-: C O M P O S T :-

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What it is · How it is made
What it does

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H. H. Koepf

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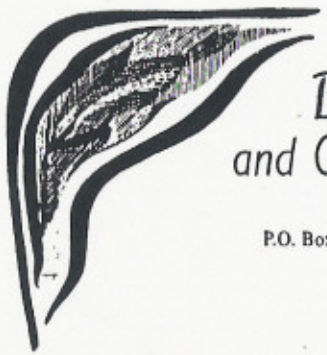

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erosion and carries *antibiotic* and other factors which *enhance growth* and *protect* the plants. Quite a lot more research would still be needed to show the value of all these beneficial effects in dollars and cents. What existing research and practical experience indicate, however, is that these advantages are there.

(30) How and How Much To Apply. In the *garden*, one will usually work compost into the surface layer, that is, 2-4" top layer, or put it into the row for seeding, or in the hole for planting. For *row crops* on the farm, it is usually worked into the topsoil or broadcast on *grasses* and *hayfields*. As a supplement to *chopped corn stalks, straw, etc.*, it should be broadcast in the fall or spring and disked in. The *new granulated material* mentioned above can be used in the row for corn or banded, as well as broadcast, with conventional fertilizer spreaders and plant attachments.

An old rule suggests that good compost can be applied at any time on any crop and in any amount.

Partly processed *garbage compost* and comparable materials for land reclamation and for combating erosion can be applied in a layer of ½-2 inches. This would be some 40-160 tons/acre.

Ripened composts for *basic soil improvement* — for example, on graded land — would be worked into the upper 2-4 inch topsoil layer in amounts of 15-30 tons/acre.

Manure composts on the farm are applied in amounts of 6-15 tons/acre. On soil with a good tilth, frequently repeated, smaller applications are more effective than larger ones spread at longer intervals. If run-down soil has to be rebuilt, one will supply as much compost as one can afford.

The figures mentioned apply to composts with 55-75% moisture content, applied at 1-4 year intervals.

Good *commercial* and *mineralized composts* which come with an 8-15% moisture are, at present, applied in annual amounts of 400-1,500 lbs./acre.

CONTENTS:

Residues from corn and cereal grain crops, when left on poor soils, will hinder their productivity and probably also the growth of the succeeding crop unless a sufficiently long period of time for breakdown is allowed before the next crop is started. For a *limited number* of years, rich soils can digest crop residues without strikingly negative reactions. Actually, these crop residues need to be supplemented. This can be done with either *a legume seeded as green manure* in the corn or grain field or with *compost spread* on chopped stalks or straw and disked in. In other words, the principles of making a good compost mixture apply here also.

In the garden, spent mulch may be worked only into rich soils. In all other cases, it is better to put it into the compost pile or at least *to supplement it with liberal amounts of compost or composted manure or a legume grown as a green manure crop.*

What does the *grain farmer* do who keeps no livestock? All evidence available from long-term field experiments indicates that a crop rotation with a legume or legume grass can partly replace the beneficial effects on soils and crops of organic fertilizing, and vice versa. But neither can compost entirely replace a crop rotation which includes a legume, nor can this crop rotation entirely replace organic fertilizers. In other words, it is one's choice whether one will use up, bit by bit, the potential of the soil or, rather, try to maintain it by applying farm-produced or commercial organic fertilizers.

(29) How Much Is Compost Worth? "Manure and other refuse should be disposed of at minimum cost and labor perhaps to lagoons, sanitary landfills, etc. Per unit of nutrient, it is cheaper to buy fertilizers." This argument, which is widespread, would also apply to compost accordingly. This is as wise as saying that the head of a family is worth the $5,000 or $50,000 he earns annually. True as this is in one respect, it is nonsense from another point of view.

In terms of NPK only, moist compost is worth $1.50-$3.00 per ton. For dry material, the figure would be $8.00-$12.00 per ton. Compost also helps to make soil-borne nutrients *available.* It improves the *effectiveness* of added nutrients. A *trace element* deficiency will very seldom show up in a soil well supplied with compost. One can forget about the widespread hunt for the particular deficiency believed to give the ultimate solution to trouble. Compost improves the *tilth,* the *water intake, storage, drainage* and the *aeration* of the soil. It helps to control

ammonia was used, less when calcium nitrate and ammonium sulfate were used.

Superphosphate is frequently added to manures in the barn to improve the air and to add some phosphate to the manure. 0.5-1 lb. per day is used per 1 cattle unit of 1,000 lbs. The effect of this application on the stabilization of nitrogen has frequently been over-estimated. 1 lb. per day of rock phosphate per cow can be used as well.

2% or over of superphosphate added to compost seems to impair the activity of lower animals. Michael Scully of Cockleburr Farm observed in 1965 that 50 lbs./ton of rock phosphate, when added to manure compost, apparently had no influence on the earthworms which were present in great number. 10 lbs. per ton of triple superphosphate, however, cut down considerably the number of earthworms.

Nitrogen must be added to poor materials like straw, leaves, etc., if a good composting job is to be done. *Manures, liquid manures or organic industrial wastes should be used for this purpose primarily.*

(27) Mineralized Composts. Commercial composts are frequently blended with rock phosphate, granite dust, Hybro-Tite, Sul-Po-Mag and the like. This is done with the finished compost, however. The plant nutrients of these materials become available slowly. Compost fosters the availability of nutrients.

(28) What Is Best — a Compost Pile, Sheet Composting or Loafing Barn Manure? The handling of organic fertilizers on the farm is not determined solely by what the soil needs but also by the kind of livestock operation, the building facilities, cropping system, etc. In many cases, it will be practical not to depend on just one method of handling organic farm wastes. Compost can be used to supplement crop residues in the field. This is a kind of sheet composting. Frequently one will have to clean the loafing barn. Piling up these manures will reduce their weight and volume and, *at the time when it is really needed,* a stabilized compost can be applied.

The controlled aerobic fermentation process in the compost pile is unique with respect to the organisms involved and the product it yields.

Loafing barn manure, when made with adequate amounts of bedding, will yield a product that is partially composted. Biodynamic treatment can be applied in the loafing barn. Loafing barn manure can be used best for row crops.

COMPOST

WHAT IT IS * HOW IT IS MADE * WHAT IT DOES

H. H. KOEPF

Many inquiries come to us concerning methods of composting, questions about raw materials, questions about the values of composts and composted manures. In response to these we have brought both theoretical and practical information together in this article about composts and composting practices.

Economic pressure pushes the commercial growers to do everything that increases the yields from their gardens, fields and barns. Even backyard gardeners, however quality-minded they may be, frequently confuse big yields with true nutritional values. While fertilizing is the most efficient tool in increasing yields, it is much more than that. It influences the quality of products and the sturdiness of plants, their capacity to resist diseases and pests. But one does not get these benefits unless composts, cured manures and properly used crop residues are made the backbone of the fertilizing program. In the Bio-Dynamic movement, the superiority of well-cured composts over crude organic residues has been emphasized for a long time. Ripened compost adds nutrients and stable humus to the ground, improves the water-holding capacity, the drainage and the aeration of the soil. It quickens and not only adds but also fosters the formation of protective organisms, antibiotics, auxins and other biotic substances. It makes soil-borne and added plant nutrients available. Compost is more than just a carrier of plant nutrients.

(1) Types of Compost.

a) *Garden Composts* are mostly made of weeds, clippings

and trimmings from grass and shrubs, leaves, spent mulch, vegetable trimmings, kitchen wastes and the like. They frequently contain (and should do so) a considerable amount of soil. Fresh or dehydrated manure of any kind is a valuable supplement; so are some commercial organic materials which add nitrogen. These composts are allowed to ferment for a year or longer and are applied when well-ripened. They are worked into the soil or applied in the row at planting time, or screened and mixed with soil for potting plants.

b) *Composted Manures.* Composting *animal excretions* with litter such as straw, chopped corn stalks, sawdust, etc., is a well-established method of using farm wastes effectively. This compost is superior to crude wastes disposed of by spreading them on the fields in a raw state. The use of manures from feeding lots, chicken houses, etc., for commercial composting is a promising and growing industry. It is the most sanitary and safest method of disposal in humid areas.

c) *Mineralized Composts* are commercial products made from compost that is blended with rock phosphate and some kind of a potash material. Recently a free-flowing granulated blend of this kind has been offered.*

d) *Special Composts* are made by some skilled gardeners, e. g., from leaves and/or evergreen needles, peat, etc. These are used for plants which prefer an acid soil, or on soils with a high pH to improve the availability of trace elements or correct an excessively high pH. Composts from tomato vines are recommended for tomato crops.

(2) Garbage Compost. Although not yet widely used, composting of urban refuse is a disposal method many municipalities will increasingly depend upon. In this country, the annual outlay for refuse collection and disposal services is over 1.5 billion dollars. The annual refuse production in the U. S. was 50 million tons in 1920; it was 150 million tons in 1963. 260 million tons annually are expected by 1980. The daily per capita production is now about 4.5 lbs. The DHEW 1964 report, "Solid Waste Handling in Metropolitan Areas" states: "Research efforts by a variety of disciplines have demonstrated that, in addition to the traditional sanitation aspects, vector control, occupational health, accident prevention and fire prevention are frequently important in metropolitan areas." Ground refuse, when fer-

* Badger Soil Service, 3691 Fon du Lac Road, Oshkosh, Wis.

fying zones are present. The compost must be neither too dry nor too moist if the full effect of sanitation by antibiotic effects is to be achieved.

All this emphasizes the fact that *living soil and composts are indispensable factors for maintaining a healthy environment for man and livestock.*

(25) What Ripened Compost Consists Of. Compost contains the sand, silt and clay that was in the initial mixture. A part of the organic matter disappears during the composting. A second part is more or less decomposed and will become *food for the soil life.* A third part of the organic matter is *stabilized humus.* It will increase the storage capacity of the soil for nutrients and water. A fourth part is *living organisms,* bacteria and low animals. When incorporated into the soil, part of them will continue to grow and propagate.

Compost contains 0.5-2% of the major *nutrients* — nitrogen, phosphorus, potassium and practically all the trace elements. In the soil, these will become gradually available.

In the organic fraction of soils and composts, *numerous organic substances* have been found — short-lived and more persistent ones. Among these are a number of *amino acids, organic acids, aldehydes, etc. Vitamins,* B_1, B_2, *and* B_{12}, *auxins, biotins* and over a dozen *enzymes* have been determined. Anaerobic fermentation may yield some growth-delaying organic substances. *Aerobic composts* contain a number of *antibiotics* which may play a *protective role in plants.* These are produced by microorganisms. In special experiments, it was shown that *antibiotics would stay active for* 2-6 *weeks after they had been incorporated in the soil.*

(26) Should Chemical Fertilizers be Added to the Composting Process? *Lime* must sometimes be used to correct the pH in leaf composts and similar materials. It was sometimes attempted to correct the carbon:nitrogen ratio of the initial mixture by adding nitrogen fertilizers. In this context, it may be mentioned that 20-30 years ago so-called artificial manure was made in European countries. It consisted of straw, liquid manure, green plants and 2-4% of a slow-working chemical fertilizer.

Recent research with urban wastes, however, has revealed that chemical nitrogen, when added to the initial mixture in amounts of 0.2-1% nitrogen, will delay or temporarily inhibit the fermentation. The deleterious effect was strongest when

ners, etc. Aerobic fermentation and *good housekeeping* at composting sites will avoid problems from flies and, by the way, also from rodents.

In an article of October 1965 in "California Agriculture" about housefly resistance to insecticides, it is stated: "Resistance to new compounds appears to develop even more rapidly when the flies are already resistant to an earlier used compound. Well known fly control methods, including good manure management and general farm sanitation, remain essential as a means of reducing the need for frequent insecticide applications and thus delaying the development of resistance."

Of course, there exist livestock operations housed in structures which make it difficult to meet these requirements. In this laboratory, a *formula* has been developed which controls ammonia odor and improves the fermentation of wet manure before it is disposed of. This material, XPM, is now under field testing by Badger Soil Service. Preliminary evidence suggests that this material discourages flies from laying their eggs in treated wastes.

(24) Self-Sanitation. Only a few spore-forming bacteria like Bac. anthracis, Clostridium tetani and some others have their natural habitat in the soil. All other microorganisms occurring in soils and composts are not harmful to man. Putrefying wastes will breed pathogenic germs and infection-spreading insects. *Living soils and aerobic composts will, rather, kill them.*

Pathogenic germs which may be present in crude refuse will die in composts from *high temperature* and the *competition* and *antibiotic effects* of other microorganisms. In less than an hour's time and at a temperature of 140°F. or over, the following organisms will die: poliomyelitis and hepatitis viruses, Micrococcus aureus and Streptococcus pyogenes, Mycobact. tuberculosis, Brucella abortus, Salmonella spec.; the eggs of Ascaris lumbricoidis will die and also Entamoiba hystolitica cysts and Fasciola hepatica. When a temperature of 140°F. is reached in garbage or farmyard composts, it will last for days rather than for just an hour. Longer exposures to 130°F. or over will also kill most of the pathogenic germs.

Composts which contain much soil or are made from leaves, weeds and similar materials will not reach very high temperatures. According to Knoll, *antibiotic and other antagonistic effects of the aerobic microflora will make a compost sanitary-safe within* 2-3 *weeks.* This applies when no anaerobic putre-

mented in digestors or piles, reaches temperatures which *kill pathogenic germs.* Partially processed, non-ripened refuse compost can be applied in large amounts for *land reclamation, erosion control* and *reforestation.* Ripened city garbage compost contains enough organic matter to make it a valuable *soil conditioner.* It contains a total of 0.5-1.5% of each of the major plant nutrients N, P and K.

(3) Successful Composting. It is more helpful to understand and know how to apply a few relatively simple principles than to follow "cookbook instructions". These can hardly answer the various questions which come up in individual cases. Successful composting depends upon:

a) *the right initial mixture;*
b) *controlled aerobic fermentation;*
c) *Bio-Dynamic treatment.*

The composting process and the quality of the resulting product are influenced by the proportions of various components in the mixture, such as plant materials, manures, litter, soil, etc. The particle size of the solids, the size and shape of the pile and its moisture content determine the necessary aeration of the fermenting compost and the temperature it reaches.

(4) Plant Materials for the Compost Mixture. The organic materials which are used for composting derive directly or indirectly from plants. They vary with respect to their

organic matter content;
carbon: nitrogen ratio;
water content;
particle size.

For composting, a high content of organic substances in the raw materials is desirable. Old or *matured plant tissue* that goes into the composting process consists mainly of carbonaceous compounds such as cellulose and lignin (= wood fiber), but it contains very little *nitrogen* or water. It breaks down slowly and needs to be supplemented. *Young* green plant *material* contains more water, more nitrogen and a number of organic compounds which break down more quickly than old plant tissue. Besides its maturity, the value of plant materials for composting depends mainly on their ratio of carbonaceous compounds to nitrogen. This is called the *carbon:nitrogen ratio.*

The following list of materials is arranged so that the old, slow-working ones with a low nitrogen content are mentioned first, the young, quick-working, richer ones at the end:

wood shavings — sawdust — paper —— rice hulls — corncobs — corn stalks — straw — spent mulch — old hay — dry leaves — withered green plants — green weeds — grass clippings — vegetable trimmings — kitchen waste (without packing materials).

(5) Manure in the Compost Mixture. Manures from cattle, sheep, swine, poultry and other domestic animals can be composted as such. They are most valuable when added to the above-mentioned plant materials, which they *supplement* with nitrogen, organic matter, digestive fluids, etc. They enhance the composting process. Pure droppings of any kind, or a mixture which contains solid and liquid excretions only, are unsuitable for composting. They must be mixed with litter. Dehydrated manure, which is available commercially, is a valuable supplement for garden composts. It can be mixed in as it is. Depending on how moist the other materials are, one needs or does not need to add water.

(6) Industrial Wastes in the Compost Mixture. Private gardeners may use some of them as a nitrogen supplement. Farmers may be interested in getting litter that can be mixed with animal excrement. In the following series, materials with the highest nitrogen content are mentioned first:

blood meal — meat scraps — bone meal — (also contains phosphorus) — cottonseed meal — castor pomace — other oil seed meals — fish wastes or fish meal — horn meal — wool dust — hair — leather waste — tankage.

Peanut skins and cocoa wastes are litters with a medium nitrogen content.

(7) Soil in the Compost Mixture. Weed composts usually contain a certain amount of soil. 2-5% of the total mixture of soil in manure, leaves, litter, sawdust or any other kind of compost will greatly improve the fermentation. Topsoil is preferred. If one has a chance to stockpile (not higher than 5') top or subsoil, one should do so. This will increase the beneficial effect which the soil has on the composting process.

(8) Lime in the Compost Mixture. Acidifying materials like sawdust, leaves, needles from coniferous trees, much green or old grass in the mixture, acid bog soil and the like, will ferment better if 50-100 lbs./ton of agricultural lime is added to the mixture. Lime must not be used if the mixture contains any

todes, mites, collemboles and other arthropods form a population known only to the specialist. They dig, chew, digest, mix, perform daily migrations up and down, and so on. Thus, they contribute to the digestion and transformation of crop residues, etc., in the soil. All counts point to the fact that the occurrence of these animals is decreased by 1:5 to 1:10 on *cropland* as compared with adjacent *grass* or *forest* soils.

Compost contains a population of animals that is still richer than that of soil. Using composts gives back to the cropland the growth factors elaborated by animals.

Some time after a compost pile is built, it will be invaded by earthworms and other animals. Those which were already in the initial mixture will increase their number. In compost which contains manure, the small red, pointed-at-the-ends manure earthworm will show up. The number of animals decreases again as the compost matures. Inoculation with seeding compost from old composting sites will enhance the growth of useful animals.

(23) Flies. A fly lays approximate 200 eggs, which, at the proper temperature, will hatch within a day. While the maggot will finish its life cycle in less than a week, the pupal stage lasts only 2-3 days. An adult fly emerges. 70,000 flies were produced per cubic foot of garbage which was exposed to ovipositing flies, Siverly and School reported in 1955.

Putrefying masses of garbage, manures and other kinds of moist or wet refuse breed flies and other insects. In a community of organisms where neither animal nor man is crowded together, flies of various kinds do away with excretions and refuse. They prepare the aerobic stage of fermentation, as you can observe in any cow droppings lying on the pasture. A concentration of putrefying wastes makes them a nuisance and a health hazard, although they always do only the usual job they are designed for.

When the fermentation becomes aerobic, little or no flies will breed any more in manures or other wastes. Putrefying masses release such odors as ammonia, hydrogen sulfide, indol, skatol and merkaptan. They attract flies.

As yet incomplete evidence suggests that compost piles made from manure undergo only *one inoculation* with fly eggs during a limited period of time. When the cycle is finished, the insects will leave the pile. Small *puddles* around manure piles will breed flies, of course. So will *dirt* that lies around in cor-

yards and load the spreader.

Power take-off spreaders, when *used stationary*, are the best tools to run the material through and obtain an ideal mixture. Backed up towards the end of the pile, the *spreader chops, mixes and builds the pile in one operation.* Building piles with a front-end loader results in less mixing. However, it is very frequently done with this machine.

Farm composts are usually not turned. If necessary, this is usually done with the front-end loader. In commercial composting, special devices are used for turning.

The most important tool for the backyard gardener is a shredder to chop, grind and mix his raw materials.

(21) Microorganisms in the Compost. The main job of transforming raw materials into ripened compost is accomplished by myriads of *bacteria, fungi, actinomycetes, yeasts, algae* and the like. Since many of them are specialists in distinct steps of breakdown and humus formation, the occurrence of various species varies in the course of time. In normal soil, the weight of living bacteria is about 5% of the organic matter. This would be approximately 2,500 lbs./acre. Similar figures must be added for other microorganisms and animals. In composts, the amount of living organisms is still higher. One applies a high amount of living organisms to the soil with each shovelful of compost.

For practical composting, one has to remember that two main groups of microorganisms exist. *Aerobic organisms* depend on air for their activity, *anaerobic* ones do not. *Composting is a strictly aerobic fermentation.* Anaerobic fermentations will cause *nitrogen losses, obnoxious odors, fly problems* and even *produce growth-delaying substances.* Aerobic fermentation produces all the beneficial effects on plants and soil which good compost has. That is why *controlled aerobic fermentation* is the main objective of compost making.

(22) Compost Animals. As long ago as 1881, Charles Darwin established the role of the *earthworm* in the formation of productive soil. When exposed to the joint action of lower animals and bacteria, plant residues will soon be turned into a brown, amorphous mass. When exposed to bacteria alone, it will take longer. The manifold lower animals living in soils and composts has only recently attracted considerable attention by researchers. The weight of lower animals in the living layer of a good soil may exceed by far the weight of the cattle which get their feed from the same area. Earthworms, enchytrae, nema-

appreciable amount of animal manure or blood meal, etc. Manure and other materials which contain much nitrogen can correct the acidity. Garbage compost from kitchen waste only, which contains much carbohydrate readily available to microorganisms, needs 50 lbs./ton of lime. In most cases, however, urban wastes will contain enough, in some areas even too much lime.

(9) Urban Wastes in the Compost Mixture. These materials are disposed of by large scale composting, which is not discussed here. Composts on the market must be sanitary-safe. The gardener or farmer who uses these should ask for *ripened compost.* In some cases, it may be all right to use partially processed city garbage in a compost mixture or as litter for conditioning animal wastes.

Sewage sludge, in any case, must be treated to be *sanitary-safe.* The author suggests that products which contain sludge should be used first for land reclamation, reforestation, grasses, forage crops, etc., rather than directly for or in composts to be applied on vegetables, fruit trees or shrubs.

(10) The Carbon: Nitrogen Ratio of the Compost Mixture. The most important information about just how rich or poor a compost mixture is, is indicated by the ratio of carbonaceous materials and nitrogen it contains. This is the so-called carbon: nitrogen ratio. Too little nitrogen causes a compost to work slowly. The product will be rather poor. More nitrogen than required for optimum fermentation is likely to cause nitrogen losses from the pile. It very likely also creates odor problems, since ammonia is the chemical compound by which nitrogen escapes into the atmosphere. The carbon:nitrogen ratio is expressed in a figure like 25:1 or simply 25. This means that the compound in question contains 25 times as much carbon as nitrogen. These are examples of the carbon:nitrogen ratio of materials or mixtures used for composting: sawdust 150; peat moss 50; straw, cornstalks, etc., 50-150; hay from legumes 15; leaves from alder and ash 20-30; leaves from oak, birch, maple, etc. 40-60, animal droppings 15; manure with bedding material 20-25.

The ideal initial mixture for composting 25-30
Finished compost of any kind 14-20
Stable humus in fertile soils 9-14

The practitioner need not worry about how to determine the carbon:nitrogen ratio. The information given may guide him,

however, if he has to select materials.

(11) Summary on the Compost Mixture. A mixture of rich (low figure for the carbon:nitrogen ratio) and poor substances, and young and matured plant materials in all cases ferments better than either a single or just a few materials. The respective shares of either materials may vary within a wide range however. It is adequate to follow the rule of thumb that about *equal shares* of rich and poorer plant materials will make for a good fermentation.

For cattle, 5-15 lbs. of bedding per 1,000 lbs. of animal should be applied daily. Fattening pigs in confinement require 4-10 lbs. of dry bedding per 1,000 lbs. daily. Compost made with this ratio of droppings and bedding will ferment well. In floor houses for poultry, one starts each batch with a layer of litter 3-5" thick. Rather liquid droppings from cage houses or manure pits should be dried by mixing in sawdust, straw, etc., until they have a crumbly to slightly sticky consistency.

A garden compost consisting of refuse like weeds, spent mulch, kitchen garbage, much soil, etc., can be supplemented with any amount of manure that contains bedding material. Up to 1/3 of the total mixture of pure excrement can be added. Dehydrated manure in amounts of 2-5 bags per ton will help towards a good breakdown. Commercial nitrogen suppliers which are listed under (6) will, in most cases, be added in amounts of 4-8% of the total mixture.

It has already been said that 2-5% of soil should be added, if at all possible, to raw materials which do not contain it.

(12) Controlled Aerobic Fermentation and How to Achieve It. Aerobic fermentation means that air or, rather, *oxygen*, should reach all parts of the compost pile at all times. The activity of microorganisms yields carbon dioxide, which must find a way out to the atmosphere. *Proper aeration of the compost pile is the basic condition for fermentation.* Only aerobic fermentation yields a product with all the beneficial effects on soils and plants attributed to composts. If the pile suffers from a lack of oxygen, the fermentation is called an *anaerobic* one.

In living topsoil, only 40-50% of its volume is filled with solids. The remainder is pore space which contains water and air and gives way to the oxygen which moves in and vapor and carbon dioxide which move out. The same figures, namely 40-60%, of total pore space and 60-40% of the total volume of

surround the compost site with evergreens or shrubs. *Alder* is frequently preferred for this.

If composting is always done at the same site, where the area gets some shade and never dries out too badly, *earthworms* and other useful lower animals will stay in the ground and *invade the next piles.* New composting sites can be successfully *inoculated* with a few bags of ripened compost from older sites.

(19) When is compost finished? During the fermentation, straw, etc. will become brittle and the fibrous structure gradually changes into a more or less fine, crumbly, friable, sponge-like mass. Careful checking will show that much of it consists of round-shaped *castings* of earthworms and other animals. The color turns from gray or light brown to dark brown. Ripened compost has a pleasant odor.

Garbage composts are sometimes used, or dried and ground after 3-7 days of digestion. This material is, at best, sanitary-safe. When applied in high amounts, it may for a short period *slow down the growth of plants.* One usually allows additional fermentation in the storage pile, however.

Other types of garbage composts undergo fermentation for 3-6 weeks. They are fairly stabilized, although not ripened, and good for land reclamation, erosion control and mulching.

Manure composts at the farm will ferment for 2-8 months. They will not be ripened after 2 months but are usually ready to be applied. Actually, composts are applied in the spring and fall. The period of the animals' confinement, pasturing and the need for cleaning the barn will determine the time for compost making.

Garden composts will ferment from 6-18 months. They are also applied in the spring and fall.

Ripened composts can be left alone and stored for several months, even until the next year. They will undergo only slight changes, without any appreciable loss in value.

Earthworms will leave a compost pile before it is completely ripened because the food they prefer has been eaten up.

(20) Equipment. Some time ago, making compost on a large scale, as well as applying it, used to entail much *labor.* It no longer does, especially if one realizes that it frequently does not add substantially to the disposal problem which is present in any case.

Farms are equipped with barn cleaners or scrapers for free stalls. The front-end loader is used to clean loafing barns and

can their production be controlled to the extent we would like. Until then, it may be advisable to leave the door open to specific measures. This does not mean that all the products now on the market are also good.

Seeding the initial compost mixture with a small percent of well-ripened compost is a well-established measure, however. This *seeding compost* provides not only *microorganisms* but also the *proper growth medium* for them. It can also be used to start earthworms and other lower animals useful in composting at the compost site.

(17) The Compost Pile. Compost piles are shaped like a roof, or their cross section is a trapezoid. They are 2-5' high, 7-10' wide at the bottom, 1-3' wide at the top and any length beyond 3'. 3-3½' high is found in most cases. Coarse material, long straw or hay, a high amount of bedding in manure and a water content below normal call for bigger piles. Fine, rather moist material, young plant materials, manure with only a little bedding, are put into smaller piles.

Many sophisticated procedures have been described as to how to build piles in very regular, neatly arranged layers of various materials. However, the optimum fermentation is reached with a *very even mixture which contains neither coarse lumps nor dry, very loose or very compact zones.*

A *thin layer of earth* or *straw* or other litter prevents the outer layer from drying out or getting soaked by excessive rainfall. Properly built and covered piles will very seldom be found getting soaked by rain.

In northern areas where piles are built during the cold season, a plastic cover, extending from the top not quite down to the ground, enhanced the fermentation and prevented piles from freezing.

(18) The Compost Site. On a farm, one will pick a *permanent* composting site which is easily and always accessible to vehicles. Piles are also frequently built near the field for which the compost is prepared. In the garden, one will put aside a small corner for the compost pile.

Compost sites must be *well drained.* If at all possible, the terrain should be *slightly sloped.* Wet spots or standing water will impair the fermentation.

Some trees or shrubs should provide *partial shade.* The distance between the trunks of bigger trees and the compost pile should not be less than 6'. In the garden, one will want to

solids also apply to compost piles. They have approximately the consistency of a good topsoil that is not too loose or too dense.

This is achieved by mixing raw materials with proper particle size and water content. Solids should have a size from very small to ½". Corn stalks, straw, hay, leaves, etc., should be chopped. They should expose a frayed surface. If manure is present, the bedding should be coated with the excrement.

50-60% moisture by weight is required for proper fermentation. This figure is not much help to the compost maker. Fermenting compost should be moist — neither dripping wet nor dusty dry. Each particle or fiber should be soaked with moisture, almost shining wet, but when pressed with the hand, no liquid should come out.

Relatively dry, coarse materials are built into bigger, relatively moist and fine materials into smaller piles.

Controlled aerobic fermentation is achieved when the pile

a) shows a normal temperature curve;

b) does not dry out and/or form a grey, moldy layer 3-10" below the surface;

c) does not form a black, unpleasant-smelling zone in the center;

d) contains many earthworms and other lower animals.

(13) The Temperature Curve of a Fermenting Compost Pile. In newly built piles, an enormous growth, increase and activity of *microorganisms* begin. Their metabolism yields *heat.* Within 1-3 days, the piles will reach a temperature peak which may be slightly higher than the environmental temperature or as high as 170°F. Only some microorganisms will remain active at this high temperature. 150-160°F. over a period from a few days to a few weeks is desirable. Then the temperature will gradually drop to or slightly above the environmental temperature. Composts which contain much soil will seldom get very warm. Composts which contain much manure, young plant tissue, garbage, etc., will become hot. A higher moisture content keeps the temperature lower. If a pile dries to below 50% moisture and gets very warm, then the gray layer of mold mentioned under (12b) appears.

(14) Turning and Other Control Measures. If the mixture, the *moisture content,* the size of the *particles* and the size and shape of the *pile* are adequate, then a pile of garden or farm compost need not be turned at all or only once. Adjusting the proper fermentation conditions at the beginning is less trouble-

some and expensive than doing so later. One will find out what these optimum conditions are if one follows the indications given here.

Piles which are too moist, slow-working and develop an unpleasant odor should be turned, placing the outer layer in the center, and vice versa. If water has to be added, one must pour it into holes which reach half way down, or sprinkle the compost while one turns it. A loose layer of coarse material, like corncobs, about half a foot thick, placed in the center along the long axis of the pile, will improve the fermentation.

In *commercial* composting on a large scale, the *time* required for finishing the compost and the *space* at the composting site are important cost items. In that case, one follows a rigid turning schedule to speed up the fermentation. This is not required for farm and garden composting.

(15) The Bio-Dynamic Treatment of Composts. To increase their effect on plants or soils, in the *Bio-Dynamic* method several *preparations* are administered to manures, composts, and liquid manures. They are fermented from some common plants, namely, dandelion, chamomile, stinging nettle, yarrow, oak bark and valerian. A great mass of information on *composting with preparations* has been gathered for many years by practitioners. Those who apply such composts make claims about the good taste and high nutritional, technological and keeping quality of their products and also the ability of plants to withstand diseases.

E. E. Pfeiffer reported detailed data on the microorganisms which live in the finished preparations, the trace elements they contain and how they change the fermentation of manure under experimental conditions.

In several separate composting tests carried out in Germany in 1953/54, it was shown that preparations administered to composts influenced the formation of *stabilized humus*. This was shown in this case by determining the capacity of the organic matter in the ripened compost *to store nutrients*. This capacity increases as compost ripens into stable humus. This is expressed in the following figures.

	T/Ct value of composts made with Bio-Dynamic	without Preparations
compost from fermented farm manure	8.81	8.51
compost from crude farm manure	10.59	10.34
compost from manure, ground basalt rock, soil, weeds	4.38	3.03
compost from pure cow droppings	4.55	4.32

In our laboratory, we employ wheat seedlings in nutrient solutions for tests. Diluted extracts from manure, compost, etc., are added during the second to fifth day of growth. The reaction of the plant will show *whether growth-enhancing or delaying biotic factors other than nutrients are present in the extract.* This can be used to check on the type of fermentation an organic material underwent. These are the results of a growth test:

added to the nutrient solution	average length in mm. of roots	shoots	dry wght. in grams of 1000 roots	shoots
control	49.7	72.8	3.57	6.82
compost extract 1:20	80.1	76.7	3.50	6.88
same compost but with B. D. treatment 1:20	85.0	78.1	3.83	6.88

When compared with the control, compost extracts considerably increased the length of the roots. Compost treated with preparations added some to the length of the roots and added considerably to their *weight*.

Making these preparations requires some practical experience, skill, and, of course, time. Preparations and instructions on how to apply them are available from the office of the B. D. Farming and Gardening Association, R. D. 1, Stroudsburg, Pa. 18360. The B. D. Compost Starter is a bacterial formula which contains these preparations. It is marketed and manufactured by The Pfeiffer Foundation, Inc., Spring Valley, N. Y.

(16) Should Composts Be Inoculated? The *transformation* of raw materials into finished compost is performed by numerous bacteria, fungi, lower animals, etc. Closer examination reveals that there are not only many different species. These are actually temporal series of *specialists among the microorganisms.* Each link of the chain has its function. This situation suggests the inoculation of a compost with a diversified mixture of microorganisms.

There has been some *discussion* about the usefulness of such a measure. It has been said that the organisms needed will be present anyhow and will multiply quickly under proper conditions. Indeed, the speed of fermentation, the temperature reached, etc., depend very much on the proper mixture and the environmental conditions discussed earlier. Inoculants can only be expected to alter such basic conditions within certain limits. But compost piles contain many *minor factors*, intermediary compounds of breakdown, vitamins, antibiotics, etc. They have or may have an effect on plants other than nutrients and organic matter. These minor factors are not yet fully understood, nor