Columbia River Fibre Mat Study: 1990 to 1994

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1. INTRODUCTION

Prior to modernization in 1992, untreated effluent from the Celgar Pulp mill was discharged into the Columbia River at Castlegar, B.C. The effluent included settleable solids such as lime, sewered fly ash, pulping chemicals and pulp fibres. Settleable solids from these historical mill operations, as well as from log storage and adjacent sawmill activities, have created a "fibre mat" in the Columbia River immediately downstream from the mill outfall.

The term "fibre mat" describes an upper layer of sediment in which fibre and wood debris are the most visible components and that is contaminated with chlorinated organics, such as furans. The fibre mat can be divided, based on composition, into two types: (1) fibre/slime mat which is a wood fibre material covered by a layer of slime/silt/wood where the slime consists of algae/fungus-like growth; and (2) fibre/black silt mat which is fibre within a black silty material.
This short paper summarizes the findings of the 1990, 1992 and 1994 investigations by EVS Consultants. The objectives of this study was to visually describe and chemically characterize the fibre mat, to assess any trends over time, and to determine potential ecological effects of the fibre mat.

2. METHODS

In 1990, 1992 and 1994, the spatial extent of the fibre mat was determined by diver surveys of the sediment along transects (Figure 1). Transects were set across the river at 120 m upstream, and at 0, 120, 160, 500 and 700 m downstream of the diffuser.

In 1990, core samples of the fibre mat were collected for chemical analysis at five sites on the river bottom. Coring depth varied from 10.2 cm to 50.8 cm. In 1992 and 1994, six sediment samples were collected for chemical analysis using an Ekman grab sampler following Environmental Effects Monitoring (EEM) standard operating methods[1]. In 1994, toxicological analysis were conducted on the samples from sites 94-2 and 94-4, and benthos analysis were done on a sample collected from 94-2. Reference sites were different for each study year: 1990 reference sites were upstream of the fibre mat, 1992

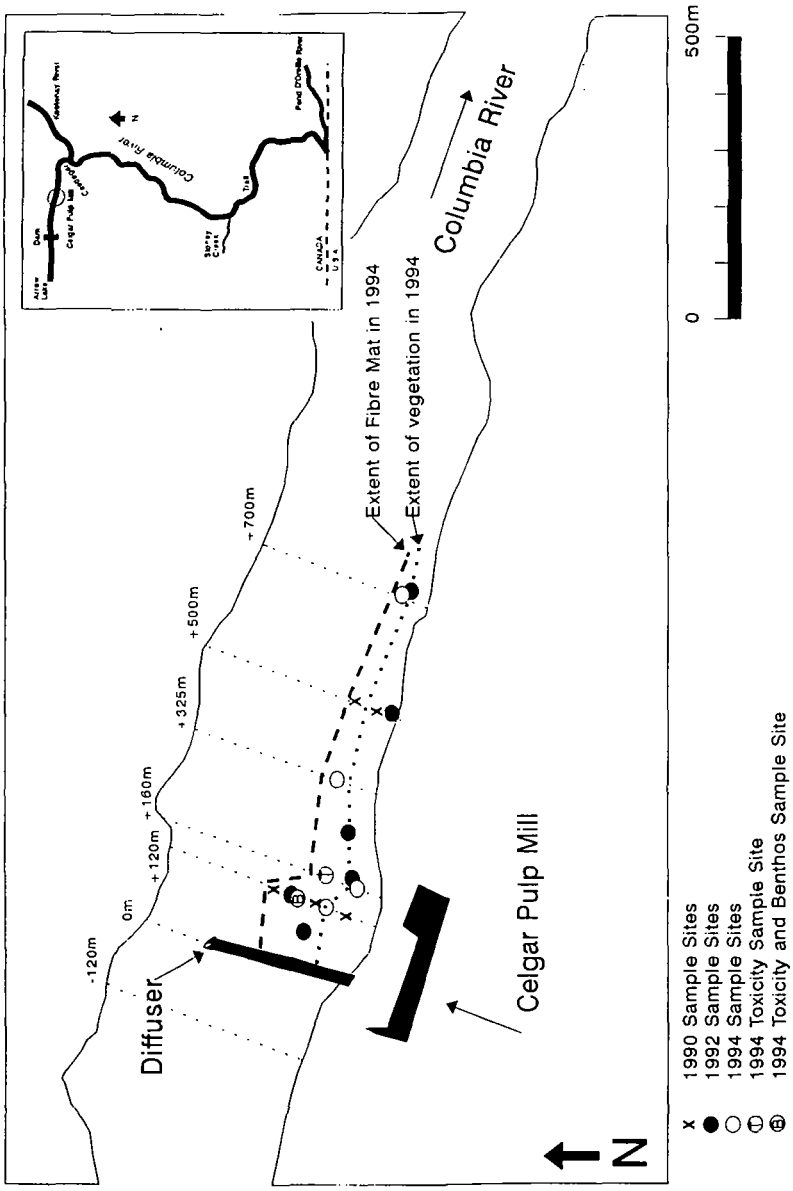

Figure 1. Map of Study Site.

reference sites were both upstream and downstream, and 1994 reference sites were located upstream at Revelstoke.

3. RESULTS

Between 1990 and 1994, the total fibre mat decreased from an estimated volume of 40,500 m^3 to 16,000 m^3, and the fibre/slime mat completely dissipated. The remaining fibre/black silt mat is a heterogenous mixture composed of bleached fibres, chip fines and bark mixed with sand and algae.

Chemical Compounds

Within the fibre mat, concentrations of ammonia, sulphide, metals and non-chlorinated organic compounds were not considered to present as great an environmental concern as the chlorinated organic compounds.

The chlorinated compounds of greatest concern included a chlorinated resin acid (dichlorodehydroabietic acid), chlorinated phenols (2,4-dichlorophenol, 2,4,6-trichlorophenol, chlorocatechol and chloroguaiacol) and furans (2,3,7,8-T_4CDF). While some chlorinated organics appear to be degrading, other compounds such as dichlorodehydroabietic acid, 2,4,6-trichlorophenol and furans appear to be persistent. Generally, highly chlorinated compounds are more hydrophobic, more stable, and more persistent in the aquatic environment than non-chlorinated compounds[2]. In particular, hydrophobic organic compounds, such as dioxins, will be more persistent in the fibre mat. In addition, the fibre mat is an anaerobic environment which is much less conducive to biodegradation than aerobic conditions[3]. However, some degradation of chlorinated compounds appears to be occurring. Specifically, the mills' effluent prior to modernization contained high concentrations of several tri- and tetra-chlorinated phenols and no detectable 2,4-dichlorophenol, whereas the fibre mat was the reverse. Since dichlorophenols are known to be the degradation products of more chlorinated phenols[3], some degradation of chlorophenols is likely occurring within the fibre mat. In addition, the concentrations of chlorocatechols and chloroguaiacols appears to be decreasing with time. However, other compounds such as dichlorodehydroabietic acid and 2,4,6-trichlorophenol do not appear to be readily degrading. Levels of 2,3,7,8-T_4CDF were much higher in 1992 than in the 1990 and 1994 studies. The cause of the decrease from 1992 to 1994 is not known but it may be one of the following:

- It might be the result of degradation of 2,3,7,8-T_4CDF. The fibre mat was suspected of being eroded by the high flow rates during the summer of 1992[4]. The newer top sediments were removed to reveal older fibre mat material deposited when the Celgar Mill did not have effluent treatment. Consequently, the material sampled in 1992 could be older than in 1994 and therefore have higher concentrations of 2,3,7,8-T_4CDF. The lower concentrations of T_4CDF found in the 1994 study may be the result of the

subsequently release and degradation of T_4CDF to the water column in following years.

- It may be an artifact of the heterogenous nature of the fibre mat. However, no other compound displayed similar variability.

Toxicity

Toxicity Tests

In terms of any toxic impacts to benthic invertebrates (i.e., bottom dwelling organisms). *Chironomus tentans* showed no toxicity in toxicity tests and is considered to be representative of the kind of macroinvertebrate that would inhabit the fibre mat[5]. *Hyalella azteca*, a more sensitive organism[5], had lower survival rates in one of two fibre/black silt mat samples compared with both a laboratory control and a reference site (i.e., upstream sample).

Algae and Aquatic Plants

Both algae and aquatic macrophytes are inhabiting parts of the fibre mat. Macrophyte growth is thick along the shoreline; thus these plants seem well adapted to living on the fibre mat. Also, these plants are an important source of food and habitat for macroinvertebrates and fish.

Toxic Equivalence

Toxic equivalence refers to determining which member of the chlorinated phenol, and the dioxin and furan groups represent most of the groups potential toxicity. Based on relative toxicities or TEU developed by Fleming[6], most of the toxicity associated with chlorophenolic compounds in the 1992 and 1994 fibre mat samples was from 2,4,6-trichlorophenol. This compound was not measured in 1990.

The fibre mat, and not the reference sites, exceeded sediment quality objective of TCDD TEQs[7] of 0.7 pg/g sediment organic carbon in both 1992 (4.8 pg/g sediment organic carbon) and 1994 (1.6 pg/g sediment organic carbon)[8]. However, the fibre mat appears to be decreasing in TCDD TEQs with time. Almost all of the dioxin and furan toxicity can be attributed to concentrations of 2,3,7,8-T_4CDF. The potential bioaccumulation of 2,3,7,8-T_4CDF in the food chain is of concern because fish and piscivorous mammals are more sensitive to 2,3,7,8-T_4CDF and other chlorinated compounds than lower food chain organisms[9].

Bioaccumulation

Bioaccumulation studies using mussels were not conducted due to the unavailability of these organisms within the fibre mat. However, a review of previous and current studies

indicates that levels of chlorinated organics in fish tissue have been declining since 1988[10].

4. References

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