorus and nitrogen based manure and compost applications. *Agronomy Jr.* 94:128-135.

Eghball, B., Power, J.F., Gilley, J.E., and Doran, J.W., 1997. Nutrient, carbon, and mass loss during composting of beef cattle feedlot manure. *Jr. Environ. Qual*. 26:189-193.

Francis, J., Larney, L., Yanke, J., Miller, J.J. and McAllister, T.A., 2003. Fate of Coliform Bacteria in Composted Beef Cattle Feedlot Manure. *Jr. Environ. Qual*. 32:1508–1515.

Freitas, D., J.R., Schoenau, J.J., Boyetchko, S.M. and Cyrenne, S.A., 2003. Soil microbial populations, community composition, and activity as affected by repeated applications of hog and cattle manure in eastern Saskatchewan. *Canadian Jr. Microbio.* 49(9):538-548.

Fulhage, C.D., 2000. Reduce environmental problems with proper land application of animal manure. University of Missouri Extension. USA.

Ghuman, B.S. and Sur, H.S., 2006. Effect of manuring on soil properties and yield of rainfed wheat. *Jr. Indian Soc. Soil Sci.* 54(1): 6-11.

Goff, J.P., 2006. Macromineral physiology and application to the feeding of the dairy cow for prevention of milk fever and other periparturient mineral disorders. *Animal Feed Sci. Tech*. 126:237-257.

Golueke, C.G., 1992. Bacteriology of composting. *Biocycl*. 33:55-57.

Gopinath, K. A., Saha, S., Banshi, Mina L., Kundu, S., Selvakumar, G. and Gupta, H.S., 2008. Effect of organic manures and integrated nutrient management on yield potential of bell pepper (*Capsicum annuum*) varieties and on soil properties. *Arch. of Agro. and Soil Sci.* 54(2):127-137.

Goyal, S., Chander, K., Mundra, M.C., Kapoor, K.K., 1999. Influence of inorganic fertilizers and organic amendments on soil organic matter and soil microbial properties under tropical conditions. *Biol. Fertil. Soil*. 29:196–200.

Gupta, N., Sabat, J., Prida, R. and Kerkatta, D., 2007. Solubilization of tricalcium phosphate and rock phosphate by microbes isolated from chromite, iron, and magnese mines. *Acta Botanica Croatia*. 66:197-204.

Hameeda, B., Harinib, G., Rupelab, O.P., Wanib, S.P. and Reddy, G., 2008. Growth promotion of maize by phosphatesolubilizing bacteria isolated from composts and macrofauna. *Microbio. Resr.* 163:234-242.

Hao, X. and Chang, C.D., 2003a. Does long-term heavy cattle manure application increase salinity of clay loam soil in semi-arid southern Alberta? *Agric. Ecosyst. Environ*. 94:89-103.

Hao, X., Chang, C., Travis, R.G. and Zhang, F., 2003. Soil carbon and nitrogen response to 25 cattle manure applications. *Jr. Plant Nutri.* 166:239-245.

Hargerty, D.J., Pavoni, JL., Heer, J.E., 1999. Solid Waste Management. New York: *Van Nostrand Reinhold*. 12-13.

Hernando, S., Lobo, M. and Polo, A., 1989. Effect of the application of a municipal refuse compost on the physical and chemical properties of soil. Sci. *Total Environ*. 81/82: 589–596.

Hicklenton, P., Rodd, V. and Warman, P.R., 2001. The effectiveness and consistency of source-separated municipal solid waste and bard composts as components of container growing media. *Sci. Hort*. 91: 365-378.

Hoitink, H.A.J., Boehm, M.J., 1999. Biocontrol within the context of soil microbial communities: Asubstrate-dependent phenomenon. *Annu. Rev. Phytopathol*. 37:427-446.

Hongli, W., Zuli,Z., Xiaohu, B., 2003. Exploitation and Utilization of Crop Straw Feed Resourc. *Jr. Shenyang Agri. Univer.* 34: 228-231.

Iglesias-Jimenez, E., Garcia, V., Espino, M. and Hernandez, J., 1993. City refuse compost as a phosphorus source to overcome the P-fixation capacity of sesquioxide-rich soils. *Plant Soil* 148:115–127.

Inselsbacher, E., Hinko-Najera Umana, N., Stange, FC., Gorfer, M., Schuller, E., 2010 Short-term competition between crop plants and soil microbes for inorganic N fertilizer. *Soil. Biol. Biochem.* 42: 360–372.

Irshad, M., Eneji, A. E., Hussain, Z. and Ashraf, M., 2013. Chemical characterization of fresh and composted livestock manures. *Jr. Soil Sci. and Plant Nutr.* 13(1):115-121.

Islam, M.M., Karim, A.J.M.S., Jahiruddin, M., Majid, N.M., Miah, M.G., Mustaque, A.M. and Hakim, M.A., 2011. Effects of organic manure and chemical fertilizers on crops in the radish-stem amaranth- Indian spinach cropping pattern in homestead area. *Austr. Jr. Crop Sci*. 5(11):1370-1378.

Ivon, V.M., Maria, E.S., Celia, M.M. and Olga, C. N., 2007. Diversity of Bacterial Isolates from Commercial and Homemade Composts. *Microbial Eco*. 55(4):714-22.

Jenkinson, D.S. and Ladd, J.N., 1981. Microbial biomass in soil: measurement and turnover. In: Paul, E.A. and J.N. Ladd (eds.). *Soil Biochem*. 5:415-417.

Johnston, A. E., Poulton, P. R., and Coleman, K. 2009. Soil organic matter: its importance in sustainable agriculture and carbon dioxide fluxes. *Adv. Agron*. 1–57.

Katkar, R.N., Kharche, V.K., Sonune, B.A., Wanjari, R.H., and Singh, M., 2012. Long term effect of nutrient management on soil quality and sustainable productivity under sorghum- wheat crop sequence in vertisol of Akola, Maharashtra. *Agropedology,* 22(2):103-114.

Klausner, S.D., Mather, A.C. and Sutton, A.L., 1984. Managing animal manure as a source of plant nutrients. *National Corn Handbook, Cooperative Extension Service*. Purdue University. West Lafayette, Indiana, USA.

Korodjouma, O., Badiori, O., Ayemou, A. and Michel, P.S., 2006. Long-term effect of ploughing, and organic matter input on soil moisture characteristics of a Ferric Lixisol in Burkina Faso. *Soil & Til. Resr*.88:217–224.

Kravchenko, A. N., Snapp, S. S., Robertson, G. P., 2017. Field-scale experiments reveal persistent yield gaps in low-input and organic cropping systems. *Proc. Natl. Acad. Sci. U.S.A*. 114:926–931.

Kumar, S.P., Rattan, R.K. and Singh, A.K., 2004. Chemical forms of zinc soils and their contribution to available pool. *Jr. Indian Soci. Soil Sci*. 52(4):421-425.

Lal, R., 1997. Residue management, conservation tillage and soil restoration for mitigating greenhouse effect by CO2-enrichment. *Soil Till. Res*. 43:81-107.

Lal, R., Kimble, JR., 1997. Conservation tillage for carbon sequestration. *Nutr. Cycl. Agroecosys*. 49:243-253.

Le Bissonnais, Y., Arrouays, D., 1997. Aggregate stability and assessment of soil crustability and erodibility. 11. Application to humic loamy soils with various organic carbon contents. *Eur. Jr. Soil Sci*. 48:39-48.

Leytem, A.B., Dungan, R.S. and Moore, A., 2011. Nutrient availability to corn from dairy manures and fertilizer in a calcareous soil. *Soil Sci*. 176:426-434.

Li, F., Chen, L., Zhang, J., Yin, J., and Huang, S. (2017). Bacterial community structure after long-term organic and inorganic fertilization reveals important associations between soil nutrients and specific taxa involved in nutrient transformations. *Front. Microbiol*. 8:187.

Macdonald, Dow MGC., Griffin, S.E., 1981. Returning wastes to the land. In: food, fuel and fertilizer from organic wastes. Report of ad hoc panel of the advisory committee on technology for international development commission on international relations. *National Research council. National Academy Press, Washington.*

Mader, P., Fliefback, A., Dubois, D., Gunst, L., Fried, P. and Niggili, U., 2002. Soil fertility and biodiversity in organic farming. *Science*. 296(5573):1694-1697.

Marschner, P., Kandeler, E., Marschner, B., 2003. Structure and function of the soil microbial community in a long-term fertilizer experiment. *Soil Biol. Biochem*. 35, 453–461.

Martens, D.A., 2000. Plant residue biochemistry regulates soil carbon cycling and carbon sequestration. *Soil Biol. Biochem*. 32:361–369.

Martins, O. and Dewes, T., 1992. Loss of nitrogenous compounds during composting of animal wastes. *Biores. Techn.* 42:103–111.

Meena, B.P., Ashok, K., Lal, B., Sinha, N.K., Tiwari, P.K., Dotaniya, M.L., Jat, N.K. and Meena, V.D., 2015. Soil microbial, chemical properties and crop productivity as affected by organic manure application in popcorn (*Zea mays* L. var. *everta*). *Afri.Jr. Microbio. Resr.* 9(21):1402-1408.

Miller, F.C., 1993 . Ecological process control of composting. In: Metting F.B., *Jr., Ed., Soil Microbial Ecology*. Marcel Dekker, New York, pp. 529-536.

Mishra, S., Maikhuri, R.K. and Dhyani, D., 2008. Sequestering carbon through indigenous agriculture practices. G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, P.O. Box 92, Srinagar (Garhwal) 246 174, India.

Mkhabela, M. and Warman, P.R., 2005. The influence of municipal solid waste compost on yield, soil phosphorus availability and uptake by two vegetable crops, grown in a Pugwash sandy loam soil in Nova Scotia. *Agric. Ecosyst. Environ*. 106:57–67.

Overcash, M.R., Humenik, F. and Miner R., 1983. Livestock Waste Management. Vol. I. Boca Raton, FL: CRC Press.

Parkinson, R., Gibbs, P., Burchett, S. and Misselbrook, T., 2004. Effect of turning regime and seasonal weather conditions on nitrogen and phosphorus losses during aerobic composting of cattle manure. *Biores. Tech.* 91:171–178.

Peacock, A.D., Mullen, M.D., Ringelberg, D.B., Tyler, D.D., Hedrick, D.B., Gale, P.M., White, D.C., 2001. Soil microbial community responses to dairy manure or ammonium nitrate applications. *Soil Biol. Biochem.* 33:1011–1019.

Poudel, D.D., Horwarth, W.R., Lanini, W.T., Temple, S.R. and Van Bruggen, A.H.C., 2002. Comparison of soil N availability and leaching potential, crop yields and weeds in organic, low-input and conventional farming systems in northern California. *Agric Eco Environ*. 90:125–137.

Poul, A.S., More, S.D., Lohot, V.D. and Bodke, R.G., 2004, Effect of organic and inorganic nutrient sources on growth, yield and nutrient uptake in tomato. *Jr. Soils and Crops.* 14(1):40-45.

Pratt, P.F., 1984. Salinity, sodium, and potassium in an irrigated soil treated with bovine manure. *Soil Sci. Soci. of America Jr*. 48:823–828.

Rajshree, M., Wandile, M., Raul, M., Swati, V., Washimakar, and Bharti, S.B., 2005. Residual effect of long-term application of N, P, Zn and FYM on soil properties of Vertisols, yield, protein and oil content of soybean. *Jr. Soils and Crops*. 15(1):155-159.

Ramos, M C., Marttinez-Casasnovas, J A., 2006. Erosion rates and nutrient losses affected by composted cattle manure application in vineyard soils of NE Spain. *Catena* 68:177-185.

Rebollido, R., Martinez, J., Aguilera, Y., Melchor, K. and Koerner, I., 2008. Microbail populations during composting process of organic fraction of municipal solid waste. *App. Eco. and environ. Reser.* 6(3):61-67.

Reddy, K.S., Blamey, F., Pax, C., Ram, C., Dalal, M.M., Singh, M., Rao, A.S., Pandey, M. and Menzies, N.W., 2010. Leaching losses of nutrients from farmyard manure pits in Central India. 19th World Congress of Soil Science, *Soil Solutions for a Changing World*. 1-6 August 2010, Brisbane, Australia. Published on DVD.

Reza, A., 2008. Microbial Count and Succession, Soil Chemical Properties as Affected by Organic Debrises Decomposition. *American-Eurasian Jr. Agric. & Environ. Sci*. 4(2):178-188.

Roy, S. and Kashem, M.A., 2014. Effects of Organic Manures in Changes of Some Soil Properties at Different Incubation Periods. *Open Jr Soil Sci*. (4):81-86

Ryckeboer J., Megaert J., Coosemans J., Deprins K., Swings J., 2003(a). Microbiological aspects of biowaste during composting in a monitored compost bin. *Jr. App. Microbiol*. 94(1):127-137.

Ryckeboer, J., 2003. A survey of bacteria and fungi occurring during composting and self-heating processes. *Annals of Microbiology.* 53(4):349-410.

Safley, L.M., Westerman, P.W and Barker, C., 1985. Fresh dairy manure characteristics and barnlot nutrient losses. Pp. 191-199. In: Agricultural Waste Utilization and Management. Proceedings of the Fifth International Symposium on Agricultural Wastes, Chicago, Illinois, December 16-17, 1985. St. Joseph, MI: *Amer. Soci. of Agri. Eng*.

Santillan, Y.M., 2014. Effect of the Application of Manure of Cattle on the Properties Chemistry of Soil in Tizayuca, Hidalgo, Mexico. *Intr. Jr. App. Sci. Tech*. 4(3).

Sawant, AA., Hegde, NV., Straley, BA., Donaldson, SC., Love, BC., Knabel , SJ., Jayarao, BM., 2007. Antimicrobial-resistant enteric bacteria from dairy cattle. *Appl Environ Microbiol*. 73:156–163.

Saxton, K.E., 2003. Soil water characteristics. United States Department of agriculture, *Washington State University.* 13 pp.

Schen, P., Christensen, BT., Carstensen, B., 1994. Physical and chemical properties of a sandy loam receiving animal manure, mineral fertilizer or no fertilizer for 90 years. *Eur. Jr. Soil Sci*. 45:257–268.

Schoenau, J.J. and Davis, J.G., 2006. Optimizing soil and plant responses to land applied manure nutrients in the Great Plains of North America. *Can. Jr. Soil. Sci*. 86:587-595.

Shanmugam, G.S., 2005. Soil and plant response of organic amendments on strawberry and half-high blueberry cultivars. *Master's Thesis*. Dalhousie University, Halifax, Nova Scotia, Canada.

Shanmugam, G.S., 2005. Soil and plant response of organic amendments on strawberry and half-high blueberry cultivars. *Master's Thesis*. Dalhousie University, Halifax, Nova Scotia, Canada.

Sinegani, A.A.S., Ghanbari, M., Janjan, A., 2009. Improvement of digestibility of sunflower and corn residues by some saprophytic fungi. *Jr. Mater. Cycles & Waste Manag.* 11: 293-298.

Singh, C.P., 1987. Preparation of High grade Compost by an enrichment on organic matter decomposition. *Biol. Agric. Hort*. 5:41-49.

Singh, S. and Rachel, G., 2010. Inputs in Organic Farming: Are They Factual in Plain and Hill Regions of Uttarakhand. *Jr. Hum. Ecol*. 32(1): 55-61.

Soumare, M., Tack, F. and Verloo, M., 2003. Characterisation of Malian and Belgian solid waste composts with respect to fertility and suitability for land application. *Waste Manag*. 23:517–522.

Stockdale, E. A., Lampkin, N.H. and Hovi, M., 2001. "Agronomic and environmental implications of organic farming systems," *Adv. in Agronomy*. 70:261-327.

Subrahamanyeswari, B. and Chander, M., 20007. Compatibility of animal husbandry practices of registered organic farmers with organic animal husbandry standards (OAHS): A assessment in Uttarakhnd. *Ind. Jr. of Ani. Sci.* 78(3):322-327.

Swain, MR., Laxminarayana, K., Ray, RC., 2012. Phosphorus solubilization by thermotolerant *Bacillus subtilis* isolated from cow dung microflora. *Agric. Res*. 1:273–279

Swer, H., Dkhar, M.S. and Kayang, H., 2011. Fungal population and diversity in organically amended agricultural soils of Meghalaya, India. *Jr. Organic Sys*. 6(2):2011.

Taiwo, L.B. and Oso, B.A., 2004. Influence of composting techniques on microbial succession, temperature and pH in a composting municipal solid waste. *Afri. Jr. of Biotech*. 3(4):239-243.

Tian, G., Brussaard, L. and Kang, BT., 1995. Breakdown of plant residues with contrasting chemical compositions under humid tropical conditions: Effects of Earthworms and Millipedes. *Soil. Biol. Biochem*. 27: 277-280.

Tiquia, S.M. and Tam, N.F.Y., 2002. Characterization and compositing of poultry litter in forced aeration piles. *Proc. Biochem*. 37:869-880.

Tiquia, S.M., 2005. Microbiological parameters as indicators of compost maturity. *Jr. App. Microbiol.* 99: 816–828.

Tuomela, M., Vikman, M., Hatakka, A., Itävaara, M. 2000. Biodegradation of lignin in a compost environment: A review. Bioresour. Technol., 72: 169-183.

Umanu, G., Nwachukwu, SCU., Olasode, OK., 2013. Effects of cow dung on microbial degradation of motor oil in lagoon water. *GJBB*. 2:542–548.

Uniyal, A., Kainthola, A., Bisht, NS., 2016. Phosphate solubilising and indole acetic acid producing potential of mycoflora associated with traditional livestock manure in indian himalayan region. *Plants Arch.* 16:925-930.

Uroz, S., Calvaruso, C., Turpault, M.P. and Frey-Klett, P., 2009. Mineral weathering by bacteria: ecology, actors and mechanisms. *Trends Microbiol*. 17:378–87.

Von Klopotek, A., 1962. Uber das Vorkommen und Verhalten von Schimmelpilzen bei der Kompostierung städtischer Abfallstoffe. *Antonie van Leeuwenhoek*. 28: 141-160.

Wakelin, S.A., Warren, R.A., Harvey, P.R. and Ryder, M.H., 2004. Phosphate solubilisation by *penicillium* species closely associated with wheat roots. *Bio. and Fert. of Soils*. 40:36-43.

Waksman, S.A., Cordon, T.C. and Hulpoi, N., 1939. Influence of temperature upon the microbiological population and decomposition processes in composts of stable manure. *Soil Sci.* 47: 83- 114.

Wang, Q.K., Wang, S.L., 2007. Soil organic matter under different forest types in Southern China. *Geoderma*. 142:349-356.

Warman, P.R., Murphy, C., Burnham, J. and Eaton, L., 2004. Soil and plant response to MSW compost applications on lowbush blueberry fields in 2000 and 2001. *Small Fruit Rev*. 3(1/2):19-31.

Westerman, P.W., Safley, L.M., Barker, C. and Chescheir, G.M., 1985. Available nutrients in livestock waste. Pp. 295-307. In: Agricultural Waste Utilization and Management. Proceedings of the Fifth International Symposium on Agricultural Wastes, Chicago Illinois, December 16-17, 1985. St. Joseph Ml: *Amer. Society of Agri. Eng*.

Willer, H., Yussefi-Menzler, M. and Sorensen, N., 2008. The world of organic agriculture-statistics and emerging trends 2008. http://orgprints.org/13123/4/world-of-organic-agriculture- 2008.pdf

Wright, S.F., 2003. The importantce of soil microorganisms in aggregate stability. Proc. North central extension. *Industry Soil Fertility Conference*, 19:93-98.

Yang, K., Zhu, J., Zhang, M., Yan, Q. and Sun, O.J., 2010. Soil microbial biomass carbon and nitrogen in forest ecosystems of Northeast China: a comparison between natural secondary forest and larch plantation. *Jr. Plant Ecol*. 3:175-182.

Zaman, M., Di, H.J., Cameron, K.C., 1999. A field study of gross rates of N mineralization and nitrification and their relationships to microbial biomass and enzyme activities in soils treated with dairy effluent and ammonium fertilizer. *Soil Use Managem.*15:188–194.

Zhang, H., 1998. Animal Manure Can Raise Soil pH. *Production technology*, Oklahoma State University.10: 7.

Zhang, M., Heaney, D., Henriquez, B., Solberg, E. and Bittner, E., 2006. A fouryear study on influence of biosolids/MSW cocompost application in less productive soils in Alberta: nutrient dynamics. *Compost Sci. Util*. 14(1):68–80.

Zhang, Q., Zhou, W., Liang, G., Wang, X., Sun, J., He, P., 2015. Effects of different organic manures on the biochemical and microbial characteristics of albic paddy soil in a short term experiment. *PLoS ONE* 10:e0124096. doi: 10.1371/journal.pone.0124096.

Zheljazkov, V. and Warman, P.R., 2004. Source-separated municipal soil waste compost application to Swiss chard and basil. *Jr. Environ. Qual*. 33:542-552.

Zhen, Z., Liu, H., Wang, N., Guo, L. and Meng, J., 2014. Effects of Manure Compost Application on Soil Microbial Community Diversity and Soil Microenvironments in a Temperate Cropland in China. *PLoS ON*E. 9(10):e108555.

Zucconi, F. and de Bertoldi, M., 1987. Compost Specifications for the Production and Characterization of Compost from Municipal Solid Waste. In: de Bertoldi, M., Ferranti, M.P., L'Hermite, P., Zucconi, F., editors. Compost: Production, Quality and Use. Barking: *Elsevier.* 30-50.