



Food Animal Residue Avoidance and Depletion Program

RADIOACTIVE FALLOUT CONTAMINATION OF FOOD-PRODUCING ANIMALS AND FOOD SAFETY CONSIDERATIONS

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The recent natural disaster and unfolding events at nuclear facilities in Japan raises concerns over the potential for contamination of production livestock and food products by radioactive fallout. Following a similar incident in 1986 at the Chernobyl nuclear power facility in Ukraine, FARAD played a role in determining withdrawal times after radionuclide exposure. Based upon available studies that examined animals exposed to Chernobyl fallout, it is clear that a number of issues must be considered for animals in proximity of such a disaster. Since data are scarce from Japan, specific recommendations are impossible to make as the dose, duration and route of exposure must be known. A number of potential considerations are listed below. Acute and chronic radiation poisoning of animals is beyond the scope of this outline. In addition, contamination of livestock and grazing areas by tsunami contaminated debris (chemicals, petroleum products, etc) introduces the real risk for chemical contamination of animals and feed, a situation seen in hurricane flooded areas. These threats are not considered here.

- Radionuclides presently implicated in the Japanese incident include iodine-131, cesium-137 and strontium-90. The specific element involved is one of the primary determinants of animal tissue (s) that are targeted as well as the route and rate of clearance from the body. For example, iodine accumulates in the thyroid, cesium uniformly distributes throughout the body similar to that of potassium but can concentrate in muscle tissues, while strontium mirrors the biodistribution and clearance of calcium. The radioisotope determines half-life for radioactive decay, which is very long for many of the radioisotopes of concern here (*e.g.* half-lives for cesium-135 and cesium-137 are 2.3 million years and 30 years, respectively).
- To estimate exposure, radioactivity must be quantified using appropriate units, including Curies and Becquerels. Units of radiation exposure use different metrics, including Roentgens, Sieverts, REM, or Coulombs. The level of radiation exposure correlates with health effects at specific levels and durations of exposure. These are not units of radioactivity which are required to calculate absorption and clearance of radioisotopes in an exposed animal.
- When considering disposition in animals, the radioactive decay “physical” half-life has no relation to pharmacokinetic elimination or “biological” half-life. As an example, cesium-137 has a “physical” half-life of 30 years, but has a “biological” half-life on the order of weeks to months. The actual dose and duration of exposure, often very difficult to obtain in field studies, would significantly impact these values.
- There are three distinct scenarios for radioactive fallout exposure to food producing animals:
 - i. Direct contamination by exposure to radioactive fallout (skin, inhalation, food)
 - ii. Exposure via consumption of contaminated feed or forage
 - iii. Exposure from contaminated drinking water.All three have different considerations and remediation strategies since the routes of exposure and exposed doses are very different. Management generally involves the latter two scenarios.
- The first consideration is to remove livestock and feed from potential fallout by going indoors. One must secure contaminant-free feedstuff. Cover bales of hay. If bales of hay are contaminated, outer layers may be removed and uncontaminated hay obtained from the center. These are emergency management issues and are most effective if instituted as soon as possible.

- Determination of the absorption and subsequent fate of radioactive fallout is both a function of the specific radionuclide and the radioactive dose. Direct exposure to high level radiation which results in clinical signs in animals should lead to immediate carcass contamination with appropriate disposal taking into consideration protection against human radiation exposure. Such tissues should not enter the human food chain.
- Therapy of exposed or ill animals could be considered only on a humane basis. For example, use of Ca-DTPA (diethylenetriaminepentaacetate), a systemic decorporation and chelating agent, is designed to increase excretion of already absorbed radionuclide. It is very expensive and not practical for food animals. Other approaches to protect exposed animals from biological effects are calcium salts and alginate after strontium exposure and potassium iodide for radioiodine exposure. There is evidence of their marginal effectiveness and some potential adverse safety issues.
- The most common post-exposure scenario is one of managing nonexposed grazing animals on long-term low-level contaminated pastures or when exposed to low level contaminated feed or water.
- Purification strategies are available for decontaminating water using ion-exchange and filtering approaches.
- The primary management step post-exposure is feeding animals uncontaminated feed and water. An effective remediation strategy after cesium exposure in Chernobyl was to feed contaminated pigs clean fodder two months prior to slaughter, allowing depletion of absorbed compound to occur.
- Therapeutic compounds are used to prevent animals from further radioisotope absorption after exposure to such contaminated feedstocks. Compounds such as colloidal Prussian Blue (Ammonium-Ferric-CyanoFerrate-AFCF) and clay minerals (bentonite, etc) trap the radionuclide before absorption can occur, thereby significantly reducing radiation levels in milk and meat. Prussian Blue irreversibly binds cesium in the gastrointestinal tract and is not absorbed after oral administration with 99% being excreted in feces in pigs. Also note that feces from treated animals would be expected to have increased radiation due to excretion of the bound radionuclide. In humans, AFCF reduces cesium's biological half-life by almost 50%. AFCF administered at 2-3 grams/day has been shown to be economically effective in treating cesium contamination of feedstuff contaminated by Chernobyl in Europe by reducing cesium-137 levels in milk and meat up to 80-90%. At low cesium contamination levels (e.g. 10 Bq/day), milk levels were below detection. Such a regimen was approved in West Germany and Austria in the late 1980s. Prussian Blue has been shown to be relatively safe to animals and considered safe and effective for use in humans.
- Reinforcing feed with excessive clay minerals is less effective than using Prussian Blue and may alter mineral and trace element homeostasis.
- Milk is a significant source of human exposure in post-crisis contamination areas. Radionuclides of strontium and cesium are the primary concerns for milk contamination. Strontium's biological half-life in milk is from 10 to 40 hours while cesium has a reported half-life up to 9 days. Transfer coefficients (the equilibrium ratio between radionuclide activity concentration in milk or meat and the daily intake of radionuclide) are used to predict contamination of animal products following the release of radionuclides into the environment. This is complex, for as in the case of strontium, dietary calcium alters this ratio. Soil type has a major effect on these values, with transfer from soil to plants favored in peat versus clay soils. After exposure, radioisotope uptake into plant roots determines how long fields, and thus feedstuffs, stay contaminated. This must be monitored on the ground. Finally, there have been some reported practical approaches to removing radionuclides from milk.

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