Thermic insulation and sieve plates – beneficial equipments for a rapid and high quality degradation in household composting?

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Wärmeisolierung und Siebplatte – Ausstattungen, durch die die Abbaugeschwindigkeit und die Qualität der Kompostierung in Haushaltskomposten positiv beeinflußt werden?

1. Introduction

Non-central household composting in backgardens presents several advantages compared to central, commercial compost preparation facilities. Nutrient cycles can be closed where garbage is produced and so the gathering, the intermediate storage and the preliminary treatment of wastes and finally the marketing of mature composts can become obsolete. Infra structure and also a lot of money can be saved both from community and from private persons. Therefore the trend towards household composting is not surprising.

Understandably industry has responded to this demand and produces a lot of different household composters. Composters made from wood, metal and plastics, with and without covers and/or insulation and/or contact to the ground are available. This steadily increasing supply is hard to survey for laymen.

The aim of the present investigation was therefore to throw some light on the complex supply of household composters especially where insulation and sieve plates are concerned. An attempt is made to detect differences concerning the speed of degradation and the maturity of composts depending on the above mentioned equipments by using (bio-)chemical and biological methods.

2. Materials and Methods

2.1 Composters

The investigation was carried out throughout one entire year using household composters with volumes of 600 l. All composters were made from recycled polyethylene and equipped with covers to protect against rain (ILLMER and SCHINNER, 1997).

Eight composters supplied with sieve plates were investigated, four of them with and four without insulation. Sieve plates were made of high grade steel and perforated (12 mm

Zusammenfassung

Es wurde während eines Jahres untersucht, ob der Verlauf der Kompostierung in Haushaltskompostern oder die Qualität des reifen Kompostes durch Wärmeisolierungen oder Siebplatten beeinflußt wird. Die Isolierung bewirkte ein stärkeres Auftreten von Insekten und unangenehmen Gerüchen. Demgegenüber hatte die Siebplatte eine verstärkte Volumensreduktion und einen geringeren Wassergehalt im verbleibenden organischen Material zur Folge, was insofern von großer Bedeutung ist, als sich der Wassergehalt für die Heimkompostierung als zentraler Faktor herausstellte. Obwohl eine breite Palette von (mikro-)biologischen und chemischen Parametern erfaßt wurde, konnte auf Grund der großen Streuung eine Beeinflussung dieser Kenngrößen durch die Isolierung oder die Siebplatte statistisch nicht abgesichert werden. Trotz des nur schwach positiven Effektes einer Siebplatte, wird diese wegen des Schutzes vor Schädlingen wie Ratten und Mäusen dennoch empfohlen. Da die Isolierung von Kompostern abgesehen von den damit verbundenen Kosten wenn überhaupt nur negative Auswirkungen zeitigte, muß von einer solchen abgeraten werden.

Schlagworte: Kompost, organischer Abfall, Isolierung, Sieb, Abbau, Reife.

Summary

Household composters, supplied with thermic insulation and/or sieve plates, were compared with control variations without these equipments throughout one entire year. Compost processes took place under more favourable conditions in not-insulated composters regarding the occurrence of flies and bad smells. Existence of sieve plates resulted in an enhanced reduction of volume and in less water content of remaining organic material. Water content was shown to be the central factor in decomposition processes during household composting. Neither insulation nor sieve plates showed any significant influence with respect to several chemical and (micro-)biological parameters. In spite of these rather poor effects, sieve plates are recommended for the control of rats and mice. Insulation of composters on the other side caused mainly negative effects (if any) and should therefore be avoided.

Key words: Compost, organic waste, insulation, sieve, decomposition, maturity.

in diameter) thus being permeable to air. Thermal insulation on the side walls was made of Styropor®. As composters should have openings at the bottom for practical reasons (e.g. to avoid banked-up water, cleaning, etc.), an insulation towards the ground is not practicable. Four additional composters without sieve plates were used to investigate the effects of ground contact on quality of compost and the speed of degradation. Thus as a whole, three types of composters were tested in 4 replicates each, giving a total of 12 composters.

2.2 Composting material

In regular intervals of three weeks each composter was filled with about 85 l of waste derived from greengrocers and florists. To improve physical structure and C/N ratios chopped wood (made from a chaff-cutter) was attached in thin layers between green waste. To strengthen the anyway existing seasonal variations lawn cuttings was added in spring and early summer. Over the course of the entire year about 1500 l green waste, 80 l chopped wood and 170 l lawn cuttings were added to each composter.

2.3 Sampling and Analysis

Temperature in composts, ill-smells and occurrence of flies were estimated weekly throughout one year by measurement and subjective assessment respectively.

All six weeks several subsamples from different sections of the composters were taken and mixed together. Sample preparation (sieving, drying, grinding) and basic analysis (pH, moisture, content of organic matter, concentrations of C and N) were performed according to standard methods (ÖNORM S 2023). Analysis of available nutrients followed the methods described by ILLMER (1996) for phosphorus and PAGE et al. (1982) for potassium, magnesium and calcium. Microbial parameters were determined following the methods of the corresponding authors: microbial biomass (SIR), ANDERSON and DOMSCH (1978); microbial respiration, ÖHLINGER (1996); activities of CMC-cellulase, SCHINNER and MERSI (1990); activity of protease, LADD and BUTLER (1972); N-mineralization, KANDELER (1996). The number of colony forming units of thermo-(45° C) and mesophilic (25° C) bacteria and fungi were determined using the plate count method at the given incubation temperatures. The occurrence of coliform bacteria was determined on ENDO-C Agar (Merck Nr. 4044). All analyses were carried out in three to six replicates depending on the particular experiment.

Abundance and distribution of animals were analyzed by Kempson Extraction with a steep light and temperature gradient. Animals were gathered in soluted picrinic acid, transferred to ethanol (75% w/v), enumerated and identified.

To survey the great number of different taxa, animals were divided in 5 functional (not taxonomic!) groups:

i) phytosaprotrophs (including *Oribatida, Diplopoda, Isopoda, Sciaridae, Psychodidae, Enpididae*);
ii) mycetotrophs *(Mesostigmata [Uropodidae], Collembola, Ptilidae);*
iii) microsaprotrophs *(Lumbricidae, Scatopsidae, Shaeroceridae, Muscidae, Fanniidae, Cecidomyidae, Chironomidae, Drosophilidae, Trichoceridae, Hydrophilidae);*
iv) "great" predators *(Chilopoda, Aranei, Staphylinidae);*
v) "small" predators *(Mesostigmata [Parasitidae]).*

2.4 Statistical treatment of data

According to the presence or lack of normal distribution (KOLMOGOROFF-SMIRNOFF Test) data were investigated with regression analysis or with analysis of rank correlation differing between three levels of significance ($p < 0.05$; $p < 0.01$; $p < 0.001$). ANOVA or rank-analysis of variance was used to detect significant differences between types of composters.

Notched box and whisker plots were used for figures. The central line stands for the median. The central box covers the middle 50 % of the data, between the first and the third quartiles. The whiskers extend to the extremes (within 1.5 times the interquartile range) whereas more remoted values are plotted separately. The notches are added to each box, corresponding to the width of the confidence interval for the median. The confidence level on the notches is set to allow pairwise comparisons (at the 95 % level) by examining whether two notches overlap. (ANONYMOUS, 1992)

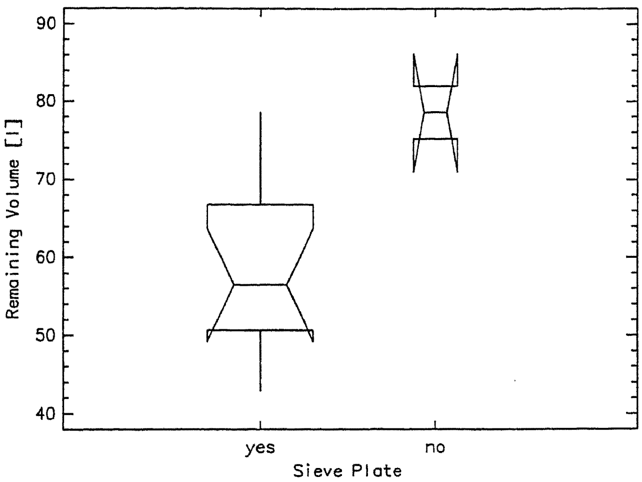

Figure 1: Volume of the remaining composts at the end of the investigation depending on the presence or lack of sieve plates. For explanation of the figure see text (statistical treatment).

Abbildung 1: Volumen des verbleibenden Materials am Ende der Untersuchung in Abhängigkeit vom Vorhandensein einer Siebplatte. Zur Erklärung der Abbildung siehe Text (statistical treatment).

3. Results and Discussion

Irrespective of the presence or lack of insulation and/or sieve plates the reduction of volume from about 1750 l to about 60 l was remarkable.

The presence of sieve plates caused an additional reduction of the remaining volume (figure 1) which was probably caused by an increased decomposition. A stronger compression of the material as a possible alternative reason could be excluded as a greater water content should have been detectable in this case (actually water content in composters with sieve plates was lower). As the "elimination" of waste is one of the priority tasks of household composting this outcome is of great practical importance. Insulation on the other hand had no significant influence on the volume of the remaining matter.

Weekly temperature measurement in the compost material showed that surprisingly not insulation but ground contact resulted in a significant ($p < 0.05$) increase. However, magnitude of difference between the temperatures in composts and ambient air was neglectable (0.3° C throughout the year). So neither insulation nor the occurrence of sieve plates resulted in temperature increases, high enough to cause some beneficial effects for the degradation of organic matter.

This outcome indicates to a distinct difference between household and commercial composting: Our knowledge about degradation processes including typical temperature phases is nearly exclusively derived from industrial composting or heaps prepared only once (GARCIA et al., 1993, MATHUR et al., 1993, CANET and POMARES, 1995). Due to continuously addition of fresh material these typical courses of temperature, C/N-ratios, moisture, etc. do not occur at household composting. Thus chemical, physical and biological properties are evenly distributed. Through the lack of high temperatures the speed of decomposition is slow and the reaching of hygienic and mature conditions is a long lasting process – a fact, which is unfortunately often neglected (DAVIS et al., 1992, HUGHES and STEELE, 1994, OBERFELD, 1996).

Occurrence of flies and bad smells was distinctly increased in insulated composters whereas the existence of sieve plates did not have any discernible effect. Differences brought about by insulation were most probably caused by significant higher ($p < 0.05$) water contents in these composters which probably results in oxygen deficiency and putrid conditions (figure 2).

Although moisture is known to be a central factor for degradation processes (SNAPE et al., 1995), an optimal moisture content is hard to ascertain. Optimum water content depends both on structure, kind and composition of wastes and on stage of decomposition.

Abundance of animals categorized in groups i), ii), iv) and v) as well as the occurence of thermophilic bacteria were (highly) significant increased through decreased water con-

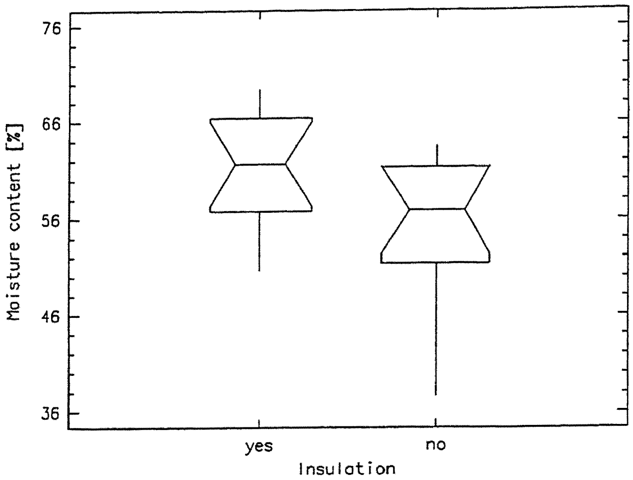

Figure 2: Percentage of moisture content (MC) depending on the presence or lack of thermic insulation.
Abbildung 2: Prozentueller Wassergehalt (MC) in Abhängigkeit vom Vorhandensein einer Wärmeisolierung.

tent (table 1). This positive effect (an increased abundance of all animals except those grouped in category iii) was assessed positively) again points to the central role the water content has during decomposition processes. Thus in the present study a lower water content seems to be preferable.

Within the scope of zoological investigations we focused on the question if differences in animal colonization, distribution and abundance were detectable depending on the existence of insulation and/or sieve plates. Surprisingly only the abundance of animals comprehended in functional group iv) (great predators) was significantly ($p < 0.01$) increased by the existence of sieve plates. However, predators are for sure important for compost regarded as an ecosystem and are therefore interesting for scientists but degradation process itself is unlikely to be influenced by this functional group.

Larvae of flies are mainly comprehended in category iii) thus making this group particularly interesting for practical operation. Although the occurrence of these undesirable animals was increased by 10 % and 30 % through insulation and soil contact respectively, differences were not significant at the 5 % niveau. Nevertheless the above mentioned positive influence which was ascertained between water content and occurence of desired animals (table 1) opens a promising field of improvements in decomposition processes.

Contents of organic matter and C/N ratios are often used to describe maturity of composts and speed of degradation (CIAVATTA et al., 1993, GARCIA et al., 1993, MATHUR et al., 1993, CANET and POMARES, 1995, HE et al., 1995). Outcomes of our investigation showed that the avoiding of too wet conditions resulted in enhanced degradation and thus in decreased contents of organic matter and lower C/N ratios (table 1). Following this hypothesis not insulated composters with lower water contents should possess advanced decomposition when compared to insulated ones. Indeed decreases in the above mentioned parameters were detected when ANOVA was applyed but as difference were not significant at the 5 % level data are not shown.

Also all other physical, microbial, and (bio-)chemical parameters under investigation were not influenced significantly neither through insulation nor through sieve plates. Frequent lack of significance is probably due to the great inhomogenity usually found in composts (GOLUEKE, 1992) even more where household composting without professional mixing supports is concerned (ILLMER and SCHINNER, 1997).

Nevertheless one advantage of sieving plates is worth being mentioned: through the addition of "wrong" waste (e.g. meat, cooked food, carbohydrate-rich garbage, etc.) to household composters the occurrence of rats and mice can distinctly increase (OBERFELD, 1996). Besides careful selection of compostable materials a sieve plate (with openings not greater than 1.5 cm in diameter) is nearly the only possibility to keep these parasites away.

So although hardly a difference in speed of degradation or quality of the endproduct was detectable, sieve plates are recommendable for pest control. Insulation on the other side causes mainly negative effects. Therefore and for the additional but superfluous costs of an insulation we have to advice not to install such an appliance.

Table 1: (Rank-)correlations between moisture content on the one hand and several biological and chemical properties of investigated composts on the other hand. + positive correlation; – negative correlation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ($n = 31$); *OS* organic matter [%]; *pH* (in water as well as in $CaCl_2$); *C* organic carbon [%]; *bac45* thermophilic bacteria; *i), ii), iv)* and *v)* functional groups (see text), *MC* moisture content [%].
Tabelle 1: (Rang-)Korrelationen zwischen dem Wassergehalt einerseits und verschiedenen biologischen und chemischen Faktoren andererseits. + positive Korrelation; – negative Korrelation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ($n = 31$); *OS* organische Substanz [%]; *pH* (in Wasser und $CaCl_2$); *C* organischer Kohlenstoff [%]; *bac45* thermophile Bakterien; *i), ii), iv)* and *v)* funktionelle Gruppen (siehe Text), *MC* Wassergehalt [%]

	OS	pH	C	C/N	bac45	i)	ii)	iv)	v)
MC	+**	+***	+**	+*	-**	-**	-*	-**	-**

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