

• **Ecological Distribution and Fate of Plutonium and Americium in a Processing Waste Pond on the Hanford Reservation**

Principal Investigators: R. M. Emery, D. C. Klopfer and M. C. McShane

U Pond, located on the Hanford Reservation, has received low-level quantities of plutonium (Pu) and americium (Am) longer than any other aquatic environment in the world. Its ecological complexity and content of transuranics make it an ideal resource for information concerning the movement of these actinides within and out of an aquatic ecosystem.

U Pond has been intensively inventoried for Pu concentrations in the ecological compartments and characterized limnologically in terms of its physicochemical parameters, biological productivity and community structure. This work provides a basis for evaluating the pond's performance in retaining waste transuranics. The quantitative estimation of export routes developed by this study is important in determining how effectively such ponds act as retainers for transuranic wastes. A more complete report has been prepared.

Ecological Export of Pu

One of the major goals of the U Pond study has been to obtain sufficient information about the pond's ecosystem, and the distribution of Pu within it, so that Pu export routes can be assessed quantitatively. Although it is often difficult to measure with reasonable certainty the parameters necessary for describing these export routes, the purpose of this work is to formulate the best expressions of export given the conditions which limit this process. The objectives are to determine ranges of quantities of Pu in the pond's ecosystem and assess the amount of Pu being exported in relation to this inventory. To accomplish this task, estimates were made of the pond's Pu inventory quantities on a basis of minimum, mean and maximum values for each ecosystem compartment, shown in Figure 2.3, to postulate the amount of these inventories that are exported yearly.

In its 33-yr history, U Pond has received an estimated 1 Ci of Pu which appears to

have been retained by the sediments. In relative terms, sediments, submerged plants and gastropods have the highest concentrations of Pu, ranging from 3.2×10^0 to 6.9×10^2 pCi/g. Emergent plants and the remaining fauna have Pu concentrations ranging from 4.0×10^{-1} to 6.1×10^1 pCi/g. Emerging insects have the highest Pu concentrations of the latter group, ranging from 3.2×10^1 to 6.1×10^1 pCi/g.

The mean Pu inventory of the sediment is 1.7×10^9 nCi, ranging from 1.3×10^9 to 2.0×10^9 nCi of Pu (Figure 2.4). This essentially represents the total pond inventory, since > 99% of the Pu in the pond are found in the sediments. The mean Pu inventory for the biota is 6×10^6 nCi, ranging from 1×10^6 to 1×10^7 nCi (Figure 2.4). Among the biota, plant life contain > 99% of the Pu. Diatoms and pondweed (*Potamogeton*) alone account for > 99% of the Pu in plants. Emergent insects contain < 1×10^{-1} % of the Pu in biota and < 1×10^{-3} % of the Pu in the pond. The inventory of this compartment has particular relevance, since it is the only direct

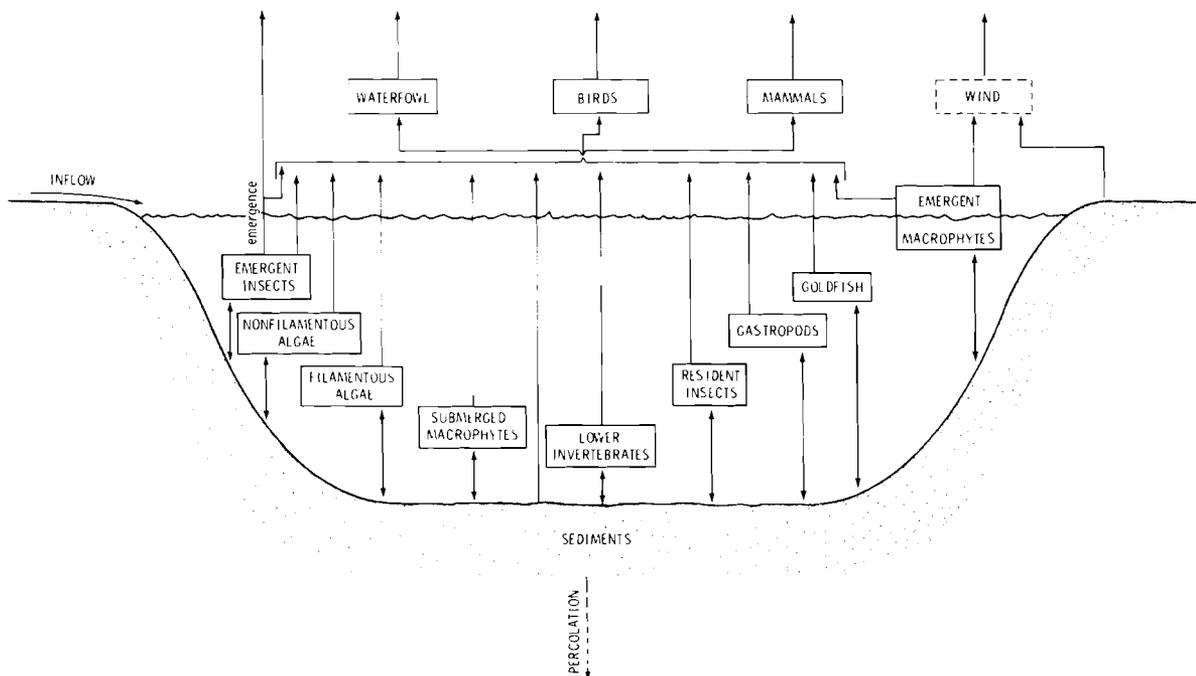


FIGURE 2.3. Schematic Representation of Ecosystem Compartments and Pu Export Routes from U Pond via Biological Mobilization, Wind and Percolation.

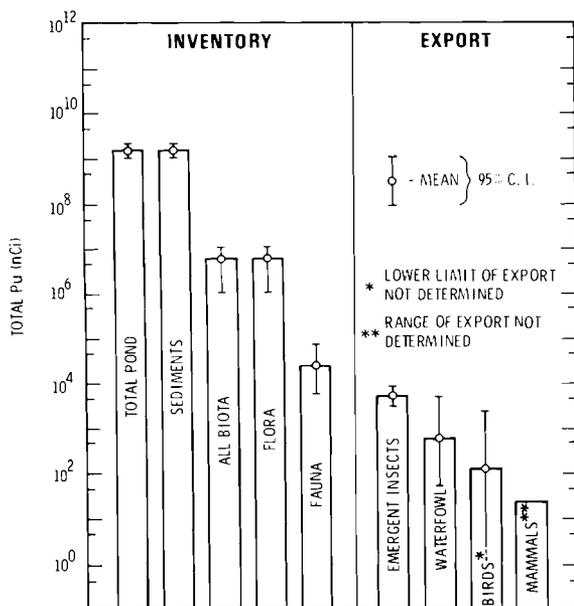


FIGURE 2.4. Inventories of Pu in Ecological Compartments of U Pond Compared with Estimated Quantities that are Exported from the Pond Annually. Export of Pu by percolation or wind do not appear to be significant.

biological route of export from the pond. Remaining pond biota contain $< 1 \times 10^{-2}\%$ of the total Pu inventory in the pond and can leave the pond only by the forces of external export vectors.

If all emergent insects successfully leave the pond, they could export from 3.5×10^3 to 7×10^3 nCi of Pu. These quantities are more than 5 orders of magnitude lower than the total pond Pu inventory (Figure 2.4). Estimated quantities of Pu annually exported by waterfowl range from 4×10^1 to 4×10^3 nCi, with a mean annual export of 5×10^2 nCi of Pu (Figure 2.4). Other birds appear to export about 1×10^2 nCi of Pu each year, with a maximum of 2×10^3 nCi (Figure 2.4). These export quantities are about 6 orders of magnitude lower than the total inventory of Pu in the pond. Mammals are estimated to annually export a maximum of 3×10^1 nCi of Pu from the pond (Figure 2.4), which is at least 5 orders of magnitude lower than the minimum total Pu inventory of the pond. There is no apparent significant export of Pu from the pond via wind.

U Pond has been exposed to Pu since 1944, longer than any other aquatic system. In its lifetime, it has received about 1 Ci of $^{239,240}\text{Pu}$ and ^{238}Pu from reprocessing operations. This 14-acre pond provides a realistic

illustration of the mobility of Pu in a lentic or nonflowing ecosystem. Although this pond has a rapid flushing rate, it is highly enriched with plant nutrients, ecologically well established with a natural complexity of populations and diversity of communities, and in continuous contact with associated terrestrial life. It appears to effectively bind the Pu discharged into it and prevent

it from moving significantly into routes leading to man and other remote life. The environmental behavior of Pu in U Pond appears to be quite similar to that of other aquatic systems having vastly different ecological character. As long as this pond remains in its present condition, the likelihood of it releasing hazardous quantities of Pu to man and his environment is very small.