Selenium Case Study: Kesterson National Wildlife Refuge

HISTORY:

The story begins in 1949 when the United States Bureau of Reclamation (USBR) recommended to congress a plan for water development in the central valley that included subsurface drainage to help head off salt buildup from intensive irrigation. The original plan was to create a large scale drainage that ultimately released the water into the San Francisco Bay. Subsurface irrigation was installed in the 1960's and the construction of the major San Luis Drain began in 1969. The drain was a canal combined with a series of reservoirs to allow for seasonal release of the drainage water in to the bay. The first of these reservoirs was Kesterson, which was actually the cumulation of 12 shallow ponds. In 1970, the 518ha Kesterson reservoir was combined with the surrounding 1872ha of grasslands to form Kesterson National Wildlife Refuge. In only two years, the funding for completion of the San Luis drain had run out, which resulted in the Kesterson NWR being the end of the line.

The main area served by this drain was the Westlands Water District which was 3240ha of agricultural land that was overlaying a shale with naturally high levels of selenium in it. The movement of the water over this shale resulted in the leaching of the Se and its movement into the San Luis drain. The continual flow of agricultural drainage water into the shallow ponds at Kesterson NWR and the subsequent evaporation resulted in high salt and Se concentrations in the ponds, sediment and adjacent soils. At this time, from 1981-1982, the Se concentrations in the water ranged from 15-400ppb. Biological surveys were conducted starting in 1982 which found that the Se was bioaccumulating in the food chain of the refuge. Everything from the invertebrates in the water to reptiles and even small mammals were found to have higher concentrations of Se in their tissue then what was present in the water, up to 370ppm in some fish species.

Field studies of the area found that the high levels of Se were causing developmental deformities in both embryos and chicks of the majority of the birds nesting at Kesterson. The deformities were present in up to 65% of the birds and consisted of missing eyes and feet, protruding brains, and deformed beaks, legs and wings. Estimates suggested that several thousand birds had been poisoned. In addition, in 1983 there was a massive fish kill followed by high numbers of still births in the mosquito fish population, which happened to be the only fish that could "survive" the seleniferious conditions.

Overall, there were several duck species, other aquatic bird species and other adult wild birds including the Black crowned night heron, whose local population was almost completely wiped out.

DEALING WITH THE SELENIUM:

The death and deformity in the wildlife at Kesterson quickly reached the media and thus

the public. Several law suits were threatened based on the Migratory Bird Treaty Act (MBTA) and also the Endangered Species Act (ESA). For each migratory bird death the penalty is a $500(US) fine and 6 months in jail. For each death of an endangered species (San Joaquin kit fox was threatened at Kesterson) the penalty is a fine of $10,000(US) and 12 months in jail. These suits can be brought by everyone from private citizens to regulatory authorities, and the most important thing to keep in mind is that for these acts to be enforced, the killing of the animals does not have to be intentional.

In 1986, Kesterson was removed from the wildlife refuge list and was handed over to the USBR as a contaminated site to be cleaned up. The San Luis drain was closed and all inflow of agricultural drainage water was stopped, and the ponds were drained. The initial plan of the USBR was to excavate the top .15m of soil and to contain it in a lined and capped landfill. The estimated cost of this cleanup would be $50 million (1987 dollars). However, before this plan was implemented, research was conducted that showed the formation of ephemeral pools with toxic levels of Se would continue even after the removal of the top soil. In 1988, the USBR filled the low lying pond areas with clean soil (ranging in depths from 15cm to 150cm) to help counter the formation of the toxic ephemeral pools. Unfortunately, along with the “clean” soil came at least 20 different species of weeds that are able to deep root and pull the Se up to the surface and thus, recontaminate the surface. The final decision was made to use management of the soil, water and vegetation to dissipate the Se from the environment.

The current situation at Kesterson is better, but definitely is still not good. Se bioaccumulation is still occurring, but at about 10% of the amount of Se that was being moved into the food chain by the wetland. A five year study from 1989 to 1993 found that the distribution of the Se in the soil did not change significantly and there was not an increase in the mobilization of the Se from the soil.

Even though the San Luis Drain was originally constructed for the Westland Water District, the adjacent Grasslands irrigation area never made use of the drain, and instead allowed toxic irrigation water to run into the San Luis refuge complex through natural channels and eventually into the San Joaquin River. Due to this flow, contaminated water continued to flow into Kesterson after the initial closure of the San Luis Drain.

To try to address this problem, an idea was offered that would allow the toxic drainage water to avoid the refuges and instead bypass them directly into the San Luis drain and later into the San Joaquin River. This project, called the Grasslands bypass project, is currently underway and is managed by an interagency group which includes the USBR and the USFWS along with state and local agencies. During the initial 6 months of the project, Se levels in the fish and invertebrates rose substantially in the drain area. Since then the concentrations have declined but they are still above the pre-project levels. Continual monitoring will determine if the project benefits are biologically justifiable.

For an overview of the project click here.

References:

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