Water – The Transporter

Introduction

Water plays an important role in the transformation of the Canadian landscape by moving large amounts of soil, in the form of **sediment**. Sediment is eroded from the landscape, transported by river systems, and eventually deposited in a lake or the sea. For example, the Fraser River carries an average of 20 million tonnes of sediment a year into the marine environment.

The sediment cycle starts with the process of **erosion**, whereby particles or fragments are weathered from rock material. Action by water, wind, glaciers, and plant and animal activities all contribute to the erosion of the earth's surface. Fluvial sediment is the term used to describe the case where water is the key agent for erosion. Natural, or geologic, erosion takes place slowly, over centuries or millennia. Erosion that occurs as a result of human activity may take place much faster. It is important to understand the role of each when studying sediment transport.

Any material that can be dislodged is ready to be transported. The **transportation** process is initiated on the land surface when raindrops result in sheet erosion. Rills, gullies, streams, and rivers then act as conduits for sediment movement. The greater the discharge, or rate of flow, the higher the capacity there is for sediment transport.

The final process in the cycle is **deposition**. When there is not enough energy to transport the sediment, it comes to rest. Sinks, or depositional areas, can be visible as newly deposited material on a flood plain, bars and islands in a channel, and deltas. Considerable deposition occurs that may not be apparent, as on lake and river beds. A knowledge of sediment dynamics is an integral part of understanding the aquatic ecosystem.

Canada's waterways move many millions of tonnes of sediment annually in this never-ending cycle of erosion, transportation, and deposition. Sediment is measured and classified according to its dynamic characteristics:

- suspended load (suspended in the water)
- bed load (rolling or bouncing along the bottom)
- bed material (stationary on the bed)

Why is Sediment Important?

Sediment carried in water has a variety of effects: what are they and why are they important?

Toxic chemicals

Sediment plays a major role in the transport and fate of pollutants and so is clearly a concern in water quality management. Toxic chemicals can become attached, or adsorbed, to sediment particles and then transported to and deposited in other areas. These pollutants may later be released into the environment. By studying the quantity, quality, and characteristics of sediment in the stream, scientists and engineers can determine the sources and evaluate the impact of the pollutants on the aquatic environment. Once the sources and impact are known, action can be taken to reduce the pollutants. The association of toxic chemicals with sediment is an issue of national importance.

Navigation

Deposition of sediment in rivers or lakes can decrease water depth, making navigation difficult or impossible. To ensure access, some of the sediment may be dredged from the stream or harbour, but this may release toxic chemicals into the environment. To determine how much dredging needs to be done and how often, water levels must be monitored, and the rates of sediment transport and deposition estimated. Sedimentation of navigation channels is a concern in the Fraser River (British Columbia), the Mackenzie River (Northwest Territories), and the Great Lakes-St. Lawrence system (Ontario and Quebec).

Fisheries/Aquatic habitat

Streamborne sediment directly affects fish populations in several ways:

- Suspended sediment decreases the penetration of light into the water. This affects fish feeding and schooling practices, and can lead to reduced survival.
- Suspended sediment in high concentrations irritates the gills of fish, and can cause death.
- Sediment can destroy the protective mucous covering the eyes and scales of fish, making them more susceptible to infection and disease.
- Sediment particles absorb warmth from the sun and thus increase water temperature. This can stress some species of fish.
- Suspended sediment in high concentrations can dislodge plants, invertebrates, and insects in the stream bed. This affects the food source of fish, and can result in smaller and fewer fish.
- Settling sediments can bury and suffocate fish eggs.
- Sediment particles can carry toxic agricultural and industrial compounds. If these are released in the habitat they can cause abnormalities or death in the fish.

Forestry

Some forestry practices have negative impacts on the environment. Extensive tree cutting in an area may not only destroy habitat but increase natural water runoff and accelerate soil erosion. These can lead to increased flow and sediment loads in nearby streams. They can also release chemical substances occurring naturally in forest soils, and allow them to contaminate rivers or lakes. Both the chemicals and the additional sediment can harm fish and other organisms. Sediment problems resulting from forestry practices are prevalent in British Columbia, Ontario, Quebec, New Brunswick, and Newfoundland.

Water supply

Sediment can affect the delivery of water. When water is taken from streams and lakes for domestic, industrial, and agricultural uses, the presence of sediment in the water can wear out the pumps and turbines. As this increases maintenance costs, it is important to determine the amount of sediment in the stream so that the appropriate equipment can be chosen when designing a water supply plant.

Energy production

The amount of sediment transported affects both the size and the life expectancy of reservoirs created for power generation. A dam traps sediment that would normally be carried downstream, and that sediment decreases the size of the reservoir and thus its use for power generation. Therefore, it is necessary to know the amount of sediment to ensure the effective design of reservoirs for the long term.

Agriculture

Some farming practices increase soil erosion and add toxic chemicals to the environment. Thus, productive soil is lost to farms, sediment and pollutants are added to streams, and maintenance costs of irrigation systems are increased. Sediment data and information are necessary in the evaluation of cropping practices and their environmental effects. Sediment-related problems associated with agriculture occur across the country.

Case study: aquatic habitat and construction in St. John's, Newfoundland

A considerable amount of sediment is lost from building sites during construction. Depending on its location, this sediment finds its way to sewer or stream systems, increasing the costs of water treatment or impacting on aquatic habitat. In 1982, construction was started on a building to house the Institute for Marine Dynamics in St. John's, Newfoundland. The site, near the Rennie's River, required massive excavation. To minimize the impact of the sediment on the aquatic environment, a de-sedimentation facility was built. A settling pond was used, and alum was added to help settle the sediment, alum having no significant impact on the ecosystem. Without the de-sedimentation facility, toxic chemicals and sediment could have contaminated the fish, buried fish eggs, dislodged aquatic plants, and generally overwhelmed the aquatic habitat. Over three years, 1250 tonnes of sediment were kept from entering the river waters. The cost of the de-sedimentation was less that one tenth of one percent of the building costs, and a highly productive trout habitat was protected from contamination.

How is Sediment Sampled?

Sediment quantity and quality are sampled in a variety of ways:

- Specially designed **suspended-sediment** samplers are used to collect water/sediment samples that are analyzed for sediment quantity and sometimes quality.

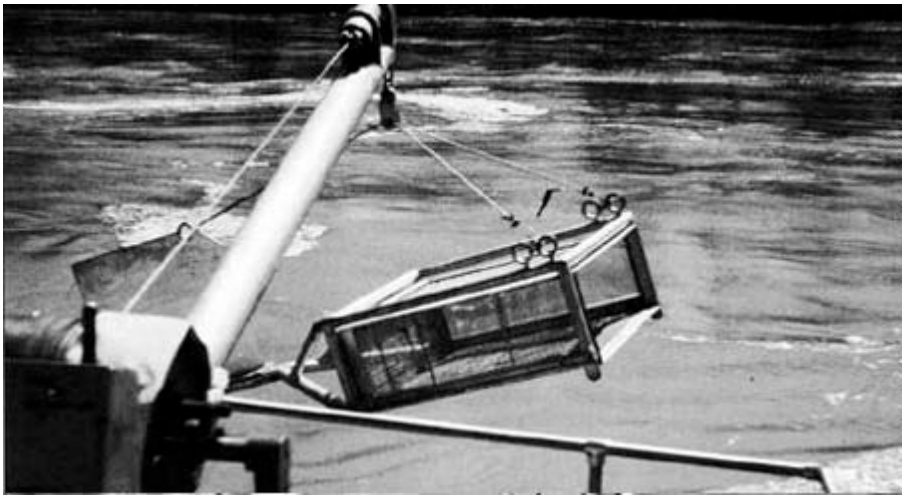
Removing a suspended-sediment sample

Fraser River, British Columbia

The technician retrieves the glass bottle from the sampler by opening the front of the sampler. The bottle is then capped, labelled, and placed in a box to be shipped to the laboratory for analysis.

- **Bed-load** samples are usually taken by lowering a specially made sampler to the stream bed. Resting there, the sampler traps the material moving along the bottom.

Bed-load sampler



Fraser River, British Columbia

A bed-load sampler is lowered into the river bed with the opening facing upstream. The wire mesh allows water to pass through but traps the sediment. In this case the mesh is large enough so that only large material, such as gravel, is trapped.

- **Bed-material** samples may be taken simply by hand from exposed bars or stream banks, or by samplers from the stream bed. Some samplers scoop sediment by simply digging into the bed, while other kinds extract a core from the bed.

Once collected, suspended-sediment samples are analyzed for concentration and particle size. This is usually done in a laboratory. The **concentration** is the ratio of sediment (dry weight) to the total water-sediment mixture, expressed as milligrams per litre (mg/L). The **particle size** is simply the size of the sediment particles. Depending on their size, they are classified as sand, silt, or clay.

Laboratory analysis

Regina, Saskatchewan

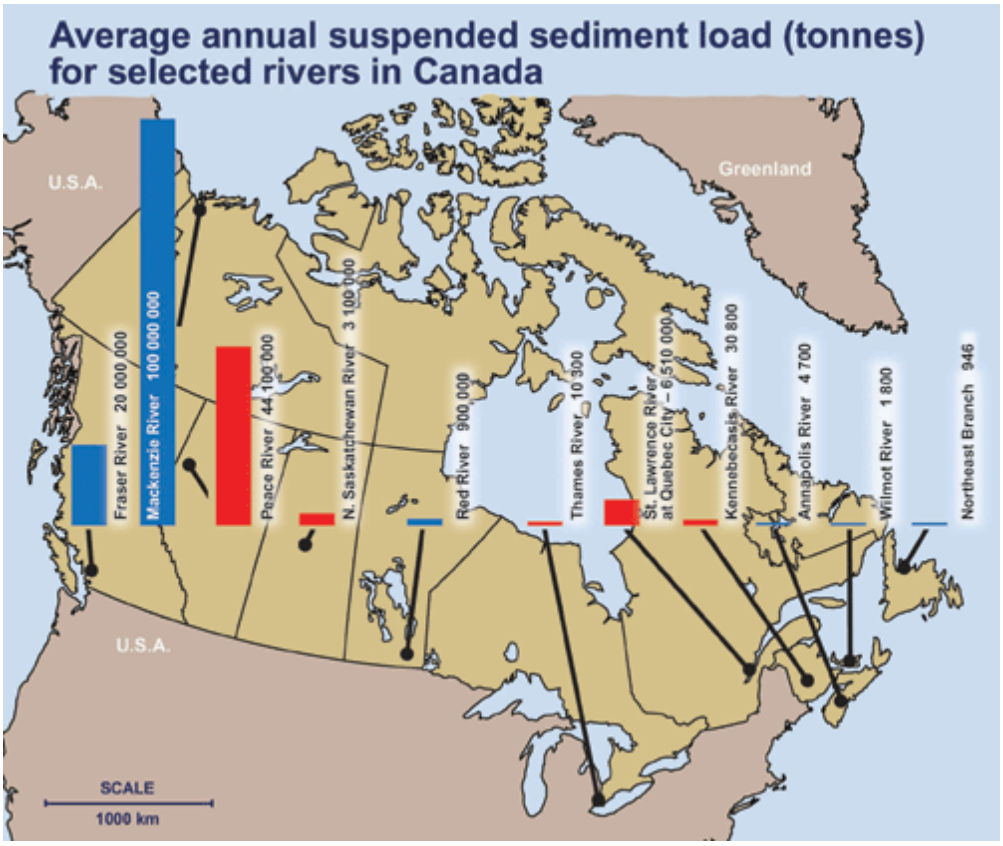
Suspended-sediment samples are analyzed in the laboratory. Here the laboratory technician is removing the clear water (supernatant), leaving the settled sediment to be filtered to determine concentration.

To find out how much material is transported by a river, one can combine the concentration with the stream discharge, or flow. This gives the sediment load, which indicates the total amount of sediment transported over a certain time period, whether an hour, a day, month, or year. In such a way, it has been estimated that at Montreal the St. Lawrence River transports 2.3 million tonnes of sediment in suspension each year, or the equivalent of 230 000 truck-loads of soil.

Water, and more specifically the hydrologic cycle, plays a major role in driving the sediment life cycle. The amount of water and its distribution over time influence how and when sediment is sampled.

In Canada, sampling is usually for suspended-sediment data. Most of this sampling is done during high-flow conditions (spring, summer, and fall rainstorms), when most of the sediment is transported through the river system. However, a few samples may be taken at other times throughout the year, to better define the sediment regime. Bed-load sampling is typically undertaken in the spring, when high discharge mobilizes the stream bed. Bed-material may be sampled during the summer, when low-flow conditions may expose parts of the stream bed, making sampling easier.

Once the samples have been analyzed, the data on concentrations, particle sizes, or loads can be applied to engineering and environmental questions.



Glaciers retreated 10 000 years ago, leaving large amounts of easily erodible material across much of western Canada. In mountainous areas (e.g., the Fraser, Peace, and upper Mackenzie rivers), steepness and abundant water supply enable large amounts of sediment to be carried away. In contrast, the flat and dry conditions of the Prairies result in much lower sediment loads. In eastern Canada, where much of the land is bedrock, there is a limited sediment supply and therefore smaller loads.

Sediment Data and Information

The measurement of sediments in streams in Canada dates back to 1948, in Saskatchewan. The federal government has conducted a national sediment program since 1961 in cooperation with the provinces, territories, and other interested agencies, such as hydroelectric companies. Data-collection techniques are standardized across the country to maintain data quality and comparability. Provincial governments also collect sediment data either as part of a regular sampling program or for specific studies. Consulting engineers and planners, as well as university researchers, also carry out sampling for site-specific projects.

These data have been used extensively to address reservoir sedimentation, environmental impact assessment, sediment-associated contaminant transport, and other concerns.

Sediment data and information are available from a variety of sources. A large amount of data is contained in a national computer data base operated by Environment Canada. The

data base contains historical and current data for about 750 stations throughout the country, about 300 of which are currently monitored.

The types of data that are stored in the national computer data base are as follows:

- suspended-sediment concentrations
- suspended-sediment loads
- suspended-sediment particle size
- bed load
- bed-load particle size
- bed-material particle size
- sediment quality

The data are published annually and are available from the Water Survey of Canada.

Freshwater Series A-8

Note: A resource guide, entitled Let's Not Take Water For Granted, is available to help classroom teachers of grades 5-7 use the information from the Water Fact Sheets.

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