

SELENIUM STUDIES IN THE ELK RIVER BASIN OF THE EAST KOOTENAY

Roger Berdusco
Fording Coal Limited
Fording River Operations
Elkford, B.C.

Brenda Dixon
Elkview coal Corporation
Sparwood B.C.

Jim Lant
Luscar Line Creek Mine
Sparwood B.C.

Ron Jones
Fording Coal limited
Greenhills Operations
Elkford, B.C.

Matthew Cole
Fording Coal Limited
Coal Mountain Operations
Sparwood B.C.

ABSTRACT

This paper outlines the history, current work performed and future studies planned to investigate selenium concentrations in the Elk River. One of the sources of selenium appears to be related to coal-mining activity; measured selenium concentrations in the stream systems below coal mines are consistently higher than waters above the mines. Various selenium studies have been conducted by government ministries and the coal mines. Further studies are planned to determine what, if any, environmental effects have occurred or can occur. Preliminary results show no effect on native Cutthroat trout embryos in exposed versus reference populations.

Results of studies performed in the local waters are discussed here, as well as the proactive approach being taken by industry and government to developing site-specific water quality criteria.

INTRODUCTION

Selenium first became a topic of discussion in 1995 when an increasing trend of selenium in the Elk River near its mouth was highlighted by The Ministry of Environment Lands and Parks (MOELP). Initial work performed involved additional selenium sampling and subsequent selenium studies by both industry and government. In 1998, the five Elk Valley mines [Fording River, Greenhills, Coal Mountain (Fording Coal Limited), Luscar, Line Creek and Elkview Coal Corporation] formed the "Elk Valley Mines Environmental Management Committee" (EVMEMC).

This paper will describe the results of meetings between industry and government and the action plan that was established. An update on the studies completed, those in progress and potential future areas for investigations are also described.

HISTORY

One of the initial concerns in 1995 was that the levels of selenium in water column samples taken near the mouth of the Elk River, downstream of the coal mines, was increasing. Concurrently a permit application for ongoing coal mine development indicated elevated levels of selenium below the mine site. Initially, there was scepticism about the potential negative effects on fisheries because decades of fish population studies showed healthy populations in the Elk River Basin. However, after reviewing information from other areas, it was agreed that the subject warranted further investigation. All of the mines agreed to consolidate resources and seek outside independent professional assistance.

The purpose of the EVMEMC was to determine:

- Any current effects from selenium,
- Any future effects from selenium, and
- Site-specific water-quality guidelines for selenium.

Dr. Peter M. Chapman of EVS Environment Consultants was hired to provide direction and to structure a selenium study plan. The study plan involved:

- Complete the Fish Embryo Study in progress.
Evaluate if there are any reproductive effects in Elk River Basin fish as a result of fish accumulating selenium in their reproductive organs.
- Status of fisheries
Provide an overview of the general condition of fisheries in the watersheds downstream of coal-mining operations.
- Geochemical mobilization mechanisms.
Determine selenium release rates and quantities from different, representative mined rock.

- Design and implement a selenium-monitoring program.
- Future Studies.

In conjunction with these activities, water-column sampling for selenium was being carried out at all mine sites, and the mining companies joined with the MOELP in gathering sediment and fish data. A report was written by Mark Stroscher and Les MacDonald of the MOELP. The report is entitled "Selenium Mobilization From Surface Coal Mining in The Elk River Basin of B.C. A Survey Of Water Sediment And Biota" (McDonald et al, 1998). A follow-up study on fish embryos was also completed and a draft report circulated in early 1999. That study addresses the effects of selenium in adult West Slope Cutthroat Trout (WCT) eggs, larvae and fry and was jointly undertaken by MOELP, Simon Fraser University and the Elk Valley Coal Mines.

While the original study plan proposed for the Elk Valley Mines by Dr. Chapman has been modified as a result of ongoing information development, it basically remains on course. The scope has been expanded to include evaluation of the risk to human health.

At an inaugural meeting on March 8, 2000 in Sparwood, the MOELP, the Ministry of Energy and Mines (MEM) and the Elk Valley Coal mines formed the Elk Valley Selenium Task Force (EVSTF). Formation of the EVSTF reflects recognition and formalization of common goals and objectives between industry and government.

The EVSTF, comprised of a steering committee and a technical committee, has as its overall goals and objectives:

- Determine if effects from selenium are occurring at present,
- Determine if effects from selenium could occur in the future,
- Provide input to the review of provincial and national guidelines on selenium,
and
- Determine site-specific environmental criteria for selenium, where possible or necessary.

Other important agreements reached were recognition of a need to have a communications protocol and an agreement to use a "Status Report" to document

significant milestones in the selenium study process. The structure and mandate of the two Task Force committees are outlined below:

1) Steering Committee

Mine representatives

Ministry of Energy and Mines manager (plus any necessary support staff)

Ministry of Environment, Lands and Parks manager (plus any necessary support staff)

Mandate

Set overall study direction/process

Dispute resolution

Information dissemination protocol

Secure funding/resources

2) Technical Committee

Mine representatives or designates and technical support staff.

Ministry of Environment Lands and Parks manager representatives (both regional and provincial)

Ministry of Energy and Mines representatives (both regional and provincial)

Mandate

Set priorities

Develop study terms of reference and other technical aspects of studies

Review of study drafts

STATUS OF STUDIES

Fish Embryo Study

The fish embryo study conducted in 1998 and expected to be published in 2000, was co-authored by Simon Fraser University and the MOELP. Financial support and review of draft reports were provided by the Elk Valley Coal Mines. The objective of this study was to determine if elevated selenium levels affect WCT reproduction. This was accomplished by raising WCT eggs in a laboratory setting and comparing exposed embryo survival to those of a control or background population from a nearby provincial park.

Results of the study concluded that there was no significant effect of selenium at the measured concentrations on fertilization; time to hatch; percent hatch; or egg, larvae or fry deformities or mortalities. The results suggest that toxic threshold values developed using warm water species of fish may not be applicable to salmonids such as the West Slope Cutthroat Trout or other cold water species. (Kennedy et al, in press).

Status of Fisheries

An internal report on the general condition of fisheries in the southeastern British Columbia and southwestern Alberta coal areas was commissioned by the EVMEMC in 1999. The objective of this study was to provide a general overview of the condition of the fisheries in these coal drainages where coal mining and logging activity has been conducted for over a century.

Results of the study conducted by Pisces Environmental Consulting Services Ltd. concluded that the Elk and Crowsnest River basins are supporting an intensive, high-quality recreational fishery, and may be approaching the state first observed by European pioneers early in the 20th century.

Human Health Risk Assessment

In order to put into perspective the issue of possible effects of selenium from the waters and fish downstream of mining operations to humans, a Human Health Risk Assessment (HHRA) for ingestion of fish containing elevated levels of selenium was conducted. The Elk Valley coal mines contracted the services of Dr. Peter M. Chapman of EVS Environment Consultants to review the existing data and conduct the HHRA. The results of this study show that there is a negligible human health risk of selenosis due to consumption of Elk River basin fish. Dr. Chapman goes on to further conclude that moderate quantities of fish consumed from the Elk River (i.e. 2-3 meals / week) would actually have a net positive impact on human health. Selenium is an anti-oxidant and an essential mineral in human health. Intake can be optimized by diet or vitamin supplements to improve human health.

Geochemical Mobilization

A three-part study on the geochemical mobilization of selenium from minesites in the Elk River Basin is currently under way.

The overall objective of the geochemical mobilization studies is to identify the source or parent material for dissolved selenium found in waters downstream of the mines. It is anticipated that this information can ultimately be used as part of the development of a model to predict trends in selenium concentrations.

The first part of the study involved sampling and analyses to determine what the concentration of selenium was in each rock type throughout the mining areas. The MEM funded this work. Flock analysis is complete and the report by Dr. Barry Ryan of MEM is now being prepared.

The second part of the program involves geochemistry. The three mining companies are sponsoring a University of British Columbia graduate student, Ms. Christine Lussier, who is working under a two-year National Research Council Industrial post-graduate scholarship. The objective of her work is to determine release rates from

selected rock types. It may well *be* that the highest and lowest release rates will not necessarily be from the rock type with the corresponding highest or lowest selenium concentrations.

The third part of the program involves preparation of a Management Report that will integrate the technical information developed by Dr. Ryan and Ms. Lussier. Stephen Day of SRK Consulting will integrate these two studies in a management report that will be prepared for the three mining companies. The objective of the management report will be to consolidate the research information into practical applications at a minesite.

Monitoring

Water-quality monitoring is currently undertaken by all three mining companies. The separate programs will be consolidated to develop an integrated program that will minimize overlaps and avoid gaps. A detailed monitoring program will be designed to fully assess trends in water quality and other relevant parameters that can be determined as the projects currently under way are completed and assessed.

Historically, management of quality assurance and quality control (QA/QC) for selenium analytical data have been problematic. Data without documented QA/QC should be used with great caution. Through the use of split samples and blind duplicates, the laboratory facilities demonstrated a high level of analytical confidence and provided an accurate database for the studies.

In addition, only research laboratories are currently able to distinguish the oxidation state of selenium. The various oxidation states of selenium, (selenate, selenite, etc.) have very different toxicity. The inability to reliably distinguish the proportion of the selenium in various oxidation states results in the data being lumped together and reported as total or dissolved selenium. As oxidation state is determined by a large number of environmental variables, there may be widely varying, species-specific, responses to the same total concentration of selenium.

The ongoing monitoring programs will build on the results of the work under way as outlined above.

Potential Future Studies

The program is projected to include additional studies on various aspects of the selenium issue including environmental interactions within the watershed. The focus of this work will be on examining the selenium issue within the context of the cold, generally fast-flowing water environment of the Elk River Basin in the Rocky Mountains. Much of the current understanding of this issue is based on warm-water studies in standing-water ecosystems. The results and predicted effects, based primarily on studies in California to date, have proven not be applicable in the Elk River Basin.

Future studies will fall into three broad categories:

- Ongoing monitoring and modification of the monitoring programs as new information becomes available,
- Development of a model for determining present trends and predicting future trends, and
- Ecosystem effects.

The dynamics of different ecosystems are an important consideration in assessing the potential for effects. No reproductive effects were found in WCT at selenium concentrations that were anticipated to have significant effects, based on the warm-standing water studies. As a result, a number of 'ecosystem' studies may be undertaken to determine if there are any other effects. These studies include:

Watershed Mapping

Watershed mapping will determine how much standing-water habitat exists. A map-based quantification of the limited swampy or backwater areas that exist downstream of the Elk Valley mines is planned. The Elk Valley area is characterized by steep terrain and fast-flowing water as one would expect to find in the Rocky Mountains. There are no lakes downstream of the mines, but the Elk River drains into Koocanusa Reservoir.

Avian Studies

The literature suggests that elevated selenium levels may affect certain avian species. Field monitoring has the highest degree of realism, but also the highest degree of interference from natural factors. Laboratory studies in contrast, though less realistic, provide controlled conditions for assessing causal relationships (EVS, 1999). The study design has not yet been finalized.

Terrestrial Studies

Terrestrial Studies will be initiated by a literature review. All three companies undertake vegetation monitoring for uptake of selenium. Initial results indicate that selenium levels were highest in vegetation from native sites unaffected by mining; these results suggest that this is not a mining-related issue.

Summary

In 1998 a jointly funded program between the three companies, MOELP and Simon Fraser University was undertaken to assess if reproductive effects were occurring in Cutthroat trout native to the area. While the results of this study are currently being printed, they essentially show that there was no difference in egg survival between samples taken from waters downstream of a mine, and a reference population in a nearby watershed unaffected by changing selenium concentrations.

A Human Health Risk Assessment indicated that there is negligible risk of selenosis due to consumption of WCT in the Elk River Basin.

A three-part study on geochemical mobilization of selenium from minesites is currently under way. The MEM funded a geological assessment of the various rock strata in the area and the report is now being prepared. The three mining companies are sponsoring a UBC graduate student doing leaching and lithographic investigations. A consultant has also been retained to review the MEM and UBC reports, and assemble the resulting research information into a management report.

The balance of the program is projected to include additional studies on various species and environmental interactions within the watershed.

The existing water-quality objectives for the Elk Valley are overly restrictive, as no detrimental effects have been documented in the watershed at concentrations well above water quality guideline levels set by the Canadian Council of Ministers of the Environment.

References

McDonald, L.E. and M.M. Stroscher. 1998. Selenium mobilization from surface coal Mining in the Elk River Basin, British Columbia: A survey of water, sediment and biota. B.C. Environment, September 1998.

Kennedy, C. J., L.E. McDonald, R. Loveridge and M.M. Stosher. The Effects of Selenium Contamination in Adult Cutthroat Trout on Eggs, Larvae and Fry. Archives of Environmental Toxicology and Chemistry.

EVS Environment Consultants (EVS). 1999.