Nutrients and Their Impact on the Canadian Environment

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The report, *Nutrients and their Impact on the Canadian Environment*, provides information on sources of nutrients (nitrogen and phosphorus) to Canadian air, water and soil, and effects of these emissions on the health of humans and ecosystems. This assessment was conducted under the direction of an interdepartmental working group of officials from Environment Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Natural Resources Canada, and Health Canada. Working group members provided overall direction on the approach, as well as technical information on specific topics. Members of the working group were:

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Executive Summary

In 1994, the Parliamentary Standing Committee on Environment and Sustainable Development reviewed the Canadian Environmental Protection Act (*CEPA*) and identified several issues related to nutrients and their environmental impact and management: first, that only one class of nutrient is currently regulated (namely phosphorus in laundry detergents) and, second, that other nutrient classes and sources may be adversely affecting the environment (HCSCESD 1995). In response to these concerns, the Government of Canada committed to undertake "a comprehensive study of nutrients that enter the environment through human activities … to determine whether or not nutrients in general are causing negative environmental effects; whether only certain nutrients, rather than nutrients as a class, are problematic, and; whether those effects are limited … to water or to entire ecosystems, including wildlife" (Government of Canada 1995). This report meets the Government of Canada's commitment to document the nature and extent to which nutrients derived from human activity may be impairing Canadian ecosystems and affecting the quality of life and health of Canadians. This assessment was undertaken by representatives from five federal departments (Environment, Natural Resources, Agriculture and Agri-Food, Fisheries and Oceans, Health) under a Memorandum of Understanding to encourage collaboration and co-ordination amongst these departments in the use of science and technology for sustainable development.

Based upon our assessment of nitrogen (N) and phosphorus (P) loading from Canadian sources and the effects of these nutrient loads on forest, freshwater and coastal ecosystems, it is clear that nutrients are causing problems in certain Canadian ecosystems and affecting quality of life for many Canadians. We are certain that N and P loading from human activity has:

- accelerated eutrophication of certain rivers, lakes and wetlands in Canada, resulting in loss of habitat, changes in biodiversity and loss of recreational potential.
- increased the frequency and spatial extent to which the drinking-water guideline for nitrate has been exceeded in ground waters across Canada and caused economic burden for those Canadians who must transport household water from off-site sources.
- caused and continues to cause fish kills due to ammonia toxicity.
- contributed to a decline in amphibians in southern Ontario due to long-term exposure to elevated nitrate concentrations.
- led to elevated risks to human and livestock health through increased frequency and spatial extent of toxic algal blooms in Canadian lakes and coastal waters.
- contributed to acidification of soils and lakes in southern Ontario and Québec and resulted in incipient N saturation in some forested watersheds.
- increased carbon production in Canada's forests due to N deposition.
- increased concentrations of the potent greenhouse gas N_2O and increased concentrations of nitrogen oxides contributing to formation of photochemical smog in certain Canadian cities.
- contributed to quality of life concerns for Canadians through water use impairments (e.g., excessive algal and aquatic weed growth; blockages of screens and filters) and aesthetic (taste and odour) concerns related to water supplies.
- increased the economic burden to Canadians as a result of the need for treatment, monitoring and remediation of contaminated water.

We estimate that more than 12 thousand tonnes of P and 304 thousand tonnes of N entered Canadian fresh, ground, and coastal waters in 1996 as a result of human activity. The largest point source was municipal sewage, adding an estimated 5.6 thousand tonnes P (as total P) and 80 thousand tonnes N (as total N). Discharge of industrial wastewater added at least 2.0 thousand tonnes P and 11.8 thousand tonnes N (as nitrate and ammonia) to Canadian surface waters. The industrial loads are an under-estimate, however, as data were not available for New Brunswick, Nova Scotia, Prince Edward Island, and, in the case of Québec, industries discharging to waters other than those in the St. Lawrence River Basin. There are no national estimates of nutrient losses due to leaching or runoff from agricultural fields. A recent assessment of N losses from agricultural land where the soils have a water surplus predicted that 17% of Ontario, 6% of Québec and 3% of Atlantic farmland would produce runoff or seepage water with > 14 mg N/L (MacDonald 2000b). In British Columbia, 5% of the agricultural land has a water surplus and 69% of this area was predicted to generate runoff or seepage water with N concentrations > 14 mg/L.

At least 1 400 thousand tonnes N were released to the atmosphere in 1996 as a result of human activity in Canada. The largest single source of N emissions to the atmosphere was agricultural activity, in particular the release of ammonia (NH_3) associated with handling and application of manure and fertilizer. Release of nitrous oxide (N_2O) was split approximately evenly among industrial, transportation-related, and agricultural sources. In the case of nitric oxide and nitrogen dioxide (i.e., NO_x), the largest emissions were from industrial and transportation-related sources; NO_x emissions are not available for agricultural emissions but are likely similar to industrial emissions (Janzen et al. 1998). Reliable data were not available for P emissions to air.

At least 4 287 thousand tonnes of N and 449 thousand tonnes of P were added to Canadian land in 1996. Of this, 1 968 thousand tonnes N and 442 thousand tonnes P were applied to cropland in Canada in the form of fertilizer, manure, and biosolids. An additional 773 thousand tonnes N were added to cropland as a result of nitrogen fixation by legumes and 43 thousand tonnes N atmospheric deposition of nitrate and ammonium. Harvesting of crops removed 386 thousand tonnes P and 2 491 thousand tonnes N, or 87% of the added P and 89% of the added N. Nutrients were also added to non-agricultural land by atmospheric deposition, N fertilization of British Columbia coastal and interior conifer forests managed for timber harvest, and landfilling of industrial and municipal waste.

In fulfillment of the objectives of this assessment as identified by the Government of Canada (1995), we conclude that:

- nutrients released to the environment from human activity are impairing the health of certain ecosystems, contributing to quality of life concerns for Canadians and, on occasion, endangering human health.
- nutrient impacts tend to be associated with certain nutrient forms. For example, most inland waters in Canada are intrinsically P limited and thus addition of P has accelerated eutrophication. In contrast, leaching of nitrate-N has increased the frequency and spatial extent to which the drinking-water guideline for nitrate has been exceeded in ground waters. Concerns about nutrients in the atmosphere relate largely to the role of dissolved inorganic N (in the form of nitrate and ammonium) as a fertilizer to forest ecosystems and a contributor to acid rain, NO in urban smog production, and N_2O in greenhouse warming.

- although the predominant and most demonstrable impacts to date have occurred in aquatic ecosystems and caused water use impairments, the first symptoms of negative effects on forest ecosystems have also been observed.

In Canada, environmental problems caused by excessive nutrients are less severe and tend to be more localized than in countries with a longer history of settlement and agricultural production. This situation is due to our relatively small population compared to our land base and the protective measures implemented by both the federal and provincial/territorial governments in the last 30 years. Given the problems already caused by nutrient loading in Canada, as well as newly-emerging concerns, it is critical that gains achieved by improved wastewater treatment and other control measures not be reversed by relaxation of standards or by failure to keep pace with population growth. The best and most advanced science should continue to be integrated into practical solutions to maintain or improve the quality of Canadian air, water and soil environments.

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