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SPECIAL ARCTIC ISSUE

In this Issue:

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Back: Cottongrass in Rankin Inlet, Arctic Poppies, Polar Bear sow and cub, Caribou, Nunavut.

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CSEB NEWSLETTER 2011

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The Canadian Society of Environmental Biologists Newsletter is a quarterly publication. The Newsletter keeps members informed of the Society's activities and updates members on the current affairs and advances in the field of environmental biology. This publication draws together the widely diverse group of Canadian environmental biologists through a national exchange of ideas. Members are invited to contribute papers, photos or announcements that are of a national biological and environmental interest. Letters to the editor are welcome. This is a volunteer non-profit organization and we rely on your participation to make the newsletter a productive forum for ideas and discussion.

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LE BULLETIN de la SCBE 2011

Vol. 68, Numéro 2 Éte 2011

Le Bulletin de la SCBE est une publication trimestriel de la Société Canadienne des Biologistes de l'Environnement. Le Bulletin informe les membres des activité de la Société sur événements courant ainsi que les progrès qui font en sciences de l'environnement. Par un échange d'idées au niveau national, cette publication intéresse un groupe très diverssifié d'environnementalistes Canadien. Les membres sont invités a contribuer des articles, photos (noir et blanc) ou des messages qui sont d'intérêt nationale en sciences biologiques et environnementales. Les lettres à l'editeur sont bienvenues.

Tout la correspondence d'affaires, y compris les abonnements, les changements d'adresse, les exemplaires retournés et les formulaires: CSEB National Office, P.O.Box 962, Station F, Toronto, ON, M4Y 2N9. **Les lettres à l'editeur: Gary Ash, Editor, courriel: gash@golder.com**

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The Canadian Society of Environmental Biologists

CSEB OBJECTIVES

The Canadian Society of Environmental Biologists (CSEB) is a national non-profit organization. Its primary objectives are:

- to further the conservation of Canadian natural resources.
- to ensure the prudent management of these resources so as to minimize environmental effects.
- to maintain high professional standards in education, research and management related to natural resources and the environment.

OBJECTIFS de la SOCIÉTÉ

La Société Canadienne des Biologistes de l'Environnement (SCBE) est une organisation nationale sans but lucratif. Ses objectifs premiers sont:

- de conserver les ressources naturelles canadiennes.
- d'assurer l'aménagement rationnel de ces ressources tout en minimisant les effets sur l'environnement.
- de maintenir des normes professionnels élevés en enseignement, recherche, et aménagement en relation avec la notion de durabilité des ressources naturelles et de l'environnement, et cela pour le bénéfice de la communauté.

ARCTIC ISSUE Preface

Anne Wilson, CSEB Regional Director.

Welcome to the Northern-themed Summer CSEB Newsletter. There is a lot going on in the north, and that was a factor in getting busy people to contribute their articles! To provide some context for the activity happening in the North, current environmental assessments include mining proposals for gold, base metals, iron ore, uranium, rare earth elements, and diamonds. There are all-season cross-tundra road proposals, municipal wastewater issues, oil and gas exploration and production, and hydroelectric projects. Each of these will leave a footprint that touches the terrestrial and aquatic ecosystems, the airshed, and subsurface regimes for permafrost and groundwater.

There are many dedicated and diligent people working in the field of natural sciences in the North, and I would like to take this opportunity to recognize all the good work that is being done. This issue features an article on the wastewater work being done in support of the Canada-wide Strategy for Municipal Wastewater Effluents. I've had the pleasure (really!) of participating in some of the lagoon sampling and am so pleased this work is being done. There is not enough known about biological processes at high latitudes, given the seasonal extremes of light and dark, and the winter temperatures. I am grateful to our colleagues at BHP Billiton's Ekati mine for an excellent article on the progress being made with revegetation techniques. I've taken the liberty of including a photo from the early test plots on Long Lake (Photo 1). At that time one of the biggest challenges was keeping the hares from eating the test subjects! Thanks also to the Snap Lake Mine folks for the Golder submission on work done on major ions. This is an issue that has been emerging on the regulatory front for several years, and is stimulating some good research.

And, no Northern piece would be complete without a picture of a husky – to tickle your funny bone!

This will be my last submission from Yellowknife; after 32 years in the North, I will be relocating to Alberta, although still working on many NWT and Nunavut files.

Paula Smith, CSEB Regional Director.

Between Canada's three territories, the Yukon, the Northwest Territories, and Nunavut, Canada's Arctic accounts for 40% of the landmass and covers 3.5 million square kilometers. Within this huge area, the Arctic includes many landscapes, habitat, and features not to mention incredible floral and faunal species, not seen south of 60°.

Despite the Arctic comprising such a big part, physically, of Canada, few experience its beauty. Access is limited and costly, and weather conditions generally aren't hospitable but the rewards of research in the North are unparalleled. Those of us that live up here experience a different side of Canada.

Unfortunately, it seems that the North is in the news for all the wrong reasons these days – the poor shape of our landfills, historical contamination, the effects of climate change on Arctic species – not exactly encouraging or inspiring reasons. Interest in oil and gas, and the mining sector in the region also has researchers concerned with balancing the demand for development with the protection of critical habitats and species at risk.

Anne suggested the idea of an Arctic edition of the newsletter and this is our first attempt.

We're hoping that this issue is an opportunity to share work that is occurring in the North and hopefully inspire others to explore the region. We're grateful for the contribution of content from researchers in the North, and hopefully this will become an annual issue to spotlight what is truly an amazing part of Canada.

Photo 1. EKATI Mine's Cell B test plots, on Long Lake. 13/07/2003 Photo Credit: Steve Harbicht.

Revegetation Research at the Ekati Diamond Mine

Written by H.E. Martens, Acknowledgements to Helen Butler of BHB Biliton.

Introduction

The land north of 60° includes a wide range of vegetation, terrain and climatic conditions. As one moves northwards, coniferous forest gradually gives way to open woodland, tundra and polar desert in response to increasingly cooler and drier conditions. Much of the land is flat to gently rolling and underlain by permafrost (ground that remains frozen for at least two consecutive summers). Although many of the principles of reclamation applicable to southern areas can be applied in the North, they must be modified in response to a rigorous climate and permafrost soils.

The focus of this article is on the EKATI Diamond Mine revegetation research conducted as part of mine reclamation planning. The EKATI Diamond Mine is operated by BHP Billiton Canada Inc. (BHP Billiton). Considerations and limitations are discussed with respect to the revegetation of disturbed areas following management of permafrost soils, surface drainage and erosion control, and site recontouring at this northern mine site.

EKATI Mine Site

The EKATI Diamond Mine lies within the Bear Slave Upland of the Canadian Shield (Bostock 1970). Glacial features including boulder fields, till blankets, eskers, and numerous kames and kettle lakes dominate the landscape. Where fine-grained sediments have accumulated, plant communities have formed. The vegetation is dominated by ericaceous shrubs and lichens, while riparian willow, emergent wetland, and tussock tundra communities occur in stream drainages, along lake margins and in till depressions (Photo 1). The climate is continental with long, cold winters (-10°C to -30°C) and short, cool summers (10°C to 20°C). Precipitation is sparse (average 300 mm/year) and consists of approximately equal amounts of rain and snow. Winds are moderate and predominately from the northwest. The mine area lies within the zone of continuous permafrost. The depth of the active layer depends on soil composition, but generally ranges from 30 to 40 cm in organic-rich soils and greater than 2 m in areas of coarse-textured soils and areas of exposed bedrock. Well-developed soils generally are lacking within the mine area as a result of the extensive glaciation (Kidd 1996).

Northern Considerations and Limitations

Resource development in northern areas is met with similar reclamation requirements as those in southern areas. The expectation is that the land will ultimately retain it's current land use in spite of these land disturbances. Vegetation may be affected on a local scale by activities that remove soil, change soil drainage or compact soils. Even with localized impacts, the effects will persist for a long time due to the slow growth and recovery rates of tundra plants. Vegetation is a key component of local biodiversity in the sparsely populated tundra. It is therefore important to reestablish the sites' indigenous species because there is a high reliance on the native vegetation by the people and wildlife as a food source. A short growing season, sparse precipitation, a low mean daily temperature, coarse, cold soils all combine to constrain plant growth. A limited database on the development of sustainable plant communities on reclamation sites in northern areas also presents a serious limitation when attempting to define requirements for mine closure.

Photo 1. Aerial view of the terrain in the EKATI lease area, showing a landscape vegetated primarily with ericaceous shrubs in upland areas and grasses, sedges and willow in lowland areas. Boulder fields and lakes are distributed throughout the area. An esker crosses the photo in the foreground.

The supply of suitable seed is a major limitation to achieving reclamation goals in northern areas. Seed of several of the grass species found at EKATI is commercially available and can be used to establish a primary plant cover. Seed of tundra species, however, is not commercially available; yet it is critical to the development of sustainable, diverse plant communities adapted to local soil and climatic conditions.

Vegetative propagation, i.e., the use of stem cuttings or root sprigs, is an effective method of establishing plants such as *Salix* spp. and *Arctophila fulva* (Arctic pendant grass), respectively, in riparian habitat (Kidd and Max 2002). Tundra sod transplants is another method of introducing plant propagule's into reclamation sites, via seed dispersion and root creep. While the use of vegetative propagation and transplants are important in the revegetation of the minesite, they have limited application largely because suitable habitat where these methods can be applied accounts for only a small portion of the area to be reclaimed.

Use of Native Seed

Research into the use of native seed in site revegetation began in 1996. Seed of a number of herbaceous [e.g., *Epilobium* spp. (fireweed), *Oxytropis* spp. (locoweed), *Carex aquatilis*, (water sedge), *Eriophorum* spp. (cotton grass)] and shrub species, e.g., *Betula glandulosa* (dwarf birch), was collected around the mine site and broadcast in revegetation study plots. Direct seeding has generally been unsuccessful. Dry surface conditions on the coarse mine soil or excessive burial by erosion on fine textured tailings has severely limited seedling establishment.

Results of research indicate that seedling root plugs, established from seed, are an effective and efficient method of establishing native species, suited to most tundra species and the majority of reclamation sites. Some of the issues associated with use of native seed are seed supply and processing, seed germination, seedling production and seedling establishment in reclamation sites.

Collection sites have been established within the EKATI mine lease area, GPS referenced and outlined on an aerial photograph. When possible, sites are located near established roadways for convenience and to limit effects on the landscape. Several collection sites have been established for each species and used on a rotational basis to minimize potential negative effects to the plant community dynamic. Additional collection sites will be added as the requirement for seed increases. Research is underway to identify phenological indicators that can be used to determine when seed is ready to collect. Seed production and viability of produced seed can vary considerably from one year to the next. This uncertainty must be accommodated, to the extent possible, when considering supply and demand of native seed for site reclamation.

Seed processing has presented a variety of challenges, especially seed that is embedded in a mass of fluffy filaments, such as *Epilobium* spp. and *Eriophorum* spp. Specialized screens and methods have been developed to thresh (remove seed from its capsule or seed head) and separate the seed from the chaff. Requirements and procedures often vary from one species to the next. Once dry the seed is stored in a freezer. Germination tests are run periodically to determine effects of storage on viability. Results of these tests are factored into seed collection schedules. Seed with poor storage viability must be collected shortly before its scheduled use. A SOP has been developed identifying collection sites, timing, collection methods and seed processing methods and procedures.

Seedling production has been contracted out to a commercial nursery, Coast to Coast Reforestation in Smoky Lake AB. Their experience producing native seedling stock for oil sands mine revegetation has assisted in the identification of germination requirements and seedling production methods and procedures for tundra species.

Research into the establishment of seedling plugs in reclamation sites is in progress. First-year mortality of actively growing stock out-planted in late spring (late June-early July) has been relatively high and related largely to planting shock, despite the fact that the plants had been hardened off at the nursery prior to shipment (Martens 2005). Herbaceous plants (e.g., *Epilobium* spp. and *Oxytropis* spp.) generally died back to the soil surface after planting and shrubs (e.g., *Betula glandulosa*) typically lost their leaves, before starting new growth. Many plants could not survive such extensive die-back.

Preliminary results of research into planting dormant rather than actively growing stock are encouraging (Martens 2011). First year survival of dormant planting of shrubs and herbaceous species exceeded 90% on average, when planted into an established grass cover (Photos 2 and 3). Following senescence, dormant stock was removed from styroblock root trainers, tightly bound in groups of five with plastic wrap to conserve soil moisture and minimize root ball damage during shipping, placed into cardboard shipping boxes (100 per box) and then in cold storage until they were shipped air freight to the minesite in early July for immediate planting. New growth that developed in spring, after fall or spring planting, was adapted to the local climate and, therefore, not subject to planting shock.

Photo 2. First year growth in mid-August 2010, of *Oxytropis deflexa* (locoweed)

Photo 3. *Betula glandulosa* (dwarf birch) planted July 4, 2010 as dormant seedling plugs into an established seeded grass cover on a reclamation site at the EKATI Mine.

Planting seedlings into coarse mine soil required the development of special techniques and considerable effort. The use of a crowbar was found to be the most efficient method of preparing (punching) a planting hole to receive the root plug.

Closure

Major strides have been made within the last two decades in understanding the limitations placed upon revegetation processes in northern areas. Continued research, monitoring of progressive reclamation sites and sharing information on successes and failures at different resource development sites is required to expand and develop the knowledge base that will ultimately lead to the development of sustainable plant communities.

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Sludge sampling Lagoon

Near Contwoyto Lake

Erratic

Assessing Wastewater Treatment in Canadian Arctic Communities

Jane Challen Urbanic and Laura Grace. Environment Canada.

Abstract

Small communities often rely on the use of stabilization ponds or lagoons for the treatment of municipal wastewater. Reliance on lagoon treatment is particularly prevalent in communities in Canada's Arctic region. Due to the unique limitations inherent to these locales (climate, remoteness, scarcity of trained personnel), lagoon treatment is favoured and practical compared to other forms of wastewater treatment. However, there is a lack of information on the performance and operation of these systems. This article provides an overview of the performance of 10 sewage treatment lagoons in Canada's Arctic, with specific focus on dissolved oxygen characteristics within the lagoons and its importance in wastewater treatment, and an understanding of each system's influent and effluent concentrations.

Introduction

Small communities often rely on the use of stabilization ponds or lagoons for the treatment of municipal wastewater. This type of wastewater treatment is favoured by small communities due to low operating and maintenance costs as well as the ability to provide effective treatment with minimal impact to the receiving environment (Prince *et al*. 1995a; Shammas *et al*. 2009). Interestingly, lagoon systems represent half of all municipal wastewater treatment facilities in Canada (Henry and Prasad 1986; Heinke *et al.* 1991), although the overall population served by these systems may be quite low because lagoons are usually found in smaller communities. Reliance on lagoon treatment is particularly prevalent in communities in Canada's Arctic region. Due to the unique limitations inherent to these locales (climate, remoteness, scarcity of trained personnel), lagoon treatment is favoured and practical compared to other forms of wastewater treatment. Of the 81 communities located within the Northwest Territories, Nunavut and the most northern regions of Quebec and Labrador, 66 employ lagoon treatment. These lagoons are assumed to operate differently from wastewater lagoons in more southern locales due to the fact that they experience much colder temperatures, longer periods of ice cover and fluctuating periods of 24 h of light in the summer and 24 h of darkness in the winter. However, despite the prevalence of lagoon treatment in Canada's Arctic, there is a striking lack of information on the performance and operation of these systems.

Lagoon Types - Functional

Lagoon characteristics vary widely, and these characteristics directly affect the performance of the system. Functionally, lagoons may be subdivided into four major categories: anaerobic, facultative, aerated and high-rate aerobic lagoons (Shammas *et al*. 2009). Anaerobic lagoons are usually deep (>3 m), with low concentrations of dissolved oxygen, high organic loading rates and limited biochemical oxygen demand (BOD) removal (Prince *et al*. 1995a; Shammas et al. 2009). Facultative lagoons tend to be shallower (1-1.5 m), with oxygen introduced through wind and algal photosynthetic activity at the surface, and an anoxic layer at the bottom of the lagoon. These systems generally have medium to low organic loading rates and BOD removal tends to be greater than in anaerobic systems (Prince *et al.* 1995a; Shammas *et al*. 2009). Aerated lagoons are systems equipped with mechanical devices that provide oxygen to the volume held in the lagoon. Aerated lagoons may have medium to high organic loading rates; however, due to the input of oxygen, they typically attain high treatment efficiency (Shammas *et al*. 2009). High-rate aerobic ponds are characteristically shallow, allowing for optimal light penetration to promote algal production. Due to this high algae production and the subsequent generation of oxygen, these lagoons can accommodate high organic loading rates (Shammas *et al*. 2009). Lagoon systems in Canada's Arctic have almost exclusively been designed to operate facultatively; however, there are a small percentage of aerated lagoons and some lagoons have been found to operate anaerobically.

Lagoon Types - Operation and Design

Wastewater lagoons may also differ with respect to their operation and design. In Canada's Arctic, lagoons are either engineered or derived from a natural lake (Heinke *et al*. 1991). Engineered lagoons may be advantageous in that the physical lagoon attributes (i.e., surface area, slope, depth, liner material and location) can be controlled to provide optimal treatment. However, limitations may exist with regard to finding a suitable geographical, topographical and stable permafrost location where effluent can drain properly (Grainge *et al*. 1972; Heinke *et al*. 1991). Natural lake lagoons may be advantageous in that they eliminate the cost associated with lagoon construction, and they already have an established natural bacterial and algal population for wastewater treatment. Disadvantages to natural lake lagoons include the presence of natural vegetation, which may trap floating solids, as well as the possibility of uneven pond dimensions, which can affect the flow of effluent and lead to short-circuiting (Grainge *et al*. 1972). Additionally, designating a natural lake as a wastewater lagoon poses challenges to controlling the retention time and effluent discharge, and excludes the lake from further use in any other capacity (i.e., fishing, recreation).

Operationally, lagoons in the north also differ with respect to the timing of effluent discharge into the receiving wetland or water body. Because of the severe cold experienced in northern Canada, there is typically a very short ice-free season of 2-4 months, with warmest temperatures experienced between June and September. Some systems in Northern Quebec experience of longer ice free seasons of up to six months. Wastewater lagoon discharge typically occurs only during those months. Some lagoons are operated with an annual discharge, meaning the effluent decant occurs once a year, targeting a time when lagoon treatment is optimal. In the Arctic, this generally occurs between late August and October when bacterial and algal communities have had an entire growing season to populate the lagoon and provide the highest level of treatment. Other lagoons are operated with continuous discharge, meaning effluent flows continuously from the lagoon into the receiving environment during the ice-free period. This discharge may be controlled by means of a valve or may flow freely without operational constraints. Effluent quality from continuous lagoon systems may differ greatly between the spring when effluent first begins to discharge and the fall at the end of the growing season. Indeed, past studies have found lagoon effluent quality to be better in the fall compared to the spring. To capitalize on the superior quality of effluent in fall versus the spring, some regions, such as the province of Alberta, require an annual discharge in the fall for their wastewater lagoons (Prince *et al*. 1995b).

Although information exists on the different factors that will affect lagoon performance, there are few studies that have actually measured lagoon effluent quality in Canada's Arctic region. The study reported in this paper sets out to assess performance at 10 wastewater lagoon sites in Canada's Arctic region. Specific research questions addressed in this article include the following:

1. Are lagoons operating facultatively or anaerobically?
2. What range of influent and effluent concentrations are found for parameters of interest, namely 5-day carbonaceous biochemical oxygen demand (cBOD5), total suspended solids (TSS) and total ammonia nitrogen (TAN)? and
3. Is there a difference between effluent quality in the spring versus the fall?

Site Selection
Results discussed in this article come from ten sites sampled in 2009 and 2010. These sites include four communities in the Northwest Territories, four communities in Nunavut and two communities in Northern Quebec. Sampling sites fell within the 61° and 72° northern parallels and populations within the communities ranged from 290 to 2,130 people. None of these sites have pipes delivering sewage from the buildings to the lagoons. Instead these communities rely on pumper trucks to collect wastewater from tanks at individual homes and community buildings and transport the wastewater to the lagoon for treatment.

Of the 10 sites visited, two were natural lake lagoons and the remaining eight were engineered lagoons. Most of the lagoon systems were one-celled; however, three systems were two-celled and one was five-celled. One of the two-celled systems was only using one cell during the year that sampling took place and so data from this site reflect treatment and lagoon characteristics of a single lagoon. Half of the sampling sites were meant to operate as continuously discharging lagoons, while the other half were operating as annual discharge lagoons. However, two of the continuous discharge sites were only operating during one of the sampling seasons (spring or fall) and so the data set is incomplete for those two sites in terms of effluent quality. Another one of the continuously discharging sites was sampled in both 2009 and 2010, and, therefore, two years worth of spring and fall effluent data from this site are presented here. The fourth continuous discharge lagoon was only sampled during one fall period in 2009, and, as such, no spring data are available for this site. The final continuous site was operating as expected during the one year of sampling conducted at this site. The five annual discharge lagoons were each sampled once during their fall discharges. Two of the five annual sites were not operating properly when sampling occurred, which led to incomplete datasets. The data presented in this article come from a total of 16 site visits to the 10 communities. Information about the sites is summarized in Table 1.

Table 1: Site characterization

Site	Design	Discharge	Cells	Sampling		Comments
				Spring	Fall	
A	Natural Lake	Continuous	1	Jul 2009 Jun 2010	Sep 2009 Sep 2010	no in-situ lagoon measurements
B	Engineered	Continuous	1	Jun 2010	Sep 2010	
C	Engineered	Continuous	1	Jun 2010	Aug 2010	no discharge in fall; samples taken from lagoon
D	Engineered	Continuous	1	Jul 2010	Aug 2010	no discharge in spring; samples taken from lagoon
E	Engineered	Annual	2		Aug 2010	operating as single cell lagoon; samples taken from first cell overflow
F	Natural Lake	Continuous	1		Aug 2009	no in-situ lagoon measurements; no spring sampling
G	Engineered	Annual	2		Aug 2010	no discharge; samples taken from 2nd cell
H	Engineered	Annual	5		Sep 2010	
I	Engineered	Annual	1		Sep 2009	
J	Engineered	Annual	2		Sep 2010	Two days of samples reported

Methods

Site Characterization

Initial site information was gathered upon arrival at each community's wastewater lagoon. Details of the lagoon operation, such as the frequency and volume of influent deposited into the lagoon and timing of effluent discharge, were noted. When available, information on other lagoon characteristics, such as detention time, design capacity and annual discharge volumes, was also recorded. Pictures and Global Positioning Satellite (GPS) coordinates were taken around the perimeter of the lagoon, with significant features (i.e., influent and effluent discharge points) marked. Lagoon characteristics, such as shape, dimension, freeboard height, odour and colour of lagoon contents, were also noted. When a site was sampled in both spring and fall, observations of seasonal differences in the lagoon and surrounding environment, such as differences in vegetation, were recorded.

Influent Sampling

Raw sewage, also referred to as influent, in each of the communities was collected three times during each site visit. Each sample set was collected from a different truck load when the wastewater trucks deposited influent into the lagoon. Previous experience indicated that influent quality did not vary substantially between truck loads on different days or different times of the day. Therefore, the three trucks chosen for sampling were selected based on convenient timing for field staff.

Once the wastewater truck began to discharge, volumes from the beginning, middle and end of the influent discharge were collected and composited into a single sample. This sample was sub-divided into lab bottles to be analyzed for a variety of nutrients, solids, metals and cBOD concentrations. Standard analytical methods were used for the analysis of these parameters (Standard Methods 2005).

Effluent Sampling

At each sampling site, samples of effluent discharging from the wastewater lagoon were collected using an automated sampler or autosampler. The autosampler was programmed to collect equal volume samples at set intervals over three 24 h periods. At the end of each 24 h period, the autosampler had collected 24 L of effluent volume distributed equally between 24 bottles, each bottle representing one hour of discharge. Portions of each of the 24 effluent bottles were sub-divided into composite samples over eight equal time intervals. These samples were designated EF3, as they typically represented a 3 h period of sample collection. The remaining volume from each bottle was composited into a final sample designated EF24 and represented a full 24 h period of sampling. Discharges at Sites H and I were interrupted each night due to operational constraints. As such, three sets of effluent were collected over 8 h and 12 h periods, respectively. The corresponding EF3 samples were collected over shorter time periods but in the same proportion as the typical 24 h sites. Temperature within the autosampler, as monitored using Hobo Tidbits™, was maintained around 4°C using ice packs, snow or shading. EF3 samples were analysed for nutrients, solids and cBOD5. EF24 samples were analyzed for nutrients, solids, cBOD5, metals and total phenols. Grab samples for oil and grease were taken if an oily sheen was noted anywhere in the lagoon during the site characterization. The parameters were analyzed using Standard Methods (2005).

In the case where effluent was not flowing from the lagoon, samples from within the lagoon were obtained instead. This occurred on four of the 16 sampling trips. At two of these sites, grab samples were obtained once daily over three days. At the other two sites, the autosampler was set up as indicated previously to collect both EF24 and EF3 samples over three days despite a lack of flowing effluent. These samples were analyzed for the same set of parameters as the EF24 samples. Lagoon effluent at all sites was measured for temperature, pH, conductivity, DO and alkalinity.

Water Column Measurements

In-situ measurements were taken of the water column within the lagoon at seven of the 10 communities. Measurements were taken at several depths, with an emphasis on obtaining readings at the top, middle and bottom of the water column. Parameters of interest included pH, conductivity, temperature and dissolved oxygen concentrations. This process was repeated at several locations around the lagoon and every effort was made to obtain readings at locations evenly distributed across the surface area of the lagoon. GPS coordinates were recorded for each sampling location.

Sample Handling

All sampling equipment was washed with Contrad™ and deionized water prior to use in the field. Sample collection tools and bottles were rinsed with a small volume of the media being sampled prior to sample collection.

All samples except those for cBOD5 analysis were preserved according to Standard Methods (2005). Nutrients samples were preserved to pH<2 with H_2SO_4, metals samples were preserved to pH<2 with HNO_3 and solids samples were kept at 4°C but required no additional preservation.

Standard Methods (2005) recommends that samples collected for cBOD5 are analyzed within 24 hours. Due to the logistical difficulties and cost associated with transporting samples to an accredited lab within 24 hours, cBOD5 samples were frozen at each location and maintained in a frozen state until analysis. Research has shown that samples can be frozen for up to 6 months without significant degradation (Fogarty and Reeder 1964; Miller and Harkness 1964).

Storage and Shipping

Once a set of samples had been properly obtained and preserved, they were kept between 0-4°C (with the exception of the BOD samples, which were kept frozen) until analysis at an accredited laboratory. Temperature was measured in the sample coolers using Hobo Tidbit dataloggers between sample collection and arrival at the laboratory. All efforts were made to ensure that sample bottles arrived at the laboratory and were processed within the holding times recommended for each parameter.

Results and Discussion

Lagoon Characterization

In-situ measurements of temperature, pH and conductivity were recorded at seven sites over 10 site visits (Table 2). These in-situ measurements varied both within the same site on different sampling trips and between different sites. Average temperatures within the lagoons ranged between 0.8-14.0°C. Where spring and fall measurements were taken at the same site, average temperature was 2-4°C higher in the fall versus the spring. Lagoon pH ranged from 7.0-9.0. At the two sites where pH was measured in both the spring and fall, pH was somewhat higher in the fall. Conductivity fluctuated between sampling sites, with a range of 523-1713 μS/cm. Although there were two sites at which conductivity was measured in the spring and fall, there was no consistent seasonal pattern noted.

Dissolved oxygen (DO) concentrations were also measured in six of the 10 sampling sites. In general, the average DO concentrations were highest in the top layer of the lagoon, with concentrations decreasing with depth (Table 3).

Results indicate that there was considerable variability amongst the average DO concentrations between different sites, as well as between different cells operating in the same wastewater system. Site H provides an example of variability in DO concentrations between lagoon cells within the same treatment system. This site operates with five lagoon cells, although only four cells were measured for DO concentrations. Results show that the range of average DO concentrations was low in the first two cells (0.65-1.8 mg/L) and that this range increased considerably in the other two cells (0.38-12.7 mg/L) (Table 3). Variability within a sampling site was also demonstrated between spring and fall seasons. Site B, for example, had an average DO concentration ranging from 1.7 to 1.9 mg/L in the spring, whereas an average concentration of 14.7 mg/L was measured in both the top and bottom layers in the fall (Table 3).

Average DO concentrations were also markedly different between different sites. Sites B and H for example, demonstrated DO concentrations >2 mg/L in certain locations within the lagoons during specific sampling trips (Table 3). This suggests that these lagoons are operating facultatively. Sites C, D, E and I, on the other hand, demonstrated average DO concentrations that were almost always <1 mg/L (Table 3). This may indicate that these lagoons are operating anaerobically. Figure 1 shows the difference in average DO concentrations between Site B and Site C in the spring and the fall, and indicates that even in the spring when DO concentrations should be the lowest, Site B is operating with much higher DO concentrations than Site C in either the spring or the fall.

Table 2. Wastewater lagoon characteristics from the 10 sampling sites. Temperature, pH and conductivity measurements are mean values taken from varying depths within each lagoon cell. Dashes indicate that this information was not collected.

Site	Temperature (deg C)		pH		Conductivity (μS/cm)	
(Cell)	Jun/Jul	Sep	Jun/Jul	Sep	Jun/Jul	Sep
A09	-	-	-	-	-	-
A10	-	-	-	-	-	-
B	2.6	4.6	7.8	9.0	523	1713
C	4.1	8.4	7.5	7.9	1677	1607
D	-	8.0	-	7.6	-	1077
E (1) [1]	-	14.5	-	7.7	-	1120
F	-	-	-	-	-	-
G (1)	-	16.0	-	7.7	-	688
G (2)	-	12.7	-	-	-	135
H (1)[1]	-	14.0	-	7.0	-	1394
H (2)	-	13.0	-	7.0	-	1338
H (3)	-	12.0	-	8.0	-	1077
H (4)	-	13.8	-	8.3	-	1057
I	-	0.8	-	8.0	-	-
J (1)	-	-	-	-	-	-
J (2)	-	-	-	-	-	-

[1] Site E is a two-celled system; however in-situ measurements were only taken in the first cell. Site H is a five-celled system; however in-situ measurements were only taken in four cells.

Table 3. Average dissolved oxygen (DO) concentrations in seven sampling sites taken at the top, middle and bottom of the lagoon. Spring (S) and fall (F) measurements were recorded for sites with continuous discharge.

	Site B		Site C		Site D	Site E	Site I	Site H			
Season	S	F	S	F	F	F	F	F (Cell1)	F (Cell2)	F (Cell3)	F (Cell4)[1]
Top	1.9	14.7	0.3	1.5	0.08	1.2	0.47	1.5	1.5	12.7	6.9
Middle	1.9	-	0.1	0.7	0.07	0.15	0.16	1.0	0.73	1.8	6.3
Bottom	1.7	14.7	0.1	0.7	0.07	0.23	0.02	1.8	0.65	0.95	0.38

[1] Cell 4 sampled at the end of August as opposed to the other three cells at this site where DO was measured in mid-September

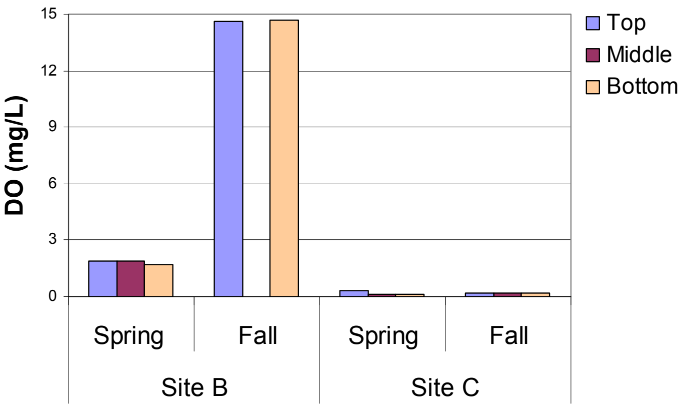

Figure 1. A comparison of DO concentrations between Site B and Site C in the spring and fall sampling seasons at the top, middle and bottoms depths of the lagoons. Note that there is no middle depth measurement for Site B in the fall.

Influent and Effluent Characterization
The data reported in this article include influent and EF3 data from the 16 different site visits, with the exception of the four sites that did not have flowing effluent. In these instances, the effluent data are from samples taken from within the lagoon. For both influent and effluent data, results included the mean and standard deviation of a data set (i.e., all of the data from one site visit).

Data collected to characterize the trucked influent are presented in Table 4. The information shows that the characteristics and composition of the trucked raw sewage were similar across the 10 communities presented in this study in terms of total suspended solids (TSS), carbonaceous biochemical oxygen demand (cBOD5) and total ammonia nitrogen (TAN). The only exception was Site I, which showed unusually low influent concentrations compared with the other sites. Because the sewage is predominantly domestic with no industrial inputs, variations seen in the data set are assumed to represent natural variation as well as variation caused by sample collection and handling techniques. The data also show, that the raw sewage is considered high strength by conventional standards (Metcalf and Eddy 2003). Communities in the Arctic typically receive piped water delivery and so water consumption rates are approximately 90 L per person per day (Dillon Consulting Limited 2007). This is considerably lower than the approximately 335 L per person per day used in more southern regions, which receive piped water deliver (Exall et al 2006). Low rates of water use contribute to the highly concentrated quality of influent in the Arctic.

Effluent TSS, cBOD5 and TAN for each site are presented in Figure 2. Effluent TSS at most sites ranged from 5 to 200 mg/L. Effluent cBOD5 measurements varied considerably across the sites, between 2 and 300 mg/L. TAN was also variable, but fell into two categories. Sites tended to have either effluent TAN less than 40 mg/L or effluent TAN between 60 and 80 mg/L.

Seasonal variation was evident at sites where spring and fall measurements were taken, although patterns were not always consistent. For instance, Site A09 demonstrated higher TSS concentrations in the spring compared with the fall, whereas this same site in the following year, A10, showed higher TSS concentrations in the fall. Seasonal patterns in cBOD5 concentrations tended to demonstrate a decrease in cBOD5 concentrations from the spring to the fall sampling periods. This is consistent with other research documenting improved treatment in the fall compared with the spring (Prince *et al.* 1995b). Similar to TSS, seasonal trends in TAN concentrations varied between sites.

Table 4: Data characterizing mean influent (trucked sewage) concentrations with the associated standard deviation. Low, medium and high parameter concentrations at the bottom of the table references expected influent concentrations characteristic of more southern wastewater systems.

Site	TSS (mg/L)		cBOD5 (mg/L)		TAN (mg/L)	
	mean	st.dev.	mean	st.dev.	mean	st.dev.
A	310	96	354	63	111	33
B	347	117	462	145	111	26
C	385	132	391	48	118	19
D	365	24	421	80	117	10

Site	TSS (mg/L)		cBOD5 (mg/L)		TAN (mg/L)	
	mean	st.dev.	mean	st.dev.	mean	st.dev.
E	294	9	425	23	70	34
F	867	511	452	103	83	6
G	313	100	330	67	71	9
H	345	154	311	144	86	21
I	99	9	71	2	81	5
J	181	99	268	141	72	51
Overall	**348**	**209**	**362**	**124**	**100**	**30**
Low[1]	120		110		12	
Medium[1]	210		190		25	
High[1]	400		350		45	

[1] adapted from Metcalf and Eddy (2003)

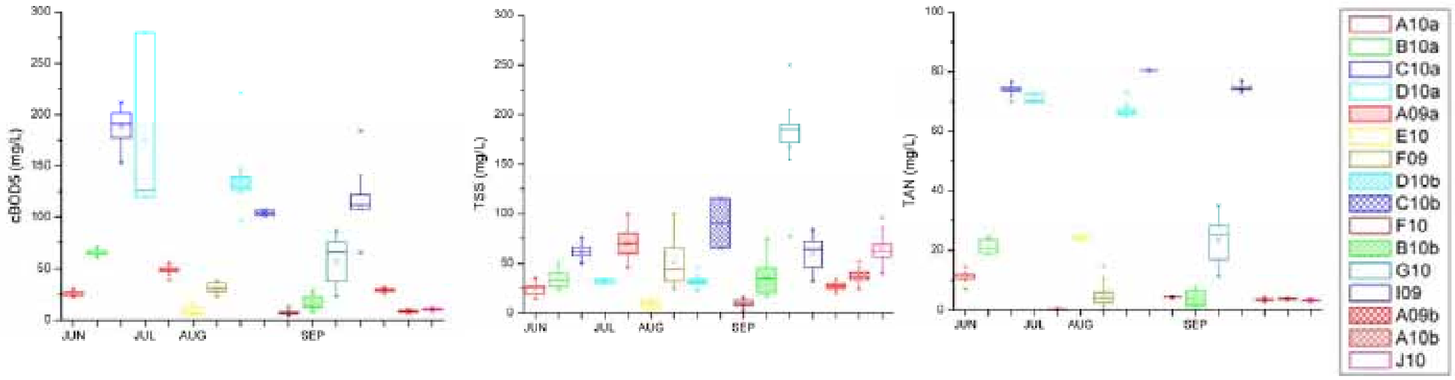

Figure 2: Effluent cBOD5, TSS and TAN characteristics of all sites.

Conclusions

Results from this study have highlighted the large variation in performance in wastewater lagoon systems across Canada's Arctic region.

Effluent concentrations at the 10 sampling sites differed considerably between sites and sometimes within the same site during different seasons. The dissolved oxygen concentrations within lagoon systems indicate that some lagoons are operating facultatively whereas others may be entirely anaerobic. This variation in dissolved oxygen concentrations within the lagoons may partly explain why effluent quality differed so greatly between sites, as oxygen availability will dictate the type of microbial communities providing treatment within the lagoon.

Results from influent sampling demonstrated that influent quality was highly concentrated as compared with standards concentrations found in more southern locales. This is important to note, as highly concentrated influent will require greater treatment within the lagoon for effluent to attain low concentrations of harmful constituents such as cBOD5, TSS and TAN.

Further data collection and analysis will be conducted to improve our understanding of wastewater lagoons operation in Canada's Arctic. Through this work, we hope to ascertain what factors influence lagoon treatment in cold climates and gain greater comprehension of the complex interactions within these lagoons that affect effluent quality and overall lagoon performance.

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Total Dissolved Solids - Snap Lake Mine, NWT

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The total dissolved solids (TDS) concentration of a freshwater body, which is essentially an expression of salinity, is the sum of the concentrations of common dissolved ions (e.g., sodium, calcium, magnesium, potassium, chloride, sulphate, bicarbonate) in those waters. In the North of Canada, freshwaters typically have low TDS concentrations. However, mining can increase TDS concentrations in receiving waters by liberating deeper (connate) waters characterized by high salinity.

Snap Lake Mine, owned and operated by De Beers Canada Inc. (De Beers), is an underground diamond mine situated on the northwest peninsula of Snap Lake. Construction of the mine began in 2005; mining operations commenced July 1, 2008. The lake is located 220 km northeast of Yellowknife, NWT. It is a relatively small lake, with a surface area of approximately 17 km^2.

The mine discharges treated effluent including mine water and domestic wastewater to Snap Lake. The Environmental Assessment Report (EAR) for the mine (De Beers 2002) predicted that concentrations of TDS, primarily consisting of calcium and chloride, would increase in Snap Lake over the operational life of the mine. However, TDS concentrations in Snap Lake are increasing at a faster rate than anticipated, and are currently conservatively predicted to exceed the mine's Water License (MV2001L2-0002) compliance limit of 350 mg/L TDS, whole-lake average, in 2018.

The compliance limit was not established on the basis of potential for adverse effects, but rather was management-based. The EAR predicted that TDS concentrations in Snap Lake resulting from the mining activities would rise from baseline conditions of 15 mg/L to approximately 330 mg/L over the mine life. A management-based limit of 350 mg/L was, therefore, recommended by the Mackenzie Valley Environmental Impact Review Board. As a result of the apparent likelihood of exceedence of the compliance limit, there is now a need to determine an effects-based limit.

A literature review was conducted to determine TDS concentrations that have had no effects in other water bodies, and to review information on previous TDS testing used to determine site-specific effects levels. This information was then used in a problem formulation to develop necessary information to guide future site-specific studies. Representative test species for the major groups of biota in Snap Lake were determined, specifically for phytoplankton, zooplankton, benthic invertebrates, and fish (Figure 1).

Chironomids, which dominate the sediments of Snap Lake and are important food organisms for fish, were chosen for initial laboratory toxicity testing. This testing was designed to determine their tolerance to TDS with the same ionic composition as the connate water currently being discharged to Snap Lake. A 10-d aquatic toxicity test was conducted with larvae of the freshwater midge, *Chironomus dilutus* (formerly identified as C. *tentans*), to assess the effects of that TDS on survival and growth. Testing was conducted following the standardized methodology of Environment Canada (1997), but modified to use clean sediment as a substrate and TDS test solutions as overlying water.

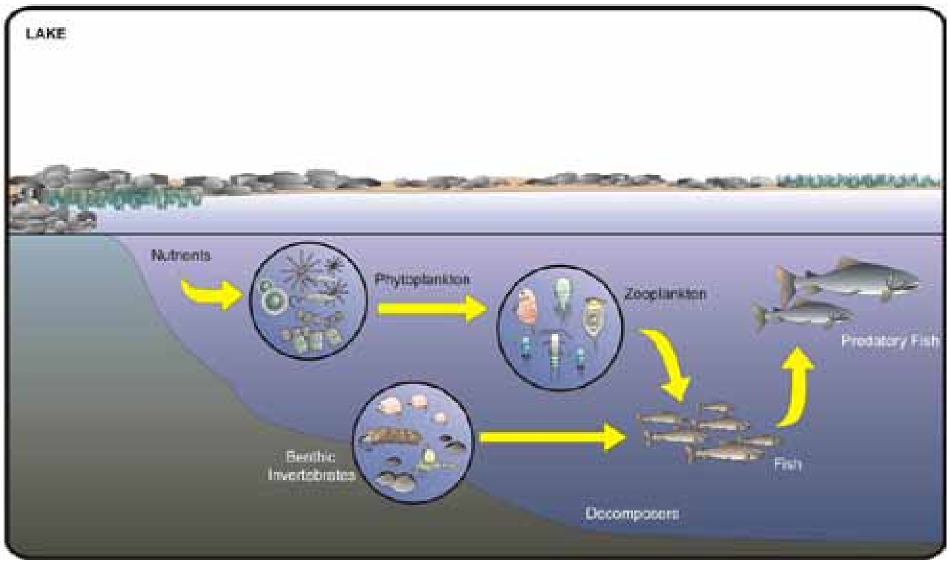

Figure 1. Schematic of the Snap Lake Aquatic Food Web

The objective of the 10-d chironomid toxicity test was to test a series of TDS concentrations that encompassed the current maximum average TDS concentration in Snap Lake as well as concentrations well above what would be expected to occur in Snap Lake in the future. TDS concentrations tested ranged from 205 to 2115 mg/L, based on means of measurements made at the start and end of the toxicity test. The ionic composition of this TDS solution was measured, and matched the current composition of TDS in Snap Lake.

The negative (clean) control met the test acceptability criteria of ≥70% mean survival and ≥0.6 mg/chironomid average dry weight. Mean survival in the negative control was 80%, and ranged from 80 to 87.5% in the test solutions. Mean dry weight in the negative control was 2.34 mg/chironomid, and ranged from 2.03 to 2.36 mg/chironomid in the test solutions. The LC_{25} and LC_{50} for survival were >2115 mg/L TDS and the IC_{25} and IC_{50} for dry weight were also >2115 mg/L TDS. The concentrations of chloride and calcium measured in the highest TDS concentration used in the chironomid toxicity test were 720 and 299 mg/L, respectively.

The results of these laboratory toxicity tests show that chironomids can tolerate much higher TDS concentrations than the current Water License Limit. However, determination of a site-specific effects-based limit that is protective of the Snap Lake ecosystem will require additional testing of phytoplankton, zooplankton, and in particular, of sensitive life-stages of fish species. It is anticipated that full details of these studies will be published in the peer-reviewed literature when completed.

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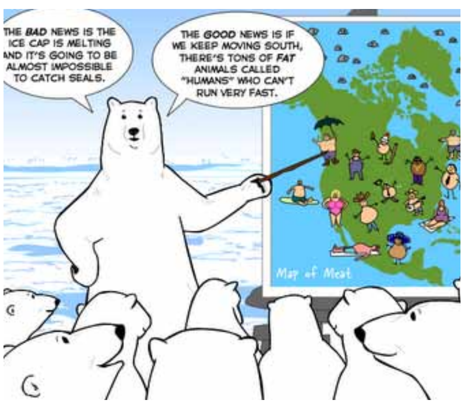
Arctic Media Articles

Arctic Ice Melt Hikes Sea Level Forecast

-The Associated Press, May 3, 2011



Arctic ice is melting faster than expected and could raise the average global sea level by as much as 1.6 metres this century, an authoritative new report suggests.

The study by the international Arctic Monitoring and Assessment Program, or AMAP, is one of the most comprehensive updates on climate change in the Arctic, and builds on a similar assessment in 2005.

The full report will be delivered to foreign ministers of the eight Arctic nations next week, but an executive summary including the key findings was obtained by The Associated Press on Tuesday.

It says that Arctic temperatures in the past six years were the highest since measurements began in 1880, and that feedback mechanisms believed to accelerate warming in the climate system have now started kicking in. One mechanism involves the ocean absorbing more heat when it's not covered by ice, which reflects the sun's energy. That effect has been anticipated by scientists "but clear evidence for it has only been observed in the Arctic in the past five years," AMAP said.

The report also shatters some of the forecasts made in 2007 by the U.N.'s expert panel on climate change.

The cover of sea ice on the Arctic Ocean, for example, is shrinking faster than projected by the U.N. panel. The level of summer ice coverage has been at or near record lows every year since 2001, AMAP said, predicting that the Arctic Ocean will be nearly ice free in summer within 30-40 years.

U.N. Panel Too Conservative: REPORT

Its assessment also said the U.N. panel was too conservative in estimating how much sea levels will rise — one of the most closely watched aspects of global warming because of the potentially catastrophic impact on coastal cities and island nations.

The melting of Arctic glaciers and ice caps, including Greenland's massive ice sheet, are projected to help raise global sea levels by 90 to160 centimetres by 2100, AMAP said, though it noted that the estimate was highly uncertain.

That's up from a 2007 projection of 19 to 59 centimetres by the U.N. panel, which didn't consider the dynamics of ice caps in the Arctic and Antarctica.

"The observed changes in sea ice on the Arctic Ocean, in the mass of the Greenland ice sheet and Arctic ice caps and glaciers over the past 10 years are dramatic and represent an obvious departure from the long-term patterns," AMAP said in the executive summary.

The organization's main function is to advise the nations surrounding the Arctic — the U.S., Canada, Russia, Denmark, Norway, Sweden, Iceland and Finland — on threats to the Arctic environment.

The findings of its report — Snow, Water, Ice and Permafrost in the Arctic — will be discussed by some of the scientists who helped compile it at a conference starting Wednesday in the Danish capital, Copenhagen.

Scientists are still debating how much the changes observed in the Arctic are due to natural variances and how much to warming caused by the release of carbon dioxide and other greenhouse gases. AMAP projected that average fall and winter temperatures in the Arctic will climb by 3 to 6°C by 2080, even if greenhouse gas emissions are lower than in the past decade.

http://www.cbc.ca/news/canada/north/story/2011/05/03/science-arctic-ice-melt-sea-level.html

HMCS Montreal Passes an Iceberg Near Nanisivik, Nunavut

Ship Soot Hurting Arctic

-Edmonton Journal, May 11, 2011

Fires, diesel-burning power generators, trucks and ships all have something in common: their ability to generate soot in the Arctic, which accounts for as much as 30 percent of the warming in the region.

"It's an Arctic problem," Andreas Stohl from the Norwegian Institute for Air Research said at last week's Arctic climate change and pollution conference in Copenhagen. Finding ways to limit soot production in the Arctic is likely to be on the agenda of this week's Arctic Council meeting in Nuuk, Greenland. That's because the Arctic nations, including Canada, the United States, Denmark, Norway, Sweden and Finland, can curb some Arctic warming simply by reducing soot in the Arctic. That will provide the Arctic some relief from rising temperatures while the world's nations take their time on reaching an agreement to slash greenhouse gas emissions. "It wouldn't solve the issue of climate change," Stohl said. "But you can still do something." For example, the shipping industry could retrofit its vessels with "relatively cheap" exhaust filters to catch tiny airborne soot particles, while Arctic communities could also look at other ways to generate electricity than diesel-burning generators and turn to incineration instead of open burning to dispose of trash. "It could make a difference," Stohl said. "If you're careful, it could reduce the local impact."

Locally, these efforts would "dramatically" reduce soot, Stohl said — and these efforts could cut down on warming in the Arctic, particularly around communities that may not realize how much soot contributes to heating up the lands and waters in the Arctic. The impact of soot on the climate doesn't last as long as the warming from greenhouse gas emissions — only up to a month at most. But soot which originates in the Arctic has a powerful, "very, very important" impact, Stohl said. With shipping and cruises expected to increase in the region and spew out more soot, there's an urgency to act on soot reduction, he said.

Reducing the level of soot in the air could also improve human health, because soot particles are known to trigger asthma attacks. Other major producers of soot within the Arctic include gas and oil burning at natural gas plants and wells or along pipelines. Soot also comes to the Arctic from the South. Soot-laden smoke from agricultural or forest fires can stay in the atmosphere for about a week, where it leads to thicker, warmth-catching clouds and what's often referred to as "Arctic haze."

Pollutants Take Toll on Polar Bears, Researchers Say

People, other animals in Arctic at risk from toxic 'cocktail'
-Edmonton Journal, May 10, 2011

Persistent organic pollutants used in industry are changing the genitals and bones of polar bears in East Greenland, says a Danish wildlife veterinarian and toxicologist.

The fertility of polar bears is threatened by toxins found in the Arctic, a climate-change conference in Copenhagen, Denmark, was told recently.

"Shrinking balls and degraded bones," linked to the presence of pesticides and flame retardants in the Arctic, are likely to affect the animals' fertility and reproductive success, Christian Sonne said at the conference on Arctic climate change and pollution held in Copenhagen, Denmark.

These impacts are "not just" affecting polar bears, said Sonne, who works at the National Environmental Research Institute of Denmark.

People, as well as other animals, in Canada's Arctic may also be at risk of similar effects from these pollutants, although the toxic "cocktail" becomes somewhat lower as you head west from Greenland across the Arctic region, he said.

Polar bears from East Greenland are among the most polluted species in the Arctic because their diet depends on contaminant-loaded blubber from ringed and bearded seals. Add a warming climate to this mix, and the combined effect may be disastrous for the survival of the species.

Sonne's latest research shows East Greenland polar bear bones are getting weaker. For his study, he looked at a wide sample of polar bears from 1983 to 2001, then went to museums to analyze samples from polar bears captured as far back as 120 years ago. Bone weakness reveals the amount of stress that an organism experiences, Sonne said.

In East Greenland, that stress can be related to contaminants, temperature, precipitation and decreasing sea ice. Sonne's study established a link between bone density and the presence of polychlorinated biphenyls (PCBs), chemicals used in industry. Because polar bears are highly adapted to their Arctic environment, they're also highly vulnerable to environmental changes. This makes them an "excellent global thermometer" for showing environmental changes, he said. The bone density decrease was severe in some of the adult male polar bears he studied. In fact, their bones were in such bad shape that those polar bears could develop chronic osteoporosis, which leads to bone fractures and deformities, he said.

Sonne, who has also studied genitals from East Greenland polar bears, continues to find links between the presence of the pollutants and the size of polar bear testes. Sonne and his colleagues say the higher the level of the pesticide chlordane found in bears, the smaller the size and the weight of their testicles and penis bones. As a result, there's "a reduction in quality and quantity of semen."

Ovary size and weight in female bears also decreases as contaminant levels rise, Sonne has found. The presence of flame retardants also may be linked to bone strength and sexual organs, particularly in cubs. The sum of these impacts can affect polar bear fertility and reproduction, he said. Sonne's latest research shows that sled dogs are also damaged by contaminants from a diet heavy in marine mammal blubber, because it appears to weaken their immune system. This would make the dogs more susceptible to infectious disease.

And, we'll give the last word to Ivan Duplessis, who says…

"All the headlines & press go to the wild animals that will be affected by the disappearance of sea ice, but what about the other animals who will share in that impact? We're all going to have to be a little more creative."

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Associate Members: persons who support the purposes and activities of the Society but who do not qualify for Regular or Student membership.

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Membres Réguliers: les personnes ayant un degré ou diplôme d'un collège ou une université dans une discipline des sciences biologiques et qui sont ou qui ont déjà éte engagé professionnellement en aménagement, enseignement ou recherche tenant a l'environnement ainsi que ressources naturelles.

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