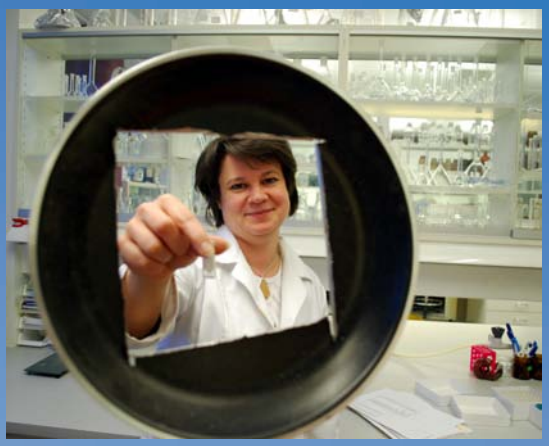
Annual Magazine

NILU

2009



A new European *supersite* observatory opened at Birkenes

New methods in the hunt for environmental toxins

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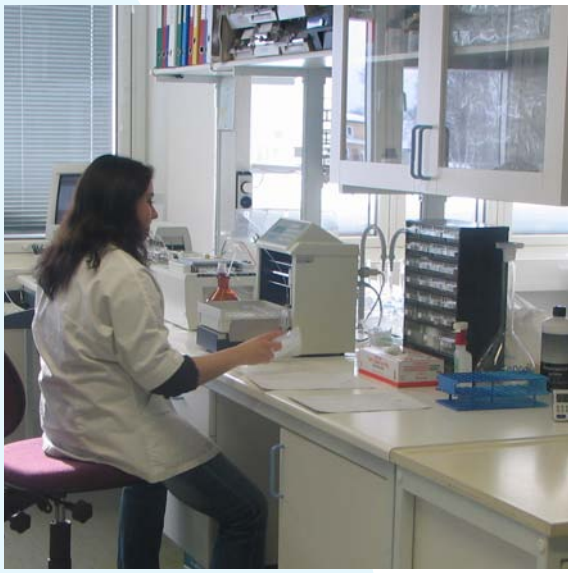

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40 Years of Research for a Better Environment

2009 was NILU's forty year anniversary. Research on the climate system and monitoring of pollution for better air quality has been the main focus since the start of the institute in 1969.

A major event for NILU in 2009 was the opening of the new observatory at Birkenes in southern Norway. Birkenes has been an important site for monitoring and research for more than 30 years. With substantial investment in time and resources the station has now turned into a world class observatory for the monitoring of climate gasses and drivers of long range transport of air pollution.

NILU's vision is to promote sustainable development and a better quality of life through research on climate change, air quality, and hazardous substances. Climate change and emmisions of harmful substances are major treats to the environment and to human health. A changing climate brings many new challenges to the field. NILU is challenging the currently established knowledge and tools developed for trying to understand the dynamics of nature. We will need all our experience and be able to combine it in new ways in order to give the best advice to the government. They must in turn choose the right solutions and abatement strategies based on our scientific recommendations.

The strategies will have to be a combination of combating pollution and reducing emissions of GHG's. NILU's experience of researching long range transport of pollution and climate drivers, as well as on industrial emission, levels and effects, will be a valuable contribution to this work.

Also, the long time series of monitoring data needs to be taken into account, without which the research on the climate change and abatement strategies will be far more complicated. NILU is pleased that there is a growing concern and awareness among our political administration to take care of this heritage and to develop it for future needs.

An anniversary is a good opportunity to celebrate achievements throughout the years, to congratulate all the enthusiastic and hard working NILUists and last, but not least, to look to the future and use this great heritage to remain at the forefront in the days and years to come!

Kari Nygaard

New Observatory at Birkenes

After a major overhaul of the Birkenes atmospheric research station, a brand new observatory was opened in November. For the first time in history, CO_2 will be measured from the Norwegian mainland.

ANNE NYEGGEN
Head of Communication

– This is a great day for atmospheric and climate research, both nationally and internationally, NILU director Kari Nygaard stated at the opening of the new observatory at Birkenes in November.

Since its establishment in 1971, The Birkenes atmospheric research station has been one of the major sites in Europe for the study of long-range transported air pollution.

Up until now, the station has measured ozone and other parameters such as heavy metals and organic pollutants in air and precipitation. The establishment of the station was crucial in putting the problem of acid rain on the agenda in the 70's and 80's. Being conveniently situated in the middle of the wind trail of the continent, it is possible to carry out direct measurements of pollution coming from Europe and the British Isles.

The opening took place in November.

The observatory at Birkenes is fully equipped with advanced technical measuring equipment.

– At Birkenes we can actually trace the emissions all the way back to their sources, and we will eventually be able to verify the information given by the countries about their emissions, Nygaard said.

New instruments

Since 2000, NILU has gradually expanded the monitoring programme at Birkenes to include more sophisticated measurements of the characterization of particles, measurements that are very important both in respect to climate and to health issues.

In addition, NILU has acquired several instruments for the measuring of

At first the company was given a tour around the old station, which has instruments still in use.

greenhouse gases, including CO_2. CO_2 has never before been measured on the mainland of Norway.

European super-site

– The upgrading of Birkenes will turn it into one of the main observatories in Europe when it comes to understanding trends in emissions of greenhouse gases and pollution, Kjetil Tørseth said at the opening. Tørseth is the Director of the Department of Atmospheric and Climate Research at NILU.

– This will strengthen the field of particle research. A better understanding of the composition and mechanisms associated with particles is essential in order to make climate modelling more accurate, he pointed out.

Tørseth also claimed that the new activity at Birkenes will strengthen the national expertise on climate research, and strengthen the link between monitoring and research.

Birkenes Observatory now fulfils the requirements to be a "super site" in the European measurement network EMEP, which was established in 1979.

Important environmental monitoring

– Monitoring is the most important cornerstone in environmental work, Deputy Director at the Climate and Pollution Agency, Marit Kjeldby emphasized in her speech.

– The problems have to be detected and defined. Secondly, they need to be monitored in order to see if there are any changes. We also need to find out whether the initiatives actually work. Our influence on international decisions would indeed be very poor if we did not have environmental data to display, Kjeldby said.

Engineer and veteran Harald Willoch presents the meteorological equipment on the roof of the station to a shivering Liv Schance (NIVA) and Helge Corneliussen (Fædrelandsvennen).

About Birkenes

Continous monitoring by NILU at Birkenes:

- Main components (e.g. sulphur and nitrogen compounds) in air and precipitation (from 1973)
- Ground level ozone (from 1985)
- Persistent Organic Pollutants (POPs) in air and precipitation (from 1992)
- Particle mass and determination of elemental and organic carbon (from 1999)
- Optical and physical properties of particles, such as size distribution, AOD (Aerosol Optical Depth), distribution and adsorption (from 2009; size distribution from 2002)
- The greenhouse gases methane and carbon dioxide (from 2009)
- Volatile Organic Compounds (VOCs) was measured from 1988-1999, including some components up to 2005. There is no VOC monitoring in Norway today.

The time series from Birkenes are internationally unique.

With its localisation in the southern part of Norway, about 15 km southeast of Lillesand, Birkenes is one of two advanced monitoring stations for the study of climate change and long-range transported pollution in Norway. The other station is located on the Zeppelin Mountain close to Ny-Ålesund in Svalbard.

No surprise: Champagne at the air intake gave high levels of CO_2 on the measuring instruments. Senior scientist Terje Krognes allows himself a somewhat unserious sampling on the occasion of the opening.

Up in the Air for Forty Years

NILU celebrated its 40th anniversary with a brand new book, a Family Day event, and an anniversary symposium focusing on the Artic and air pollution in the 20th century.

ANNE NYEGGEN
Head of Communication

The 40th anniversary book is edited by Associate Research Director at NILU, Bjarne Sivertsen. It tells the story from the very beginning, when a total of seven employees had their offices in the barracks at Kjeller in 1969, to the present day where NILU has bloomed into a professional, internationally oriented institute, with 180 employees, branch offices in several countries and observation stations on both poles. Sivertsen, who himself has been involved since the beginning, describes NILU's history as one filled with both ups and downs.

In recent years, however, NILU had a substantial expansion and has taken in a number of outstanding employees from all over the world. In addition, revenue over the past five years has increased by 75%.

Dr. Eldbjørg S. Heimstad, NILU.

Senior scientist Fred Prata gave a 3D presentation of pollution from a cruise ship near Svalbard. Pink glasses were handed out to the audience on the occasion.

Acid rain

NILU was established as a result of the "Committee for combating air pollution", whose task was to assess the need for developing the necessary expertise in this field.

The institute's first Director, Dr. Brynjulf Ottar, spent much time and effort convincing sceptical Europeans that acid rain in Scandinavia originated from the continent. This laid the foundation for the international and national monitoring of air pollution today.

Erik Solheim, Minister of the Environment and International Development, is welcomed by Chairperson Suzanne Lacasse (left) and Managing Director Kari Nygaard.

Unlimited challenges

Although NILU has many achievements to commemorate, the institute doesn't spend too much time looking back. Moreover, it celebrates its anniversary by looking ahead.

On October 15, the institute organized a symposium on the topic "Unlimited challenges" with speakers and guests from home and abroad. Minister of the Environment and International Development Department, Erik Solheim, opened the symposium, where contamination in the Arctic was one of the main themes.

Black carbon melts Arctic ice

Increased activity in the Artic will also certainly increase the emissions of black carbon, according to NILU scientist Andreas Stohl. In the Arctic areas, the impact of black carbon on melting ice is equal to that of CO_2.

Increased activity in the Artic will cause increased emissions of soot, NILU researcher Andreas Stohl states.

ANNE NYEGGEN
Communication manager

With rich deposits of oil and gas, there are considerable opportunities in the Artic. But the exploitation of these natural resources also poses significant threats to the vulnerable arctic environment.

– It may be hard to quantify, but it is clear that any source of pollution in the Artic has a greater climate impact, probably much greater, than the same pollutants further south, Stohl says. He has done extensive research in the field of arctic pollution.

According to Stohl, all sources of black carbon – or soot – have a huge impact on the climate.

Contributes to global warming

In addition to CO_2, which is important in a global perspective, emissions of nitrogen oxides (NO_x) will lead to the formation of particles and ground-level ozone in the Arctic, which again will cause additional warming of the atmosphere.

The black carbon particles deposited on snow and ice will contribute to further melting and warming of the surface. This effect will increase as the melting snow and ice give way to dark surfaces which do not reflect light from the sun as strongly.

Initiatives will work

The effect of black carbon on the Arctic ice-melt is a well-known problem. Previously NILU has shown how pollution from Europe, Russia, and Canada falls down over the Arctic, and how this accelerates the ice-melt. Although black carbon is equally important to the climate balance in the Arctic as CO_2, black carbon has a life-span of only a few weeks. CO_2 on the other hand, has a lifespan of almost 100 years.

– This means that measures to reduce black carbon will work fast, Stohl says. He also points to the fact that a large part of the pollution is manmade.

– It should be possible to do something about the burning of agricultural land in Russia, for instance, a major contributor to black carbon pollution, he says.

New Managing Director

The new Managing Director of NILU, Kari Nygaard, started just in time to kick-start the 40th anniversary.

SUSANNE M. STEPHANSEN
Journalist

– A great way to start, Nygaard said as she was appointed new Managing Director of NILU in October 2009, thus becoming the first ever female Managing Director of NILU.

The 49-year-old doctorate in marine microbiology has worked at the Norwegian Institute for Water Research (NIVA) for 21 years before accepting the position. When the position as Managing Director of NILU was announced, she casually points out how the decision to apply was an easy one to make.

– I wanted to head what I consider to be a professional, dynamic and internationally oriented organization that is concerned with some of my deepest concerns, namely, climate and the environment, Nygaard comments.

Nygaard has held numerous positions, both internationally and nationally, experience that comes in handy as the new Managing Director of NILU.

– NILU is involved in numerous international processes, and is thus able to influence the formation of directives. I find that very exciting. While it is important that NILU is internationally acclaimed, I will also emphasize the task of making us visible nationally, Nygaard says.

– This also applies to climate research, which is an important topic today and of great consequence for our future.

Managing Director Kari Nygaard.

The observation on Zeppelin, Svalbard.

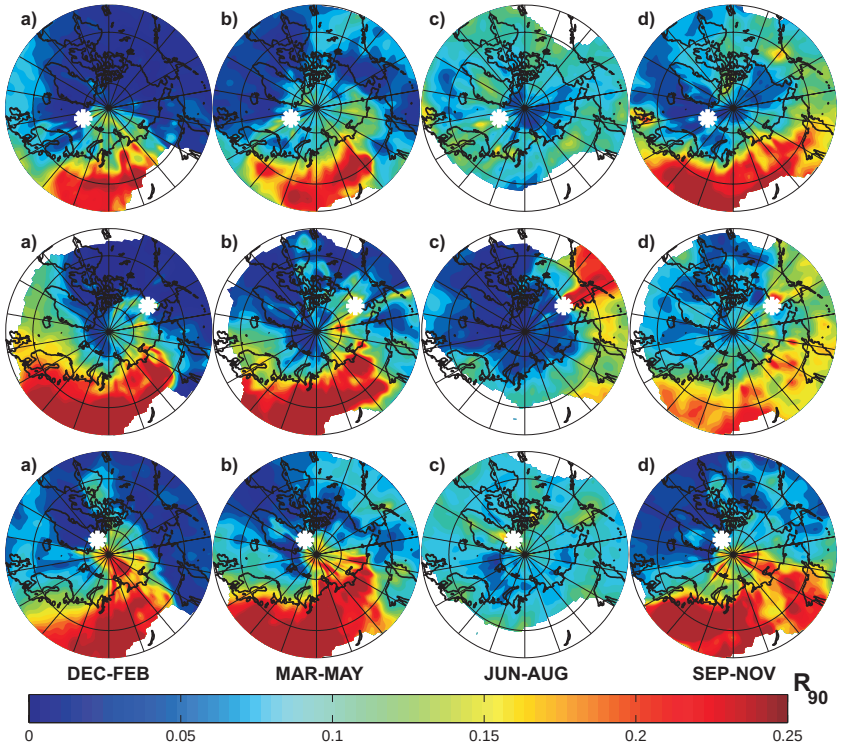
Soot in the Arctic

Pollutants with a short atmospheric lifetime – black carbon (BC) in particular, have recently received attention as potentially significant climate forcers, especially in the Arctic.

DAVID HIRDMAN
PhD fellow

With an analysis combining measurement data of Equivalent Black Carbon (EBC) from several Arctic stations, together with calculations from the Lagrangian particle dispersion model FLEXPART, we have identified the most important source regions of black carbon that are transported into the Arctic troposphere and how this changes with the seasons.

For all seasons except summer, long-range transport from Northern Eurasia is the dominating source of EBC at the Arctic stations Alert (Canada), Barrow (Alaska, USA) and Zeppelin (Svalbard, Norway). However, the situation during the summer is more complex, with the major contribution coming from regional sources such as boreal forest fires. These records of measured EBC are now also long enough for performing meaningful trend analysis. We confirm in our analysis that there has been a general downward trend in the EBC at all three stations. They also show that the decrease of EBC in the Arctic troposphere is largely attributed to decreasing emissions in Northern Eurasia. A long-term change in the atmospheric circulation may additionally explain a minor fraction. Despite the overall trend of EBC observed at the observatories, recently, there is evidence in wintertime that the EBC emissions in the eastern parts of Northern Eurasia have increased over the last decade.



Source regions defined by the highest 10% of measurements of EBC at Alert (top row), Barrow (middle row), and Zeppelin (bottom row), for December-February (far left column), March-May (middle left column), June-August (middle right column) and September-November (far right column). The locations of the stations are marked by white asterisks.

Hirdman, D., Sodemann, H., Eckhardt S., Burkhart J.F., Jefferson A., Mefford, T., Sharma, S., Ström, J. and Stohl, A. (2010) Source identification of short-lived air pollutants in the Arctic using statistical analysis of measurement data and particle dispersion model output. *Atmos. Chem. Phys., 10, 669-693.*

Hirdman, D., Burkhart J.F., Sodemann, H., Eckhardt S., Jefferson A., Quinn, P.K., Sharma, S., Ström, J. and Stohl, A. (2010) Long-term trends of black carbon and sulphate aerosol in the Arctic: Changes in atmospheric transport and source region emissions. *Atmos. Chem. Phys. Discuss., 10, 12133-12184.*

Black Carbon in the Antarctic Traced to Forest Fires in Brazil

NILU scientists have proven that the icy solitude of Antarctica is not safe from the world's pollution. A study verifying the fact was published in the journal *Geophysical Research Letters* in 2009.

SUSANNE M. STEPHANSEN
Journalist

– The fact that particles are transported through the atmosphere from north to south, and over such vast distances such as from the tropics to the Antarctic is surprising, but now we have actually managed to track pollutants measured at the Troll Research Station in Antarctica back to a specific forest fire in Brazil, Markus Fiebig says. He completed the study, which was published in Geophysical Research Letters, together with Chris Lunder and NILU scientist, Andreas Stohl.

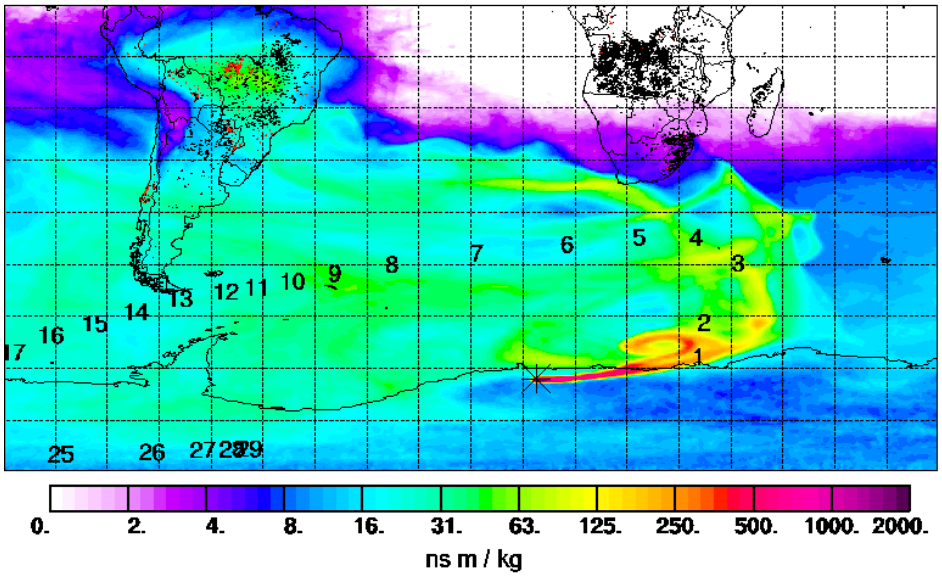
In 2005, Norway extended its activity in Antarctica by turning the Troll Research Station in Queen Maud Land into an all-year station. NILU was commissioned to set up an atmospheric observatory, and in February 2007 the first year-round measurement of size and distribution of aerosols in the atmosphere were initiated.

– We observed aerosols in the atmosphere above Troll that seemed to be particles originating from biomass burning in June, Fiebig says. – We also observed that the measurements peaked on two specific days (June 19th and 20th), and began to investigate the cause of it. Since there is no biomass like trees or plants in the Antarctic, the source had to have originated on continent further north.

The timing of the peak in the Troll-measurements happened to coincide with a peak in the forest fire season in Brazil. Thus the researchers had established a connection.

Proven by FLEXPART

The source turned out to be one specific forest fire activity in the middle of Brazil, and it took 11-12 days before the aerosols were observed at the Troll station. This was proved using the transport model FLEXPART, a sophisticated modelling tool for air pollution, developed by NILU scientist, Andreas Stohl.



Occurrence of fires and pollution illustrated by using the FLEXPART model. Black spots indicates fires without flames, red spots indicates fires with flames. The red field at the bottom right shows heavy pollution over the Antarctic.

– We ran the model four weeks back in time, and assembled the results by using a satellite map (MODIS) that shows fire activity. As such we managed to establish a secure source-recipient relationship between the forest fire activity in Brazil and the aerosols we observed at the Troll Research Station, Fiebig explains.

The study confirms earlier indications that emissions from forest fires on other continents reach the Antarctic. The fact the emissions occurred as far north on the southern hemisphere as the tropics is sensational.

– This is the first time we have final evidence that emissions originating as far north as in the tropics, affect Antarctica, Fiebig concludes.

Geophysical Research Letters: M. Fiebig, C.R. Lunder og A. Stohl: Tracing burning biomass aerosol from South Amerika to Troll Research Station in Antarctica. Geophys. Res. Lett. 36, L14815, doi: 10.1029/2009GLO038531

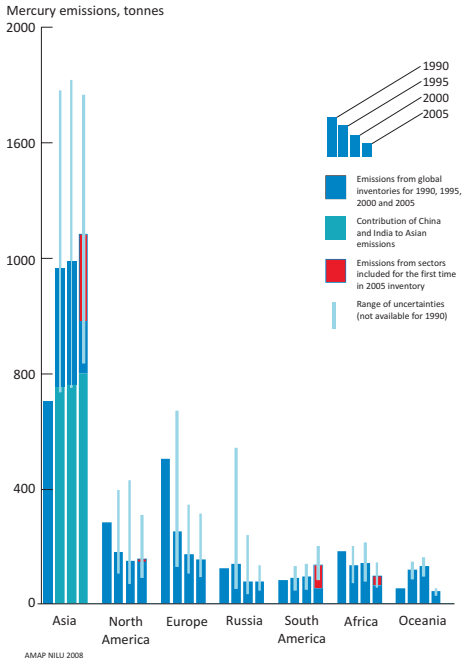
Scientist Markus Fiebig at NILU has found soot from the tropics in the Antarctic.

Moving Towards a Global Treaty on Mercury

Thousands of tons of mercury are released into the air every year. It easily finds its way into the food chain, and eventually to our dinner plates – causing major health problems. Now, a global treaty that will reduce mercury emissions worldwide is on the way.

ANITA THOROLVSEN MUNCH
Journalist

Mercury (Hg) poses a serious threat to our global ecosystem. According to the United Nations Environment Programme (UNEP), coal-fired power plants and garbage incinerators emit thousands of tons of mercury into the atmosphere every year.



Trends in emissions of mercury to air from 1990 to 2005.

The consequences are alarming. Several studies have already documented that exposure to mercury, particularly in infants, can affect their attention span, language and visual-spatial skills, memory, and coordination. The effects of mercury toxicity also include paraesthesia (a pricking, tingling or creeping sensation on the skin), depression, and blurred vision.

Supported by research from NILU, UNEP is now working on a global, legally binding treaty to control mercury pollution. According to plan the treaty will be implemented by 2013.

– Reducing mercury pollution is urgent. On a global basis, the total, anthropogenic emissions of mercury are already too high. Compared to measurments from 2005, the emissions will increase by 25% by 2020, Director of the Center for Ecology and Economics (CEE) at NILU, Jozef Pacyna says.

Conducted research for the UN

Pacyna was asked by UNEP to prepare the scientific basis that will enable UNEP to present the worldwide treaty.

– We have studied the major emission sources of mercury, the amounts of mercury emitted, in both water and on land, which regions have the highest emissions and where the burden is greatest. We have also estimated the potential damage in the case of no restrictions on the emissions. Both in terms of how the environment will react, and how the numerous health problems resulting from the emissions may affect the economy, Pacyna says.

He is considered a pioneer in the field, and received the assignment from UNEP together with his NILU-colleagues in 2007.

After five months of intense work Pacyna presented the results to delegates from more than 150 countries, in October 2008, at UNEP's headquarters in Nairobi.

– What we would like, is a sort of Kyoto-agreement concerning mercury, Pacyna says.

Mercury for dinner

– Mercury is one of the most important environmental contaminants that need more attention from policy makers, industry, and the general public, Pacyna says.

It is toxic, persistent, and long-lived

Mercury is one of the most dangerous environmental contaminants today. There is a critical need for a greater focus on this issue, Jozef Pacyna, Director of CEE, states.

in the atmosphere. It is released into air and water through industrial production, combustion of coal for energy production, cement production, and waste disposal.

As the mercury is deposited on land or in water, the ecosystem cannot break it down. Instead bacteria and natural processes can transform mercury into the organic mercury compound methyl mercury (MeHg), which is a poisonous substance, and easily accumulated in the food chain.

– The substance is absorbed by fish, birds, and mammals, and is accumulated in the food chain in increasing concentrations. Emissions are also transbordered. Norway receives significant amounts of mercury annually from long-range transboundary pollution, Pacyna says.

Light switches made from mercury were once installed in great numbers, also in private homes.
Photo: Wikipedia Commons

Decrease in Europe

Pacyna explains that even though there has been a decline in mercury emissions in Europe over the past decade, there is a sharp increase in the rest of the world. The largest contributions come from large new economies, such as India and China.

– The global anthropogenic emissions are estimated at approximately 2000 metric tons per year. China, U.S. and India are responsible for about 55%, Pacyna says.

Most of the global emissions come from fossil fuels like coal (46%), illegal and small scale gold mining operations (18%), metals (including large-scale gold mining operations) (13%) and cement (10%).

In Europe and North America, on the other hand, there is a reduction of emissions resulting from increased pollution control in recent years.

Raising the quality of life

One of the points Pacyna and his colleagues have stressed in their report is the fact that society may experience significant costs if the exposure of MeHg on humans and wildlife continues at this pace.

– There are documented health risks such as neurotoxicological damage on children who eat fish with high concentrations of MeHg. Thus we have to expect problems. In a worst case scenario, it may lead to reduction of school attendance and future loss of income and opportunity, he notes.

– According to our calculations society will save money by reducing the emissions as mercury related health issues will be fewer.

He believes the treaty is a good example of what scientists, policy makers and national authorities can achieve by collaborating.

– This work shows how research can contribute to a higher quality of life in the future, he concludes.

©Foto: Helge M. Markusson, Polarmiljøsenteret, Tromsø.

New Methods to Isolate Environmental Toxins

At NILU's laboratory at the Polar Environmental Centre in Tromsø, scientists search for environmental toxins in just about anything: soles of shoes, codfish, frying pans, etc. Thousands of samples are analysed every day using "CSI-like" methods.

HELGE M. MARKUSSON
Journalist Polar Environmental Centre

Senior scientist at the Norwegian Institute for Air Research, Dorte Herzke, finds it completely natural to dissect any given object, like for instance, a frying pan.

– We have recovered Teflon, as well as other substances used in clothes, shoes, kitchenware and other products, in our surroundings. We are looking for toxins in everything that we analyse here at the lab, Herzke tells us.

Senior scientist Dorthe Herzke at NILU Tromsø showing a sample of one thousandth of a millimeter. Samples are scaled down until they are pure before being analysed. Possible environmental toxins are recovered in chromatograms.
©Photo: Helge M. Markusson, Polar Environmental Centre, Tromsø

The lab in Tromsø has a number of highly advanced instruments and the scientists use techniques developed by NILU. Basically it works like this: Take a piece of a frying pan, or a codfish if you prefer. Remove all interfering substances until you are left with the environmental toxin you are looking for. There is also the potential to discover new toxins through this process.

Step-by-step separation

– When we receive a codfish, for example, we take samples of 2-3 grams. And there may be hundreds of samples. We then move on to a separation, or purification, process where we isolate the fat and toxins using appropriate solvents. Finally, we remove all interfering fats and proteins. Most environmental toxins follow the fat through the food chain but for many of the new environmental toxins this is not the case, Herzke explains.

PhD student Linda Hanssen showing an example of what can be sampled: the contents of a fire extinguisher.
©Photo: Helge M. Markusson, Polar Environmental Centre, Tromsø

The samples taken are scaled down until they are pure, before being ana-

©Photo: Helge M. Markusson, Polar Environmental Centre, Tromsø

lysed by using the advanced instruments. Scientists recover the environmental toxins – both known and unknown – in the so-called chromatograms.

– We are always looking for new substances. That's our job.

Unique in Norway

A lot of the work the scientists carry out at the NILU lab in Tromsø is unique. No one else does this in Norway.

– We can find out if there are toxins in just about everything, PhD student Linda Hanssen explains as she pulls out one object after the other from a big plastic box: a shoe, a piece of an iron, textiles, cans of spray paint and the contents of a fire extinguisher.

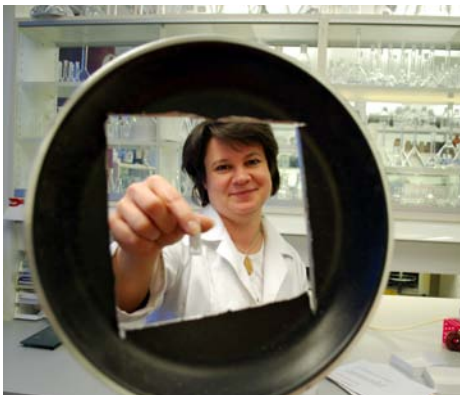
– Yes, it's a bit like CSI, she says with a smile, referring to the popular TV show Crime Scene Investigation.

– The difference is that here it takes two or three days to run the analysis, not a couple of minutes.

Looking to expand

As there are plans to expand the Polar Environment Centre, NILU has expressed a wish to expand their laboratory as well.

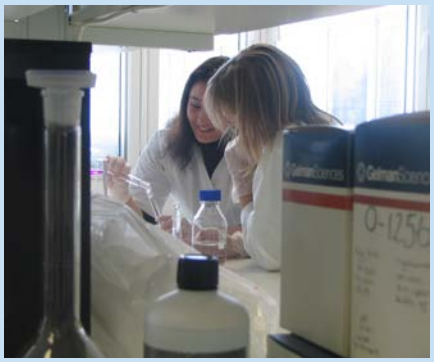
– One of the things we want to do is to build a dust-free lab, with an airlock and everything else that is needed. In fact, this means doubling the floor space we have today, Herzke says.



A square hole in a frying pan actually is part of the research at the advanced laboratory at NILU's department at the Polar Environmental Centre in Tromsø. Senior scientist Dorthe Herzke is able to measure possible toxins in the teflon coating.
©Photo: Helge M. Markusson, Polar Environmental Centre, Tromsø

Acclaim for NILU´s Environmental Chemistry Department

In 2009 basic research in Chemistry in Norway was evaluated. NILU´s Environmental Chemistry Department was among those who received the highest score.



It has been 11 years since the last time an International Committee convened by the Research Council of Norway (RCN) carried out an assessment of basic research in Chemistry in Norway. The evaluation included the chemistry departments in all Norwegian Universities (with the exception of Agder University College), in addition to the Chemistry Department at NILU.

The Committee evaluated the research groups on a scale of 1 to 5 in six selected fields. NILU´s Environmental Chemistry Department was among those who achieved the highest score in the evaluation, with 27 points out of 30 possible.

The Environmental Chemistry Department was partly acclaimed for its clear focus and its prominent position internationally in persistent and semi-persistent pollutants in the environment. The report concluded that NILU´s research is of high quality, and its work in the field of environmental chemistry is widely recognized.

The Evaluation Committee, led by Professor Evamarie Hey-Hawkins from the University of Leipzig, Germany, based their work on review of the self-assessments provided by the institutions, discussions and interviews with staff, and visits to the research facilities. A bibliometric analysis conducted by NIFU STEP, was also used as a basis for the evaluation.

Searching for Tomorrow's Toxins

A new model developed at NILU provides scientists with a promising, new technique in the search for environmental toxins.

ANNE NYEGGEN
Head of Communication

Thousands of individual chemical compounds are produced in large scale over the entire planet. However, the effect these new substances have on humans and on the environment remains largely unknown. It is a major challenge to identify new pollutants and foresee where problems may occur.

Mechanistic multimedia model

For several years, scientists at NILU have worked on developing mathematical models to understand the way organic environmental toxins spread.

Whereas previous models would focus on limited parts of a chemical's environmental fate, or be based on statistical correlations, senior scientist Knut Breivik at NILU and a team of international experts have developed a mechanistic multimedia model to give more precise information.

This model can clarify how changes in the emissions of organic environmental toxins affect different levels of the external environment, including food chains on land and in the ocean.

Assessing the long-term impact

The model is different from most previous models in that it is dynamic and may be used to study the response of ecosystems to change in emissions over time.

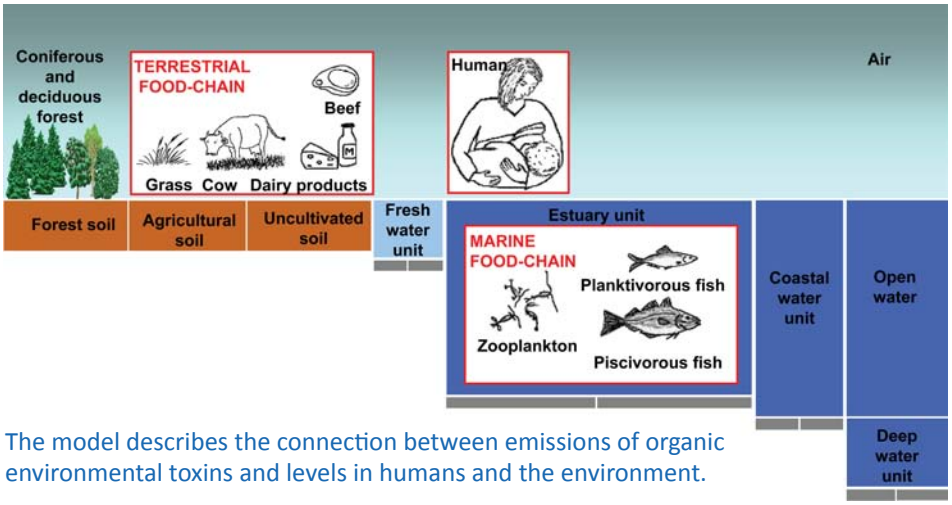
This is particularly relevant for studies of organic environmental toxins with poor biodegradability, i.e. which take a long time to decompose. Hence, the model can be used to examine how fast efforts to cut emissions will reduce the future environmental impact on humans and the environment.

The model has been thoroughly evaluated to see if it is capable of explaining the historical impact of the well-known toxin PCB (polychlorinated biphenyls). A new study concludes that most of the relevant monitoring data on PCB from the Baltic region can be explained using this model.

Ambitious plans

– Our vision is to be able to uncover new environmental toxins at a much earlier stage than before, Breivik says. He and his colleagues have great plans for the use of the new model.

– So far, most of the toxins we know about have been identified more or less accidentally by chemists. By continuously improving the knowledge that becomes part of the models, we hope to contribute to the discovery of unknown pollutants that circulate. In this way, the models will contribute more effectively in the identification of new environmental toxins and reduce their impact in the future, Breivik says.

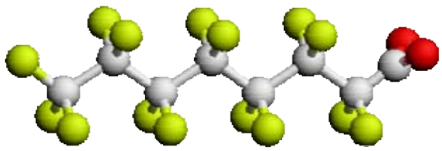


The model describes the connection between emissions of organic environmental toxins and levels in humans and the environment.

Knut Breivik has developed the model in close cooperation with scientists from the University of Stockholm and the University of Toronto.

Finding Sources of PFC's in Norway

As NILU explored possible sources of the environmental toxin PFC (perfluorinated compounds), samples were taken from everything from textiles to food packaging. The substance was found in 29 of the 34 products examined.



ANITA THOROLVSEN MUNCH
Journalist

Perfluorinated compounds (PFCs) are used in numerous industrial and consumer products due to their unique chemical properties. With the ability to repel both water and oil, PFCs are used in a whole range of products: non-stick frying pans, waterproof clothing and fire extinguishing foam. The problem is, PFCs are hard to degrade and there is insufficient knowledge of their impact on human health and the natural environment. PFC has also been detected in human blood and has therefore received more international attention in recent years.

Commissioned by the Norwegian Climate and Pollution Agency, the study was carried out by NILU and the Swedish research institute Swerea IVF. The study examined a total of 34 products divided into six categories: waterproofing/impregnation products, paint and ink, pre-impregnated materials such as coated paper, textiles, carpets and leather, non-stick products, electronic devices and fire extinguishers. The objective was to identify possible sources of PFC in industrial and consumer products in Norway.

Special method

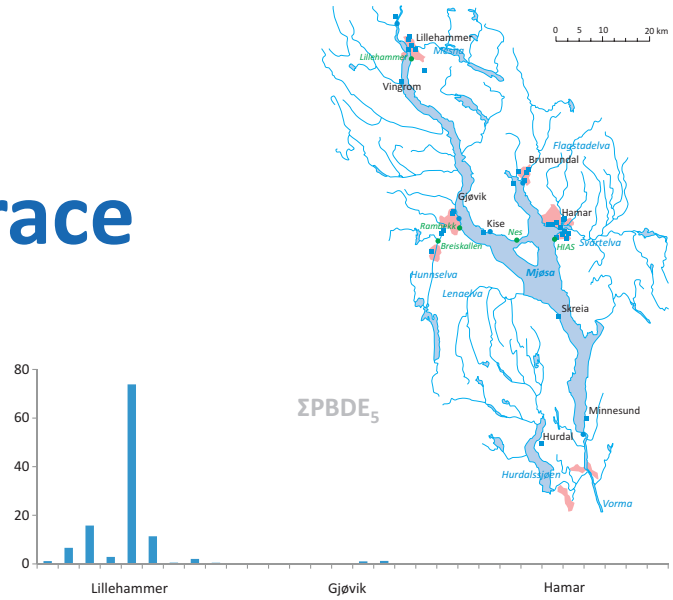
The method used to chemically analyse the PFC's has been developed by a team of NILU and Swerea experts. It is the same step-by-step purification method described in the previous article about the NILU lab in Tromsø .

Only five of the 34 products analysed were shown to contain none of the perfluorinated compounds they were tested for. However, this does not exclude the possibility of there being unknown forms of PFCs in the samples. Furthermore, four of the samples, all in the category of impregnated carpets and leather, were shown to contain the PFC compound PFOS The levels were close to, or in excess of the limits set by the EU for this substance. PFOS was prohibited in Norway in 2007.

The level of PFCs in the other products that were tested did not exceed the EU limits. The researchers behind the study, Dorte Herzke (NILU), Stefan Posner and Elisabeth Olson do however recommend further testing and analysis.

The researchers also concluded that although the levels of PFC may seem low in some products, the huge consumption of these products may lead to considerable emissions to the Norwegian ecosystem, especially in the form of waste.

New Technique to Trace Pollution Sources



Concentrations of five selected brominated flame retardants around Mjøsa (from north to south).

Fish from Norway's biggest lake, Mjøsa, have shown high levels of organic environmental toxins. Now NILU is able to identify the sources of pollution more accurately by using a brand new passive sampling technique.

ANITA THOROLVSEN MUNCH
Journalist

NILU and the Norwegian Institute for Water Research (NIVA) have conducted new research to assess the environmental state of Lake Mjøsa. The studies, commissioned by the Norwegian Climate and Pollution Agency, have used passive sampling – a brand new and cost efficient technique – to trace residue of organic environmental toxins.

– Passive sampling techniques are useful in tracing the origin of organic environmental toxins. Using passive samplers, we can identify the sources of these toxins and find out where they come from in a more efficient way, says Kine Halse at NILU. She has played an important part in the project.

Pollutants from air

Halse says the sampling technique provides vital information about where the pollutants come from and how they are transported.

– We are also able to obtain valuable information about the general environmental toxin impact. Hence, the samplers can be useful in similar studies in the future.

In Lake Mjøsa the problem is primarily PCB (polychlorinated biphenyls), dioxins and brominated flame retardants (BFRs). Dioxins are formed through combustion processes, while PCB and BFRs are industrial chemicals. BFRs were previously used at a plant in Lillehammer.

Organic environmental toxins are easily spread through the atmosphere and a significant part of the toxins in the lake come from the air.

Improving knowledge

In order to reduce the environmental impact in Lake Mjøsa, it is crucial to know more about the origin and transport of toxins. It is especially important to be able to distinguish between air pollution from afar and residue from local sources. The first type of pollution requires international agreements, whereas the second one can be reduced more easily, provided that one has been able to identify the source.

Results from the studies around Lake Mjøsa showed that emissions of BFRs to air were considerable around Lillehammer, even after the company stopped using these substances. Studies also showed that the environmental toxin PCB was emitted to air from an industrial area in Hunndalen around the town of Gjøvik.

Research fellow Kine Halse demonstrates a passive sampler.

CO_2 Capture & Amine Emissions

– NILU pioneering environmental effects research

Currently the most popular technology to capture CO_2 in Norway is through the use of injecting the compound "amines" in industrial processes before the emissions are released to air.

SCOTT RANDALL

Scientist

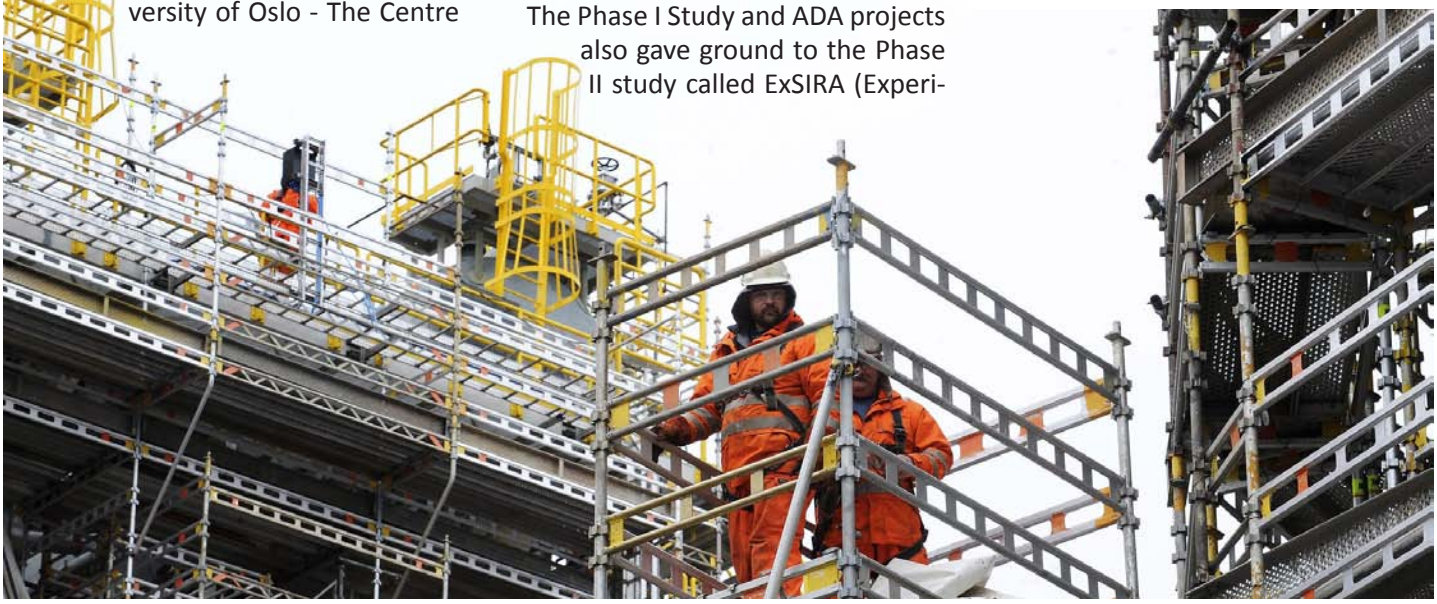
Amines are chemical components derived from ammonia, where the hydrogen atoms are replaced by organic groups. While amines are the most efficient and effective technology currently available to capture CO_2, the effects of amine emissions to the environment are relatively unknown. NILU has been performing ground-breaking research to analyze these compounds and their associated effects, and strongly encouraging industry to take these issues into consideration.

Starting in early 2007, NILU first raised these concerns and initiated a theoretical study with the Norwegian research institutes of Norwegian Institute for Water Research (NIVA), Norwegian Institute for Nature Research (NINA), Norwegian Institute of Public Health (FHI), University of Oslo - The Centre for Theoretical and Computational Chemistry (UiO/UiT-CTCC) through a joint industry/Norwegian Research Council funding mechanism to preliminarily investigate the environmental effects (to terrestrial systems, aquatic systems, and to humans). The Phase I Study concluded in early 2009 and disclosed the findings that there are potential toxicological risks with amine emissions, but the extent of these risks are unknown due to limited prior research regarding amines.

The Phase I results spawned the ADA projects (Atmospheric Degradation of Amines) managed by UiO-CTCC with NILU participation (jointly funded through industry/Gassnova) which began early 2009 and recently concluded that one type of amine, "MEA", may produce harmful degradation products through photo-oxidation; follow-up investigations are currently ongoing to better quantify these degradation products.

The Phase I Study and ADA projects also gave ground to the Phase II study called ExSIRA (Experimental Studies Investigating the Risks of Amines) - funded by industry/NFR to begin mid-2010. ExSIRA will follow-up on the Phase I theoretical work by conducting actual experiments to measure the toxicological and corrosive effects of amines, as well as advanced modeling to determine emission dispersion.

The results from this series of large NILU projects, including other ongoing smaller projects, will provide the carbon capture industry with valuable information regarding how their favorite amines are going to affect the ecosystem when they move to full-scale capture; this can in turn give industry the time and power to adapt the technology as deemed necessary. An additional benefit of this research is for regulatory agencies to use the results when they are considering establishing emissions limits and standards for this technology.



Mongstad energy project EVP, foto: Marit Hommedal

Science Out in the Open

In an effort to make their knowledge available to the public, NILU brings science to the streets and into the classrooms.

ANITA THOROLVSEN MUNCH
Journalist

"Wow! Cool!" Five eighth graders from Oslo glow with excitement as they watch the researcher in front of them, wearing a white coat and protective gloves. In a magic moment, she makes the liquid in the transparent glass tank change colour.

We're at the annual National Science Week in Norway, Forskningsdagene, in the fall of 2009.

This annual event is Norway's foremost arena for publicly targeted information about science and research activities, with events taking place at various locations throughout the country.

With a makeshift lab and a handful of dedicated researchers, NILU has brought their science to street level.

Atmospheric superheroes

– The kind of work we do here is incredibly inspiring. In these kinds of settings we get questions we are completely unprepared for, and approaches we hadn't thought of before. It is both fun and challenging, chemist Hilde Uggerud said.

On a daily basis Uggerud is at The Environmental Chemistry Department at NILU. During the Science Week she set her regular work aside in order to demonstrate how the atmospheric super heroes, OH-radicals, break down pollutants in the atmosphere.

– We hope we can trigger curiosity, and inspire more young people to study the natural sciences, she said.

Engineer Ågot Watne at NILU explains the OH radicals. *Photo: Anita T. Munch*

Polar research

The open air science event was not restricted to the capital city. While Uggerud demonstrated atmospheric super heroes in Oslo, NILU researchers from the International Polar Year project COPOL (Contaminants in Polar Regions) and The Polar Environmental Centre showcased their research at the National Science Week in Tromsø. Here they demonstrated how global warming may enhance the uptake of contaminants in polar marine ecosystems.

Scientist Scott Randall at NILU tells enthusiastic students from class 7A at Jar school about the student project "Indoor climate in the classroom: CO_2 and mould". From left: Anne, Karoline, Helene, Nina and Erland. Photo: Anita T. Munch

According to Communications Manager Anne Nyeggen, the Science Week is a great opportunity to showcase a small part of all the research conducted at NILU.

– It is important to NILU that their research reaches the general public. The Science Week is one of the arenas where we reach a wide audience.

Research in the Classroom

Another important arena is the Norwegian classrooms. For several weeks in 2009, hundreds of students from the Nordic countries set out to measure the level of CO_2 and mould in their own classroom, as a part of the joint Nordic research campaign, Indoor climate in the classroom: CO_2 and mould. The campaign was a joint collaboration between NILU, The School Laboratory – University of Bergen, The Norwegian Centre for Science Education, NordForsk and The Norwegian Science Week.

– CO_2 and mould are both important indicators of how healthy the indoor environment is, Scott Randall, Scientist, said.

– The goal was to find out just how good the indoor climate of Norwegian, Swedish and Danish schools really is. The last time we measured the level of CO_2 in Norwegian classrooms was in 2003. So this has been interesting, especially since the campaign enabled us too see if there were any changes from 2003 to 2009, he said.

Youth visiting NILU

NILU was also one of the partners when the youth research initiative UNGforsk 2009 was organized by Lillestrøm Centre of Expertise and Akershus University College.

Groups of 9. and 10. graders visited NILU in the fall, to get an introduction to the exciting technology at the institute.

– It's incredibly important that children and young people are curious about science, and that they get an understanding of how exciting this research can be. Some of them will become scientists themselves. That's a goal. But it is just as important that we raise awareness on important issues such as the climate crisis and pollution in the cities, Nyeggen concludes.

Can OH radicals be explained by a chemical experiment? NILU tried. Laboratory engineer Mebrat Ghebremskel, right and scientist Lise M. B. Fjellsbø, middle.

Dust Storms Dominate the Air Pollution in the Emirates

NILU has been selected by the Environment Agency in Abu Dhabi (EAD) as the strategic partner for all issues related to air pollution and GHG emissions. NILU is undertaking the air quality measurements and management on behalf of EAD, and is reporting the state of environment in the Emirate.

Satellite photo of a dust cloud moving into the Gulf area on 31 July 2009.

BJARNE SIVERTSEN
Associate Research Director

Suspended particles in the air is one of the main problems in the region, and dust storms give occasionally very high levels of dust in the air.

NILU operates ten automatic monitoring stations located throughout the Abu Dhabi Emirate. Air pollution in Abu Dhabi is dominated by suspended particles in the air. The main sources are linked to dust from the desert areas and to the occurrence of sand storms. These "natural" sources give normally rise to the highest concentrations of suspended particles. Also particulate matter from combustion sources such as traffic and industries can be seen in the data.

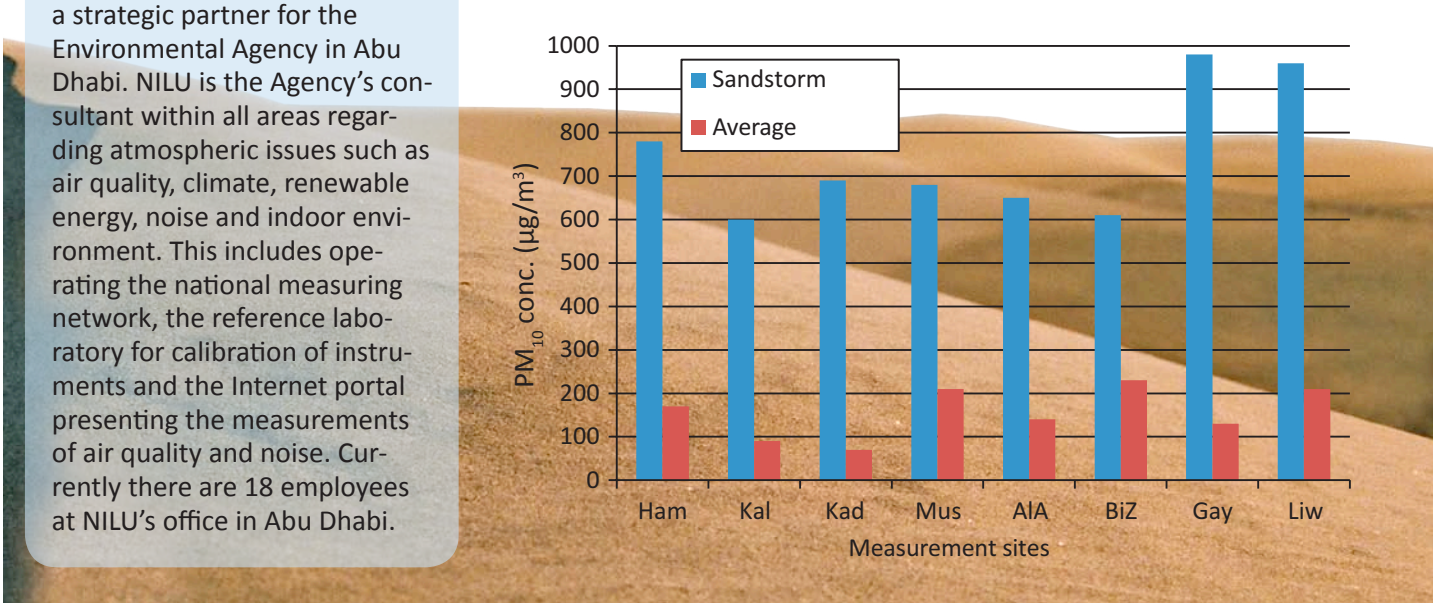
The daily average concentration of PM_{10} often exceeded national and international air quality standards. Violations of the PM_{10} limit values occurred between 20 and 67% of the time in 2007 and 2008. The situation in 2009 has not changed significantly. During dust clouds and sand storms the maximum hourly concentrations of PM_{10} often exceeded 1000 µg/m^3.

Other air pollutants such as carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) were seldom observed at levels above air quality limit values. Concentrations measured near busy streets inside the city of Abu Dhabi normally reached levels less than 50% of the limit concentration levels.

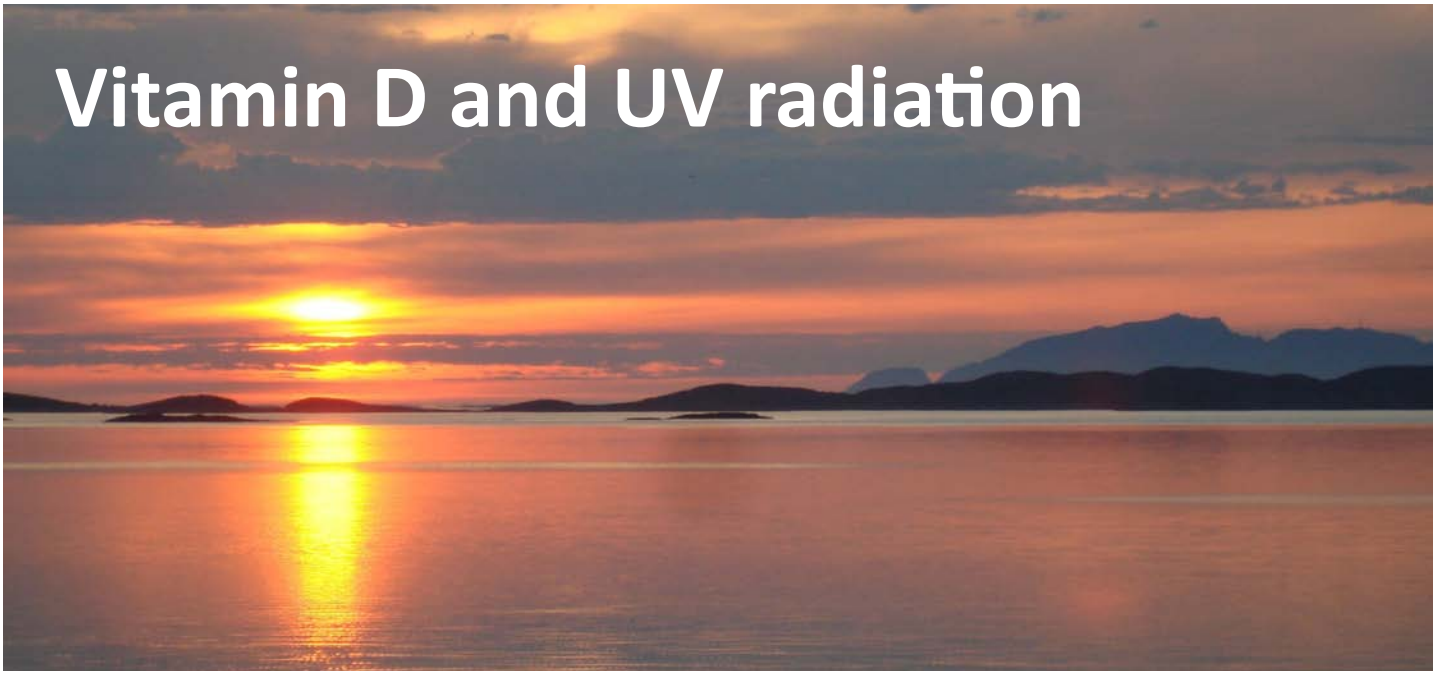
NILU in Abu Dhabi

In 2007 NILU was chosen as a strategic partner for the Environmental Agency in Abu Dhabi. NILU is the Agency's consultant within all areas regarding atmospheric issues such as air quality, climate, renewable energy, noise and indoor environment. This includes operating the national measuring network, the reference laboratory for calibration of instruments and the Internet portal presenting the measurements of air quality and noise. Currently there are 18 employees at NILU's office in Abu Dhabi.

PM_{10} concentrations measured during a sand storm in Abu Dhabi recorded on 3 March 2009. Short term concentrations measured during the storm are shown together with typical average PM_{10} concentrations at 8 sites in Abu Dhabi



Vitamin D and UV radiation

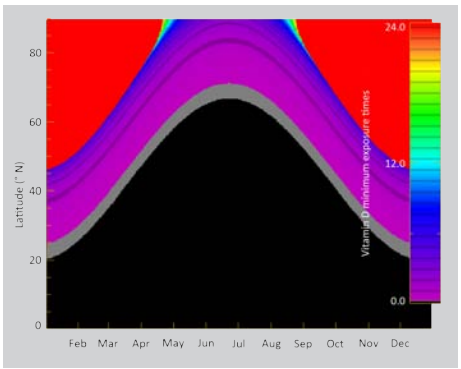


The body needs vitamin D for proper skeletal development. The vitamin has also been shown to have a positive impact on the immune system, and can prevent some diseases such as cancer and osteoporosis. Research shows however that vitamin D is not produced in skin when the UV-B intensity is below a certain level.

OLA ENGELSEN
Senior Scientist

A "vitamin D winter" arises when there is insufficient UV radiation for any vitamin D synthesis to occur in human skin, even for clear sky conditions.

There are just a few dietary sources of vitamin D. In the Norwegian diet, fatty fish such as salmon, mackerel, and trout, in addition to cod liver oil and enriched margarine, butter and milk, constitute the most important vitamin D sources. For most populations, the sun is the most important source of vitamin D, and the diet is of less significance.



Required sun exposure time in hours in order to obtain recommended vitamin D doses in terms of latitude and time of year.

Large seasonal variations in sun intensity in northern Norway make its population particularly at high risk for low vitamin D levels. The traditional marine diet in northern Norway is rich in vitamin D, but this can change with the influx of more international diets in the region.

Vitamin D winter

The half-time of blood serum vitamin D is approximately two months, so the storage capacity of vitamin D is limited. The potential health hazard associated with the vitamin D winter is real: studies show that approximately 2/3 of the Northern Norway population has vitamin D levels below the recommended level in winter. In Norway the vitamin D winter lasts for several months. Vitamin D supplements are then necessary in order to avoid vitamin D deficiency. The weather, ozone, and geography play important roles. Clouds and ozone keep the UV rays out, and greatly limits the ability to synthesize vitamin D from the sun.

An online calculator to estimate the required duration outdoor exposure in order to obtain the recommended dose of vitamin is available at NILUs web page www.nilu.no/VitD

Estimates show that in general more than just occasional exposure in the sun is required in order to obtain adequate vitamin D. The best option, however, is to obtain adequate vitamin through the diet.

Photo: Wikipedia Commons

Fatty fish such as salmon, mackerel and trout are important sources for vitamin D.

NILU as the National Reference Laboratory for Air

Senior scientist Kjersti Karlsen Tørnkvist is head of the reference laboratory at NILU.

NILU acts as the National Reference Laboratory for Air (NRL-Air) in Norway according to demands in the EU Air Quality Directive (2008/50/EC).

KJERSTI KARLSEN TØRNKVIST
Senior Scientist

The NRL assignment was commissioned by the former Norwegian Pollution Control Authority in 2001, now the Climate and Pollution Agency.

The main tasks of the laboratory are to ensure a high quality and comparability of the measuring data collected through the surveillance program for air quality in Norway.

The air pollution legislation in Norway and the European Union sets demands regarding the concentration levels of the various pollution gases through the Norwegian Pollution Regulations and the EU Air Quality Directive.

Quality control and traceability

The quality of the measuring data from the various measuring networks is ensured by using a comprehensive quality control system developed by NRL-Air. The system states procedures for the operators of the instruments in their daily work.

As of 2009, this system is in active use with 14 different network owner/operators in the city surveillance networks in Norway. The system ensures the comparability of the collected data by using measuring instruments calibrated with reference standards that are traceable to common national reference standards.

National database and www.luftkvalitet.info

Each network operator provides monthly reports of quality controlled data to the national database for local air quality. This database is run and maintained by NRL-Air. In Norway, air quality is assessed by seven geographical zones; three city areas and four large regions.

The zones are decisive for the status of air quality reported to the European Union from the national database. The data is also presented online, at www.luftkvalitet.info, where anyone in Norway can check the air quality and status relating to limit values in their area.

Eyjafjälljökull, Iceland, seen from north, 2 April 2010.
Photo: Wikipedia Commons

Innovation at NILU

Innovation at NILU is something which began in the early seventies and continues strongly today. Innovation takes the form of improving or creating new technologies to the development of new processes and analytical techniques. The goal is simply to increase the understanding of our environment by creating new ways of providing more information – more efficiently.

JOHN J. ACKERMAN III
Director of Marketing and Innovation

Innovation can have many definitions and interpretations but the most important focus is the link between research based innovation and commercial opportunities.

NILU conducts more than 250 projects annually and for most of these projects NILU is called upon to be innovative. That is, to create new technologies or techniques which are either not available within the market, or, simply don't meet NILU's current requirements.

In these cases a commercial opportunity may exist. NILU has created an "innovation process" where various steps are followed to determine the commercial viability of the innovation in question. Questions such as funding, resources, market research, IPR (Intellectual Property Rights) etc. must be answered before a project is taken forward. If it meets our criteria then we develop the concept to create a new product or service. If the concept and market potential is strong enough then it would be considered as a potential spin-off company.

NILU has created spin-off companies in the past and the latest, Nicarnica AS, has become the perfect example of research based innovation having an obvious commercial and societal value. The company was established in 2009 to promote solutions for remote SO_2 and ash detection; strong technologies with several commercial possibilities. In light of the recent volcanic eruption in Iceland, the Nicarnica technology for ash detection has been featured in the press on nearly every continent and this looks to be a success story in the making.

We owe it to our funding mechanisms and society in general to make the most of the research we conduct and if commercial opportunities arise, then we must investigate those opportunities.

Senior scientist Fred Prata with his infra red camera to map smoke plumes from the eruption of the Tavurvur volcano in Rabaul harbour in Papua New Guinea.

NILU – Making a Difference for the Environment

NILU is an independent, non-profit institution established in 1969. The institute holds a strong position both on the national and international level within its core fields. NILU's 190 researchers, technicians and other experts are primarily commissioned by the Norwegian research council, by industry in Norway and offshore, and by governmental institutions at local, national and international level. NILU also takes an active part in the EU research programmes.

NILU topics

- Atmospheric composition
- GHG and climate change
- Ozone layer depletion and UV radiation
- Long range transport of air pollution
- Urban and industrial pollution
- Aerosol and particulate matter
- Chemicals and their environmental effects
- Health effect studies
- Ecological economics

Services

NILU offers a range of services and products to customers in Norway and internationally, among them:

Air quality consulting services

NILU has 40 years of experience in handling air pollution issues. By combining highly qualified scientific researchers and in-house software developers, NILU has introduced a complete range of air quality consulting services to meet any requirement.

Chemical analysis

NILU's laboratories can perform advanced analysis on a broad range of organic and inorganic pollutants on all kinds of samples.

From Pole to Pole

NILU monitors climate change, global air quality and air pollution transport pathways through observatories in Norway (Birkenes and ALOMAR – Andøya), in the Arctic (Svalbard, Zeppelin) and in Antarctica (Troll). NILU's observatories supply researchers all over the world with important data on a wide spectrum of pollutants, climate gases and climate forcing agents.

Laboratories

NILU's chemical laboratories are among the most advanced in Europe. The laboratories have a range of state-of-the art analytical equipment, including a series of high-resolution mass spectrometers to determine a broad range of organic and inorganic pollutants.

Health effect laboratory

With the new health effect laboratory, NILU will investigate the direct health impact of pollution, climate change and new materials on humans and animals. Its establishment completes the "circle" of monitoring, modelling, analysing, evaluation and effects implemented at NILU.

International activities

NILU has a long experience in co-ordinating international research projects. The institute takes an active part in the EU's 6th and 7th framework programmes for research. It is also co-ordinating the Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP).

NILU also has a leading international role in collecting and storing measurement data from atmospheric research and monitoring programmes.

Innovation

NILU markets its innovations through affiliates such as:

Nicarnica – a company specializing in the development of UV and IR imaging camera technologies for the detection of hazardous substances in pollution. The first products offered will focus on observations of ash particles from volcanic hazards and industrial SO_2 emission monitoring and applications.

EIFAir – the only existing web based tool for simulation of Environmental Impact Factors of emissions to air. It can be operated from the client's office without any need for special software or hardware.

Some major international NILU clients

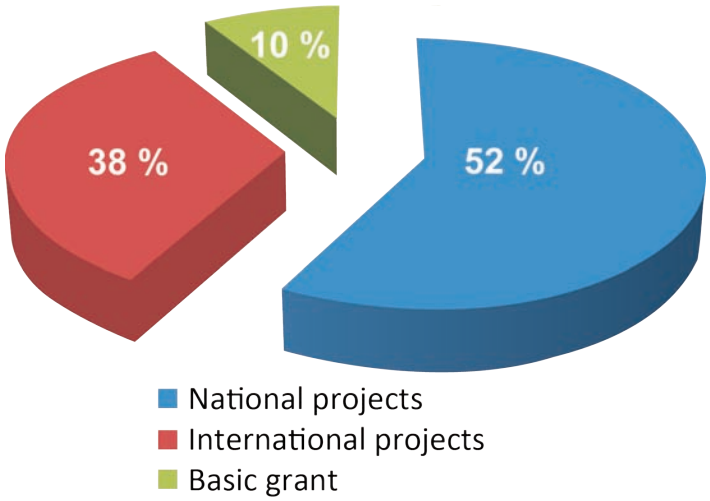
- European Commission (EC)
- European Environmental Agency (EEA)
- United Nations Environment Programme (UNEP)
- United Nations Economic Commission for Europe (UNECE)
- Environment Agency - Abu Dhabi (EAD)
- World Bank (IBRD)
- World Meteorological Organization (WMO)
- World Health Organization (WHO)

Key Numbers

Extracts from the Annual accounts All figures in MNOK

Profit and loss account	2009	2008
Project revenue	164.4	146.9
Basic grant	18.6	15.3
Other operating income	1.4	1.8
Operating revenue	**184.4**	**164.0**
Personell expenses	-117.3	-104.7
Direct project expenses	-31.8	-27.3
Other expenses	-29.0	-36.0
Operating profit/loss	**6.3**	**-4.0**
Net financial items	-1.8	0.4
Operating profit/loss	**4.5**	**-3.6**

Balance	31.12.2009	31.12.2008
Total current assets	66.6	59.6
Total fixed assets	49.2	47.2
Total assets	**115.8**	**106.8**
Liabilities	57.6	52.7
Equity	58.2	54.1
Total equity and liabilities	**115.8**	**106.8**



	2009	2008
Number of man-years	**177**	**173**
- whereof research man-years	95	86
- whereof man-years of other personnel	82	77
Turnover per research man-year	**1 941**	**1 908**

	2009	2008
Number of employees	**192**	**191**
- whereof women	83	82
- whereof men	109	109
Number of employees holding a doctorate	**51**	**48**

International projects - numbers	2009	2008
European Commission	34	29
Nordic Council of Ministers	3	1
United Nations	1	2
World Bank	1	2
Other projects	9	9
Total	**48**	**43**

Project portfolio in NOK and numbers	2009	2008
0 - 100 000	89	80
101 000 - 500 000	84	113
501 000 - 2 000 000	89	88
2 001 000 and over	66	52
Total	**328**	**333**

NILU publications	2009	2008
Scientific papers	124	
Scientific reports	57	82
Technical reports	2	3
EMEP/CCC reports	6	7
Lectures	131	95
Posters	32	27
NILU scientists also contributed to the publishing of:		
External reports	15	25
Papers in books/reports	70	25

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