Annual Report Kretsløp SIS 2017

Strategisk instituttsatsing (SIS): Sustainable recycling of organic waste resources in the future bioeconomy

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Project period: 2017 – 2021

Budget: 3.5 mio NOK per year

Innhold

Introduction

The main objective of the strategical programme is to provide new knowledge to promote sustainable use of organic waste resources as fertiliser.

The project group includes Roald Aasen, Thorsten Heidorn, Eva Brod, Anne Falk Øgaard, Annbjørg Øverli Kristoffersen, Trond Henriksen, Erik Joner, Claire Coutris, Ola Hanserud, Anne-Grete Roer Hjelkrem, Bjørn Egil Flø and Valborg Kvakkestad.

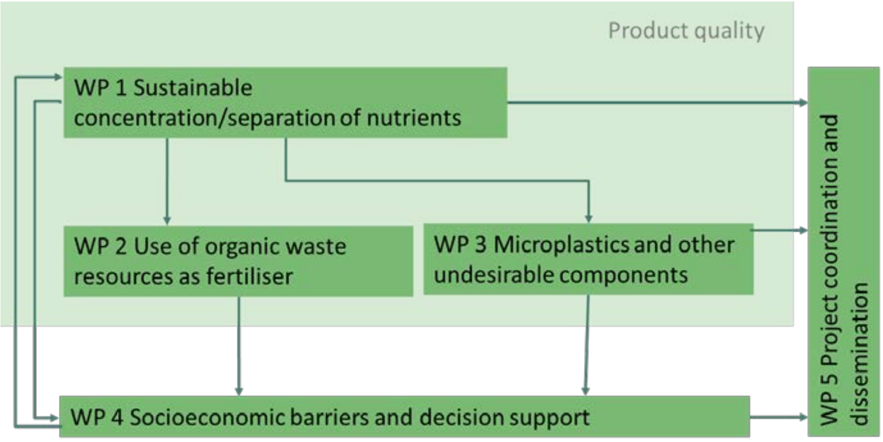


Figure 1. Overview of how the different work packages are interrelated

In early 2017, the project with it's 5 work packages (WP) was built. Figure 1 gives an overview of how the project is built up.

In the following, activities conducted in 2017 in work packages (WP) 1-5 will be described, achievements in 2017 will be evaluated and plans for 2018 will be described. The paragraphs are written by the respective WP leaders: Roald Aasen (WP 1), Eva Brod (WP 2), Erik Joner (WP3), Ola Hanserud (WP 4) and Eva Brod (WP 5).

WP 1. Sustainable concentration/separation of nutrients

(Roald Aasen)

WP 1 is further divided into WP 1.1 Nutrient concentration with microalgae and WP 1.2 Sorption and desorption of nutrients. WP1.2 needs to be divided further in tasks and experiments in order to answer the proposed hypothesis given in the SIS Project description. New milestones and deliveries will also be added to this part during planning in 2017 and work in 2018 as work progresses.

Activities conducted in 2017

<u>WP 1.1 Nutrient concentration with microalgae</u>

The aim of WP 1.1 is to investigate the use of microalgae for the concentration of nutrients (N, P) from waste streams (Figure 2), particularly domestic wastewater. Additionally, a collaboration with the research group around Prof. Arve Heistad at REALTEK/NMBU has been planned to be established.

In the first phase of the project a photobioreactor system was built up in our lab (Figure 3) and a continuous culture of the green microalgae *Chlorella sorokiniana* sp. CHL 176 was cultivated on pre-treated waste water from the lab of Prof. Arve Heistad (REALTEK/NMBU). Black water from a student dormitory was pretreated by an UASB biogass reactor and subsequent 2 filtration/adsorption columns and UV hygienisation. Starting with a 1:10

dilution of the pretreated wastewater and addition of nutrients inclusively phosphate the microalgae culture was growing well and used up all nitrogen (Figure 4). Comparing the ammonium, nitrite and nitrate concentrations of samples directly taken after the adsorption columns with those of samples taken after some time in the medium bottles for the photobioreactors showed a significant nitrification (Figure 4). By separating the biomass from the liquid, purified water with very low nutrient concentration could be produced (Figure 5). When increasing the concentration of the treated wastewater to a 1:2 dilution the continuous microalgae culture became unstable (decreasing dissolved oxygen and biomass concentration). The reason is not yet clear. The assumption is either a too high ammonium concentration or too high concentrations of certain other molecules, e.g. heavy metals. This is under further investigation.

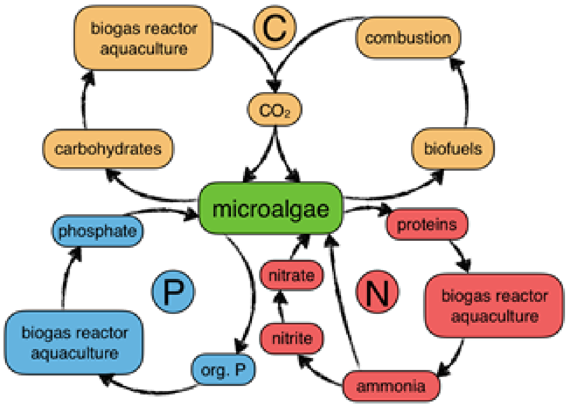


Figure 2. Nutrient circulation with microalgae

Figure 3. Set-up of photobioreactor

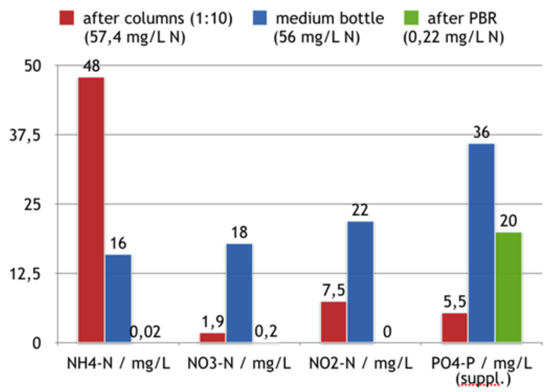


Figure 4. N and P concentrations after columns, in medium bottle and after photobioreactor

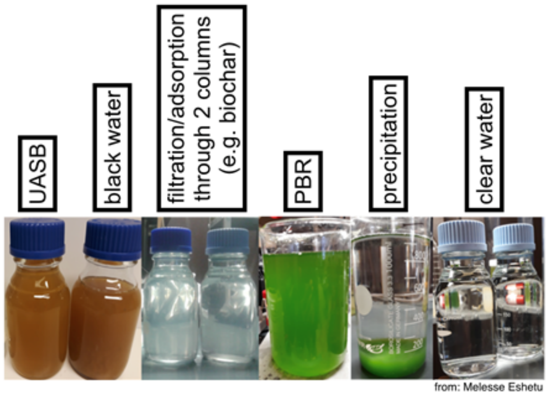


Figure 5. From blackwater to clear water

WP 1.2 Sorption and desorption of nutrients

Providing and characterization of sorbents have started in 2017, but will continue in 2018. Establishing methodology has started in 2017 and will also continue in 2018. Methodology for determination of sorption strength has been started in 2017 (sequential extraction). Focus on different methods and techniques primarily in anaerobic digestion (AD) to concentrate nutrients in diluted liquid waste and in nitrogen rich waste will be given in 2018. This may also include drying and de-watering.

Evaluation of achievements in 2017

Table 1 describes activities in 2017 in relation to milestones and deliverables described in the project description.

Table 1. Evaluation of achieved activities in relation to key milestones described in project description

Milestone		From	To	Status
M 1.1	Literature review on growing microalgae on wastewater, digestate and fish sludge, technologies for volume reduction/ concentration of nutrient rich liquids and sorbents for use in biogas	2017	2018	Will be finished by the end of 2017
M 1.2	Establishing photobioreactors for microalgae at Vollebekk/NMBU/Statskraft district heating plant	2017	2017	Photobioreactors have been established at Vollebekk and are in process at NMBU; at Statskraft district heating plant is postponed to 2018
M 1.3	Test of pre-treatment of substrates and solutions of microalgae	2018	2018	Cancelled, as explained below
M 1.4	Microalgae growth experiments with different substrates	2017	2019	Activities have been started and gave first results
M 1.5	Evaluating the effect of concentrating of nutrients with use of algae	2017	2019	Activities have been started and gave first results
M 1.6	Investigating the potential for sorbents to concentrate nutrients during biogas processes, and use of N-rich substrate as a sole substrate	2017	2021	First experiments to start in 2018
M 1.7	Method evaluation for sorption experiment	2017	2018	Activity starting late 2017, and is to be continued.
M 1.8	Providing and characterization of sorbents and experimental studies for determination of sorption kinetics and capacity for nutrients.	2017	2021	Activity starting late 2017, and is to be continued.
M 1.9	Evaluation of sorption of non-target substances to microalgae and sorbents.	2017	2018	Activity starting late 2017, and is to be continued.

Plans for 2018

WP 1.1 Nutrient concentration with microalgae

Experiments will be continued and the reason for the inhibition at higher wastewater concentrations will be investigated. Photobioreactors will be established at NMBU for having the whole process line installed at the same place. The final aim is to find an overall process to take up all nutrients (N, P) from the wastewater and find the bottlenecks, i.e., limiting or inhibiting substances. In addition, the fertilising potential and harmful components in the microalgal biomass are to be investigated. As methods for pre-treatment are already well established at NMBU we will cancel this activity (M 1.3 “Test of pre-treatment of substrates and solutions of microalgae”) and use the resources for the cultivation activities.

WP 1.2 Sorption and desorption of nutrients

The first activity of WP 1.2 will be to study sorption kinetics, desorption, capacity and mechanisms of nutrients such as N and P to selected sorbents (WP 1.2.1) to deliver milestone M 1.8.

Sorption of ammonium will be studied further in biogas processes with fish waste (WP 1.2.2) as substrate as part of M 1.6. Digestate and some other liquid waste streams are rich in ammonium. To get more of that ammonium in the solid phase, sorbents can be used. Sorbents are solid material with high surface area. In addition, other properties that make dissolved particles attach to them. Sorbents can therefore be used to take solutes e.g. nutrients out of solution and into the solid phase during separation of liquid waste streams. Little is known about how easily those nutrients are then desorbed in soil.

A master student is also being requited to evaluate desorption of ammonium in the plant-soil system using ^{15}N as a tracer. This will provide extra valuable insight into how added sorbents affects subsequent plant availability.

Evaluation of sorption of non-target substances to microalgae and sorbents will continue in 2018 to fulfill deliveries M 1.9.

WP 2. Use of organic waste resources as fertiliser

(Eva Brod)

The aim of this work package is three-fold:

1) We will explore the suitability of organic waste resources as fertilisers,

2) Identify a set of analytical parameters and tools to predict N and P fertilisation effects compared with mineral fertiliser, and

3) Develop guideline models for balanced nutrition application with organic waste resources in fertilisation plans.

Activities conducted in 2017

In 2017, we planned on working on WP 2.1 Nitrogen and WP 2.2 Phosphorus. For several reasons activities in WP 2 are delayed and will therefore have to be postponed to 2018.

<u>WP 2.1 Nitrogen</u>

The main aim of WP 2.1 is to identify parameters, which can predict N fertilisation effects of various <u>*waste products*</u>. To achieve this aim we will determine the <u>*N fertilisation effects*</u> of all waste products included in the experiment. Further, we will conduct <u>*incubation experiments*</u> and apply various <u>*laboratory methods*</u> to the waste products to determine their N quality. We will then compare fertilisation effects with the determined parameters to identify those that best predict fertilisation effects of waste products, and to develop simple model-based tools that can be used in fertilisation planning. The WP 2.1 has been planned and started up, and activities described below have been or will be conducted during autumn 2017.

<u>*Waste products*</u>

We have selected and collected 10 waste products with the aim to cover a broad range of materials in terms of original material and N fertilisation effect. Table 2 gives an overview over selected waste products, which will be used in N experiments.

Table 2. Waste products used in N experiments

Waste product	Description	Estimated N quality

Digestate, municipal	Digestate based on food waste, cow dung, milk and slaughterhouse waste. Originating from Greve digestion plant.	Good
Food waste, reactor-composted	Reactor-composted and dried food waste originating from Lindum.	Low
Sewage sludge, limed	Limed sewage sludge originating from VEAS	Medium +
Sewage sludge, unlimed	Unlimed sewage sludge originating from HIAS	Medium
Struvite	Struvite based on biological sewage sludge originating from pilot plant at HIAS	Medium
Dried fish sludge	Dried fish sludge treated by technology developed by Sterner Aquatek AS, originating from smolt production plant Flatanger Settefisk	Good
Fish sludge digestate	Digestated fish sludge originating from Sterner Aquatek AS pilot plant at smolt production plant Smøla Klekkeri og Settefiskanlegg AS	Good
Swine slurry		Good
Horse manure, Equus Pluss	Horse manure mixed with straw and fish sludge produced bio Bioretur	Low
Commercial organic fertiliser		Medium

The waste products have been sent to NIBIO Apelsvoll/v Trond Henriksen, and to Eurofins for full chemical characterisation. Further activities are delayed amongst other reasons because the chemical analysis to be conducted at Eurofins is delayed.

Determination N fertilisation effects

A pot experiment is planned to be conducted in autumn 2017/winter 2018 to determine the N fertilisation effects of the selected 10 waste products. Barley will be used as model crop. The pot experiment (3 kg soil per pot) will be conducted in a greenhouse at Apelsvoll. The soil for the pot experiment is collected from the NIBIO station at Apelsvoll, and has been air-dried. The N fertilisation effects of waste products will be compared with increasing rates of mineral N fertilisation equivalent to 0, 5, 10 and 15 kg N/daa. Waste products will be applied based on total N contents equivalent to 15 kg N/daa. All other nutrients will be applied as mineral fertiliser solution to ensure that growth is only determined by N availability. Barley plants will be harvested at three time points to determine N uptake following waste product application over time. Soil samples will be collected and analysed at the same time points to determine N release patterns in the soil. Results of the pot experiment are expected to be available in spring 2018.

Incubation experiments

Further, incubations experiments are planned to be conducted in autumn 2017. Incubation experiments will show N release patterns of the studied waste products. To this aim, all 10 waste products will be incubated in the same soil as used for the pot experiment in an incubator at 15°C. The release pattern of the waste products will be compared with an unfertilised control to determine release of plant-available N from the soil. Waste products will be mixed with soil equivalent to ca. 40 kg N/daa (40 mg tot-N/250 g soil kg^{-1} soil) at ca. 50% water holding capacity. Soil samples will be extracted with 1 M KCl after 0, 5, 10, 20, 30, 50 and 100 days. The extract will be analysed for both N, P and S.

Additionally, an extra incubation experiment will be conducted at 5 °C and 30 °C with three selected waste products: Commercial organic fertiliser, horse manure, dried fish sludge in addition to an unfertilised control. The aim of this incubation is to determine temperature response functions compared with the main incubation experiment and to determine whether incubations can be shortened in time by higher incubation temperature.

Laboratory methods

Additionally, a range of analytical parameters will be determined in the waste products:

- C/N
- C/organic N
- Water-soluble C
- Water-soluble C/water-soluble N extracted in warm water
- Øien-N (extraction in 2 M KCl at 80 °C for 20 hours)
- Van Soest fractionation, determination of N in C in 3 extracts
- Various C and N fractions determined by FT-IR spectroscopy

Analytical parameters will be determined by Eurofins, or in cooperation with NMBU. FT-IR spectroscopy will be conducted in cooperation with the University in Copenhagen/v Sander Bruun.

WP 2.2 Phosphorus

There has already been conducted research on how to predict P fertilisation effects of waste products both in Norway and abroad e.g. in Denmark, Finland and Switzerland. We therefore aimed at collecting produced results, standardise them and identify those methods, which best predict P fertilisation effects when all data are compiled in a common data set.

As a first step, we collected data from three Norwegian studies conducted at NIBIO and published in international journals: Experiment 1 included waste products in which P is mainly present as Ca-phosphates of various solubility and the bioassay was conducted at two soil pH levels (Brod et al. 2015). Experiment 2 (published in Øgaard and Brod 2016) and experiment 3 (published in Alvarenga et al. 2017) included 11 and 8 sewage sludge in which P mainly was present as various Al- and Fe-phosphates. Fertilisation effects were determined by bioassays with nutrient-deficient model soil, and various extraction methods were applied to the waste products.

Based on the collected data we cannot recommend using P-AL as an indicator for plant-available P in organic waste products. The current fertiliser regulation recommends indicating the P fertilisation effects of waste products by P-AL.

Amongst all 9 extraction methods, which we tested, extraction with (H_2O) + $NaHCO_3$ resulted in best correlation with fertilisation effects (Figure 6). Extraction with (H_2O) + $NaHCO_3$ directly correlates with the Olsen P fraction ($R^2 = 0.79$). We therefore recommend using Olsen P as an indicator for plant-available P in organic waste products.

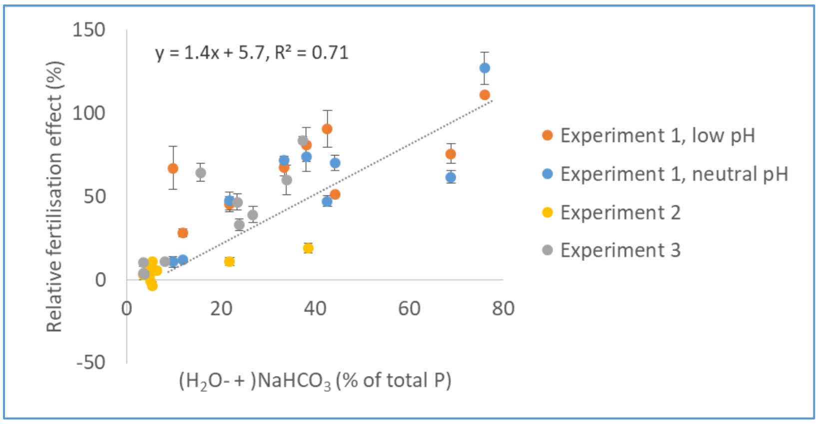


Figure 6. Relationship between fraction of total P in waste products soluble in (H_2O) + $NaHCO_3$ and relative fertilisation effects in 3 experiments.

The Norwegian fertiliser regulation is currently under revision. As part of the revision work, the results of the data compilation on P fertilisation effects of waste products conducted in this SIS were used for an investigation by order of the Norwegian Food Safety Authority. In the report draft delivered to the Norwegian Food Safety Authority, we recommend declaring the plant-availability of P in waste products by:

- Total phosphorus content – Gives the possibility to calculate total phosphorus application with the waste product.
- Olsen P – Gives information on relative plant-availability of phosphorus compared with mineral fertiliser. Method can be used for waste products in which phosphorus is bound to Ca, Al or Fe.
- Total aluminium and iron in sewage sludge – Has importance for availability of phosphorus in sewage sludge.

The compilation of international data had to be postponed, as involved researchers wish to publish their own data first.

Evaluation of achievements in 2017

Table 3 describes activities in 2017 in relation to milestones and deliverables described in the project description.

Table 3. Evaluation of achieved activities in relation to key milestones described in project description

Milestone		From	To	Status
M 2.1	Literature review on methods to predict N fertilisation effects and selection of methods	2017	2017	Conducted as part of the planning process for N experiments described above.
M 2.2	Growth experiment to study N fertilisation effects and application of laboratory methods to predict N fertilisation effects and incubation experiment	2017	2019	Planned and started as described above.
M 2.4	Compilation of own and international data on predicting P fertilisation effects	2017	2017	Compilation of own data conducted as planned. Compilation of international data postponed, as involved researchers wish to publish own data first.

M 2.7	Literature review on extraction methods for S	2017	2017	Postponed. Data on S availability is planned to be collected as part of coming experiments.

Plans for 2018

WP 2.1 Nitrogen

In 2018, we plan to conduct the activities that had to be postponed from 2017 to 2018. We also plan to conduct field experiments at two sites to study N fertilisation effects of selected waste products under practical conditions. The randomized block field experiments will be conducted in cereals (ca. 3x8m per plot, three replicates). Waste products will be applied based on total N contents equivalent to common fertiliser practice, and N fertilisation effects will be compared with an unfertilised control treatment and increasing rates of mineral N fertiliser (response curve at site). Soil will be sampled during the first part of the growing season to study the release pattern of plant-available N. Fertilisation effects will be determined by yield and nutrient uptake. Before establishment and after each harvest, soil samples will be analysed for pH and plant-available nutrients including soluble P.

WP 2.2 Phosphorus

In 2018, we plan to conduct experiments in WP 2.2 with the aim to validate the models previously suggested for prediction of P fertilisation effects of waste products. Activities in WP 2.2 will be conducted in close cooperation with the Bionær project Mind-P that started in September 2017.

References

Alvarenga E, Øgaard AF, Vråle L (2017) Effect of anaerobic digestion and liming on plant availability of phosphorus in iron- and aluminium-precipitated sewage sludge from primary wastewater treatment plants. Water Science & Technology 1743-1752

Brod E, Øgaard AF, Haraldsen TK, Krogstad T (2015) Waste products as alternative phosphorus fertilisers part II: Predicting P fertilisation effects by chemical extraction. Nutrient Cycling in Agroecosystems 103: 187–199

Øgaard AF, Brod E (2016) Efficient phosphorus cycling in food production: Predicting the phosphorus fertilization effect of sludge from chemical wastewater treatment. Journal of Agricultural and Food Chemistry 64 (24): 4821-4829

WP 3. Microplastics and other undesirable components

(Erik Joner)

The aims of WP 3 are:

1) Develop methods for quantification and identification of microplastics, and tracing microplastics in different waste streams where organic waste ends up in soils.

2) Evaluate risks associated with microplastics entering arable soil, focusing on fate and exposure to soil organisms of different types of plastic polymers and associated organic pollutants.

Activities conducted in 2017

The activities in 2017 have consisted of four elements:

1) Conducting a literature review of methods and findings regarding microplastics in waste, sludge and soils. This has been carried out and continues as new publications appear. A literature library has been established on the NIBIO server and will be updated regularly.

2) Calibrating and optimization of newly acquired thermogravimetric (TG) probe with improved sensitivity (heating rate, temperature range, gas flow, cycles, dehydration, etc.). This was conducted and the TG-DSC-FTIR now works well and has improved detection limits using this new thermocouple.

3) Establishment of an in-house library for polymers based on common consumer products with main plastic components. This is an ongoing task where new products are continuously added, and now consist of the common plastic types in different versions (PE, PE-LD, PE-HD, PET, PP, PS, PA, PU, elastomers like TPS, BR, SBR and EPDM (car tire and rubber granulate used at football fields with artificial grass). Acquisition of a standard library for pure polymers to assist in identification of unknown polymers in environmental samples. This library was purchased and proved useful in identifying components of complex samples analysed. It will be amended with the data from in-house measurements on consumer product-derived plastics (which are often presented as pure PE, PP, PS, etc. but which contain additives like dyes, softeners, etc.).

4) Analysis of environmental samples containing or suspected to contain synthetic polymers. A wide range of samples have been analysed, including biogas residue, sewage sludge, compost, road dust (containing synthetic polymers from car tires and road paint) and soil. The results have not shown any clear signals from plastics (except from car tires in road dust). This may be due to low levels of plastic (below our detection limits of ca 0.1 %, thus escaping detection) or some sort of quenching by other organic materials. As a possible solution in case of low amounts of plastics in the samples, we are developing sample oxidation pre-treatments to remove organic materials except plastics, using concentrated lye (KOH) or concentrated H_2O_2 combined with heating. This does not affect pure plastics, but has so far not removed all other organic materials. The methods are thus under further improvement, including the use of urea and thiourea under alkaline conditions.

Evaluation of achievements in 2017

The only milestone that was scheduled to be reached within the reporting period is M 3.1. (Literature review on methods to quantify microplastics in waste and soil). Such a review has been made, but as new publications appear continuously, this work will be continued. The conclusion (supporting our preliminary conclusions from the experimental work) is that thermal desorption GC-MS seems to be the best suited method for solid sample analyses. Such equipment is used for polymer analyses in environmental samples by the group of Dr. Ulrike Braun at Bundesamt für Materialforschung und -prüfung, Berlin, Germany. Contact with this group is scheduled in order to exchange knowledge and attempt to improve the analytical approach at NIBIO.

Milestone 3.2. (Development of a base-line analytical method for quantification of individual polymers) is well under way, and due 31.12.2017.

Plans for 2018

Activities in 2018 will include four main routes:

1) Continued analyses of environmental samples with TG-DSC-FTIR, with particular focus on improvements of sample digestion.

2) Spiking experiments will be conducted where defined microplastic particles are added to bioreactors and composting organic materials, and where the recovery and alterations of the added plastics will be followed.

3) In the context of identifying plastics that may have been modified during waste treatment, changes in FT-IR signatures after exposure to UV light and biofouling will be measured.

4) As a projected collaboration with the research group at BAM, Berlin, samples from the above screening/experiments will be analysed by TD-GC/MS and the results evaluated against the results obtained by TG-DSC-FTIR. If results point towards the former as a far better method, a possible change of methods from TG-DSC-FTIR to TD-GC/MS may be attempted in 2018, in cooperation with NIBIO Plantehelse analytical section who plans to replace a GC/MS where a thermal desorption unit may be fitted at a modest additional cost (if this is a crucial upgrade, partial funding by the SIS may be demanded).

WP 4. Socioeconomic barriers and decision support

(Ola Hanserud)

The main tasks conducted in WP 4 are:

1) Explore socioeconomic barriers for demand for and supply of waste-based fertiliser products, and
2) Propose a framework to describe and compare waste-based fertiliser products.

Activities conducted in 2017

In 2017, the activities are mostly centered around exploring socioeconomic barriers for demand together with a head start on the barriers for existing suppliers.

A literature review has been carried out on the sociology of use of waste-based fertilisers in agriculture. This serves the purpose of getting us updated on the published scientific works on the topic and helps us prepare for our own qualitative work. The literature review also provides a good basis for writing up our results at a later stage for scientific publication.

In June, one test interview of a cereal farmer in the county of Akershus was carried out to test the interview guide and give feed back on the relevance of the questions. More test interviews were planned at the same time, but they were cancelled due to that agronomic circumstances demanded the farmers' immediate attention.

Further full-fledged interviews are planned in autumn 2017 to explore barriers for demand of waste-based fertiliser products among cereal farmers in Southeastern Norway. Interviews of suppliers of waste-based fertilisers are also planned in Autumn 2017. Interviewees are livestock farmers with manure nutrient surpluses and fish producers – both located at the west coast of Norway.

Prior to the full-fledge interviews, work has been put into further developing the interview guides to be used in the semi-structured interviews.

For the autumn of 2017 it is also planned to start looking into the relevant quality aspects of waste-based fertiliser products from the perspective of authorities. We want to find both the current and the desirable future indicators that authorities want to use in their evaluation of both waste-based and primary fertiliser products.

Evaluation of achievements in 2017

Weather events make farming unpredictable and also the time farmers can set aside for activities like participating in interviews planned for this project. This has delayed the progress of WP4, but the interviews of end users of waste-based fertiliser products will still be carried out during autumn 2017.

We will also start the work on exploring important environmental indicators for authorities in autumn 2017, as stated above.

Plans for 2018

In 2018, the plans in WP 4 is to continue qualitative interviews with authorities and both existing as well as potential suppliers of waste-based fertiliser products to explore the formal institutional barriers in play. We will also continue eliciting relevant product indicators from authorities and relevant environmental indicators based on scientific literature. Work will be started on developing a guideline for labelling waste-based fertiliser products to inform both authorities and end-users.

WP 5. Project co-ordination and dissemination

(Eva Brod)

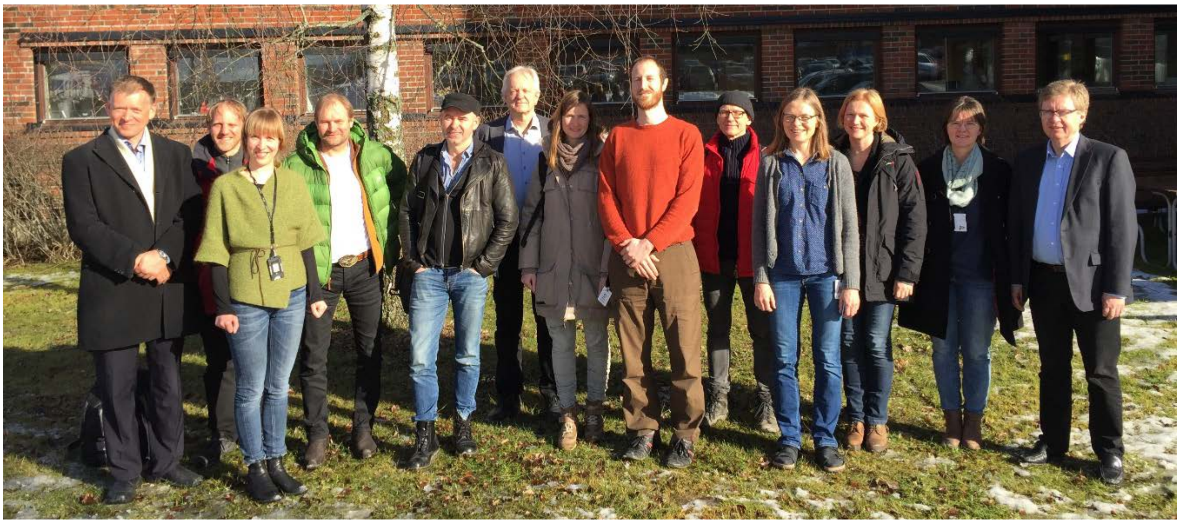
The main tasks conducted in WP 5 are:

1) Coordination of all activities in all WPs, and

2) Popular-scientific dissemination from the project.

Activities conducted in 2017

The first activity of WP 5 was to build the project and to write the project description. On March 1st 2017, the kick-off meeting for the project was arranged (Picture 1).



Picture 1. Project group at kick-off meeting March 1st 2017. From the left: Roald Aasen, Thorsten Heidorn, Eva Brod, Trond Henriksen, Bjørn Egil Flø, Øistein Vethe, Anne-Grete Roer Hjelkrem, Ola Hanserud, Erik Joner, Anne Falk Øgaard, Annbjørg Øverli Kristoffersen, Trine Eggen and Roald Sørheim.

Afterwards, the main activities of WP 5 in 2017 comprised information about the project's start-up both within NIBIO and outside of NIBIO:

- News about the project on NIBIO's intranet "Gull av møkk", March 13th 2017
- News in newsletter of Division Environment and Natural Resources Miljønytt #1 2017, March 20th 2017
- Presentation of the project at seminar arranged by Avfallsforsk, April 27th 2017
- Presentation at lunch meeting Faglig Forum at Division Environment and Natural Resources, May 3rd 2017

Evaluation of achievements in 2017

In early 2017, the project was successfully built and the project description was delivered.

The kick-off meeting (March1st) and the first regular project meeting (September 27th) were arranged according to the plan.

Information about the project has caused positive feedback from the industry, and confirmed the need for competence building related to recycling of organic waste in agriculture.

It remains to establish a homepage about the project under the NIBIO domain. This activity, however, was postponed to after the release of NIBIO's new homepage.

Plans for 2018

Each year, two project meetings are planned. For the project meeting in spring 2018. we intend to invite relevant stakeholders (i.e. industry partners, Norwegian Environment Agency, Norwegian Food Safety Authority, Norwegian extension service).

Other activities in WP 5 in 2018 involve coordination of all activities in all WPs, and popular-scientific dissemination from the project, when relevant.

Deliverables WP 1-5 in 2017

External presentations

Fongen M, Treu A, Coutris C, Joner E (2017) Differential scannning calorimetry coupled with FT-IR. A sensitive method for measuring microplastics in sewage sludge, biogas digestate, food waste compost, and road dust? 16th International Conference on Chemistry and the Environment 2017, 2017-06-18 - 2017-06-22

Popular scientific presentation

Brod E (2017) Kretsløp SIS: Bærekraftig resirkulering av organiske avfallsressurser i den fremtidige bioøkonomien. Presentation at Workshop Avfallsforsk Oslo, April 27th 2017