

**2016-01345****Dahlin, Sigrun****Brg1603**

## Information about applicant

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## Information about application

**Call name:** Annual open call 2016**Type of grant:** Project grant**Focus:** Project grant**Call for proposals subject area:** Formas**Project title (english):** Biogas digestate and bio-ash as fertiliser replacements**Project start:** 2017-01-01**Project end:** 2019-12-31**Review panel applied for:** Brg1603, Brg1601, Brg1605**Classification code:** 40106. Soil Science incl. Biogeophysics, Biogeochemistry, Soil Microbiology, Plant-Soil Interactions, 40501. Renewable Bioenergy Research, 40504. Environmental Sciences related to Agricultural and Land-use incl. Research on Biodiversity, Risks, Ethics**Application subject area:** 5102. 22.0 Jordbruk**Keywords:** gödsling med restprodukter, spårelement, geokemisk modellering, AMF och Rhizobium, klimateffekt

## Funds applied for

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## Participants

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**Basic information**

**Number of project years\***

3

**Calculated project time\***

2017-01-01 - 2019-12-31

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**Project title (Swedish, max 200 characters)\***

Rötrest och bioaska som ersättning för mineralgödselmedel

**Project title (English, max 200 characters)\***

Biogas digestate and bio-ash as fertiliser replacements

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## Popular scientific description (Swedish) (max 4500 characters)\*

Vårt samhälle behöver utvecklas till ett kretsloppssamhälle där naturresurser återbrukas så att exploateringen av nya resurser kan minska. Denna omställning inkluderar ett ökat bruk av förnybara energikällor och återförsl av växtnäringsämnen till åkermark. Bottenaska från värmeverk där man eldar rena biobränslen och rötresten från biogasanläggningar har stor potential att bidra till denna omställning.

Den mesta forskningen om askgödsling har genomförts i skogssystem, men det höga näringsvärdet i aska motiverar att vi använder den även på åkermark. I jordbrukssammanhang har man mest studerat askans kalkningseffekt och askan har då tillförts i stor mängd, betydligt större än motiverat från ett gödslingsperspektiv. Effekten på grödorna och marken vid lägre doser behöver undersökas. Rötresten har visat sig kunna vara effektiva gödningsmedel som kan ge goda skördar. Mindre är dock känt om hur rötresten påverkar växtprodukternas kvalitet såsom protein- och mineralinnehåll.

Gödsling med restprodukter regleras baserat på innehåll av näring och potentiellt giftiga ämnen. Den giftiga metallen kadmium är av särskilt intresse eftersom den kan ge skador på njurar och benvävnad samt ge cancer. Vi har sett att restprodukter även kan påverka hur växterna tar upp markens eget kadmium, vilket sammanhänger med hur rörligt kadmiumet är. Därför behöver restprodukter bedömas även utifrån hur de påverkar kadmium och andra ämnens rörlighet i marken. En ändrad rörlighet kommer även att påverka i vilken grad åkermarken anrikas eller utarmas på både önskade och oönskade ämnen.

I marken finns svampar som bildar s.k. mykorrhiza i symbios med växter och som bl.a. förbättrar växtens närings- och vattenupptag. I marken finns också baljväxtbakterier som i symbios med t.ex. klöver kan använda luftens kväve och på det sättet tillföra jordbrukssystemen stora mängder kväve. Detta är särskilt viktigt i ekologisk produktion men också i annan odling av djurfoder med klöver och andra baljväxter. Vi har sett att de här organismerna ökar i antal av måttliga mängder rötrest och aska, men vi vet inte hur diversiteten eller symbiosen med växterna påverkas.

I ett uthålligt samhälle måste utsläppen av växthusgaser (koldioxid, metan, kväveoxider) minska så att den globala uppvärmningen kan begränsas. Att använda organiskt avfall för att producera biogas kan hjälpa oss att ersätta fossila drivmedel, samtidigt som avgången av dessa gaser kan minska från bl.a. jordbruket. Det organiska materialet som tillförs jordbruket kan dessutom bidra till att bygga in kol i marken vilket betyder att mindre koldioxid frigörs till atmosfären, vilket i sin tur minskar växthuseffekten. Den totala effekten av att använda rötrest och aska beror dock också på hur väl grödorna växer (eftersom de också för ned kol i marken) och på hur markens stora, befintliga kolförråd påverkas av gödslingen. Den sammanlagda effekten på den globala temperaturen över lång tid kan studeras genom miljösystemanalys. En sådan analys tar bl.a. hänsyn till hur markens kolförråd förändras, energianvändning vid transporter och exploatering av råvaror.

Detta projekt kommer att i fältförsök undersöka effekten av två rötresten och två askor från anläggningar med olika ingångsmaterial och processförlopp. Där kommer vi att bestämma skördens storlek och kvalitet med avseende på protein- och mineralnäringshalt samt kadmiumhalt. Rötresten är förhållandevis kväverika och askor fosforrika varför möjligheten att få en bättre avpassad gödsling genom att kombinera de två produkterna ska undersökas. Vi kommer även att hämta jordprov för att studera hur mikronärings- och kadmiumets rörlighet påverkas och vad det betyder för växternas upptag av dessa ämnen och för risken för utarmning respektive anrikning i jorden. Diversiteten hos de mykorrhizabildande svamparna och baljväxtbakterierna kommer att bestämmas. Vi kommer sedan att bedöma om gödsling med rötrest och aska kan användas för att öka markens bördighet för mer effektiv växtproduktion och högre näringsinnehåll i jordbrukets produkter, eller om vi riskerar att få ökade problem med t.ex. kadmium. Slutligen kommer en miljösystemanalys att ge kunskap om i vilken mån gödsling med rötrest och bioaska kan bidra till att begränsa den globala uppvärmningen och till ett uthålligt kretsloppssamhälle. Studentarbeten kommer dessutom att undersöka konsumenters och lantbrukares inställning till gödsling med dessa restprodukter.

**Abstract (Swedish) (max 1500 characters)\***

Bottenaska från biobränslen (bioaska) och rötrest från biogasproduktion kan bidra till ett kretsloppssamhälle som till stor del är biobaserat. Detta projekt ska undersöka hur rötresternas och bioaskornas sammansättning och näringstillgänglighet påverkar jordbruksgrödors avkastning och kvalitet. Möjligheten att få en balanserad näringsförsörjning genom att kombinera kväverik rötrest och fosforrik aska kommer särskilt att studeras. Gödslingens effekt på rörligheten hos mikronäringsämnen och kadmium (Cd) i marken och dess betydelse för växternas närings- och Cd-upptag samt balans i marken står också i fokus. Effekter på mykorrhizasvampar och Rhizobium-bakterier kommer att undersökas eftersom dessa organismer ligger bakom viktiga ekosystemtjänster i jordbrukssystem. Projektet syftar till att utvärdera om rötrest och bioaska kan användas för att öka markens bördighet och grödors näringsförsörjning för ökad produktivitet i växtodlingen och nutrition för människor, samt utvärdera risken för ökat Cd-intag och/eller ackumulering i marken. Slutligen kommer vi göra en miljösystemanalys där faktorer som energiproduktion och -förbrukning, effekter på markens kolbalans samt klimatteffekterna i livscykelperspektiv ingår. Mastersarbeten ska dessutom undersöka konsumenters och lantbrukares inställning till näringsåterföring. Projektet har stor potential att direkt bidra till effektiv och långsiktigt gynnsam användning av restprodukter från bioenergisektorn inom jordbruket.

**Abstract (English) (max 1500 characters)\***

Bottom ash from bio-incinerators ('bio-ash') and biogas digestates have the potential to significantly contribute to a circular and bio-based economy. The project will investigate the influence of digestate and bio-ash application and origin on crop yield and quality. The potential of achieving a more balanced nutrient supply to crops and higher yields by combining nitrogen-rich digestate and phosphorus-rich bio-ash will be specifically tested. We will further investigate effects on micronutrient and cadmium (Cd) mobility and the further influence on crop nutrient and Cd uptake and on micronutrient and Cd balances in soils. Effects on arbuscular mycorrhizal fungi and rhizobia will also be studied, as these organisms provide important ecosystem services in agricultural systems. The project aims to evaluate if digestate and bio-ash can be used to increase soil fertility and mineral supply to crops for enhanced crop productivity and human nutrition, and assess the risk of increased Cd intakes in humans and/or Cd accumulation in soils. Finally, an environmental systems analysis will be made including energy aspects, potential implications for soils as carbon sinks or sources, and emissions of climate gases. The results will contribute to efficient and long-term beneficial use of nutrient-rich by-products from the bio-energy sector within the agricultural sector. Satellite MSc studies will investigate consumer and farmer attitudes.

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## Research programme

### Specific aims and objectives of the proposed project and a background description containing an overview of the research area, including key references (max 7 000 characters)\*

#### Aim and objectives

There's need for a more circular and bio-based economy [1]. This includes use of renewable energy and recycling of plant nutrients to replace or complement mineral fertilisers. Bottom ash from bio-incinerators ('bio-ash') and digestates from biogas plants are by-products from bio-energy generation that may be used as fertilisers. Few studies of ash use have been carried out in agricultural systems. Use of digestates has been more studied in agricultural systems but more knowledge is needed concerning the influence of feedstocks and process additives on digestate composition and nutrient availability, and effects on soils triggered by digestate use [2]. We also lack knowledge on how crop quality is affected by digestate and ash. Can these resources be used to enhance mineral concentrations in crops for enhanced crop productivity and human nutrition, or do they pose a threat? The potential of combining nitrogen (N)-rich digestate and phosphorus (P)-rich bio-ash for increased yields has also not been tested. Finally, an environmental systems analysis is needed including energy aspects and potential implications for soils as C sinks or sources.

The overall aim is to enable efficient and long-term beneficial use of nutrient-rich by-products from the bio-energy sector within the agricultural sector. We focus on biogas digestates and bottom ash from biomass-fuelled incinerators as they have a potential to significantly contribute to a circular economy.

Specific objectives are to test the hypotheses that:

1. combining digestate and moderate amounts of bio-ash gives a more balanced nutrient supply to crops than either by-product separately, leading to higher crop yields,
2. digestates produce crop Cd concentrations that are similar to conventional NPK fertilisation. Co-application of bio-ash decreases crop Cd concentrations,
3. bio-ash application decreases the concentration of most trace elements in the soil pore water; hence leaching losses will decrease and retention of elements in the soil increase,
4. application of digestate and bio-ash stimulate AM fungi and rhizobia, in contrast to the general repression by conventional fertilization,
5. fertilisation with digestate and bio-ash can contribute to net C sequestration in soil and decreased climate gas generation in a systems perspective, hence contributing to a decreased greenhouse effect.

#### Overview of the research area

##### *Crop yield and quality*

Anaerobic digestion enables higher use efficiency of applied nutrients if N losses are prevented at land application, and can thus increase crop yields. Less is known about effects of digestates on crop quality (e.g. protein and mineral content). Riding et al. [3] suggested that digestates may increase crop micronutrient concentrations, especially when applied in combination with ash, but Demeyer et al. [4] found that ash may decrease micronutrient concentrations at high application rates because of the resulting high soil pH. Studies using lower application rates of ash are scarce.

Legislation regulates content and application rates of potentially toxic elements in by-products. A recent study [5] showed that recycling products also affect the mobility and uptake of native soil Cd. By-products for recycling thus need to be evaluated also for how they affect mobility of the soils' native elements.

##### *Element mobility and balances*

The mobility of elements in soil affects their plant-availability and leaching and thus their accumulation or depletion in soil (i.e. their balances). Swedish arable soils are often low in boron (B), copper (Cu) and nickel (Ni), and deficiencies in crops are relatively common on light soils [9]. Accumulation of these elements may be positive, but sustainable use of soils requests that soil balances of (potentially) toxic elements such as Cd remain low or even negative to prevent increased concentrations in crops and ill-health in humans [6]. Increased retention of Cd in the soil can be expected upon bio-ash application due to increased soil pH [7], and maybe also phosphates released from the ash contribute to stronger binding of Cd to the soil [8]. Digestates with a significant content of chlorides may on the contrary contribute to increased Cd mobility, potentially increasing crop uptake and leaching [5]. The overall effect on Cd plant-availability of digestate and ash applied singly and in combination needs investigation under field conditions.

##### *Soil biology effects*

Soil microbial activity increases after field application of digestates, reflecting the inputs of available organic matter. Research has been carried out for example on the overall microbial biomass size, substrate-induced respiration, N cycling, activities of individual enzymes, and earthworm populations [2, 10]. However, we have found no published studies on AM fungi or rhizobia — organism groups that provide important services in agricultural systems. Our preliminary data indicate larger communities of AM fungi than in NPK fertilized soil in three investigated soil types, whereas the effect of digestates on Rhizobium biomass was inconsistent.

Bio-ash also serves as a liming agent. Large increases in soil pH may be undesirable in Scandinavian forest ecosystems adapted to somewhat acid conditions. However, liming is regularly undertaken in agricultural systems. Nevertheless, rapid change in soil pH may potentially affect soil organisms negatively, but Lupwayi et al. [11] found increased soil microbial biomass and functional diversity after ash application. In a three-year pot experiment, Dahlin et al. (preliminary data) also found increased overall microbial biomass in ash-amended soils, and strongly enhanced populations of AM fungi and Rhizobium. Effects on the diversity and composition of AM fungi and Rhizobium communities were not investigated.

#### *Soil C balance and climate effects*

Sustainable development towards a circular economy calls for lower emissions of greenhouse gases in order to limit global warming. Recycling organic wastes to produce biogas can potentially replace fossil fuels while at the same time decreasing CO<sub>2</sub> and methane emissions from arable land, manure storage and landfills. However, the effect of recycling nutrient-rich by-products to arable land also depends on effects on sequestration of C in soils directly from the added materials but also from C in crop residues and thus on the yield levels achieved. Furthermore, effects of the recycled products on the turnover of native soil organic C are potentially important. This is particularly important as the soil C stocks are normally much larger than the application rates. Climate effects due to dynamic and long term changes on carbon stocks and soil productivity can be assessed with new LCA-based methodology, describing the effects on global temperature in degrees Celsius and for any time perspective [12]. Traditional LCA methodology is not suited for evaluation of such long term dynamic effects.

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### **• Description of the project including a summary of the structure, theory, methods, performance and a plan for scientific deliverables (max 15 000 characters)\***

#### **Project description and a summary of the project's organisation**

The project is organised in four closely interlinked work packages (WP) where WP1 includes field experiments that provide samples and data to WP2-4. Crop, soil and pore water samples will be collected and analysed and used for geochemical modelling and assessment of risk and opportunity regarding soil and crop quality and implications for human health. Soil samples will further be analysed regarding AM fungi and Rhizobium abundance and diversity, using molecular markers. <sup>13</sup>C abundances in soil as well as respired CO<sub>2</sub> will be determined to provide input to life cycle analysis.

Two types of digestates and two bio-ashes will be applied singly or in combination, with non-fertilised and conventional NPK fertilised treatments as controls. All treatments will be replicated 4 times. For the digestates, differing trace element-to-N ratios will be sought, either derived through different feedstocks or through micronutrient addition made during the fermentation to optimise the digestion process. For the bio-ashes, one wood ash from a plant with good incineration (low biochar content) and one straw ash from a plant with less efficient incineration (high biochar content) will be selected. The by-products represent inflow of additional organic C from non-agricultural sources and recycling of C of arable origin, as well as organic C that is relatively degradable (digestates) and such that is very stable and can be expected to remain in the soil in the very long term (biochar). In the selection of digestates and char-rich ash we will ensure that the natural abundance of <sup>13</sup>C differs sufficiently from that at the field sites so that the relative contribution of by-product C and original soil C to the combined C pool (1-3 years after application) as well as total emitted CO<sub>2</sub> can be reliably estimated.

The field experiments will be located at two sites differing in soil Cd concentration and texture (e.g. Vreta kloster, Mellby), selected to specifically target the effect of the digestate and ash on element leaching losses and balances, and crop Cd concentration.

Three satellite MSc studies will be initiated on consumer and farmer attitudes to recycling by-products in general and digestates and bio-ashes in particular.

#### *WP1 Crop yield and quality (hypotheses 1-2)*

The field experiments will be carried out over three years. Spring wheat will be used as experimental crop, because wheat is an important crop and also responds clearly to nutrient supply and to changes in the availability of Cd. Crop development will be assessed three times during the growing season through grading of vigour and phenological stage, leaf chlorophyll content (indicating N supply) and visual observations of deficiency symptoms at key growth stages. At harvest, the number of heads  $m^{-2}$ , number of spikelets  $head^{-1}$ , number of grains  $spikelet^{-1}$  and 100-grain weight will be determined. Areal grain and straw yield, grain quality (nutrients and non-nutrient elements, protein content), and element off-takes though harvests will also be determined. Effects of treatments on crop yield and quality parameters will be evaluated by analysis of variance and crop quality data evaluated in relation to requirements by the milling industry and regarding implications for human Cd intake. Offtake data will be delivered to WP2 for element balance calculations.

#### *WP2 Element mobility and balances (hypothesis 3)*

Soil will be sampled from the top soil (0-25 cm) and subsoil (35-55 cm), and analysed for soil chemical and physical properties. Geochemical modelling of the solubility of B, Cu, Ni, Zn and Cd will be carried out to determine to what extent different treatments may lead to changes in trace metal binding and speciation patterns that may affect (i) the soil's ability to bind the trace metal and (ii) the bioavailability of the trace metal. For this purpose we will set up a so-called multisurface model, which we used previously e.g. for Vietnamese agricultural soils [13] and for evaluating the effects of ZVI stabilization on Cu and As speciation [14]. Water-saturated pastes will be used to assess the element concentration in the pore water of a subset of topsoil samples, in order to calibrate and validate the model. Element balances will be calculated for the macro- and micronutrients and for Cd from element inputs via fertilisation and atmospheric deposition and outputs via crop offtakes and leaching losses.

#### *WP3 Soil biology effects (hypothesis 4)*

Arbuscular mycorrhizal fungi and Rhizobium are targeted soil organisms in this project, as they provide important ecosystems services to agricultural lands. Most of our crops can host AM fungi. The fungi may stimulate release of nutrients from organic substrates [15] and also increase crop nutrient and water uptake through their large mycelia, but the symbiosis is commonly repressed by high availability of inorganic nutrients [16]. Rhizobium bacteria are N<sub>2</sub> fixing symbionts of legumes and thus important for leys, which cover the largest share of agricultural land in Sweden. Between legume crops, these bacteria are free-living in the soil, and their persistence in soil is thus vital for N<sub>2</sub> fixation in the next legume crop and, thus, for sustainable agriculture. Top soil from the field experiments will be sampled for DNA extraction and quantitative PCR analysis of AM fungi and Rhizobium abundances. Changes in diversity and community composition will be monitored by high-throughput sequencing of the obtained amplicons.

#### *WP4 Soil C balance and climate effects (hypothesis 5)*

Changes in total soil C pools are slow, why changes occurring over a few years cannot be distinguished against the background variability. Hence changes in soil C pools will be assessed by stable isotope analysis through determination of the fate of by-product C and through C losses from by-products and the native soil C pool via respiration. Respired C from the applied by-products and native soil stock will be determined in the field at intervals during the years following by-product application and used to calibrate the ICBM model for soil C dynamics [17] and to calculate C balances. The effects on global temperature in degrees Celsius (and the Radiative Forcing, RF) will then be calculated for cropping systems based on mineral fertiliser and on digestate and bio-ash, respectively. Input data will be collected from this and previous WPs (C balances, yields, application technology etc) and from the literature. Also emissions of methane and nitrous oxides and their climate effects will be included. The LCA-based methodology used [12] will calculate temperature effects for each year in the modelled period, which preliminary will be 50 years.

#### *Satellite MSc studies*

A transformation to a recycling economy requires that consumers accept commodities produced with recycled inputs. Two MSc studies will therefore investigate consumer attitudes to foods produced in systems fertilised with by-products in general and digestates and bio-ashes in particular. The studies will be designed to allow analysis of generation and gender differences, and geographical differences, respectively, through careful respondent selection and semi-structured questionnaires. Another study will investigate farmer attitudes to and confidence in using recycled nutrient sources on their farms. These studies will be financed and supervised within the frame of MSc programs at the university and carried out in collaboration with relevant agencies (the Swedish Consumer Agency, Swedish Environmental Protection Agency and Swedish Board of Agriculture) and The James Hutton Institute, UK.

### **Description of method and project implementation**

#### *Methods*

Measures to prevent contamination [18] will be taken throughout sampling and sample preparation. Dried plant biomass will be ground using a Grindomix GM 200 fitted with a titanium blade (Retsch, Germany) and analysed for element concentrations after digestion in conc. HNO<sub>3</sub> and HF. Soil samples will be analysed for pH, pseudo-total element concentrations (aqua regia-digestible, ISO 11466), total organic C and N, 'geochemically active' trace metals (0.1 M HNO<sub>3</sub>), exchangeable Ca, Mg, K, and oxalate-extractable Fe and Al (to provide the content of soil (hydr)oxides). Pore water will be analysed for pH, major cations and anions (including PO<sub>4</sub>-P), dissolved organic C, and dissolved trace metals. The speciation of the trace elements in the pore water will be modelled with Visual MINTEQ [19].

The multisurface geochemical model will consider: trace metal binding to organic matter, binding to Al/Fe hydrous oxides, and clay minerals + precipitation/dissolution reactions if important (see e.g. [14] for description of the procedures and submodels used). The modelling work will deliver:

- (i) an estimate of what phases that control the solubility of the trace metals in the soils, and how these have responded to the treatments
- (ii) the speciation of the trace metals, which indicates the bioavailability as free ions and simple complexes (e.g. with Cl) which are the ones that are most easily taken up by plants. Considering also other factors that influence uptake (e.g. pH) the results can be used to understand what factors that govern responses in plant uptake to different treatments.

Top soil (including roots) from the field experiments will be sampled for DNA extraction (NucleoSpin; Machery-Nagel) and quantification of AM fungi and Rhizobium by qPCR, using specific primers [20, 21]. Changes in community composition will be monitored using high throughput sequencing of the amplified markers followed by clustering of sequences and identification against reference databases [22]. Results will be evaluated by multivariate statistical tools.

In a first step of the LCA based time dependent climate impact methodology the system borders and the functional unit(s) are defined, followed by a time distributed inventory (the magnitude and timing of all activities described for all activities taking place in the system). Then the temperature responses are calculated for each individual emission impulse [12]. The algebraic solution [23] for the absolute global temperature potential (AGTP) will then be used to calculate the total system response as the sum of all individual responses, using updated parameters from the Fifth IPCC AR [24]. As a last step, an improvement analysis will be performed, in order to find possible adjustments of the fertilising strategies with potential to substantially improve the climate characteristics in a system and life cycle perspective.

#### *Implementation*

The research partners involved in the project have long and successful experience within complementary aspects of soil science and systems analysis related to by-product recycling and soil quality. Assoc. Prof. Sigrun Dahlin, Dept. of Soil and Environment, is a soil scientist with a background in soil fertility, nutrient cycling and plant nutrition. She will act as overall project manager, lead WP1 and the C determinations in WP4 and contribute to WP2-3, and will be responsible for communication with the reference group. Prof. Jon Petter Gustafsson, Dept. of Soil and Environment, is a soil geochemist specializing in speciation and solubility of metals and phosphorus in soils, he is also the developer of the geochemical code Visual MINTEQ. He will lead WP2. Prof. Björn Lindahl, Dept. of Soil and Environment, is a leading expert in molecular ecology of plant-soil interactions and will lead WP3. Prof. Per-Anders, Dept. of Energy and Technology, has a long experience in Systems analyses and LCA and will lead WP4. Hansson has also long experience in research on the bioenergy systems producing ash and digestate.

#### *Plan for scientific deliverables and communication with stakeholders*

The project team has a large network covering their respective disciplines. Results will thus be communicated at a wide range of national and international meetings and conferences, and will be published in peer-reviewed journals such as *Agronomy for Sustainable Development*, *Soil Biology and Biochemistry* and *Ecosystems and Environment*. At least three papers will be published Open access. Public access will be achieved for the remaining papers by using Epsilon open-access archives at SLU for depositing the papers.

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### **Description of the potential societal value of the research and a plan for communication with stakeholders/end users (max 8 000 characters)\***

**Societal value of the research**



The EU action plan for the Circular Economy [1] lays out a route to decreased generation of wastes by reuse of resources as required to develop a sustainable, low carbon, resource-efficient and competitive economy. The Swedish government supports this strategy. Replacement of fossil energy with renewable energy is one of the changes needed and bioenergy can make a major contribution to this. We foresee an increase in the yearly production of the by-products digestate and bio-ash from the production of approximately 1.7 million tons [25] and 1 million tons [26], respectively. To complete the cycle, these need to be recycled to land to boost new biomass production and can simultaneously substitute mineral fertilisers, thus saving raw materials otherwise exploited. However, it is vital not to jeopardise the long-term fertility and health of soils or the well-being of the human population and a number of questions remain. This project can answer several of these and thus contribute to the development of a sustainable circular economy: It specifically will provide knowledge on the availability of nutrients and potentially toxic elements in biogas digestate and bio-ash and also on changes in availability of the same elements in the soil. In this way it can contribute to a better targeted use of digestate and bio-ash on a range of soils. A low-carbon economy also contributes to lower emissions of greenhouse gases needed to limit global warming. This project will provide predictions of climate effects due to energy generation from biogas plants and bio-incinerators, and the use of the by-products digestate and bio-ash as fertiliser replacement.

### **Communication with stakeholders**

The research group members are experienced in communicating scientific findings to stakeholders via popular science publications (e.g. SLU Fact sheets, Greppa Näringen news), during stakeholder conferences and meetings, and through courses for e.g. extension officers organised by the Swedish Board of Agriculture and the Swedish Rural Economy and Agricultural Societies. The researchers have also developed LCA climate data on direct commission from the Swedish authorities, for use in EU's Renewable Energy Directive (RED), and presented material directly aimed for and used by the Swedish negotiators for the new solid biofuel directives.

We will have recurrent meetings with a reference group of representatives from the Swedish Board of Agriculture (to be confirmed), the Federation of Swedish Farmers (to be confirmed), the Swedish Energy Agency (to be confirmed) and Bioenergiportalen (Ola Palm). At the start of the project this will confirm that the experimental setup is optimised regarding selection of digestates and ashes, sites, etc. It will also be important for the overall evaluation of the results from a commercial perspective and later serve as a medium to communicate and discuss results.

### **Equipment and other facilities**

The Dept. of Soil and Environment has modern experimental facilities and laboratories for chemical soil and plant analysis and staff well trained in the tasks of sample preparation and analysis of trace elements which is sensitive to contamination. Our laboratory can analyse total soil and plant C and N (LECO CHN Analyzer), mineralised C (colorimetric and conductometric methods), exchangeable Ca, Mg and K and oxalate extractable Fe and Al (ICP-OES), and Cl<sup>-</sup>, PO<sub>4</sub>-P and SO<sub>4</sub>-S (ion chromatography). <sup>13</sup>C abundance in collected samples will be determined at a commercial laboratory. Determination of pseudototal concentrations of macro and trace elements and 'geochemically active' trace metals will be carried out at ALS Scandinavia, Luleå, with whom we have long-term experience and who provide analysis according to our stated protocols. Molecular analyses of symbiont communities will be carried out at the Dept. of Forest Mycology and Plant Pathology (SLU), where all necessary equipment is available. Sequencing will be carried out in collaboration with SciLifeLab Uppsala.

### **National and international collaborations**

The project will link to on-going and planned projects by Monica Odlare (Mälardalens Högskola/BIOUSE), Bo Svensson and Sepehr Shekeri (Linköping University) and Sofia Delin, Thomas Kätterer, Sara Hallin and Georg Carlsson (SLU). The project will further benefit from our collaboration networks at The James Hutton Institute (UK), The Scottish Rural College (UK), KU Leuven (Belgien).

### **References**

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## Budget

### Salaries including social fees

Role in the project	Name	Percent of salary
1 Applicant	Sigrun Dahlin	30
2 Other personnel with doctoral degree	Niclas Ericsson	15
3 Other personnel without doctoral degree	Labass AMF + Rhizobium	10
4 Other personnel without doctoral degree	Fält- och labass	8
Total		

	2017	2018	2019	Total
1	220,614	220,614	220,614	661,842
2		84,840	84,840	169,680
3	54,540	54,540	54,540	163,620
4	35,603	26,702	26,702	89,007
Total	310,757	386,696	386,696	1,084,149

### Dedicated time for this project

Role in the project	Name	Percent of full time
1 Applicant	Sigrun Dahlin	30
2 Participating researcher	Jon Petter Gustafsson	10
3 Participating researcher	Per-Anders Hansson	5
4 Participating researcher	Björn Lindahl	10

## Running Costs

Running Cost	Description	2017	2018	2019	Total
1	Field trial	95,000	95,000	95,000	285,000
2	Plant analyses	160,000	160,000	160,000	480,000
3	Soil chemistry analyses	64,400	19,600	38,400	122,400
4	Pore water analysis	45,600	37,600	45,600	128,800
5	DNA sequencing		25,000	25,000	50,000
6	Respired C, 13C	16,200	16,200	16,200	48,600
7	Travel to field sites and accommodation	12,000	12,000	12,000	36,000
8	Consumables	10,000	10,000	10,000	30,000
9	Equipment for CO2 collection	10,000			10,000
10	Conference participation		20,000		20,000
11	Open access publication			45,000	45,000
12	Reference group travel	1,000	1,000	1,000	3,000
Total		414,200	396,400	448,200	1,258,800

(1) - Materiel etc. refers to equipment and other research materiel not classified as fixed assets, e.g. chemicals, literature, and software.

## Equipment depreciation costs

Depreciation cost	Description	2017	2018	2019
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## Premises

Type of premises	2017	2018	2019	Total
1 Offices and laboratories	63,801	73,415	77,231	214,447
Total	63,801	73,415	77,231	214,447

**Total Budget**

Specified costs	2017	2018	2019	Total, applied	Other costs	Total cost
1 Salaries including social fees	310,757	386,696	386,696	1,084,149		1,084,149
2 Running costs	414,200	396,400	448,200	1,258,800		1,258,800
3 Depreciation costs				0		0
4 Premises	63,801	73,415	77,231	214,447		214,447
5 Subtotal	788,758	856,511	912,127	2,557,396	0	2,557,396
6 Indirect costs	126,856	150,815	160,033	437,704		437,704
7 Total project cost	915,614	1,007,326	1,072,160	2,995,100	0	2,995,100

## **Budget specification (max 7000 characters)\***

### **Comments to the budget**

#### **Research team; role of researchers, their time allocation and funding**

Assoc. Prof. Sigrun Dahlin (30%), Dept. of Soil and Environment, is a soil scientist with a background in soil fertility, nutrient cycling and plant nutrition. She will act as overall project manager, lead WP1 and the C determinations in WP4 and contribute to WP2-3, and will be responsible for communication with the reference group.

Niclas Ericsson (15% during year 2 and 3) will carry out the LCA in collaboration with Hansson.

One qualified laboratory assistant (10%) will be required for sample preparation for AMF and Rhizobium work.

A field/laboratory assistant (8%) will be required for sampling in the field experiment, sample preparation, pH and CO<sub>2</sub>-determinations.

Prof. Jon Petter Gustafsson (10%) will lead WP2. Prof. Björn Lindahl (10%) will lead WP3. Prof. Per-Anders (5%) will lead WP4. They will participate in the project in their capacity of faculty-financed professors and thus do not require any salary.

#### **Running Costs**

The field experiments will be located on experimental farms that have all the required infrastructure and expertise and will amount to 95 000 per year.

Soil and pore water analysis will include a range of analyses to enable development of modelling of the trace elements and will amount to an average 100 000 per year.

Plant analysis of both grain and straw is required to enable element balances to be calculated and will amount to 160 000 per year.

Costs for the AMF and Rhizobium investigation is largely covered by the salary cost of the laboratory assistant, with an additional of 50 000 in total needed for sequencing.

One meeting annually with the reference group (1000 SEK for journeys) and a contribution to one conference participation per applicant over the whole project period (5000 each).

We will publish at least three papers with Open Access at 15 000 SEK per paper.

#### **Equipment**

No equipment will be purchased. Analytical instruments are either present at SLU or at the institutes of collaboration partners, or analyses will be carried out at commercial laboratories. SLU has the required SPAD-meters for measurement of chlorophyll content of crops. The field experiment will be located at two experimental farms with all necessary equipment and experienced staff.

#### **Travel and field costs for the Swedish staff**

The field work is estimated to require 2 2-day visits to each location each year for Dahlin and a field assistant. Train tickets, accommodation, a rented car for local transports, etc., will require 12 000 SEK annually.

## **Ethics**

**Animal testing**

**Human testing**

## Classifications

**Subject area (min/max 1 subject area)\*** 51. PROGRAMOMRÅDE JORDBRUK MM > 5102. 22.0 Jordbruk

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**SCB-codes (min 1, max 3 SCB-codes)\*** 40106. Soil Science incl. Biogeophysics, Biogeochemistry, Soil Microbiology, Plant-Soil Interactions  
40501. Renewable Bioenergy Research  
40504. Environmental Sciences related to Agricultural and Land-use incl. Research on Biodiversity, Risks, Ethics

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### **Keyword 1\***

gödsling med restprodukter

### **Keyword 2**

spårelement

### **Keyword 3**

geokemisk modellering

### **Keyword 4**

AMF och Rhizobium

### **Keyword 5**

klimateffekt

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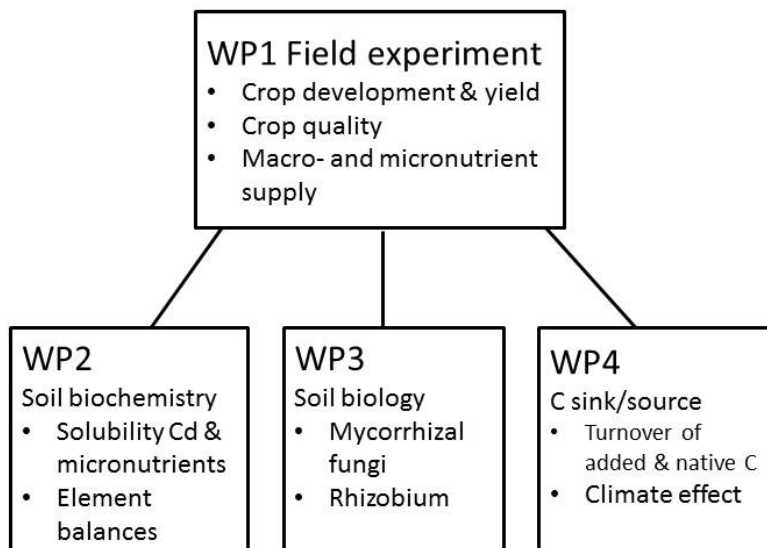


## Appendices

Appendix J. Illustrations. If figures, tables or images are needed to describe the project, an appendix may be uploaded here. The total size of the attachments can be maximum 4 MB in the formats jpg, png or gif

### Appendix J

## Project overview



**Table 1. Work and time plan**

Package	Activity	2017	2018	2019
WP1-4	Analysis and selection of digestate ashes Site characterisation.	■		
WP1	Field experiment			
WP1a	- Crop development		■ ■ ■	■ ■ ■
WP1b	- Crop yield		■ ■ ■	■ ■ ■
WP1c	- Crop quality		■ ■ ■	■ ■ ■
WP2	Element mobility & balances			
WP2a	- Pore water		■ ■ ■	■ ■ ■
WP2b	- Soil geochemical response, sample analysis and modelling		■ ■ ■	■ ■ ■
WP2c	- Element balances		■ ■ ■	■ ■ ■
WP3	AM fungi and Rhizobium		■ ■ ■	■ ■ ■
WP4	Soil C balance & LCA			
WP4a	- Fate of added C		■ ■ ■	■ ■ ■
WP4b	- Response of soil C		■ ■ ■	■ ■ ■
WP4c	- LCA			■ ■ ■

Appendix K. Climate and environmental data (The [form for the publication of data](#) that is available from the ECDS (Environment Climate Data Sweden) must be used.)

**Appendix K**

No file has been attached

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# CV

## CV - Sigrun Dahlin

**Name:** Sigrun Dahlin  
**Birthdate:** 19650306  
**Gender:** Female  
**Country:** Sweden

**Doctorial degree:** 1997-02-21  
**Academic title:** Docent  
**Employer:** Sveriges lantbruksuniversitet

## Educational history

### Research education

Examination	Organisation	Dissertation title (en)
Doctors degree, 40106. Soil Science incl. Biogeophysics, Biogeochemistry, Soil Microbiology, Plant-Soil Interactions, 1997-02-21	Swedish University of Agricultural Sciences, Mark och miljö	The soil microbial biomass and environmental stress

### Basic education

Year	Examination
1991	40102. Horticulture, Degree of Master of Science in Horticulture, Swedish University of Agricultural Sciences

## Professional history

### Employments

Period	Position	Part of research in employment	Employer	Other information
januari 2001 - Present	Researcher, Permanent employment	84	Swedish University of Agricultural Sciences, Mark och miljö	
januari 1998 - december 2000	NO-lärare, högstadiet, Temporary employment	0	Mora kommun	Part-time
juli 1999 - december 1999	Projektledare, Temporary employment	0	Naturresurscentrum Dalarna	Part-time
januari 1991 - december 1996	PhD student, Temporary employment	100	Swedish University of Agricultural Sciences, Mark och miljö	

### Research exchange assignments

Period	Type	Organisation	Subject
september 2011 - oktober 2011	Guest researcher	International Center for Tropical Agriculture	40101. Agricultural Science incl. Plant Production, Plant Genetics, Plant Breeding, Plant Protection, Plant Pathology, Agricultural Ecology, Agricultural Technology, Agricultural History

Period	Type	Organisation	Subject
juni 2010 - augusti 2010	Guest researcher	Tropical Soil Biology and Fertility Institute/International Center for Tropical Agriculture	40101. Agricultural Science incl. Plant Production, Plant Genetics, Plant Breeding, Plant Protection, Plant Pathology, Agricultural Ecology, Agricultural Technology, Agricultural History
september 2009 - september 2009	Guest researcher	Tropical Soil Biology and Fertility Institute/International Center for Tropical Agriculture	40101. Agricultural Science incl. Plant Production, Plant Genetics, Plant Breeding, Plant Protection, Plant Pathology, Agricultural Ecology, Agricultural Technology, Agricultural History
mars 2009 - mars 2009	Guest researcher	Macaulay Land Use Research Institute	40106. Soil Science incl. Biogeophysics, Biogeochemistry, Soil Microbiology, Plant-Soil Interactions

### Interruptions in research

Period	Description
1997-03-10 - 2001-01-01	Maternity leave second child followed by other work as commuting to Uppsala was not possible in the current family situation. I also worked part-time the first few years after 2001-01-01.
1994-08-22 - 1995-02-01	Maternity leave with first child.

### Merits and awards

#### Docentur

Year	Subject	Organisation
2013	40106. Soil Science incl. Biogeophysics, Biogeochemistry, Soil Microbiology, Plant-Soil Interactions	Swedish University of Agricultural Sciences, Mark och miljö

#### Supervised persons

Year	Supervised persons	Role
2019	PhD student, Miriam Larsson	Secondary supervisor
2019	PhD student, Sussy Munialo, University of Nairobi	Secondary supervisor
2018	PhD student, Marguerite Mukangango	Main supervisor
2017	Licentiate, Lisbeth Linse	Secondary supervisor
2015	PhD student, Workneh Bedada	Secondary supervisor
2013	PhD student, Bodil Lindström	Secondary supervisor
2013	PhD student, Atefeh Ramezani	Secondary supervisor
2013	Student, Helena Ström	Secondary supervisor
2013	Student, Kajsa Alvum-Toll	Main supervisor
2012	Student, Kajsa Söderström	Main supervisor
2010	Student, Hanna Almqvist	Secondary supervisor

#### Research grants awarded in competition

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2015 - 2017	Formas	Ingrid Öborn	Co-applicant	2075333	6225999

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2015 - 2020	Sweden - Other governmental agencies	Herbert Talwana	Co-applicant	0	8700860
2014 - 2014	Stiftelsen Svensk Växtnäringsforskning	Sigrun Dahlin	Applicant	0	139000
2013 - 2013	Sweden - Higher education institutions	Sigrun Dahlin	Applicant	0	135320
2011 - 2015	Formas	Sigrun Dahlin	Applicant	0	3622000
2010 - 2013	Formas	Sigrun Dahlin	Applicant	0	743000
2007 - 2007	Sweden - Other governmental agencies	Sigrun Dahlin	Applicant	0	330000
2005 - 2007	Formas	Formas	Applicant	0	2835000
2005 - 2007	Sweden - Higher education institutions	Sigrun Dahlin	Applicant	0	1458000
2002 - 2003	Formas	Sigrun Dahlin	Applicant	0	1170000

### Other merits

Period	Type of merit	Description
2015 - 2020	coordinator	SLU coordinator in a bilateral capacity building programme with 4 Ugandan universities.
2016 - 2016	Stakeholder communication	I have communicated my research findings during stakeholder conferences and meetings (e.g. Regionala växtodlings- och växtskyddskonferenserna and the Swedish Rural Economy and Agricultural Societies conferences), through courses for e.g. extension officers organised by the Swedish Board of Agriculture and by feeding in data to Greppa Näringen for inclusion in their newsletter and digital tool.
2016 - 2016	Publicering och citering	During the last five years I have published 16 and 32 papers in peer-reviewed scientific journals over the last 5 years and in total, respectively. Web of Science indicates an H-index of 5 (2 most recent papers not included) and 9, respectively. I have over the last 5 years co-authored 1 tutorial book (ISBN 978-91-44-06920-3) and 1 chapter in the tutorial book (ISBN: 9789144092805). I have also been the main author of 2 scientific reports and co-authored 1 peer-reviewed chapter, as well as authored and co-authored a number of conference abstracts. Over the whole period I have also published 2 popular science reports, 1 chapter and 1 fact sheet.
2010 - 2014	committee member	Member of the NL/NJ faculty committee of Global affairs.
2010 - 2011	coordinator	Coordinator for the research school "The Natural Resource Management & Livelihoods in International Development Research School (NRLM)"
2004 - 2005	coordinator & communicator	Coordinator and communicator in the research programme Food21.
2004 - 2005	guest editor	Guest editor at Soil Use and Management for the thematic issue 'Nutrient management in sustainable agricultural systems'.
2003 - 2004	coordinator	Coordinator in the project "Nutrient management in sustainable agricultural production systems"

### CV - Jon Petter Gustafsson

**Name:** Jon Petter Gustafsson  
**Birthdate:** 19641209  
**Gender:** Male  
**Country:** Sweden

**Doctorial degree:** 1995-06-01  
**Academic title:** Professor  
**Employer:** Sveriges lantbruksuniversitet

### Educational history

#### Research education

Examination	Organisation	Dissertation title (en)
Doctors degree, 10506. Geochemistry, 1995-06-01	KTH Royal Institute of Technology, Institutionen för Hållbar utveckling, miljövetenskap och teknik	Sulphur, selenium and arsenic in forest soils - Retention mechanisms and solid-phase speciation

### Basic education

Year	Examination
1988	10509. Oceanography, Hydrology and Water Resources, Degree of Bachelor, Uppsala universitet

## Professional history

### Employments

Period	Position	Part of research in employment	Employer
januari 2015 - Present	Professor	65	Swedish University of Agricultural Sciences, Mark och miljö
januari 2009 - Present	Professor	50	KTH Royal Institute of Technology, Institutionen för Hållbar utveckling, miljövetenskap och teknik
januari 2013 - december 2014	Professor	50	Swedish University of Agricultural Sciences, Mark och miljö
januari 1996 - december 2012	Researcher	50	Swedish University of Agricultural Sciences, Mark och miljö
januari 2002 - december 2008	Senior lecturer	50	KTH Royal Institute of Technology, Centrum för hållbart samhällsbyggande
juli 1995 - december 2001	Assistant professor	80	KTH Royal Institute of Technology, Institutionen för Hållbar utveckling, miljövetenskap och teknik
juli 1989 - juni 1995	PhD student	90	KTH Royal Institute of Technology, Institutionen för Hållbar utveckling, miljövetenskap och teknik

### Post doctoral assignments

Period	Organisation	Subject
augusti 1995 - oktober 1995	James Hutton Institute	10506. Geochemistry

### Research exchange assignments

Period	Type	Organisation	Subject
maj 2005 - juli 2005	Guest researcher	University of Toledo	10506. Geochemistry

### Interruptions in research

Period	Description
1995-01-01 - 1995-06-30	Parental leave. 6 months full time
1993-01-01 - 1993-06-30	Parental leave. 6 months full time

## Merits and awards

### Docentur

Year	Subject	Organisation
2000	10506. Geochemistry	KTH Royal Institute of Technology, Institutionen för Hållbar utveckling, miljövetenskap och teknik

Supervised persons			
Year	Supervised persons	Role	Number
2016	PhD student, Ann Kristin Eriksson, Sveriges lantbruksuniversitet	Main supervisor	
2016	PhD student, Charlotta Tiber, Sveriges lantbruksuniversitet	Main supervisor	
2016	PhD student, Sabina Hoppe, Stockholms universitet	Secondary supervisor	
2014	PhD student, Maja Larsson, Sveriges lantbruksuniversitet	Main supervisor	
2013	PhD student, David Eveborn, Kungliga Tekniska högskolan	Main supervisor	
2012	PhD student, Carin Sjöstedt, Kungliga Tekniska högskolan	Main supervisor	
2008	PhD student, Susanna Toller, Kungliga Tekniska högskolan	Main supervisor	
2008	PhD student, Joris van Schaik, Sveriges lantbruksuniversitet	Secondary supervisor	
2007	PhD student, Nguyen Manh Khai, Sveriges lantbruksuniversitet	Secondary supervisor	
2005	PhD student, Mats Linde, Sveriges lantbruksuniversitet	Secondary supervisor	
	Student	Main supervisor	26
	Student	Main supervisor	11
	PhD student	Main supervisor	3
	PhD student	Main supervisor	3

Research grants awarded in competition					
Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2016 - 2019	VR - Vetenskapsrådet	Jon Petter Gustafsson		0	3685000
2016 - 2017	Energimyndigheten	Stefan Löfgren	Co-applicant	1000000	2000000
2015 - 2020	Stiftelsen Lantbruksforskning	Jon Petter Gustafsson	Applicant	0	3149821
2013 - 2016	Formas	Dan Berggren Kleja	Co-applicant	200000	6390000
2011 - 2016	Formas	Kevin Bishop	Co-applicant	2500000	25000000
2011 - 2014	Formas	Jon Petter Gustafsson	Applicant	0	3903000
2008 - 2011	VR - Vetenskapsrådet	Jon Petter Gustafsson	Applicant	0	3240000
2007 - 2011	Formas	Jon Petter Gustafsson	Applicant	0	3580000
2003 - 2007	Formas	Jon Petter Gustafsson	Applicant	0	3240000

Other merits		
Period	Type of merit	Description
2016 - 2020	Member of Faculty Board	NJ Faculty Board, SLU
2015 - 2016	Member of Editorial Board	Associate Editor of Applied Geochemistry
1997 - 2016	Member of PhD examination committees	21 times member of PhD examination committees, 17 in Sweden, 2 in Finland ("pre-examiner"), 1 in USA (committee member + supervisor), 1 in Netherlands (committee member + opponent).
2008 - 2016	Beamtime at synchrotron light sources	MAX-Lab, Lund (10 occasions), SSRL, California (4), NSLS, New York (6), The Diamond, UK (1), SLRI, Thailand (4) – at MAX-Lab, SSRL, NSLS, SLRI as PI.
2016 - 2016	Ongoing supervision of PhD students (as main supervisor)	Sabina Braun, SLU (from 2015), Hugo de Campos Pereira, SLU (from 2016)

Period	Type of merit	Description
2000 - 2016	Software development (Intellectual property)	- Visual MINTEQ (2000-). Used in > 2 000 peer-reviewed international journal papers since 2000, which makes it the world's second most used software for geochemical equilibrium calculations in low-temperature systems. Web: <a href="http://vminteq.lwr.kth.se">http://vminteq.lwr.kth.se</a> . - HD-MINTEQ (2014-). Tool for scenario modelling of soil chemical processes. Still under development, planned public release on web: september 2017. - Pb-BLM (2015-). Calculation core of the Pb-BLM software, see: <a href="http://www.leadblm.com">http://www.leadblm.com</a> - Full BLM (2016-). Ongoing development of full European BLM for risk assessment of surface waters. Planned release September 2017. - Add-in to FITEQL (2003-2004). Facilitates use of the CD-MUSIC model in the FITEQL code. See: <a href="http://rymd.lwr.kth.se/forskningsprojekt/mow/fiteql.htm">http://rymd.lwr.kth.se/forskningsprojekt/mow/fiteql.htm</a> - WinHumicV (1998-2001). Windows version of Ed Tipping's WHAM V model for organic complexation. <a href="http://rymd.lwr.kth.se/English/OurSoftware/winhumicv/index.htm">http://rymd.lwr.kth.se/English/OurSoftware/winhumicv/index.htm</a>
1992 - 2016	Bibliometric summary	From 1992 to 2016 I was author or co-author to: 86 peer-reviewed international journal papers, 2 peer-reviewed book chapters, 60 conference abstracts, 25 research reports / popular reports / books, 4 publicly available software programs / add-ins For this period my h-index is 28 (WoS) and the total no. of citations is 2458 (WoS). From 2011 to 2016 I was author or co-author to: 31 peer-reviewed international journal papers, 14 conference abstracts, 5 research reports / popular reports / books, 1 publicly available software program / add-in (excluding Visual MINTEQ) For the publications from 2011 to 2016 my h-index is 10 (WoS) and the total no. of citations is 216 (WoS), again excluding citations of recent Visual MINTEQ versions. See ResearcherID page at: <a href="http://www.researcherid.com/rid/B-1655-2010">http://www.researcherid.com/rid/B-1655-2010</a> (this list does not, however, include citations of software packages).
1992 - 2016	Collaboration network	I have published papers together with 127 other researchers from 19 countries, see <a href="http://www.researcherid.com/rid/B-1655-2010">http://www.researcherid.com/rid/B-1655-2010</a>
2000 - 2016	Interactions with stakeholders	Many projects have been conducted in collaboration with stakeholders, examples: SSAB, LKAB, Svenskt Vatten, Swedish Chemicals Agency, Swedish EPA etc. For examples of reports from such collaborative projects, see <a href="https://www.kth.se/profile/62929/page/publications-93/under%20Book%20chapters%20and%20reports">https://www.kth.se/profile/62929/page/publications-93/under "Book chapters and reports"</a>
2000 - 2015	Opponent on PhD defence	6 times: Lena Ringqvist, SLU (2002), Ulf Pettersson, LTU (2002), Jelena Todorovic, LTU (2006), Andre van Zomeren, WAU, NL (2008), Linda Önnby, LU (2013), Maryam Latifian, LU (2015).
2006 - 2008	Member of national research councils or their committees	FORMAS Panel member on "Constructions and urban technical systems". Vice chairman 2007-2008.

## CV - Per-Anders Hansson

**Name:** Per-Anders Hansson  
**Birthdate:** 19641003  
**Gender:** Male  
**Country:** Sweden

**Doctorial degree:** 1993-02-19  
**Academic title:** Professor  
**Employer:** Sveriges lantbruksuniversitet

## Educational history

Research education		
Examination	Organisation	Dissertation title (en)
Doctors degree, 21199. Other Engineering and Technologies not elsewhere specified, 1993-02-19	Swedish University of Agricultural Sciences, Energi och teknik	Modelling and optimization of passive and adaptively controlled active cab suspensions on terrain vehicles
Licentiate degree, 21199. Other Engineering and Technologies not elsewhere specified, 1991-03-08	Swedish University of Agricultural Sciences, Energi och teknik	Simulation and optimization model for vibration damping cab suspension

## Basic education



Year	Examination
1988	21199. Other Engineering and Technologies not elsewhere specified, Degree of Master of Science in Agriculture, Swedish University of Agricultural Sciences

## Professional history

Employments				
Period	Position	Part of research in employment	Employer	Other information
december 2007 - Present	Professor, Permanent employment	80	Swedish University of Agricultural Sciences	Fakultetsprofessur, (50% uppdrag som prefekt hittills)
januari 2004 - december 2007	Professor, Permanent employment	75	Swedish University of Agricultural Sciences	50% uppdrag som prefekt fr.o.m. juli 2006
januari 1997 - januari 2004	Professor, Permanent employment	75	Swedish University of Agricultural Sciences	vikariat
november 1994 - januari 1997 (Present)	Assistant professor, Temporary employment	95	Swedish University of Agricultural Sciences	
februari 1993 - november 1994	Forskningsledare, Temporary employment	95	Swedish University of Agricultural Sciences	
januari 1989 - februari 1993	PhD student, Temporary employment	95	Swedish University of Agricultural Sciences	

## Merits and awards

Docentur		
Year	Subject	Organisation
1996	211. Other Engineering	Swedish University of Agricultural Sciences, Energi och teknik

Supervised persons			
Year	Supervised persons	Role	Number
2015	PhD student, Johanna Spångberg, Sveriges lantbruksuniversitet	Secondary supervisor	
2015	PhD student, Marie Kimming, Sveriges lantbruksuniversitet	Main supervisor	
2015	PhD student, Niclas Ericsson, Sveriges lantbruksuniversitet	Main supervisor	
2015	PhD student, Mattias Eriksson, Sveriges lantbruksuniversitet	Main supervisor	
2015	Licentiate, Torun Hammar, Sveriges lantbruksuniversitet	Main supervisor	
2014	PhD student, Elin Röös, Sveriges lantbruksuniversitet	Main supervisor	
2014	Licentiate, Sheshti Johansson, Sveriges lantbruksuniversitet	Main supervisor	
2014	Licentiate, Hanna Karlsson, Sveriges lantbruksuniversitet	Main supervisor	
2014	Licentiate, Anders Eriksson, Sveriges lantbruksuniversitet	Secondary supervisor	
2010	PhD student, Eva-Lotta Lindholm, Sveriges lantbruksuniversitet	Main supervisor	
2009	PhD student, Serina Ahlgren, Sveriges lantbruksuniversitet	Main supervisor	
2009	PhD student, Carina Gunnarsson, Sveriges lantbruksuniversitet	Main supervisor	
2007	PhD student, Björn Vinnerås, Sveriges lantbruksuniversitet	Secondary supervisor	

Year	Supervised persons	Role	Number
2004	PhD student, Magnus Lindgren, Sveriges lantbruksuniversitet	Main supervisor	
2004	PhD student, Alfredo deToro, Sveriges lantbruksuniversitet	Main supervisor	
2004	PhD student, Lena Rodhe, Sveriges lantbruksuniversitet	Main supervisor	
2004	PhD student, Sven Bernesson, Sveriges lantbruksuniversitet	Main supervisor	
2001	PhD student, Sven-Axel Svensson, Sveriges lantbruksuniversitet	Main supervisor	
1999	PhD student, Berit Mattson, Sveriges lantbruksuniversitet	Secondary supervisor	
1999	PhD student, Daniel Nilsson, Sveriges lantbruksuniversitet	Main supervisor	
1999	Licentiate, Karolina Hovellius, Sveriges lantbruksuniversitet	Main supervisor	
	Student	Main supervisor	30

### Research grants awarded in competition

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2016 - 2018	Energimyndigheten	Per-Anders Hansson	Applicant	0	1500000
2015 - 2018	European Union (EU)	Sigfried Egner	Co-applicant	3700000	55000000
2013 - 2016	Energimyndigheten	Per-Anders Hansson	Applicant	0	2000000
2013 - 2019	Formas	Mats Sandgren	Co-applicant	2500000	12093000
2010 - 2016	Sveriges regering, strategisk forskningsansatsning	Kristina Edström	Co-applicant	13000000	31000000
2008 - 2012	Formas	Per-Anders Hansson	Applicant	0	3030000
2007 - 2010	Formas	Per-Anders Hansson	Applicant	0	1620000
2006 - 2012	Stiftelsen lantbruksforskning	Per-Anders Hansson	Applicant	0	4000000
2004 - 2006	Formas	Per-Anders Hansson	Applicant	0	1890000
2004 - 2009	Emmissionsforskningsrådet	Per-Anders Hansson	Applicant	0	6148000

### Awards and distinctions

Year	Name of award/distinction	Issuer
1993	Benzeliuspriset	Kungliga Svenska Vetenskaps societeten

### Other merits

Period	Type of merit	Description
2012 - 2100	Member KSLA	Member of KSLA (The Royal Swedish Academy of Agriculture and Forestry)
1993 - 2016	Activities in evaluation of higher positions and doctoral students.	Evaluator of Professorship and Ass Professorship at Chalmers institute of technology, Uppsala University and Lund University Opponent and member of doctoral and licentiate evaluation committees 15-20 times in Sweden and Denmark
2006 - 2016	Head of Department	From 2006 I have been Head of the department of Biometry and Engineering (2006-2008) and department of Energy and Technology (2008-)
2016 - 2016	Course and program development and course leading	I have been engaged in several Faculty level educational boards and program boards, both at SLU and Uppsala University. I have also developed and been responsible for the MSc and PhD courses described below. • Logistics and operational research (5 cr.) (1994-2003) • Natural resource theory (5 cr.) (1997-2002) • Renewable energy (5 cr.) (1997- ) and Energy systems (5 cr.) (1997-2000) • Production planning and optimisation, optimisation part (ca 1.5 cr. of total 5 cr.) (1999-2005) • Energy- and Life cycle analysis (2-5 cr.) Several courses (2003-) • Logistics for energy systems (4-5 cr.) (2003-) • Energy system selection (5 cr.) (2004-2008)

Period	Type of merit	Description
1993 - 2016	Activities in research councils	1997-2002 I was member of the SJFR and FORMAS evaluation group for the agricultural program (maximum 6 years was allowed). I am also engaged in evaluation of applications for NorFa ("Nordisk forskarutbildningsakademi"), NKJ ("Nordiskt kontaktorgan för jordbruksforskning"), the Norwegian research council, The Danish research council, ICROFS and "Stiftelsen för regional jordbruksforskning i norra Sverige". I have also in 6 years been engaged in SLF's (Swedish Farmers' Foundation for Agricultural Research) evaluation group for their Bioenergy program, and from 2008 in STEMs programs for Energy systems and Sustainable bioenergy.
1989 - 2016	Research profile and bibliometrics	My research profile can be summarized with the key-words: bioenergy, agricultural energy systems, systems analysis of food and energy production, operational research, environmental systems analysis, LCA, machinery systems. I have published in total ca 74 articles in scientific journals (26 since 2011) (H-index 22, Scopus), ca 30 conference abstracts and papers, most of them reviewed (ca 10 since 2011), ca 10 book chapters and reports (3 since 2011), and 10-15 popular science and educational works. I have also been responsible main supervisor for ca 22 published licentiate and doctoral theses (9 since 2011). Since 2006 I have worked half time (50%) as Head of department ("prefekt") and been forced to focus my scientific publication on articles in scientific journals.
2011 - 2012	University evaluations	Evaluator of Helsinki University (International evaluation of research and doctoral training at the University of Helsinki) in 2011-2012

## CV - Björn Lindahl

**Name:** Björn Lindahl  
**Birthdate:** 19721202  
**Gender:** Male  
**Country:** Sweden

**Doctorial degree:** 2001-12-20  
**Academic title:** Professor  
**Employer:** Sveriges lantbruksuniversitet

## Educational history

### Research education

Examination	Organisation	Dissertation title (en)
Doctors degree, 10699. Other Biological Topics, 2001-12-20	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi	Nutrient Cycling in Boreal Forests - a Mycological Perspective

### Basic education

Year	Examination
1997	10611. Ecology incl. Aquatic Ecology, Terrestrial Ecology, Biodiversity Conservation, Degree of Master, University of Gothenburg

## Professional history

### Employments

Period	Position	Part of research in employment	Employer
september 2014 - Present	Professor	90	Swedish University of Agricultural Sciences, Mark och miljö
maj 2013 - september 2014	Professor	90	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi

Period	Position	Part of research in employment	Employer
juli 2002 - maj 2013	Researcher	90	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi
december 1997 - juni 2002	PhD student	75	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi
juni 1997 - december 1997	Research assistant	100	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi

### Interruptions in research

Period	Description
2014-01-01 - 2014-08-18	Föräldraledighet
2008-08-01 - 2009-02-17	Föräldraledighet
2005-09-01 - 2006-03-06	Föräldraledighet

### Merits and awards

#### Docentur

Year	Subject	Organisation
2007	10699. Other Biological Topics	Swedish University of Agricultural Sciences, Skoglig mykologi och växtpatologi

#### Supervised persons

Year	Supervised persons	Role
2016	PhD student, Erica Sterkenburg, Sveriges lantbruksuniversitet	Main supervisor
2015	Postdoc, Michaela Schiller, Sveriges lantbruksuniversitet	Main supervisor
2012	PhD student, Inga Bödeker, Sveriges lantbruksuniversitet	Main supervisor
2011	Postdoc, Karina Clemmensen, Sveriges lantbruksuniversitet	Main supervisor
2009	PhD student, Johanna Boberg, Sveriges lantbruksuniversitet	Main supervisor
2008	PhD student, Fredrik Heyman, Sveriges lantbruksuniversitet	Secondary supervisor
2008	PhD student, Cajsa Nygren, Sveriges lantbruksuniversitet	Secondary supervisor
2006	PhD student, Jonas Toljander, Sveriges lantbruksuniversitet	Secondary supervisor

#### Research grants awarded in competition

Period	Funder	Project leader	Your role	Total amount (SEK)
2016 - 2018	VR - Vetenskapsrådet	Björn Lindahl		2100000
2016 - 2018	Formas	Björn Lindahl	Applicant	3000000
2011 - 2015	Formas	Björn Lindahl	Applicant	25000000
2011 - 2013	Formas	Björn Lindahl	Applicant	1986000
2008 - 2010	Formas	Björn Lindahl	Applicant	2107000
2005 - 2007	Formas	Björn Lindahl	Applicant	2200000
2002 - 2004	Formas	Björn Lindahl	Applicant	1820000

#### Other merits

Period	Type of merit	Description
2015 - 2016	Editor	Editor för New Phytologist (Blackwell)
2008 - 2016	Editor	Editor för Fungal Ecology (Elsevier)

## Publications

### Publications - Sigrun Dahlin

<b>Name:</b> Sigrun Dahlin	<b>Doctorial degree:</b> 1997-02-21
<b>Birthdate:</b> 19650306	<b>Academic title:</b> Docent
<b>Gender:</b> Female	<b>Employer:</b> Sveriges lantbruksuniversitet
<b>Country:</b> Sweden	

Scientific publication - peer-reviewed

#### Original journal article

**Title:** Soil amendment affects Cd uptake by wheat — are we underestimating the risks from chloride inputs?

**Authors:** A. Sigrun Dahlin, Jan Eriksson, Colin D. Campbell, Ingrid Öborn

**Date of publication:** 2016-06-01      **Volume:** 554-555      **Issue number:** 555

**Name of journal:** Science of the Total Environment

**Academic publication - peer-reviewed:** Original journal article

**Title:** Waste recovered by-products can increase growth of grass-clover mixtures in low fertility soils and alter botanical and mineral nutrient composition

**Authors:** A. S. Dahlin, A. Ramezani, C. D. Campbell, S. Hillier, I. Öborn

**Date of publication:** 2015      **Volume:** 166      **Issue number:** 1

**Name of journal:** ANNALS OF APPLIED BIOLOGY

**Academic publication - peer-reviewed:** Original journal article

**Title:** Short-Term Effects of Biogas Digestates and Pig Slurry Application on Soil Microbial Activity

**Authors:** Jamal Abubaker, Kajsa Risberg, Erik Jönsson, Sigrun Dahlin, Harald Cederlund, Mikael Pell

**Date of publication:** 2015      **Volume:** 2015      **Issue number:** 5

**Name of journal:** Applied and Environmental Soil Science

**Academic publication - peer-reviewed:** Original journal article

**Title:** Assessing biogas digestate, pot ale, wood ash and rockdust as soil amendments: effects on soil chemistry and microbial community composition

**Authors:** Atefeh Ramezani Bajgiran, Sigrun Dahlin, Colin Campbell, Stephen Hillier, Ingrid Öborn

**Date of publication:** 2015      **Volume:** 65      **Issue number:** 5

**Name of journal:** Acta Agriculturae Scandinavica, Section B - Soil and Plant Science

**Academic publication - peer-reviewed:** Original journal article

**Title:** Micronutrient concentrations in relation to phenological development of red clover (*Trifolium pratense* L.), perennial ryegrass (*Lolium perenne* L.) and timothy (*Phleum pratense* L.)

**Authors:** B. E. M. Lindstrom, B. E. Frankow-Lindberg, A. S. Dahlin, M. Wivstad, C. A. Watson

**Date of publication:** 2014      **Volume:** 69      **Issue number:** 2

**Name of journal:** GRASS AND FORAGE SCIENCE

**Academic publication - peer-reviewed:** Original journal article

**Title:** Addition of a volcanic rockdust to soils has no observable effects on plant yield and nutrient status or on soil microbial activity

**Authors:** Atefeh Ramezani, A. Sigrun Dahlin, Colin D. Campbell, Stephen Hillier, Birgitta Mannerstedt-Fogelfors, Ingrid Oborn

**Date of publication:** 2013                      **Volume:** 367      **Issue number:** 1-2

**Name of journal:** PLANT AND SOIL

**Academic publication - peer-reviewed:** Original journal article

**Title:** Revisiting herbage sample collection and preparation procedures to minimise risks of trace element contamination

**Authors:** A. Sigrun Dahlin, Anthony C. Edwards, Bodil E. M. Lindstrom, Atefeh Ramezani, Charles A. Shand, Robin L. Walker, Christine A. Watson, Ingrid Oborn

**Date of publication:** 2012                      **Volume:** 43      **Issue number:**

**Name of journal:** EUROPEAN JOURNAL OF AGRONOMY

**Academic publication - peer-reviewed:** Original journal article

**Title:** Using soil and plant properties and farm management practices to micronutrient composition of food and feed

**Authors:** C. A. Watson, I. Oborn, A. C. Edwards, A. S. Dahlin, J. Eriksson, B. E. M. Lindstrom, L. Linse, K. Owens, C. F. E. Topp, R. L. Walker

**Date of publication:** 2012                      **Volume:** 121      **Issue number:**

**Name of journal:** JOURNAL OF GEOCHEMICAL EXPLORATION

**Academic publication - peer-reviewed:** Original journal article

**Title:** Mulch N recycling in green manure leys under Scandinavian conditions

**Authors:** A. Sigrun Dahlin, Maria Stenberg, Hakan Marstorp

**Date of publication:** 2011                      **Volume:** 91      **Issue number:** 2

**Name of journal:** NUTRIENT CYCLING IN AGROECOSYSTEMS

**Academic publication - peer-reviewed:** Original journal article

**Title:** Perspectives on nutrient management in arable farming systems

**Authors:** M Wivstad, AS Dahlin, C Grant

**Date of publication:** 2005                      **Volume:** 21      **Issue number:**

**Name of journal:** SOIL USE AND MANAGEMENT

**Academic publication - peer-reviewed:** Original journal article

## Publications - Jon Petter Gustafsson

**Name:** Jon Petter Gustafsson

**Doctorial degree:** 1995-06-01

**Birthdate:** 19641209

**Academic title:** Professor

**Gender:** Male

**Employer:** Sveriges lantbruksuniversitet

**Country:**Sweden

Scientific publication - peer-reviewed

### Original journal article

**Title:** Phosphate effects on cadmium(II) sorption to ferrihydrite

**Authors:** Charlotta Tiberg, Jon Petter Gustafsson

**Date of publication:** 2016-03-11      **Volume:** 471      **Issue number:**

**Name of journal:** Journal of Colloid and Interface Science

**Academic publication - peer-reviewed:** Original journal article

**Title:** Immobilization of Cu and As in two contaminated soils with zero-valent iron  
**Authors:** Charlotta Tiberg, Jurate Kumpiene, Jon Petter Gustafsson, Aleksandra Marsz, Ingmar Persson, Michel Mench, Dan B. Kleja  
**Date of publication:** 2016                      **Volume:** 67              **Issue number:**  
**Name of journal:** Applied Geochemistry  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Molybdenum binding to soil constituents in acid soils  
**Authors:** Jon Petter Gustafsson, Charlotta Tiberg  
**Date of publication:** 2015                      **Volume:** 417              **Issue number:**  
**Name of journal:** Chemical Geology  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Vanadium bioavailability in soils amended with blast furnace slag  
**Authors:** M. A. Larsson, S. Baken, E. Smolders, F. Cubadda, Jon Petter Gustafsson  
**Date of publication:** 2015                      **Volume:** 296              **Issue number:**  
**Name of journal:** Journal of Hazardous Materials  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Long-term fate and transformations of vanadium in a pine forest soil with added converter lime  
**Authors:** Maja A. Larsson, Marilena D'Amato, Francesco Cubadda, Andrea Raggi, Ingrid Oborn, Dan Berggren Kleja, Jon Petter Gustafsson, Ingrid Öborn, Dan Berggren Kleja  
**Date of publication:** 2015                      **Volume:** 259              **Issue number:**  
**Name of journal:** Geoderma  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Chromium(III) Complexation to Natural Organic Matter: Mechanisms and Modeling  
**Authors:** Jon Petter Gustafsson, Ingmar Persson, Aidin Geranmayeh Oromieh, Joris W. J. van Schaik, Carin Sjostedt, Dan Berggren Kleja  
**Date of publication:** 2014                      **Volume:** 48              **Issue number:** 3  
**Name of journal:** ENVIRONMENTAL SCIENCE & TECHNOLOGY  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Modelling lead(II) sorption to ferrihydrite and soil organic matter  
**Authors:** Jon Petter Gustafsson, Charlotta Tiberg, Abubaker Edkymish, Dan Berggren Kleja  
**Date of publication:** 2011                      **Volume:** 8              **Issue number:** 5  
**Name of journal:** ENVIRONMENTAL CHEMISTRY  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Geochemical Modeling of Trace Element Release from Biosolids  
**Authors:** Defne S. Apul, Maria E. Diaz, Jon Petter Gustafsson, Lakhwinder S. Hundal  
**Date of publication:** 2010                      **Volume:** 27              **Issue number:** 9  
**Name of journal:** ENVIRONMENTAL ENGINEERING SCIENCE  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Modeling of metal binding in tropical Fluvisols and Acrisols treated with biosolids and wastewater  
**Authors:** Nguyen Manh Khai, Ingrid Oborn, Steve Hillier, Jon Petter Gustafsson  
**Date of publication:** 2008                      **Volume:** 70              **Issue number:** 8  
**Name of journal:** CHEMOSPHERE  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Effects of changed soil conditions on the mobility of trace metals in moderately contaminated urban soils  
**Authors:** Mats Linde, Ingrid Oborn, Jon Petter Gustafsson  
**Date of publication:** 2007      **Volume:** 183      **Issue number:** 1-4  
**Name of journal:** WATER AIR AND SOIL POLLUTION  
**Academic publication - peer-reviewed:** Original journal article

### Publications - Per-Anders Hansson

<b>Name:</b> Per-Anders Hansson	<b>Doctorial degree:</b> 1993-02-19
<b>Birthdate:</b> 19641003	<b>Academic title:</b> Professor
<b>Gender:</b> Male	<b>Employer:</b> Sveriges lantbruksuniversitet
<b>Country:</b> Sweden	

Scientific publication - peer-reviewed

### Original journal article

**Title:** Time-Dynamic Effects on the Global Temperature When Harvesting Logging Residues for Bioenergy  
**Authors:** Torun Hammar, Carina A. Ortiz, Johan Stendahl, Serina Ahlgren, Per-Anders Hansson  
**Date of publication:** 2015      **Volume:** 8      **Issue number:** 4  
**Name of journal:** BIOENERGY RESEARCH  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Replacing fossil energy for organic milk production - potential biomass sources and greenhouse gas emission reductions  
**Authors:** Marie Kimming, Cecilia Sundberg, Åke Nordberg, Andras Baky, Sven Bernesson, Per-Anders Hansson  
**Date of publication:** 2015      **Volume:** 106      **Issue number:**  
**Name of journal:** Journal Of Cleaner Production  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Environmental impact of recycling digested food waste as a fertilizer in agriculture-A case study  
**Authors:** Yoon Lin Chiew, Johanna Spångberg, Andras Baky, Per-Anders Hansson, Håkan Jönsson  
**Date of publication:** 2015      **Volume:** 95      **Issue number:**  
**Name of journal:** Resources Conservation And Recycling  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Faba beans for biorefinery feedstock or feed? Greenhouse gas and energy balances of different applications  
**Authors:** Hanna Karlsson, Serina Ahlgren, Ingrid Strid, Per-Anders Hansson  
**Date of publication:** 2015      **Volume:** 141      **Issue number:**  
**Name of journal:** AGRICULTURAL SYSTEMS  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Vertical integration of local fuel producers into rural district heating systems - Climate impact and production costs  
**Authors:** Marie Kimming, Cecilia Sundberg, Åke Nordberg, Per-Anders Hansson  
**Date of publication:** 2015      **Volume:** 78      **Issue number:**  
**Name of journal:** Energy Policy  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Carbon footprint of food waste management options in the waste hierarchy - a Swedish Case study  
**Authors:** Mattias Eriksson, Ingrid Strid, Per-Anders Hansson  
**Date of publication:** 2015      **Volume:** 93      **Issue number:**  
**Name of journal:** Journal Of Cleaner Production  
**Academic publication - peer-reviewed:** Original journal article



**Title:** Waste of organic and conventional meat and dairy products—A case study from Swedish retail  
**Authors:** Mattias Eriksson, Ingrid Strid, Per-Anders Hansson  
**Date of publication:** 2014      **Volume:** 83      **Issue number:**  
**Name of journal:** Resources Conservation And Recycling  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Climate impact and energy efficiency from electricity generation through anaerobic digestion or direct combustion of short rotation coppice willow  
**Authors:** Niclas Ericsson, Ake Nordberg, Cecilia Sundberg, Serina Ahlgren, Per-Anders Hansson  
**Date of publication:** 2014      **Volume:** 132      **Issue number:**  
**Name of journal:** APPLIED ENERGY  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Time-dependent climate impact of a bioenergy system - methodology development and application to Swedish conditions  
**Authors:** Niclas Ericsson, Charlotta Porsö, Serina Ahlgren, Åke Nordberg, Cecilia Sundberg, Per-Anders Hansson  
**Date of publication:** 2013      **Volume:** 5      **Issue number:** 5  
**Name of journal:** Global Change Biology. Bioenergy  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Environmental impact of meat meal fertilizer vs. chemical fertilizer  
**Authors:** Johanna Spångberg, Per-Anders Hansson, Pernilla Tidåker, Håkan Jönsson  
**Date of publication:** 2011      **Volume:** 55      **Issue number:** 11  
**Name of journal:** Resources Conservation And Recycling  
**Academic publication - peer-reviewed:** Original journal article

## Publications - Björn Lindahl

<b>Name:</b> Björn Lindahl	<b>Doctorial degree:</b> 2001-12-20
<b>Birthdate:</b> 19721202	<b>Academic title:</b> Professor
<b>Gender:</b> Male	<b>Employer:</b> Sveriges lantbruksuniversitet
<b>Country:</b> Sweden	

Scientific publication - peer-reviewed

## Original journal article

**Title:** Carbon sequestration is related to mycorrhizal fungal community shifts during long-term succession in boreal forests  
**Authors:** Karina E. Clemmensen, Roger D. Finlay, Anders Dahlberg, Jan Stenlid, David A. Wardle, Bjorn D. Lindahl  
**Date of publication:** 2015      **Volume:** 205      **Issue number:** 4  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Changes in fungal communities along a boreal forest soil fertility gradient  
**Authors:** Erica Sterkenburg, Adam Bahr, Mikael Brandstroem Durling, Karina E. Clemmensen, Bjoern D. Lindahl  
**Date of publication:** 2015      **Volume:** 207      **Issue number:** 4  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Ectomycorrhizal Cortinarius species participate in enzymatic oxidation of humus in northern forest ecosystems  
**Authors:** Inga T. M. Bodeker, Karina E. Clemmensen, Wietse de Boer, Francis Martin, Ake Olson, Bjorn D. Lindahl  
**Date of publication:** 2014      **Volume:** 203      **Issue number:** 1  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Roots and Associated Fungi Drive Long-Term Carbon Sequestration in Boreal Forest  
**Authors:** K. E. Clemmensen, A. Bahr, O. Ovaskainen, A. Dahlberg, A. Ekblad, H. Wallander, J. Stenlid, R. D. Finlay, D. A. Wardle, B. D. Lindahl  
**Date of publication:** 2013                      **Volume:** 339      **Issue number:** 6127  
**Name of journal:** SCIENCE  
**Academic publication - peer-reviewed:** Original journal article

**Title:** New primers to amplify the fungal ITS2 region - evaluation by 454-sequencing of artificial and natural communities  
**Authors:** Katarina Ihrmark, Inga T. M. Bodeker, Karelyn Cruz-Martinez, Hanna Friberg, Ariana Kubartova, Jessica Schenck, Ylva Strid, Jan Stenlid, Mikael Brandstrom-Durling, Karina E. Clemmensen, Bjorn D. Lindahl  
**Date of publication:** 2012                      **Volume:** 82      **Issue number:** 3  
**Name of journal:** FEMS MICROBIOLOGY ECOLOGY  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Archaeorhizomycetes: Unearthing an Ancient Class of Ubiquitous Soil Fungi  
**Authors:** Anna Rosling, Filipa Cox, Karelyn Cruz-Martinez, Katarina Ihrmark, Gwen-Aelle Grelet, Bjorn D. Lindahl, Audrius Menkis, Timothy Y. James  
**Date of publication:** 2011                      **Volume:** 333      **Issue number:** 6044  
**Name of journal:** SCIENCE  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Disruption of root carbon transport into forest humus stimulates fungal opportunists at the expense of mycorrhizal fungi  
**Authors:** Bjorn D. Lindahl, Wietse de Boer, Roger D. Finlay  
**Date of publication:** 2010                      **Volume:** 4      **Issue number:** 7  
**Name of journal:** ISME JOURNAL  
**Academic publication - peer-reviewed:** Original journal article

**Title:** Spatial separation of litter decomposition and mycorrhizal nitrogen uptake in a boreal forest  
**Authors:** Bjorn D. Lindahl, Katarina Ihrmark, Johanna Boberg, Susan E. Trumbore, Peter Hogberg, Jan Stenlid, Roger D. Finlay  
**Date of publication:** 2007                      **Volume:** 173      **Issue number:** 3  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Original journal article

### Research review article

**Title:** Ectomycorrhizal fungi - potential organic matter decomposers, yet not saprotrophs  
**Authors:** Bjorn D. Lindahl, Anders Tunlid  
**Date of publication:** 2015                      **Volume:** 205      **Issue number:** 4  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Research review article

**Title:** Fungal community analysis by high-throughput sequencing of amplified markers - a user's guide  
**Authors:** Bjorn D. Lindahl, R. Henrik Nilsson, Leho Tedersoo, Kessy Abarenkov, Tor Carlsen, Rasmus Kjoller, Urmas Koljalg, Taina Pennanen, Soren Rosendahl, Jan Stenlid, Havard Kauserud  
**Date of publication:** 2013                      **Volume:** 199      **Issue number:** 1  
**Name of journal:** NEW PHYTOLOGIST  
**Academic publication - peer-reviewed:** Research review article

## Register

### Terms and conditions

Ansökan ska förutom av den sökande även signeras av behörig företrädare för medelsförvaltaren. Företrädaren

är vanligtvis prefekten vid den institution där forskningen ska bedrivas, men ska i vissa fall utgöras av exempelvis rektor. Detta framgår i sådana fall av den aktuella utlysningstexten för bidraget.

Signering av *den sökande* innebär en bekräftelse av att:

- uppgifterna i ansökan är korrekta och följer Formas instruktioner
- bisysslor och kommersiella bindningar har redovisats för medelsförvaltaren och att det där inte framkommit något som strider mot god forskningssed
- nödvändiga tillstånd och godkännanden ska finnas senast vid projektstart, exempelvis avseende etikprövning.

Signering av *medelsförvaltaren* innebär en bekräftelse av att:

- den beskrivna forskningen, anställningen och utrustningen kan beredas plats inom institutionen under den tid och i den omfattning som anges i ansökan
- institutionen godkänner kostnadsberäkningen i ansökan
- projektet bedrivs i enlighet med svensk lagstiftning.

Ovanstående punkter ska ha diskuterats mellan parterna innan företrädaren för medelsförvaltaren godkänner och signerar ansökan.

*Ansökningar där en organisation är sökande signeras automatiskt vid registrering av ansökan.*