

Effects of mid-term application of composts on agricultural soils in field trials of practical importance: Possible risks

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Materials and methods

Field trials

- Research period: Beginning 1995 (3 sites) and 1998 (2 sites), ending 2005
- Sites in typical tillage regions of B.-W, 4 at private farms, 1 at the trial field of LTZ
- Compost application: 0, 5, 10, 20 t ha⁻¹ y⁻¹ DM
- Compost type: Quality assured composts from regional compost plants, produced from bio-wastes mainly
- Mineral N-fertilization: 0, 50 %, 100 % of the official fertilizer recommendation
- Trial type: Bi-factorial with randomised plots.



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Materials and methods (2)

Analyses of composts:

- General properties (pH, contents of DM, OM, basic active substances)
- Contents of nutrients (total N, P, K; soluble N, P, K, Mg)
- Contents of heavy metals (Pb, Cd, Cr, Cu, Ni, Hg, Zn; *aqua regia* extract)
- Contents of organic pollutants PCBs, PCDD/F
- Pathogenic organisms (*Salmonella*, coliformic bacteria, phytopathogenic agents)
- Seeds and regenerating parts of weeds
- Impurities (stones, foreign matter)



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Materials and methods (3)

Analyses of **soils**, partially at the end of the trial periods, to compare sites without and with compost application. Besides other the following ones were performed:

- pH (CaCl₂), OM, N_t, contents of soluble main nutrients (N_{min}, P, K (CAL), Mg (CaCl₂))
- Total content of heavy metals (Pb, Cd, Cr, Cu, Ni, Hg, Zn; *aqua regia* extract)
- Contents of soluble heavy metals (NH₄NO₃ extract) at 2002
- Contents of organic pollutants (OCP, PAK, phthalates, organic Sn compounds, chlorophenols, nonylphenols)

Determination of weed coverage at the trial **sites**, every year

Analyses of **harvested plants** on heavy metal contents



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Results and discussion

The limit values of **heavy metal contents** [mg/kg] in composts according to the German Biowaste Ordinance (1998)

Element	Application of up to 20 t DM ha ⁻¹ (3 y) ⁻¹	Application of up to 30 t DM ha ⁻¹ (3 y) ⁻¹
Pb	150	100
Cd	1,5	1,0
Cr	100	70
Cu	100	70
Ni	50	35
Hg	1,0	0,7
Zn	400	300



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Results and discussion (2)

The exhausting rates of **heavy metal contents** in the composts used, based on the limit values given by the German Biowaste Ordinance (1998)

Elements	Mean range [%]	0,9 Quantile [%]	Comment
Hg	10 to 15	25	low exhausting rate of the limit
Pb, Cd, Cr, Ni	20 to 30	40 to 50	
Cu, Zn	40 to 50	65 to 80	medium exhausting rate of the limit



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Results and discussion (3)

The change of **heavy metal contents** in the plough layer of the trial soils after compost application during 9 and 12 yrs., resp., of up to 20 t DM ha⁻¹ y⁻¹

Elements	Change	Comment
a) Total contents		
Pb, Cd, Cr, Ni, Hg	not detectable	In the medium term (10 to 30 yrs) no risk of critical enrichment
Cu, Zn	increase by 2 (Cu), 4 (Zn) mg/kg	No critical enrichment (nutrients!)
b) Mobile contents		
Pb, Cr	not detectable	No risk of heavy metal mobilization; reduced contents may be caused by liming effects of the composts
Cd, Ni, Zn	contents reduced (8 yrs appl.)	
Cu	minimum enrichment	



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Results and discussion (4)

Heavy metal contents in plants at harvest and **withdrawal** of them, with and without compost application during 9 and 12 yrs., resp., of up to 20 t DM ha⁻¹ y⁻¹

Elements	Change by compost applic.	Comment
a) Contents of heavy metals in plants		
Pb, Cd, Cr, Ni, Cu, Zn	not detectable, in some cases reduced contents	No risk of increased heavy metal uptake; reducing may be caused by liming effects of the composts
b) Withdrawal of heavy metal by plants (% of the delivery by compost application)		
Elements	Withdrawal	Comment
Pb, Cr, Ni	< 5	The balance of heavy metals is always clearly positive, but the delivery in absolute amounts is low.
Cu, Cd	5 to 10	
Zn, Hg	10 to 30	



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Results and discussion (5)

Content of **organic pollutants** in the composts applied (n = 54)

Compounds	Mean range ¹⁾	Comment
PCB	20 to 30	Absolutely low values, pollution not problematic
PCDD/F	35 to 45	

¹⁾ % of the guide values according to the Compost Edict of B.-W. (200 µg/kg PCB, 17 ng/kg ITEQ)



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Results and discussion (6)

Organic pollutants in the soils without and with compost application at the end of the research project

Compounds	Results/Comment
Organo-Chloro-pesticides (OCP)	Contents are mainly absolutely low, mostly in the region of the analytical detection limit and of the background values of uncontaminated soils. No influence of the mid-term compost application is detectable, even after application of high (normally not allowed) amounts.
Poly-Aromatic Hydrocarbons (PAH)	
Phthalates	
Organic Sn compounds	
Chlorophenols	
Nonylphenols	



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Results and discussion (7)

Human, animal and plant pathogenic organisms in the composts used

Organisms	Results	Comment
<i>Salmonella</i>	Not present in all analyzed samples	Application is not dangerous with regard to the health of human beings and animals, if the composts are processed by hot rot; the hygienic quality of harvest products is guaranteed.
Coliformic bacteria	Contents mostly below guide values	
Plant pathogenic agents	No infection detected	No hygienic problems are given, if the composts are processed by hot rot.



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Results and discussion (8)

Germinating seeds and regenerating parts of weeds

Results	Comment
0,5 to 0,6 Ind./L FM (mean of 41 samples)	Appreciable dissemination of weeds is not given, when composts of assured quality (processed by hot rot) are used.
Weed coverage in plots with and without compost application did not differ (54 records)	



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Results and discussion (9)

Impurities in composts

Type	Results	Comment
Foreign matter > 2 mm (e.g. glass, metals, plastic foils)	< 0,1 % (mean) 0,37 % (0,9 quantile)	Foreign matter and stones are of no problem with composts of assured quality. ²⁾
Stones > 5 mm	1,6 % (mean) ¹⁾ 3,5 % (0,9 quantile) ¹⁾	

¹⁾ According to a survey of the German Compost Quality Assurance Organization (BGK, 2007; about 5 700 samples)

²⁾ Limit values according to the German Biowaste Ordinance: 0,5 % of DM (foreign matter), 5 % (stones)



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Results and discussion (10)

Risk of increased nitrate leaching

The comparison with plots, where mineral nitrogen was given, shows:

- In the first 3 years after beginning of application, mineralization of compost nitrogen is quite low (about 3 to 5 % of $N_t y^{-1}$);
- In this period also immobilization of fertilized nitrogen is possible to some extent, especially when green and fresh composts are used;
- When compost is applied steadily, utilization rates of 5 to 12 % are attainable between the 4th and 12th year, with green composts of good quality even 15 to 20 %;
- These high rates have to be accounted for in the fertilization management, to avoid excessive nitrate nitrogen in the soils and enhanced leaching;
- Measuring of soil mineral nitrogen before planting is recommended, to match the nutrient demand of plants and the supply of the soils;
- Thus leaching of nitrogen seems to be controllable.



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General Conclusion

To our opinion, the application of composts with assured quality in agriculture, horticulture, landscaping and for the improvement of soils is sustainable.

Thank you very much for your attention!



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