HEAVY METALS IN THE ARCTIC: AMAP PHASE II PLAN

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Abstract

The Arctic Monitoring and Assessment Program (AMAP) results from AMAP Phase I were published in 1998. Data for the U.S. Arctic were under-represented, especially for heavy metals. At a workshop in Anchorage, AK, during September, 1999 the international plan for heavy metals research was defined and prioritized for AMAP Phase II. The world wide web site for AMAP to obtain the proceedings is http://www.grida.no/amap

Introduction

The Arctic Monitoring and Assessment Programme (AMAP) was established in 1991 to implement components of the Arctic Environmental Protection Strategy (AEPS) as adopted by the Ministers of the eight Arctic countries (Canada, Denmark, Finland, Iceland, Norway, Sweden, Russia, United States). Phase I of AMAP was completed in 1996, culminating in the publication of the AMAP Assessment Report: Arctic Pollution Issues (AMAP, 1998). The Ministers recommended continuation of AMAP activities for a second phase now described in the AMAP Strategic Plan: 1998-2003 (AMAP Report 99:6).

Workshop

To fulfill requirements for AMAP Phase II, the U. S. Environmental Protection Agency (EPA) sponsored the international workshop *Heavy Metals in the Arctic* held in Anchorage, Alaska, September, 1999. The workshop served to bring together US and foreign experts in heavy metals in the areas of both exposure and effects to generate the final plan. Recommendations for AMAP Phase II: Heavy Metals are contained in the final proceedings (AMAP-EPA, 1999). The following is a summary of the plan, modified from the proceedings Executive Summary. It is presented here to inform, and where possible, facilitate and enhance coordination of research among scientists across government, academia and other institutions conducting heavy metals research.

AMAP Heavy Metals Trends and Effects Program

Trends in Exposure. Experts addressing exposure issues at the workshop discussed the status and trends of heavy metal contamination in the Arctic air, water and terrestrial environments. The experts agreed that mercury would serve as the priority metal during AMAP Phase II with a focus on measuring total mercury in the Arctic and its physical and chemical speciation. Both anthropogenic and natural sources and fluxes of Hg and other heavy metals in air were targeted research areas. Particular emphasis was placed on measures of long range transport of heavy metals from air emissions particularly from Russia and China, considered two of the largest producers of Hg emissions to air.

Changing world conditions will serve as principal drivers of increases in air emissions and should be considered. Dispersion modeling tools for assessing the contribution of heavy metals from outside sources was targeted as an area for research.

Major river systems draining into the Arctic Ocean were considered important sources of dissolved metals and contaminated sediments requiring further investigation including data on heavy metal loadings in water, suspended sediments and sediments. It was also recommended that more accurate quantitative assessments of ocean transport of heavy metals using available data on water volume, patterns of ocean currents and ice be used to obtain a more complete understanding of the total budget and transport of heavy metals in the Arctic. Finally, animal transport of contaminants is an area requiring further investigation.

These discussions led to specific recommendations. To verify models estimating pollutant transport, additions to the AMAP Air Sampling Network were recommended to include: Pt. Barrow (US), Alert (CA), Ny Alesund (Norwegian Arctic), Nord (Denmark), Pallas (Finland), Anderma and Ioni Lake (Russia) with additional recommended sites at Pevek and in the Norilsk region (Russia). In the atmospheric subprogram, the need for measuring different forms of mercury were targeted including elemental mercury, divalent mercury in gas phase, and total mercury on particles. Recommendations to the atmospheric media parameters include changing Hg to "essential" for all countries, and considering measures of Cd, Hg, Pb, As, and Se in snow pack as "essential sub-regional." To assess inputs of heavy metals into the Arctic Ocean from rivers, assessments of Lena, Ob, Yenisey, Pechora, Kolima, Yukon, and rivers in Northern Canada were recommended. For the marine abiotic media program, all metals, originally listed under "sediments" were moved to "sediment cores" to facilitate trend studies. Cd was moved to "essential sub-regional," now consistent with other heavy metals. Under the marine biotic subprogram, changes were made for Beluga whales where Cd is now "essential sub-regional" with recommended measures in liver and kidney; and a further recommendation to add muscle tissue because of the importance of Beluga whales for subsistence. Under the freshwater program, sediment cores were targeted for all metals to facilitate trend analysis. Measures of Hg, Se and Annual Temporal Trends (ATT) are considered "essential sub-regional" for lake trout and pike. Hg in loon chick feathers are proposed as "essential sub-regional." The terrestrial subprogram included both abiotic and biotic media and parameters. Measures of soil, peat cores, and ice cap cores are considered "essential sub-regional." Media and parameters for biotic media were changed to include measures of Se in lichens as "essential," Cd, Hg, and Se in mushrooms is "essential sub-regional," and measures of Hg in rock ptarmigan liver is "essential" and kidney is "essential sub-regional." The need to fully integrate the terrestrial program with the atmospheric and freshwater programs was emphasized. To address quality assurance, it is recommended that more sensitive and reliable methods for measuring concentrations of heavy metals be developed. More inter-comparison of sampling procedures and analytical methods need to be completed, particularly for atmospheric sampling.

Effects. Discussions by experts on the effects of heavy metals in the Arctic focused on addressing the cumulative impacts, particularly sub-lethal effects, of Arctic contaminants on biological

organisms. Preliminary discussions focused on existing information on sub-lethal biological effects in Arctic organisms. Though information is recognized as limited, available information on effects in fish, birds, plants, mammals and others are provided in the proceedings.

It was recognized that to assess effects of heavy metals on flora and fauna of the Arctic is a challenging task. Two approaches were taken to build a plan including one based on ongoing and planned activities, the other on a long range view for developing a monitoring and assessment strategy. Based on results several recommendations for the research plan were possible. Species characteristics considered appropriate for an effects program would include species that are important functional components of a community (e.g., keystone); species that are susceptible (both sensitive and likely to be exposed) to the heavy metal, and species that are logistically amenable to study. Methods considered to be sufficiently developed for determining biological effects included body condition, evidence of lesions, histopathology, and presence of metallothionenin, or d-aminolevulinic acid dehydratase indicative of exposure to particular contaminants that result in known effects. Additional methods recognized as potentially powerful given further development include change in immune function, plasma protein profile changes, reproductive parameters, developmental effects and neurotoxicity. To be successful in understanding changes in animal and plant populations from heavy metals exposure, a linkage must be made between known exposures and observed effects. It was strongly recommended that when a particular animal species is being studied, tissue concentrations should be coupled with previously observed biological effects recorded on the same animal. In addition, both tissue concentration studies and biological effects studies should routinely record age, size, sex, date of collection and reproductive condition to provide a standard set of descriptive information. To address quality assurance and quality control, it is recommended that AMAP countries join existing inter-comparison studies.

The focus for assessing effects of heavy metals during Phase II is on Hg, Cd, Pb, As, and Se. To measure biological effects, contaminant specific endpoints are needed to detect exposure to a specific heavy metal. General measures of effects at the individual, population and community levels of biological organization are also needed to identify cumulative impacts and the combined effects of multiple stressors. There is a clear need to develop more non-lethal sampling methods that would allow study of threatened and endangered species and fragile Arctic ecosystems.

Based on these results and the immediate needs of AMAP Phase II, a draft plan was produced that includes terrestrial, freshwater and marine components. Within the terrestrial component, media selected for the program include epiphytes, ground dwelling lichens or bryophyes for the plant community and rock ptarmigan, snow bunting and caribou in the animal community. Grouse were eliminated. In the freshwater environment, algae, stream and lake benthic invertebrates, resident Arctic char, and Pacific or Arctic tern are targeted. The marine environment media included under-ice algae, blue mussel, Arctic cod, sculpin species, black guillemot or thick billed murre, eider, ringed seal, walrus, beluga whale, pilot whale, and polar bear. The glaucous gull was dropped. For each of these media, specific endpoints are recommended and the rationale provided for selection The media and

endpoints were not given a priority status. General comments relating to this program re-emphasize the need for other important endpoints like behavior, immune function, reproductive and developmental parameters, and endpoints at higher levels of biological organization. Traditional knowledge is a potential source of valuable information on observed effects and should be used.

To increase the potential for success in addressing biological effects, it is recommended that research move toward cross-cutting research that would evaluate effects that may be caused by a suite of contaminants, including heavy metals. Arctic organisms are impacted by multiple stressors. Observed effects are likely linked to exposure to more than heavy metals. In addition, few contaminant specific endpoints are available.

These recommendations are considered incomplete. The proposed plan is intended to inform future biological effects activities within AMAP. It is assumed that each nation will prioritize the proposed plan as appropriate for their national monitoring programs. Greater dialogue with a larger contingent of heavy metals experts is needed to refine research direction and expand our ability to address the effects of heavy metals in the Arctic.

Conclusion

The *Heavy Metals in the Arctic* international workshop was one event in a continuum of effort to plan, collect data and summarize results of research on exposure and effects of heavy metals in the Arctic. For successful implementation of AMAP Phase II for heavy metals it is important to establish an international Heavy Metals Team comprised of designated key experts from each Arctic nation in exposure and effects. We hope this plan will stimulate greater participation among heavy metals experts in the AMAP heavy metals team.

References

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