SFI earthresQue

Centre for Rescue of Earth Materials and Waste in the Circular Economy (2020-2028)

Annual Report 2024

Norwegian Centre for Research-based Innovation

earthresQue Annual Report 2024

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Summary

Our society generates excess earth materials and waste at an increasing rate. Nearly 5 million tons of inorganic waste are landfilled in Norway every year. Current methods of handling excess earth materials and waste are often unsustainable, and we lack suitable locations for storage. These materials should be recycled, upcycled, or reused in infrastructure and construction projects, instead of relying on virgin raw materials.

earthresQue focuses on innovations to improve treatment solutions for excavated materials and strengthen the market for recycled raw materials. Since its inception in 2020, earthresQue has fostered long-term collaboration between stakeholders, including municipalities, NGOs, citizen groups, innovation-oriented R&D-performing companies (waste management companies and contractors), and prominent research groups. The work involves a broad range of disciplines, from natural sciences to socio-economic sciences.

The centre has established a leading industry-oriented research cluster with strong links between collaborating partners, researchers, stakeholders, and students in our educational programs. By building on an international network, earthresQue also enhances the internationalization of the Norwegian business sector. Further, the centre ensures researcher training and the transfer of knowledge and technology in areas with major potential for future value creation. This is achieved through close collaboration between stakeholders and research partners.

The research is centered on multiple case studies grouped into ten key topics. To ensure a higher degree of circularity in mass handling, three disciplinary work packages—Reuse Technology, Sustainable Reuse, and Regulatory Framework—work together across the topics and cases. The case studies are defined in close collaboration with 25 user partners and address key research questions:

– How can new treatment processes for earth material wastes be developed to make them suitable as raw materials in new products, satisfying end-of-waste criteria?
– How can waste materials and buried landfills be managed sustainably, addressing environmental, social, and economic aspects?
– How can obstacles in economic, regulatory, and governance frameworks be removed to enable more reuse and recycling?

Currently, 16 PhD students are funded or associated with the SFI centre, and there is great interest from master's students. A wide range of research activities, both on-site and in laboratories, were carried out in 2024.

Promising results were achieved using bottom ash from waste incineration as a supplementary cementitious material or geopolymer precursor. This may help reduce CO2 emissions in the building and construction industry by decreasing the need for cement.

Work on acid-draining rocks proposes refined classification methods, including the AMIRA NAG test to replace existing protocols. Workshops have fostered collaboration among stakeholders to improve guidelines for managing sulphide-rich gneisses and mitigate acid drainage risks.
Efforts to tackle the PFAS challenge have yielded encouraging results, including a two-step remediation process combining coagulation-flocculation with biochar sorption. Pilot-scale experiments on biochar's role in stabilizing PFAS-contaminated soil underscore the progress made.

Advancements in landfill management include methane oxidation studies and geophysical craterization of closed sites, aiming to minimize the need for destructive investigations.

Additionally, clay-rich waste soil is under evaluation as a hydraulic barrier, with ongoing field pilots at NOAH-Langøya. Preliminary results show that press filter residue may be a suitable replacement for dry crust clay as a hydraulic barrier. We are also continuing our tests of tunnel boring machine masses in the protective top layer. Both innovations will reduce the need for extracted virgin materials.

For land use assessments (e.g., closed landfills, shooting ranges), researchers identified discrepancies in life cycle assessment (LCA) models, recommending greater transparency and restoration-focused approaches. An LCA study assessing the environmental impact of remediating a shooting range in a peatland was the first of its kind. It highlights the need to balance remediation benefits with carbon emissions resulting from soil disturbance.

The annual meeting in Horten in 2024 attracted 92 participants and featured engaging discussions and presentations on framework aspects and challenges of circular mass handling. Thanks to Forsvarsbygg and NOAH, we had very interesting field trips to a restored contaminated area and Langøya, a landfill for hazardous waste, which is a showcase project for nature restoration, including the establishment of rare native flower species.

earthresQue successfully completed its Mid-Term Evaluation by the Research Council. An evaluation panel, comprising researchers from Sweden and Finland, reviewed our reports, assessed our progress towards goals, and evaluated our future plans.

Vision and Objectives

The objective of earthresQue is to develop technologies, systems, innovations, and a governance framework for the most sustainable management and treatment of wastes and earth materials, building on science-based education and information.

To achieve this, our research and innovation activities include work to develop and improve:

Recycling and reuse technologies such as treatment and documentation processes of contaminated soils, surplus materials, construction and demolition wastes, to make them suitable as raw materials in new products. Hence, achieving the end-of-waste-criteria. Sustainable management of old landfill sites and solutions for future landfills

Sustainability assessment methods, including models to assess and document environmental, social and economic aspects of recycled materials and treatment methods. Environmental aspects include use natural resources, areas, biodiversity and use of areas.

Regulatory framework and governance to remove current obstacles for circular mass handling. This includes optimised material flow and business concepts to encompass society's need for more re-use/recycling and less use of virgin earth materials.

The ambition of the Centre is to become the nationally leading and internationally renowned research and innovation centre for sustainable use of earth materials.

Research Plan and Strategy

Our strategy revolves around addressing the most pertinent research and innovation needs by maintaining open communication with our user partners.

Research efforts are concentrated on case studies (Figure 1), which may focus on a particular geographic area or a shared challenge, such as addressing a specific contaminant.
User partners play a crucial role in identifying obstacles to the sustainable handling of surplus materials and highlighting knowledge gaps. The collaboration between user and research partners is deeply intertwined, with ongoing research projects and activities.
Student activities and educational programs at NMBU and BI are strongly integrated into the case studies. Key waste fractions and 'rescue' operations with innovation potential are defined by the user partners. The focus is on earth materials, viewed from technical, sustainability, and regulatory perspectives (Figure 2).

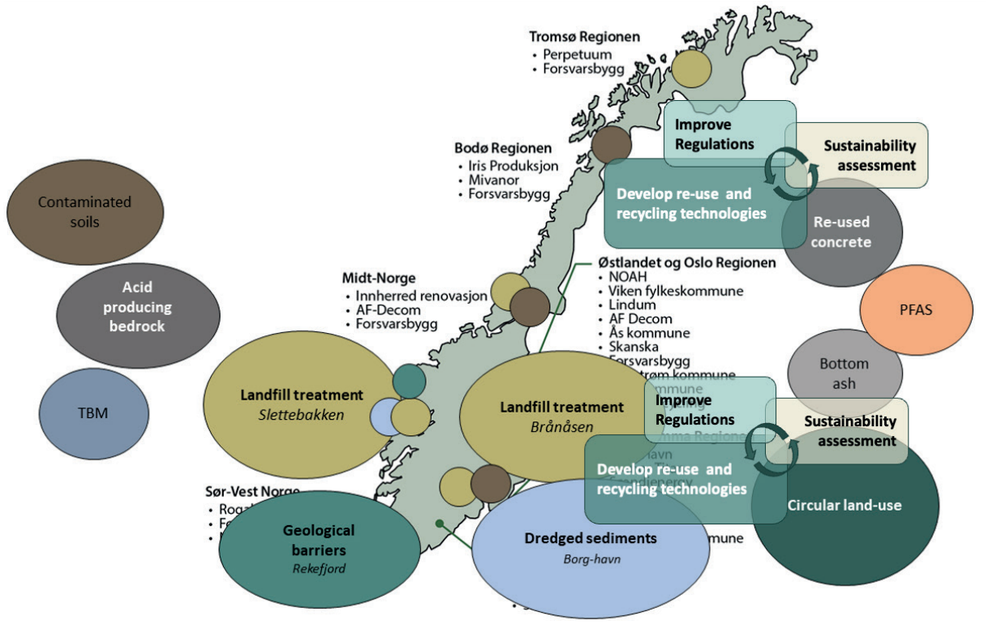


Figure 1: earthresQue cases (geographic and overarching), different colours indicate cases grouped into different Topics. Interdisciplinarity of work indicated for a couple of the cases.

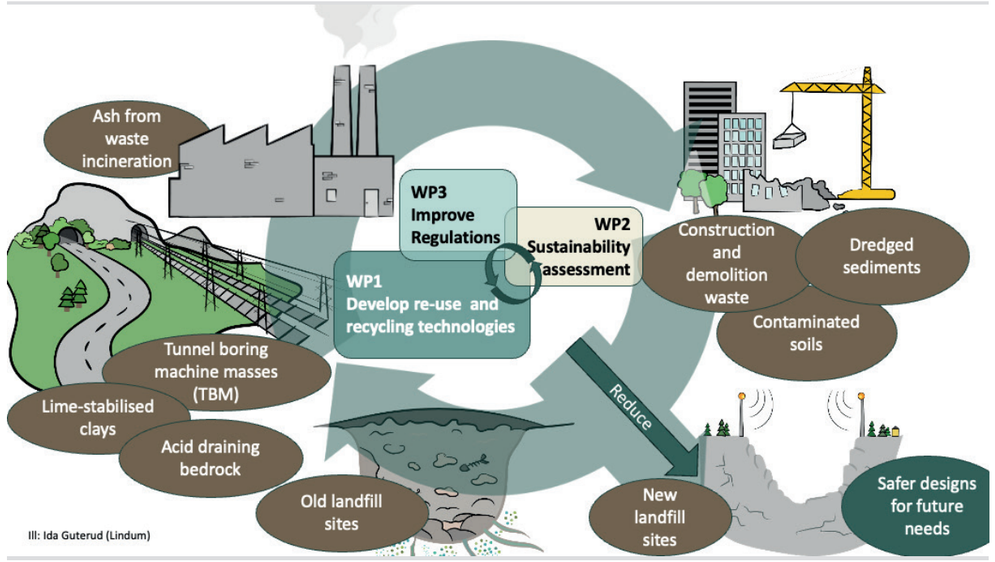


Figure 2, Overview of the earth materials in focus and the scientific interdisciplinarity.

Dredged sediments: Norway has a long coast and there is a continuous need for dredging harbour areas. Dredged sediments usually contain pollutants and there is a need for improved methodology to separate contaminated from clean sediments. Potential for reuse in new products and or use for recreating wetland need documentation and innovative solutions.

Contaminated soils: Contaminated soils include soils from construction projects containing mineral and organic pollutants, press filter residue from soil washing facilities, PFAS contaminated soil. The objective of our work is to i) reduce transport (cost and distance) ii) reduce costs for soil disposal and purchase of natural aggregates, iii) pre-serve landfill space, vi) conserve mined natural aggregate resources and reduce environmental and ecological impacts.

Tunnel operation: Tunnel boring machine, TBM, materials have mixed particle sizes and their contamination potential is related to the host bedrock. earthresQue aims to recycle full-face tunnel boring machine masses from larger tunnelling projects.

Acid draining bedrock, these are a challenge in geologic regions with sulphide containing gneiss (Lillesand region) and black shale (Oslo region): The aim is to develop novel methods for testing and treatment to mitigate oxidation both on-site (road construction) in in-situ stabilization at landfills.

Construction & Demolition wastes: C&D wastes with focus in earthresQue are concrete and bricks. The objective is to develop technologies for recycling wastes from construction materials.

Lime-cement stabilized clays: Lime and cement are used to stabilize soft and quick clay in construction projects. The objective is to make way for new and better uses of this material.

Ashes from municipal solid waste incineration: have high pH and contain several unwanted trace elements, requiring safe handling and disposal. We aim to develop novel methods for utilising ashes as a secondary resource.

Old landfill masses: These usually contain mixed domestic and industrial wastes. High carbon content prevents re-landfilling. Treatment and handling solutions, tailored sustainability assessment tools and regulatory framework are required.

Landfill treatment: There is a need to develop safe storage and control of waste and water at landfills. Designs should isolate waste from the surrounding environment (atmosphere and water), they should also allow for potential use of the stored wastes by future technologies. Needs include improved methodology to delineate extent and contents of old landfills and develop methods to reclaim such areas, e.g.: remove contaminants, recycle materials, collect, and utilize or remove methane releases. For both old and new landfills it is necessary to remove pollutants and risks associated with leachate, as well as reduce costs and prepare for aftercare.

Impermeable barriers: Four critical elements are required for a secure landfill: a bottom liner, a leachate collection system, a cover, and a suitable natural hydrogeologic setting. The natural setting should be selected to minimize the possibility of wastes contaminating groundwater and surface waters. earthresQue is developing methods for assessing hydraulic properties of fractured rock systems as a natural barrier. We are also testing the use of wastes, such as lime stabilized clays, as impermeable barriers.

Circular land use and nature restauration: Conventional methods to evaluate nature through impact assessments and value-neutral surveys cannot quantify the impact of various measures, neither negative nor positive. Better tools for weighting and measuring natural diversity based on concretization and typification of nature are required. These will be tested on reclaimed contaminated areas and landfill sites.

Innovation in earthresQue

The centre is unique in its holistic approach to the recycling and reuse of waste and surplus materials, bridging the gap between academia, private industry, and public authorities.

We have a highly competent group of user partners operating in this landscape through their work with infrastructure, construction, demolition, waste deposits, and contaminated land areas. earthresQue serves as an intermediary between stakeholders managing different earth materials and the relevant regulatory framework overseen by authorities.
Close collaboration between user partners and researchers, coupled with a holistic approach, is vital for defining the required research and innovation for sustainable circular mass handling and its implementation into society.

According to one of our active partners, Lindum:

"The collaboration with researchers gives us, as a user partner, increased knowledge of both subjects and methodology, which we use as a basis for new solution choices/facility design, methods, and routines. This applies to researchers with specialist knowledge in environmental chemistry, geosciences, construction engineering, waste science, and water treatment"

Potential for Innovation and Enhanced Competitiveness

The centre develops knowledge essential for innovation and value creation with the user partners. The overall goal is to develop technologies and systems for the sustainable handling and treatment of waste and surplus materials, alongside knowledge about market innovations and value chain reconfigurations necessary for creating new business models from these materials.

With a wide range of partners from industry to the public sector, the innovation categories are varied and will evolve throughout the centre's lifetime. Examples of innovations and their categorization are shown in Table 1.

One of the innovations already being used among partners, and externally (e.g., Norsk Gjenvinning, NG), is the use of press filter residue. This "waste fraction" (mainly silt and clay) is derived from the sorting and washing facilities for contaminated soils. The material is used as a replacement for dry crust clay as an impermeable barrier in the top cover of closed landfills, reducing the need for virgin dry crust clay, a limited natural resource. Another example is the use of crushed concrete as a replacement for aggregates in concrete, which demonstrates new markets for recycled materials in AF Decom's business portfolio.

Table 1. Innovation results up to now have and categorised inspired by Autio (1995) and Abrnaty and Clark (1984).

Innovation	Description	earthresQue examples
Processes	Development of new models for assessing sustainable management, treatment, and material recycling in the waste sector	Excavation process through acid rock
Methods	Methods for monitoring, mapping, characterisation, and sorting	GIS tool for environmental sustainability assessment
Products	Products made from fractions considered as waste in the linear economy	Press filter residue in impermeable barrier at landfills
Organisational	Methods for value creation that support business models promoting circular resource use and sustainability	Centre transition from WP to Case
Regulative	Regulations (legal aspects, interpretations/precedent and permits) and tax systems to ensure greater circularity in the use of soil materials	New precedent for end-of waste criteria related to use of treated soil.

As a direct result of work in earthresQue, AF Decom established a new company, BetongHUB, with Betong Øst in 2024, focusing on the reuse of waste and surplus materials in concrete. Acquired knowledge on contaminated soils and tunnel boring machine (TBM) masses has led to competitive offers by Skanska, enabling the use of such masses in infrastructure projects.

The Bottom Ash team is working to make better use of 80% of the bottom ash from waste incineration, which is currently used for road construction on landfills. The research involves characterisation and homogenization of bottom ash from waste incineration as a supplementary cementitious material.

There are many examples of user partners intensifying their efforts to remove PFAS from soil and water, such as leachate from landfill cells and contaminated sites (Perpetuum, Forsvarsbygg, Lindum, AF Decom). Experimental work is being conducted in laboratories and field pilots, involving MSc, PhD, and Erasmus students.

As an example of how earthresQue's work has influenced regulatory frameworks (see Table 1), there has been a shift in the requirements for end-of-waste products (e.g., cleaned materials) under Chapter 5, Section 27 of the Pollution Act. Previously, these products had to meet standard requirements, regardless of their intended use. Now, however, the requirements are more nuanced, depending on the product's final use. This change in regulatory interpretation encourages increased use of recycled materials from mass separation and washing facilities.

Organisation

Organisational Structure

The organisational structure of the earthresQue Centre (Figure X) fosters strong collaboration between researchers and user partners. Each case is led by a case leader (research partner) and a case promoter (user partner), ensuring shared responsibility and close involvement from the user partners. Cases and topics hold regular meetings and workshops, attracting interest from external groups and companies for potential partnerships. Some topics are large, involving multiple cases and user partners, while others are smaller with varying meeting frequencies.

The Faculty of Environmental Science and Natural Resource Management (MINA) at the Norwegian University of Life Sciences (NMBU) oversees the Centre's administration, ensuring coordination of dissemination activities and adherence to the project plans approved by the Research Council and the Board.

The Centre management team includes the Centre Director, Deputy Director, Administrative Coordinator, Communication Advisor, and other advisors. Case leaders manage individual projects with user partners and topic leaders, ensuring the involvement of students and researchers. They oversee work plans, progress, financial forecasts, and goal achievement, regularly reporting to topic managers. Case leaders also coordinate student research projects with educational institutions.

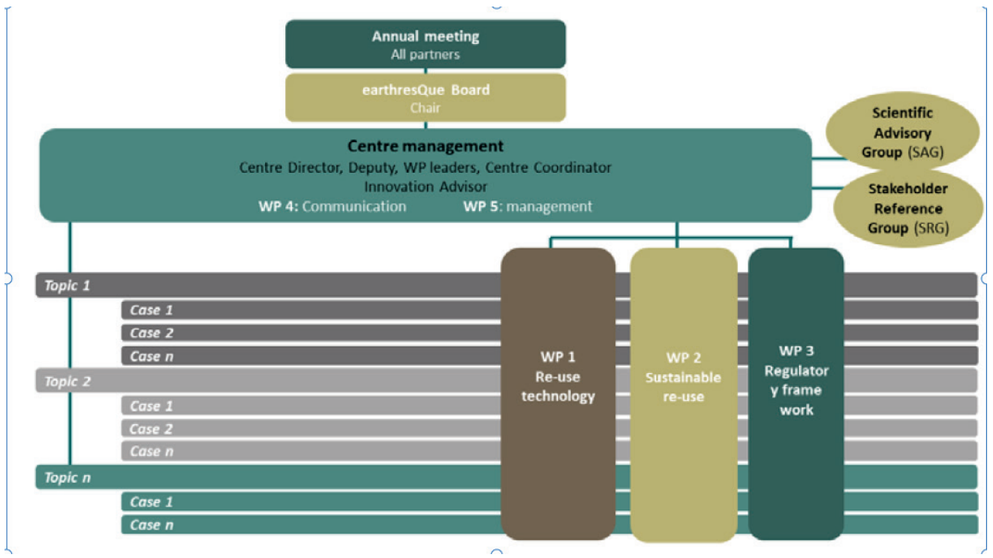


Figure 1: Organisational structure

Centre Management

Centre Director, Professor at NMBU Helen K. French
Deputy and scientific lead on recycling technology, Technical Expert at NGI Gudny Okkenhaug
Scientific lead on sustainability assessment, Senior Researcher at NORSUS Ole Jørgen Hanssen
Scientific lead on Regulatory Framework, Professor at BI Debbie Harrison
Administrative Coordinator, Marte Norum Guttulsrød
Communication advisor, Siri Skogsrud Funnemark
Other Advisors, Sjur Tveite and Peter Karlsaune

Centre Board

Magnus Sparrevik, Chair, Forsvarsbygg
Ågot Aakra, MINA, NMBU
Thomas J. Henriksen, AF Decom
Andreas O. Harstad, Skanska
Dag Lauvås, Skien municipality
Guro Grøneng, NGI
Hanne Lerche Raadal, NORSUS
Terje Kirkeng, Lindum
Ragnhild Kvålshaugen, BI

earthresQue Partners

Our user partners range from municipalities and entrepreneurs to small start-up companies and business clusters, geographically spread across Norway. They represent an enthusiastic group, and together with our scientific partners, they create an inspiring working environment. Close collaboration between these diverse groups is essential for understanding the challenges faced by both the industry and society, which in turn fosters creative research and innovation.

Research Institutes

BI – Norwegian Business School, IFE – Institute for Energy Technology, NGI – the Norwegian Geo-technical Institute, NORSUS – Norwegian Institute for Sustainability Research, NIBIO – Norwegian Institute of Bioeconomy Research, NILU – Norwegian Institute for Air Research, NIVA – Norwegian Institute for Water Research, and NMBU-MINA – Norwegian University of Life Sciences, Faculty of Environmental Sciences and Natural Resource Management as Centre coordinator.

Private Sector

AF Decom, Borg havn, Borregaard, Eyde-klyngen, Frevar, Kronos Titan, Lindum, Iris, Innherred Renovasjon, NCCE, NOAH, Perpetuum, Scandi Energy, Skanska, Stena Recycling.

Public Sector

Bergen Municipality, The Norwegian Defence Estate Agency (Forsvarsbygg), Fredrikstad municipality, The Norwegian Coastal Administration (Kystverket), Lillestrøm municipality, Oslo municipality, Rogaland County, Skien municipality, Akershus County, Østfold County, Ås municipality.

Collaboration between the Centre's partners

There is strong collaboration between research and user partners. In 2024, several meetings, seminars, workshops, and field trips were organized, both virtually on Teams and in person.
The Case and Topic organizational structure enhances the relevance of research and innovation activities for the user partners and provides a platform for interdisciplinary interaction – a crucial element for increased circularity.

Topic and case leaders come from the research team, while case and topic promoters are drawn from the user partners. These working groups serve as excellent platforms for exchanging experiences, information about new projects, and more.

At the annual meeting, over 90 researchers and user partners gathered. The agenda included presentations and collaborative sessions aimed at strategizing activities for the upcoming period. The annual meeting also featured two site visits: 1) to the stabilized and treated contaminated site at Horten's former military site, guided by our user partner Forsvarsbygg, and 2) to Langøya, a partly closed and partly still active landfill for hazardous waste, hosted by our user partner NOAH. The site hosts several earthresQue pilot experiments, as well as an advanced press filter for compacting treated waste and a test laboratory. This annual gathering strengthens partnerships within the centre and fosters the exchange of innovative ideas.

The strong involvement of user partners in research activities is evident from the numerous pilot experiments hosted by our partners, such as NOAH-Langøya, AF Decom, Skanska (Fornebu/Olum/tunnel material), Innherred Renovasjon, Rekefjord (NOAH), Lindum Oredalen, Slettebakken (Bergen), Kjørbekk (Skien), and Brånåsdalen (Lillestrøm). Our user partners have invested in research equipment, such as sensors to monitor heat and water transport, divers, meteorological stations (NOAH), pore pressure sensors, and multi-sensors for monitoring landfill leachate (Skien, Brånåsdalen, Lindum). Furthermore, the user partners are actively involved in co-supervising master's students and collaborate closely with PhD and Postdoc fellows.

Photo: Acid- producing gneiss, Lindum Lilleeland

Scientific Activities and Results

Surplus masses from Tunnelling

Skanska has taken an active role in testing a new type of explosive that will positively impact reuse potential and reduce environmental risks associated with the use of blasted rock. This development will unlock greater reuse potential, allowing such materials to be used for a wider range of purposes and in various natural environments. earthresQue Report No. 15, "Reuse of TBM Spoils/Muck/Masses: Experience from Norwegian and International Projects & Research Perspectives," provides a thorough background on tunnel boring machine (TBM) materials. In 2024, work has also commenced on exploring the potential for recycling tunnel excavation sediment, with several students engaged in testing at NMBU.

Safer handling of acid draining rocks

Weathering of exposed amphibolite- to granulite-facies gneisses in southern Norway produce acid drainage with high metal content, posing significant challenges for construction projects. This issue has been a focus of earthresQue, in collaboration with partners Lindum Sør and NOAH. The findings from a MSc work entitled: Acid Leaching of Gneisses in Southern Norway: An Evaluation of H2O2 Oxidation Testing for the Determination of the Acid-Producing Potential of Sulphide-Rich Rocks, was used as the basis for revising the current guidelines on characterizing acid-producing gneisses (the Agder Method: Retningslinjer for tiltak i områder med syredannende gneiss).

The Agder Method involves a three-step assessment: degree of weathering, sulphur content, and temperature change when hydrogen peroxide (H2O2) is added (H2O2 test). The test of the H2O2 test indicated that the Agder Method can lead to false classifications of acid-producing gneiss. Consequently, acid-producing rocks have been placed in non-approved landfills, and non-acid-producing rocks have been placed in approved landfills, resulting in negative environmental and economic consequences. The research suggests replacing the Agder H2O2 test with the AMIRA single net acid generation (NAG) method to improve accuracy and prevent further damage.

In collaboration with Lillesand Municipality, facing severe challenges with building on acid-producing gneiss, earthresQue organized a workshop in November 2024 titled "Basis for the Revision of the Agder Guidelines – Characterization of Acid-Producing Gneiss." Stakeholder representatives from the entire value chain, including regional and local authorities, entrepreneurs, project owners, consultants, and researchers, participated. This led to in-depth discussions and provided a broad foundation and strong support for revising the guidelines.

Further reading: MSc thesis by Ada Marie O. Karlsen

Steps to solve the PFAS challenge

Per- and polyfluoroalkyl substances (PFAS) are ubiquitously present in soil and water worldwide. Conventional methods are inefficient in treating PFAS contaminated water. Treatment trains that connect or combine multiple approaches are considered promising to increase the overall removal success. A two-step water remediation process combining coagulation and flocculation with biochar sorption was tested by the earthresQue team in 2024. The experiments were conducted at user partner, Lindum ‘s lab. Reference water and leachate from two collaborative partners was used in the experiments.

In another study it was shown that biochar produced from low-value organic waste, such as sewage sludge, can be of particular interest in stabilizing PFAS contaminated soil. The most effective biochars have a combination of aromatic carbon-rich regions and high porosity with a pore size that can accommodate the molecular size of PFAS. Thus, biochar production from waste may have a potential to both enhance circularity in waste management and hold back PFAS contamination. Follow-up experiments are currently conducted in pilot-scale outdoors at one of Lindum’s landfills and labs to investigate the long-term remediation effects of biochar in PFAS contaminated soil.

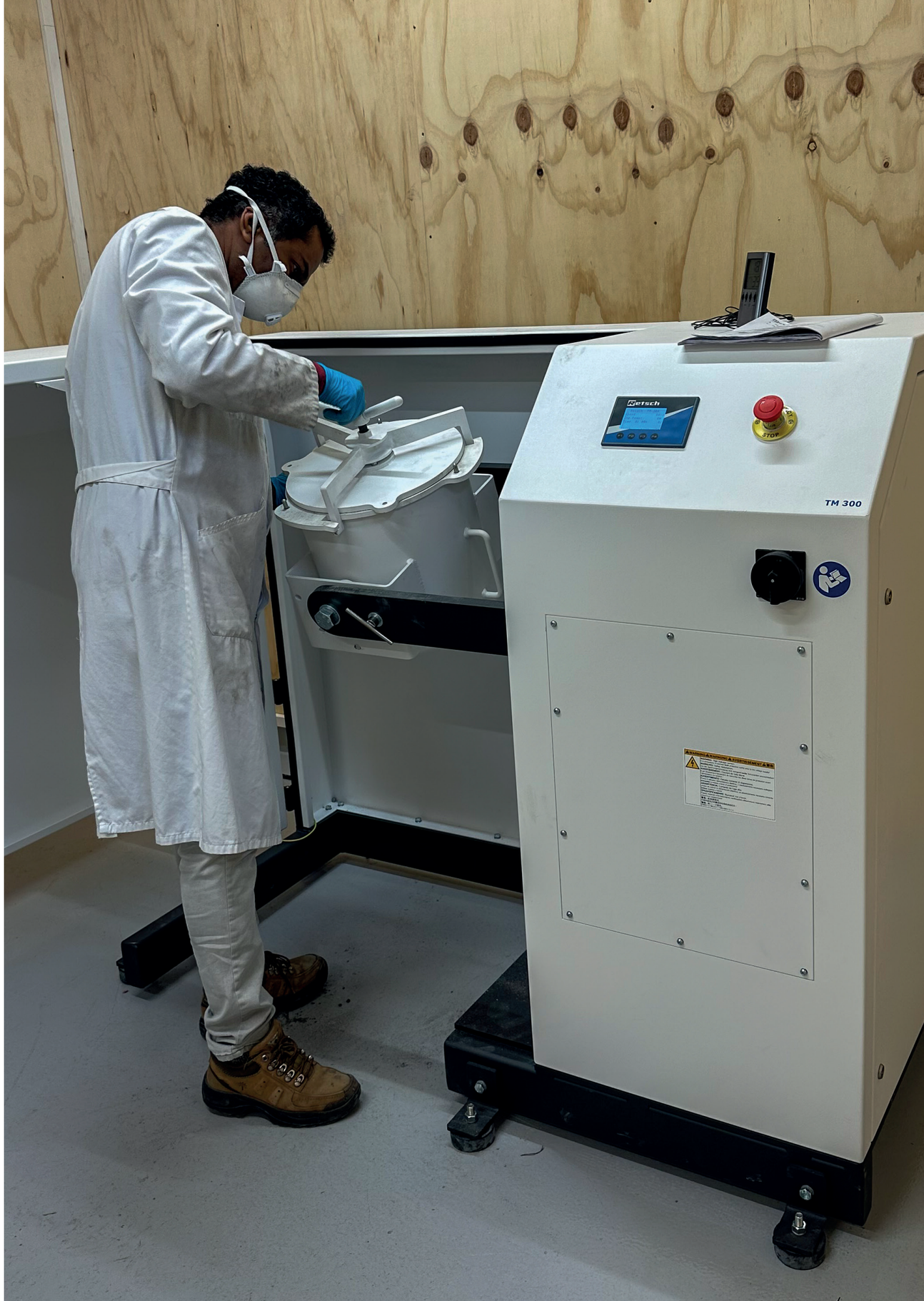
The earthresQue report no. 11, Concentrations of PFAS in soil affected by diffusely dispersed PFAS contamination, is available on the earthresQue website. PFAS was presented at a earthresQue webinar in February 2024.

Photo: Håkon A. Langberg

Bottom ash from solid waste incineration

Norway generates approximately 300,000 tonnes of municipal solid waste incineration (MSWI) bottom ash annually, most of which is currently landfilled. Due to its chemical composition—containing calcium, silica, and alumina—this ash has potential for developing it as a binder material in construction, either as a supplementary cementitious material (SCM) or as an aluminosilicate precursor for geopolymer production. SCMs are fine materials that can partially replace cement in concrete and form additional binding compounds. Geopolymers are binding materials derived from aluminosilicate sources that polymerize in alkaline solutions. Utilizing bottom ash in these ways could reduce reliance on cement clinker, lowering emissions from the cement industry, which contributes about 7% of global CO_2 emissions. It could also address Norway's shortage of supplementary cementitious materials.

The user partners Stena, Lindum, NOAH, Borregaard work with researchers in earthresQue on pretreatment of ash between the waste incineration and secondary use. This is crucial to enable its practical use, making it a key focus of this research. The study explores industrially feasible treatment processes to enhance the ash's reactivity and improve its mechanical and environmental performance. Preliminary findings indicate that environmental compliance can be achieved by selectively removing finer particle size fractions from the bulk ash. At the same time, an optimized milling and screening approach has shown promising improvements in the mechanical properties of the resulting binder material.



Shooting range remediation

An explorative case study was conducted to evaluate the environmental impacts of remediation of shooting ranges in peatland environments. This is the first life cycle assessment study of remediation of a shooting range in the scientific literature. The purpose of this remediation was to reduce the risk to human health from contaminants to an acceptable level (700 mg Pb/kg soil) and to enable the development of the site into a recreational area. The site is situated in a remote peatland in SW Norway, and remediation required the construction of intermediate roads to access the site, and excavated soil was sent to a landfill accepting contaminated soil with a high total organic carbon content.

The largest impacts were connected to downstream treatment of soil, i.e. in landfill. The study also quantified the potential of various greenhouse gas emission reduction measures: biofuel, electric excavators, optimal road material selection and reuse. The total greenhouse gas emission reduction potential was estimated to be 17 %. While the impacts from infrastructure and excavation may be reduced through planning, the greenhouse gas emissions are proportional to the excavated volume of carbon-rich peat soil.

The study recommends considering alternative remediation options and to weigh the impacts identified against the benefits of reduced local exposure. The study also recommends implementing soil carbon emission estimates in life cycle assessments due to its potential greenhouse gas impact potential. So far, few LCA studies assess these emissions. This becomes especially important when the volume of soil is high, rich in carbon and is disposed on a landfill.

Read the publication here.

Photo: Anders Gunnar Helle

Better control of buried municipal landfills

Leachate from different types of landfills and landfill-cells (content and age) was sampled from user partners including Perpetuum, and Lindum. This was done to improve characterisation of the leachate composition and the need for purification. Treatment options for PFAS and other stressors was assessed. The work will continue in 2025. User partners are exploring innovative treatment solutions for both leachate and methane gas. To reduce methane, passive oxidation in microbiologically reactive top layers was tested at Innherred and Brånåsdalen (Lillestrøm municipality) landfills. Compost layers at hot spot areas seem promising as a cost-effective measure to prevent diffuse methane emissions from old landfills.

Several master students have conducted geophysical measurements on closed landfills, recognizing the need for further work in this field in Norway. While these results require validation through physical ground investigations, it's essential to note that drilling into such masses poses the risk of unintentionally releasing methane gas and creating leakages in sealing layers. Drilling and sampling polluted groundwater and soil was carried out with great care to avoid unintentional effects at one Kjørbekk landfill (Skien municipality). Though ground truthing is needed for validation of geophysical measurements, minimizing the need for such investigations is paramount.

In 2022-24, earthresQue researchers and user partners collected knowledge and experience concerning leachate treatment and current challenges at Norwegian landfills. This formed the basis for a new web-based guideline for handling landfill leachate, which will be launched by the Norwegian Environment Agency in spring 2025. The guidelines provide a methodology for assessing leachate emissions based on current understanding of leachate contamination and the relevant regulatory framework.

Assessing and modifying bedrock surrounding landfills

Pressure on areas, encourages the establishment of new waste landfills in areas already subjected to interventions, such as inactive rock quarries, closed mines etc. Often the natural bedrock at such sites is too fractured to satisfy the necessary requirements for a hydraulic barrier. Hence, a constructed geological barrier is required. An established method for lateral sealing of walls of rock quarries is based on the so-called ”Christmas tree method”, i.e. embankments are built along the rock wall in stages upwards as the landfill is filled. A disadvantage of this method is that part of the volume below the landfill area is occupied by natural bedrock, in addition it can be demanding to build such a structure with the desired quality, robustness and documentation.

Vertical lateral sealing provides better volume utilization of the landfill area. Through SFI-earthresQue, Lindum AS therefore wants to develop a solution for establishing a suitable, sufficient and durable barrier for use on vertical rock faces. In addition, the solution must satisfy relevant functional requirements in the current framework for establishing a landfill for ordinary waste, so that it can be recognized by relevant authorities. The function and quality of the solution must be documented and verified as a basis for recognition as a pre-accepted solution for the purpose. The work including the construction and detailed monitoring of water in the bedrock before, during, and after the implementation of the new design was started in 2024. The constructed barriers will prevent water flow between clean and contaminated zones. This will be the first landfill to feature such a solution. Consequently, guidelines for this design approach are being developed in parallel to support potential regulatory interpretations.

Figure E1: Quantification of large-scale performance under field conditions. Langøya final cover pilot during construction (compaction) of hydraulic barrier and after the application of 1.8-2 m of crushed limestone as frost protection. In addition to measuring the percolation through sections with different waste clays used in the barrier, the sections are heavily instrumented to measure soil temperature, water content and electrical conductivity at various depths.

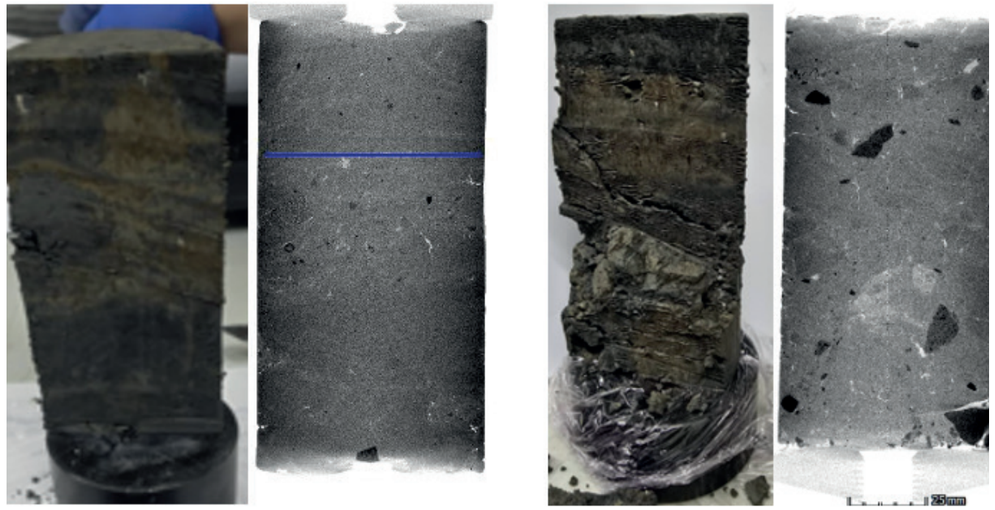


Figure E2: Evaluation of suitability of heterogeneous masses in laboratory. Cross-section of compacted (72 mm in diameter) samples of an excavated stabilised clay from the pilot. The structure and content of gravel and lime- and cement-lumps were carefully investigated with X-ray Computer Tomography (X-CT, collection of X-ray images to form a 3D visualisation of the internal features of the object).

Waste clays as the hydraulic barrier in final cover for landfills

Construction projects in Norway produce large volumes of clay-rich soil during groundwork. Rather than treating these materials as waste, efforts are being made to repurpose them for landfill barriers, such as bottom liners or final covers, to regulate water flow. While synthetic materials or commercially produced clays are alternatives, they rely on finite resources. Using surplus clays not only supports a circular economy and resource efficiency but also offers economic benefits for landfill and construction project owners.

Before practical use, these materials must meet stringent criteria. They need to compact effectively to meet regulatory standards for hydraulic conductivity, ensure long-term performance (often for centuries), and avoid leaching hazardous substances into the environment. Special attention must be given to material heterogeneity and potential contaminant leaching when assessing their suitability.

Together, the user partners NOAH AS, NGI and AF Decom are evaluating different types of waste clays for use in hydraulic barriers. A large-scale field pilot was constructed in 2022 and has since provided continuous data that allows assessment of the field performance over time of the three tested barriers. Intact samples of the compacted clay were collected and brought back to the NGI laboratory in Oslo where they are tested in more controlled conditions with different objectives. Figures E1 to E3 shows images from some of the different studies that are performed in the project.

In 2024, progress was also made on an industry guide for landfill closure and top sealing. In October, a workshop on the topic was held in collaboration with Sirk Norge, involving highly competent user partners (Lindum, Perpetuum, NOAH, Frevar, AF Decom, and Iris Salten). The goal is to have a draft of the guide ready in early 2025.

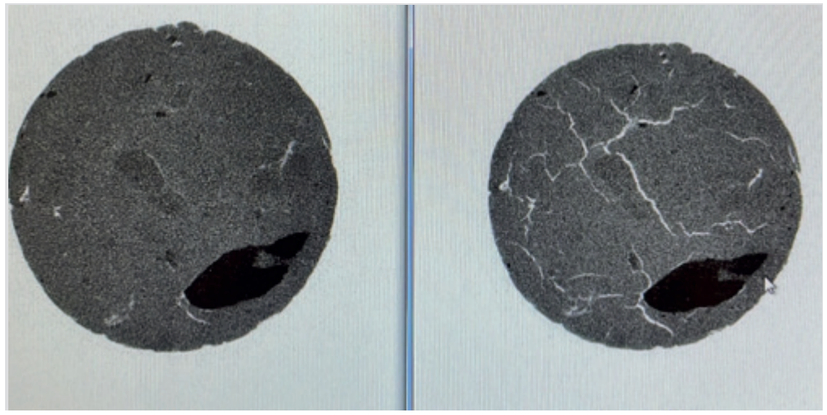


Figure E3: Effect of freeze-thaw on the structure and hydraulic conductivity of compacted clays. X-CT image before and after 5 freeze-thaw cycles (one cycle was 24 hours at -8 degC followed by 24 hours at room temperature). The hydraulic conductivity was also evaluated before and after, with only minor increase because the cracks did not extend through the sample.

Transition to a circular economic system

What characterizes a circular economic system and what structures support organizations and industries to transition toward it? While many organizations recognize the importance of circularity, they remain dependent on the linear use of materials, missing out on potential circular business opportunities. Several earthresQue partners, including AF Decom, Borg havn, Skanska, Kystverket, and the Fredrikstad municipality, have provided key contributions to understanding these issues.

Two PhD projects, in progress at BI, centre on how establishing successful circular systems hinges on the ability to deliver value with reused resources and the establishment of multi-actor systems of resource reuse to change the status of waste to product. For example, our research centres on how industry actors collectively build new narratives about how circular business can come into being, and on how cross-sectoral partnerships play a key role in underpinning the establishment of secondary markets for aggregates. Enhancing both new and existing knowledge will pave the way for deeper insights and the refinement of tools essential for effective risk management. This advancement is pivotal in guiding the development and updating of regulations concerning surplus masses and waste.

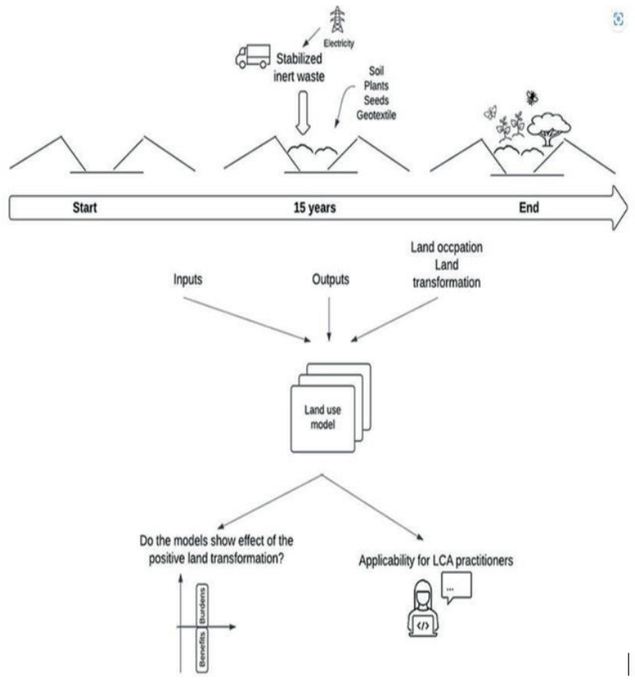
Choosing the right models for land use assessment

Anthropogenic land use has received increasing attention due to its negative impacts on food security, ecosystem services and biodiversity. While many activities lead to negatively impacted land occupation and transformation, some contribute to a positive transformation through active land restoration. Currently, several life cycle impact assessment (LCIA) models denoted as 'land use' exist, but transparency is limited ragarding the environmental problems they address. In a new article in Journal of Cleaner Production, NORSUS researchers Ingunn Saur Modahl and Kari-Anne Lyng explore how land use is addressed in Life Cycle Assessment (LCA) modelling. Modahl and Lyng identified 48 models with respect to ecosystems and resources and examined nine of them for practical applications on a specific case, an inert landfill, to assess if and how the models address positive land transformation (post-operation phase).

The functional unit is the treatment and landfilling of 1 tonne of inert hazardous waste. Life cycle stages include waste transport, neutralisation, landfill operation, and active restoration. Restoration converts quarry craters into a natural landscape. Results show that land use LCIA models vary in how they assess restoration, mainly due to differing environmental focus.

Key findings:
- There is a need for greater transparency regarding which environmental problems the models assess.
- There are significant differences in how the models account for positive land transformation.
- Three specific models are recommended for use in future studies where land use is in focus.

Read the full article here



Spin-offs

Two collaborative and knowledge-building projects were funded in 2024, both as direct spin-offs from the work in earthresQue. These projects are:

Don't Waste: Framework to Support Valorisation of Excavated Stabilised Soils (Project no. 353073), as a direct spin-off from the work in earthresQue, a consortium consisting of several key earthresQue partners (AF Decom, NMBU, NGI, NORSUS) along with Bane NOR, Keller, Heidelberg Materials, and Trondheim Municipality. These projects aim to develop new knowledge and build research competence that society or industry needs to address important societal challenges.

The project, led by Dr. Gudny Okkenhaug NGI/NMBU, starting in 2025, addresses environmental challenges related to the excavation and disposal of stabilized soil and clay, thereby continuing the theme of earthresQue with significantly more depth and breadth. The project aims to develop sustainable reuse strategies for these materials, with optimized practices for planning and managing construction projects where stabilized materials arise. The findings will be integrated into a decision-making tool and framework to maximize utilization, with the Sandbukta-Moss-Såstad railway project serving as a case study.

TISE: Tunable Ion Separations with Micro-Structured Composite Membranes (Project no.: 352835), is led by Dr. Zakhar Maletskyi, NMBU/Realtek. The TIES project, with earthreQue partner Lindum, aims to develop a highly selective process for fine ion separation, enhancing rare earth element recovery in hydrometallurgy and removing micropollutants from water. It bridges membrane and electrophoretic techniques by advancing electro-osmo-dialysis from theory to application. The project will experimentally validate the concept, test theoretical predictions, and integrate an electromembrane system to separate rare earth elements or remove PFAS from water.

International Cooperation

Although earthresQue reflects a strong emphasis on national partners and research and innovation needs, the centre has been actively involved in several EU framework projects and other international collaborations, adding a global dimension to its work. In 2024, the Centre hosted several international students and researchers.

In July 2024, the earthresQue acid-draining rocks group hosted a visit by Michael Descostes from the Environmental R&D department at ORANO Mining and Paul Sardini from the Geoscience Department at the Université de Poitiers, both based in France. The purpose of the visit was for the French scientists to learn about earthresQue activities on alum shale waste rocks and explore areas for collaboration. Alum shale is highly enriched in uranium and other contaminants of concern. NMBU scientists Estela Reinoso-Maset and Jan Marten Huizenga organized a laboratory visit on the NMBU campus in Ås and a field trip to the alum shale outcrops at Slemmestad (south of Oslo), where weathering of alum shale is easily visible.

Thomas Pabst hosted a meeting at NGI, where long-term management of acid-generating rock waste from industrial and civil activities was presented, including the involvement of various academic and industrial actors. earthresQue focuses on the long-term management of acid-draining rock waste. Research interests and common areas of expertise were identified, and by the end of the 4-day visit, all parties agreed on an action plan to establish collaborative research between ORANO, Université de Poitiers, NGI, and NMBU in 2025. The focus will be on understanding the geochemical and geophysical heterogeneities in the source rock formation to better predict and manage alum shale.

Master's student Marie Wagner from the National School of Bridges and Roads (ENPC) in Paris completed a six-month internship at NGI. She made a significant contribution to the Tunnel Boring Machine (TBM) project, focusing on the use of TBM spoils as protective covers for constructed geological barriers at landfills. Using data from the NOAH Langøya TBM pilot, she modeled frost intrusion. The results were presented at Nordrocs 2024 in a poster titled "Large-Scale Evaluation of Valorisation Potential of Tunnel Boring Machine (TBM) Spoils as Protection Layer Against Freeze and Thaw in Engineered Cover Systems."

User partners also have active international collaborations. Skanska is working with a German company to evaluate the reuse potential of press filter residue from tunnel sludge. This initiative could lead to more sustainable construction waste management. The Norwegian Defence Estates Agency has extensive collaboration on PFAS removal through their NATO defence alliances. Perpetuum was involved in the completed Danish project: PFAS inator: elimination of unwanted PFAS compounds from water.

On a longer-term basis, earthresQue collaborates with researchers and research groups from France, Brazil, Canada, and India, in alignment with the Norwegian Government's Panoramic strategy, which aims to strengthen Norway's relations with selected countries. Collaboration with INRAE, France, involves Dr. Remi Clement and Dr. Nicolas Forquet, who are testing and developing the OhmPi instrument for electrical resistivity measurements. In 2025, laboratory tests using this instrument will begin to study water dynamics and gas release in homogenized waste from the Brånåsdalen landfill.

In 2024, earthresQue researchers also held active international roles as opponents for PhD defences at Luleå Technical University, Lund University (Sweden), and Wageningen University (Netherlands). We also organized university campus visits to establish student exchange programs, for example with the University of Montpellier, France.

EU Funded Collaboration and proposals

The ARAGORN, EU Soil Mission EU HORIZON project, funded in 2023 (aragorn-horizon.eu), focuses on the remediation of shooting range soil, central to research on soil restoration and contamination. Proposals include UPGRADE, a Marie Curie joint PhD application proposed in collaboration with Luleå Technical University, Sweden, and the University of Nancy, France, and the recently submitted Horizon Europe proposal CHESS: "Enhanced Quantification and Understanding of Natural and Anthropogenic Methane Emissions and Sinks," led by Stephane P. (IFE). earthresQue is a partner in the EIC Accelerator proposal led by Envit/University of Ljubljana, Slovenia, showing its active role in EU-funded innovation.

Recruitment

earthresQue has been highly successful in attracting a large pool of PhD fellows and MSc students to pursue earthresQue-related research and innovation topics. Many of these are drawn to the Centre's focus on sustainability. Although the subjects of the PhD and Post-doc projects are highly varied, PhD workshops and involvement in the centre's user partner activities have created new and cross-cutting ideas.

The connection between education and hands-on experience benefits both the Centre and its user partners. Such examples of researcher training play a vital role in developing highly skilled personnel. earthresQue is actively engaged in education, particularly at the Master's level, and works to promote recruitment. This is done through regular NMBU and BI courses and Master's thesis topics that are advertised. Teams of MSc research assistants are also part of the research strategy of the academic participants.

Additionally, NMBU and NORSUS have hired MSc students to conduct laboratory work and field surveys, a strategy that not only contributes to the Centre's research but also fosters future recruitment to earthresQue projects.
Close collaboration with user partners helps to design Master's and PhD projects that align with industry needs, with many partners acting as co-supervisors, ensuring the relevance and application of research to real-world challenges.
Involvement with educational programmes occurs through field visits to user partners like AF Decom, Lindum, NOAH, Oslo and Ås Municipalities as part of the curriculum. These visits are incorporated into Master's courses, thesis work, and offer opportunities for summer jobs and internships, enriching the practical experience of students. The collaboration with user partners enhances the quality of education by providing current, relevant examples and insights into real-world challenges, promoting applied research and reinforcing the links between academia and industry.

PhD candidates and post docs financed by the Centre

Cathrine Eckbo
Ingvild Haneset Nygård
Bilal Tariq
Anders Gunnar Helle
Olav Bjerke Soldal
Saheed Opeyemi Adebunmi
Anna Maria Hatland
Arun C Emmanuel
Eivind Wiik Ånes

Associated PhD candidates

Fanjing Meng, NMBU
Håvard Bergheim, NMBU
Karen Ane Skjennum, Lindum
Christian Schöpke, IFE
Simen Arne Kirkhorn, FFI
Einar Bratteng, NRC and 11 partners + Berngaard
Hugo Firmo, BI

Key Researchers

Name and Institution	*Main Research Area*
Helen K. French, NMBU / NIBIO	Hydrogeology
Zakar Maletskyi, NMBU	Artificial membranes and separation processes in resilient and versatile filtration technologies
Gudny Okkenhaug, NGI / NMBU	Environmental chemistry, environmental Geology
Andreas B. Smebye, NGI	Environmental chemistry, environmental Geology
Gabrielle Dublet-Adli, NGI	Soil sciences and biogeochemistry
Håkon A. Langberg, NGI	Environmental chemistry, environmental Geology
Ole Jørgen Hanssen, NORSUS	Sustainability, life cycle assessment, waste resources
Hanne Lerche Raadal, NORSUS	Sustainability, life cycle assessment, waste resources
Trond Mæhlum, NIBIO	Leachate treatment
Stephane Polteau, IFE	Geology
Marit Sjøvaag, BI	Governance
Debbie Harrison, BI	Strategy
Knut-Erik Tollefsen, NIVA	Risk assessment
Babak Ebrahimi, NILU	Environmental effects and sustainability

Annual dinner: HOT or NOT? We foster a fun, social approach to innovation by voting for 'wild' innovations involving products or activities of our user partners during our annual dinner.

Communication and Dissemination Highlights

Lectures and Educational Interactions

earthresQue is continuously working to recruit students to write their MSc thesis on earthresQue-related topics, preferably in strong collaboration with user partners.
In August, we presented lectures and organised field activities to show how earthresQue activities may potentially affect water quality in a catchment. This was done in the regular MINA-NMBU courses MILJØ100 Introduction to Environmental Sciences, MILJØ302 Environmental Sciences, and Forny302 Sustainable Management of Resources in a Circular Economy.

In 2024, collaboration was initiated with the Oslo School of Architecture and Design (AHO) and their project "studio Circular Prototyping." earthresQue contributed with lectures, discussions, and facilitated access to 'waste materials' for master's students, focusing on the use of surplus materials such as bricks in construction. This collaboration provides students with an opportunity to think creatively about the skills needed for handling surplus materials, pollution, and construction grounds.

Architecture master students visited a location with surplus materials of lime-cement stabilized clay (construction site Oslo Tennis Club), and Nes Environmental Park, with AF Decom's washing facility for contaminated soil. The students collected samples of lime-cement stabilized clay, washed soil fractions, and filter cake, and worked with them to design and create bricks (illustration photo). The students explored a range of creative and innovative solutions for utilizing these materials, and in a concluding seminar, the student projects were presented and discussed.
The collaboration with AHO will continue in 2025.

earthresQue fagprat

In January 2024, we launched the seminar series "earthresQue fagprat," which explores issues, cases, and topics within the SFI. These sessions have been well-attended, with audiences ranging from 30 to 130 participants. The year's final seminar, held in collaboration with the NMBU university library, was open to everyone and attracted 70 physical attendees, with nearly as many joining online.

Knowledge Sharing and Outreach

A total of 126 presentations have been given by both researchers and user partners among the earthresQue partners since 2020. A complete list of contributions to international conferences is given in the Publication list at the end of this report.

Other presentations include those given at national conferences such as Miljøringen, Geologisk vintermøte (Geological Winter Meeting), Deponiseminaret (The Landfill Seminar), Byggavfallskonferansen (The Construction Waste Conference), Grønn anleggssektor (Green Construction Sector), Arendalsuka (The Arendal Week), at several meetings and webinars organised by SirkNorge (previously AvfallNorge), as well as a webinar for Statsforvaltere.

In addition, we have contributed several lectures in regular courses at NMBU, including MILJØ100, MILJØ320, VANN310, INN301, and at The Oslo School of Architecture and Design (AHO).

Annual Account

Funding

	Amount
The Research Council	16,420
The Host Institution, NMBU	7,670
Research Partners	5,998
Industry Partners	8,104
Public Partners	2,810
Total	41,002

Costs

The Host Institution, NMBU	13,866
Research Partners	17,622
Industry Partners	7,267
Public Partners	2,247
Total	41,002

Numbers in 1000 NOK

Publications and International Conferences

Articles in Scientific journals

2024
Ghorbani Mooselu, Mehrdad; Dehghani, Omid; Eslami, Abolfazl; Mahdavipour, Mohammad Ali; Mostofinejad, Davood; Pilakoutas, Kypros. Ceramic waste powder as a cement replacement in concrete paving blocks: mechanical properties and environmental assessment. International Journal of Pavement Engineering 2024 ;Volum 25.(1) NORSUS

Kirkhorn, Simen Arne; Sparrevik, Lars Magnus; Lyng, Kari-Anne Kallerud; Hanssen, Ole Jørgen. Assessing the life cycle impacts of the remediation of shooting ranges in peatland environments. Science of the Total Environment 2024 ;Volum 958. FFI NORSUS NMBU NTNU

Tang, Darrel W.S.; French, Helen Kristine; Leijnse, A.; Bartholomeus, R.P.; van der Zee, S.E.A.T.M. Reactive contaminant infiltration under dynamic preferential flow. Journal of Hydrology 2024 ;Volum 634. NMBU

2023
French, Helen Kristine; Hansen, Mona Cecilie; Moe, Kamilla G.; Stene, Julie. Modelling Plume Development with Annual Pulses of Contaminants Released from an Airport Runway to a Layered Aquifer, Evaluation of an In Situ Monitoring System. Water 2023 ;Volum 15.(5) s.1-16 NMBU NIBIO NGI

Skjennum, Karen Ane Frøyland; French, Helen Kristine; Carotenuto, Pasquale; Okkenhaug, Gudny. Combined column test for characterization of leaching and transport of trace elements in contaminated soils. Water 2023 ;Volum 15.(5) NMBU NIBIO NGI
Sparrevik, Lars Magnus; Qiu, Xinlu; Stokke, Raymond Andreas; Borge, Iselin; Boer, Luitzen de. Investigating the potential for reduced emissions from non-road mobile machinery in construction activities through disruptive innovation. Environmental Technology & Innovation 2023 ;Volum 31. NTNU

2022
Eckbo, Cathrine; Okkenhaug, Gudny; Hale, Sarah. The effects of soil organic matter on leaching of hexavalent chromium from concrete waste: Batch and column experiments. Journal of Journal of Environmental Management (JEM) 2022 ;Volum 309. s. - NGI NMBU
Zhang, Yaxin; Cornelissen, Gerard; Silvani, Ludovica; Zivanovic, Valentina; Smebye, Andreas; Sørmo, Erlend; Thune, Gorm; Okkenhaug, Gudny. Industrial byproducts for the soil stabilization of trace elements and per- and polyfluorinated alkyl substances (PFASs). Science of the Total Environment 2022 ;Volum 820. NMBU NGI

2021
Hale, Sarah; Roque, Antonio José; Okkenhaug, Gudny; Sørmo, Erlend; Lenoir, Thomas; Carlsson, Christel; Kupryianchyk, Darya; Flyhammar, Peter; Žlender, Bojan. The reuse of excavated soils from construction and demolition projects: Limitations and possibilities. Sustainability 2021 ;Volum 13.(11) NGI NMBU

International Conferences

2024
Bjerke Soldal, Olav; Sjøvaag, Marit. 'On the Road to Circular Aggregates'. IMP Conference 2024; 2024-08-26

Cappelen, Paul. Sustainable recycling of dredged sediments. NORDROCS 2024 9th Joint Nordic Meeting on Remediation of Contaminated Sites; 2024-09-09

Cappelen, Paul; Hansen, O.J. Sustainable recycling of dredged sediments, Nordrocs 2024. NORDROCS 2024; 2024-09-09

Devegowda, Vani; Schöpke, Christian Alexander. Understanding water bodies in and around Romerike region in Norway through strontium isotope analysis using MC-ICP-MS. 11th Nordic Conference on Plasma Spectrochemistry; 2024-06-09

Engebretsen, Erna; Flygansvær, Bente Merete; Sjøvaag, Marit. Boosting green public procurement through introduction of environmental criteria in supplier selection process in Norway. IMP Conference 2024; 2024-08-28

Flygansvær, Bente Merete; Engebrethsen, Erna; Bygballe, Lena Elisabeth. The role of hubs as enablers of circular supply chains. NOFOMA Conference 2024; 2024-06-13

French, Helen Kristine; Tariq, Bilal; Jervidalo, Hanna; Polteau, Stephane. Investigations towards characterising igneous rocks as a natural geological barrier for potential landfill sites in southern Norway. World groundwater Congress; 2024-09-08

Hansen, Caroline Berge; Okkenhaug, Gudny; Baardvik, Gunvor; Totland, Christian; Braathen, Petter. Reuse of lime and cement stabilized clay: Geochemical and geotechnical challenges. NORDROCS 2024 9th Joint Nordic Meeting on Remediation of Contaminated Sites; 2024-09-09
Helle, Anders Gunnar. Circularity in dredging and reuse of dredged material. Workshop on Dredging and Surveying (WSDS), The Netherlands, 2024-06-12

Loche, Paul; Garnier-Laplace, Jacqueline; Laurier, Dominique; Chauhan, Vinita; Klokov, Dmitry; Rodriguez-Sanchez, Neus; Priest, Nick; Tollefsen, Knut-Erik. Developing a Communications Strategy for Low Dose and Low Dose-Rate Exposures: Reducing Uncertainty Through Global Networking and the Adverse Outcome Pathway Approach. 6th International Congress of the International radiation Protection Association (IRPA); 2024-12-07

Pabst, Thomas; Nemes, Attila; Harstad, Andreas Olaus; Stridal, Ann-Cathrin; Wagner, Marie; Okkenhaug, Gudny. Large scale evaluation of valorisation potential of Tunnel Boring Machine (TBM) spoils as protection layer against freeze and thaw in engineered cover systems. NORDROCS 2024; 2024-09-09

Raadal, Hanne Lerche; Lyng, Kari-Anne Kallerud; Mooselu, Mehrdad Ghorbani. LCA for Multi-Functional Systems in a Circular Economy: the case of Anaerobic Digestion of Waste and Recycling Contaminated Soil. SETAC Europe 26th LCA Symposium; 2024-10-21

Schöpke, Christian Alexander; Johansen, Ingar; Devegowda, Vani. Tracing Landfill Leachate in Environmental Samples Using a Triple Isotope Approach – d13C, d11B and 87/86Sr in Norwegian Landfill Leachate. Nordic Plasma conference; 2024-06-09

2023
Engelmann, Christian; French, Helen Kristine; Lari, Kaveh Sookhak; Werth, Charles J.; Scheytt, Traugott. Delineating external stressor signals as time-variant conditions affecting DNAPL source zone formation. Abstract ID: 674, Poster Presentation. InterPore 2023, 15th Annual International Conference on porous media; 2023-05-22

Firmo, Hugo. Searching for services: emerging narratives for sustainable business. The Spring Servitization Conference 2023; 2023-05-08

Flygansvær, Bente Merete; Sjøvaag, Marit. Boosting green public procurement through introduction of environmental criteria in supplier selection process. Ipsera workshop on Sourcing and Innovation Ecosystems for Circularity; 2023-12-05

French, Helen Kristine; Tariq, Bilal; Polteau, Stephane. Geological barriers; criteria for securing safe waste storage. Final seminar CERAD; 2023-06-06

Harrison, Debbie; Sjøvaag, Marit. Levelling the CO2 business network playing field: The role of international CBAM regulation. IMP Conference 2023; 2023-08-23

Okkenhaug, Gudny; Eckbo, Cathrine. Utlekking av Cr(VI) fra betong. Cr6 & betongkross i vägkonstruktion; 2023-06-02

Okkenhaug, Gudny; Eckbo, Cathrine; Hale, Sarah Elizabeth; Breedveld, Gijs D. Recycling of concrete in Norway: Example of risk assessment model for determination of accept criteria for Cr(VI). How to establish environmental product criterias for rock materials; Nordic partnership –How to establish environmental product criteriasfor rock materials, Massbalans, 2023-11-09

Ritter, Stefan; Ånes, Eivind Wiik; Hovland, Kristin; Stridal, Ann-Cathrin; Hansen, Harald; Henriksen, Thomas Jolstad; Okkenhaug, Gudny. Sustainable impermeable landfill barriers: The potential of using geological waste and surplus masses. 9th International Congress on Environmental Geotechnics; 2023-06-25

Tariq, Bilal; French, Helen Kristine; Polteau, Stephane; Anschütz, Helgard; Salazar, Sean. Connecting the dots: Fracture mapping for landfill sites in fractured bedrock. EGU (European Geoscience Union) General Assembly; 2023-04-23

Ånes, Eivind Wiik; Ritter, Stefan; Okkenhaug, Gudny. Use of numerical modelling when designing a full-scale field test of landfill top covers. 9th International Congress on Environmental Geotechnics; 2023-06-25

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Eckbo, Cathrine; Hale, Sarah; Okkenhaug, Gudny. Reuse of concrete waste: Challenges with hexavalent chromium. Nordrocs 2022; 2022-09-06

French, Helen Kristine. Bærekraftig gjenbruk av overskuddsmasser, relevant studiekompetanse fra NMBU og earthresQue (SFI). Grønn anleggssektor; 2022-10-25

French, Helen Kristine. earthresQue – fra avfall til ressurs, Senter for bærekraftig bruk av overskuddsmasser og avfall i den sirkulære økonomien. INN301 - Nyskaping; 2022-08-17

French, Helen Kristine. Senter for bærekraftig bruk av overskuddsmasser og avfall i den sirkulære økonomien, faglig presentasjon av earthresQue for Ola Borten Moe, forsknings- og høyere utdanningsminister. Senter for bærekraftig bruk av overskuddsmasser og avfall i den sirkulære økonomien; 2022-01-14

French, Helen Kristine; Henriksen, Thomas; Eckbo, Cathrine. earthresQue - fra avfall til ressurs, Senter for bærekraftig bruk av overskuddsmasser og avfall i den sirkulære økonomien. GreenSmart frokost- seminar; 2022-09-02

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Skretting, Erlend; Ritter, Stefan; Okkenhaug, Gudny. TBM muck as a resource. NORDROCS 2022; 2022-09-05

Strømø, Tonje; French, Helen Kristine; Harstad, Andreas Olaus; Okkenhaug, Gudny. Environmental effects of building and construction in black shale: The mobility of trace elements and uranium in crushed black shale. Nordrocs; 2022-09-05

Tariq, Bilal; French, Helen Kristine; Polteau, Stephane; Anschütz, Helgard; Røseth, Kari. Hydrogeological Study of Potential Landfill Sites. Nordrocs; 2022-09-05

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Okkenhaug, Gudny; Hale, Sarah; Sørmo, Erlend. Reuse of low-level contaminated soil - Lessons learnt from projects in Norway. Eurosoil 2021; 2021-08-23

Media

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Hordnes, Lars Ivar; French, Helen Kristine; Okkenhaug, Gudny; Stridal, Ann-Cathrin. Forskning på Langøya skaper ny kunnskap - Gir store fordeler. Jarlsberg [Avis] 2024-09-26 NMBU

2023
Soldal, Olav B.; Firmo, Hugo; Skaldehaug, Espen Roy. Etterspurt: Nye finansverktøy for å verdsette en grønnere fremtid. Energi og Klima [Internett] 2023-04-26 BI.
Firmo, Hugo; Sjøvaag, Marit. Naturpositive mudringsmuligheter. Dagsavisen 2023 BI

Fjeldberg, Øyvind. Bruk muddermassene til noe konstruktivt. Fredriksstad Blad 2023 s.14

French, Helen Kristine. Høring "Forslag til nye normverdier og tilstandsklasser for forurenset grunn". Høringsnr.: 2022/12201 (Høring 20.02.2023). Miljødirektoratet. Høring. 2023 NMBU

French, Helen Kristine. Innspill fra SFI earthresQue til ekspertgruppe for ulike deponeringsformer, Kap. 2 Norges mineralstrategi (Høring 21.11.2023). Innspill 2000 2023 NMBU

French, Helen Kristine; Sparrevik, Magnus. Innspill fra SFI earthresQue til Klima- og miljødepartementet og Nærings og fiskeridepartementets Stormøte om sirkulær økonomi (Høring 03.02.23). Klima og Miljødepartementet, innspill 2023 NMBU

Wold, Gry Catinka. Lærerik prøvemudring i Fredrikstad. Dagsavisen 2023 s. 8-9

Jakobsen, Nina H. Lærerik prøvemudring i Fredrikstad. extraavisen.no 2023

Kristiansen, Martin Næss. Vasking av mudringsmasser ga positive resultater. Dagsavisen 2023 s.6-7

Langset, Per Christian; French, Helen Kristine. NMBU deltar aktivt på Arendalsuka. nmbu.no 2023 NMBU

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Skift, Skift; French, Helen Kristine. Science 4 Impact - Om forskningsdrevet innovasjon og en sirkulær avfallssektor. Spotify [Radio] 2022-06-16 NMBU

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2021
Eckbo, Cathrine; Lokna, Maria. Hvor ble det av Y-blokka?. Morgenbladet [Avis] 2021-08-15 NGI NMBU

Eckbo, Cathrine; Søderholm, Jørn. Det kan bli lettere å bygge med knust betong. Anleggsmaskinen [Fagblad] 2021-04-22 NGI NMBU

2020
Engelsen, Christian John; Eckbo, Cathrine. Nå kan det bli lettere å gjenbruke betong. Vanlig jord har forbløffende virkning på fryktet giftstoff. tu.no [Internett] 2020-12-01 SINTEF NGI 2020

Eckbo, Cathrine. Jord hindrer spredning av giftig krom fra betong. Aftenposten Viten 2020 NGI