Water Quality in the Colorado R

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The health of the riparian ecosystem of the Colorado River Delta depends not only on the quantity of water available, but also on its quality. For many years, the lower Colorado River has experienced high salinity and elevated concentrations of selenium, a nutrient that can be toxic to wildlife. These problems are exacerbated as the river flows south, and concentrations increase. Where the Colorado River reaches the Imperial Dam, about 20 miles north of the United States-Mexico border, concentrations of salinity and selenium are the highest measured in the United States, with specific conductance reaching 2,600 microseimens per cubic centimeter (μS/cm^3) and selenium at 2.0 micrograms per liter (μg/l, ppb) in water and 7.1 micrograms per gram (μg/g, ppm) in sediments (Radtke et al., 1988). In 1984, concentrations of selenium in sediments were five times higher than the geochemical baseline for soils from the western United States, which range from less than 0.39 to 1.4 μg/g (Shacklette and Boerngen, 1984). At the Colorado River Delta in Mexico, the terminus of the river, we would therefore expect salinity and selenium concentrations to be at their maximum. Measurements along the mainstem of the river in Mexico have shown salinity as high as 4,000 ppm and selenium up to 6.3 ppb (Valdéz-Casillas et al., 2000), supporting this argument. However, the associated riparian areas and wetlands in the delta area are supported primarily by irrigation runoff, and several studies have shown that agricultural practices do not appear to exacerbate salinity and dissolved selenium concentrations there (Radtke et al., 1988; García-Hernández et al., 2000; García-Hernández et al., 2001).

Salinity Sources

Salinity in the Colorado River primarily originates from geologic sources, saline springs, and agricultural sources. Almost half the total salt load is from natural sources, with irrigation return flows adding more than one-third, and municipal and industrial sources responsible for the small remaining portion. According to the U.S. Department of Interior, more than a million tons of salt per year will have to be removed from 2003 until 2010 to maintain average salinity below the criterion of

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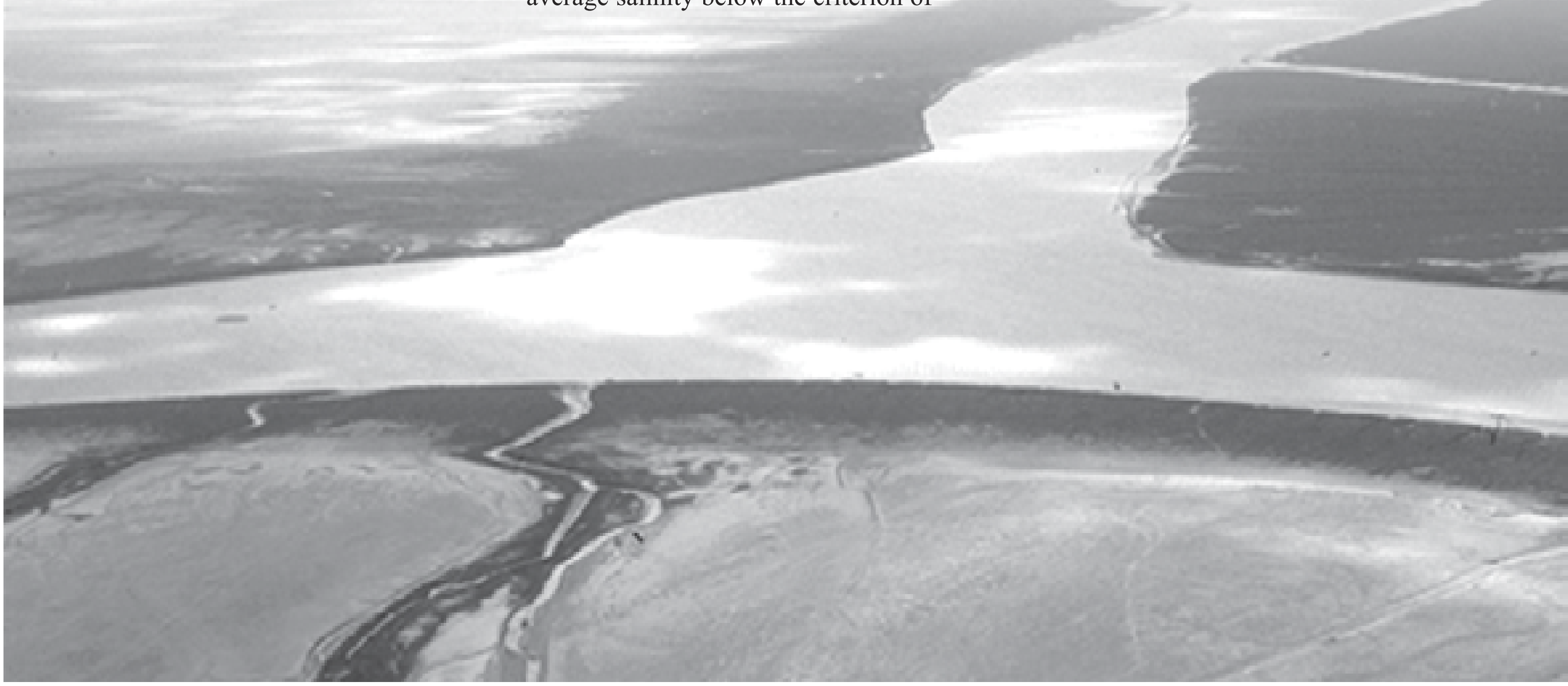
880 mg/L at Imperial Dam set by the U.S. Bureau of Reclamation Colorado River Basin Salinity Control Program.

Selenium

Dissolved selenium concentrations in water from the lower Colorado River appear to have multiple origins. The natural weathering of seleniferous soils or rocks in the upper basin is attributed to selenium concentrations of up to 1,300 ppb in shallow groundwater near upstream reaches of the river (Presser et al., 1994), far exceeding the U.S. Environmental Protection Agency’s standard of 5 ppb for



Colorado River at its junction with Montague Island in the upper Gulf of California. Photo by C. Valdes.

River Delta

wildlife protection. Additional sources of dissolved selenium in the river may include the combustion of seleniferous coal at electric generating stations and the extraction of seleniferous ore deposits. All of these sources may contribute to the downstream loading and transport of selenium and hence its distribution and availability for biaccumulation in the ecosystem (Radtke et al., 1988). The construction of dams, mining, and intensive agriculture activities may also increase the concentrations of salinity and selenium in the lower Colorado River.

In the Colorado River Delta, selenium is found in greater concentrations in aquatic organisms compared to terrestrial wildlife (see table). The selenium cycle is enhanced in aquatic ecosystems due to selenium's solubility and bioaccumulation first in sediments, then plants, fish, and birds. Despite elevated selenium concentrations found in birds and bird eggs in the delta wetlands, no evidence of deformed embryos has yet been found. However, continued monitoring will be necessary to promptly detect any toxic changes that may occur.

Species	N	Se (ppm)	Reference
BACKGROUND LEVELS		**<2.0**	
Double-crested cormorant	9	16.7	Mora & Anderson, 1995
Cattle egret	15	4.6	Mora & Anderson, 1995
Red-winged blackbird	8	5.1	Mora & Anderson, 1995
Great-tailed grackle	14	5.3	Mora & Anderson, 1995
Mourning dove	15	2.3	Mora & Anderson, 1995
Tilapia (*Tilapia zilli*)	6	6.8	Mora & Anderson, 1995
Largemouth bass (*Micropterus salmoides*)	11	5.1	García-Hernández *et al*., 2000
Marsh wren (*Cistothorus palustris*) eggs	18	5.3	García-Hernández, unpublished data, 2002
Mourning dove eggs	27	1.7	García-Hernández, unpublished data, 2002

Concentrations of selenium (Se) in fish and birds from the Colorado River delta wetlands, in ppm dry weight (N = number of samples).

Other Contaminants

Water quality in the Colorado River Delta is affected not only by salinity and natural elements such as selenium, but also by raw sewage from the city of San Luis and numerous agrochemicals, including organophosphorate and carbamate pesticides. Most delta wetland ecosystems are supported, however, by irrigation runoff from the local agricultural valleys. Although agricultural practices do not appear to increase dissolved selenium concentrations in water from the lower Colorado River and its delta, agricultural runoff can carry other contaminants such as pesticides, fecal coliforms, and other metals.

Concentrations of dichlorodiphenyl-dichloroethylene (DDE, a degradation product of DDT) in aquatic organisms and birds have been reported in several studies conducted in the Colorado River Delta, but show a marked decrease over time. However, fish-eating birds like cormorants still show elevated concentrations of DDE. The presence of organochlorine compounds in wildlife is possibly due to the past intensive use of DDT in agriculture in the Mexicali Valley.

The wetlands of the delta are inhabited by a wide variety of wildlife, including the largest population of the endangered Yuma clapper rail in the Ciénega de Santa Clara. For the protection of the wetlands and its inhabitants, it is important to maintain an inventory of the chemicals present in delta wetlands, their behavior in the system, and their effects on wildlife. Studies on concentrations of chemicals in different matrices (water, sediment, soil, and wildlife), cholinesterase inhibition in birds exposed to pesticides, nest success of different species, and other studies will be necessary to protect the environmental health of this rich and unique delta.

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References

García-Hernández, J., E.P. Glenn, J. Artiola, and D.J. Baumgartner. 2000. Bioaccumulation of selenium (Se) in the Cienega de Santa Clara Wetland, Sonora, Mexico, Ecotoxicology and Environmental Safety 45: 298-304.

García-Hernández, J., K.A. King, A.L. Velasco, E. Shumilin, M.A. Mora, and E.P. Glenn. 2001. Selenium, selected inorganic elements, and organochlorine pesticides in bottom material and biota from the Colorado River Delta, Journal of Arid Environments 49(1): 65-89.

Mora, M.A., and D.W. Anderson. 1995. Selenium, boron, and heavy metals in birds from the Mexicali Valley, Baja California, Mexico, Bulletin of Environmental Contamination and Toxicology 54: 198-206.

Presser, T. S., M.A. Sylvester and W.H. Low. 1994. Bioaccumulation of selenium from natural geologic sources in western states and its potential consequences, Environmental Management 18(3): 423-436.

Radtke, D.B., W.G. Kepner, and R.J. Effertz. 1988. Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the lower Colorado River Valley, Arizona, California, and Nevada, 1986-87. Tucson, AZ, U.S. Geological Survey. Water-Resources Investigation Report 88-4002.

Shacklette, H.T., and J.G. Boerngen. 1984. Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geological Survey Professional Paper 1270.

Valdés-Casillas, C., O. Hinojosa-Huerta, E.P. Glenn, Y. Carillo-Guerrero, J. García-Hernández, F. Zamora-Arroyo, M. Briggs, and E. Chavarria-Correa. 2000. Demonstration sites for wetland management in the Colorado River delta. Reporte final para el Consejo para la Conservación de Humedales de Norteamérica Guaymas, Sonora, México.