Danish Research Centre for Organic Food and Farming

Final Report

For DARCOF II research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

CRUCIAL – Closing the Rural Urban Nutrient Cycle (III.3)

3. Head of project

Jakob Magid, Department of Agricultural Sciences - KVL

4. Participating institutes

DJF	Danish Institute of Agricultural Sciences
DMU	National Environmental Research Institute
KVL	Royal Veterinary and Agricultural University

Other project staff

KVL	Jacob Møller , Lasse Dam Rasmussen, Jesper Luxhøi, Lars Stoumann Jensen, Sander Bruun, Andreas de Neergaard
DMU	Paul Henning Krogh, Thomas Larsen
DJF-Foulum	Gitte Rubæk, Bent T. Christensen

6. Project period (month, year)

Start of project: August 2001
End of project: June 2006

7. Final report

A. Project summary

The purpose with the project was the establishment of a field-scale facility for assessing the feasibility of improved recycling of nutrients from urban areas to organic farms, in the form of a long-term field trial. By examining urban fertiliser pre-treatment, turnover in soil and impact on crop growth, the project should provide practically useful results. With the initiation of a monitoring programme for biological soil quality it will attempt to take eventual unforeseen ill effects of increased re-circulation into account. Finally project should provide a concrete platform for the public debate, and possibilities for the public to visit the field trials.

After some adjustments the development of the field trial (WP1) is well established, and has been strongly appreciated by the public and private sector. The Professional Association for Use of Organic Residual Products for Agricultural Purposes – www.genanvendbiomasse.dk has decided to provide partial support for the running of CRUCIAL's long-term field trials at the end of the project, based on financial support from their own members and from organizations that collaborate with them. In addition KVL has given the field trial a special project status, which implies continued internal funding for land use and basic field operations. The outputs from the field trials, as well as the underlying design logic have been reported in a special volume on long-term field experiments of organic farming (Magid et al., 2006).

The work on pretreatment strategies (WP2) focused on composting, addressing questions on survival of GMO material's, pathogens and optimal practices regarding compost quality. This has gave rise to additional projects ('Short-Circuit' funded by EU-Life and 'Functional Compost' funded by DFFE) that allow further development of pretreatment processes. The main conclusions from 'Short-Circuit' have been submitted to the EU commission, while the Functional Compost project is still in progress.

Studies of C and N dynamics (WP3) have been carried out, both as laboratory, field and modelling interpretation studies. The measuring and monitoring needed for modelling (5 years) has been more or less completed by now, and the model interpretation activity will be continued after the end of project. Compared to the original aims, the model interpretation has extended to more general scenario studies of composted and anaerobically digested municipal waste on leaching of nitrogen, denitrification and soil C storage in typical Danish agroecosystems (Bruun et al. 2006).

A PhD study (2003-2006) dealing with detailed process studies of C and N dynamics in urban fertilizers and of isotopic fractionation through soil food webs will be completed by the end of 2006.

Agronomic research on P turnover in soil with applied Urban Fertilisers and its subsequent availability in pot trials (WP4) has been carried out according to plans, and reporting to scientific audience is under way.

The soil quality monitoring package (WP5) was terminated by the FØJO board in early 2003. However due to the interest for raising funds for future support and the need to gain internal support from KVL for continuation of the field trial after the end of project,

a partial soil quality analysis of some urban fertilizer treatments has been carried and will be finalized during 2006.

In quantitative terms the project has so far fed into 4 full-length papers in peer reviewed journals and 4 invited chapters in refereed books. A further 5 manuscripts have been submitted for peer review, and at least 3 more will be submitted during 2006/7.

It is noteworthy that the CRUCIAL project and the ensuing portfolio of projects has been highly appreciated by KVL. Thus KVL has announced a Professorship with special responsibilities in Soil biological fertility as influenced by manure and waste products in the international press.

Furthermore in order to embed the CRUCIAL research into educational activities a M. Sc. course on **'Urban Ecology'** has been developed at KVL and run for the first time in 2004. In 2005 the course was integrated in the educational reform program and is now running under the name **Urban Ecosystems: structures, functions and designs**. Based on the large interest it has generated the first two years (34 and 29 registered students in 2004 and 2005, respectively) there is reason to believe that the course will be able to continue developing in the years to come. It has been decided that the course will become an integral part of the future specialization in Urban Planning, which will be available from 2007.

Based on the demand for inputs from local municipalities and citizens groups there is good reason to claim that the course development has become a significant contribution to Objective 2: *To facilitate the process of sustainable urban development, by providing a platform for public debate*

Table A.1: Work package list (from application)

WP no.	Work package title	participants	Revised budget	Start	End	Deliverable No:
1	Establishment and running of Long-term field trials with urban fertilisers	KVL	727	2001	2006	1-7
2	Development of composting practises for food waste and human faeces	KVL	2055	2001	2005	8-13
3	C and N dynamics of urban fertilisers	KVL, DMU	1673	2002	2006	14-18
4	Agronomic research on P turnover in soil with applied Urban Fertilisers and its subsequent availability in pot trials	DJF	462	2003	2004	19-21
5	Soil quality monitoring programme	DMU, KVL	323	2001	2006	22-25

* Responsible participants are underlined

B. Objectives and expected achievements

WP's	Objectives	
1	1	To provide the field-scale facility for assessing the feasibility of improved recycling of nutrients from urban areas to organic farms
1	2	To facilitate the process of sustainable urban development, by providing a platform for public debate
2	3	To gain basic knowledge regarding co-composting of municipal solid waste and human faeces, with special emphasis on the effect of different mixing ratios and addition of green waste as structural material on self heating capacity, and nitrogen loss.
2	4	To develop a 'High temperature – Low emmision – Low cost' composting sys-tem that can be operated at farm level and at the same time comply with the upcoming EU regulation on the use of waste products in agriculture
2	4a	Examining the potential of the composting process to reduce or eliminate GMO-materials
2	4b	Examining claims that the effluent from the composting process has phyto-sanitary and other plant health promoting capabilities.
2	5	To provide sufficient amounts of composted material for the field trials in a quality that will comply with future EU-standards on agricultural use of urban waste
3	6	To perform a comprehensive mesocosm study on urban fertiliser impact on nutrient cycling where the temporal and spatial dynamics of plant nutrient cycling is linked to the biological activity of soil organisms
3	7	To provide experimental data for modeling plant nutrient dynamics of soil receiving urban fertilisers via incubation studies and the mesocosm study mentioned above
3	8	Model interpretation and extrapolation of urban fertilizers laboratory and field trial data
4	9	To assess the availability of P in urban wastes and characterize the fertilizer value of waste-derived P following introduction to arable soil
5	10	To deliver an initial characterisation of soil quality in the field experiment
5	11	To initiate a long-term monitoring of soil biological quality in the field experiment

C. Progress and results

C.1 Description (summary) of main results and conclusions

WP1

Objective 1: To provide the field-scale facility for assessing the feasibility of improved recycling of nutrients from urban areas to organic farms

The field-scale facility for assessing the feasibility of improved recycling of nutrients from urban areas has been re-structured.

Results from year 2002-2004 has been analysed (chemical analysis of plant materials and N_{min}), and are presented in Magid et al. (accepted) and will provide the backdrop for part of the modelling to be done in connection with WP3. Human urine has proved as a very reliable fertilizer – almost as efficient as mineral fertilizer, while sewage

sludge and composted household waste seem to provide substantially lower mineral fertilizer equivalents than what was hypothesized at the outset of the project. The acceptability of human urine as a fertilizer has been further investigated in a literature review (Lindedam et al., 2006), by evaluating the oestrogen load on the environment from human urine spread on the field, compared with human urine going through a sewage plant treatment. The environmental impact from oestrogen from human urine is assessed to be considerably lower by applying to the field.

A concern with annual repeated use of urban fertilizers is the accumulation of heavy metals and other xenobiotics in soil. However, a core question in the CRUCIAL project is, whether concentrations of heavy metals at ecotoxicological limits actually impair key biological functions in the soil. In a worst case scenario, the concentration of heavy metals can accumulate to ecotoxicological limits within 11-13 years. In a more average case scenario, ecotoxicological limits may be reached within 38-41 years. Hence in neither of the scenarios the ecotoxicological limits can be reached within the timeframe of the project. To approach the ecotoxicological limits within 3-5 or 7-10 years for a worst case or average case scenario, respectively, plots with accelerated inputs of urban fertilizers are part of the experiment. An in depth presentation of the outputs from the field trials, as well as the underlying design logic have been reported in a special volume on long-term field experiments of organic farming (Magid et al., 2006)

Objective 2: To facilitate the process of sustainable urban development, by providing a platform for public debate

There has been public interest in the field experiment, as indicated by reports in national daily newspaper articles, national and international radio and television broadcasts, and requests for input to DAKOFA's (Danish Committee for Waste Management) conference on Agricultural Waste Utilization, in relation to the 3rd action plan for the Environment, request for publication in special issue on long-term trials, in International Society of Organic Agriculture Research. Furthermore the CRUCIAL project and related work was presented at the 3'rd ECOSAN World Conference in Durban, South Africa in May 2005, and will be presented at ORBIT's 5th International Conference on Biological Waste Management, in September 2006.

The Professional Association for Use of Organic Residual Products for Agricultural Purposes – www.genanvendbiomasse.dk has decided to provide partial support for the running of CRUCIAL's long-term field trials at the end of the project, based on financial support from their own members and from organizations that collaborate with them. Similarly KVL has given the field trial a special project status, which implies continued internal funding for land use and basic field operations. This is due to the recognition of the need for such long-term experiments in relation to the problems that can be addressed regarding impact on soil quality and production system integrity.

Some presentations to the public

A National Daily Newspaper (Berlingske):
Andersen Pauli: Forskere ser en guldgrube i de danske kloakker. Berlingske fredag d. 5 oktober 2001

From the Danish Public Service Radio (Program 1)
The 'Miljømagasinet' 19th april 2002, running title 'Urin kan blive fremtidens gødning' ('Urine may become a future fertiliser'), please refer to:
http://www.dr.dk/p1/miljoemagasinet/arkiv.asp?action=showarticle&id=22147

The 'Miljømagasinet' 21th march 2003
Urin fra 100 familier i Roskilde bruges om gødning
http://www.dr.dk/p1/miljoemagasinet/arkiv.asp?action=showarticle&id=17282

A National Daily Newspaper (Politikken):
7. august 2003: Urin fra mennesker er god gødning, forside, samt 1. sektion side 2
9. august 2003: Penge lige ned i kloakken
18. august 2003: Modvilje mod urin på marker, 1. sektion side 7
25 august 2003, Kloakker og veje slidt ned, 1. sektion, side 4

From the Danish Public Service Television (DR TV 1)
Usædvanlig gødning , TV-Avisen, DR1, kl. 18.30 26 August 2003

From the Norwegian Public Service Radio (Program 4)
Tiss på grønnsakene! '..Lektor Jakob Magid ved Landbohøjskolen i Frederiksberg i den danske hovedstaden sier uringjødsling kan ha en stor framtid, både i Danmark og i utviklingslandene. Men den bør skje i ordnede former. Folk skal ikke tisse direkte på salaten, understreker han'
http://www.p4.no/txo/94227.asp

DAKOFA's konference om Vandmiljøhandlingsplan III og affaldsprodukter til jordbruget, 23. Marts 2004, Markforsøg med slam og organisk affald – hvor stort er problemet? ved. Jakob Magid.

Magid, J., Luxhøi, J., Jensen, L.S., Møller, J. and Bruun, S. **Establishment of a long-term field trial with urban fertilizers – is recycling of nutrients from urban areas to peri-urban organic farms feasible?** Accepted for publication in International Society of Organic Agriculture Research.

Establishment of the course Urban Ecosystems in 2004 and in 2005 under the new statutory curriculum regulation at KVL the course was further adjusted to Urban Ecosystems: Structures, Functions and Designs

J. Magid, A. M. Eilersen, S. Wrisberg, and M. Henze. **A technical theoretical framework for ECOSAN applied to the medium sized Danish town Hillerød**. Oral presentation at 3rd World ECOSAN Conference, 24 May 2005 - Durban, KwaZulu Natal, South Africa

J. Luxhøi, M. Brøgger, I. M. B. Knudsen, P. H. B. Poulsen, J. Møller, B. Jensen, D. F. Jensen and J. Magid. **Functional Compost.** Oral presentation at ORBIT's 5th International Conference on Biological Waste Management – From Local to Global, 13-15th September 2006, Weimar, Germany

WP2

Objective 3: To gain basic knowledge regarding co-composting of municipal solid waste and human faeces, with special emphasis on the effect of different mixing ratios and addition of

green waste as structural material on self heating capacity, and nitrogen loss.

It proved difficult to obtain substantial quantities of human faeces so the use of this type of feed stock was abandoned in full-scale, but human faeces was used as feedstock in lab-scale experiments at KVL's composting laboratory to determine best practice of composting household waste and faeces and to study in more details the effect of mixing ratio of the feedstock on the composting process as well as the sanitation effects on pathogens and indicator organisms at different process temperatures.

A pilot experiment showed N-emission to be highly dependent on mixing ratio of the feedstock. This was investigated in more depth in lab experiments during the rest of the project period. Experiments were set-up with human faeces, organic household waste and rape straw mixed to C/N- ratio between 18 and 49. These mixes were composted in the lab reactors and ammonia-loss, condensate-pH, temperature, CO2 and O2 were observed during the experiment. Furthermore the content of C, total-N, dry-matter, ash and pH of human faeces, organic household waste, rape straw and the finished composts were analysed.

The main conclusions were: The nitrogen losses were in general small (0.04% - 6.76%) and the loss was smallest at a C/N-ratio of 36 and was twice as big at a C/N-ratio of 46. This was possibly due to the relatively little degradation of organic matter (4.8% - 36.1%). About 87% of the nitrogen lost was emitted as ammonia. The emission of ammonia started right after pH had reached the alkaline area. Ammonia emission was at its highest under the thermophile phase of composting. The presence of substantial amounts of household waste and faeces in the feedstock thus decreased nitrogen loss and demonstrated that these materials are very suitable for composting.

Following a number of pilot experiments, the survival of the indicator organisms termotolerant coliforms, Salmonella Senftenberg, Salmonella phage 28 B, and enterococci was investigated at temperatures from 50-65°C. Curves of survival were calculated for the microorganisms as a function of exposure time at the different temperatures investigated. Based on the curves of survival, the times needed for a 4-log reduction in numbers were calculated. Similar calculations have been used in previous investigations assessing the effect of different sanitation measures. The time needed to obtain a 4-log reduction was inversely related to composting temperature and the indicator organisms showed increasing susceptibility to heat in the order enterococci, Salmonella phage 28 B, Salmonella Senftenberg and termotolerant coliforms. The results show that these organisms are susceptible to heat generated by the composting process even below 70°C.

Objective 4: To develop a 'High temperature – Low emmision – Low cost' composting sys-tem that can be operated at farm level and at the same time comply with the upcoming EU regulation on the use of waste products in agriculture

The on-farm composting facility at Taastrup was constructed as a closed system in order to allow a high degree of process control, especially regarding time/temperature regimes. The system consists of a 20 ft. container with a roof-cover that functions as a heat exchanger trapping water vapour from the compost and thereby diminishing NH3-loss. The compost is actively aerated, and to ensure a more even distribution of heat in the system hot process air is recirculated through the compost mass by means of a ventilator. The air is distributed through the composting material by perforated tubes at

the floor. The system also include a data collection system that is used to monitor measurements form 14 temperature probes placed in the compost matrix, exhaust air, inlet air, between the plastic sheets of the heat exchanger etc. Based on these temperature data it was possible to calculate the systems energy balance. The specification of the composting system was made to comply with EU regulation on composting systems, i.e. all the material should be heated to at least 70°C for at least one hour. Furthermore, the system should minimize N-emissions during composting and should be relatively cheap to construct, hence the name "Hi-Lo" composting system (High temperature, low emission, low cost). The compost container can be loaded by a tractor with a manure spreader in tow. The composting experiments were conducted using a feedstock of source separated household waste mixed with rape straw and other farm residues.

The first tests in the Hi-Lo system showed temperatures above 70°C in the centre of the composting material, but along the sides of the container maximum temperatures were around 63°C. The next series of experiments therefore focused on optimization of the composting process in order to get the temperature above 70°C in the entire mass, e.g. by a better aeration scheme, by recycling of process water to prevent drying-out of the compost and by altering the mixing ratio of the feedstock.

The process conditions and temperature development during a representative optimised composting run were as follows: The feedstock was a mixture of source separated household waste, farm yard manure, and rape straw. In total, the temperature was measured at 14 different locations and logged by a computer every minute, but the most important measurements were the temperatures at the hottest and coolest position, i.e. in the middle of the compost and at the surface of the composting container, as well as the temperature in the recycled process air. The temperature in the middle of the compost exceeded 70°C for a total of approx. five days, and the material in this way complied with EU regulations (at least one hour treatment at minimum 70°C to secure a sanitised product). The material adjacent to the surface of the container, i.e. the coolest part, did not reach 70°C, but even at this position a maximum temperature of 62°C was measured and the temperature exceeded 60°C for more than 24 hours in total.

Thus based on the combined results from the lab experiments and farmers should be capable to handle household waste and faeces in a farm scale system. The obstacles not quite overcome was reaching a temperature of 70° in the whole composting mass in one hour. Even though microbial testing show satisfactory results the temperature limit is important, but overall, the HI-LO system produced high quality compost.

Objective 4a : Examining the potential of the composting process to reduce or eliminate GMO-materials

Studies of degradation of transgenic DNA and screening for horizontal gene transfer from GMO-plant material during composting have been completed. These have proven to be more challenging and intriguing than we had ever imagined, and a number of hard won lessons have been learned (Rasmussen et al., 2005; Rasmussen et al., in prep).

In the following some of lessons are summarized:

Initial results indicated very fast decomposition of non-transgenic DNA, compared to transgenic DNA. We later realized that the basis for comparison might be faulty, since the primer for non-GMO material targeted a 1000 base-pair strand; where as the primer for the GMO DNA targeted a 325 base-pair strand, which should theoretically be able to survive longer during decomposition. We designed a new primer (325 bp) for the non-GMO plant DNA and found quite similar decomposition rates.

In a 100 day decomposition experiment we found clear indications of horizontal gene transfer (HTG) of the GMO material to Bacillus. In order to be sure that this was not based on some mistake or strange artefact, we decided to do a completely independent (in time) replication of the experiment, and again found clear signs of HTG. In order to confirm the finding we decided that it was necessary to pure culture these Bacillus strains, and subsequently isolate and sequence the DNA strand that reacted with the PCR primer. Much to our surprise we found that the DNA from Bacillus reacting with the primer was in fact not from the GMO plant material, but sufficiently alike to induce a reaction.

Compared to decomposition of GMO DNA in soil, composting greatly increased breakdown of GMO DNA. No GMO DNA could be detected in compost after 10 days of reaction whereas it could easily be detected in soil after 77 days.

Conclusion

If the persistence of transgenic DNA in the environment is considered as the only risk factor, composting is a 'DNA-safe' method to treat GM plant residues.
However, even though transgenic plant DNA was not detected in bacterial isolates in our experiments, we cannot conclude that horizontal gene transfer did not take place. The 300 isolates tested proved to be too low a number to be conclusive.
The numbers of isolates tested were based on the screenings indicating high transfer, but the screenings were biased apparently because some Bacillus species gave PCR products matching the transgenic DNA. Thus, it is still an open question if composting constitutes a safe way of disposing of GM plant residues. Furthermore, these experiments give rise to other interesting questions, e.g., the behaviour of GM plant materials decomposing in waste piles or manure yards under composting-like conditions and the possibility of horizontal gene transfer to indigenous bacteria at the comparably lower temperatures present at these environments. Finally, it must be noted that the plant material we used (Arabidopsis) consisted of very fresh green material with decomposition characteristics that are far from those which would be typical of mature straw or other residues from field grown plants. We would expect slower decomposition in such materials, and thus longer time exposure to HTG even in a best case composting scenario. This is just another reason to seek a continuation (beyond the scope of the current project) with further adjustments of methodology and more types of GMO plant materials to be tested.

These questions need to be assessed if the risk associated with the use of GM plants is to be thoroughly investigated.

Objective 4b

Examining claims that the effluent from the composting process has phyto-sanitary and other plant health promoting capabilities.

We have performed a pilot experiment using compost tea extracts on spinach, and attempted to discern eventual effects into nutrient effects, hormonal effects and microbial effects. The results indicated that the yield effect was related to transfer of protein bound nutrients (N and S), but must be considered preliminary.

In the literature, one of the theories for plant health promoting capabilities of compost, is increased chitinase activity, possibly due to specific microorganisms. We have performed an experiment where we have linked microbial genetic- and functional diversity in compost: DGGE-profiling separated different types of compost regarding chitinase activity (Poulsen et al., submitted).

We have pursued the idea of reviewing the state of the art on compost teas and fermented natural products from Asian and US organic farmers that have increased the use of this technology. Initial attempts to provide funding for this have been unsuccessful (FØJO3). A partnership has been developed for this purpose with Steve Scheuerell, Evergreen College, Olympia, Washington. Steve Scheuerell has a large expertise on phyto-sanitary effects of compost teas, and is currently responsible for developing the organic farming curriculum at Evergreen College. Currently Steve Scheuerell is building adata base with his students on compost teas and fermented natural products.

Objective 5: To provide sufficient amounts of composted material for the field trials in a quality that will comply with future EU-standards on agricultural use of urban waste

We have chosen to supply the field-trial with composted municipal waste from SOLUM's AIKAN facility, rather than relying on the meso-scale composting facility. Partly this is due to the real difficulties in obtaining human feaces or faecal sludge in sufficient quantities to supply the field experiment with a reasonably balanced mixture of household wastes and faecal waste. However in the longer term it will be possible to keep up supplying the field trial from these outside sources which is a clear benefit for its long-term nature, and a reason for systematic use from early on.

WP3

Objective 6: To perform a comprehensive mesocosm study on urban fertiliser impact on nutrient cycling where the temporal and spatial dynamics of plant nutrient cycling is linked to the biological activity of soil organisms

Two mesocosm experiments have been performed using degassed household waste as well as composted household waste as representative urban fertilizers. Results on mesofaunal growth from the first experiment are currently being written up as part of Thomas Larsen's PhD study, in a working paper (Larsen et al., submitted), and shows substantial differences in the way degassed and composted municipal waste affects the dynamics of mesofaunal growth. Results on C and N transformation from the second experiment are currently being subjected to computer modelling (Luxhøi et al., submitted). The results show substantial N immobilization after application of urban fertilizers to soil, followed by a re-mineralization. Based on the relatively low C/N ratio of the fertilizers the initial N immobilization is unexpected. In fact C and N transformation from the urban fertilizers behave very different compared to C and N transformation from plant residues. Since our computer model is optimized to predict C and N transformation from plant residues, we have proposed a different strategy for predict C

and N transformation from urban fertilizers that seem to be very different than e.g. plant residues.

The PhD study has continued this line of work, along with some very fundamental methodological studies on the validity of various types of isotope techniques (natural abundance and pool dilution of enriched food sources in food web studies). To obtain dual-labelled organic material, we have used green manure instead of urban fertilizer, which has been written up in Larsen et el (submitted).

Objective 7: To provide experimental data for modeling plant nutrient dynamics of soil receiving urban fertilisers via incubation studies and the mesocosm study mentioned above

As it is described in Objective 8, uncertainties regarding the mineralization pattern of some of the organic fertilizer has complicated the Daisy simulation and interpretation of the results. The fact that Daisy has been developed with regard to plant residues and animal manure, has turned out to be a constraint to the simulation. We therefore decided to initiate a mesocosm experiment to qualify the parameterization of the urban fertilizers included in the field experiment.

Thus, we are currently conducting a long-term incubation experiment of the organic fertilizers that was initiated on 1. May and will run for one year. The experiment includes all the urban fertilizers included in the experiment except urine. During the incubation the amount of evolved CO_2 and mineralized N is measured providing a good assessment of the mineralization pattern of the materials.

Objective 8: Model interpretation and extrapolation of urban fertilizers laboratory and field trial data

Simulations of the effects of the urban fertilizers on plant production and distribution of N in the soil profile of the Crucial field has been prepared. The final intrepretation of the results, however, awaits the results of the pending mesocosm experiment to qualify the parameterization of the mineralization pattern of the applied fertilizers.

A scenario analyses has been carried out employing the agro ecosystem model Dasiy to simulate leaching of nitrogen, denitrification and carbon storage caused by application of composted or anaerobically digested (biogasification) municipal solid waste, to various Danish farm types and soils under different climates. This scenario analysis is valuable in a larger environmental perspective when the consequences of land application of urban fertilizers are compared with alternative waste management strategies. The work has been carried out in collaboration with the research group developing the waste management model EASEWASTE at Dept. of Environment and Resources, DTU. The results of the simulations now forms the basis for the landapplication module of the waste management model EASEWASTE. Furthermore, they have been used to qualify the consequences of land application of compost in life cycle analyses performed with the Swedish ORWARE model in the associated EU-LIFE project ‘Short-Circuit’.

This application of the CRUCIAL project is an important and unexpected benefit that has impacted models that are currently used in Scandinavian policy making.

An internal report has been produced describing the scenario analysis. The paper de-

scribing the scenario analysis is published in the journal Environmental Modelling and Assessment. Furthermore, an associated paper made in collaboration with DTU describing how the results of the scenario analysis has been incorporated in the waste management model EASEWASTE developed at DTU has been published in Waste Management and Research. These documents have been uploaded to the orgprint database.

The scenario results are surprisingly complex and the main findings is that the emission coefficients are very sensitive to the animal density of the farm rotation in which the waste is applied (due to redistribution of existing animal manure within the farm), but also sensitive to soil type and type of waste (composted vs. digested waste). The strength of the simulations is that they show the combined effect of the input of C and N with the municipal waste product on crop productivity, N utilization and soil C sequestration, including also interactions between all the plant and soil processes. Therefore the simulation results give a more detailed and refined picture of the environmental consequences of municipal waste product application to arable land, than what has been seen before in decision support systems.

WP4

Objective 9: To assess the availability of P in urban wastes and characterize the fertilizer value of waste-derived P following introduction to arable soil

Analyses of soils from field experiment in (WP1) were not carried out, due to changes in timing and priorities in (WP1 and) WP4, that were accounted at the mid-term review.

Experimental work was finalised in 2004 and a first draft international scientific paper was prepared during 2005.

Results

Analyses of data have revealed the following, which will be discussed further in the paper being prepared presently:

1. Treatments with equal amounts of P in different types of organic amendments affected the P concentrations in the plant tissue in the first cut of rye grass, the cumulated dry matter yield and crop P off-take.
2. Responses in dry matter yield and crop P off-take to the organic amendment treatments differed distinctly from the soil P test responses: In the crop, the sludge-Fe amendment resulted in increased crop P off-take and dry matter yield, while the soil P tests generally showed little or no response.
3. Manure treatments had significant effects on manganese concentrations in plant tissue
4. The soil P tests (Olsen P, Resin, Pw, E1min) responded differently to the equal amounts of P added with different organic amendments.
5. The resin P method was the most responsive soil P test method and Olsen P the least

During the preparation and discussions of the first draft among the authors Gitte Rubaek, Bent T. Christensen DIAS and Emmanuel Frossard, ETH, Zurich, it became clear that the scientific value of our results would increase significantly by including additional analyses of C and N in the stored plant samples and of total sulphur content of the stored organic amendmendt. These analyse were therefore carried out during

spring and summer 2006. The draft manuscript will be updated with these results during winter 2006/2007 and a paper will be submitted to e.g. "Waste Management" during winter 2006/2007 (Working title: Responses in crop and soil P tests to waste-derived phosphorus".

WP5

Objective 10:
To deliver an initial characterisation of soil quality in the field experiment, and
To initiate a long-term monitoring of soil biological quality in the field experiment

For soil quality characterization of the field, soil samples in three depths has been collected, for analysis of heavy metals. The analysis of heavy metals has been carried out in the laboratory at KVL but the results are not convincing, and the analysis may have to be repeated.

The soil biological quality in the field experiment is a main topic in an ongoing M. Sc. Thesis (Jane Lindedam).

A PhD study on Biological Management of Urban Waste and Organic Waste Imprint on Soil Quality is currently being advertised by the Research School of Organic Agriculture Research (SOAR), and partial funding has been assured. If this project is elected on a competitive basis it will give rise to in depth probing into soil quality issues in the CRUCIAL trial.

C.2 Fulfilment of deliverables and milestones

WP1 Establishment and running of Long-term field trials with urban fertilisers	Time schedule	Deviations, if any*
Deliverables		
Annual reports 2001-2005	2001 – 2005	Final report in 2006
Materials and protocol for guided tour (public relations)	May 2002	
Report on crop yields and quality, and soil N_{min} status over 2002 – 2004 (input needed in WP3)	Dec 2004	
Milestones		
Establishment of permanent grass strips	Oct. 2001	March 2002
Spreading of fertiliser with high N availability (to be repeated yearly)	Apr. 2002 – 2006	
Sowing of crops (to be repeated yearly)	Apr. 2002 – 2006	
Characterization of crop growth (to be repeated yearly)	May - August 2002 – 2005	
Public presentation of the field experiment (to be repeated yearly, and on request)	Jun. 2002 – 2005	
Spreading of fertilisers with low N availability (to be repeated yearly)	Nov. 2002 – 2005	

WP2 Development of composting practises for food waste and human faeces	Time schedule according to application	Deviations, if any*
Deliverables		
Composted MSW and faeces for use in the field experiment each year from autumn/winter 2002	Oct 2002 & onwards	Mar 2003 & onwards
Report on best practice for full-scale co-composting of municipal solid waste and human faeces based on laboratory scale experiments and trials with meso-scale experiments on KVL's experimental station	Dec 2003	
Presentation at conference	2004	April 2003 and Sep 2004
Scientific manuscript on composting trials	Jul 2004	Dec 2004
Report on phyto-sanitary effects of compost effluent	Jul 2005	December 2005
Scientific manuscript on GMO materials in compost	Jul 2005	
Establishment of a composting facility at KVL's experimental station	Apr. 2002	Sep 2002
Milestones		
First meso-scale composting trial completed (to be repeated each year)	Oct. 2002	Dec 2002
Laboratory studies on composting completed	July 2004	Sep. 2004
Laboratory studies on GMO material in compost completed	Dec. 2004	Sep. 2004
Trials with compost effluent completed	Dec. 2004	

WP3 C and N dynamics of urban fertilisers	Time schedule according to application	Deviations, if any*
Deliverables		
Contributions to status and final project reports	Oct 2002 & onwards	
Synthesis report comprising the mesocosm system elements	Dec 2003	
Popular presentation	2004	
Four scientific papers		
Milestones		
Comprehensive mesocosm study completed	Dec. 2003	
Further incubation studies on quality and temperature effects on temporal patterns of nutrient fluxes completed	July 2004	
Model interpretation of relevant parts of the aforementioned milestones	Dec. 2004	Dec 2005
Simulation completed of the field trials based on parameterisation of urban fertilisers, climate data and relevant crop modules and concomitant testing of the predictive capability based on data from the field (WP1)	July 2004	

WP4 C and N dynamics of urban fertilisers	Time schedule according to application	Deviations, if any*
Deliverables		
Contributions to status and final project reports	Oct 2003 & onwards	
Popular presentation	2004	
Presentation at conference	2004	Plantekongres, 2006
International scientific paper	2005	working paper
Milestones		
Characterization of waste completed	2004	
Pot experiment completed	2004	
Analyses of soil from field experiment (WP1) completed	2004	Resources relocated to other WP4-activities
Final report submitted	Dec. 2005	August 2006 (contribution to final report)

WP5 Soil quality monitoring programme	Time schedule according to application	Deviations, if any*
Deliverables		
Contributions to status and final project reports	Oct 2002 & onwards	
Report on soil characteristics, and motivated recommendation for the lay-out of the field trials	Dec 2002	Oct 2002
Report on urban fertiliser impact on soil quality	2004	Can not be delivered
Milestones		
Establishment of soil archive	Sep. 2001	
Layout of plots	Oct. 2001	March 2002 revised Dec. 2002
Sampling of plots for faunal and other biological characterisation (soil quality baseline study)	Oct. 2002	
Completed baseline study	Mar. 2003	Can not be delivered
Sampling of plots for faunal and other biological characterisation	Aug. 2004	Can not be delivered
Completed soil quality impact study after 3 years of treatment/fertilisation	Oct. 2005	Can not be delivered – *but possibly approached*

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

There are no deviations worthy of mention in relation to the earlier reports on the project.

Compared to the original project document the project has delivered more than expected, as indicated by the quantitative overview below.

		Actually delivered	Originally Planned
Scientific Manuscripts directly related to the project activity	Published or in press	3 invited book chapters + 3 peer reviewed papers	7 in total (printed, in press or submitted)
Scientific Manuscripts directly related to the project activity	Submitted	4 papers for peer review	
Scientific Manuscripts partially related to the project activity		2 invited book chapters + 2 published peer reviewed papers + 3 submitted papers	0
Oral Presentations in international fora		4	2
Oral Presentations in national fora		3 + large number of high school student groups	2
Poster Presentations in international meetings		4	0
PhD program		1 pending + 1 announcd	0
M.Sc. Thesis		2 completed + 2 pending	0

E. Project publications and other products

[Produkter under 1 skal kopieres fra Organic Eprints. Dette gælder også for produkter, som kun delvist er finansieret af FØJO. Listen fra Organic Eprints kan findes på hjemmesiden http://www.okoforsk.dk/projekt/index.html under "Project publications" på de enkelte projekter.]

Peer-reviewed and accepted

English

Bruun, Sander; Hansen, Trine L.; Christensen, Thomas H.; Magid, Jakob and Jensen, Lars S. (2006) Application of processed organic municipal solid waste on agricultural land - a scenario analysis. *Environmantal Modeling and Assessment* 11:pp. 251-265.*

Refsgaard, Karen; Jenssen, Petter D. and Magid, Jakob (2006) Possibilities for closing the urban rural nutrient cycles, in Halberg, N.; Knudsen, M.T. and Kristensen, E.S., Eds. *Global Development of Organic Agriculture: Challenges and Prospects*, chapter 7, page pp. 181-214. CaB International.**

Hansen, Trine L.; Bhander, Gurbakhash S.; Christensen, Thomas H.; Bruun, Sander and Jensen, Lars S. (2006) Life cycle modelling of environmental impacts of application of processed organic municipal solid waste on agricultural land (EASEWASTE). *Waste Management and Research* 24:pp. 153-166.**

Magid, Jakob; Eilersen, Ann Marie; Wrisberg, Simon and Henze, Mogens (2006) Possibilities and barriers for recirculation of nutrients and organic matter from urban to rural areas: a technical theoretical framework applied to the medium sized town Hillerød. *Ecological Engineering*.*

Magid, Jakob; Luxhøi, Jesper; Jensen, Lars S.; Møller, Jacob and Bruun, Sander (2006) Establishment of a long-term field trial with urban fertilizers – is recycling of nutrients from urban areas to peri-urban organic farms feasible?, in Raupp, Joachim; Pekrun, Carola; Oltmanns, Meike and Köpke, Ulrich, Eds. *Long-term field experiments of organic farming*, chapter 5, page pp. 59-78. ISOFAR Scientific Series - International Society of Organic Agriculture Research. Verlag Dr. Köster, Berlin, Germany.

Magid, Assoc. Prof. Jakob (2002) Hard and soft science issues to be negotiated to improve urban metabolism. Paper presented at Urban areas – Rural areas and recycling – the organic way forward?, Royal Veterinary and Agricultural University, 20–21 August 2001; To be published in Magid, Jakob; Granstedt, Arthur; Dýrmundson, Ólafur; Kahilouto, Helena and Ruissen, Theo, Eds. *DARCOF report nr. 3*. DARCOF.*

Pernin, C.; Ambrosi, J.P.; Cortet, J.; Joffre, R.; Tabone, E.; Torre, F. and Krogh, P.H. (2006) Effects of sewage sludge and copper enrichment on both soil mesofauna community and decomposition of oak leaves (Quercus suber) in a mesocosm. *Biology and Fertility of Soils*.**

Dansk - Danish

Magid, Assoc. Prof. Jakob (2002) Byernes affaldshåndtering og næringsstofkredsløb [Urban waste management and nutrient cycles], in Jensen, E.S.; Vejre, H.; Højbjerg Bügel, S. and Emanuelsson, J., Eds. *Visioner for Fremtidens Jordbrug*, chapter 10, page pp. 181-202.

Gads forlag.

Submitted for peer-review but not yet accepted

English

Holmqvist, Annika; Dalsgaard, Anders and Møller, Jacob (2004) Thermophilic composting - a hygienisation method of source-separated faecal toilet waste. [preprint]*

Larsen, Thomas; Magid, Jakob and Gorissen, Antonie (2006) Wheat assimilation of carbon and nitrogen investigated by amendments of dual-labelled (13C and 15N) green manure. [preprint]

Larsen, Thomas; Magid, Jakob; Luxhøi, Jesper; Jensen, Lars S. and Krogh, Paul H. (2006) Properties of anaerobically digested and composted municipal solid waste assessed by integrating soil mesofauna manipulations and nutrient modelling. [preprint]

Luxhøi, Jesper; Bruun, Sander; Jensen, Anne; Larsen, Thomas; Jensen, Lars Stoumann and Magid, Jakob (2006) Modeling C and N mineralization during decomposition of anaerobically digested and composted municipal solid waste. [preprint]

Tønner-Klank, L.; Møller, J.; Forslund, A. and Dalsgaard, A. (2005) MICROBIOLOGICAL ASSESSMENTS OF COMPOST TOILETS: IN-SITU MEASUREMENTS AND LABORATORY STUDIES OF THE SURVIVAL OF FECAL MICROBIAL INDICATORS USING SENTINEL CHAMBERS. *Waste Management and Research.**

Not peer-reviewed

English

Bruun, Sander and Jensen, Lars Stoumann (2004) Simulations of the effects of application of composted and anaerobically digested municipal waste on leaching of nitrogen, denitrification and soil C storage with the agroecosystem model Dasiy . Report, Department of Agricultural Sciences, Royal Veterinary and Agricultural University.*

Holmqvist, A.; Møller, J. and Dalsgaard, A. (2003) LATRINE COMPOSTING – A HYGIENIC EVALUATION. Poster presented at ECOSAN 2end International Symposium on Ecological Sanitation, Lübeck, Germany, 7-11 April, 2003.**

Larsen, T.; Magid, J.; Luxhøi, J.; Jensen, L.S. and Krogh, P.H. (2005) Integrating foodweb dynamics with nutrient and energy flows in soil amended municipal sorted waste. Working Paper.

Larsen, Thomas; Krogh, Paul-Henning; Magid, Jakob and Gorissen, Antonie (2006) Dual-labelled (13C/15N) green manure to differentiate between plant uptake of organic and inorganic N. Poster presented at Iso Life.

Luxhøi, Jesper; Brøgger, Morten; Knudsen, Inge M.B.; Poulsen, Pernille H.B.; Møller, Jacob; Jensen, Birgit; Jensen, Dan F. and Magid, Jakob (2006) Functional Compost. Paper presented at ORBIT 2006: Biological Waste Management, Weimar, Germany, 13. September 2006 - 15 September 2006; To be published in *The ORBIT 2006 Conference Proceedings publication.***

Magid, Jakob (2006) Short-Circuit Short circuiting the carbon and nutrient cycles between urban and rural districts by establishing three new systems for source separation, collection and composting of organic waste in the greater Copenhagen area Final report presented to the EU-Life programme May 2006(LIFE02/ENV/DK/00150) . Report.*

Magid, Jakob; Eilersen, Ann Marie; Wrisberg, Simon and Henze, Mogens (2004)

Possibilities and barriers for recirculation of nutrients and organic matter from urban to rural areas: a technical theoretical framework applied to the medium sized town Hillerød. Working Paper, Plant and Soil Laboratory, Department of Agricultural Sciences, The Royal Veterinary and Agricultural University, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark.*

Magid, Jakob; Rasmussen, Lasse Dam and Moeller, Jacob (2004) Measuring degradation of transgenic DNA and screening for horizontal gene transfer from GMO-plant material during composting. Poster presented at 1st international Conference on SOIL AND COMPOST ECOBIOLOGY, Leon – Spain, September 15th-17th, 2004.

Møller, J.; Bruun, S. and Magid, J. (2005) Three new systems for recycling of urban organic waste to agriculture. *DARCOFenews*(1). Online at <http://www.darcof.dk/enews/mar05/recycle.html>*

Møller, J.; Forslund, A. and Dalsgaard, A. (2003) REDUCTION OF FAECAL MICROBIOLOGICAL INDICATORS IN DIFFERENT COMPOST TOILETS. Poster presented at Ecosan - 2end International Conference on Ecological Sanitation, Lübeck, germany, April 7-11 2003.**

Poulsen, P.H.B; Møller, J. and Magid, J. (2005) Linking microbial genetic- and functional diversity in compost: DGGE-profiling separated different types of compost regarding chitinase activity. Working Paper.**

Rasmussen, L.D.; Møller, J. and Magid, J. (2005) Survival of DNA from a transgenic plant during composting. Working Paper.

Rasmussen, L.D.; Møller, J. and Magid, J. (2004) Composting rapidly degrades DNA from genetically modified plants. *DARCOFenews*(2). Online at <http://www.darcof.dk/enews/june04/gmo.html>

Reeb, U. and Møller, J. (2002) EVALUATION OF DIFFERENT BIOLOGICAL WASTE TREATMENT STRATEGIES, in Magid, J.; Lieblein, G.; Granstedt, A.; Kahiluoto, H. and Dyrmundsson, O., Eds. *Urban Areas - Rural Areas and Recycling - The organic way forward?*. DARCOF Report no. 3.**

Rubæk, Gitte; Frossard, Emmanuel and Christensen, Bent Tolstrup (2006) Crop and soil P-test responses to agronomic use of waste-derived phosphorus. [preprint]

Dansk - Danish

Lindedam, J.; Jensen, K.S.; Luxhøi, J. and Magid, J. (2006) Østrogener fra human urin i miljøet [Oestrogens from human urine in the environment]. *Jord og Vand* 13(2):pp. 44-46.*

Møller, J.; Backlund, A.; Jørgensen, L.T.; Forslund, A. and Dalsgaard, A. (2003) OVERLEVELSE AF INDIKATORORGANISMER OG SMITSTOFFER I KOMPOSTTOILETTER OG VED SIMULERET CENTRALISERET EFTERKOMPOSTERING AF AFFØRING FRA MENNESKER [SURVIVAL OF INDICATOR ORGANISMS AND PATHOGENS IN COMPOST TOILETS AND DURING SIMULATED CENTRALISED COMPOSTING OF FAECES FROM HUMANS]. Økologisk byfornyelse og spildevandsrensning, Dept. of Agricultural Sciences, KVL.**

Quitzau, Maj-Britt; Moeller, Jacob and Magid, Jakob (2004) Attitudes towards utilization of composted domestic waste, sludge, urine and faeces as manure in agriculture. Report, National Environmental Research Institute of Denmark, Dept. of Policy Analysis.

This list was generated on **Fri Sep 15 06:52:14 CEST 2006**.

2. Other products (oral presentations, public meetings, field days, etc.)

A national workshop on 'Composting Plant Residues and Human Waste in support of High Value Organic Plant Production' was organised by the CRUCIAL project on 28th February 2002 at KVL.

Wrisberg Simon, Eilersen Ann Marie: Nye håndteringssystemer til recirkulering af spildevand og organisk affald fra byer. Foreningen Dansk Byøkologi juni 2001. nr.2 årgang 4.

Association of Organic Farmers theme lectures 7th November 2001
Nutrients in circulation – how can urban fertilisers contribute, Jakob Magid, KVL

Magid J. (2003) Closing the Rural Urban Nutrient Cycle – Services from Peri-Urban Agriculture in Containing and Managing Risk from Urban Metabolism. Invited speaker at Bertebos conference 'Ecosystem services in European agriculture: Theory and practice', 14-16 September, 2003, Falkenberg, Sweden

Presentations for 2 high-school groups on separate occasions in September 2001, Jakob Magid, KVL

Presentations for 3 high-school groups on separate occasions in february- april 2002, Jakob Magid, KVL

Presentations for 4 high-school groups on separate occasions in november- December 2002, Jakob Magid, KVL

Presentations for 3 high-school groups on separate occasions in february – april 2003, Jakob Magid, KVL

DAKOFA's konference om Vandmiljøhandlingsplan III og affaldsprodukter til jordbruget, 23. Marts 2004, Markforsøg med slam og organisk affald – hvor stort er problemet? ved. Jakob Magid

J. Magid, A. M. Eilersen, S. Wrisberg, and M. Henze. A technical theoretical framework for ECOSAN applied to the medium sized Danish town Hillerød. 3rd World ECOSAN Conference, 24 May 2005 - Durban, KwaZulu Natal, South Africa

Magid J. (2005) Presentation at UC-Davis and Arizona State University: **Closing the Rural - Urban Nutrient Cycles: managing risk and containing the urban metabolism - an ecosystem service**

J. Luxhøi, M. Brøgger, I. M. B. Knudsen, P. H. B. Poulsen, J. Møller, B. Jensen, D. F. Jensen and J. Magid. (2006) **Functional Compost.** Oral presentation at ORBIT's 5th International Conference on Biological Waste Management – From Local to Global, 13-15th September 2006, Weimar, Germany

F. Scientific education

1. A European Science Foundation LinkEcol grant supported visting scientist, Dr Michaël Coeurdassier. He has conducted a study to evaluate the quantitative effects of decreasing the diversity, using pesticides as a tool, on the foodweb structure of the soil communities (particularly microarthropods, earthworms and bacteria) and the possible consequences of community structure modifications on soil functions, i.e. decomposition of cow dung and N cycling.

2. Thomas Larsen has been employed by October 1st 2003, to undertake a 3 year PhD program entitled 'Soil Ecological Modelling of Urban Fertilizer Turnover'. This is funded jointly by KVL-DMU and SOAR

G. National and international cooperation

Institute of Plant Science, Group Plant Nutrition, Swiss Federal Institute of Technology, Zurich (Prof. Emmanuel Frossard). All isotopic exchange kinetic experiments and ICP-MS analyses have been carried out at the Group of Plant Nutrition (Prof. Emmanuel Frossard) during June14 to August 19, 2004 by

senior scientist Gitte Rubæk and senior technician Karin Dyrberg. This cooperation has allowed an expansion of the analytic work in WP4 and will result in a jointly authored scientific publication.

The CRUCIAL project is part of a portfolio hosted by:

NUTRAP
CENTRE FOR APPROPRIATE TECHNOLOGIES FOR NUTRIENT RECYCLING FROM HUMAN WASTE TO AGRICULTURE IN PERI-URBAN AREAS

A number of research departments have signed the MOU and take part in its activities. For further information on NUTRAP please refer to: www.agsci.kvl.dk/nutrap

Via the EU-Life funded activity, of which CRUCIAL is an integral part, a collaboration has been developed with:

- The Department for Industrial Ecology, Royal Technical University (KTH), Stockholm, Sweden
- Aarstiderne A/S
- Krogerup Avlsgaard A/S
- Dansk Jordforbedring, SOLUM Gruppen A/S

Furthermore international collaboration has emerged in two areas:

The project leader of CRUCIAL has delivered input to an integrated waste management plan for Kuching (Sarawak state, Malaysian Borneo). The Sarawak government has recently decided that ecological sanitation will be the main pillar of the waste management, and that conventional sanitation will be used only in the central business district. Upon successful implementation of pilot scale projects for some housing and institutional areas, the state has decided to enlarge an ecological sanitation scheme to 250.000 people in the first instance. Jakob Magid has been asked to provide further input into this process, by Kuching's Sustainable Urban Development Project.

The Environmental Engineering Group, Swedish University of Agricultural Sciences, Proffesor Håkan Jönsson and co-workers

H. Critical reflection on the project

The project has unfolded in a satisfactory and in many respects unexpectedly fruitful manner.

In quantitative terms the project has so far fed into 4 full-length papers in peer reviewed journals and 4 invited chapters in refereed books. A further 5 manuscripts have been submitted for peer review, and at least 3 more will be submitted during 2006/7.

CRUCIAL has been the core project in a portfolio that seeks to reinvent urban waste management to allow for improved recycling of nutrients and organic matter from urban areas to organic farms. Based on the CRUCIAL activity it has been possible to further initiate a number of projects that add to these activities:

i. The EU life funded project Short-Circuit (2003-2005),

ii. A pilot project involving ecological sanitation in the capital of Sarawak, Bornean Malaysia (2004-2005), and

iii. A DFFE project seeking to investigate possibilities for producing 'Functional compost' with assured disease suppressive and plant nutritional qualities. This last project is an interdisciplinary collaboration with plant pathologists and the commercial compost producer 'Dansk Jordforbedring' – SOLUM A/S (2004-2008)

Furthermore the CRUCIAL project has allowed participation in the public debate and investment of time in organizational development for example within KVL and DAKOFA (Danish committee for waste management). This has resulted in three potentially important decisions:

iv. KVL has offered a Professorship with special obligations to deal with recirculation of nutrients and organic matter from urban to rural areas. Final decision on applicants expected at the end of 2006

v. The Professional Association for Use of Organic Residual Products for Agricultural Purposes – www.genanvendbiomasse.dk has decided to provide partial support for the running of CRUCIAL's long-term field trials at the end of the project, based on financial support from their own members and from organizations that collaborate with them. In addition KVL has given the field trial a special project status, which implies continued internal funding for land use and basic field operations.

vi. An M.Sc. Course on the **'Urban Ecology'** has been developed at KVL. Based on the large interest it has generated this first year of implementation (34 registered students) it has been further refined to a problem and project oriented course with the running title Urban Ecosystems: Structures, Functions and Designs. In 2005/6 29 students signed up, while in 2006/7 21 students have signed up. This course will become a core educational activity in the future 'Urban Planning' curriculum at KVL.

While the above mentioned points are manifest outside the project proper, but emanating from the projects activities some more fundamental scientific gains have been made within the projects own framework.

GMO survival during composting

In connection with the project revision we offered to study the breakdown of transgenic plant material during composting and we have done so successfully although it has become abundantly clear that this area presents a challenge both with regard to methodology and with regard to assuring the integrity of organic farming systems, that we cannot possibly meet within the CRUCIAL project. Discussions with other research teams (national and international) have shown that this is an area that is considered sufficiently important to gain priority in the coming years.

We are sure that our results will stand up to the most careful scrutiny from outside. However with the current state of our knowledge we cannot say with certainty that we have proven that GMO material will not be transferred to bacteria that are naturally competent in taking up naked DNA, and multiply during the composting process. Although the likelihood for this to happen appears to be low, there is a great uncertainty due to lack of knowledge. Similarly we are very aware that there is a complete lack of

knowledge about HTG (horizontal transfer of genes) when it comes to digestion of feed containing GMO material. Therefore we have developed an expression of interest to FØJOIII, in which we recommend that these questions be considered for further studies.

PhD program on 'Soil Ecological Modelling of Urban Fertilizer Turnover'
The Ph.D. study on energy flows through food webs in soil has also given rise to fundamental methodological studies and development, the key question being whether or not we can rely on isotopically enriched materials in studies of fluxes (as claimed by agronomically oriented researchers) or only on natural abundance studies (as claimed by traditional soil ecological researchers).

Thus in two separate areas the project will contribute to fundamental knowledge creation, which was not foreseen in the original project proposal.

Finally the model simulations that have been carried out so far have served the waste management model EASYWASTE. At the moment the scenarios are also to being incorporated in the further development of the Swedish ORWARE model in the associated EU-LIFE project 'Short-Circuit'.

This application of the CRUCIAL project is an important and unexpected benefit that will impact models that are currently used in Scandinavian policy making.

All in all the project management is confident a continuation of key activities beyond the scope of FØJOII will be possible.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

Total consumption of funds from DARCOF and expected consumption this year and coming years

Year	Consump-tion before 2003	2003	2004	2005	2006	Total
Man-months						
Scientific personnel	21,8	17,9	24,6	15,3	1,5	81
Technical personnel	0,8	2,4	5,0	1,6	1,2	11

Year	Consump-tion before 2003	2003	2004	2005	2006	Total
Salaries						
Salary (coordination)	30	20	50	70	40	210
Scientific personnel	804	612	804	511	0	2730
Technical personnel	20	61	73	40	30	224
Other operational costs	149	224	170	81	40	664
Transport af 'By-gødninger'	31	2	8	15	35	91
Special field operations	45	0	15	35	20	115
Composting facility and equipment	125	46				171
Characterisation of the experimental field	110			51		161
Direct costs	1314	964	1120	803	165	4366
Indirect costs (20% of direct costs)	263	193	224	161	33	873
Total	1576	1157	1344	964	198	5239

Comments:

9. Signatures and stamps

Name	Department	Date	Signature
Jakob Magid	Agricultural Sciences, KVL	15. September 2006	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Institution 1 (KVL)	2001	2002	2003	2004	2005	2006	Total
Salary (coordination)	0,5	0,3	0,5	1,0	1,0	1,5	4,9
Scientific personnel	2,3	9,8	6,3	16,8	9,2	0,0	44,3
Technical personnel	0,0	0,8	0,0	2,4	1,6	1,2	6,1

Institution 1 (KVL)	2001	2002	2003	2004	2005	2006	Total
Salaries							
Salary (coordination)	20	10	20	50	70	40	210
Scientific personnel	80	337	216	565	326		1524
Technical personnel	0	20	0	9	40	30	99
Other operational costs	22	70	171	111	70	40	484
Transport af 'By-gødninger'		31	2	8	15	35	91
Special field operations		45	0	15	35	20	115
Composting facility and equipment		125	46				171
Characterisation of the experimental field		110	0		51		161
Direct costs	122	748	454	758	607	165	2854
Indirect costs (20% of direct costs)	24	150	91	152	121	33	571
Total	146	898	545	910	728	198	3425

Institution 2 (DMU)	2001	2002	2003	2004	2005	2006	Total
Scientific personnel	0,0	5,7	6,0	2,5	5,1		19
Technical personnel	0,0	0,0	0,0	0,0			0

Institution 2 (DMU)	2001	2002	2003	2004	2005	2006	Total
Scientific personnel		201	216	89	185		691
Technical personnel							0
Other operational costs		27	19	19	11		76
Direct costs		228	235	108	196		767
Indirect costs (20% of direct costs)		46	47	22	39		153
Total		274	282	130	235		920

Institution 3 DJF Foulum	2001	2002	2003	2004	2005	2006	Total
Scientific personnel			1,7	4,3			6,0
Technical personnel			2,4	2,6			5,0

Institution 3 DJF Foulum	2001	2002	2003	2004	2005	2006	Total
Scientific personnel			60	150			210
Technical personnel			61	64			125
Other operational costs			10	40			50
Direct costs			131	254			385
Indirect costs (20% of direct costs)			26	51			77
Total			157	305			462

Institution 4 FSL	2001	2002	2003	2004	2005	2006	Total
Scientific personnel		3	3				6
Technical personnel							

Institution 4 FSL	2001	2002	2003	2004	2005	2006	Total
Scientific personnel	75,7	110	120				306
Other operational costs	15	15	24				54
Direct costs	91	125	144				360
Indirect costs (20% of direct costs)	18	25	29				72
Total	109	150	173				432

Comments:

B. Budget for each participating department (1.000 DKK)

Comments: Budgets for departments within participating institutions not relevant

C. Budget for co-financing from each participating institute (1.000 DKK)

Name of Institute: KVL – Department of Agricultural Sciences KVL-DAS)

Year	2001	2002	2003	2004	2005	2006	Total
Scientific personnel	0.5	0.5	0.5	0.5	0.5	0.25	2.5
Technical personnel	1.0	1.0	1.0	1.0	1.0	0.5	5.0

Year	2001	2002	2003	2004	2005	2006	Total
Scientific personnel	18	18	18	18	19	10	101
Technical personnel (basic field operations)	22	23	23	24	24	12	128
Alternative costs using 11.5 hectares	92	96	100	103	108	111	610
Use of machinery	25	26	27	28	29	15	150
Direct costs	157	163	168	173	180	148	989
Indirect costs	31	33	34	35	36	30	198
Total financing from KVL-DAS	188	196	202	208	216	178	1187

Comments: