COMMISSION OF THE EUROPEAN COMMUNITIES

environment and quality of life

Economic, technical and ecological aspects of the production, use and marketing of compost in the Member States of the European Economic Community

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compiled for the
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Environment and Consumer Protection Service

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Contents

Introduction

The purpose of this study is to investigate whether the composting of domestic refuse and sewage sludge provides a suitable way of disposing of waste without polluting the environment. With the growing awareness of the environment, the question of what processes should be used to enable organic wastes to be reintroduced properly into the natural cycle has been raised increasingly in recent years. The problem has become more acute as urbanization has spread; at the individual economy level, the problem was still overcome largely by natural means, when the majority of the population lived off mixed farming. It has been reported (1) that in earlier centuries farmers took back with them from the markets in the towns in which they sold their products the town-dwellers' refuse to use on their fields. But urbanization, the increasing though not always sensible use of mineral fertilizers, the concentration by many farms on either field crop cultivation or animal husbandry and, finally, mechanization and the discovery of a system of catch crops which are rich in organic matter (green manuring), have resulted in the virtual disappearance of composting, or at least of the composting-like process formerly applied.

Apart from the successful efforts made in the Netherlands to produce and market compost, which will be described later in this report, the idea of composting did not start to gain ground in the West European countries until the second half of the 1950's.

However, as this report will show, it is very difficult to accord to composting the importance which this method of waste utilization warrants from both the ecological and economic viewpoints. There are several reasons for this.

(1) Although the incineration of organic matter presents chemical and physical problems, most of which appear to have been solved, the processes involved in composting are far more complicated. Composting involves simultaneous and consecutive biological, chemical and physical processes, and it is only very recently that important new discoveries have been made in connexion with their control.

(2) The ecological aspects of composting are complex. An attempt will be made in this report to show the connexions between the use of the soil, the removal and application of organic humus formers, good tilth (humus supply), the susceptibility of plants to pest damage, the misuse of pesticides and the consequent increased disruption of the ecological equilibrium.

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(1) Arnold von Hirschheydt, Die Kompostierung von Müll und Klärschlamm. Prace Naukowe Instytutu Inżynierii Ochrony Srodowiska Politechniki Wroclawskiej. 1973.

(3) The subject has an ideological aspect, since the absolutely correct fundamental discovery made by Rudolf Steiner, the founder of anthroposophy, that the organic cycle and the health of the soil, vegetation and man are closely interlinked, has been raised by both its supporters and its opponents to a level at which it can no longer always be discussed objectively. This investigation must resist the temptation of entering into the idealogical dispute. It will, however, be one of the rare cases in which a warning has to be given in a study devoted to objective questions against misrepresentation of the facts on ideological grounds.

(4) A further difficulty lies in the fact that two principles, which are to some extent contrary, must be combined : on the one hand, the authorities are confronted with the responsibility of disposing of the population's wastes in the cheapest possible way. On the other hand, society expects the authorities to choose non-pollutant processes based on the recycling principle. It can, however, be stated even at this stage that composting meets the requirements to quite a large extent as far as being non-pollutant, economical and convenient are concerned.

(5) Discussions concerning the optimum process have not always contained sufficient objective warnings against burdening the soil with heavy metals and polychlorinated biphenyls (PCB's). This investigation must therefore endeavour to describe the latest technological developments in these fields.

The cardinal question must be asked first : is it better to convert organic wastes in the form of domestic refuse and sewage sludge into ash, which must in turn be disposed of, or is it better to bury wastes in airtight conditions so that at best they behave neutrally, or should they be processed into a biologically active substance which has a chance of being returned to the organic cycle? The principal question to be answered is whether there is an economically and ecologically suitable alternative to composting which can be used specifically for the disposal of sewage sludge.

From the viewpoint of the space required, hygiene and protection against immissions, the tipping of sewage sludge presents an even more difficult problem than that of refuse. It would be nonsensical to incinerate sewage sludge in view of the enormous quantities of energy required to evaporate the water, especially at a time when energy costs are rising. The difficulties involved in composting, which is still at the pioneer stage to some extent, should of course, likewise not be concealed. Special attention must be paid to the growing proportion of plastics and glass present in refuse.

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What is Compost?

Compost is the product of the microbial decomposition of animal and vegetable wastes in the presence of oxygen (aerobic). Detailed descriptions will be given later of the different transformation processes. It should first be stated here that, in the process of the decomposition of organic wastes into mineral raw materials, compost is the stage at which pathogenic organisms and plant seeds are destroyed and, with the formation of humus substances, the entire mass achieves a degree of biological stability. As explained later, this stability can, of course, be said to exist only with some qualification since the prevailing environmental conditions (moisture, temperature, light, and lack of or excess oxygen) govern the onset of new biological processes.

This is, however, at the same time the principal function of compost. It is the very fact that it contains highly concentrated quantities of humus-forming substances and a wide range of micro-organisms that enables it to supply arable land with the micro-organisms necessary for plant life. To make this easier to understand, some brief information must be given on the conditions necessary for plant life. Plants are autotrophic organisms; this means that they obtain the nitrogen and carbon compounds which they require from inorganic substances.

As organic compounds contain more energy than inorganic compounds, additional energy is required to enable organic compounds (sugar, starch, cellulose, protein, fats) to be formed, and plants obtain this from the sun. Heterotrophic organisms (many bacteria, fungi, animals and man) must obtain the nitrogen and carbon compounds which they require from the vegetable kingdom (fruit, vegetables, sugar, starch, flour, etc.) or from the animal kingdom (meat).

Theoretically, plant roots could merely be placed in a nutrient solution to ensure their growth. This process has been, and still is, used to a limited extent (hydroponics). However, quite apart from the fact that this cannot represent any alternative to large-scale farming, hydroponics also causes a noticeable degeneration in plant life in the long term. In order to fulfil the practical function of solving the problem of feeding the population and, to this end, preserving and improving existing soil, developing infertile soil and protecting crops against pests, as far as possible without using poisonous pollutant substances, it is most important to ensure that the soil is healthy.

For the purposes of plant nutrition, this means that the soil must be loose and permeable to air. At the same time it must perform the function of a sponge; in other words, it must store moisture and release it again at the right moment. Although the symbiotic processes which occur in the soil between plants, bacteria and fungi have not yet been investigated fully, the following facts are certain.

(1) The micro-organisms in the soil, which amount to several thousand million per cubic centimetre, loosen the soil and ensure that it acts as a sponge.

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(2) The most important aspect of the interaction between plants, bacteria and fungi is the fact that the micro-organisms prepare the correct doses of nutrients and supply them to plants at the right moment.

(3) A biological equilibrium between plants and the animal kingdom (including larger soil fauna such as earthworms, wood-lice, beetles and spiders) reduces susceptibility to pest damage. It is becoming increasingly clear that pests are always a sign of a defect in the ecosystem.

(4) It follows from this that malfunctioning of the ecosystem as indicated by the presence of pests cannot be corrected by destroying the pests, but only be restoring the equilibrium. This is especially important since increased awareness of the environment has resulted in the use of pesticides being monitored particularly carefully. The use of mineral fertilisers is also involved here.

When describing compost, it can never be stressed sufficiently that compost cannot be regarded as a substitute for mineral fertilisers. Compost certainly also contains inorganic compounds which have the same effect as fertilisers, e.g. ammonium (-nitrogen) compounds, phosphates, etc., some of which come directly from domestic refuse, and some of which are a product of microbial action in the substrate. It also contains metallic compounds, which should be classified as trace elements. (Heavy metal compounds and their disputed role will be described in a different context). On the other hand, the mineral content varies too greatly to enable compost to be used systematically in agriculture, viticulture and horticulture.

Although compost cannot serve as a substitute for mineral fertilisers, it can nevertheless help to achieve substantial reductions in the costs involved in their use. This is also important in connexion with efforts to achieve energy savings.

The possibility of reducing fertiliser consumption by using compost arises from the fact that the smaller the proportion of humus and micro-organisms in the soil the more the soil tends to become hard and crack. This means that a considerable proportion of the fertilisers applied to the soil seep through cracks into the groundwater, without being able to be absorbed by plant roots. This fertiliser solution in the groundwater passes in turn into rivers and lakes, where the well-known effect of eutrophication occurs. As only a limited proportion of the fertilisers applied to the soil is used by plants, considerably larger quantities of fertilizer must be applied than would be necessary if the soil were organically healthy. The link between the biological equilibrium of the soil, fertiliser consumption and the eutrophication of water with the associated hazards for this water has been recognised and pointed out repeatedly.

This is just where compost, which provides the soil with a rich organic substance containing a wide range of micro-organisms, can become increasingly important for the preservation of a healthy environment. The

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nutrient "compost", which is quite distinct from the fertilizer "compost", develops a fertilizer quality which cannot be achieved by mineral fertilizers: as already explained, compost contains only a small proportion of the mineral nutrients required by plants in a directly analysable mineral form. A considerable proportion of the nutrients is either bonded exchangeably to the sorption agent humus or is a component of organic organo-mineral compounds (1). How are these compounds released for the benefit of plants?

A complicated combination of processes occurs, which cannot be described in detail here. A decisive factor seems to be the fact that these processes are dependent on weather conditions. This exactly matches the "interests" of the vegetable kingdom, which requires relatively little prepared nutrition during the cold season, like the micro-organisms which are largely dormant at that time, whereas at the other end of the scale, viz a warm biotope with sufficient moisture, accelerated decomposition of organic matter into mineral plant nutrients occurs. Thus the vegetable kingdom receives nutrition in a naturally controlled way from compost.

Another effect of compost must be pointed out here : many years of investigations and practical application, especially in the Netherlands, have revealed that refuse compost is the only solid matter which piglets are willing to accept even in the first few days of their life. By feeding compost to piglets, a drastic reduction has been achieved in the mortality rate due to the much dreaded anaemia caused by lack of iron, with the result that it has been possible to abandon the very difficult task of giving injections.

Processes Involved in Composting

Compost is formed as a result of numerous different biochemical processes, some of which occur simultaneously, some successively, and which are all extremely complicated. These processes have not yet been examined to the last detail. Although the function of this report cannot be to produce an exhaustive list of the biochemical processes involved in composting, nevertheless a rough outline of these processes must be given, as otherwise the advantages and disadvantages of composting, the hygienic aspect of the problem and the special features of the various composting methods will not be sufficiently clear.

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(1) Vor- und Nachteile, volume 2, p. 527

The high-molecular organic animal or vegetable compounds which are processed during composting have their origin in synthesizing processes involving the carbon, nitrogen and sulphur cycles. The photosynthetic process is well known : a plant first produces sugar, from the carbon dioxide in the atmosphere, and water by using solar energy with chlorophyll as a catalyst; this sugar is converted directly into assimilation starch.

This process is indicated by the following formula :

$$6\ CO_2 + 12\ H_2O \xrightarrow{675\ kcal} C_6H_{12}O_6 + 6\ O_2 = 6\ H_2O$$

In chemical terms, what is involved is the separation of hydrogen from water, with the release of oxygen. From the monosaccharides and disaccharides (sugar) a plant produces its structural and reserve substances. The most important of these substances are starch, cellulose and glycogen, i.e. polysaccharides. These synthesizing processes occur within the carbon cycle.

While plants synthesize some very complex compounds (proteins including conjugated proteins, fats, fatty acids, sugar, cellulose, alkaloids, resins, rubber, etc.) by themselves, animal bodies in their turn synthesize new substances from vegetable compounds, likewise using energy, which they, on the other hand, obtain as a result of the decomposition of compounds. It is evident how wide a range of substances is involved in composting.

In addition to photosynthesis there is also the chemosynthetic process, in which bacteria obtain energy for the synthesis of organic matter from the oxidation of inorganic compounds. Some of these processes are of practical importance for composting. Waste water purification, which in fact plays an important indirect role in composting, also involves such processes. When the bacterial putrefaction of proteins occurs in the absence of oxygen (anaerobic), hydrogen sulphide, a foul-smelling toxic gas is produced. The smell is characteristic not only of septic waste water but also of compost heaps in which the desired anaerobic (rich in oxygen) micro-organisms have been driven out by anaerobic microbes. As soon as oxygen is available (an important point in all composting methods), the sulphur bacteria act on the hydrogen sulphide, obtaining energy from the reaction, transforming it first into elemental sulphur and then, by further oxidation, into sulphuric acid. In this process too heat energy is released :

$$2\ H_2S + O_2 \longrightarrow 2\ H_2O + 2\ S + 118\ kcal$$

$$2\ S + 3\ O_2 + 2\ H_2O \longrightarrow 2\ H_2SO_4 + 286\ kcal$$

Another chemosynthetic process, the work of the nitrifying bacteria inhabiting the soil will be discussed elsewhere.

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In referring to chemosynthesis we have already entered the field of decomposition processes to a certain extent. Generally speaking, the following can be said of the decomposition of organic compounds, which is a vital part of composting : decomposition can be regarded as the inverse of synthesis. However, this also means that heat energy is released during decomposition, just as heat energy was needed previously for the synthesis of the organic substances. The ecological significance of these processes is clear; the cycle includes not only the synthesis of the substances and their decomposition into components for use in a new synthesizing process, but also the adsorption and release of energy.

What are the principal substances decomposed during composting? The most important compounds are :

monosaccharides, disaccharides and polysaccharides

proteins

conjugated proteins

fats

alkaloids

tanning agents

lignin.

The decomposition process can best be illustrated by the breakdown of glucose. The ideal form is the inverse of the photosynthesis equation :

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + 675 \text{ kcal}$$

Before this stage is reached, at which sugar is "breathed away" with the release of heat, numerous processes are necessary. For example, the polysaccharides must be decomposed into monosaccharides, fats broken down into fatty acids and glycerine, proteins into α-amino acids and conjugated proteins initially into the protein fraction and the lactoprotein groups contained in conjugated proteins (fats, carbohydrates, phosphoric acid, pigments and nucleic acids). The principal chemical components of all of these compounds are carbon, hydrogen, oxygen, nitrogen and sulphur. The groups can also be classified according to the presence of these elements, which is not without importance as far as the practical implementation of composting processes is concerned.

(1) Hydrocarbons : only carbon with hydrogen

(2) Carbohydrates : carbon, hydrogen and oxygen

(3) Lignins : no complete information yet on composition

(4) Fats, oils, waxes and resins

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(5) Proteins : all of the above-mentioned elements
(C + H + O + N + S).

The organisms actively involved in the decomposition of the high-molecular compounds can be divided into the following groups :

(1) Algae (can be ignored in connexion with rotting processes).

(2) Bacteria. The principal agents in the decomposition process.

(3) Yeasts. Play no appreciable role.

(4) Actinomycetes. Important at an advanced stage in rotting processes. The greyish-white hyphae visible to the naked eye and the characteristic forest soil odour are typical.

(5) Fungi, especially mould (Penicillium). Likewise active at an advanced stage in the rotting process.

In practice it is important to remember that all of these micro-organisms are always present in abundance. They do not need to be specially injected into the rotting substrate. Expenditure on relevant preparations which are sometimes put on the market is unnecessary. If composting occurs under optimum conditions, the micro-organisms required for each stage of the transformation process multiply sufficiently on the basis of an optimum biotope exists for micro-organism activity.

A decisive factor for the success of the rotting process is the presence of oxygen. The transformation processes involve aerobic bacteria which cannot act without oxygen. There are cryophilic, mesophilic and thermophilic bacteria, which thrive best at temperatures of 15 - 20°C, 25 - 35°C and 50 - 55°C respectively. The maximum temperature for the thermophilic group can even be as high as 80°C. However, many of the microbes necessary for the composting process are no longer active at this temperature. Mesophilic and thermophilic micro-organisms are necessary for the composting process. Symbiotic and metabiotic processes are involved here.

When organic wastes, irrespective of whether they consist of domestic refuse or sewage sludge or a combination of the two, are composted under aerobic conditions, considerable temperatures are reached. The self-ignition of grain silos or stacks of other feedstuffs is proof of the development of heat which has been observed from time immemorial. The positive feature to be noted in the composting process is the fact that pathogenic germs are destroyed. These pathogenic organisms have adapted themselves to human and animal body temperatures, i.e. to temperatures of between 29 and 43°C. They are destroyed partly because they are exposed for a fairly long period to the typical temperatures involved in the hot rotting process, and partly by the actinomycetes and mould fungi (Penicillium) which develop as the rotting process progresses. Since Fleming discovered penicillin it has been known

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that certain fungus cultures develop toxins to fight off rival micro-organisms. Actinomycetes, which come between bacteria and moulds, are a typical feature of the advanced stage in the rotting process. They form a whitish-grey mycelium which is visible to the naked eye and is characteristic of forest soil which is rotting well. Actionmycetes produce the typical forest soil odour. They are capable of forming certain types of humus and of using existing humus to bond carbon and nitrogen. Actinomycetes work on cellulose, fats, paraffins and even phenols, tannin and lignin.

This important function which actinomycetes perform alongside moulds is by no means of purely acedemic signicifance. Bacteria act very fast. They start to work in household dustbins. Actinomycetes and fungi, on the other hand, need some time to develop their hyphae and mycelia. It is particularly important to remember this when selecting composting methods : the methods selected should be such that it is possible for actinomycetes and fungi to develop. All rapid processes in which the rotting matter is constantly turned prevent the growth of fungi. Consequently, at the same time they prevent important hygienisation and humus-forming processes from occurring. Rotary drums, which are used in some processes, are an example of this type of equipment. The fact that they prevent fungus growth does not mean, of course, that the growth of fungi is therefore entirely out of the question. In such processes the matter which has started to rot in the drum must, however, finish rotting in windrows, so that fungi can grow undisturbed. It will be explained later in connexion with the question of the marketing of compost that the sale of only partly rotted material as compost leads to a disappointment on the part of the user and can therefore jeopardize the saleability of all compost. "Fresh compost" should be sufficiently clearly labelled.

An important factor for the success of the rotting process is the correct amount of moisture. If the substrate is too dry, which is the case if it has a moisture content of less than 30%, some important micro-organisms become inactive. If the water content is too high, which is the case if it exceeds 65%, anaerobic putrefaction occurs. The material must therefore have the right moisture content, which is between 50 and 55%. Remembering that the temperature rises to up to 70°C during the first few days, it is clear that evaporation can easily cause the water content to fall below the critical lower limit. This can be remedied by spraying and turning the material.

Another important quantity which must be mentioned if the composting process is to be understood is the carbon/nitrogen ratio (C/N ratio). This expresses the quantity of carbon contained in the substrate as a multiple of the nitrogen content. A C/N ratio of between 30:1 and 35:1 is the optimum ratio. If it is too high, what is known as the nitrogen barrier sets in : the matter will not rot. This failure can often be observed in the needle litter on forest soil in pure Spruce plantations. It can be remedied by spreading nitrogen fertilizers or by injecting ammonia into the forest soil (trials carried out by Ruhrstickstoff AG, for example). Although there is no risk of a direct nitrogen barrier arising in the composting process, nevertheless excessively high C/N ratios can occur, for example if the paper content is disproportionately high or often in the case of garden refuse where the carbon content is particularly high because of the cellulose in plants.

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Organic wastes have a high nitrogen content.

Both the need for moisture and the significance of the C/N ratio as described above demonstrate the advantage of the combined rotting of domestic refuse and sewage sludge. While domestic refuse, depending on its origin, contains an excessive amount of carbon, sewage sludge contains an excessive amount of nitrogen.

The C/N ratio is calculated at 15 in fresh sludge, at only 13 in digested sludge and at only 6 - 8 in activated sludge. Thermophilic aerobic rotting is virtually impossible with these ratios. If sewage sludge is to be composted, matter with a high carbon content, such as straw or peat, must be admixed, in order to trigger the rotting process. In addition, the water content of the sludge must be reduced to the necessary level to enable aerobic composting to take place.

Both a balanced C/N ratio and the correct moisture content can be achieved if an equivalent quantity of sewage sludge in terms of population is mixed with domestic refuse. This equivalent quantity in terms of population can be determined as follows, according to Hirschheydt (1): an average of 250 kg refuse with a water content of approximately 40%, and 365 kg digested sludge with a 95% water content, are produced per year per inhabitant. This adds up to a total of 615 kg with a 73%, i.e. 447 kg, water content. This is an excessive water content. However, if the water content of the sludge is reduced to 79%, a mixture is produced with the optimum water content of 50%. The solid matter in the sewage sludge amounts to 18 kg.

Sewage sludge with 18 kg solid matter and a 79% water content contains 69 kg water. This figure is added to the 100 kg (= 40%) water contained in the refuse, to produce 169 kg. The total solid matter in the refuse and sewage sludge adds up to the same amount, i.e. 168 kg. This gives a solid matter : water ratio of 50 : 50.

The Quantitative Aspects : Volume and Composition of Domestic Refuse and Sewage Sludge

Where the quantities and composition of compostable wastes are concerned, we can concentrate on domestic refuse and sewage sludge produced by households; trade refuse is generally included in domestic refuse for practical and statistical purposes, and most industrial refuse is not suitable for composting. However, a separate study will have to be made to ascertain the extent to which wastes from slaughterhouses and factory farming could be used for composting.

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(1) A. von Hirschheydt, Die Kompostierung von Müll und Klärschlamm. (1973 Breslau Conference)

There is remarkably little difference between the figures given for quantities per inhabitant in international publications. Here are some examples : according to the environment report produced by the Government of the Federal Republic of Germany, domestic refuse arisings in the Federal Republic of Germany in 1971 ranged from 189 kg per inhabitant per year in municipalities with fewer than 20,000 inhabitants, to 265 kg in municipalities with 10,000 or more inhabitants. As a weighted average, refuse arisings amounted to 234 kg per inhabitant per year. According to a study made in the United Kingdom (1), arisings of domestic and trade refuse per inhabitant per year for all areas in England in 1968/69 averaged 292 kg. The figures ranged from 259 to 367 kg. Almost the same figures were obtained for the Scottish cities of Edinburgh and Glasgow. Reference is made in the same study to an international comparison according to which in 1967 weekly refuse arisings for a household of three persons ranged between 11 and 17 kg. This represents annual arisings of 208.6 kg per person. If it is assumed that since 1967 specific refuse arisings have risen by 5% per year, the figure of 294 kg is reached after seven years. However, on the basis of longer term forecasts, a slower rate of growth of the weight of refuse must be assumed, as the proportion of specific heavy ash (changeover from coal heating to other sources of energy) has declined and the proportion of specific light plastics and paper has grown with the increased use of packaging materials. Assuming one-half of that ratio of increase, i.e. 2.5%, specific arisings would increase to 248 kg in seven years. This is almost identical to the generally favoured figure of 250 kg per inhabitant per year adopted for the Federal Republic of Germany by most authors. Information produced by the Department of Local Government in Dublin for the Republic of Ireland gives the following quantities of wastes disposed of for the population :

	Inhabitants	Refuse per inhabitant per year
Dublin City	268,000	264
County Dublin	231,000	260
Cork	57,000	246
Ireland (total)	1,870,000	256

The preamble to the Netherlands Waste Disposal Law (21 March 1975) states that 3.9 million tonnes of domestic and trade refuse are generated every year in the Netherlands, which represents 280 kg per inhabitant. Here, too, the figure differs very little from the generally favoured figures adopted in other countries.

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(1) Department of the Environment : Refuse Disposal, London 1971

If domestic refuse arisings are estimated at between 250 kg (a) and 300 kg (b), the following calculations can be made for the EEC Member States :

(in '000 tonnes)	a	b
Federal Republic of Germany	15,493	18,592
France	13,033	15,640
Italy	13,725	16,470
Netherlands	3,359	4,032
Belgium	2,436	2,923
Luxembourg	88	106
United Kingdom	14,005	16,806
Ireland	763	915
Denmark	1,256	1,507

The larger quantities indicated under (b) would seem to take into account longer-term growth. Sensationalist reports of an allegedly avalanche-like development of a torrent of waste must be contradicted here. There has already been a very considerable slow-down in recent years. This is due not only to the energy crisis and to the deterioration in the economic situation since 1973 which is expected to show signs of recovery by the end of 1976. It can also be attributed to the stagnation in population growth which has been recorded in several countries, and to the fact that saturation point has been reached where the consumption of foodstuffs requiring large quantities of packaging material is concerned. Furthermore, in most of the EEC Member States, the main reason for the flood of packaging materials and therefore also of refuse, i.e. the change-over from service to self-service in the retail trade, has by now largely been completed. It is in this light that the estimates produced by experts as material for the Environment Programme of the Federal Republic of Germany, which give figures of between 300 and 500 kg per inhabitant per year in the Federal Republic of Germany by 1980, will probably have to be viewed. These figures represent increases of 8.5 and 7.4% per year respectively, compared with the figures of 200 to 350 kg given for 1975. However, the experts (1) themselves state that : "The measurements and investigations carried out hitherto are unsatisfactory and enable neither a reliable survey nor a sufficiently accurate forecast to be made, because they :

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(1) Materialien zum Umweltprogramm der Bundesregierung, p. 41

(a) are based on differing definitions of terms and methods of analysis,

(b) have not been carried out sufficiently frequently to guarantee representative results, and

(c) have not been repeated at regular intervals."

It is not only the total volume of refuse which is important in connexion with composting, but also its composition. The following table has been drawn up on the basis of :

(a) documents produced by the Düsseldorf municipal authorities,

(b) information provided by the Hamburg authorities,

(c) a computer forecast for the Federal Republic of Germany, produced for the Federal Government by the Battelle-Institut,

(d) calculations made by the Technische Hochschule, Aachen.

%	Federal Republic of Germany	Aachen	Düsseldorf	Hamburg
Paper, cardboard	28	30.8	27.8	32.0
Glass	9	13.5	16.4	17.0
Metal	7	6.9	4.4	4.0
Plastic	3	4.5	6.2	5.5
Textiles	3	1.6	3.1	3.0
Organic kitchen wastes	15	16.6)	38.0)	35.0
Fine refuse	28	22.0)	)	
Other wastes	7	4.1	4.0	3.5

By way of a qualifying statement, it must be pointed out that the figures are not directly comparable. What part is played in a town, for example, by warehouses and cut-price supermarkets which produce large quantities of packaging materials? What periods of time are covered in each case, so that seasonal fluctuations can be taken into account?

Nevertheless, the similarity between the figures is striking. Remarkable similarities are also apparent at international level. In the "Report on Refuse Disposal" (London 1971) the composition of domestic and trade refuse generated in fifteen local authority areas in the United Kingdom is described. The table is also interesting because the information extends back to the pre-war period.

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%	1935/36	1963	1967	1968
Ash and fine refuse	56.98	38.83	30.95	21.89
Organic kitchen wastes	13.71	14.07	15.50	17.61
Paper	14.29	23.03	29.50	36.91
Metal	4.00	8.02	8.00	8.87
Textiles	1.89	2.61	2.10	2.35
Glass	3.36	8.56	8.10	9.11
Plastics	-	-	1.15	1.12
Unclassified	5.77	4.88	4.70	2.14

This list reveals clearly how, with the growing dominance of oil and gas heating, the proportion of ash in refuse has declined sharply. A very marked increase has been recorded for the proportion of paper in refuse. This is essentially a result of increasing sales of wrapped goods, although it is at the same time a result of the decline in the use of coal-fired and coke-fired domestic heating systems, which formerly burned a large proportion of combustible household wastes. Although the proportion of metal has risen compared with the pre-war period (more cans), it nevertheless remained fairly stable in the 1960's. The increase in the proportion of glass is also striking. It could mark the beginning of the non-returnable bottle era. The proportion of plastics may well continue to increase in the 1970's.

How does the composition of refuse and/or the trend in this composition affect the possibilities of composting? This is more or less equivalent to asking how suitable domestic refuse is for composting. Microbial decomposition is axiomatically possible for kitchen wastes of animal or vegetable origin, and also for garden refuse (which has, unfortunately, not been indicated separately in the tables and which should not be underestimated with the increase in small gardens around private houses). Natural textiles (wool, cotton, linen and silk) can be decomposed without any problem. Paper and cardboard are also good for composting. With wood, millboard, leather and bones it is primarily a question of comminuting the refuse first. If the refuse is communuted sufficiently, to a diameter of approximately 2 - 3 cm, the particle surface area is large enough to be attacked by micro-organisms.

Plastics, glass, earthenware, porcelain and metal are never compostable. This does not mean, of course, that these groups of substances must be removed completely from the matter to be composted. Iron and non-ferrous metals must be recovered for economic reasons, for a start. There is always some revenue to be obtained from sales of scrap metal, although it must be remembered that the scrap metal recovered from refuse, which consists primarily of tin or aluminium cans, bottle tops and similar

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types of small metal items, comprises some of the lowest-grade scrap metal available on the market.

Although glass is not directly compostable, nevertheless the aversion shown by gardeners, foresters and farmers towards glass residues in compost is based largely on preconceived ideas. If the rotting matter is ground sufficiently and the fresh compost has enough time to mature after the hygienising preliminary rotting process, the sharp edges of the glass splinters are worn away by both mechanical (friction during movement of the material) and microbial action. It might be advisable to extract the glass by air separation when manufacturing garden mould for ornamental gardens and domestic purposes. However, small glass splinters in compost are just as safe where the reclamation of waste land, quarries, etc. is concerned as for the grassing of motorway embankments or for supplying humus to grassland. Many wine-growers even consider the reflexions of light given off by the numerous small splinters on the surface of the soil to be beneficial. However, the principal effect of glass splinters, like earthenware and porcelain splinters, is to loosen the soil. This is particularly beneficial in places with heavy clay soil. If the proportion of glass were to increase further from the current figure of 9 - 10%, this would of course mean that there would be a corresponding decrease in the proportion of biologically active organic substances. However, exaggerated forecasts should not be made. No further major fluctuations in substitution possibilities in the packaging sector between glass, tin, light metal and plastics are to be expected. Furthermore, the growth curve for waste glass arisings resulting from the increasing dominance of non-returnable bottles has levelled off considerably.

The proportion of plastics in domestic refuse will probably continue to increase. Speculation as to whether strains of bacteria will develop which will also be capable of decomposing plastics is of no help at present as far as the implementation of practical solutions is concerned. Nevertheless, it is to be hoped that experiments such as those carried out by Dr. Peter Chrometzka (University of Saarbrücken) and Franz X. Kneer with regard to the decomposability of thermoplastics and thermosetting plastics in the bioreactors in the Blaubeuren refuse composting plant will be followed up, and their scope extended. Polyethylene, polyvinyl chloride, aminoplastic and phenoplastic foils and sheets were left to rot for varying lengths of time (up to twenty-one days) at temperatures of up to 80°C at depths of 50 and 100 cm. Dense colonies of actinomycetes formed, in particular Actinomyces globisporus albus. The authors also observed surface roughnesses in the case of polyethylene and polyvinyl chloride and found severe attacks in that of aminoplastics and phenoplastics, with the result that carrier-bags, generally made of polyethylene, virtually disappear at the latest during subsequent rotting process in windrows. In the fresh compost resulting from the preliminary rotting process the carrier-bags are reduced to a thin, retiform consistency. This can be attributed primarily to the fact that the plasticizer is attacked by heat and probably also by chemicals. Stronger plastic containers must be extracted before or after the hygienization process.

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At this point reference should be made to an objection which is constantly being raised against composting in connexion with glass and plastic wastes : it is said that incineration is preferable to composting as this is the only really effective way of disposing of glass and plastics. In actual fact, however, glass presents considerable problems on the incinerator grid, as it becomes doughy, settles between the grid bars and impedes the incineration process. The incineration of polyvinyl chloride causes considerable pollution as chlorine or hydroged chloride (hydrochloric acid) are produced. Consequently, as far as the harmless disposal of glass and plastics is concerned, incineration is at least no less problematic than composting. On the basis of the generally accepted theory that 15 - 20 % of the refuse over and above its metal content must be extracted, only relatively small quantities are left for disposal, even in fairly large municipalities, and these can be used without exception for land-fill purposes (controlled tipping).

Another possibility, of course, is to pulverize all the refuse (after recovering any metal), whereby plastics are torn, ground or smashed into particles of only a few centimetres, or even millimetres, in diameter. Plastics wastes which are reduced to granulated form can be used without hesitation at least for land reclamation or for the preservation of the countryside. Here, too, they have the effect of loosening the soil.

A further increase may be expected in the proportion of paper in refuse. Paper consumption is still increasing and coal heating is still on the decline, so that more paper remains to be disposed of as refuse. Although, as indicated above, paper is good for composting, as cellulose with a high carbon content it raises the C/N ratio to an extent liable to hinder composting. The higher the proportion of paper and board in refuse, the better it is to compost it together with nitrogen-containing sewage sludge.

Composting Methods

Numerous methods of composting domestic refuse and sewage sludge have been developed in a number of countries (especially in the Netherlands, the Federal Republic of Germany, France, Denmark and the United Kingdom). Before giving details of the various methods, a few fundamental points must be made :

(1) Methods should be as simple as possible. Complex equipment is not only likely to break down, with unpleasant consequences in view of the unavoidable daily volume of wastes produced, but also requires specialized staff who are by no means always easy to find and are also very expensive.

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(2) There is no "rapid process" capable of producing compost which is compatible with plant roots within only a few days. All equipment used to accelerate the composting process can only ever enable preliminary rotting to occur, which must be followed by a subsequent period during which the fresh or crude compost must mature in windrows, unless the partly rotted matter is tipped or used as mulch for the long-term reclamation of waste land.

(3) Composting plants should take up as little space as possible. The amount of space required is the main disadvantage of composting plants compared with incineration plants, although it should of course be remembered that the amount of space required for refuse incineration is also by no means small if the need to dispose of the ash, which still represents 40% of the weight of the crude refuse, is taken into account.

(4) Wherever possible, plans should also include the utlisation of sewage sludge. Whereas controlled tipping is at least still technically possible for domestic and bulky refuse, the disposal of sewage sludge is still a considerably more difficult problem.

All the methods used at present can be broken down into several stages; transportation to the plant, sorting, comminution, preliminary rotting, subsequent rotting. Differences arise depending on whether comminution and sorting occur before or after the rotting process, or on whether any distinction is in fact made between the preliminary and subsequent rotting processes. The methods can be divided roughly into the following categories :

(a) composting in windrows without comminution,

(b) composting in windrows after comminution,

(c) controlled preliminary rotting without comminution, and subsequent rotting in windrows,

(d) controlled preliminary rotting after comminution, and subsequent rotting in windrows.

Subsequent rotting in windrows which are approximately 1.20 to 1.50 metres high and which should be turned several times to facilitate aeration follows the preliminary rotting process in a fairly uniform manner. Only the details differ. Differences are observed between the various preliminary rotting processes. These different processes can be divided into several categories:

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(1) Preliminary rotting in windrows with controlled aeration. The material (refuse with or without sewage sludge) is placed in windrows as in the case of conventional composting in windrows, but the rotting process is accelerated by suction or injection of air.

(2) Preliminary rotting in immobile cells. The refuse (comminuted or non-comminuted) is placed in cells made of gratings, wire netting or concrete. Sewage sludge can be processed at the same time. Air is sucked in or injected through a system of pipes.

(3) Preliminary rotting in mobile cells. The refuse, usually combined with sewage sludge, is subjected to a preliminary rotting process in a slowly rotating drum, while oxygen is injected into it.

(4) Preliminary rotting in silos. A silo is filled from above with refuse (with or without sewage sludge). The rotting matter is moved downwards by various different technical processes. On its way down it is aerated and undergoes the preliminary rotting process at the appropriate temperatures. One special type of silo system which will be described is the sewage sludge silo developed by Franz Xaver Kneer, which is specially designed to guarantee the hygienization of sewage sludge by the addition of carbon-containing matter (straw, paper, lignite, etc.).

(5) The briquetting method is a special case. Here, as explained later, refuse and sewage sludge are briquetted and hygienized to such a degree that long-term storage with a view to re-utilization in agriculture, viticulture and forestry is possible.

The task of disposing of the residues should not be underestimated. This task can best be accomplished where land in the vicinity of a composting plant needs to be filled (tip). The incineration of residues requires costly measures to guarantee protection against emissions. One solution is to compost wastes outside a congested area and to transport the small quantities of residues into the centre of the congested area where an incineration plant operates in accordance with the provisions governing protection against emissions. It is of course questionable whether this is an ideal solution as the ash must then be transported from the incineration plant back to the outskirts of the area.

Various methods can be applied not only for preliminary comminution but also for subsequent comminution after the preliminary rotting process, all of which have greater or lesser advantages and disadvantages. Refuse can be comminuted and screened at the same time by screen shredders or by screening jacket crushers. It can be smashed in hammer mills or ground in impact breakers or multi-stage crushers. Opinions differ as to the size to which the rotting matter should be ground or shredded. On the one hand a fairly coarsely comminuted substrate facilitates aeration, while on the other hand, thorough grinding means that the rotting matter is homogenized, which helps the rotting process to proceed evenly.

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The most important methods are outlined below. We shall refrain from expressing any opinion on individual advantages of the various processes. The decisive factor has been found to be correct treatment of the refuse or sludge/refuse mixture rather than the actual method used. However sophisticated the method, if it is applied incorrectly bad compost is produced. This is another reason for advocating the simplest methods possible.

I. Composting in windrows

(1) Van Maanen system. Applied in the Netherlands since 1929. Refuse from 110 municipalities is transported in special railway wagons to the two plants in Wijster and Mierlo. The refuse is composted, without being comminuted, in 6 m high windrows and is turned several times during the six-month rotting period by grab cranes. At the end of the rotting period the compost is screened and, depending on the use to which it is to be put, glass and other foreign matter are extracted. The residues are incinerated or taken to tips.

(2) Baden-Baden system. Refuse passes through a rotary screen, is mixed with sewage sludge once the coarse matter has been extracted, and is placed in windrows (8 m wide, 3.50 m high). Air is sucked into the windrows from outside for aeration purposes, and mobile tent roofs protect them against rain. The rotting period is three months. The matter is comminuted after the preliminary rotting period. Screening residues are taken to tips, and bulky matter is incinerated. The plant is considered antiquated even by its operators and is being closed down in 1976.

(3) Systems involving preliminary comminution. Various small plants in several countries. Windrows of 1.00 to 1.50 m high. No controlled aeration. Repeated turning. Suitable for smaller municipalities.

(4) Giessen model. Preliminary comminution and mixing with sewage sludge in an impact breaker. After three to four weeks, crude compost is placed in new windrows. Left for a further three to four weeks.

(5) Konstanz rural district model. Specially developed for rural municipalities using equipment manufactured by the Fahr agricultural machinery factory. Collection of refuse in containers. Comminution of refuse, addition of appropriate quantities of sewage sludge, 1.50 m high windrows. Turning by means of tractor-drawn turning equipment with a centrifugal roller.

(6) Heidenheim (Voith-Müllex) system. Comminution by means of a Voith shredder and a hammer mill. Mixing with sewage sludge. Composting on compost plates (up to 20 m wide, 100 m long) in windrows up to 2 m high. Aerated by means of a radial ventilators. Rotting period of two months without turning. Subsequent maturing for six months in aerated windrows. Residues are incinerated.

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(7) Landau (Dieffenbacher) system. Composting in 4 m high windrows after preliminary comminution. Air is sucked in or injected as required through a pipe system.

(8) Briquetting (Caspari-Meyer method). This method occupies a special position between the windrow and cell methods. After coarse pieces of iron have been removed magnetically, domestic refuse is shredded. Inorganic substances, plastics and textiles are not comminuted and are tipped or incinerated. Pieces of iron are removed magnetically from behind the shredder, glass and ash are removed in the de-splintering process, non-ferrous metals, bones, bottle tops, etc. are extracted by ballistic methods. The comminuted and decontaminated refuse is mixed thoroughly with digested sludge (water content reduced to 70 - 74%) in a twin-shaft mixer. This mass is pressed to form briquettes similar to building bricks. The briquettes are stacked on pallets, where microbial activity rapidly sets in. Within three weeks the briquettes are hygienized, and there is considerable fungus growth. Their water content is reduced to 20%, and in this condition they can be stored for years. When needed, the briquettes can be broken up in a pulverizer and returned to crude compost.

II. Preliminary rotting in cells and silos

(1) Dano stabilizer. After recovering scrap iron, bulky matter and other unwanted objects, the refuse is placed in a 26 m long rotary rotting cell with a diameter of 3.50 m, and sewage sludge is added. The matter passes through the slowly rotating drum in three to five days and comes out as hygienized crude compost. Air is blown in during the rotting process. At the end of the preliminary rotting process the matter is screened and any glass removed.

(2) Rheinstahl-Bühler. This process likewise involves a rotating drum, but in this case the matter is comminuted first. The refuse is moistened with water or sewage sludge. The rotting matter passes through the drums in one to two days. Oxygen is supplied by creating a vacuum by means of suction at the drum exit point. The rotor is approximately 20 m long and 3.75 m in diameter. The partly rotted matter is screened and placed in 4 m high windrows for five days to enable the subsequent composting process to take place, and it is then sold as fresh compost or continues to mature in windrows.

(3) PRAT. This method, which was developed in France and is also the principal method applied there, involves an immobile cell (static method as opposed to the dynamic drum method). It was originally used only for comminuted material, but it has also been used successfully to treat refuse which has undergone preliminary comminution (with and without sewage sludge). The rotting cells are made of wire netting and hold 36m^3 of material. They are aerated through perforated pipes on the floor of the cell. Preliminary

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rotting in the cell standing in a shed takes approximately one week. The crude compost is comminuted and screened and foreign substances are removed.

(4) Humusol. This method also originated in France. It involves the treatment in immobile cells of refuse which has undergone preliminary comminution and separation of foreign substances. Its special feature lies in the fact that the refuse is inoculated with bacterial cultures before it is placed in the cell.

(5) Blaubeuren breathing method. In this method develped by Dr. Eberhard Spohn, comminuted domestic refuse is composted together with sewage sludge in concrete cells. Depending on the oxygen content of the rotting gases, air is sucked in through the rotting matter. This "breathing" occurs at the fastest rate at the beginning when there is a great deal of microbial activity. The moisture content of the rotting matter is also checked regularly and adjusted by spraying. The crude compost is placed in layers in windrows where the subsequent composting process takes place.

III. Preliminary rotting in silos

(1) Multibacto (rotting silos arranged in decks). The refuse, which has undergone preliminary comminution and is mixed with largely de-watered sewage sludge, is placed in the top deck of an eight to ten-deck rotting silo. The material is turned slowly by a stirring mechanism and gradually moves downwards through various openings. A counter-current of air moves upwards from below to ensure that the process remains aerobic. The rotting period lasts sixteen to twenty-four hours. According to the operator, preliminary rotting in a silo corresponds to a three- to five-month rotting period in windrows. The material which has undergone preliminary rotting is then left to mature in windrows or is sold as fresh compost.

(2) TRIGA system. Several rotting cells stand next to each other. The refuse, which has undergone preliminary comminution passes downwards through the first cell and is then moved into the next cell, in which it continues to rot. Several plants of this type are in operation in France.

(3) Jersey (Thompson) method. Six static cells with perforated floors which can be opened downwards are placed on top of each other. The comminuted refuse is mixed with sewage sludge and placed in the cells. Every day the floors of the cells, starting at the bottom, are opened, so that the rotting matter falls downwards to the next level, and is turned and aerated in the process. The topmost cell is filled daily with fresh refuse. The material removed from the lowest cell, which has thus completed preliminary rotting, is six days old. The composting process can continue in windrows.

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(4) Carel Fouché method. This method is almost identical to the Jersey method; the top five cells can be specially aerated.

Heavy Metals and Polycyclic Hydrocarbons

Following the growing interest in the composting of refuse and sewage sludge shown by the population and by the waste disposal authorities in the EEC Member States and elsewhere in the second half of the 1960's, discussions on the quantities of toxic and carcinogenic substances in compost have become more frequent since the beginning of the 1970's. In some cases political bodies and administrative authorities, disturbed by the results of various investigations, have at least deferred decisions on the construction of composting plants. Fear of hazards to the health of the population can never have been the sole reason for this. Concrete economic interests were also at stake: how can a ministry justify promoting the construction of composting plants, possibly even by providing subsidies, if in the foreseeable future more stringent environmental protection regulations will necessitate their closure? And how can local authorities justify expenditure on such plants if their operation is liable to be jeopardized in the long term?

It must be pointed out first of all that the unrest has arisen to a large extent from misinterpretations of the results of scientific investigations. The debate is in some cases becoming highly emotional. The assertion which has frequently been maintained in the past, is that the chemical industry is in favour of a negative decision on compost because the use of compost would mean a decline in the market for mineral fertilizers and pesticides, is reiterated. It must be pointed out, by way of objection, that the chemical industry has itself shown, in numerous publications, the casual relation between humus supply, fertilizer consumption and pest infestation. However, the debate appears to have become more objective since 1974.

The question of harmful components in refuse compost, sewage sludge or sludge/refuse compost revolves around two main factors.

(1) The quantities of heavy metal compounds in compost. The principal compounds concerned contain copper, zinc, molybdenum, manganese, iron, cobalt, cadmium, mercury, lead, arsenic and chromium.

(2) The quantities of polycyclic aromatic substances: 3,4-benzopyrene; 3,4-benzofluoranthene; fluoranthene. These are polycyclic hydrocarbons with condensed benzene nuclei. The most important and obviously also the most dangerous of these is 3,4-benzopyrene, whose carcinogenic effect has been established as a certainty by a number of authors. The question of polychlorinated biphenyls (PCBs), is also raised, although their use has already been strictly limited for several years.

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A. Heavy Metals

Small quantities of heavy metals are found in numerous foodstuffs, consumer durables and consumer goods. According to Siegel (1), some heavy metals, eg. copper, zinc, molybdenum, manganese, iron and cobalt, are even essential to animals and man and (with the exception of cobalt) also to green plants. Siegel is not the only author who therefore considers the supply of heavy metal compounds as part of the necessary trace elements via compost even to be beneficial.

It is, of course, the quantities involved which are decisive here. The quantities of heavy metal compounds in refuse and/or sewage sludge fluctuate considerably. The largest quantities are found in sewage sludge. However, this is the case only if industrial and trade effluent is discharged into sewage works together with domestic effluent. In this case, the concentrations of heavy metals discharged by galvanizing plants, electroplating plants or tanneries, for example, may be so high that even the hygienization of refuse and sludge may be jeopardized.

> Wherever refuse and sewage sludge are to be composted, care must be taken to ensure that only domestic wastes are treated.

Sludge digestion in sewage plants is disrupted by heavy metals when the concentrations of those metals reach certain levels; for example, chromium: 1 - 2% content; copper: 0.25 - 0.5%; nickel: 0.5 - 1.0%; zinc: 0.3%. Sewage works operators are therefore anxious to ensure that sewage sludge contains the smallest possible quantities of heavy metals, regardless of the subsequent use to which the digested sludge is to be put.

An important question here is how and to what extent heavy metal compounds

- enter compost from refuse and/or sewage sludge,
- pass into the soil from compost and remain at plant root level,
- pass from the soil into plants,
- can form high concentrations in the long term.

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(1) Professor Dr. O. Siegel : Beurteilung der verschiedenen Kompostierungsverfahren und der Verwendung von Kompost bezüglich der Anreicherung von Schwermetallsatzen und kanzerogenen Stoffen im Boden. In : Vor-und Nachteile der Verbrennung und der Kompostierung, p. 635.

As far as the first point is concerned, there is probably little chance of exerting any influence over refuse composting processes, apart from the fact that the pollution of main sewage channels by trade effluent with a high heavy metal content must be prevented. Certain basic quantities of heavy metals are unavoidable.

The absorption capacity of plants as a function of soil grade is a particularly important point. The higher the pH value of the soil, in other words the more basic it is, the lower the capacity of plants to absorb heavy metals. (1) Refuse composts, and to an even greater extent sludge/refuse composts, have high pH values. This means that, although they may contain certain heavy metal solutions, because of their basic character they nevertheless inhibit transmission of these compounds to plants. Furthermore, humus adsorbs heavy metal compounds. The strong adsorption power can be attributed to the large surface area of the colloidal substances. In addition, the compounds move very slowly in the soil. It is very difficult, at least, for them to be leached into the groundwater.

According to Professor Dr. Hermann Kick of the Agrikulturchemisches Institut, Universität Bonn, if the zinc, lead, titanium, copper, arsenic, nickel and cadmium content of sludge/refuse compost is less than 100 mg per kg dry matter and the pH value is 6 or more, it is absolutely safe. Kick mentions some types of compost and gives averages which he has calculated (kg per 100 tonnes of dry matter):

	Blaubeuren	Kreuznach	Average
Cu	10	9	8 - 12
Zn	34	87	80 - 120
Mn	43	41	42 - 60
Co	0.5	-	-
Pb	10	71	-

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(1) The pH value represents the number of hydrogen (H) ions contained in one litre of solution. The value given is the positive number contained in the negative exponent of the base 10 of the H ion concentration. For example, a solution of 10-3 is expressed by the pH value 3. This indicates a very acid solution, whereas a solution of more than 10-7.2 with a pH value of 7.2 is basic or alkaline.

A comparison of the metal content of arable soils with the toxic level on the one hand and with the average quantities of metal in compost on the other, is particularly informative. For example, a 6-300 kg copper content was determined for one hectare of arable soil; a 16-20 kg content is considered adequate, while copper becomes toxic at a level of 90-1200 kg, depending on the type of soil and crop. However, the quantity of copper in compost is not likely to exceed 15 kg/100 tonnes. Chromium becomes toxic at a level of 540 kg/hectare, whereas the average quantity in compost is estimated at 6 kg/100 tonnes. Similar ratios are obtained for the other heavy metals. In the case of phosphate fertilizers, the metals form phosphates which are not readily soluble, which reduces their availability to plants still farther.

Leading scientists conclude that sewage sludge and sludge/refuse compost should be examined regularly to determine the quantities of heavy metals which they contain. Siegel recommends that special attention be paid to the cadmium content. In all cases, observers consider the use of compost in public parks, land reclamation, forests and wherever plants are not to be used as foodstuffs to be completely safe. However, the majority also definitely tends to recommend the use of compost for grassland, arable land, market gardens and vineyards. The natural quantities of heavy metal compounds, which are constantly changing as a result of the chemical reaction of minerals in the soil, generally exceed those quantities which can be introduced into the soil even if large amounts of compost are applied over several decades.

B. Polycyclic Aromatics

Siegel (1) has carried out thorough tests to ascertain the behaviour of 3,4-benzopyrene, 3,4-benzofluoranthene and fluoranthene in soil. He concluded from these tests "that the quantities of polycyclic substances in soil can be increased by applying compost produced from municipal refuse". However, as he then proceeds to point out, "the wide range of cases which we investigated shows quite clearly that, entirely irrespective of whether compost produced from municipal refuse is applied, the natural quantities of polycyclic substances in soil fluctuate enormously and can reach very high proportions which far exceed the quantities of polycyclic substances in soil to which compost is applied".

A particularly important fact is pointed out in the same study : polycyclic substances are produced, for example, wherever organic substances are incinerated or are heated to a temperature exceeding 500°C. This is why they are also produced in cigarette smoke. When refuse is to be disposed of by incineration or pyrolysis, it should be remembered that heat produces polycyclic aromatics. Polycyclic substances are produced in both cases; in the incineration process they pass into the atmosphere.

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(1) Siegel, op. cit.

From the ecological view point this is a point which should be considered when choosing between the incineration and composting of refuse.

Markets for Compost

Viewpoints differ greatly where markets for compost are concerned. They range from the opinion that there is no problem whatsoever as far as marketing is concerned, to the assertion that there will never be an adequate market for compost. Both extremes are wrong. Composting should never be rejected as a means of disposing of domestic refuse simply because there is allegedly no market for it. It is, for example, impossible to agree with the opinions along these lines expressed by the Battelle-Institute (1), which has for years generally advocated incineration rather than composting. It cannot be said that there is no market for a product when no system has yet been developed for marketing that product. The Vuilafvoer Maatschappij in Amsterdam, for example, has had good experience with the marketing and sale of compost; the company's activities will be described later. France has also had considerable experience with the satisfactory marketing of compost to its wine-growing industry. (Von Hirschheydt study on compost in France). In the Federal Republic of Germany there are several examples of successful sales of compost, such as in the Duisburg-Krefeld area by the Duisburg-Huckingen composting plant or in the Kreuznach region, in Blaubeuren, in Wiesloch near Heidelberg or in Schweinfurt. This is by no means an exhaustive list of all the plants in operation which market compost successfully.

On the other hand, it is misleading to state a priori that no problems are involved in the marketing of compost. Poor compost which has not matured sufficiently, which easily becomes anaerobic (putrid) and emits a strong odour and is, moreover, difficult to spread, cannot have the effect of promoting sales. Once confronted with these products, farmers will always reject compost as a soil-improver. Nor will they accept the justifiable claim that compost which has not yet matured and is partly anaerobic will soon become aerobic again once it is applied to the soil, as a result of the abundant supplies of oxygen and the activity of the microbes in the soil, and will play its full role as a soil-improver.

Past experience has shown one factor, which was not appreciated at first, to be of vital importance where the saleability of compost produced from domestic refuse and sewage sludge is concerned : the attitude of composting plant operators towards the product and/or its raw material, refuse. Here, too, there are two extremes.

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(1) Abbaubare Kunststoffe und Müllprobleme, p. 11

In the first case the idea of waste disposal is most important; the quality of the product, and more especially the development of markets, is neglected. Experience has shown that an employee or official who is neither trained nor experienced in selling is often made responsible for sales. It is obvious that such a policy is doomed to failure. At the other extreme, only the production and sale of a soil-improver is in the forefront, and the function of disposing of domestic refuse and sewage sludge is neglected. In such cases plants may be constructed which involve above-average capital expenditure and expenditure on staff while their capacity is lower than the volume of refuse and sewage sludge generated. In addition, such a large proportion of the refuse is extracted before the composting process in order to guarantee good quality compost that new tipping and incineration problems arise.

A balance is therefore necessary, combining a process which is technically as simple as possible to enable a large proportion of the refuse to be treated together with sewage sludge and yield a good product, with an effective marketing system. This task cannot be entrusted to a team which has received excellent training in administration but has no experience whatsoever of marketing and sales.

Agricultural organizations play a key role in the marketing of compost. However, in the Federal Republic of Germany at least, the greatest opposition to composting has so far come from agricultural organizations. This is understandable in view of the bad experience which they have had with the application of non-composted sewage sludge to agricultural land. The Chambers of Agriculture and the farmers' associations must be made better informed of the advantages of composting so that they themselves are activated to make recommendations to farmers.

The marketing of compost for piglets has met with opposition, in the Federal Republic of Germany at least, from veterinary associations and some health authorities. The question of whether compost for piglets should be subject to the law governing the manufacture and prescription of medicines has been raised and not adequately answered. Experience in the Netherlands agricultural sector can serve as a model here. (1)

The possibilities of selling compost to individual consumers should not be underestimated. Compost is sold as a garden compound in small packets mixed with peat, sand and mineral fertilisers.

The Netherlands, in particular, have been very successful in this connexion too. The principal market in this case is the florist trade. The attempt to introduce partly rotted, compressed, crude compost as fuel, resembling lignite briquettes and with similar calorific value, was evidently not very successful. The use of compressed, hygienized compost as building material

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(1) See Uebbing in "Blick durch die Wirtschaft" of 16 May 1969.

which was advertised for a time by some suppliers is scarcely heard of any longer. Experiments are now being carried out with the addition of fresh compost to clay in brickworks. The organic matter vaporizes when incinerated so that a porous, thermally insulating, sound-absorbing brick is produced.

One major market, i.e. the use of compost for the grassing of motorway embankments, parks and sports grounds, is a public authority market. A special type of marketing is required here as both contracting parties are generally representatives of public authorities.

Assumptions Concerning the Practical Opportunities for Marketing Compost

In the EEC Member States, with the exception of France and several cases in the Federal Republic of Germany and in the Netherlands, there is no compost industry as such. Nevertheless, sufficient experience has been gained from the various individual cases to enable assumptions to be formulated which must now be substantiated.

(1) Compost is not a commodity that travels well.

Consequently, whenever possible compost should be transported only over short distances. This in itself suggests that composting plant operators, almost always public bodies (local authorities, associations of local government units, regional or national authorities) should look for markets, for a large part of their compost at least, in the vicinity. Compost can be used for : sports grounds, parks, playgrounds, cemeteries, municipal gardens, communal forests, green spaces in new housing areas, road embankments.

Another aspect of these uses is important : they relate to cultivation which does not produce commodities for human consumption. This means that the problem of the harmful effects of any heavy metals and polychlorinated biphenyls present never arises. An attempt has already been made in the first section of this report to show how some publications exaggerate the dangers of these substances.

The statement that compost does not travel well must, however, be qualified. The higher the production value per unit area of the crops to be treated with compost, the further the compost can travel. The degree of maturity is also important in this connexion. Here is one important example : the Netherlands company Vuilafvoer Maatschappij in Amsterdam sends the compost produced in its composting plants, enriched with peat and earth and packed in small garden packets, to Westphalia. Another example : the composting plant in Blaubeuren has been selling compost to the Bavarian hop-growers for more than ten years, and this involves distances of up to 170 or even 200 km. A particularly interesting example is found in the French compost industry. Here, as indicated in our Annex on France, compost from the Paris region is delivered to the wine-growing areas of Champagne and even to the Pas-de-Calais area. Compost from the Paris region is also delivered to the mushroom-growers in the Loire Valley. The names of the products alone (champagne, mushrooms) show clearly that these are products with a high production value per unit area, for which correspondingly high expenditure on compost is acceptable.

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The fact that medium-quality compost for products not having a high production value per unit area does not travel well gives rise to another practical conclusion which is currently being discussed by the directors of German composting plants : assuming, as experience has shown, that the best marketing opportunities from a freight cost viewpoint are within a radius of twenty to thirty kilometres, exchanges of orders should be arranged within a joint marketing system operated by several composting plants. Deliveries should always be made by the plant nearest to the customer concerned. This of course requires the interchangeability of composts and therefore comparable, homogeneous and controlled quality standards.

The interchangeability of composts between several plants has a further advantage : the best time to apply compost to soil varies according to the type of crop. At the same time, the amount of compost generated may fluctuate. If several composting plants form a supply association within which they can exchange mutually agreed quantities, a better distribution of quantities over the various seasons can be achieved. The aim is therefore to develop the widest possible range of uses covering the largest possible area.

Such a large area can be used as a market to launch the product. If the construction of a composting plant is planned for a particular area, sales of compost from another plant can pave the way for sales of compost from the new plant to be built. In this way future compost consumers can be convinced of the possibilities open to them for using compost sufficiently early to ensure that sales of compost from the new plant do not come up against any problems.

(2) Compost is not a waste product but a product sui generis where the original product (in this case refuse) is of secondary importance.

Where marketing is concerned, this means that the term "refuse compost" evokes misleading ideas in the minds of potential buyers who are approached. It always tends to be associated in their minds with the original material, i.e. refuse. However, it is not the origin that should be stressed, but the aim, namely soil improvement. It would therefore be better to speak of "plant compost" or "humus formers" or to use similar terms. Here, too, the question of quality and its control arises. One important question in this connexion is whether the composting process itself should not be defined more precisely. The proposal put forward years ago by some specialists, that the term "reduction to earth" should be used instead of "composting" to distinguish the process from the "reduction to ashes" which occurs in the case of incineration, also stresses the product rather than its origin.

.../...

(3) Preparations for marketing compost should begin as soon as a composting plant is planned.

Surveys should be made of the utlization of the surrounding countryside for agricultural and forestry purposes. The public authority demand discussed under point (1) should also be studied. It could transpire that the public authority demand might be able to absorb the entire compost output or at least a large proportion of it.

(3.1.) When making preparations for marketing, early contact should be established with professional agricultural and conservation organizations. Past experience has shown that the agricultural organizations in the Federal Republic of Germany are never very co-operative. Their reluctance to accept innovation seems to be linked with the fear of increased expenditure and - recently - also of the repeated and emphatic claims about heavy metal or chemical admixtures. In the Netherlands this newly voiced fear has also tended to make the agricultural organizations less co-operative. In France there is a greater tendency to co-operate as a result of longer experience, and the highest degree of co-operation has been developed in Switzerland. These could serve as models.

These observations about agriculture also apply mutatis mutandis to forestry. Various contributions to the debate from the forestry sector reveal that, if the very receptive Swiss forestry officials are excluded, there is very little knowledge of sludge/refuse compost in the Community countries. It is sometimes even confused with digested sewage sludge.

(4) As compost is a commodity and not waste, it should in principle not be given away. Even giving away compost to launch it on to the market should be avoided (although this does not necessarily exclude introductory offers at particularly low prices). If compost is given away, there is the danger that the user will feel that he is serving as a rubbish tip. This is precisely what must be avoided. Experience with composting plants in the Netherlands, Switzerland, France and the Federal Republic of Germany shows that consumers, especially those engaged in horticulture and viticulture, accept compost even against payment once they are convinced of its usefulness.

(5) As marketing involves expenditure that must be recouped, a painstaking examination should be made to ascertain where in the range of potential users expenditure would be most worthwhile. Ernst (1) lists the following potential sectors for the use of compost :

.../...

(1) A.A. Ernst : Absatzmöglichkeiten und Einnahmen für verschiedene Kompostarten. In : Vor- und Nachteile der Verbrennung und der Kompostierung von kommunalen Abfällen. Berlin 1975.

root crops
corn
fodder
grassland farming
animal husbandry
viticulture .
horticulture
ornamental plants
vegetables
fruit
landscaping
tree nurseries
cemetery gardens
forestry
special plantations
mushroom-growing
asparagus-growing
allotments
horticultural soil
fibres
filtering material
decomposition of odorous substances
absorption layers on tips

This is probably the most complete list on the basis of the literature available. However, it does not include the production of air bricks which is still at the experimental stage (firing of a quantity of clay mixed with compost to obtain porous bricks).

As far as the classification of spheres of application according to market possibilities is concerned, it can be said, generally speaking, that all mass cultivation (arable and pasture farming) should if possible be excluded, while intensive cultivation (fruit-growing, mushroom-growing, viticulture) is automatically of interest. The cultivation of young trees, for example, in the forestry sector, should also take preference over already stocked forest as a field of application.

(6) To be successful, the production and marketing of compost must be directed at the development of higher-grade products. The costs of producing compost will probably not rise quite so fast as those for the more capital-intensive incineration process. However, the most important point is that, in contrast to incineration where the only product is, at best, ash, composting leads to a product whose quality can be improved by a maturing process, by adding peat or by combining it with fertilizers. Mention must be made of another particularly interesting procedure : the production of lime compost or fertilizer-compost granules. One good example of successful constant refinement is provided by the Vuilafvoer Maatschappij, the Netherlands State-owned compost concern. Its revenue per tonne has multiplied in the course of twenty years, not as a result of rising prices for the same product but because of increasing sales of higher-grade products right down to small packets for ornamental gardens.

.../...

(7) Efforts to find a use for compost must be accompanied by the introduction of a generally accepted system of quality standardization. Compost sales have frequently suffered setbacks in the past as products sold as "compost" have not merited this name on grounds of either consistency or effect. It is difficult to win back consumers to real compost once they have been deceived by offers of this type. The quality standards should be based on the following criteria :

1. particle size
2. degree of maturity
3. pH value
4. water content

It would be useful if quality standards could be drawn up at supranational level. Experience gained in France, the Netherlands and the Federal Republic of Germany could then be used as a basis. Mention should also be made in this connexion of the survey of the French compost industry contained in this report.

Composting is a complex technology which requires suitably trained staff.

Whenever complaints have been made in the past about environmental pollution caused by composting plants, the pollution has in most cases been caused not primarily by the process or by the plant but because of the way in which the plant was operated. As indicated in the introduction in the first part of this report, composting is a highly complicated set of interacting biological, chemical and physical processes. If an employee or official in normal local authority employment is entrusted with the direction of a composting plant, he does not have the necessary knowledge to enable the rotting process in the composting plant to proceed smoothly, nor can he provide potential buyers of compost with proper advice.

Guidelines for the training of composting plant operators should be drawn up at European level. Reference should be made in this connexion to guidelines and experiences in the German Democratic Republic (GDR) which are certainly worth heeding. They (1) include, for example, proposals concerning the qualifications and responsibilities of persons working in a mechanical composting plant using windrow systems, which will be set out below as there is a lack of suitable criteria within the European Communities. It goes without saying that the aim is not to copy these guidelines, which have already been perfected to a large extent, in a slavish manner.

.../...

(1) "Kommunale Dienstleistung" of the Institut für Kommunalwirtschaft, Dresden, 5/65 and 2/66.

Courses must be organized for composting plant operators, designed principally to meet the following requirements and to impart the following knowledge :

1. Complete vocational training as a gardener or farmer;

2. Work in a composting plant, including analyses of the composition and quality of compost;

3. A course in the operation of sewage works, which is imperative if the future composting plant operator is to master the combined use of refuse and sewage sludge in the composting plant;

4. An introduction to marketing methods and sales techniques.

Proposal concerning the qualifications and responsibilities of persons working in a mechanized composting plant using windrow systems

Position	Qualifications	Special knowledge	Responsibilities
Director	Agronomist (completion of technical college training)	SAV course; driving licence III and certificate for the operation of two pieces of equipment	Direction and supervision; compliance with quality standards; humidity and temperature measurements; allocation of refuse collection vehicles; recording of quantities of refuse; compost sales; records; instruction in industrial safety provisions and other responsibilities of a director.
Mechanic	Skilled metal-worker	SAV course; driving licence and certificate for the operation of all equipment	Building and turning of windrows using a T 172; minor repairs to all equipment; capable of supervising several employees.
Tracked vehicle driver	Skilled worker (electrician)	SAV course; driving licence and certificate for the operation of all equipment	Building of windrows using a tracked vehicle; space-use planning; operation and servicing of the diesel generator set and electric power supplies; building of windrows using a T 172; capable of supervising several employees.
Grab crane operator	Skilled metal-worker	Driving licence and certificate for the operation of a T 172 and one other piece of equipment	Building and turning of windrows; screening and building of windrows using a T 172; minor repairs to equipment.

Position	Qualifications	Special knowledge	Responsibilities
Local staff	Fairly long training period	-	Work in accordance with the Director's instructions; responsible for scrap collection, removal of screening residues and for keeping the site tidy.

(SAV = utilization of urban wastes)

All employees are responsible for servicing and looking after the equipment entrusted to them, save where other arrangements are made by the Director in exceptional cases.

Source : Institut für Kommunalwirtschaft, Dresden

Composting in the Federal Republic of Germany

The original objective of composting in the Federal Republic of Germany was not waste disposal but soil improvement. This had some advantages: knowledge of good compost qualities was acquired at an early date. It also had some disadvantages, however: in the efforts to achieve high-quality compost, the development of methods for the relatively rapid hygienization in the smallest possible area of the wastes produced by a large population was at first neglected. The balance between efforts to achieve high-quality compost, on the one hand, and mass methods pure and simple, on the other, is still a prominent feature of the present debate in the Federal Republic of Germany and, unlike the attitude in France, for example, which is far more pragmatic, the dispute about polychlorinated biphenyls (PCBs) and heavy metals has for several years prevented the construction of composting plants which many experts consider necessary and possible. Furthermore, the fact that farmers, wine-growers, foresters and conservationists have been inadequately informed has meant that they have so far not shown much willingness to use compost. Most Chambers of Agriculture show very little willingness to co-operate with composting plants and their operators.

The possibilities for the use of compost in the Federal Republic of Germany are almost unlimited, if the theoretically possible compost production figures are considered. Let us first consider the quantities of compost which could be produced from domestic refuse and sewage sludge. Let us assume, although this is not possible in practice, that all the domestic refuse and sewage sludge in the Federal Republic of Germany were to be composted. The volume of domestic refuse per inhabitant is estimated at 250 kg/year. If the domestic refuse has a 40% water content, the volume of dry matter amounts to 150 kg per inhabitant per year. Digested sludge has a 95% water content on average. The annual volume per inhabitant is estimated at 365 l (1). The volume of dry matter thus amounts to approximately 20 kg. In practice a ratio of 10:1 can be taken as a basis, assuming equivalent population for the production of sludge and refuse: one-tenth of the volume of refuse can, in terms of dry matter, be said to be sewage sludge. Remaining with our example: 150 kg of domestic refuse (dry matter) and 20 kg of sludge (dry matter) produce 170 kg of compostable substrate per inhabitant. If 60% of that volume remains after the extraction of non-compostable substances which can be removed, and after oxidation losses, the annual volume produced per inhabitant totals 100 kg. This would mean six million tonnes a year for a population of sixty million. It must be remembered that this would involve the treatment of the total volume of sewage sludge generated by households, in addition to domestic refuse, and its preparation for beneficial application in agriculture, or at least to enable it to be tipped safely. However, it is precisely this which presents the most difficult problems in the disposal of urban wastes.

.../...

(1) See Hirschheydt : Die Kompostierung von Müll und Klärschlamm

These purely theoretical figures which, as already stated, can never be achieved in practice, must be compared with the theoretically possible demand. Various different quantities are considered necessary for the restoration or maintenance of the humus content of soil used for agricultural or forestry purposes. The biological activity and the degree of maturity of the compost play just as important a role as the soil quality, the intensity of cultivation and the climatic conditions. On the basis of the view of various individual authors, a volume of between 15 and 30 tonnes per hectare of usable land per year is considered necessary to ensure the maintenance of the required humus content.

The area of usable land in the Federal Republic of Germany totals 24.28 million hectares. Of this, 13.34 million hectares are used for agricultural purposes. If all the domestic refuse and sewage sludge generated in the Federal Republic of Germany were to be manufactured into compost, an area of between 200,000 hectares (at a rate of 30 tonnes per hectare) and 400,000 hectares (at a rate of 15 tonnes per hectare) per year could be supplied with soil nutrients. The areas no longer put to economic use plus waste land and uncultivable land alone are thought to cover a total of 960,000 hectares. Consequently, on the basis of the entirely theoretical assumption that all the domestic refuse and sewage sludge in the Federal Republic of Germany were to be composted, not even the fallow and waste land could be provided with adequate supplies of compost. Professor Dr. Hans Straub, Municipal Building Director in Baden-Baden, spoke along these lines in a public hearing of the Internal Committee in the Federal German Bundestag (Lower House): "... prominent farmers state that the quantity of compost which would be produced from urban wastes in the Federal Republic of Germany would be so small compared with the demand from the agricultural sector that it could be used to supply only approximately two-thirds of the area used for the cultivation of feedstuffs and sugar-beet". This information is essential as it is constantly argued that there are insufficient markets for compost in the Federal Republic of Germany.

A rate of 15 tonnes per hectare is, however, very low. The average quantities per hectare differ depending on the type of cultivation.

The following figures have been taken from the relevant literature (in some cases much higher figures were quoted):

viticulture	80 tonnes per hectare
fruit-growing	50 tonnes per hectare
vegetable-growing	65 tonnes per hectare
tree nurseries	50 tonnes per hectare
ornamental plants	30 tonnes per hectare
preservation of the countryside	50 tonnes per hectare
hop-growing	50 tonnes per hectare
land reclamation	100 tonnes per hectare

.../...

If the compost requirements, i.e. the potential capacity of major areas of cultivated land, are estimated on the basis of these figures, the following quantities are calculated:

vineyards	96,000 hectares x 80 tonnes =	7,680,000 tonnes
orchards	84,000 hectares x 50 tonnes =	4,200,000 tonnes
horticultural land	330,000 hectares x 50 tonnes =	16,500,000 tonnes
parks and ornamental gardens	358,000 hectares x 50 tonnes =	17,900,000 tonnes
		46,280,000 tonnes

This means that the potential capcity of a fraction of the land used for horticultural, agricultural and forestry purposes in the Federal Republic of Germany is almost double the theoretically possible, but in practice impossible, total compost production for the entire EEC.

Whether the consumption areas and composting plants are always located sufficiently close to each other from the point of view of transportation to make the application of compost to the land worthwhile is quite a different matter. It should, however, be remembered that compost-based garden compound produced in the Netherlands, for example, has been supplied to Switzerland for years.

At present, in fact, at least 2% of the domestic refuse produced in the Federal Republic of Germany, and a slightly lower proportion of the sewage sludge, is treated in composting plants. Nineteen plants (see table) serve a population of 1.9 million. The quantity of compost produced cannot be determined precisely, as the information provided by operators is sometimes rather vague. The annual quantity can probably be estimated at 130,000 to 150,000 tonnes. This represents slightly less than the estimated flat-rate figure of 100 kg per inhabitant. No definite figures have been drawn up for the volume of compost per tonne of refuse or per cubic metre of sewage sludge treated at the same time, as opposed to standard practice in the case of other technical production processes, e.g. in the metallurgical industry. The volume of compost depends on the seasonally fluctuating composition of refuse just as it depends on the degree of maturity of the compost and on the extent to which foreign substances (glass and stones) has been screened out.

.../...

There was, in fact, already a plant with a DANO drum in operation in Germany before the war, which was dismantled at the end of the war. However, composting did not begin seriously in the Federal Republic of Germany until the 1950's. The first plants were constructed in Baden-Baden and Blaubeuren. Both began operation in 1953, not counting the years during which processes were tried out experimentally in preparation for their application. Both plants originally used windrows. Since 1968 a "breathing method" developed in Blaubeuren has been in operation in that plant. It involves the use of aerated rotting cells. The partly rotted material then continues to rot in windrows. Composting plants using the drum method have been brought into operation at various stages throughout the period since the 1950's. The oldest plants of this type date from 1957 (Duisburg-Huckingen) and 1958 (Kreuznach), and the most recent from 1973 (Sylt and Flensburg) and 1974 (Pinneberg). Although the windrow process requires more time and space than processes involving rapid preliminary rotting, this process cannot simply be rejected on the basis of present-day views. The plants in Geiselbullack and Wiesloch, for instance, which began operation in 1971, are examples of modern open-air windrow composting plants. One method found on only one site in the Federal Republic of Germany, the multi-deck silo, in which the rotting material fed in at the top moves slowly downwards and is aerated at the same time, is in operation in Heidelberg: the first plant began operation in 1954, the second in 1973. Another special case is the briquetting method developed by the German engineer Dr. Caspari. This method involves reduction of the residual water content of domestic refuse and digested sludge to 70 - 74%, intensive mixing of the domestic refuse and digested sludge, and briquetting in a press. The coarse (capillary) structure of the briquettes rapidly gives rise to aerobic reaction and fungus growth, and the material stabilizes with a 20% residual water content. The finished briquettes can be stacked and stored for a long time and can be crushed to form compost at any time. There is only one plant of this type in the Federal Republic of Germany, although another plant came into operation in Biel, Switzerland, in 1975.

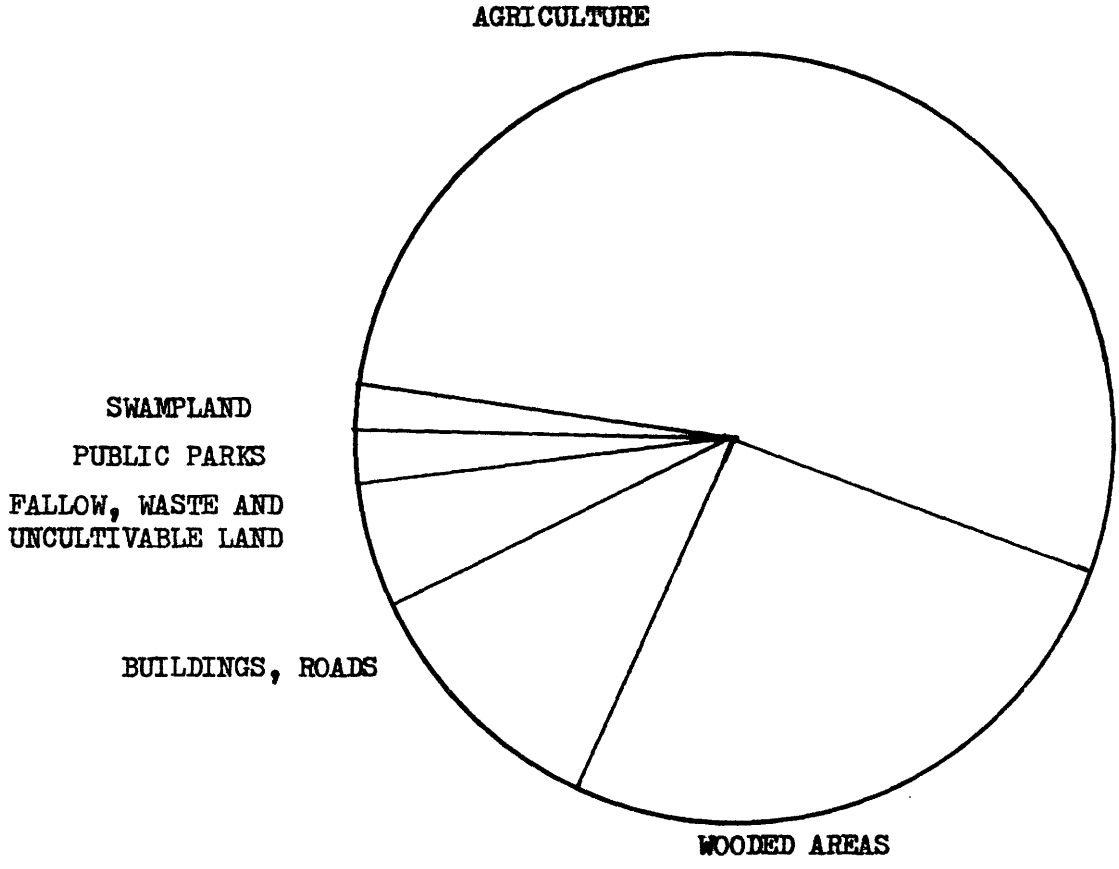
As indicated earlier, opinions concerning the saleability of refuse compost differ greatly in the Federal Republic of Germany in particular. Good experience has been gained in the wine-growing sector, where, as in France, the sites of vineyards have in many cases constituted an important factor in the selection of refuse disposal methods; examples are the plants in Kreuznach, Landau, Heidenheim, Alzey, Baden-Baden and Schweinfurt. It has been far more difficult to find markets in North Germany, where it is not at all easy to win over the agricultural sector (arable farming and animal husbandry) to the use of compost.

In this connexion, the plants in Flensburg and Sylt are rather interesting. Here, a private concern which had already been collecting the refuse on the island of Sylt for some time concluded a fifteen-year contract with the Sylt refuse disposal associations and the town of Flensburg for the operation of the plants. There are some other examples of private refuse composting plants and, to all appearances, these concerns succeed at least in covering their costs.

.../...

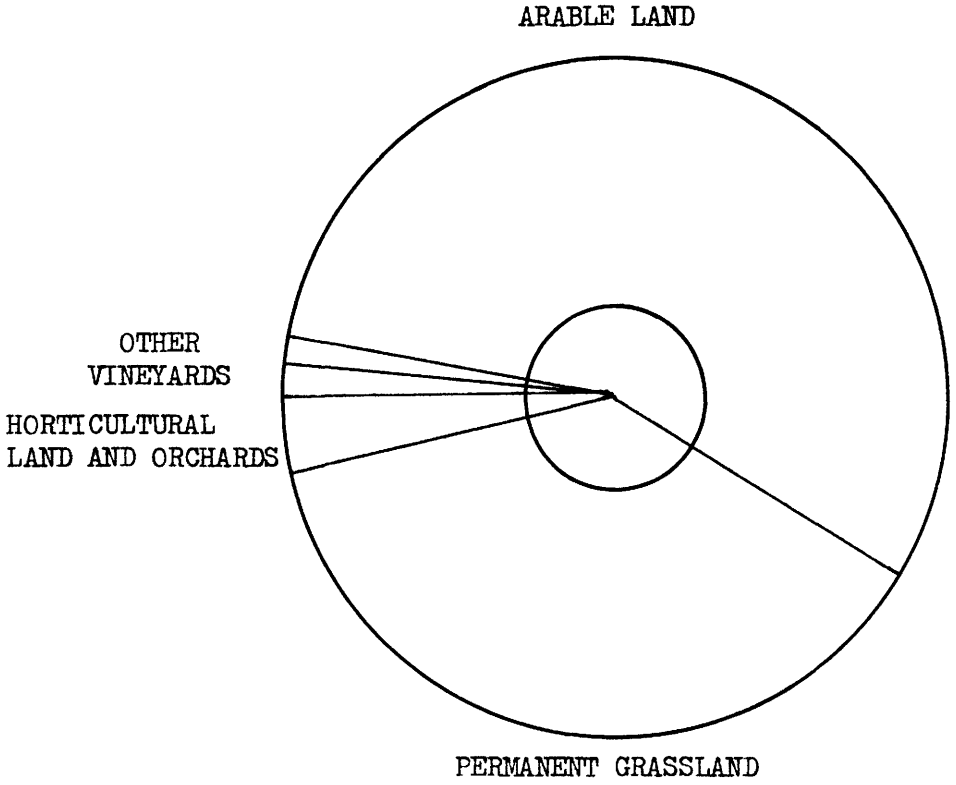
LAND DISTRIBUTION ACCORDING TO PRINCIPAL USES IN

THE FEDERAL REPUBLIC OF GERMANY



DISTRIBUTION OF AGRICULTURAL LAND ACCORDING TO TYPE OF CULTIVATION

IN THE FEDERAL REPUBLIC OF GERMANY



The inner circle represents the area which could be supplied with compost if the total volume of domestic refuse in the Federal Republic of Germany were to be composted together with the equivalent quantities of sewage sludge in terms of population. A rate of 30 tonnes per hectare per year is assumed.

Composting in the Netherlands

The Netherlands may well serve as the most interesting example in the field of composting within the entire European Economic Community. The compost industry has been operating here on a large scale since as early as 1929. At the same time a form of marketing based on private-sector principles has been developed. Nevertheless, the Netherlands serve at the same time as an example of how, even with a good marketing system, interest in composting can suffer for various reasons, not least as a result of ignorance and misinterpretations of alleged environmental hazards.

It should be pointed out that in the Netherlands composting was not originally based on the idea of refuse disposal. On the contrary, the original idea was to make the sandy soils of the province of Drente fertile. This is a remarkable reason for starting up a composting system, and it is nowadays found only in the Middle East, where (for example in Libya) the idea of importing refuse for composting or of buying compost is even being considered. A similar motive may be found in the Federal Republic of Germany in the construction of the Blaubeuren composting plant started at the beginning of the 1950's (reclamation of old quarries).

Refuse from the city of The Hague and a number of other municipalities has been composted in the van Maanen plant in Wijster (Drente), described in the section on composting methods, since the end of the 1920's. This compost has been applied to the sandy soils of the province of Drente, obviously with considerable success.

A private and therefore profit-oriented company, Vuilafvoer Maatschappij (VAM) in Amsterdam, was set up at the outset. VAM now operates two large plants in the Netherlands using the van Maanen method, i.e. windrow composting without preliminary comminution, with the refuse being transported to the plants in special railway wagons. In addition to the plant in Wijster, there is a second plant not far from Mierlo near Eindhoven. Today, the VAM plants treat the refuse from 110 municipalities and dispose of the wastes produced by a population of approximately 2.4 million. Compared with the situation in neighbouring countries, this is an exceptionally high proportion of the population.

Intensive advertising campaigns have for a long time been directed at the horticultural sector and at the amateur gardener, since the agricultural sector has shown little interest in compost for arable farming. VAM currently supplies the following types of compost :

- horticultural compost, particularly suitable for heavy soils;
- high-grade compost, a material developed for sports grounds;
- peat compost as a soil improver for all soils and types of cultivation;
- potting soils;

.../...

- "Horto-VAM" for tree nurseries;
- "VAM-terra" for growing flowers and ornamental plants.

In addition there is a product called "Champost". This is an example of VAM's flexible marketing system : the company sells the compost produced in the Netherlands mushroom industry. It is a well-known fact that mushroom growers use horse manure. This must be changed after a certain period of time as it loses its ability to stimulate the growth of mushrooms. However, it then becomes a highly suitable soil improver for application to other types of cultivation - a largely composted material which is easily absorbed by the soil and provides soil organisms with a strong stimulus. Nevertheless, the quantity that the mushroom growers have to dispose of amounts to 300,000 m^3 , weighing 150,000 tonnes, per year.

VAM also sells its products outside the Netherlands. Bagged goods are sent to Switzerland, for example, a fact of which the Swiss are not unaware and which, for instance, was conducive to the construction of a plant in Biel using the briquetting method. Information and advertising material is published in German, and there is a VAM representative in Venlo specially for the purpose of marketing VAM compost. A graduated price list based on five zones is applicable to the Federal Republic of Germany. Zone V lies roughly between Dortmund and Soest, and Zone I includes towns situated near the border such as Kempen and Goch. According to the price list (October 1975), the price of horticultural compost ranges from DM 27.50 to DM 39.50 per tonne, depending on the zone; the price of high-grade compost ranges from DM 33.00 to DM 45.00 per tonne; the price of peat compost ranges from DM 27.90 to DM 38.20; the price of VAM-terra ranges from DM 39.40 to DM 49.70, and the price of Champost from approximately DM 10.00 to DM 23.00.

Likewise in the Netherlands, compost for piglets has been developed to a level at which it is fully effective. Some pig breeders in the Netherlands have been using the specially screened piglet compost for years to prevent the young animals from developing the much dreaded aneamia and the associated symptom of biting each other.

However positive this may all sound, the Netherlands compost industry too has suffered setbacks in the past ten years. In the mid 1960's there were still sixteen composting plants in the Netherlands (1). Five of those had already been closed down by 1969. Today (1976), there are only four composting plants left in the Netherlands:

.../...

(1) Rudolf Mack: Herstellung und Absatz von Kompost in der Bundesrepublik, in Holland und in der Schweiz. Kuratorium für Technik und Bauwesen in der Landwirtschaft, Frankfurt 1971.

(1) the two VAM plants in Wijster and Mierlo;

(2) Kompostbedrijf "Meerlanden" in Rijsenhout. This plant disposes of the wastes produced by 83,000 inhabitants of the municipalities of Aalsmeer and Haarlemmermeer. It is a Dano plant with a capacity of 7.5 tonnes per hour;

(3) Kompostbedrijf Soest for the municipalities of Baarn and Soest with a total of 44,000 inhabitants. Likewise a Dano plant with a capacity of 7.5 tonnes per hour.

Why have the composting plants in the Netherlands been dying? This can be attributed partly to the fact that their capacities have simply been too small and their methods too primitive, and partly to the fact that large incineration plants, such as those in Rotterdam, Amsterdam and The Hague, have such large capacities that a kind of "competition for refuse" has developed. If the volume of refuse in the Netherlands is estimated at 4.0 to 4.5 million tonnes, then the 720,000-tonne annual capacity of the Rotterdam II incineration plant alone seems colossal. However, the volume of refuse actually available is such that only a good 320,000 tonnes can be treated in this plant. Here, as elsewhere, efforts are being devoted to making local authorities advantageous offers with regard to waste disposal, in order to ensure that fuller use is made of the incineration plants. This may well have affected the capacity and viability of the smaller composting plants.

VAM is responsible for at least 80% of the compost produced in the Netherlands. It collects at least 700,000 tonnes of refuse a year and has a throughput of 300,000 tonnes. Not all of it is therefore composted; a considerable proportion is tipped. 70,000 tonnes of compost are produced.

25% of the refuse generated in the Netherlands is currently incinerated, 18% is composted, 7% is separated and tipped, and approximately one-half is tipped in an uncontrolled fashion. The problem of sewage sludge is evidently not as acute in the Netherlands as it is in the Federal Republic of Germany. The possibility of disposing of sewage sludge together with domestic refuse in a non-pollutant way has therefore obviously not yet assumed sufficient importance to counteract the "incineration euphoria".

Composting in France

This is meant to be an initial survey outlining composting in France. France is of particular interest in connexion with the topic under discussion if only because it has the longest history of large-scale composting; it dates back to the Middle Ages, and it is significant that the term "compost" comes from French. Compost was, in fact, compounds (composés) of fermented organic wastes, mineral wastes and lime which varied from region to region, and all of which had their own names.

.../...

The French compost industry, which was largely built up in its present technical form after the Second World War, was able to fall back on an awareness of the value of organic soil improvers, which had never quite died out, to a far greater extent than could the United Kingdom and the Federal Republic of Germany, for instance, where the (undeniable) advantages of mineral fertilization for plant nutrition have been overestimated to the detriment of soil nutrition.

Practice in France in many respects contradicts a number of theories put forward by observers of the compost industry. First of all there is the theory that composting cannot take place in conurbations. In France, the overwhelming proportion of compost production takes place in the Paris region. According to the most recent statistics available (1), there are eighty-six composting plants in France, forty-two of them operating in the Paris region alone. The French composting plants dispose of the wastes of 4.58 million inhabitants and, with a daily capacity of 4154 tonnes, their annual throughput can be estimated at 1.12 million tonnes of refuse. Assuming a 50% yield, annual compost production therefore totals approximately 500,000 tonnes.

In France 70% of domestic refuse is taken to tips; 20% is incinerated and 10% composted. This may not seem much, but France compares very favourably with the Federal Republic of Germany, for example, where only just under 2% of the refuse goes to composting plants. In recent years there has been a strong tendency towards incineration but, according to the observations of the Ministère de la Qualité de la Vie, realization of the need for ecological cycles appears to have increased again in France since the time of the energy crisis and the (disputed) theories of the Club of Rome.

One special feature of the French compost industry is the important role played by mushroom-growing. This somewhat reduces the extent to which France may be compared with her neighbours. The Paris region is not merely a natural and important "producer" of domestic refuse, but at the same time it consumes a considerable quantity of mushrooms. A true cycle has developed here as domestic refuse is turned into compost for use in mushroom-growing. Mushroom growers, whose traditional basic material, horse manure, is becoming increasingly scarce, offer an additional advantage as compost consumers which should not be underestimated: there are no seasonal fluctuations in this sector as production takes place under cover regardless of the weather. Nevertheless, an investigation by the Ministère de la Qualité de la Vie (2) has shown that 17% of French compost production goes to mushroom growers. In some regions, such as the Paris region already mentioned above, the proportion accounted for by mushroom growers may well be considerably higher. Overall, French wine growers head the list of compost consumers. According to the same source, they bought 61% of the compost.

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(1) Inventaire des installations de traitement des ordures ménagères (situation au 1er juillet 1975), techniques et sciences municipales, 70th year, No 11.

(2) Situation actuelle du Marché du Compost en France. (Association pour l'Etude et la Recherche sur le Compostage des Résidues ménagers et leur utilisation agricole ou industrielle). Paris, July 1974.

The high proportion of compost consumed by wine growers and mushroom growers - they purchase four-fifths of the compost between them - accounts for the difference between France and other countries. Firstly, mushroom-growing is far more widespread in France than in other countries. Secondly, French mushroom growers and wine producers are more prepared to use compost than are their counterparts in neighbouring countries.

If fruit- and vegetable-growing is included, which likewise accounts for a substantial proportion (just under 10%) of compost consumption, it becomes clear that the general proposal that compost should be used on municipal land in the vicinity of municipal composting plants does not apply in the case of France. There has so far been no need in France to discuss the idea of using compost on public land as intensively as in her neighbouring countries. As stated in the first part of this report, public land in the Netherlands has accounted for a considerable proportion of compost consumption, although a large number of agricultural and, more especially, horticultural customers have already been won over as a result of excellent marketing, which has also been described in this report.

It is remarkable that so far no French composting plant has treated domestic refuse and sewage sludge together. Nevertheless, the problem of how to dispose of digested sewage sludge is just as acute in France as it is in her neighbouring countries. Discussions have revealed that the competent authorities are aware not only of the problems involved in the disposal of sewage sludge, but also of the possibility of composting sewage sludge together with refuse and thereby speeding up the composting process (1) at the same time. This awareness has led to experiments in the composting plants in Chambéry (Savoie) and Montargis (Loiret), where optimum processes, products and their effect are to be investigated. The results of these studies should be followed closely. One important point must be made in this connexion: as the disputed heavy metals are contained mainly in effluent and only to a small extent in refuse, this problem does not affect France at present. This may change in future as sewage sludge is treated together with domestic refuse.

According to our own and other people's observations (2), one special feature of the French compost industry is that compost is supplied in quite a dry state. This may be due partly to the fact that only domestic refuse, and not sewage sludge, is treated, and it may also be attributed in part to the processes themselves. Another special feature is the rather coarse particle size of the compost. Mushroom growers, in particular, prefer relatively coarsely-screened compost, while wine growers prefer more finely-screened compost. Obviously, compost is rarely allowed to mature in windrows after preliminary rotting in silos, drums or cells. Here, too, the high

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(1) See the remarks concerning the joint composting of refuse and sewage sludge in the first part of this study.

(2) Arnold von Hirschheydt: Zur Müllkompostierung in Frankreich, Müll und Abfall 7/75.

proportion of compost consumption accounted for by mushroom growers plays an important role: mushroom growers attach a great deal of importance to a product with a high organic and low mineral content.

The establishment of quality standards is worth mentioning in this connexion. The greatest progress in setting quality standards has probably been made in France. The Norme Française Homologuée (NF U 44 - 051, December 1974) contains a standard on compost (Amendements Organiques). This not only defines the possible types of compost and the materials from which they are formed, but also differentiates between them according to degree of maturity (fresh, semi-mature, mature), organic content and particle size. It also defines the extent to which additional information (e.g. dry matter, nitrogen content, phosphorus content, potassium, calcium and magnesium) should be supplied.

The definition of urban compost (compost urbain) laid down in this standard states that it is an organic soil improver obtained by means of thermophilic aerobic reaction at a temperature of at least 60°C over a period of four days.

It is also worth examining the way in which refuse treatment plants are subsidized. Subsidies amounting to 20% of the plant's costs are granted. Although preference was for a time given to composting plants, all processes (tipping, incineration and composting) now receive the same subsidies.

In France too, composting costs are lower than incineration costs. From what we have learned so far, incineration costs can be estimated at a minimum of FF 60 per tonne, usually more, while average composting costs amount to FF 45. This does not include refuse collection and transport costs. The remarkably high sum of FF 150 per tonne was quoted for this.

Selling prices for compost are remarkably high compared with neighbouring countries. For example, von Hirchheydt (1) quotes ex-works prices mostly of between FF 12 and FF 19 per tonne for the plants which he visited during a study trip. According to the study made by the Ministère de la Qualité de la Vie (2), prices range for the most part from FF 5 to FF 10 (24.4%), although it must be remembered that these are the 1972 figures. 40.2% of compost sales come within the FF 10 to FF 30 price range. These relatively high ex-works prices, to which transport costs and the costs of spreading or application must still be added, can be explained only by reference to the prosperous intensive forms of cultivation (viticulture and mushroom-growing).

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(1) Arnold von Hirschheydt : Zur Müllkompostierung in Frankreich, Müll und Abfall 7/75

(2) Situation actuelle du Marché du Compost en France

The Annex to this study contains a list of the composting plants in France. Some explanations are called for in relation to this list. Some of the information relates to associations of local government units. The catchment area in terms of population is therefore not always identical to the number of inhabitants of the localities mentioned. The catchment area in terms of population is not always indicated.

It is striking that the production figures for some plants are exceptionally low, which could suggest that some plants operate on only a few days or during only a few months of the year.

The study entitled "Situation actuelle du marché du compost en France" contains a list of composting plants, indicating their production figures for 1972 and including a breakdown into types of use. The following figures are given :

In 1972 a total of 338,281 tonnes of compost were sold - N.B. compost, not comminuted material. Of these 338,281 tonnes, the following proportions were used for the following types of cultivation :

viticulture	61.6%
mushroom-growing	17.0%

These two major types of cultivation alone therefore consumed 78% between them. To this must be added :

horticulture	8.8%
types of cultivation covering extensive areas	8.6%
forestry	3.4%
tree nurseries	1.1%

When analysing the very large volume of statistical data on France it must be remembered that definitions of composting plants vary. In some cases comminuting plants which evidently also produce compost from time to time are indicated, and in other cases composting plants which take some of the comminuted material to tips and do not always compost it are given. A characteristic feature of French composting plants is the fact that their catchment areas in terms of population are relatively small. Thus, for the most part they serve small municipalities or associations of small municipalities which generally have a total population of between 30,000 and 50,000. In only a few cases does the population exceed 100,000. This is so for the plants in Angoulême, Boulogne, Versailles, Yerres and Senarts.

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Twenty composting plants are in operation in the seven départements within a radius of approximately 100 km around Paris. This confirms the statements made in the report entitled "Situation actuelle du marché du compost", i.e. that

1. composting plants have been set up predominantly in areas in which urban settlements are most densely concentrated;

2. they are particularly numerous in the Paris region;

3. they are found predominantly in prosperous areas;

4. there is no exclusively agricultural reason for their construction.

Composting in the United Kingdom

This section dealing with composting in the United Kingdom can be brief, as there is very little to describe. Strictly speaking, there is only one single composting plant in the United Kingdom which produces and markets saleable compost, i.e. the Wanlip plant in Leicester (Leicestershire County Council Hall, Leicester), which began operation in 1967. It treats one-half of the 90,000 tonnes of refuse generated by the city of Leicester each year. It has six DANO drums and has a daily throughput of 120 tonnes which is quite high when compared with other plants at international level.

The quality of the compost is described as good. This is not surprising in view of the method used : following manual extraction of rags and non-ferrous metals and magnetic separation of iron, the refuse, together with digested, dried sewage sludge, undergoes preliminary rotting in drums for two to four days. The material is then screened using a 1.5 inch mesh screen. The advantage lies in the fact that the tailings have thus been completely hygienized.

The partly rotted, screened material is placed in windrows where it matures as considerable temperatures are produced by thermophilic microbes and with noticeable fungus growth (Actinomyces). The windrows are turned every seven days, depending on the temperature.

After nine weeks the most intensive biological activity has died down; the material has become light brown. A further three weeks are necessary before the optimum C/N ratio for application of the compost to soil is reached. In the light of this information it is, however, also not surprising that the cost of composting in Leicester is quoted at £7 - 9 per tonne, which is practically the same as the cost of refuse incineration quoted at £7 - 8.

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The information obtained from Leicestershire contains one very interesting point : experience in the United Kingdom with the use of compost in agriculture has revealed that the application of compost prevents soil erosion to such an extent that doses of mineral fertilizers can be reduced by up to 50% and crop yields increased notwithstanding. This is also important for the energy industry, as the production of mineral fertilizers requires considerable amounts of oil and energy.

Leicester can serve as a model - for the Continent also - in another respect as well. An effective sales method has been found for the packaged product sold under the brand name of "LESCOST": it is sold through private retailers, with the result that the compost has no difficulty in finding buyers.

The fact that some of the compost produced in Leicester is used on golf courses is not surprising in the United Kingdom. However, compost is also used by horticultural firms, in the hop-growing sector and for land reclamation.

There are also some smaller plants in the United Kingdom with drum rotting systems :

Radcliffe (Greater Manchester): one drum; maximum daily throughput of 10 tonnes. The partly rotted material is used to cover refuse tips.

Worthing (Sussex): one drum with a maximum daily throughput of 10 tonnes; covering material.

Cowdenbeath (Scotland): one drum with a daily throughput of 50 tonnes; covering material.

Kirkonnel (Scotland): one drum with a daily throughput of six tonnes; covering material.

Lockerbie (Scotland): one drum with a daily throughput of 30 tonnes; covering material.

Paisley (Scotland): two drums with a daily throughput of 80 tonnes; covering material.

It seems to be a characteristic feature of all of these plants that they supply only covering material for refuse tips. However, this probably makes good sense for two reasons: firstly, the covering of refuse tips with comminuted material which has undergone preliminary rotting helps to protect the environment, since it prevents the formation of dust, smouldering fires and rat infestation. Secondly, experience has shown that partly rotted refuse taken from the drum after only a short time is difficult to sell. It is therefore preferable to use it as covering material rather than disappoint consumers at high costs.

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As a general rule, most (90%) of the refuse generated in the United Kingdom is still taken to tips. 10% is incinerated. The compilation of statistics concerning quantities of compost has hitherto not been considered important. The information available reveals that considerable reservations are expressed in the United Kingdom with regard to composting. The principal reservation, for example, in spite of the positive experience gained in Leicester, is found in the doubts which are constantly being expressed with regard to the saleability of compost. This scepticism is revealed clearly in the chapter on compost in "Waste Management Paper No 1" (Reclamation, treatment and disposal of wastes) published by the Department of the Environment, which reads as follows :

"Only a minute proportion of household and commercial waste in this country is composted. The restricting factors include the cost of screening out unsuitable constituents (glass, plastics, metals, etc.) and pulverizing the remainder into a fine particle size. The percentage of rejects is high. In addition, long-term markets for the end product are difficult to achieve in the United Kingdom.

"Compost manufactured from urban waste has sometimes been found to contain a comparatively high toxic element which could inhibit growth and seed germination rather than assist it. The compost must be stored to mature for several months for any inhibiting agents to leach out, which adds to the cost. However, such compost can be useful as covering on landfill sites, or for the improvement of marginal land. In such cases a less sophisticated system (e.g. coarse shredding followed by windrowing) is used in order to make it viable. Alternatively, on sites that have been in use for many years it is sometimes possible to excavate the waste, if stabilized, screen out any large items and produce a useful covering material for new deposits of waste. This can be attractive financially where suitable covering material would otherwise have to be imported.

"Mechanical systems for composting of household waste, sometimes with market waste or sewage sludge, have been installed in several places throughout the world, but few have proved successful. Although further development work is taking place this system is unlikely to have any significant role in the treatment and disposal of waste in the United Kingdom."

Composting in Denmark

Neither compost production nor a compost industry has yet been able to develop in Denmark, as it has in the Federal Republic of Germany, for example, not to mention France. According to the Danish Ministry of the Environment, Denmark has two comminuting plants where open-air composting is possible. One is situated in Stigø on the island of Funen and the other near Rønne on Bornholm. A rapid composting plant is planned, which will also be able to be used for experiments to provide information on possible uses for compost.

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Generally speaking, the information obtained from Denmark reveals that considerable reservations have been expressed by the official authorities with regard to the use of compost. Discussions on heavy metals and the plastics content of compost have led to the safety of compost from the health point of view being questioned on the one hand, and to doubts being raised on aesthetic grounds on the other. Reference is made to the reluctance found in the agricultural sector as a result of the plastics content of compost.

On the other hand, Denmark's urban structure and the importance and type of agriculture must also be taken into account. Some basic information is called for here : Denmark has a population of 5.045 million living in an area covering 43,075 km^2. This means an average of 117 inhabitants per km^2. However, 35% of the population lives in the Greater Copenhagen area, which covers only 1.4% of the total area of the country. The rest of the country is therefore sparsely populated. A similar situation, although not quite so marked, is found in France, where a well-developed compost industry nevertheless exists.

However, a comparison with France is in itself sufficient to confirm the theory put forward repeatedly elsewhere that type of agricultural land used is a decisive factor for the possibility of using compost. The Paris region, just like the Greater Copenhagen area, is a congested area. This means that short distances are involved in the collection of fairly large quantities of domestic refuse, whereas long distances are involved in the transportation of the refuse to peripheral or even more remote composting plants. In France, however, the compost, generally not even in a particularly mature condition, is used for intensive cultivation, whether in the mushroom-growing sector or in the wine-growing sector.

Such intensive cultivation is found only rarely in Denmark. Certainly, compared with average figures for the EEC, agriculture plays an exceptionally important role in Denmark. For example, 69.1% of the total area of the country is used for agricultural purposes, whereas the average for the European Community is only 61.4%. In 1973, 7.5% of Denmark's gross domestic product could be attributed to agriculture, forestry and fishing, leaving Denmark behind only France and Italy in the EEC. However, it is the type of use which is the decisive factor, as stressed earlier. Of the total agricultural area of 2.9 million hectares, only 91.000 hectares, i.e. 3.1%, were used for orchards, market gardens, vegetables and other garden produce in 1974.

It has already been stated in another context that large-scale field crop farming, like permanent pasture land, does not hold anything like the potential of viticulture and horticulture for the use of compost. This does not, of course, preclude the possibility of using compost in public parks or for the reclamation of the land on large construction sites.

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There is an additional factor in Denmark which stands in the way of the use of compost in agriculture : the Danish agricultural sector has stepped up animal husbandry, which has always been important, to an even greater extent in the last two decades. This means, however, that a large amount of farmyard manure is produced which must be disposed of somehow. Consequently the majority of farms do not suffer from any lack of natural soil improvers.

Composting in Belgium

Belgium has a similar agricultural structure to the Netherlands in some respects; the fact that vegetables are cultivated intensively means that there is already a natural market for soil improvers, quite apart from the numerous other possible uses found in all countries.

One particularly important feature is the intensive animal husbandry practised in Belgium. According to the most recent information available, there are 2.9 million head of cattle, 4.7 million pigs and 31.4 million chickens. In contrast to former times when there were more mixed farms (field crop cultivation and animal husbandry), the excrements produced by these animals, which are generally reared intensively in large numbers, can no longer be applied to the fields. This is a perfect argument for composting, since animal excrements, like sewage sludge, are important nitrogen carriers, and a good C/N ratio for the rotting process can be achieved if they are composted together with domestic refuse, which has a relatively low nitrogen content. This could in future provide Belgium with further incentives to carry out composting.

Out of the total area of 30,500 km^2 covered by the Kingdom of Belgium, 1.57 million hectares, or 51.4% of the total area, is used for agricultural purposes, whereas the average proportion of agricultural land in the EEC is estimated at 61.4%. Out of a gainfully employed population of 3.8 million, 3.7% are engaged in agriculture. This is considerably below the European average of 8.9%.

It is probably not mere coincidence that the only composting plant of any importance in Belgium is near Ghent. Ghent is situated in East Flanders, an area used intensively for agriculture. The plant disposes of the wastes of a population of 160,000 in an area of 7,000 hectares. According to all the information available, all of the compost produced by the Ghent plant has so far been sold without difficulty; apparently demand generally even exceeds the capacity of the plant.

The Ghent composting plant has a biostabilizer operating on the basis of the DANO system, using a 26 m long rotating cylinder with a diameter of 3.50 m. The composting plant began operation in 1964. Annual refuse arisings for a population of 160,000 total 30,000 to 33,000 tonnes. The annual throughput of the Ghent plant is currently around this level. The volume of compost produced is estimated at 60% of the volume of refuse used. This is not, of course, mature compost. 40% by weight of the refuse - mainly glass, bones, iron and rags - is screened out and removed.

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According to the information available, the Ghent sales office responsible for compost sales pays a guaranteed minimum price of BF 75 per tonne of compost. The ex-works selling price is BF 210 per tonne, and it ranges between BF 300 and BF 350 per tonne when delivered free to the consumer. These prices are comparable with those quoted for France. They appear to prove that compost has found secure markets. Broken glass is sold for BF 250 per tonne to glass purification plants which then sell it to glassworks.

Another plant is planned for Belgium, to be constructed in Hasselt.

Annex

The Use of Sludge/Refuse Compost as a Filter

An interesting variation on the possible use of sludge/refuse compost is its use as a filter. This idea originally arose as a result of a negative feature of the actual composting process : the composting plant in Duisburg-Huckingen, which operates on the basis of the DANO system, suffered from the development of strong odours during the initial years of its operation (it began operating in 1957). As the plant is situated in the immediate vicinity of residential areas, a solution was all the more urgently required. Various possible solutions were tried in turn until the right solution was found, which currently secures a market for a proportion - which is expected to grow - of the compost produced. The development of foul-smelling gases in the first stage of the composting process is not "contrary to the system", since cryophilic and mesophilic groups of micro-organisms begin to act before thermophilic micro-organisms develop. Consequently, some anaerobic processes may set in.

The Duisburg plant worked successfully on the assumption that the waste gases emitted during composting were of an organic nature and that organic decomposition by oxidizing micro-organisms must therefore be possible. The use of properly composed material offered numerous possibilities here, however. A filter composed of sludge/refuse compost was therefore developed in the Duisburg composting plant. The waste gases from the composting plant are passed through a perforated pipe into a one-metre thick layer of compost, which they pass through in an upward direction. The result is remarkable : the gases are decomposed by the micro-organisms in the compost as high temperatures develop. Carbon dioxide and water vapour are emitted from the surface. This is the solution to the odour problem. The filter material keeps for several years. Mineralization begins at the bottom, so that a reduction in volume takes place. The material is replenished with new compost from the top.

It is important that the substrate should be loose. No impermeable areas must be allowed to form, nor should any cracks develop through which the gases to be decomposed could escape untreated into the open air. The original attempts to grow plants on the surface of the filter have therefore been abandoned, despite the fact that all plants actually grow on it unaided. However, plant cover prevents the rapid discovery of any cracks which might develop. Nevertheless, an inexpensive and beneficial "assistant" has now been found : the red muckworm (Eisena foetida), which multiplies abundantly in the filter material and guarantees constant aeration.

The Duisburg composting plant now has a number of markets for compost filters or filter compost. There are numerous firms which have problems with organic waste gases, particularly following the more stringent provisions introduced with regard to protection against emissions. These include, for example, sewage works, plants responsible for the disposal of animal carcasses, fish meal factories, blood meal factories and factory farms.

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The size of the filter required by a plant depends on the volume and intensity of the gas emissions. A filter measuring approximately 20 x 30 m should be large enough for quite a sizeable plant. One cubic metre of compost is considered necessary for every square metre of area.

In Duisburg it is thought that, although filter compost is not a product suitable for mass production, in view of the large number of plants requiring it a considerable proportion of the compost produced could be sold as filter material. The most important point is that such filters can help to solve environmental problems.

Legal Aspects of Composting in Europe

Legal Basis and Comparison of Laws

The purpose of this report is not to provide a complete description of current environmental legislation in the EEC. Such an approach would be out of all sensible proportion and would go far beyond the aim of this report, which is to describe the legal aspects of composting in the EEC. It will therefore concentrate instead on showing how, and to what extent, environmental legislation in the EEC is of theoretical or practical relevance to composting.

Since no Community legislation has yet been adopted which is of practical relevance to composting in the EEC, our only alternative here is to make a comparison on the basis of existing legislation. Even a first glance at the national legislation applicable to composting leads to two basic discoveries which are duly borne in mind in this report. Firstly, there is the fact that the legal provisions governing composting differ extremely widely from country to country. The second important point is that not every country has national legislation in the usual sense of the term. The intermediate and lower administrative levels are responsible for legal matters in some EEC Member States. This can lead in practice to diametrically opposed developments in the various regions of a Member State as a result of local authority jurisdiction.

Conditions in Selected EEC Countries

The high degree to which legislation on composting varies in the individual EEC Member States could result in a study of this type endeavouring to describe the relevant legislation in all Member States. Such an approach would axiomatically go beyond the scope of this report. Despite the variety of laws, it must be pointed out that very similar developments have been recorded in several European countries. In the light of these two considerations, no attempt is made here to describe the relevant legal situation in each Community country. The following section concentrates instead on the situation in four selected EEC Member States which may be considered representative as far as the major environmental legislation applicable to composting is concerned. The four countries covered are :

(1) Federal Republic of Germany

(2) United Kingdom

(3) France

(4) Italy.

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(1) The Federal Republic of Germany

The following definition of the term compost is used as a basis for studying the applicability of the existing environmental protection legislation in force in the Federal Republic of Germany to composting : compost is the product of the microbial decomposition of animal and vegetable wastes in the presence of oxygen. Compost is the stage in this natural process at which pathogenic organisms and plant seeds have been largely destroyed and, with the formation of humus, the entire mass achieves a degree of biological stability. When studying the relevant legal provisions it is, however, particularly important to remember that this is a relatively labile stability. Depending on the environmental conditions, e.g. moisture, temperature, light, lack of or excess oxygen and contact with inorganic substances, new biological processes can occur at any time. The triggering and progress of such processes are, in fact, essential functions of compost.

The Federal Republic of Germany now has important legislation applicable to composting which is made up of a number of separate laws, regulations and implementing regulations. In practice, the Federal, Land and local laws are interlinked. In the case of local laws, a further distinction must often be made between regulations adopted by individual local authorities and those adopted by larger associations of local government units. However, the distribution of legal powers at Federal, Land and local authority levels is only one of the principal features of the environmental protection legislation applicable to composting in the Federal Republic of Germany. Equally important is the fact that, as the environmental protection legislation is designed to protect the individual citizen, there are a number of separate laws in the Federal Republic of Germany which could be of legal relevance to composting in individual cases, although not in every case. All of these individual laws together make up the environmental legislation applicable to composting, which is then supplemented by additional laws and regulations at Land and local levels.

Special mention should be made of the following Federal laws which are relevant to composting :

(a) the Waste Disposal Law

(b) the Regulation on the Noxiousness of Effluent

(c) the Federal Law on Protection against Emissions

(d) the Technical Recommendations for Air

(e) the Industrial Code

(f) the Water Resources Law

(g) the Federal Health Law.

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(As indicated by the names, these are predominantly laws, although some are regulations.)

Of the laws and regulations listed above, the Waste Disposal Law is clearly by far the most important today where composting is concerned. Firstly, this is by far the most comprehensive law. Secondly, it defines the boundary between this Law and a number of special laws which it lists. Thirdly, this Law lays down a clear goal for waste disposal. Fourthly, the boundary between this Law and Land Law is clearly defined. Fifthly, the Waste Disposal Law also governs the site selection procedure (the so-called land **designation** procedure) for the operation of refuse composting plants and other forms of composting plants.

However, the Waste Disposal Law offers the Federal German Government considerably more opportunities for action that it has so far used. As the Federal Government stresses in its 1975 Waste Management Programme (page 44), it attached particular importance to the plan to adopt a regulation under Article 15 of the Waste Disposal Law. The draft regulation is to contain provisions **governing** the application of effluent, sewage sludge, excrements, compost, farmyard manure, dung water and liquid manure to land used for agricultural, horticultural and forestry purposes. These provisions will range from restrictions to bans on use, depending on the effects of the individual substances from the viewpoints of hygiene, soil science and plant cultivation and taking into account other aspects of environmental protection.

As the Federal Government then proceeds to point out in the same part of the 1975 Waste Management Programme, the further development of waste legislation should also explicitly include provisions governing the recycling and utilization of wastes. This means that a series of special regulations and, in some cases, laws, must be expected in the next few years in this connexion. According to the Federal Government, waste legislation as a whole should also cover the technical requirements for the treatment of wastes to enable them to be utilized. As stressed particularly strongly in the Waste Management Programme (p. 45), the Federal Government is considering increasing the obligations incumbent on owners of wastes and laying down that certain types of waste should be kept separate from others, with a view to their subsequent use. In laying down this objective, the Federal Government is fully aware, as it indicates (p. 46), of the fact that such action would give rise to a multitude of problems in both governmental and economic sphere. It is impossible to foresee at present to what extent compost will also be subject to such far-reaching provisions as those planned by the Federal Government. However, the immediate or later inclusion of compost would be quite possible.

Let us return to the provisions of the current Waste Disposal Law : the Waste Disposal Law is particularly relevant to composting as it lays down clearly, for example in Article 11 "Obligation to notify and supervision", that composting is a notifiable process which must be constantly supervised.

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Composting is not actually mentioned by name. Nevertheless, the wording of Article 11 leaves no doubt as to the fact that composting is included. Furthermore, Article 11 of the Waste Disposal Law also provides the link with other relevant laws, e.g. the Federal Law on Protection against Emissions and the Industrial Code. Reference is also made in the Waste Disposal Law (Article 13) to the cross-frontier transportation of wastes or intermediate products of the composting process intended for composting.

Where composting is concerned, the Waste Disposal Law not only deals with the collection, transportation and composting of compostable wastes, but also deals to a certain extent with the utilization of the finished product resulting from the composting process, i.e. compost.

As stipulated in Article 15 of the Waste Disposal Law, Articles 2 and 11 of this Law also apply to agricultural, forestry and horticultural uses of compost. (However, this implies that compost is regarded as one of the "similar products" referred to in Article 15.) Where precise rules are laid down in the Waste Disposal Law governing collection, transportation and composting and the utlization of the intermediate or end products, they do not, however, apply if "the normal quantity" is not exceeded in agriculture.

The Waste Disposal Law deals in great detail with the site question, or the land designation procedure in the selection of sites. It gives precise details of all the steps to be taken to obtain authorization for a composting plant. A link is thus formed between the Waste Disposal Law and Land and local legislation. The legal effects of the Land designation procedure are also indicated in the Waste Disposal Law.

However, even the paramount importance of the Waste Disposal Law where composting is concerned cannot obscure the fact that even in the case of the points actually mentioned in the Waste Disposal Law, the links between this Law and a multitude of Federal, Land and local laws, by-laws and regulations must be taken into account. For example, responsibility for the collection and disposal of waste is by no means governed only by the Waste Disposal Law. Here, in particular, a multitude of other provisions, especially local by-laws and regulations adopted by associations of local government units, are applicable.

It is typical of at least some of the relevant legal provisions that they are not applicable in every case. This is especially true of the Federal Law on Protection against Emissions. Many of the provisions of this Law become applicable only if the legal provisions are contravened. Where composting is concerned, this applies particularly if offensive odours are produced. If a particularly offensive odour is produced during composting, it generally means either that a defective process is being used or that the plant is being operated incorrectly. Articles 22 - 25, in particular, of the Federal Law on Protection against Emissions, concerning "plants not requiring authorization", are applicable to the composting process.

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Articles 24 and 25 stipulate very clearly the action to be taken by the public authorities if composting plants contravene the provisions of the Federal Law on Protection against Emissions in one way or another.

However, the Federal Government does not want to see the Federal Law on Protection against Emissions regarded as being directed exclusively at the protection of the population against immissions. Wherever justifiable, the use of wastes must take precedence over their disposal (p. 45 of the 1975 Waste Management Programme). The Federal Government considers that this fundamental idea has already been taken into account to a certain extent in the Federal Law on Protection against Emissions. According to the provisions of this Law, plants requiring authorization must, for example, be constructed in such a way that the resulting residues are properly utilized in a harmless way, insofar as this is technically possible and economically justifiable. The provisions applicable to the construction of plants requiring authorization are equally applicable, as stipulated in the Law, to their operation.

However, whereas the Federal Law on Protection against Emissions is applicable to composting primarily in proven cases of contravention of its provisions, the same is not true of the provisions of the Water Resources Law. Since the practical scope of the Water Resources Law also covers groundwater, as indicated in Article 1, all composting plants are in practice subject to the Water Resources Law. Article 2 of the Law stipulates - in more precise terms - that official permission is required whenever substances are to be added to groundwater. However, this is unavoidable in the case of composting plants, as also in the case of the tipping of non-compostable residues.

The Water Resources Law contains very detailed provisions in this connexion in Article 4 on conditions for use and the corresponding obligations; it also contains provisions governing the authorization procedure (Article 9), protected water areas (Article 19) and supervision and liability (Articles 21 and 22). Furthermore, Article 26, concerning the acquisition, storage and dispatch of substances, is also applicable to composting. Almost all of the provisions of the Water Resources Law which are applicable to composting are likewise applicable to the tipping and incineration of non-compostable residues.

In connexion with the Water Resources Law, the Regulation on the Noxiousness of Effluent is also relevant in law to composting. This Regulation relates to the Law on Environmental Statistics. The Regulation on the Noxiousness of Effluent deals in particular with the concepts and definitions relating to concentrations of substances in effluent. Three important parameters are defined in particular :

(1) the quantities of substances per litre of water precipitable in two hours;

(2) the chemical oxygen requirements, in milligrams per litre, of the samples released as a result of the sedimentation of precipitable substances;

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(3) the biochemical oxygen requirements for five days of the samples released as a result of the sedimentation of the precipitable substances.

The Industrial Code is important in connexion with the operation of composting plants from two points of view. Firstly, the operation of a composting plant is necessarily subject to all the provisions of the Industrial Code insofar as they are not designed specially for other specific industries. Secondly, however, the Industrial Code governs composting through the Regulation on plants requiring authorization under Article 16. In Article 1(2) of this Regulation explicit reference is made to composting plants, in contrast to most other environmental protection legislation in force in the Federal Republic of Germany. This Regulation stipulates, for example, that composting plants require authorization under Article 16(1) of the Industrial Code, insofar as they constitute business concerns. Article 24 of the Industrial Code stipulates in particular that the Federal Government may issue regulations on a number of specific points connected with the operation of plants requiring authorization and/or supervision.

The Industrial Code also deals in detail with the powers of the legislative bodies in the Länder and of the regional authorities under them with regard to certain regulations and details.

The so-called Technical Recommendations for Air (technical recommendations for the prevention of air pollution) are likewise of considerable practical relevance to composting. This is an administrative regulation which has hitherto been used in practice as a guideline for the authorization of new plants. For some time now, however, the binding nature of the Technical Recommendations for Air has been disputed in Federal German administrative jurisdiction. The Technical Recommendations for Air may assume the form of a law in the foreseeable future so that the administrative courts cannot challange them.

In their present form, the Technical Recommendations for Air define, in particular, such terms as "air pollution", "emissions" and "immisions", describe the examination and authorization procedures, and also govern a great many other aspects, including the transportation and storage of dust residues from incineration which accumulate as a result of the incineration of non-compostable residues (see Technical Recommendations for Air, item 2.3.3.5.3.). Even the minimum height of a chimney in such an incineration plant is governed by the Technical Recommendations for Air (see item 2.6.). Item 3.2.1.1. of the Technical Recommendations for Air is likewise directly applicable to the operation of incineration plants for non-compostable residues. It gives a comprehensive list of the various minimum requirements for plants.

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Special, explicit reference is made to composting plants in item 3.2.3. of the Technical Recommendations for Air. Special requirements are laid down in this connexion particularly for :

(a) composting plants and methods involving aeration. Pursuant to the Technical Recommendations for Air, the used air must be filtered or purified to an equivalent degree;

(b) the resulting seepage water must not be used to moisten the compost. It must instead be channelled to a sewage works;

(c) the receiving hoppers in composting plants must be closed and wherever possible fitted with a sluice. The air must be extracted, filtered or purified to an equivalent degree at least when the refuse transport vehicles are opened and unloaded.

The Technical Recommendations for Air also contain equally detailed instructions with regard to plants designed to treat substances which are to be incinerated, composted or tipped. The generic term "waste treatment plants" is generally used to describe all these plants.

However, current administrative jurisdiction in the Federal Republic of Germany allows neither the limits laid down in the Technical Recommendations for Air nor the scientific methods of measurement used to remain uncontested. Consequently, the "Standard Federal Practice for Monitoring Emissions" is naturally likewise of practical relevance in connexion with the Technical Recommendations for Air. It consists of directives for testing the suitability of equipment for the continuous measurement of emissions. The suitability of appropriate measuring equipment must, of course, also be considered in the development of new composting plants.

The Technical Recommendations for Air also indirectly govern cases where harmful substances penetrate the substrate to be composted. However, this applies only to harmful substances within the meaning of the Technical Recommendations for Air, and not to harmful substances which only delay or seriously impede the composting process. Consequently, there is not yet any generally applicable regulation in the Federal Republic of Germany to prevent harmful substances from penetrating the substrate to be composted, except in the case of those harmful substances referred to directly in other connexions in the Technical Recommendations for Air.

There are also no comprehensive rules on special industrial wastes or on hospital wastes which must be kept apart from refuse and sewage sludge for composting. The waste disposal methods normally used in the Federal Republic of Germany nowadays do not fully guarantee the separation of industrial and household wastes for the purpose of composting. This is particularly true in the case of the refuse generated by smaller industrial concerns. Great efforts are currently being made in the Federal Republic of Germany to draw up legal provisions governing disposal sites for hospital wastes. The question of what hospital wastes really are in the strictest sense of the term must also be answered at the same

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time. Hitherto the only skeleton legislation has been provided by the Federal Health Law in conjunction with various implementing regulations, and especially in conjunction with the third implementing regulation on the Standardization of the Public Health Service. Article 29 (Elimination of liquid and solid wastes) of Section VIII "Water supplies, elimination of liquid and solid wastes, public watercourses" of the above-mentioned third implementing regulation gives the Public Health Office certain supervisory powers, which can cover composting plants on the one hand but also cover hospital wastes on the other.

In conclusion it can be said that the Federal Republic of Germany already has a multitude of legal provisions and regulations which are relevant to the construction and operation of composting plants. An analysis of the existing legislation must take into account the fact that Federal legislation is supplemented by Land and local legislation. It is also supplemented by regulations adopted by associations of local government units and other similar regional authorities. However, the main guiding principle behind all the known regulations, and behind all the environmental protection laws in force in the Federal Republic of Germany in general, is always the protection of man and nature from harmful influences. Regulations to facilitate the utilization of wastes, on the other hand, are quite small in number and are of secondary importance.

The legal problems connected with the treatment and other types of utilization of refuse, wastes and compost are dealt with in the Federal Republic of Germany not only by the legislative authorities but also by :

(1) the Zentralstelle für Abfallverwertung (Waste Utilization Centre) in the Bundesgesundheitsamt (Federal Public Health Office),

(2) the Bundesanstalt für Vegetationskunde, Naturschutz und Landschaftspflege (Federal Institution for Plant Science, Nature Conservation and the Preservation of the Countryside),

(3) the Verband Deutscher Landwirtschaftlicher Untersuchungs und Forschungsanstalten (Association of German Agricultural Study and Research Institutions).

Another characteristic feature of the legislation applicable to composting in the Federal Republic of Germany is the fact that the implementation of and supervision of compliance with the provisions laid down in Federal and Land legislation are both difficult and costly. These responsibilities can be entrusted only to selected, trained staff at all the levels concerned. Actual and potential composting plant operators often have only rather fragmentary knowledge of the legal provisions. Accordingly, contraventions of those provisions probably occur frequently.

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Where contraventions and penalties are concerned, the Waste Disposal Law discussed earlier is important. Under this Law, the penalty for serious contraventions is the same as for criminal offences. Less serious contraventions are regarded as breaches of the rules. The penalty for a criminal offence is either imprisonment for up to five years or a fine. The penalty for a breach of the rules, on the other hand, can only be a fine not exceeding DM 100,000 in each individual case.

The few legal provisions which can, all things considered, be classified as positive as far as composting is concerned, also include the directives governing the grant of loans from the special ERP fund for the construction of waste disposal plants.

(2) The United Kingdom

The same definition of compost as that already given in the section on the Federal Republic of Germany is used as a basis for assessing the legal situation in the United Kingdom where composting is concerned. It must be pointed out, by way of introduction, that the United Kingdom began relatively late with the development of legislation on environmental protection. As indicated below, a considerable amount of the United Kingdom's legislation in this field has not yet entered into force.

Although no direct reference is made to compost in the relevant United Kingdom legislation, there can be no doubt as to the fact that compost is included under the general term "waste". Legal definitions of waste and the treatment of waste are set out in the Control of Pollution Act adopted on 31 July 1974. The following definition of waste is given in Article 30 of Part I of the Control of Pollution Act :

"'Waste' includes

(a) any substance which constitutes a scrap material or an effluent or other unwanted surplus substance arising from the application of any process; and

(b) any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled."

According to the current interpretation of the law in the United Kingdom, compost comes under the definition set out in (a). It is, however, of little importance whether it comes under (a) or (b). If it is assumed that compost comes under (a) or (b), then there can be no doubt that the storage, manufacture and marketing of compost is subject to the Control of Pollution Act 1974.

With the adoption of the Control of Pollution Act 1974, the United Kingdom entered a new legislative arena to a large extent. In some cases, however, existing laws were incorporated into the new legislation. Only a small part of the entire Control of Pollution Act has entered into force so far,

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including, primarily, Part I mentioned earlier, which contains the general provisions, responsibilities and legal definitions. The provisions governing the so-called "licensing" system have now entered into force, although not in their entirety.

Part II of the Control of Pollution Act deals with the pollution of water. The entry into force of these provisions seems to be experiencing considerable delays at present. It is on this point that there will be particularly far-reaching changes in the United Kingdom compared with the earlier situation.

Part III of the Control of Pollution Act deals with noise. This part has not largely entered into force.

Lastly, Part IV deals with pollution of the atmosphere. This part has likewise now entered into force to a large extent. Parts I, II and IV are all relevant where legal questions relating to composting are concerned. The definitions contained in Part I, Article 30 referred to earlier, give the responsibilities and descriptions of the authorities responsible for composting in the United Kingdom. The highest executive authority is the Secretary of State for the Environment.

Various authorities are responsible for the collection and disposal of waste, depending on the part of the country concerned. The London area, like the different parts of the country, has its own system. The disposal authority is responsible for disposal. In England the council of a county is the disposal authority. In Wales it is the council of a district, and in London the Greater London Council. The authority responsible for refuse collection is called the collection authority in the United Kingdom. In England the English collection authority is the competent body. The council of a district or, in London, a London borough, works under that authority in each district. Alongside the London boroughs, responsibility for certain geographically delimited parts of the London area lies with the Common Council of the City of London, the Sub-Treasurer of the Inner Temple and the Under Treasurer of the Middle Temple. The system is based on a division into a disposal authority and a collection authority. The highest authority for the whole of England is the English collection authority, which is ultimately responsible for both collection and disposal.

In Scotland the collection authority is the council of a district or of the various islands. The same bodies also act as disposal authorities. The highest collection authority is the Scottish collection authority. The highest disposal authority is the Scottish disposal authority.

Provision is made in the Control of Pollution Act for the compilation of waste disposal plans. The Act also governs the issue and revocation of licences for the collection and disposal of waste and lays down penalties for contravention. Such licences are the precondition for the construction and operation of composting plants. At the same time, however, the provisions of the Control of Pollution Act governing water and air pollution have to be complied with.

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Where the Control of Pollution Act refers to controlled waste, refuse is meant; the United Kingdom legislation does not distinguish between domestic, industrial and other commercial wastes.

It is already quite clear that it will be years before many individual provisions of the Act enter into force, as considerable difficulties are still being experienced where their implementation and control of compliance with them are concerned. There can, however, be no doubt about the fact that the legislative and other authorities are doing everything within their power to overcome these difficulties as quickly as possible. When comparing the legislation in force in the Federal Republic of Germany and the United Kingdom insofar as it is applicable to composting, it is important to note that the Federal Republic of Germany tends to adopt a large number of individual laws, whereas the United Kingdom is endeavouring to develop the Control of Pollution Act as a single legislative act. The Control of Pollution Act covers, for example, the scope of both the Federal German Waste Disposal Law and the Federal Law on Protection against Emissions.

The United Kingdom legislation contains even fewer direct references to compost and composting than the legislation in force in the Federal Republic of Germany. The current interpretation of the law in the United Kingdom leaves no doubt as to the fact that the environmental damage caused by composting is generally not considered to be a particularly serious problem. If actual cases of environmental damage were to arise, the various parts of the Control of Pollution Act would provide sufficient possible courses of action, according to the United Kingdom's interpretation of the law. This is, of course, assuming that all the relevant parts and individual provisions of the Control of Pollution Act had entered into force. It is impossible at present to foresee when this will actually be the case for every provision.

Environmental Resources Limited in London is one of the bodies responsible in the United Kingdom for making comparative assessments of European environmental protection legislation, including its relevance to composting.

(3) France

For the purpose of describing the legal situation in France where composting is concerned, the definition of compost applicable in the Federal Republic of Germany and the United Kingdom is taken as a basis in this section. However, the legal situation in France in relation to composting is quite different from the situations described in the two previous sections. Firstly, it must be remembered that, compared with various other EEC Member States, composting in France has been developed to a relatively advanced stage and that it is at the same time consciously promoted by the French Government. Secondly, it must be remembered that French environmental protection legislation concentrates largely on the protection of water, to a greater extent, at least, than in the other countries studied.

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In France composting is promoted by the Ministère de la Qualité de la Vie, which is confronted with several competing objectives in the promotion of composting. Firstly, a better and less pollutant waste disposal system should be developed for the benefit of the population. Secondly, composting should help to improve the soil and reduce the demand for other fertilizers. Both of these fundamental objectives provide the Ministry with grounds for promoting composting.

In the construction and operation of composting plants in France, special attention has to be paid to the prevention of water pollution. All the relevant provisions are to be found in Volume No 1327/1974 of the Journal Officiel de la République Française, which bears the title "Régime de l'eau". A characteristic feature of these legal provisions is the large number of different laws and regulations (décret). No direct reference is made to composting. This does not, however, alter the fact that numerous provisions are applicable ot the construction and operation of composting plants.

The degree of importance attached to the prevention of water pollution and to water resources in France can be seen simply from the fact that there is an Interministerial Committee on Water to which a number of Ministries belong. Regional subcommittees work under this Committee (Décret No 68-335 of 5 April 1968).

The French legislation applicable to water can be divided into several categories, the principal ones being :

(a) general provisions

(b) penal provisions applicable to contraventions

(c) financial provisions

(d) water protection measures

(e) environmental protection measures

(a) General provisions

The list of such provisions ranges from the French Code Civil, through the Code Rural, which is particularly important in this connexion, and the Code de la Santé Publique, to a multitude of regulations and implementing regulations. The Code Rural is particularly important as the first reference to the operation of plants in catchment areas of water-courses is found there (e.g. in Article 107).

(b) Penal provisions applicable to contraventions

In this case the relevant provisions range from the penal code (Code Pénal) to a series of specific regulations. However, it is noticeable that most of the penal provisions - here, too, exceptions prove the rule - provide for only relatively small fines for contraventions of the rules.

(c) Financial provisions

The legal provisions in force in this connexion would in most instances seem irrelevant to composting. There is therefore no need to describe these provisions in any detail.

(d) Water protection measures

The most important of these provisions are the relevant provisions of the Code de la Santé Publique. The provisions governing the examination of water are also relevant here.

(e) Environmental protection measures

The most important provisions applicable to the construction and operation of composting plants are the general provisions of Loi No 64-1245 of 16 December 1964. This Law was followed, on 10 January 1969, by Décret No 69-50, which deals with the determination and correction of the degree of pollution of watercourses. Since then - up to the present - the legal provisions of both Loi No 64-1245 and Décret No 69-50 have constantly been supplemented and supplied with more precise details by new regulations and implementing regulations. Precise upper limits have been published and have entered into force with regard to the degree of pollution. (See in this connexion : Arrêté du 14 juin 1969 rélatif aux fossés septiques et appareils ou dispositifs épurateurs de leurs effluents des bâtiments d'habitation.) The methods of measurement to be used are also described. Finally, the provisions also even cover the forms for reporting cases of water pollution. Merely completing such forms may well cause difficulties in many cases for the lower-level administrative authorities. These forms - e.g. the "Rapport sur la Pollution des Eaux" - explicitly include tips and the disposal of domestic refuse. A characteristic feature of France's priorities in this connexion is the fact that attention is paid to odour nuisance only if tourist establishments or important tourist areas are directly affected.

It can be concluded with regard to the legal situation in France that, in the efforts to protect the environment, priority is clearly given to the protection of water. It can also be concluded that there is virtually only one single set of legislation applicable to the entire country. The lack of multi-level legislation in France constitutes the major differenc between France and the Federal Republic of Germany where legislation applicable to composting is concerned. Furthermore, the official channels can be passed through more quickly and directly than, for example, in the United Kingdom.

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The French legislation tends to concentrate primarily on prohibitions and cases requiring authorization. In other cases it can be assumed that no obstacles exist. Almost nowhere is direct reference made to composting. The fact that numerous provisions are also applicable to composting plants and tips is, however, indisputable. Nevertheless, since composting is at the same time being explicitly promoted by the French Government, derogations are highly likely in France in borderline cases involving conflicts with the various legal provisions in force.

(4) Italy

The legal provisions governing composting in Italy differ fundamentally from those in force in the Federal Republic of Germany, the United Kingdom and France. The major difference lies in the almost complete absence of any environmental protection law governing composting. The only legislation in Italy governing the construction and operation of composting plants has until now been at most provisions adopted at regional or local level. Furthermore, a composting plant operator in Italy is largely independent. However, he must reckon with the fact that Italy also will be subject to environmental protection laws in this connexion in years to come. At present it seems likely that Italy will use the French laws as a model to a certain extent. However, not even a preliminary decision has yet been adopted in this direction, and it would be premature to try to align composting in Italy on the legal maxims applicable in France.

Denmark

With Law No 372 of 13 June 1973, the Kingdom of Denmark endeavoured to incorporate all of its environmental legislation in one law. This law should be regarded essentially as a skeleton law. Details are left to special regulations adopted either by the Ministry of Environmental Protection or by the local authorities. The comprehensive nature of the Law is revealed particularly clearly in the sentence (Section 1, 1.2) stating that the Law "governs all activities which could result in the pollution of the air, soil, watercourses, stagnant water and the sea as a result of emissions of solid, liquid or gaseous substances, vibrations or noise". However, the Law also governs all activities involving hazardous processes or the storage and transportation of dangerous substances.

Special reference to refuse disposal plants is made only in passing. However, the third sentence of Section 6 refers to pollution liable to be caused by sewage works, purification plants, incineration plants and refuse tips, and the Annex mentions, for example: 1. waste tips (including sludge and slag), old cars and scrap metal; 2. plants designed to treat solid wastes, including natural manure and sludge resulting from the purification of effluent.

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A memorandum on legal provisions governing environmental protection (Bekendtgørelse af reglement om miljoebeskyttelse) published on 29 March 1974 in the wake of the adoption of the above Law deals with individual problems and specifies the authorities responsible for the issue of individual regulations. Instructions are also given (Chapter 4) with regard to the collection and transportation of domestic refuse, including, for example, the need for sufficient refuse container capacities to be available. There is one provision which at least touches on the field of refuse composting : "Local authorities can issue detailed provisions governing the operation of refuse tips and other plants for the disposal (final treatment) of wastes". This is likewise clearly a skeleton directive.

As the Danish regulations were issued before any composting plants as such came into operation, a broader or narrower interpretation of the skeleton rules could in future place serious obstacles in the way of the construction of composting plants and, of course, also of incineration plants.

Comparison of Laws in Europe

The above survey of environmental protection laws applicable to composting in four major EEC Member States reveals great differences between individual States. At one end of the scale is Italy, which so far has virtually no environmental protection legislation applicable to composting. At the other end of the scale is the Federal Republic of Germany, where an attempt is being made to draw up special laws and regulations governing an increasing number of processes and circumstances. The United Kingdom and France hold central, although different, positions in this scale.

One of the most serious disadvantages of the Italian system is the extreme uncertainty currently confronting all potential operators of composting plants in Italy as to the future development of the legal situation. A second major disadvantage of the Italian system is inevitably the fact that, as no relevant legal provisions have existed for so long, under certain circumstances it could in practice prove impossible in the end to find practicable solutions, making it particularly difficult to conform to any potential course which Community law might follow in this field at a later date. As the law stands in Italy at present, any Community legislation relating to environmental protection and composting would impose severe restrictions on operators in Italy, whereas Community legislation might perhaps even ease the situation under certain circumstances for those concerned in the Federal Republic of Germany, at least during a transitional period.

One of the most obvious disadvantages of the laws in force in the Federal Republic of Germany lies in the attempt to make virtually every trivial matter subject to an almost unfathomable number of laws, regulations and implementing regulations. The lack of clarity is clearly one of several severe criticisms of the legislation on environmental protection and composting accumulated to date in the Federal Republic of Germany.

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Where composting is concerned, a comparison of the legal provisions in force in the EEC Member States discussed in this study reveals that nowhere are there any provisions concentrating clearly on composting. Composting is, however, mentioned a few times in the legislation in force in the Federal Republic of Germany. In other respects, a general picture of the legislation applicable can in every case be obtained only by studying the general laws on environmental protection in force. It is therefore also difficult to forecast the future development of composting laws in all of the countries discussed.

It is even more difficult to gain a general picture of the environmental protection laws applicable to composting in force in the EEC Member States because of the different levels at which legislation is adopted in individual countries. In the Federal Republic of Germany, in particular, authorities at various levels have legislative powers which they all use almost to the full. In France the Central Government in Paris can clearly be regarded as the only legislative authority for the entire country. Although the legislative powers are centralized in the United Kingdom, they are becoming decentralized to a certain extent under special arrangements for certain parts of the country, e.g. parts of Greater London or Scotland. In all the countries considered, the local authorities, as the lowest administrative bodies directly concerned, do at least have a limited say in the decision-making process. This applies not only where special local provisions are concerned, but also, and not least, with regard to the discretion which these authorities are allowed to use in the supervision of compliance with the relevant provisions.

The very fact that there is such a variety of laws on composting within the national environmental protection legislation in force up to now means that the creation of Community legislation in this field will not be easy. On the other hand, it must be remembered that the amounts of refuse and compost traded between the various Community countries have so far been quite small, if not insignificant. Community legislation on compost and refuse and on composting will hardly be accorded high priority. However, it should be remembered that, because of the extremely varied trends recorded so far in this specialized branch of environmental protection legislation, it would be desirable to draw up standard European legislation as soon as possible to prevent trends in legislation, and also in composting methods, in the major Community countries from becoming even more divergent in years to come.

Summary of the Results

A study dealing with the environmental protection laws applicable to composting in major EEC Member States must necessarily also answer the question of where current legal provisions best ensure optimum utilization of compostable wastes for composting. Reduced to its simplest level, this question can be answered by saying that this has been achieved in Italy, where virtually no legal barriers stand in the way of the optimum utilization of wastes for composting.

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However, if this fundamental question is extended to include the question of where the optimum utilization of wastes together with the best protection of the general public is guaranteed, the answer is far more difficult to find. The most extensive protection of the general public is without doubt guaranteed in the Federal Republic of Germany. However, it is certainly no longer true that optimum conditions for composting exist in the Federal Republic of Germany from the legislative viewpoint. A compromise between optimum utilization of wastes for composting and the general public's need for protection has probably been achieved in France on the basis of the legal situation currently prevailing there.

Concrete Proposals for a Community Course of Action

The following proposals can only take the form of general outline proposals based on conclusions drawn from the comprehensive legislative provisions and current practices, which are at least equally divergent, in Member States. Experience in the field of environmental protection has shown that standard provisions must be sufficiently flexible to take into account special regional features resulting from differing consumption patterns, living standards and infrastructures.

(1) Recommendation I : The EEC should act quickly where composting is concerned, as some Member States have already developed very extensive legislation in this field. If much more time elapses, all Member States will eventually have their own legal provisions and it will then become increasingly difficult to reduce them to a common denominator. Furthermore, technical and economic procedures are being developed in individual countries in line with national legislation which will make it extremely difficult to achieve standardization in Europe at a later date.

(2) Recommendation II : If the EEC draws up basic legislation, it should be divided into two sections : waste disposal in general on the one hand, and environmental protection provisions applicable to composting on the other, including the processes involved.

(3) Recommendation III : Where waste disposal in general and the processes directly involved are concerned, legislation largely resembling the Waste Disposal Law in force in the Federal Republic of Germany is to be recommended. The provisions of this Law are relatively clear and comprehensible. They are also not too specialized to be adopted by the less developed Member States.

(4) Recommendation IV : Irrespective of whether the Waste Disposal Law in force in the Federal Republic of Germany is actually used as a basis for European legislation, care should in any case be taken to ensure that not too great a distinction is made in standard Community legislation between the removal of wastes from households and trade premises and subsequent waste disposal procedures. Such a distinction cannot be made in the case of directly interlocking processes which can never be completely separated in practice.

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(5) Recommendation V : The EEC should use the French legislation as a basis for adopting environmental protection provisions applicable to composting in particular, and also to the processes directly involved. The French legislation offers several advantages. Firstly, it provides a clear framework. Secondly, it is sufficiently pragmatic to enable special provisions to be adopted. Thirdly, it can also be adopted by less developed countries. The objection to the adoption of the environmental protection legislation in force in the Federal Republic of Germany is that its efforts to achieve perfection are exceeding all tolerable bounds.

(6) Recommendation VI : When considering both waste disposal and environmental protection, the situations in possible future Member States such as Greece, Spain and Portugal should even now be taken into account on all points. The situations in those countries alone would suggest that excessively high requirements should not be imposed, at least during a fairly lengthy transitional period. This applies particularly where provisions governing environmental technology are concerned.

List of Composting Plants in the EEC Member States

This list of composting plants has been compiled from various sources which are quoted where official publications are concerned.

The term "composting plant" is interpreted in various different ways. In some cases it includes plants used merely to comminute refuse. The crushed or shredded material is then either taken to controlled or uncontrolled tips, or else it is composted in windrows. This interpretation can easily give rise to the impression that a country has a great many composting plants. Information relating to France and the United Kingdom has therefore been interpreted with particular caution.

Composting Plants in the Netherlands

Site	Operator	Method	Hourly throughput
Wijster	VAM	Van Mannen[1)]	
Mierlo	VAM		
Rijsenhout	Local authorities	DANO	7.5 tonnes
Soest	Local authorities	DANO	7.5 tonnes

Composting Plants in the United Kingdom

Site	Method	Daily throughput
Radcliffe (Greater Manchester)	Drum	10
Worthing (Sussex)	Drum	10
Cowdenbeath (Scotland)	Drum	50
Kirkonnel (Scotland)	Drum	6
Lockerbie (Scotland)	Drum	30
Paisley (Scotland)	Drum	80
Leicester	Drum	120

With the exception of the Leicester plant, the United Kingdom plants cannot be described as composting plants in the strictest sense of the term. They are used to comminute and hygienize refuse to be used as covering material for controlled tips.

COMPOSTING PLANTS IN FRANCE

Department	Method	Date of commencement of operation	Principal markets	Principal markets	Catchment area in terms of population	Production 1972 (tonnes)
Aisne						
Saint-Quentin	C + Y	180	1967	.	70 000	.
Soissons	CA	50	1963	W 80, A 15, CH 5	42 000	5 000
Alpes-de-Haute-Provence						
Manosque	CL	25	1969	.	24 700	.
Digne	CL	30	1974	.	16 000	.
Barcelonnette	CL	25	1975	.	23 060	.
Alpes-Maritimes						
Grasse	CL	45	1971	G 100	50 000	8 000
Vonce	CA	45	1965-1970	W 79, G 21	30 000	4 800
Villefranche	CL	40	1968	G 100	.	250
Ardeche						
La Voulte	CL + J	30	1967	F 100	16 000	670
Ardennes						
Sédan	CA + J	32	1970	CH 70, G 30	30 000	2 700
Ariège						
Foix	CA + J	15	1971	.	15 000	.
Pamiora	CL	25	1969	A 63, G 37	13 000	3 200
Aude						
Castelnaudary	CL	90	1969	.	.	.
Bouches-du-Rhône						
Crau Alpilles	CL + J	80	.	.	60 000	.

Department	Method	Date of commencement of operation	Principal markets	Principal markets	Catchment area in terms of population	Production 1972 (tonnes)
Calvados						
Falaise	CL	50	1973	.	10 000	.
Charente						
Angoulème	CA + J	96	1973	.	101 000	.
Charente-Maritime						
Ile de Ré	CL	30	1973	.	10 000	.
Chor						
Bourges	CA	75	1966	CH 60, G 40	85 000	8 000
Vierzon	CA	50	1963	CH 40, A 35 G 25	.	2 000
Doubs						
Montbeliard	CA	100	1962	W 70, A 20, CH 5, F 5	.	2 600
Drôme						
Romans	CL	35	1963	F 60, A 30, B 6, G 3, W 1	35 000	7 000
Euro						
Vernon	CA	25	1964	A 88, G 9, CH 3	24 000	1 600
Gisor	CL	18	1969	.	20 000	.

Department	Method	Daily throughput in tonnes	Date of commencement of operation	Principal markets	Catchment area in terms of population	Production 1972 (tonnes)
Euro-et-Loir						
Maintenon	CL + J	12	1967	W 66, A 34	30 000	5 000
La Loupe	CA + J	30	1970	A 100	25 000	500
Drouai	CA + J	60	1972	.	65 000	.
Finistère						
Quimpor	CA + J	50	1967	G 77, A 13, B 8, F 2	58 000	1 950
Morlaix-St.Martin des Champs	CA	25	1968	G 100	.	1 700
Gard						
Ville les Avignon	CL	8	1967	.	10 000	.
Vigan	CL	4	1968	.	5 000	.
St. Nazaire les Bagnols	CL	30	1973	.	35 000	.
Uzes	CL	12	1974	.	14 000	.
Haute-Garonne						
Toulouse	CL	40	1971	.	.	.
Hérault						
Agde	CL	80	1970	.	60 000	.
Clermont l'Hérault	CL	10	1975	.	15 000	.
Serignan Sauvian-Valras	CL	35	1971	W 100	25 000	1 850
Ille-et-Vilaine						
Dinard	CA	50	1966	.	40 000	2 000
Indre-et-Loire						
Joue les Tours, Ballan Mire						
Chambray les Tours, Saint A-vertin	CA	100	1974	.	.	.
Tours	CA	60	1965	CH 100	.	19 500

Department	Method	Daily throughput in tonnes	Date of commencement of operation	Principal markets	Catchment area in terms of population	Production 1972 (tonnes)
Jura						
Lons le Saunier	CL	40	1967	W 51, G 23, CH 13, A 10 B 3	30 000	3 000
Landes						
Dax	CA	20	1963	CH 70, G 30	.	2 360
Parentis en Born	CA + J	60	1974	.	.	.
Loir-et Cher						
La Val du Cher	CL	10	1973	.	42 000	.
Loire						
Fores-Sud	CL + J	20	1971	.	35 000	.
Loired						
Orléans	CA + J	150	1967	CH 70, A 14, G 9, W 5, F 2	.	12 838
Montargie	CA + J	70	1969	W 55, CH 41, A 4	50 000	14 703
Pathiviers	CL + J	25	1971	A 78, CH 22	34 500	2 960
Lot-et-Garonne						
Lemante	CA	25	1974	.	26 000	.
Marne						
Reims	CA	175	1974	.	.	.
Chalons s/Marne	Cb	60	1969	W 100	.	11 200
Mourthe-et-Moselle						
Toul	CA	20	1969	CH 69, W 31	19 000	1 300
Longwy	CL + J	50	1961	W 100	47 000	8 700
Morbihan						
Auray-Quiberon	CA	130	1971	G 100	.	700

Department	Method	Daily throughput in tonnes	Date of commencement of operation	Principal markets	Catchment area in terms of population	Production 1972 (tonnes)
Nord						
Douai	CL + J	100	1971	W 100	.	15 000
Mias						
Lamorlays	CL + J	50	1966	W 99, CH 1	.	4 385
Pas-de-Calais						
Calais	CA + J	100	1958	.	80 000	.
Arras	CA	50	1968	CH 60, A 30 G 10	90 000	7 000
Boulogne (région)	CA + J	75	1974	A 47, G 41 B 12	115 000	11 000
Pyrénées-Orientales						
Loucate-Le Barcares	CA	60	1968	W 100	15 000	1 300
Vallespir	CA + J	30	1973	.	.	.
Perpignan	CA	60	1974	.	.	.
Rhône						
Lyon	CA + J	40	1966	G 100	.	1 000
Saône-et Loire						
Chalon-sur-Saône	CA + J	90	1972	.	80 000	.
Savoie						
Chambery	CL	80	1964	G 68, A 27, W 5	.	1 529
Haute-Savoie						
Annecy	CA	180	1962	B 34, F 22, CH 27, G 7	90 000	2 415
Cruseilles	C	.	.	.	.	.
Seine-Maritimes						
Montville	CL + J	60	1969	A 79, W 21	.	3 000
Seine-et-Marne						
Malun	CA + J	75	1969	A 57, W 40, CH 2	78 000	11 160
Coulommière	CA + J	55	1970	W 100	41 000	6 400

Composting plants in the Federal Republic of Germany

Site	System	In operation since	Catchment area in terms of population	Daily throughput (tonnes)	Compost production/year (tonnes)	Cost per tonne (DM)	Revenue from sales (DM)	Whether treated together with sewage sludge[2]	Principal markets[4]
Alzey	Windrows	1970	100 000	70	13 000	26,00	10,00	3)	W
Baden-Baden[1]	Windrows	1953	50 000	35	100	5)	8,00	Fa	W
Bischofsheim	Windrows	1975	230 000	288	11)	10)	10)	Fa	11)
Blaubeuren	Cell	1953	22 500	20[6]	4 000		35,00-40,00	Fr	G, Ö, R
Duisburg-Huckingen	Drum	1957	95 000	65	14 000	28,00	11,00	Fa	G, Ö
Eberbach	Windrows	1967	30 000	7-8	1500-1800		50,00[7]	Fr	Ö
Ennepetal	Cell	1974	50 000	60	12 000		10,00	-	-
Flensburg	Drum	1973	200 000	250M,40KL	60 000	25,00[8]	5,55-16,65/m3	Fa	G, Ö, R
Geiselbullach	Windrows	1971	105 000	73	12 000	-	-	-	-
Heidelberg	Silo	1973	170 000	200	20 000	-	-	Fa	-
Heidenheim	Windrows	1970	70 000	60	9 600	58,00	10-20	Fa	G, Ö, R
Kreuznach	Drum	1958	40 000	30-40	5 000	30,00	10-15	Fa	W

Site	System	In operation since	Catchment area in terms of population	Daily throughput (tonnes)	Compost production/year (tonnes)	Cost per tonne (DM)	Revenue from sales (DM)	Whether treated together with sewage sludge[2]	Principal markets[4]
Landau	Windrows	1966	230 000	180-200	35 000	69,00	4-7	- [9]	W, R
Pinneberg	Drum	1974	250 000	350	20 000	62,00	-	-	Ö, R
Schweinfurt	Briquetting	1965	80 000	52	13 900	35,00	12-50	Fa	W, Ö, R
St. Georgen	Windrows	1963	17 000	39	1 200	-	5,5-10	Fa	-
Stuttgart	Windrows	1961	40 000	-	14 400	-	2-4	-	-
Sylt	Drum	1973	65 000	77	-	[10]	9-13	Fr	-
Wiesloch	Windrows	1971	100 000	46	-	-	12	Fa	-

1) Closed down in 1976 as one of the oldest plants.

2) Fa = digested sludge; Fr = crude sludge.

3) Planned for after the opening of the sewage works.

4) A = arable farming; W = viticulture;
G = horticulture; Ö = public land;
R = land reclamation.

5) No relevant figure in view of forthcoming closure.

6) 600 tonnes per month.

7) A special type of garden compound is manufactured, which accounts for the high selling price.

8) Without service of capital.

9) Treatment together with sewage sludge is planned.

10) Too little information at present on costs and revenue.

11) Cannot yet be determined.

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