

Evaluations of the Sources of Contamination in Sediment Cores from Tenkiller Reservoir (Oklahoma, USA)

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Tenkiller Ferry Reservoir, formed by the impoundment of the Illinois River 21 km upstream of its confluence with the Arkansas River, became operational in July 1953. It has a surface area of 52 km², mean depth of 16 m and maximum depth of 42 m near the dam. Sediment deposited within Tenkiller result from the 4,330 km² watershed of the Illinois River located in NW Arkansas and NE Oklahoma. Poultry production has occurred within this watershed for more than 50 years. During that time, nearly all of the wastes generated by these poultry have been land-disposed within the watershed. The circumstances and large quantities of poultry waste disposal within the Illinois River Watershed suggest that sediment accumulating within Tenkiller Reservoir may reflect the history of watershed contamination by poultry waste. To investigate this hypothesis, undisturbed sediment cores were obtained from the reservoir and subjected to geochronological and geochemical analysis. Six core locations were selected based on sediment thickness profiles determined from a sub-bottom sonar survey and located to represent the lacustrine, transition and riverine zones of the reservoir. Cores were hand-collected by SCUBA divers. At each location, five core tubes were advanced to refusal and capped top and bottom prior to extraction from the sediment. Cores from two locations were not used in the evaluations because of evidence of disturbance or lack of sediment recovery. Sediment recovery in the remaining cores ranged from 34 to 58 cm. The cores were mechanically extruded and sectioned into two cm segments. One of the replicate cores at each location was used solely for geochronological analysis by measuring the activities of unsupported ²¹⁰Pb, ²¹⁰Bi and ¹³⁷Cs in each sediment segment from each core using gamma spectroscopy. Individual depth sections from the remaining four cores were composited for geochemical analyses (separately for each location). Each composited section was analyzed for total N, organic matter, pH, total solids, soluble salts and total metals (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, P, K, Se, Ag, Na, Th, V and Zn). Data obtained were investigated by plotting concentrations versus time of deposition, standard univariate correlation analysis and multivariate principal component analysis (PCA). In general, concentrations of constituents known to occur at elevated levels in poultry waste typically displayed increasing trends from older to younger sediments. For example, P concentrations increased from 311 mg/kg (pre-reservoir material) to 1495 mg/kg in Core1. Sediment total P concentrations were highly correlated with constituents found in poultry waste: total copper ($r^2 = 0.644$), total Zn ($r^2 = 0.599$) and total As ($r^2 = 0.537$), but not with total Pb ($r^2 = 0.106$). Correlation values were higher for sediments in the lacustrine and transition sections than for the riverine section of Tenkiller Reservoir. PCA revealed that the first two principal components explained 67 percent of the total variance. The first principal component (PC1) had high positive loading values for constituents closely related to poultry waste: organic matter, soluble salts, Na, P, K, Zn, Cu, Mg, Ca and N. The temporal and statistical evaluations of Tenkiller Reservoir sediments are consistent with the increase of poultry production and consequent increase in land application of poultry waste in the watershed, but inconsistent with changes in the populations of humans and other animals in the watershed.