STREAM CONTAMINATION FROM THE SUMMITVILLE MINE AND ITS IMPACT ON ALFALFA PRODUCTION IN PART OF THE SAN LUIS VALLEY

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INTRODUCTION

Agriculture underpins the economy of the San Luis Valley and the livelihoods of many of those who live there. Copper levels in alfalfa have been the main focus in a 3-year study (1993–1995) of fields irrigated from the lower Alamosa River and Terrace Reservoir.

Recent open-pit mining and the abandonment of the Summitville gold mine in the San Juan Mountains in late 1992 have led to serious problems with acid-mine drainage (Environmental Protection Agency, 1993). Contamination from the high-sulfidation epithermal gold mine (Plumlee and others, 1995a, b) has raised concerns over the effects of low pH and metal-laden—particularly copper—surface waters carried down the Alamosa River. High sulfidation deposits commonly contain copper-arsenic minerals, especially easily weathered sulfosalts (Stoffregen, 1987). Estimated copper loadings from the main drainage adit (now plugged) at the mine site into the Wightman Fork of the Alamosa River were 143,000 pounds per year (Williams, 1995). Previous studies of water quality of the Alamosa River and Wightman Fork showed that the Summitville site on Wightman Fork has been the predominant source of aluminum, copper, iron, manganese, and zinc discharged into the Alamosa River during most of the year (Walton-Day and others, 1995; Mueller and Mueller, 1995). Water-quality data collected by the U.S. Geological Survey during 1995 indicate that Wightman Fork was the dominant source of copper and manganese that year (USGS/WRD, Pueblo, Pat Edelmann, written commun., 1996). These waters enter the Terrace Reservoir (fig. 1), which stores irrigation water for approximately 45,000 acres of farmland downstream in the southwestern part of the San Luis Valley (Environmental Protection Agency, 1993).

Following the abandonment of the mine, which drew the focus of extensive public attention, numerous studies were begun at the mine site and downstream at Terrace Reservoir and in the San Luis Valley. Many of the results were discussed and published at a forum on Summitville in early 1995 (Posey and others, 1995). Summitville is the first of the modern, heap-leach gold mines to be abandoned and require cleanup under the EPA's Superfund program (Williams, 1995).

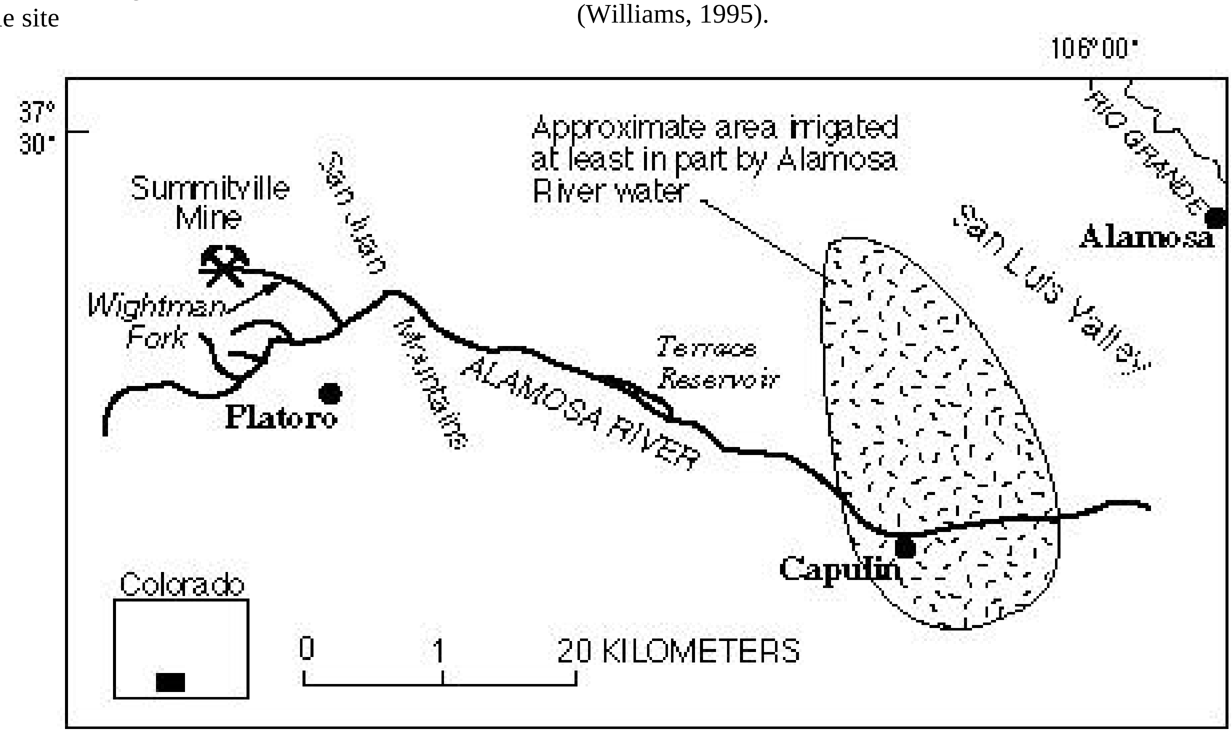


Figure 1. Index map showing location of Summitville mine and Terrace Reservoir with respect to farmlands irrigated with water from the reservoir.

Negative publicity resulting from contamination of Alamosa River water irrigating even a small part of the valley might have had a ripple effect throughout the region. However, this possibility was averted through a brief report and accompanying press release shortly after the 1993 alfalfa results became available (Erdman and Smith, 1993).

METHODS

Three alfalfa fields irrigated by water from the Terrace Reservoir and sampled in June 1993 were resampled in July 1995 using an analysis-of-variance design. Alfalfa from the Terrace-irrigated fields was compared with three control fields that were irrigated from the Rio Grande or ground water. Alfalfa samples were collected prior to each of the three cuttings in 1994 from two fields irrigated by Terrace water, but no control fields were sampled.

Soils from all fields are either mapped as the same soil series or are physically similar. Water samples were collected from the center-pivot sprinkler-irrigated fields to evaluate differences between the Terrace water and the control water. We also tested possible changes between 1993 and 1995.

Field and analytical techniques are detailed in Erdman and others (1995a, 1996).

RESULTS

An initial study of the effects of Summitville on alfalfa was conducted in June 1993. Those results, based on alfalfa sampled from Terrace-irrigated fields and control fields, were reported by Erdman and others (1995a). Analysis-of-variance showed significantly higher concentrations of copper, manganese, and nickel in alfalfa from the affected fields. More importantly, concentrations of these metals in alfalfa affected by both water sources (i) met published nutritive requirements for cattle, (ii) were far below maximum tolerable levels reported for cattle, and (iii) were comparable to concentrations in alfalfa found in other parts of the country. In looking at the nutritional needs of ***alfalfa***, Erdman and others (1995a) found that the Terrace Reservoir waters seemed to have enhanced the bioavailability of copper and manganese to optimum levels.

In the 1994 irrigation season, unexpectedly large seasonal differences in pH and the concentrations of copper and manganese (figs. 2 and 3) occurred in water from the Alamosa River (Smith and others, 1995). These figures also show the strong relationship between acidity and metal levels. Between early June and late July 1994, acidity increased 100-fold, from a nearly neutral pH of 6.6 down to 4.7. In the same period, copper concentrations increased sevenfold, manganese doubled, and zinc tripled. The profound chemical changes in the irrigation water between the first and second cuttings were not anticipated.

Fortunately, plans were already in place to sample the three cuttings of alfalfa from two adjacent fields irrigated by Terrace Reservoir water throughout the growing season. The alfalfa sampled from two adjacent fields reflected the changes in water chemistry (figs. 4 and 5), but not to the same degree (Erdman and others, 1995b).

The 1995 study of alfalfa and associated irrigation water was conducted to test whether water from the Terrace Reservoir still affected the quality of alfalfa to an important degree. An added purpose was to compare these results with previous studies conducted in 1993 and 1994.

In July 1995, the pH in the irrigation water below Terrace Reservoir, at 5.5, was comparable to that measured in 1993 (figs. 2 and 3). Concentrations of copper and manganese—two metals linked closely to contamination from the Summitville mine Superfund site—were also similar to those measured from the same irrigation water in 1993. In addition to copper and manganese, concentrations of zinc, cobalt, nickel, and the rare-earth elements lanthanum, cerium, neodymium, and yttrium were markedly higher in the Terrace waters compared to the control waters.

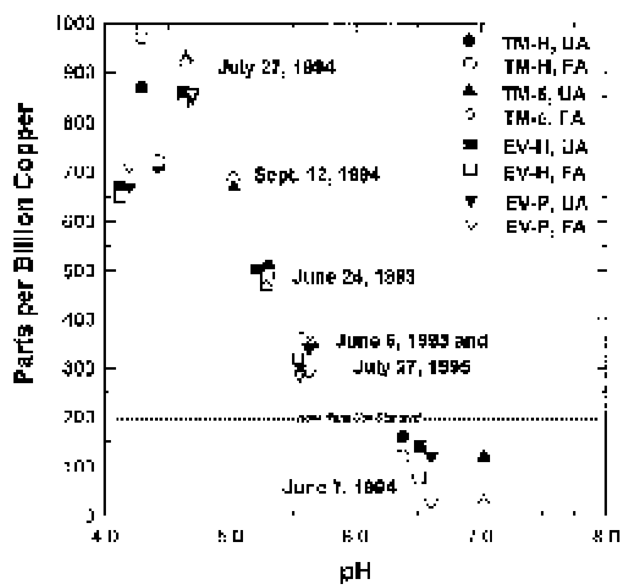


Figure 2. Plot of copper concentration as a function of pH for irrigation water originating from Terrace Reservoir for the period from June 1993 to July 1995. TM-H is the Terrace Main Canal headgate on the Alamosa River, TM-5 is a site on the Terrace Main Canal approximately 15 km from the headgate, EV-H is the El Viejo Ditch headgate on the Alamosa River, and EV-P is a storage pond on the El Viejo Ditch approximately 7 km from the headgate. UA refers to unfiltered acidified water samples and FA refers to filtered (0.45 µm in 1993 and 1995, and 0.2 µm in 1994) acidified water samples.

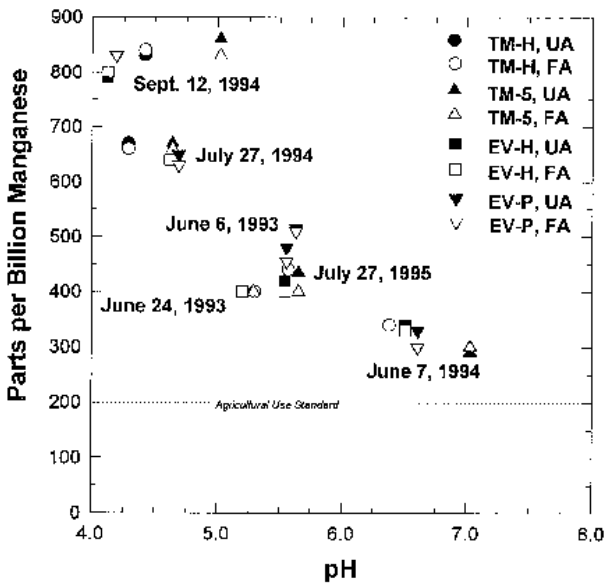
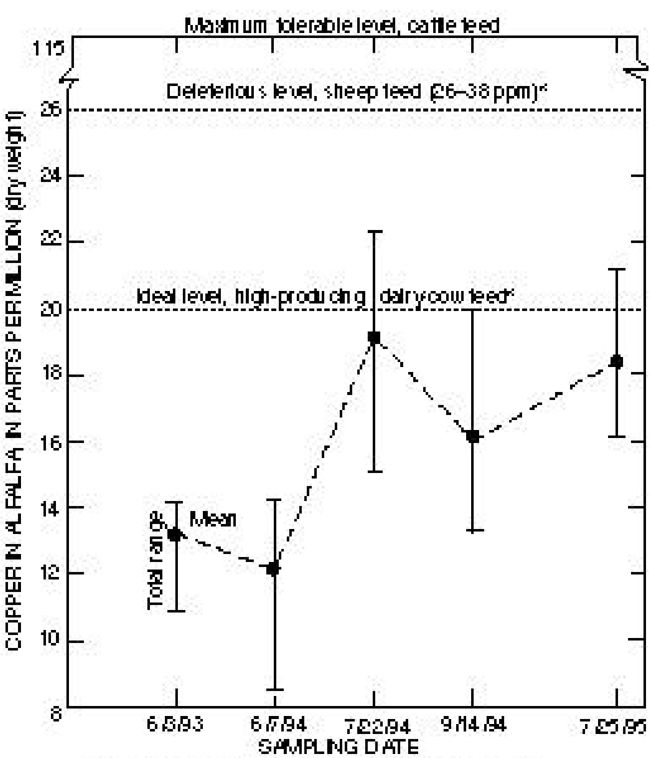


Figure 3. Plot of manganese concentration as a function of pH for irrigation water originating from Terrace Reservoir for the period from June 1993 to July 1995. See figure 2 for explanation of sources.



[1]Cheryl Nockels, Specialist, Mineral Nutrition in Livestock, Colorado State University, oral commun., 1994.

Figure 4. Plot of copper levels in alfalfa irrigated with Terrace Reservoir water over the 1993 through 1995 period.

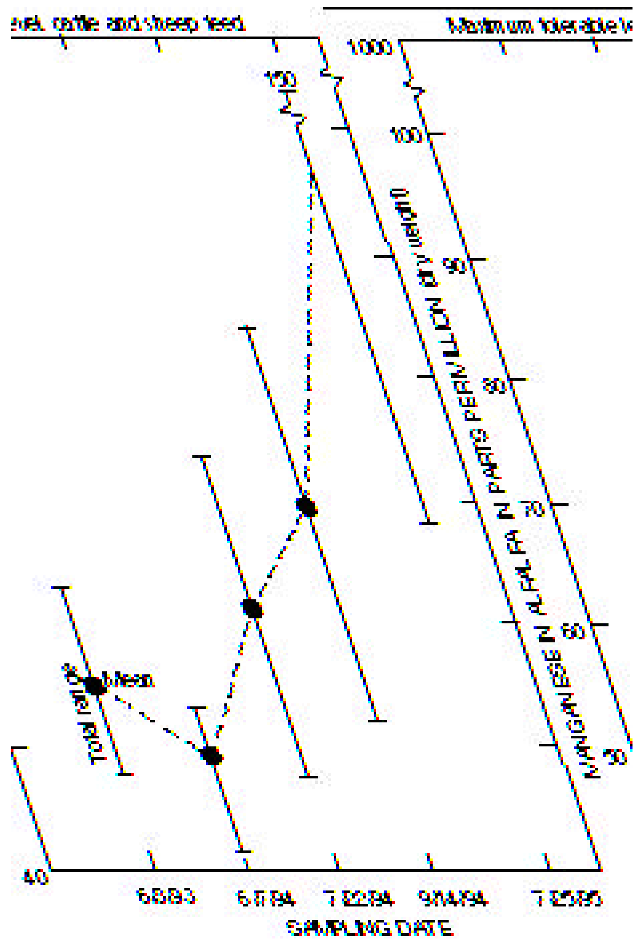


Figure 5. Plot of manganese levels in alfalfa irrigated with Terrace Reservoir water over the 1993 through 1995 period.

Only levels of copper and manganese in the contaminated water have exceeded the agricultural use standards for Colorado, although concentrations of several other metals also far exceed those of samples from the control waters.

A two-way analysis-of-variance tested, separately, the year-to-year (temporal) differences in the element composition of the test group alfalfa and the control group. The test-group samples had significantly higher concentrations of copper and manganese in the June 1995 cuttings compared to the June 1993 cuttings (figs. 4 and 5). The test-group samples also contained significantly higher concentrations of cobalt, nickel, and phosphorus. Unexpectedly, however, the control-group alfalfa also revealed significantly higher concentrations for almost the same suite of metals—copper, manganese, nickel, phosphorus, and zinc—in samples from the 1995 cutting. Although the average concentrations were lower than those samples irrigated by Terrace water, these results underscore the complexity of trying to understand relationships in the natural landscape.

The maximum copper concentration measured—21 ppm—is considered nutritionally ideal for high-production dairy ration. On the other hand, this level approached the lower end of the 26–38 ppm range considered deleterious for sheep feed (Dr. Cheryl Nockels, Colorado State University, oral commun., December 1995). The published maximum tolerance level for beef cattle is 115 ppm. Sheep are therefore much less tolerant of copper than cattle, although the copper tolerance varies with breed.

The manganese concentrations in alfalfa have increased markedly over the 3-year period (fig. 5). In the short term, this should not affect the nutritional value of this important livestock feed. The highest concentration reported, 150 ppm, is still well below the 1,000 ppm maximum tolerable level given for cattle and sheep. However, this exceeds the upper limit of the sufficient manganese requirement range for ***alfalfa*** (Jones and others, 1991).

Many irrigators who rely on Alamosa River water continue to be concerned about the marketability of their crops and livestock. Unlike the copper concentrations that appear to have leveled off, manganese concentrations have continued to climb beyond those reported in alfalfa grown in other parts of the West.

PITFALLS IN RELYING ON SINGLE POINT-IN-TIME STUDIES

Unlike the initial results from 1993, no statistically significant differences were found in 1995 for copper in alfalfa irrigated by the two water sources, in large measure because concentrations of several metals—copper, zinc, and barium—were appreciably higher in alfalfa collected from one of the three control fields. Yet concentrations of manganese in alfalfa from the two affected fields were twice the concentrations in the samples from the control fields, differences that were statistically significant (90% confidence level). Of 15 elements tested, only the concentrations of one other element—cobalt—were statistically different, but alfalfa from the affected fields contained only slightly higher concentrations of the 13 other elements tested than did the control samples. On average, the copper concentrations in alfalfa irrigated by the two different water sources were nearly the same.

Even though the nutritional quality of alfalfa as a livestock feed has not been impaired—in fact, the copper levels in the affected alfalfa are considered nutritionally ideal for high-production dairy ration—these temporal swings emphasize the critical importance of long-term monitoring. Results from this repeat sampling of alfalfa suggest that baselines which ignore the vagaries of time may be misleading.

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