

Cyanide and migratory birds at gold mines in Nevada, USA

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Since the mid-1980s, cyanide in heap leach solutions and mill tailings ponds at gold mines in Nevada has killed a large but incompletely documented number of wildlife (>9,500 individuals, primarily migratory birds). This field investigation documents the availability of cyanide at a variety of 'typical' Nevada gold mines during 1990 and 1991, describes wildlife reactions to cyanide solutions, and discusses procedures for eliminating wildlife loss from cyanide poisoning. Substantial progress has been made to reduce wildlife loss. About half of the mill tailings ponds (some up to 150 ha) in Nevada have been chemically treated to reduce cyanide concentrations (the number needing treatment is uncertain) and many of the smaller heap leach solution ponds and channels are now covered with netting to exclude birds and most mammals. The discovery of a cyanide gradient in mill tailings ponds (concentration usually 2–3 times higher at the inflow point than at reclaim point) provides new insight into wildlife responses (mortality) observed in different portions of the ponds. Finding dead birds on the tops of ore heaps and associated with solution puddling is a new problem, but management procedures for eliminating this source of mortality are available. A safe threshold concentration of cyanide to eliminate wildlife loss could not be determined from the field data and initial laboratory studies. New analytical methods may be required to assess further the wildlife hazard of cyanide in mining solutions.

Keywords: cyanide; gold and silver mining; migratory birds; mortality; Nevada

Introduction

In the 1970s the price of gold soared from about \$35 per troy ounce to more than \$600 in 1980; in the 1980s the price fluctuated between \$350 and \$450 per troy ounce, and gold is valued presently at about \$380. With this remarkable dollar incentive, cyanide processing technologies were improved to permit the economical extraction of minute quantities of gold from low-grade ore. Thus, gold mining in the United States increased dramatically in the 1980s and the State of Nevada has become one of the top gold producing areas in the world (Alberswerth *et al.*, 1992). For example, only 13 active or

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intermittent gold mines were operating in Nevada during 1980, but by 1991 the total increased to more than 70 active mines while an additional 20 intermittent mines were also registered with the Mine Safety and Health Administration (US Department of Labor, 1991). Numerous other mines have operated and closed during the period. Other western states, northern plains states, the Carolinas, and Alaska have also reported increased gold mining activity. Similar techniques are used for silver, and some mines produce both metals.

Much of this gold rush is a result of technological developments in the extraction of microscopic gold with sodium cyanide (NaCN), a highly toxic substance used in the recovery of precious metals by the international mining industry (Huiatt *et al.*, 1983). Where relatively high grade ores are found (e.g., >0.09 oz Au per ton of ore) milling techniques are used, but heap leaching of low grade ores (e.g., 0.006–0.025 oz Au per ton) is the most commonly employed extraction technique.

Milling and heap leaching require cycling of millions of liters of alkaline water containing toxic concentrations of NaCN, free cyanide, and metal cyanide complexes that may be readily accessible to a variety of wildlife. Milling operations have tailings ponds as large as 150 ha. Typical heap leach operations spray or drip cyanide solution onto the flattened top of the ore heap and then collect the metal bearing (pregnant) solution from its base for transport by small channels to a pair of solution processing ponds of about 1 ha each. Although not intentional or desired, puddling of solution is common on top of heaps. All of these puddles, ditches, and ponds are potentially hazardous to wildlife if not properly managed to exclude wildlife.

Various sized ponds are often found at the same mine, since many mines use both milling and heap leaching processes. In Nevada there are now about 300 individual ponds contain cyanide (J.W. King, Nevada Dept. Wildlife, personal communication). All ponds in the arid Great Basin and adjacent areas attract birds (especially during migrations) and other wildlife. The impact on bird populations of so many potentially toxic sites along such an arid migration route can only be speculated. Some insight into the dimension of wildlife mortality observed since the mid-1980s is provided by records submitted to the Nevada Department of Wildlife by 95 mining operations (Nevada Department of Wildlife, 1992). More than 9,500 birds, mammals, reptiles and amphibians were reported dead at mill tailings ponds and heap leach operations (Table 1). Overall, about 91% of the deaths were birds, mainly waterfowl, shorebirds and gulls. However, the ratio of birds to mammals has shifted from 94:6 during 1986–1989 to 80:20 in 1991 (Nevada Department of Wildlife, 1992). Most of the mortality is believed to be from acute response to ingestion of free or metal bound cyanide, but inhalation and percutaneous exposure may be important to aquatic species. When wildlife drink from cyanide ponds, highly toxic hydrocyanic acid (HCN) can form and either inhibit critical oxidative enzymes that may lead to cardiac arrest or react with iron in the blood to destroy the blood's ability to transport oxygen (Ballantyne, 1987). If a lethal dose is absorbed, death usually follows within minutes to one hour. If not, the cyanide is rapidly metabolized and excreted without apparent latent toxicity. The toxicity of cyanide to wildlife and its environmental presence and fate have been reviewed by Eisler (1991).

Investigations reported herein were conducted in 1990 and 1991 to enhance our knowledge of gold mining operations and cyanide solution management in relation to hazards these activities create for wildlife: (1) an interpretive laboratory study with