

# SIOS Gap Analysis Working Group 6:

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## Pollution issues in Svalbard

VERSION 3

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**Editor: Roland Kallenborn**

### Motivation

Persistent environmental pollution is a major environmental challenge that the Arctic in general and the Svalbard region in particular are facing today. Thus, the influence of anthropogenic and biogenic pollutants on the environmental quality in and around Svalbard is an integrated topic of the planned *Svalbard Integrated Arctic Earth Observing System (SIOS)*.

A major first step towards a realistic concept for a coordinated Earth System observing facility in the Svalbard region (including Bjørnøya) is to identify key scientific topics and associated infrastructure needs in order to generate an observation/instrument gap analysis. All relevant scientific priorities will be addressed in the below evaluation report. This includes topics like:

- 1.) The suitability of Svalbard to address these questions.
- 2.) The identification of already available resources and infrastructures.
- 3.) The need for new scientific tools to address the identified scientific issues adequately.

During the first stage of the SIOS project development process it was planned to deal with the topic of pollution as an integrated element of the 5 established gap analysis working groups (i.e., upper atmosphere/solar terrestrial coupling – the coupled atmosphere-ocean-cryosphere climate system – environmental changes and marine ecosystems – environmental changes and terrestrial systems – long-term geophysical processes). However, the established groups realized that pollution is relevant in nearly all working groups and research issues addressed. Thus, in most cases, environmental pollution research was not considered as a separate research issue, but integrated as a research area within complex interdisciplinary environmental research activities. Therefore, the SIOS leader group decided that also during the gap analysis process these cross-disciplinary issues should be addressed in an independent working group.

As also done in the other groups, the following questions were identified by the selected group members (experts) as scientifically relevant to be dealt with in working group 6:

- 1) What are the crucial scientific future challenges for pollutant research in Svalbard?
- 2) Is Svalbard naturally suited as a field laboratory for environmental pollutant research?
- 3) What infrastructure is available and what is needed to adequately address the above-mentioned research priorities?
- 4) How can the infrastructure be organized in the best way?
- 5) What can be the role of the Knowledge Centre in this research field?

The working group 6 was established in a relative late stage of the SIOS process and consisted of the following members and experts (C: Environmental analytical chemists, E: biologists and ecotoxicologists; A: Administrator):

- Roland Kallenborn (Group leader, Norwegian Institute for Air Research = C)
- Geir Wing Gabrielsen (Norwegian Polar Institute = E)
- Aleksey Konoplev (RPA "Typhoon" Obninsk, Russia = C)
- Lars-Otto Reiersen (AMAP = A)
- John Munthe (Swedish Environmental Research Institute, IVL, Sweden = C)
- Jonathan Verreault (University of Quebec in Montreal, = E)
- Bjørn Munro-Jensen (Norwegian Technical University, Trondheim, Norway = E)
- Henrik Skov (National Environmental Research Institute, Denmark = C)

### **SIOS research needs and scientific priorities**

As major research priorities within the SIOS co-operation the following topics are identified as most relevant for Svalbard as environmental pollutant research location. Thus, the joint research activities within the SIOS environmental pollution research (WG 6) is expected to provide:

1. Harmonized information on basic parameters ruling the dynamics of pollutant exchange processes between the different compartments.
2. Quality-controlled empirical data and information on exchange rates for indicator compounds as important input in evaluation and validation of models and empirical information.
3. Reliable information on temperature and wind dependence and other physical, oceanographic, geographic and meteorological parameters that is crucial for exchange processes.
4. Scientific information on seasonal variations influencing exchange rates and contaminant levels.
5. Scientific estimates of climate dependence for environmental pollutant exchange processes.
6. Reliable empirical data input to already existing models and important scientific input for new concepts within modeling and scenario assessments.
7. Data on potential biological effects and/or responses in exposed Arctic wildlife to environmental pollutants.

Based upon today's knowledge on pollutant influences on the Arctic ecosystems, the following research needs are identified for SIOS environmental pollution research. These key topics represent the anticipated research priority on environmental pollution for Svalbard (specifically organic contaminants as well as metals and radioactivity) for the next decade.

- The role of increasing forest fire events in boreal forests as a source and transport mechanism of pollutants into the Arctic must be investigated.
- The role of the Marginal Ice Zones (MIZ) in the Barents Sea for the (re-)distribution of ice-trapped environmental pollution in the Eastern Arctic environments is a priority research area.
- Sea surface –atmosphere exchange processes for pollutants in the light of a changing climate must be elucidated scientifically.
- Monitoring of new and emerging contaminants in Arctic environments (biota, atmosphere, sediments, and soil) must be given priority.
- New pathways and exposure risks for the Arctic terrestrial environment (biota, vegetation etc.) must be investigated.

- Migrating marine species and invading species as contaminant carriers (importers) should be evaluated.
- Increased ship traffic with the risk for introducing new species and contaminants into the Arctic ecosystems is identified as an important research subject.
- The growing complexity of new and emerging environmental pollutants in the Arctic and its potential toxicological impact in exposed wildlife must be addressed.
- Future local source evaluation (off-shore activities, on-land and coastal installations) must be included in environmental research on Svalbard.

Based upon the above described scientific information and the current research status, it seems evident that levels and distribution patterns of contaminants including POPs and volatile chemicals are influenced by long-term and rapid changes of the local and regional climate (within years). Special focus should be laid upon inter-compartment exchange processes (comparable to the ATMOKONG initiative under the flagship program in Ny-Ålesund, see Svalbard science forum). In case of substantial increase of human activities in the Arctic (incl. off-shore industry, growing settlements, on-land exploration of minerals, etc.) in the future, it is expected that new short-lived chemicals will be introduced and primary sources will move closer to the Arctic. As general tenor, we expect that the composition, distribution patterns as well as the environmental stability of priority pollutants in the Arctic will change considerably with potential consequences for human and wildlife population health.

### Background information

During the past decade, environmental pollution research has been one of the major scientific foci in Svalbard. During the International Polar Year (2007-2009), a series of comprehensive research activities on pollutant issues have been performed within various projects around Svalbard, including COPOL, OASIS, BirdHEALTH, BearHEALTH etc. (for info see project descriptions on [www.ipy.org](http://www.ipy.org) or the respective project internet pages). Today, Svalbard plays a central role as research observatory for pollution research (atmospheric transport, bioaccumulation into top predators, etc.).

In addition, for POPs, the longest continuous atmospheric data series in the European Arctic exists for the Zeppelin Atmospheric Monitoring Station in Ny-Ålesund (Svalbard). The monitoring program is established as an integrated part of the National Norwegian atmospheric pollution monitoring program and report annual results to the Arctic Monitoring and Assessment Programme (AMAP), as well as the European Monitoring and Evaluation Programme (EMEP). The data series from the Zeppelin station revealed recently that hexachlorobenzene (HCB) levels have been increasing continuously since 2003. This positive temporal trend may be due to increased volatilization of previously deposited HCB from open water surfaces along the western coast of Svalbard, which has been ice-free during four winter seasons between 2003 and 2007 (Hung et al. 2010).

During the recently finalized first efficiency evaluation of the global POP Stockholm Convention ([www.pop.int](http://www.pop.int)) it is stated that the Canadian and Eastern European Arctic (Svalbard region) belong to the best covered areas in the world with respect to atmospheric monitoring of persistent organic pollutants (POP), metals and climate related emissions (Greenhouse gasses = GHG).

Thus, Svalbard as research platform of environmental pollutant research plays a major role in the international research community with respect to environmental sciences in the Arctic. It is therefore obvious to consider Svalbard as a suitable location for a joint European research platform for Arctic pollution research as integrated part of the SIOS large scale research facilities.

## Priority frame for the gap analysis on environmental pollution research in Svalbard

### What are the crucial scientific future challenges for pollutant research in Svalbard?

As already outlined, the major future challenges with respect to international environmental pollutant research in the Arctic are expected to encircle the following five major topics:

- 1.) The influence of climate change on introduction, distribution, accumulation and transformation of anthropogenic pollutants (sources and sinks).
- 2.) The potential role (sources and effects) of new and emerging contaminants in the Arctic environment.
- 3.) Complex mixture (contaminant cocktail) effects on wildlife in the Arctic.
- 4.) The change and development of human activities in the Arctic and associated pollutant issues (local sources of new and less persistent pollutants).
- 5.) Development of new methods and technologies for the integrated “ecosystem directed” evaluation of risks associated with anthropogenic pollution in the Arctic.

The Svalbard region has the potential to play a major role in developing new research concepts under the SIOS umbrella on the local and regional processes leading to accumulation of pollution in the Svalbard ecosystems. The focus should, however, be directed towards potential local features influencing the occurrence and fate of pollution in the region. More scientific emphasis must be placed on topics like:

- Elucidation of the potential role of the increased tourist, fishing, population and industry development on the islands for the local pollutant situation (shipping, land-based activities).
- Contribution to the development of new, pollution-free technologies, with the potential for employment in Arctic activities (industry, tourism, shipping, etc.).
- Development of abatement strategies for reduction or even avoiding release of pollution into the Arctic environment in conjunction with local partners (community, tourist agencies, Store Norske Kull kompaniet = SNSK in Svea).  
Hydrological and oceanographic transition from North Atlantic to Arctic marine conditions (a pollution perspective).
- Investigation of the Marginal Ice Zone (MIZ) as accumulation zone for the release of ice-transported pollutants.
- Evaluation and baseline studies of the pollutant situation on the terrestrial ecosystems in Svalbard.
- Research on the transfer processes and dynamics between “atmosphere –sea surface”; “sediment – water”, “soil – atmosphere”; “water – biota”
- Contribute with reliable concentration data on the development of regional models for the prediction of spatial and temporal pollutant distribution.

Due to the internationally recognized relevance of pollutant research in Svalbard, all these above-mentioned topics must be embedded and harmonized with international research activity within the Arctic via direct international co-operation, via conventions (OSPAR, PARCOM, MARPOL, ICES, LRTAP Aarhus, Stockholm POP), international monitoring programs (UNECE-EMEP, CAMP, GAW) as well as through circum-arctic scientific regional co-operations (AMAP, SWIPA).

### *Requirements and future research priorities*

During the past decades, the Svalbard region has already developed into an important international research platform for environmental pollution research and is well recognized internationally. This position should, thus, further strengthen the internationally coordinated research activities via SIOS

collaboration as a primary goal. Both the development of innovative technologies for risk assessment, abatement technology, ecotoxicological investigation as well as monitoring and campaign studies on fate and levels of contaminants should be integrated into a joint SIOS concept for pollution research.

Due to optimal accessibility in conjunction with already available infrastructure both in Longyearbyen, Ny-Ålesund and Barentsburg, SIOS environmental pollution research in Svalbard has a strong potential to further develop into the world foremost research location for Arctic environmental pollution research. The implementation of local industry partners and the associated infrastructures into environmental research initiative must be considered as highly beneficial for the expected research quality. Therefore, also for future research the van Mijen fjord region and Svea should be integrated as important research platform in Svalbard (via UNIS, SINTEF or directly with SNSK as partner).

Especially, the close co-operation with Russian and Polish research partners, institutions and infrastructures in Barentsburg, Grumant, Pyramiden and Hornsund must be considered as an important future asset in Svalbard not only for environmental pollutant research.

A first study addressing the influence of earlier research activities on the Svalbard environment has been done at Kinnvika (Nord-Austlandet) as co-operative project between UNIS and the Polish Hornsund team (MSc thesis, UNIS, Eliza Harris 2009). A total of 60 soil samples have been analysed for polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCB). Very high levels of PAH and PCB have been found in contaminated soils around the old Kinnvika station more than 50 years after the research activities around the station during the second IPY were finalised. Therefore, as future challenge for SIOS, all field and research activities planned under the SIOS umbrella performed on the archipelago should consider an “environmental impact assessment” including potential pollution risk as integrated evaluation tool for the SIOS committees before the field work is accepted.

As already described, also research activities and associated infrastructures may cause continuous pollution release. Therefore, as part of the recommended SIOS environmental quality control program (SIOS-QC), it is suggested that all research locations for environmental pollutant research (including monitoring) should provide relevant information for the development of a “SIOS background station certificate”. In this context a comprehensive internal local monitoring program for the surveillance of key parameters should be established as local impact assessment on pollutants introduced via local sources (tourist activities, transportation, energy production, supporting infrastructure and research activities).

The increase of scientific activities in Svalbard will, without any doubt, result in a wealth of sample materials of unique scientific value also for future research. It is thus recommended to develop a local sample/specimen bank in Svalbard (located either in Longyearbyen or in Ny-Ålesund) dedicated for future environmental research and analysis. Otherwise, the samples will be lost and disappear in the sample archiving facilities of the respective institutions that have been responsible for the field work. All groups involved in pollutant research in Svalbard associated to SIOS and/or SSF should provide aliquots of their sample materials to the above described sample bank for potential future research. This will also render those samples available to the Svalbard research community, thus potentially enhancing collaborative initiatives beyond already established research groups in Svalbard

## Is Svalbard naturally suited as a field laboratory for environmental pollutant research?

Three major local site specific features for Svalbard as research location have been identified with the strong potential for unique international research on environmental pollution in the Arctic.

### **Transition from North Atlantic to Arctic marine conditions**

A crucial advantage with Svalbard as research area for pollutant research is the location on the oceanographic transition between North-Atlantic and High Arctic marine conditions. This dynamic transition will play a major role in the definition of climate influence on the marine and coastal environmental conditions around Svalbard including the ecosystem composition as well as the inflow and exchange of pollutants through water masses. This unique feature will strengthen the role of Svalbard as Arctic research and monitoring site in general for future integrated environmental research on the Archipelago and Bjørnøya.

In addition, the Svalbard region incl. Bjørnøya is situated on the edge of the marginal ice zone (MIZ) in the Eastern Barents Sea, where huge amounts of nutrients are released and transferred into the lower food web during the melting season (June-August). This event subsequently triggers an eminent biomass production, which is today considered as the basis for survival of almost all ice-associated organisms in the marine ecosystem of the North-western Barents Sea. The uptake of nutrients is closely associated with lipid production in the lower pelagic ice-associated food web. The lipid and associated lipophilic POP transfer from the lower into the higher trophic levels is directly associated with the high bioaccumulation potential of these POPs in Arctic top predators like seabirds (e.g., glaucous gulls) and marine mammals (e.g., Arctic Fox, polar bears). A wide range of exposure-associated biological effects or responses have been reported in Svalbard glaucous gulls and polar bears (Letcher et al., 2009; Verreault et al., 2009), which may be associated with spring pulse release of lipid rich biomass from the annual MIZ melting. In addition, the spring melting pulse is also a very sensitive period for predating sea birds, preying along they ice age. During this period of the year, the life of birds and mammals is associated with reproduction (high energy-demanding period) and fasting (emaciation).

In combination with already available infrastructure like laboratory facilities (Longyearbyen and Ny-Ålesund) and already available long-term monitoring data (Zeppelin, Bjørnøya, Ny-Ålesund), comprehensive automated *on-site* monitoring programs and ship-based sampling campaigns must be initiated along the MIZ, in order to survey the dynamics of these annual melting events and the consequences for pollutant up-take into the Arctic environment, the food web and ultimately the human consumers.

### **Long range transport**

The already available information, derived from a series of monitoring and biosurveillance programs both in Ny-Ålesund (atmospheric monitoring: Zeppelin station) and Bjørnøya (seabird monitoring) are impressive examples of the suitability of the Svalbard region. The Svalbard region belongs to the internationally high ranked Arctic location for the investigation of long-range transport of pollutants (marine and atmospheric). This position can even be strengthened by implementation and coordinating of all international research efforts within this growing field of interest by including Polish and Russian stations into the international research on LRT on Svalbard. For example, from 2002 to present time RPA "Typhoon" (Russia) implements extensive monitoring program at Barentsburg. The program includes sampling of air, snow, sea and surface water, vegetation,

sediments and soils, and analysis of samples for POPs (PCBs, OCPs, PAHs) and heavy metals. Ambient air is analyzed for SO<sub>x</sub>, NO<sub>x</sub>, greenhouse gases and ozone. These activities are not co-ordinated with monitoring and research in Ny-Ålesund, where similar research programs are performed.

### **Temporal trend of pollution in the Arctic (ice and sediment core studies)**

Beside Greenland, Svalbard is the location in the European Arctic with the highest extent of ice caps. More than 60% of the archipelago is covered by ice caps. Due to the relatively easy access and favorable logistic infrastructure, the ice caps both on the main island “Spitsbergen” as well in Nord-Austlandet” are well suited for comprehensive research activities. They are providing an excellent working ground for ice core studies on the temporal distribution of selected pollution under background conditions. First results by Hermanson et al. (2006) confirmed that this type of studies provide important information on the global behavior of pollutant transport as well as the deposition properties of new and emerging contaminants in Svalbard. First investigation on freshwater sediment cores show that similar or even complementary information can be provided by this type of research on Svalbard.

### **What infrastructure is available/what is needed to address the above mentioned research priorities adequately?**

Eight major research areas have been identified earlier (see above) describing the here identified priority research frame for future pollutant research in Svalbard. Based upon local features, significant contributions to Arctic environmental pollution issues are expected.

Although the accessibility and the available infrastructure on the archipelago must be considered as highly valuable in a general context, the hardware and infrastructure available is not suited to tackle the scientific challenge associated with the above-described scientific priorities expected for future Arctic environmental pollution research.

#### ***Basic infrastructure available***

As already described in the general introduction for SIOS, housing facilities, general laboratory infrastructures (research park, marine laboratory), Ny-Ålesund, Barentsburg, Hornsund as well as transportation support (ships, land based transportation, air based transportation) is available and accessible for all scientific priorities within SIOS. In addition, considerable expertise for planning and logistics is available at various institutions in Longyearbyen, Barentsburg, Hornsund and Ny-Ålesund, which can be utilized for planning and design of research activities on the islands. This infrastructure is considered as the backbone for field work, monitoring and campaign based research in Svalbard in general.

However, for environmental pollution research, no dedicated infrastructure currently exists in Svalbard, except for three fixed installations exclusively dedicated for pollutant research and monitoring (tool for pollutant research, table 1):

- 1.) The “environmental chemistry” laboratory at UNIS equipped with basic trace analytical instrumentation for the quantitative analysis of persistent organic pollutants (POPs).
- 2.) The long-term atmospheric monitoring program at the Zeppelin Mountain with partially automated instrumentation for the monitoring of priority pollutants under a series of international conventions and analytical programs.
- 3.) FerryBox monitoring devices installed by NIVA on MS Fram and MS Nordbjørn (commuting between Tromsø and Svalbard).

Table 1: Summary of all existing infrastructure applicable for environmental pollution research on Svalbard

Location	Infrastructure	Research focus, instrumentation and compounds	remarks
<b>Ny-Ålesund</b>	Marine laboratory	Sampling and storage facility, Pollutant uptake and fate studies	Laboratory experiments
	Zeppelin station	Monitoring of atmospheric pollution (LRT)	Continuous monitoring
	Sverdrup station	Biological exposure studies, Ozone atmospheric/ stratospheric measurements, radiation	Field studies
	AWI	LIDAR measurements	
<b>University Centre in Svalbard (UNIS)</b>	Environmental chemistry Laboratory	Process related studies, up-take, distribution and transformation of pollution (independent of compound specification. Sampling and sample preparation techniques	Laboratory experiments
	Instrument laboratory: GC/MS, GC-ECD, GC-FID, HPLC-DAD	Persistent organic pollutants, polycyclic aromatic compounds (PAH), Volatile chemicals (VOC),	Lipid, POP and VOC analysis and quantification
<b>Hornsund</b>	Ion monitoring	Ions and acid compounds	
<b>Barentsburg</b>	Field sampling/ meteorology	POPs (PCBs, OCPs, PAHs), HM	Ambient air, snow, sea water, surface water, vegetation, sediments, soil
<b>FerryBox</b>	Automated monitoring on vessels (Norbjørn)	Oceanographic parameters, various pollutants	NIVA

As normal procedure for international environmental pollution research on the island, it is accepted that the respective research groups are relying on their own fixed installations in the respective institutions, whereas logistical support and lab-access is sought for larger field campaigns in Svalbard. The advantage of these procedures is the obvious minimal requirements for instrument and laboratory support. However, long transport ways of samples and exceeding storage time is often the consequence leading to high contamination risk, thus reducing the quality of the sample material and the scientific results.

Therefore, the philosophy behind the SIOS environmental research should be to offer the respective research group reliable high quality facility and logistical support for on-site sampling, sample treatment and (if required) basic analytical/quantification instrumentation (at least the option for installation of instruments during campaigns) in a controlled “clean” laboratory in Svalbard.

In order to address the above described research priorities a series of new infrastructures must be installed or even developed as an integrated part of the research priority. Recommendations for permanent infrastructures dedicated to environmental pollution research are described (table2).

Table 2: Research infrastructure descriptions recommended for SIOS Environmental Pollution research

Priority	Infrastructure	Remarks
Local sources: Communities, stations, Tourism and industry	Emission monitors and sampling stations	Co-operation with tourist agencies and local industrial partners required
Transition North-Atlantic – Arctic conditions	Coordinated pollution research (Ny-Ålesund) Combination of long-term oceanography and environmental pollution research, continuous marine monitoring station (Buoy, etc.) with mobile monitors and sampling stations	The stations are permanently equipped with sampling equipment
MIZ	Variable mesocosms and floating/ ice associated stations employed along the ice rim (permanently equipped with basic measuring equipment, deployed by helicopter or research vessels)	
Terrestrial environment	Dedicated field locations (fixed stations), preferable research locations close to Ny-Ålesund, Hornsund or on Nordenskjöld-land). Coordinated sampling campaigns (field equipment and mobile measuring devices).	The stations are permanently equipped with sampling equipment and have basic laboratory facilities for sampling handling and storage
Transfer processes	Mesocosms, mobile field stations incl. basic laboratories (deployed by helicopter), calibrated sampling and analytical instruments feasible for field work.	
Local sample bank	Establishment of a local sample/ specimen bank in Svalbard providing sample materials well preserved for future environmental pollutant research	Located in Longyearbyen or Ny-Ålesund

**Note: More information on research priorities and economic considerations are given below.**

The above described advanced research infrastructures are not compound specific and will also be highly suitable for research on priority compounds not yet focus on in international Arctic environmental pollution research.

Due to rapid technological development, the number of new potential environmental contaminants identified is rapidly increasing. Based on this the recent experiences in pollution research, infrastructure selected should not be compound (group) specific, but considered as a frame for expanding future research on contaminants (due to the progress of research in the respective areas). Today, monitoring activities in various media (atmosphere –biota – marine) are an important tool for scientific assessments. They are considered as highly relevant and valued by many international researchers and surveillance bodies, incl. conventions and national surveillance programmes. However, for region-specific research addressing the above mentioned key priority issues on location (atmosphere) and biota (Bear Island) is not sufficient. Therefore an extension of the ongoing monitoring activities combined with the establishment of new marine and biota monitoring sites is recommended, especially with respect to the environmental transition between North-Atlantic and Arctic marine conditions (table 3). Alongside the new monitoring strategies, a local specimen/sample pool (sample bank) should be established under the supervision of the planned knowledge centre in the Research Park (Longyearbyen).

A continuous research program (incl. monitoring) for the terrestrial environments (freshwater and tundra habitats) is practically absent on Svalbard for environmental pollution research. Respective measures should be taken to install such a research priority under SIOS.

Table 3: Future long-term monitoring priorities in Svalbard

Priority topic	Planned research focus
Extension of the ongoing atmospheric pollutant monitoring at Zeppelin station and Barentsburg (ambient air) and Bjørnøya (biota)	Integration of new and emerging pollutants in the monitoring program. Establishing automated mercury monitoring of ambient air at Barentsburg
Coordination and harmonisation of pollutant monitoring in bioindicator species in Svalbard and Bjørnøya	Site specific monitoring programs with long-term commitment will be initiated and performed on an annual basis
Joint Svalbard sample bank	Co-ordinate and joint access to arctic Svalbard samples for pollutant studies.
Long-term monitoring of target pollutants in the terrestrial environment	The presence and distribution patterns of anthropogenic pollutants in the terrestrial environment will be continuously monitored in abiotic and biotic samples.
Coordination and harmonisation of biological effects monitoring at Svalbard.	Identify target species (sentinel species) and biomarkers that can unveil harmful biological effects in Arctic species and ecosystems.

### How can the infrastructure be organized in the best way?

For an integrated environmental pollution research effort in Svalbard under the SIOS umbrella, comprehensive efforts in providing and coordinating infrastructure is urgently required if SIOS wish to establish a world leading infrastructure on environmental pollution research on Svalbard. Two major concepts are identified for organizing and coordinating access to infrastructures for complex environmental pollution research in Svalbard.

1. Institute-based organization and co-ordination.
2. Knowledge Center/SIOS secretariat as central coordination office.

#### *Institute based organization and co-ordination*

The here recommended research frame is discussed with all SIOS partners distribution of priority tasks within the SIOS project is agreed upon. The respective institutions will, thereafter, strive to establish the requested infrastructures and maintain the facilities in accordance with the agreement within SIOS (according to a coordinated time frame). The institutions will, thus, have priority access to the respective infrastructure and will report available time slots to the coordination office at SIOS (e.g. knowledge Centre). The Coordination office, will thus announce opportunity for access regularly within associated research programs or via the national research coordination agencies involved in SIOS (preferred as ARCFAC type of announcement) for interested international research communities.

**Advantage:** The institutions involved will be responsible for maintenance and support of the infrastructure. A continuous access will be provided also after the SIOS co-operation has come to an end.

**Disadvantage:** The infrastructure is not directly SIOS associated. Restrictions with co-ordination and priority issues with respect to infrastructure access with other units in Svalbard may be a consequence and will hamper the scientific exchange within SIOS.

### **Knowledge Center/SIOS secretariat as central coordination office**

The respective infrastructures are installed and maintained directly under the auspice of SIOS. A SIOS coordinating office (e.g., knowledge Centre, advised by a scientific board, sub-team on environmental pollution) will coordinate the access and the availability of the units. The Coordination office will announce opportunity for access regularly within associated research programs or via the national research coordination agencies involved in SIOS (preferred as ARCFAC type of announcement) for interested international research communities. Direct access can be granted also outside the application frame in case: 1.) infrastructure is available; the requested access is justified after a thorough scientific (external) scientific evaluation of the relevance and/ or the access is required to gain complementary insights into research aspects within already ongoing SIOS research (not only in environmental pollution research).

**Advantage:** The infrastructures are well integrated into the SIOS research concept and scientific priorities. A direct SIOS ownership will guarantee SIOS associated priorities in research and access.

**Disadvantage:** The institutions involved will not be directly involved in maintenance and support of the infrastructure. Thus, SIOS has to establish a project-based economical frame and internal logistical infrastructure for maintenance and accessibility of the infrastructures. A continuous access will not be guaranteed after the SIOS co-operation will come to an end. In addition, the ownership has to be renegotiated after SIOS is not responsible for the complex infrastructures anymore.

### **What can be the role of the Knowledge Centre in this research field?**

As outline above, an important role of the knowledge centre should be associated with co-ordinating available infrastructures for environmental pollution research across the Svalbard area (incl. Bjørnøya). This includes:

- 1.) Registration of available instrumentation and associated infrastructures available at the respective institutions (infrastructure database available publically for interested scientists)
- 2.) Distribution of information material (pamphlets, and publications upon request)
- 3.) Installation of research specific webpages and preparation of information materials (specifically on environmental pollution research)
- 4.) Hosting of coordinative workshops and seminars within the SIOS family (specifically within environmental pollution research)
- 5.) Development of international research programs for environmental pollution research on Svalbard
- 6.) Follow up, coordination and communication with ongoing research activities in environmental pollution research (field work, monitoring, lab-work)
- 7.) Provide communication tools (conferences, workshops, etc) for internal and external discussions among the environmental pollution researchers involved
- 8.) Communicate the findings of SIOS environmental pollution research internally and to the interested public and outside scientists.
- 9.) Provide a literature database on SIOS research (within environmental pollution research) for SIOS environmental pollution research groups

*Eventually:*

10.) Coordinate, maintain and supervise the infrastructure provided directly through international SIOS economic resources (this incl. responsible technical and scientific personnel, consumables, IT-support etc.)

### **Priority infrastructure needed (logistical and economic considerations)**

In order to address the eight identified research priorities for SIOS environmental pollution research, the following infrastructures should be established and accessible for comprehensive international research activities within SIOS.

#### ***1.) Elucidation of local contamination incl. potential role of the increased tourist, fishing, population and industry developments on the islands for the local pollutant situation.***

Fixed installations needed to address this research priority

##### ***Research stations/communities***

Establishing of a continuous priority monitoring program for all types of human activities in Svalbard including settlements

##### ***Marine transportation and movements***

**Emission monitors** and sampling devices installed in the harbors (Longyearbyen, Barentsburg, Ny-Ålesund) for high resolution monitoring of priority pollutants emitted from ships. The instrumentation is administered by the local harbor authorities and reports to authorities and SIOS. Data will be accessible for all research institutions involved. Installation of emission monitors on the vessels located on Svalbard (NordSysse, NorBjørn, MS Fram, Ms Langøysund, evt. KV Svalbard and KV Andenes).

##### ***Land-based activities***

**Emission monitors** and sampling devices installed in the settlements and all research facilities for monitoring the pollution related impact of these activities on the local Arctic environment. This will include emissions from transportation (snowmobiles, Lorries and other priority use of fuel combustion based machinery).

##### **Expected costs:**

Establishing infrastructure:	400 kEuro
Consumables, personnel, services and maintenance/ Year:	100 kEuro
Analysis and reporting/ Year :	200 kEuro
<b>Investments:</b>	<b>700 kEuro</b>
<b>Running costs/ Year:</b>	<b>300 KEuro</b>

**Responsible institute/ scientist: Roland Kallenborn (NILU/UNIS)**

#### ***2.) Development of abatement strategies for reduction or even avoiding release of pollution into the Arctic environment in conjunction with local partners (community, industry, tourist agencies, SNSK in Svea).***

The here recommended research priority should be organized in close co-ordination with Facility recommendation No. 1, 2, and 4. Svea as research location is considered as highly suitable for field

work associated to this topic. The available energy production sites, sea going vessels and industrial facilities in Longyearbyen, Svea and Barentsburg should be considered as an important frame for the development of effective abatement strategies based upon technologies developed under the Facility recommendation (FR) No. 2. As well as research findings identified through international non-Arctic scientific activities.

Fixed installations, described under FR 2 will be utilized to evaluate potential abatement technologies as the fundament of the planned strategies. The planned knowledge Centre is expected to serve as co-coordinative secretariat for the planned work.

A scientific position at UNIS or one of the associated institution is recommended in order to coordinate research and educational activities as well as to oversee the progress of the SIOS research activities.

**Expected costs:**

Consumables, personnel, services and maintenance/ Year:	200 kEuro
<u>Laboratory and consumables</u>	<u>50 kEuro</u>
<b>Running costs/ Year:</b>	<b>250 kEuro</b>

Responsible institution/ scientist Mark Hermanson (NILU/UNIS)

***3.) Investigation of the Marginal Ice Zone (MIZ) as accumulation zone for the release of ice-transported pollutants.***

The proximity to the annual melting process at the Marginal Ice Zone (MIZ) is one of the major unique features for Svalbard and Bjørnøya as a location for Arctic environmental pollution research.

Mobile un-manned stations equipped with automated sampling and passive monitoring devices for the collection of water, ice and air samples as well as monitoring the ambient conditions during the exposure (wind, temperature, humidity, visibility, particle content in water and air, etc) should be purchased or developed as a part of the SIOS preparatory phase. These units should be able to withstand the extraordinary forces associated with ice movements. . A prototype unit suitable for testing should be developed in close co-operation with experts in Arctic Technology specialized in ice mechanics and geophysics during the preparatory phase of SIOS.

At least 4 final version of the automated station should be available for environmental research purposes. Sampling units may be modified according to the target chemicals and sample types as well as seasonal requirements. Additional devices may be installed upon request (as required by the project work). Safety and communication equipment should be included (for polar bear protection). The units will be available for the requested research activities and applications will be handled and decided upon via SIOS. The units should be stored and maintained at Bjørnøya due to the proximity to the MIZ. Skilled personnel should be available at the Bjørnøya station during the melting period for servicing the instruments and the automated stations.

**Expected costs:**

Consumables, technical personnel, services / Year:	0,2	MEuro
Logistics (access to RV and helicopter)	0.5	MEuro
Development and equipment	2	MEuro
<u>Storage facilities, maintenance and adaptations at Bjørnøya</u>	<u>2</u>	<u>MEuro</u>

**Investments:** **4,7 MEuro**

**Running costs/ Year** **0,3 MEuro**

**Responsible institute/ Scientist: Geir W. Gabrielsen (NPI/ UNIS)**

#### **4.) Evaluation and baseline studies of the pollutant situation on the terrestrial ecosystems in Svalbard**

Terrestrial biosystems are traditionally not considered as highly exposed to legacy pollutants since most of these compounds are directly lipid associated. Thus, no bioaccumulation is expected in Arctic terrestrial top predators. However, first investigation on Ptarmigans in Svalbard have indicated, that new and emerging chemicals and metals (e.g., perfluorinated organic substances, Hg) are associated with proteins and chemical complexes and thus have the potential to accumulate effectively also in terrestrial organisms. Therefore, specifically for new and emerging contaminants the terrestrial food webs must be examined thoroughly with respect to emerging chemicals and their transformation products. In Svalbard, environmental pollution research in terrestrial ecosystems has been neglected during the past decades. Thus, new dedicated infrastructures including mobile stations for housing and sample preparations should be considered. Mobile (commercially available) huts with accommodation and working facilities for 2 scientists/field workers, transportable with helicopters and/or research vessels should be equipped with basic laboratory equipment for sample preparation/clean-up and storage in the field. Around 4-5 units should be available upon request in Longyearbyen (close to the airport facilities). The sampling huts (units) must be able to withstand the harsh weather conditions all over Svalbard and safety as well as communication equipment should be available for all units. The units will be available for the requested research activities and applications will be handled and decided upon via SIOS.

**Expected costs:**

Consumables, technical personnel, services / Year:	1	MEuro
Logistics (Access to RV and helicopter)	0.5	MEuro
Purchase and adaptation, installation of equipment	2	MEuro
<u>Storage facilities, maintenance</u>	<u>0.5</u>	<u>MEuro</u>

**Investments:** **2 MEuro**

**Running costs/ Year:** **2 MEuro**

**Responsible institute/scientist: Roland Kallenborn (NILU/UNIS)**

#### **5.) Research on the transfer processes and dynamics between "atmosphere and sea surface"; "sediment - water", "soil - atmosphere"; "water -biota"**

As already described in detail in the ATMOKONG proposal (for info, contact SSF) at least one field site (preferably in Ny-Ålesund) should be permanently equipped with monitoring/ sampling devices for indicator contaminants relevant for describing exchange processes between the water phase and the adjacent atmosphere. Passive sampling devices (commercially available) suitable for simultaneous

sampling of high volume water and atmospheric samples should be employed continuously. In addition (for quality control reasons), these basic sampling devices should be regularly calibrated against active sampling units (high-vol. air samples as well as sea water samples on a campaign base). The location for the exchange of contaminants in the abiotic environment (water/sea interface) should be associated and coordinated with a similar program on contaminants in biological processes (as suggested in the flagship programs in Ny-Ålesund). Hydrological and meteorological parameters during the monitoring should be covered. As important feature for Svalbard and research location, the hydrological transfer from a North-Atlantic into an Arctic marine environment has been described earlier. The consequences for these changes for pollutant exchange are not investigated yet. It is thus recommended to establish (at least on a campaign basis) two similar stations in Ny-Ålesund (North Atlantic water inflow) and Kinnvika (Nord-Austlandet, Arctic conditions)

**Expected costs (2 units):**

Consumables, technical personnel, services / Year:	0,3	MEuro
Logistics (Access to RV and helicopter, sample change/ 2 month)	0.2	MEuro
Purchase and adaptation, installation of equipment	2	MEuro
Storage facilities, maintenance/ year	0.5	MEuro
<b>Investments:</b>	<b>2</b>	<b>MEuro</b>
<b>Running costs/ Year:</b>	<b>1</b>	<b>MEuro</b>

**Responsible institute/ scientist: Geir W. Gabrielsen (NPI/UNIS)**

**6.) Sample/ Specimen bank for future environmental pollution research**

As an important legacy component of SIOS environmental pollution research and as asset for future technological development within analytical chemistry and ecotoxicology, it is recommended to establish a sample/specimen storage bank in Svalbard under the auspice of SIOS. It is expected that SIOS will trigger a large number of environmental pollution research activities including field work on locations that might be difficult to access for subsequent sampling and scientific activities. In addition, locations are expected to change due to environmental change in the next decades. The MIZ will most probably move northwards, ice caps will decrease in size and volume and weather conditions are expected to change as well. Therefore, the preservation of representative sample materials from Svalbard is critical.

- 1.) Preservation of sample information from a period not yet strongly influenced by environmental change processes
- 2.) Allow future technologies to be tested on historical sample materials for temporal trend studies
- 3.) Identify the presence of emerging (not yet identified contaminants and/or transformation products) in historical (archived) samples

Especially the need for large volume, low temperature storage facilities is recognized based upon international experiences with this type of storage facilities. Experience personnel need to be employed for the continuous maintenance and surveillance of the storage systems. A back-up system/emergency procedure for temporarily storage of the historical samples in case of power failure or other emergency situations must be developed (in coordination with local available facilities in Svalbard). The Norwegian Directorate for Climate and Pollutants (KLiF) is recently developing a concept for a national sample bank in Norway. The here suggested facility may be linked into this initiative. Discussions with KLiF on harmonization and co-operation of the two

systems should be considered. This Svalbard/SIOS sample/specimen bank should be located in Longyearbyen due to the need for continuous electrical power and the availability of back-up storage facilities (e.g., abandoned mines, seed vault).

**Expected costs (2 units):**

Consumables, technical and scientific personnel, services / Year:	0,8	MEuro
Installation of low-temperature freezing facilities and back-up systems	1,5	MEuro
Maintenance and services/ year	0.2	MEuro
<b>Investments:</b>	<b>1.5</b>	<b>MEuro</b>
<b>Running costs/ Year:</b>	<b>1</b>	<b>MEuro</b>

**Responsible Institute/ scientist: Jonathan Verrault (U. Quebec, Can)**

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