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FUNDY ISSUES

BoFEP

Flushed with Tide:

Municipal Effluents in the Bay of Fundy

Ever since people began congregating in villages, town and cities, they have been confronted by the problem of how best to dispose of their communal sewage waste. Typically, they first opted for the easiest solution - using accumulated "night soil" for their gardens or simply emptying the contents of chamber pots into the nearby streets and ditches. However, with the coming of the industrial revolution and the influx of more and more people into cities, the shortcomings of this approach quickly became evident. They invariably adopted the next easiest option - channeling of raw sewage into the nearest convenient river, lake or estuary in hopes that it would be quickly diluted, dispersed and eventually degraded. However, the ever-expanding populations soon overwhelmed the ability of even large water bodies to absorb the volume of sewage produced. Steadily deteriorating environmental conditions in and around these waters, and the growing dependence of many municipalities on these surface waters for their primary water supply have forced more and more communities to treat their sewage before discharging it. Most inland and many coastal communities of any size in North America and Europe now have wastewater plants performing varying levels of treatment, primary, secondary or tertiary, before releasing effluent back into the environment.

Photo: Laura Park, DFO, Newfoundland

Marine sewage disposal!

Coastal communities in Canada, with seemingly limitless volumes of seawater available to flush away sewage wastes, have generally been slower to act, largely because the health and environmental effects have been easily hidden, more remote and of little direct impact on the daily lives of residents. In Atlantic Canada, for instance, major seaport cities, such as Saint John, NB and St. John's, NL, still dump large volumes of raw or partially treated sewage into coastal waters. However, Saint John, is building sewage treatment plants (STPs) and now treats about 50% of its sewage, while St. John's is making progress on constructing an STP. Halifax, NS has had two small plants and is just now beginning to treat the bulk of its municipal effluent, after centuries of discharge of raw sewage into its harbour. A 1996 survey found that in the Atlantic Provinces, 44% of sewage waste was disposed of in onsite septic systems, 29% passed through sewage treatment plants (STPs) and 27% flowed untreated into coastal waters. But each year, 100 million cubic metres of raw sewage is still dumped into the coastal waters of Atlantic Canada. In addition, 122 million cubic metres of "treated" wastewater (one quarter of this has only minimal primary treatment) also flows into coastal waters. Even Halifax's new system will only treat to the "advanced primary" level, although it has been designed so that it can eventually be upgraded to provide secondary treatment at an anticipated cost of another $100 million.

In recent decades, growing environmental awareness and public activism, coupled with mounting evidence of degradation of coastal habitats and contamination of harvested marine resources such as shellfish, has convinced many coastal communities of the need to begin treating their sewage. Now, almost 400 STPs treat over 300 million gallons of effluent produced by the more than 6 million people living around the Gulf of Maine and Bay of Fundy. The Deer Island STP, a state of the art facility servicing the Boston area, cost 3 billion dollars. Many of the remaining hold-out communities are planning to construct or upgrade their facilities to at least partially treat their municipal waste.

"there is a broad consensus that sewage pollution is still a worrisome problem in the Bay of Fundy and the Gulf of Maine."

In spite of such progress, there is a broad consensus that sewage pollution is still a worrisome problem in the Bay of Fundy and the Gulf of Maine. Older and malfunctioning treatment facilities and plants that only partially treat waste still pour contaminated wastewater into coastal estuaries and embayments, threatening human and ecosystem health as well as fisheries resources. In fact, marine scientists reviewing the effects of sewage disposal under the auspices of the United Nations concluded that coastal waters around the world in both developing and industrialized countries are being "overwhelmed" by sewage. The United Nations Environmental Program (UNEP) in a 2006 report entitled *"The State of the Marine Environment: Trends and Processes"* further warned that "sewage is a growing threat to oceans and seas, putting at risk marine life and habitats as the pollution problem escalates". The World Health Organization (WHO) also worries that "microbiological contamination of the sea has precipitated a health crisis with massive global implications". Closer to home, the Gulf of Maine Council on the Marine Environment convened a workshop in Halifax in 2002 to "review issues related to the management of sewage and wastewater and its impacts in the Gulf of Maine and its estuaries and embayments". The report from this workshop concluded that wastewater management and sewage treatment still are critical issues in the Gulf of Maine that need to be urgently addressed, despite some of the advancements already mentioned. The Gulf of Maine Council on the Marine Environment has also identified sewage as one of six priority issues in the Gulf and in its 4th Action Plan created a Sewage Task Force to encourage and coordinate research, monitoring and remediation efforts throughout the region.

Worrisome Wastewater

Technically, the term sewage refers mainly to the large volumes of organic excrement present in wastewater. To understand the nature and scope of wastewater pollution, and to appreciate the difficulties involved in trying to clean it up, we need to consider the many other different materials that are also present in municipal wastewater and how each affects aquatic environments and organisms, including people. Obviously the composition of the wastewater depends greatly on the nature and use of the entities connected to the disposal network. In most municipal sewage disposal systems, the bulk of the waste is generated by domestic sources, involving toilets, baths, sinks, dishwashers, washing machines and floor drains. In most households a huge range of powerful cleaning products, detergents, bleaches, cosmetics, soaps, shampoos, etc. comprising complex mixtures of many chemicals are flushed into sewers every day, without a second thought. In addition, in many communities there are also significant waste contributions from local businesses, hospitals, academic institutions, medical and dental clinics, small industrial operations and often many other diverse sources. As well, in towns and cities, storm drains direct water runoff from roads and parking lots into the sewers, adding other potential contaminants such as oils, greases, pesticides and road salt to the increasingly complex mixture that is sewage waste. The major categories of effluent components that pose a threat to the environment and our health areas follows:

Menacing Microbes - From the viewpoint of human health, the most significant component of wastewater is its rich community of living microorganisms that may include bacteria, viruses, protozoans and the adults or eggs of a variety of multicellular parasites. Many of

Health Canada standards for bacteria in water
[from Hawboldt in Hinch et al. 2002]

water use/activity	Coliform cells per 100 ml. of water
drinking water	0
harvesting shellfish	14
watering livestock	50
irrigating food crops	100
water contact recreation	200

these are relatively harmless, and indeed are essential to human digestion and to the successful breakdown and biodegradation of the waste in the environment. Fecal coliform bacteria are the most abundant and being natural and essential inhabitants of the human gut pose no direct health risk. They abound in sewage and are relatively easy to measure, providing a convenient indicator of water contamination. The presence of sewage raises the possibility that other less benign microbial pathogens may also be present and pose a threat to anyone contacting, bathing in, drinking, or irrigating crops with the contaminated water. Water or food contaminated with fecal coliforms may also contain bacteria such as *Cholera*, *Salmonella*, and *Shigella*, viruses such as Norwalk, Poliovirus, Enterovirus and Hepatitis, protozoans such as *Giardia*, *Cryptosporidium* and helminths, as well as a variety of intestinal parasites such as roundworms and tapeworms. Disease-causing bacteria may survive in the sea for up to a week, while some viruses remain infectious for a year or more. An overabundance of sewage borne microorganisms could also alter the natural communities of microbes in lakes and streams, with uncertain ecological consequences. Organisms such as bivalve mollusks (e.g. mussels and clams) feed by removing the particles including microbes from the water around them and concentrate them in their tissues. A common occurrence in many parts of Atlantic Canada, including the Bay of Fundy, is the prohibition of harvesting of bivalves such as clams or mussels in sewage contaminated areas because the contained pathogens pose a threat to human health.

***Suspended solids* -** Apart from water, the most common materials in sewage wastes are solids. Waste managers characterize some of the larger items as "floatables", while most consists of well-mixed suspended particles of varying size. A small proportion of these solids are plastic, such as condoms, wrappers, dental floss and similar items thoughtlessly flushed down toilets or sinks and commonly washed up on urban beaches. In many cities runoff from streets and parking lots enters storm drains connected to the sewage system and carries inorganic silt or sand particles into the sewage system. However, the bulk of the sewage solids consist of the solid organic remains of human digestive processes (euphemistically termed “finless browns” by some Haligonians). Excrement from pets may also be washed into storm drains in significant quantities. Many of these materials are not directly toxic, but in aquatic environments they can cause problems. By clouding receiving waters they reduce the penetration of sunlight and the growth of aquatic plants. Waterborne particles abrade the sensitive gills of fish and invertebrates and interfere with respiration. The particles eventually settle to the bottom where they can smother benthic organisms or fish spawning beds. Some parts of Halifax Harbour have many metres of such sewage sludge on the bottom.

The myriad microbial agents of decomposition that abound in feces and the receiving water soon attack the solid organic fractions of the waste. However, in doing so, the living microorganisms consume oxygen and give off carbon dioxide. Thus the decomposition of a given amount of organic matter results in the removal of a corresponding quantity of oxygen from the water - a "biological oxygen demand" or BOD as it is called. If the amount of organic matter is great enough, it may deplete the oxygen in the water so that aquatic organisms, be they fish or invertebrates, are deprived of oxygen and have to leave the area or die. The critical level for BOD necessary to degrade a particular aquatic habitat may vary with temperature, rate of water flow, the type of animals present and other factors. Fortunately, as we shall see below, the BOD problem is one of the easier ones to rectify during sewage treatment.

“Municipal effluents are a significant contributor of nutrients in coastal waters.”

***Fertilizer flux* -** Municipal effluents are a significant contributor of nutrients in coastal waters. Nitrates, phosphates, carbon compounds and other nutrients are water-soluble breakdown products abundant in sewage. As well, many widely used household detergents once featured "phosphates" as a key ingredient, leading to huge amounts of this nutrient being poured into municipal sewage systems from every home. A build up of such nutrients in lakes and coastal embayments can trigger "eutrophication", involving an excessive growth of seaweeds and other algae resulting in smothering and undesirable changes in the productivity and diversity of aquatic organisms. This is often seen along shorelines near urban areas and the outfalls of treatment plants.

***Chemical Cocktail* -** A disturbingly large number of other potentially harmful chemicals are also present in municipal effluents. They come from both industrial and household sources and the types of chemicals and their amounts vary depending on the mix of industries, hospitals etc. that are connected to the sewage system. Municipal wastewater has been found to contains measurable levels of more than 200 different noxious chemicals, and experts believe that, in fact, there are probably thousands of them. Unlike the suspended solids and nutrients, most are chemicals that do not normally occur in the environment and many are toxic to aquatic organisms at very low concentrations. The list typically includes dioxans, furans, many different pesticides and herbicides, more than 15 different metals, plasticizers, caffeine, nicotine, cyanide, detergents, solvents and pharmaceuticals, to name but a few. Think of the variety and composition of different personal care products (shampoos, deodorants, conditioners, etc.) and household cleaning products (oven cleaners, tile cleaners, drain cleaners etc.) that are washed down drains in the average household every day. These formulations are often labeled with a lengthy ingredient list of harmful chemicals and accompanied by a stern hazard warning. A 1997 report of a study carried out by scientists with Environment Canada includes a table of 142 different organic chemicals alone that have been detected in effluents flowing out of Canadian STPs and into the environment. Indeed, the waste treatment process itself often adds toxic chemicals to the effluent. In some plants strontium, aluminum and ferric chloride are added as chemical precipitants to remove suspended particulates. Many plants also sterilize the wastewater with chlorine before discharging it, converting some of the organic matter into more persistent and toxic residual chlorine compounds in the process. Overchlorination is reported to be a common response to malfunctions in treatment plants that are older, poorly maintained or inefficiently operated — one of the reasons ultra-violet radiation is increasingly used in newer plants. Sewage systems that collect stormwater runoff usually have an additional suite of noxious chemicals washed in from roads and parking lots, including chlorides and other chemicals used to melt snow, heavy metals and different petroleum-based hydrocarbons from automobiles and highway maintenance. And this doesn't include the periodic accidental spills or deliberate disposal of noxious materials such as automotive oils, detergents, brake fluids, pesticides, etc., that are often thoughtlessly poured into the nearest storm drain.

While laboratory studies reveal that some of these chemicals are deadly to some aquatic organisms at low concentrations, the effects of most chemicals and their mixtures have not been examined for most species. We typically know very little about the physiological, biochemical and behavioural effects of these chemicals on most organisms at concentrations below those that will kill them outright. We know even less about how animals react to these chemicals in their natural environment, particularly when they are probably being exposed to many different toxic chemicals at the same time.

***Medley of Medicines* -** One worrisome group of compounds being found increasingly in wastewater is pharmaceuticals — a myriad drugs or medicines. Some of these, such as estrogen hormones, are excreted from the human body relatively unchanged in structure, while many others are metabolized or chemically modified and excreted in urine or feces as metabolites, consisting of different chemicals resulting from the breakdown of the drug within the body. In Canada, some 24,000 different chemical products are registered for use as human pharmaceuticals, veterinary drugs or biological disinfectants according to the Drug Product database maintained by Health Canada. In view of the wide range of metabolites that could be produced from these drugs, and their potentially complex interactions in the environment and organisms, it is not surprising that scientists are having a difficult time understanding the exact nature and scope of the problem. In a study published in 2006, Environment Canada scientists acknowledged that "Sewage treatment plants … are considered to be an important and continuous source of drug input to the aquatic environment". They measured the concentrations of a dozen common pharmaceuticals in the discharges from eight sewage treatment plants in Atlantic Canada, three of them (Fredericton, Sussex and Springhill) in the Bay of Fundy watershed. They found that a few of the drugs such as aspirin were almost completely degraded during the sewage treatment process, while others such as estrogen were discharged in significant amounts into receiving waters. In larger waterways, the drugs tended to be quickly diluted, but in smaller streams they could often be detected as far as 17 km downstream from the source.

"Sewage treatment plants … are considered to be an important and continuous source of drug input to the aquatic environment".

In particular, the presence of some potent compounds known as "endocrine disrupters" are raising bright red flags among aquatic ecologists. All animals use internally secreted chemical "hormones" to regulate many of their physiological functions such as growth, development, metabolism, immune responses and reproduction. These hormones are typically produced by a gland or tissue in one part of the body and trigger a biological effect by interacting with organs or tissues (receptors) in another part of the body. This complex and carefully orchestrated internal chemical communication network is known as the "endocrine system". Usually only very small concentrations of these natural chemical messengers are needed to communicate. Endocrine disrupters are foreign chemicals that either block the functioning of hormones or imitate (mimic) them in some way. Either way, the endocrine system malfunctions because hormonal messages are not being transmitted to the receptors or the chemical mimics inappropriately trigger the receptors. Studies show that many critical physiological and biochemical processes are being disrupted in this manner in a rapidly growing list of invertebrates, marine fish, seabirds and mammals. A variety of dissolved chemicals capable of disrupting endocrine systems, including some pharmaceutical compounds consumed and excreted by humans, are present in the effluent of most sewage treatment plants. It is particularly worrisome that extremely low concentrations of dissolved endocrine disrupters can have major biological effects in the natural environment.

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Sewage Stewardship

In most developed countries it is no longer socially acceptable to discharge raw sewage into the aquatic environment. Considerable progress has been made in recent decades in developing more effective methods for removing much of the problem-causing or toxic materials from small or large volumes of sewage before releasing the treated effluent into the environment. The most widely adopted approaches range from small onsite systems for treating waste from single households or businesses to large or very large communal or municipal treatment systems (the STPs) that collect and process wastes from hundreds to thousands of homes, public institutions, commercial establishments and industrial plants. Large municipal systems are termed "point-source releases" because large quantities of treated water still containing contaminants are discharged at a single, readily identifiable, location. In contrast, septic systems are considered "non-point-source releases" because small quantities of effluent seep diffusely into the environment from many widely dispersed locations that are often difficult to pinpoint.

Onsite - It is estimated that 44% of homes throughout the Atlantic Provinces, mainly located in rural areas and villages, process household wastewater by means of an onsite domestic sewage system. Sewage and gray-water from sinks and baths flows into a concrete septic tank where particulate matter settles to the bottom as sludge while oils, greases and lighter materials accumulate as a floating mat. The remaining liquid effluent flows out through a series of branching pipes into a drainage field where it percolates slowly through the surrounding soil, being filtered and biodegraded in the process. Periodically, ideally at least annually, the sludge and surface scum are pumped out of the tank into a specially designed tanker truck and transported to an approved site where it is spread on the ground and left to decompose. When they are properly constructed and maintained, such onsite septic systems are an effective way for processing small volumes of sewage and gray water without any significant environmental impact. Unfortunately, too many onsite systems are poorly maintained or defective and cause contamination of surface and groundwater. Many of them are older units installed when regulations were far less stringent. More often though, groundwater contamination is a result of improper maintenance, particularly in neglecting to have the tanks pumped out at regular intervals. It has been estimated that as many as a third of the onsite septic systems in the Annapolis River watershed do not function effectively and contribute to contamination of groundwater and surface waters in local rivers, streams and lakes.

Communal scale - In New Brunswick, about 60% of the current population of 730,000 is connected to communal sewage treatment systems and 40% rely on onsite systems. The province has 130 municipal STPs of which 95 of them use lagoonal systems as part of the treatment process. In addition, there are 230 smaller scale treatment systems serving non-municipal entities such as hospitals, mobile home parks and private enterprises. As a result of phase one of a planning process begun in the 1960s, most municipalities in New Brunswick now have basic wastewater treatment facilities. Phase two, now underway, is largely devoted to upgrading these facilities so that they at least carry out secondary treatment of the waste.

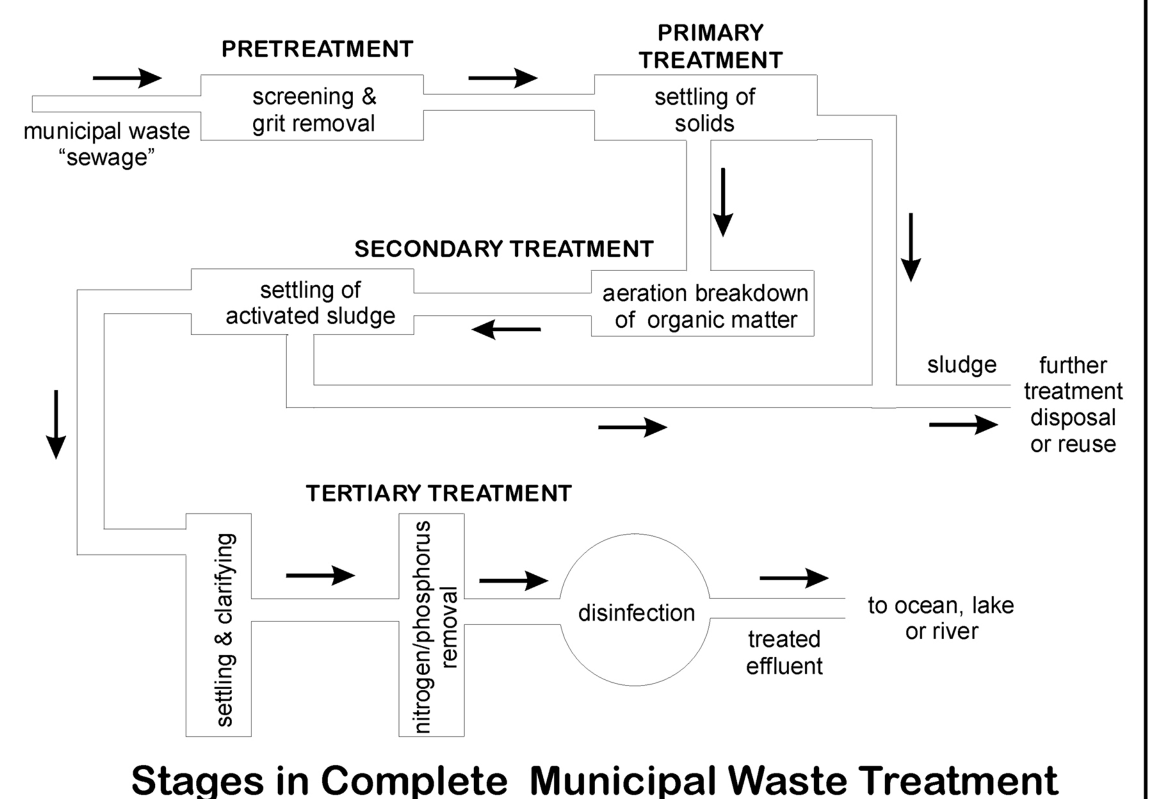
In Nova Scotia about 55% of the current population of 913,00 is hooked up to municipal sewage collection systems, while 45% use onsite systems. Connection to a municipal system does not necessarily imply treatment, since sewage from almost one third of the population is collected and discharged untreated into the sea. By the autumn of 2008 this proportion will have fallen considerably, as the Halifax Regional Municipality's new Harbour Solutions Project with three new treatment plants becomes fully operational. It is estimated that these new plants will reduce the amount of raw sewage discharged in the province by as much as 20%.

In larger urban centres, the surface water runoff from storm drains is often channeled a separate collection and discharge system from the municipal sewage. Sometimes the storm water is treated to remove noxious materials but is more often simply discharged into a bay or river. Many other communities, particularly smaller ones, have a combined storm water-sewer system in which runoff from street drains is combined with the sewage before it enters the treatment plant. This often poses a problem when rainfall is unusually heavy. The combined flow may exceed the capacity of the treatment plant and contaminated water has to be diverted and released with little or no treatment. This has happened on a number of occasions, most recently in May-June, 2008, at the Digby Nova Scotia STP. Heavy rains simply overwhelmed the facility and resulted in the contamination of large areas of the Annapolis Basin. The subsequent closure of clam and other shellfish harvesting for weeks is a significant economic blow to the area.

Sanitizing Sewage

The proper processing of large volumes of sewage in order to discharge a relatively harmless effluent into the aquatic environment can be a very expensive proposition. That is why the construction of new municipal STPs in Canada usually involves cost sharing by different levels of government. There is a wide disparity between municipalities across the country as to the degree of sewage treatment - some discharge raw sewage (e.g. Victoria, BC), others essentially potable water (e.g. Stratford, ON) - with the great majority lying somewhere between these extremes. The levels of traditional sewage processing can be categorized as preliminary, primary, secondary and tertiary treatment, typically with a final disinfection of the effluent prior to discharge.

Preliminary treatment - Sometimes called pretreatment, this process is mostly intended to remove larger objects such as plastics, tampons and other floating debris from the sewage stream that would be particularly unsightly if directly released into the environment or might interfere with subsequent stages of the treatment process. It in-



Stages in Complete Municipal Waste Treatment

(Modified from National Sewage Report Card #2, Sierra Legal Defense Fund, 1999)

volves running the raw sewage through screens of a particular mesh size, usually about 0.6 cm.. Cities such as Victoria, BC, Saint John, NB and St. John's, NL treat much of their municipal waste this way before discharging what is still essentially raw sewage.

The consequence of a raw sewage spill.

Primary treatment - This treatment process is largely designed to remove the bulk of the solids from the sewage stream. This is usually accomplished by greatly slowing the water flow, either in large settling tanks or outdoor settling ponds or lagoons, allowing the suspended solids to settle to the bottom, while lighter particles as well as oil and grease rise to the surface where they are periodically skimmed off. The wastewater may then be discharged into the environment or pass along to the next step in the treatment process. Primary processing can effectively reduce the amount of organic matter responsible for BOD by as much as 40% and the volume of suspended solids by up to 60%. Some treatment plants with advanced primary treatment (e.g. Halifax, NS) enhance the process by the addition of chemicals to speed up deposition of particulates and increase the quantity removed by as much as 90%, as well as sterilizing the effluent before discharge.

Secondary treatment - The next treatment step further reduces the amount of organic matter remaining in the wastewater by encouraging its breakdown (oxidation) by microorganisms already present. This is typically accomplished by forcefully aerating the wastewater in settling tanks or lagoons by bubbling air through it. In effect, this process causes the BOD to be satisfied in the treatment plant rather than later in the aquatic environment. Sometimes, the same end is accomplished by passing the wastewater through a series of "biological filters". These consist of layers of gravel and sand through which wastewater slowly flows. Abundant microorganisms growing on the surfaces break down much of the organic matter present. Such secondary treatment by either method may remove as much as 90% of the suspended particulate material and associated biological oxygen demand as well as greatly reducing the concentration of coliform bacteria in the effluent. Finally, chlorination or UV sterilization takes place. Advanced secondary treatment is now considered to be the minimum required for wastewater by experts in the field and is recommended by the Canadian Council of Ministers of the Environment (CCME). Unfortunately, cost usually determines what treatment system is put in place.

Tertiary treatment - Many different methods are available for the final tertiary treatment, depending on the nature of the wastewater and the compounds to be removed. Such treatment may remove even more suspended organic particles and BOD as well as dissolved materials such as nitrogen, phosphorus or ammonia. Treatment may involve use of a variety of physical (ultra filtration, reverse osmosis through membranes, ion exchange, electrodialysis, activated carbon adsorption), chemical (clarifying agents, precipitants, digesters) or biological (oxidation, metabolism) processes. Tertiary treatment methods may even remove heavy metals and some toxic chemicals. However, the process can be expensive and is not widely used. Calgary and Edmonton, discharging into rivers, are the rare Canadian cities that treat sewage at the tertiary level.

Disinfection - Many sewage treatment plants, even ones that only carry out primary or secondary treatment, disinfect the wastewater before releasing it into the aquatic environment in an effort to kill bacteria and other microorganisms. The most widely used method is the addition of chlorine to the wastewater just before discharge. This may involve bubbling chlorine gas through the water or adding measured quantities of sodium hypochlorite, calcium hypochlorite or chlorine dioxide. Although this effectively kills microorganisms, the presence of chlorine renders the effluent acutely toxic to aquatic organisms. The very reactive chlorine may also combine with various compounds in the effluent producing a wide range of toxic chlorinated compounds. Despite the implications for STPs, Environment Canada lists chlorinated wastewater as a toxic material in its Priority Substances List. A more environmentally benign way of disinfecting wastewater is to subject it to ultraviolet radiation. However, this is not widely used because it is expensive, technically more complicated and is only effective on clear effluents flowing through at a relatively uniform rate. Fredericton is one of the few East Coast municipalities using UV to disinfect its wastewater, although Halifax will also be using it in its three new STPs.

Sludge Solutions

As more municipalities install or enhance STPs to solve one environmental problem, they inevitably create another ecological issue. How does one effectively and responsibly dispose of the growing volumes of solid residue or "sludge" remaining after the water has been removed, cleaned and returned to the environment? Once widely used methods of disposing of the sludge are now considered to be environmentally harmful and are frowned upon or banned in a growing number of jurisdictions. Disposal in landfills can contaminate groundwater, incineration contributes to air pollution, while sewage sludge dumping at sea reduces water quality and contaminates bottom habitats and is now banned under international law.

It has long been known that such sludge, being a rich source of organic matter and plant nutrients such as nitrogen and phosphorus, is an ideal soil amendment and fertilizer. For decades, large quantities of municipal sludge have been applied to agricultural land in Canada as a cheap, easy disposal method. However, there are many other materials in the sludge that raise valid concerns about this practice. As discussed above, sewage, and thus its resulting sludge, is a complex blend of microbes, heavy metals, synthetic organic chemicals, petroleum products and industrial wastes. The heavy metals are of particular concern because the concentrations can build up in the soil with each successive application of sludge and can bioaccumulate in crops. Agriculture and Agrifood Canada acknowledges that applying sludge to land raises the metal concentrations in the soil and that the levels of such contaminants in the receiving soil "must be regulated". However, they suggest that there is enough information about the fate and effects of metals in different types of soils that criteria for "maximum permissible sludge loadings" (tonnes of sludge per hectare per time span) can be calculated and application guidelines developed to protect soil quality. For example, in Ontario "about 40 tonnes of dry sludge may be applied per hectare over 15 years". Less is known about the fate and effects of some of the others compounds in sludge, particularly toxic organic contaminants. There are no Canadian guidelines for most of these, although Quebec limits the agricultural use of sludge with polychlorinated biphenyl levels exceeding 10 parts per million. Agriculture and Agrifood Canada is working to " assess the need to regulate the amount of organic contaminants that can safely be added to soil".

In New Brunswick several municipalities treat and recycle sludge to improve the quality of depleted soils. Solid or semi-solid sludge that has been treated and stabilized to kill disease-causing organisms and reduce odours is euphemistically called "biosolids". The sludge can be "stabilized" by treating it with alkaline chemicals, composting it, drying it with heat or subjecting it to a digestion process. The province issues certificates of approval for the production, storage, handling and application of these biosolids according to strict guidelines that include monitoring of contaminant levels in sludge and soils. Nova Scotia issued new guidelines in 2004 for the storage and disposal of biosolids. Approval must be obtained from the provincial environment department. Only sludge that has been treated to kill pathogenic microbes and meet specified chemical criteria can be applied to land - untreated sludge can not be used. In addition, a plan for land application is required as well as regular monitoring of any nearby domestic wells. Animal grazing and the growing of crops for human consumption can only occur after a specified time has elapsed following application of municipal biosolids.

Patchwork policies

In Canada efforts to manage the discharge of sewage wastes into coastal waters have been hampered by the shared and interwoven responsibilities of different levels of government - federal, provincial, county and municipal. Internationally, Canada is signatory to both the United Nations Convention on the Law of the Sea

Heavy metal concentrations in various soil amendments

[parts per million (ppm) dry weight] — *Agriculture and Agrifood Canada*

Soil amendment	Cd	Co	Cr	Cu	Ni	Pb	Zn
Commercial Fertilizer	9	5	92	3	36	3	108
Urea	<0.1	<1	<3	<0.4	<1	<3	<1
Potassium chloride	<0.1	2	<3	<0.6	4	3	<1
Agricultural lime	<0.1	<1	<3	<0.2	5	<3	<2
Cow manure	1	6	56	62	29	16	71
Sewage sludge	5	5	350	660	35	980	800

[< = less than; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Ni = nickel; Pb = lead; Zn = zinc]

(UNCLOS) and the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), both of which have provisions to prevent the disposal of sewage into the ocean. The Federal Government has at least three legislative statutes with a direct bearing on the subject. The Fisheries Act (section 36) threatens substantial penalties for anyone discharging “deleterious substances” into waters “frequented by fish”. In addition, in response to the London Convention, the Canadian Water Act gives the government power to designate a body of water a “water quality management area” and act to protect its water quality. Finally, the Canadian Environmental Protection Act (CEPA) includes a section specifying that a permit is required to dump sewage into the ocean. Another section in CEPA regulates the discharge of a number of deleterious chemicals present in sewage, including the complex, toxic chlorinated waste effluent resulting from treatment and sterilization. Canada's Oceans Act is silent on the topic of deleterious discharges, unless they directly threaten designated Marine Protected Areas, or if marine environmental quality guidelines are required for specific chemicals or substances. Significant legislative clout thus exists at the Federal level to regulate sewage discharge, but infractions are seldom, if ever, prosecuted under these statutes. For well over a century, cities such as Victoria, Vancouver, Saint John, Halifax and St. John’s, as well as many other coastal communities, dumped large quantities of raw sewage into coastal waters with relative impunity, without federal permits, and only with occasional provincial permits. Because construction and upgrading of STPs typically involve cost-sharing agreements amongst different levels of government, the federal government is understandably reluctant to prosecute infractions for which it may share some responsibility. Instead, real responsibility for sewage management has largely devolved to individual provincial and municipal governments, resulting in an inevitable countrywide patchwork of regulatory approaches. All provinces have legislation intended to control sewage collection, treatment and subsequent effluent discharge by municipalities or other entities, but the governmental departments responsible for enforcement and the zeal to prosecute violations vary greatly across the country. However, there is a new federal sewage strategy, now approved by the Canadian Council of Ministers of the Environment, that may help to coordinate federal and provincial efforts on this issue.

“In Canada ... efforts to manage the discharge of sewage wastes into coastal waters have been hampered by the shared and interwoven responsibilities of different levels of government”

Regarding the Bay of Fundy, the New Brunswick Department of Environment is primarily responsible for the regulation of sewage treatment facilities under the authority of the provincial Clean Environment Act. It grants approvals for the construction, upgrade or expansion of municipal treatment facilities after an environmental impact assessment has been carried out. During the assessment, various federal and provincial departments review the projects and any shortcomings are identified and remedied before construction is permitted. Subsequently, in giving approval for operation of the facility, the Province establishes the required operating standards and monitoring programs. The Department is also responsible for conducting annual audits of each facility and regular site inspections. On the other hand, the provincial Department of Health is responsible for the approval of onsite septic systems and land disposal fields, although the Department of Environment still regulates the actual disposal of septic wastes.

In Nova Scotia, the Department of Environment is responsible for the management of both communal and onsite sewage collection, treatment and discharge, as set out in the provincial Environment Act. The Water and Wastewater Branch of the Environment and Natural Areas Management Division is responsible for regulations pertaining to water and wastewater management and for establishing regulatory policies and strategies, as well as setting objectives for effluents. The Environmental Monitoring and Compliance Division subsequently administers approvals required for communal and onsite wastewater systems and also monitors and inspects facilities to ensure that they comply with regulations.

The basic standards for wastewater effluents, monitoring, operator training and other operational aspects of sewage treatment are largely uniform in all four Atlantic Provinces, based on the comprehensive "Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment and Disposal, 2006", prepared by Environment Canada and the responsible provincial departments. In New Brunswick and Nova Scotia, although governments play a pivotal role in regulating the construction and operation of STPs , it is the owners, usually municipalities, which bear ultimate responsibility for maintenance, repair and operation of such facilities.

Sewage System Snapshots

Communities around the Bay of Fundy differ greatly in the degree to which they treat their sewage wastes before discharging them into rivers, estuaries or coastal waters. Many still dump raw sewage into the ocean, others provide at least primary or secondary treatment, while a few have created tertiary treatment systems. The following is a snapshot of systems currently in use in a few Fundy coastal communities that illustrate the diversity of approaches and the current status of this issue..

The largest urban centre fronting directly on the Bay of Fundy is the city of Saint John, NB, with a population of 68,000 in the city proper and 122,000 in the greater metropolitan area. It is an old city with a long history and one of the first cities in Canada to construct a municipal sewage collection system. Being located around the lower estuary of the St. John River, where the massive tidal inflow produces the world famous Reversing Falls, it was long assumed that the tidal mixing would effectively disperse and remove the sewage waste without any need for treatment. Over the years, as the suburban population expanded, efforts were made to treat some of the burgeoning sewage, at least at a primary level, by constructing four sewage lagoons at Lancaster, Millidgeville, Marsh Creek and Hazen Creek. These facilities currently provide primary or secondary treatment for only 58% of the city's sewage. An additional 55 outfalls, mainly located around the inner harbour, still discharge 6.6 billion litres of raw sewage directly into the ocean each year, enough to fill more than 150 supertankers! Faced with growing public pressure, expanding tourism near the harbour area, a steady barrage of embarrassing reports by groups such the Saint John Atlantic Coastal Action Program (ACAPSJ), and increasingly stringent federal and provincial effluent regulations, in 2000 the city launched a major initiative to treat all of the city's sewage within ten years. This is largely being accomplished by expanding the Hazen Creek facility to collect and treat sewage from a much larger area and by closing the problem-plagued Marsh Creek plant.

In the Upper Bay of Fundy, the adjacent Municipalities of Moncton, Dieppe and Riverview, New Brunswick treat their sewage at a large modern, fully automated STP operated by the Greater Moncton Sewerage Commission (GMSC) since the early 1990s. Although initially hailed as a state of the art facility, the plant offers only advanced primary treatment. The sewage first flows through a series of bar screens that remove large solid objects, that are sent then to a municipal waste disposal site. The effluent is then aerated in "grit chambers" where non-degradable particles such as sand settle out. Chemicals are then added to a settling tank, which causes suspended organic particles to settle out in a series of clarifier tanks thus separating sludge from the clarified water, which is released into the Petitcodiac River. The sludge is centrifuged to remove much of the water and then lime slurry is added to stabilize the sludge and control odours. The resulting biosolids are used as an agricultural soil additive. Each day the plant discharges 50-70 million litres of effluent that still contains large concentrations of nutrients and organic compounds that stimulate BOD in the receiving waters. Although the GMSC lauds the plant as a "source of pride to the community of Greater Moncton and a subject of interest to engineers and infrastructure planners from around the world", other are more critical. The Petitcodiac RiverKeepers have for several years nominated the plant as the second worse pollution source affecting the Petitcodiac River (after the causeway). The organization also notes that, although the plant was intended to provide full treatment, after 20 years of operation, there are still no plans to significantly upgrade the facility.

A number of small communities around the Bay such as Annapolis Royal, Bear River, Great Village and River Hebert have been in the forefront of developing better ways of dealing with their sewage, particularly in using more "natural" tertiary treatment methods. The most innovative approach was that adopted by the little community of Bear River, near Digby, NS which wanted to stop dumping its raw sewage into a nearby river. The "innovative but natural" system that opened in 1995 attracted attention worldwide, garnered many environmental awards and for awhile became a magnet for tourists who were given guided tours of the facility. In this so called "Solar Aquatic" system, sewage first passed through a large blending tank where bacteria were added and the material aerated vigorously to break up the solids. Final treatment of the effluent was carried out in a large greenhouse where the effluent flowed through a series of large clear cylinders (solar tanks) containing fish, zooplankton, snails, plants, algae, and protozoans, and then through artificial marsh beds containing cattails, irises, banana trees and other plants. Before the water was released into the Bear River, it was disinfected with UV light. The small amount of sludge remaining was composted on site. However, the plant proved expensive to operate, lacked the sewage volume to operate efficiently, and encountered other technical problems. The system, now being operated in a "more

Natural tertiary treatment in Annapolis Royal.

conventional manner" using chemicals, is no longer open to visitors because of safety concerns.

For years, the nearby community of Annapolis Royal treated its sewage in two large aerated lagoons and then chlorinated the effluent before releasing it into the Annapolis River above the causeway. The need to replace an aging chlorinator caused the town to think about other possible options for the "final polishing" of the effluent. A few years earlier, Ducks Unlimited, the Clean Annapolis River Project and other organizations had worked with the town to create a "constructed freshwater wetland" on what was originally the Town Marsh. This involved repairing a number of old dykes, excavating a few depressions, building up a few small islands and bars and creating a walking trail (the French Basin Trail) around the resulting marsh. The new wetland has not only proved a hit with residents and visitors but has also attracted a remarkable variety of wildlife to the area. This new marsh, located immediately adjacent to the sewage treatment lagoons, was soon recognized as an excellent tertiary treatment option. In 2007, effluent from the lagoons that has been disinfected by UV light, began flowing into one end of the marsh. The arrangement of islands and bars forces the water to slowly flow around the marsh to an overflow pipe where, several days later, it runs into the Annapolis River. The trail already has some interpretive signage pertaining to general marsh ecology and wildlife. The Town plans to enhance visitor appreciation of the area by adding photography blinds, viewing platforms and other amenities as well as more interpretive panels to describe the new tertiary treatment role of the marsh.

Moving forward

While Canada still lags behind the European Union and United States in terms of national standards for municipal waste treatment and in the adequacy of its system of coastal STPs, the country is, nevertheless, now moving in the right direction on the issue. Environment Canada has long recognized that inadequate municipal wastewater treatment has adverse effects on aquatic organisms, water supplies, fisheries and human health and that it is "unacceptable and shortsighted not to maintain and upgrade infrastructure." In cooperation with many other agencies it is working on a number of initiatives to improve sewage management practices nationwide. These include developing an inventory of sewage sources and environmental impacts and eliminating the discharge of untreated sewage by building new treatment plants or upgrading older ones. They are also enhancing the guidelines pertaining to wastewater discharges and developing a more effective regulatory system backed up by more rigourous monitoring for compliance. Effort is also being made to educate the public about not disposing of noxious compounds in domestic wastewater and the importance of proper maintenance of onsite septic systems. The Federal Clean Water Act calls for the eventual elimination of combined sewer systems, but this is a very costly undertaking and progress will likely be slow. In the interim, efforts are being made to reduce accidental contaminated discharges by improving sewage management practices.

Over the past decade, both Nova Scotia and New Brunswick, with financial assistance from the Federal Government, have also been making some progress in building or upgrading wastewater treatment plants throughout the region. Recent federal budgets have earmarked billions of dollars for cost-shared "green" infrastructure programs involving upgrading municipal water supply and wastewater treatment across the country. In April 2008 the Canadian Government announced a strategy that would eventually ban coastal communities from discharging untreated or partially treated sewage into the sea and require at least secondary treatment of all municipal wastes. To assist financially strapped communities the federal Environment Minister also indicated a readiness to invest $8 billion in clean water initiatives provided that municipal and provincial governments contributed a comparable amount.

Both NS and NB have also launched a number of programs to enhance the training and licensing of designers, builders and operators of STPs, as well as for those involved in the design, installation and servicing of on-site septic systems. A number of community-based groups, such as the ACAP (Atlantic Coastal Action Plan) sites in Saint John, NB and Annapolis Royal, NS, have developed public education programs pertaining to sewage issues. In 2002, the Nova Scotia Environment Department cooperated with the NS Association of Realtors to develop a training course called "Onsite Sewage Disposal Systems Awareness". The 3-hour pilot course was offered free to real estate agents so that they could better help home buyers understand their septic systems and the steps needed to maintain them properly over the years. As well, the Atlantic Intergovernmental Group on Land-based Pollution/Activities, led by Environment Canada and the NB Department of Environment, has concentrated its attention on on-site systems and their improved maintenance throughout the region.

Although much remains to be done, it is clear that steady progress is being made in the handling and processing our domestic wastewater more effectively so that it doesn't contaminate the environment. Politicians, responsive to an ever more environmentally aware public, seem more inclined to direct funding towards wastewater treatment projects and readier to adopt more stringent guidelines and regulations for managing wastewater. We must continue working towards the ultimate goal of having all municipal wastewaters discharged into the Bay of Fundy and other waters subjected to advanced secondary or tertiary treatment.

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Further Information

Impacts of Municipal wastewater effluents on Canadian waters: A review. P.A. Chambers, M. Allard, S.L. Walker, J. Marsalek, J. Lawrence, M. Servos, J. Busnarda, K.S. Munger, K. Adare, C. Jefferson, R.A. Kent and M.P. Wong. Water Quality Research Journal of Canada. Volume 32, number 4, pages 659 to 713. (1997)

The National Sewage Report Card (Number Two). Rating the Treatment Methods and Discharges of 21 Canadian Cities. Miranda Holmes and Karen G. Wristen. A Sierra Legal Defence Fund Report. 63 pages. (August 1999).

Sewage Management in the Gulf of Maine. Workshop Proceedings. Editors P.R. Hinch, S. Bryon, K. Hughes and P.G. Wells. Gulf of Maine Council on the Marine Environment. 52 pages (2002).

Microbial Source Tracking (MST): towards Effective Identification of Fecal Pollution Sources: MST Applications. Workshop Final Report. Denise Sullivan. Clean Annapolis River Project. 116 pages (2004).

Options for On-Site and Small Scale Wastewater Management in Nova Scotia. Nova Scotia On-site Wastewater Applied Research Program. D. H. Waller. Center for Water Resources Studies, Faculty of Engineering, Dalhousie University, Halifax. CWRS Internal Report 03-03. 33 pages. (2003) [http://centreforwaterresourcesstudies.dal.ca/Files/dads_report.pdf]

The State of the Marine Environment: Trends and Processes. Ljubomir Jeftic, Jennifer Laughlin and Prem Vanrompay. United Nations Environment Programme (UNEP) 42 pages. (2006) [http://www.gpa.unep.org/documents/soe_-_trends_and_english.pdf]

Websites

Municipal Wastewater Strategy. Canadian Council of Ministers of the Environment. http://www.ccme.ca/ourwork/water.html?category_id=81

Greater Moncton Sewerage Commission Website. Includes a virtual tour of the STP. http://www.gmsc.nb.ca/english/home/index.cfm

Environment Canada Wastewater Management Website: http://www.ec.gc.ca/etad/default.asp?lang=En&n=D5CE3A46-0

The Maritime Provinces Water and Wastewater Association Website: http://www.mpwwa.ca/