MILL TAILINGS

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TAILINGS PILES FROM URANIUM PRODUCERS

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INTRODUCTION

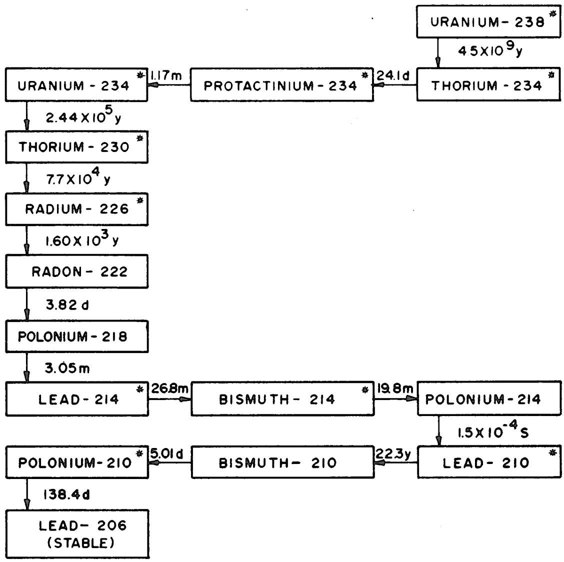
Large volumes of low specific activity (LSA) waste are generated in the mining and processing of uranium ores, phosphates and other minerals. While the activity in these wastes is not nuclear-reactor produced, they have similar characteristics to TRU waste. They are heavy metals, and long-lived alpha emitters. Special precautions must be taken in stabilizing and reclaiming these mine and process tailings materials.

The amount of this material is staggering, some 120 million metric tons of uranium mill tailings alone. It is not practical nor economically feasible to load this material in 55 gallon barrels and ship it to a commercial low-level waste burial ground; thus, separate consideration must be given these materials when providing for the health and safety of the general public.

The significant radiological hazard from these tailings materials is from the decay daughters of the U-238 chain, shown in Fig. 1. In many of the processes experienced by these materials the majority of the uranium is removed, but Th-230, Ra-226 and daughters remain at near pre-process concentrations.

The pathways through the environment from a typical tailings pile[1] are depicted in Fig. 2. Those pathways ~~through~~ which the radioactive nuclides can be transported extensive distances are the air and groundwater pathways.

The isotopes Th-230, Ra-226, Rn-222 and daughters are of particular environmental significance. The isotope Ra-226 has a relatively high dose conversion factor (rem per microcurie ingested or inhaled) and can be transported in groundwater systems. The isotope Rn-222 is an inert gas and can diffuse through materials and be readily transported via the air pathway. The short-



NOTE:
VERTICAL DIRECTION REPRESENTS ALPHA DECAY, HORIZONTAL DIRECTION INDICATES BETA DECAY. TIMES SHOWN ARE HALF LIVES. ONLY THE DOMINANT DECAY MODE IS SHOWN.
* ALSO GAMMA EMITTERS

RADIOACTIVE DECAY CHAIN OF URANIUM-238

FIGURE 1

lived alpha-emitting daughters of radon give a higher dose when inhaled than does the radon gas, but it is the mobility of radon that enables the daughters to reach man. If radon is allowed to stagnate in a closed area, the radon daughter concentrations increase to equilibrium values; hence, the "age" on air containing radon is an important factor in determining its radiotoxicity to man.

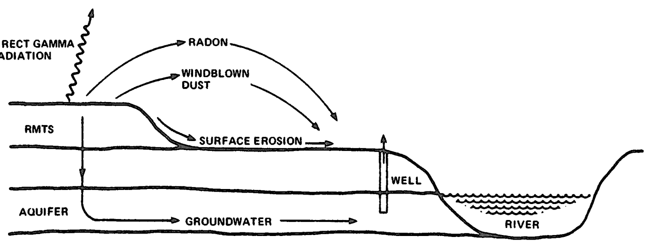


FIGURE 2 GENERALIZED POTENTIAL EXPOSURE PATHWAYS FROM RMTS

SOURCES OF URANIUM WASTE

Because nearly all geologic materials contain uranium and its daughters, practically all such wastes can fit in this category. In fact the source of major population doses from the uranium decay chain are from natural soil--the concentration is low (less than 5 pCi Ra-226/g soil) but the quantity is immense. Wastes considered herein, listed in Table I, are limited to uranium mine and mill tailings, phosphate process tailings and coal ash. Other sources of uranium production or population exposures from Ra-226 and daughters are given in Table II. Also shown in the table are typical activity concentrations. Because these sources do not yield major quantities of tailings, they are not considered further.

TABLE I. Major Sources of Radioactive Tailings

Source	Annual Production Rate (10^6 MT/yr)	Cumulative Amount (10^8MT)
U Mine Tailings	305	24
U Mill Tailings	12	1.2
Phosphate Tailings	56	10
Coal Ash	55	--

TABLE II. Other Sources of U-238 Decay Chain Isotopes

Source	Typical Concentration	Isotope
U Mine Waters[2]	12 ppm	Uranium
Cu Mine Waters[2]	8 ppm	Uranium
Building Materials[3]	8 pCi/g	Ra-226
Natural Gas[3]	20 pCi/l	Rn-222

Uranium Mine Tailings

About 54% of the uranium currently being mined is from surface mines.[4] These operations generate about 50 MT of overburden for every ton of ore, so that, with a current annual ore production of 6 million MT/yr from surface mines, about 300 million MT of overburden are generated every year.[4,5] Presently most of this overburden is used to backfill the pits and in many areas, backfill procedures are established so that the overburden with the lowest uranium concentration is placed near the surface.[5]

Underground mining accounts for about 46% of the uranium ore mined annually. The amount of mine wastes is between 1:1 to 2:1 ratio to the amount of ore. It is usually used as fill for mined-out areas.

The radon release rate from mine wastes is less than 10% of the radon release rate during operations. The estimated annual release[3] rate of Rn-222 from mine tailings is about $2x10^4$ Ci/yr.

<u>Uranium Mill Tailings</u>

Because most uranium is found in sandstone formations, uranium mill tailings are composed mainly of a sand fraction. About 30% of the solid tailings consists of fine clay material, and 75% of the activity is contained in the fines. The average Ra-226 concentration[6] in tailings is about 450 pCi/g, yielding a surface radon flux[6] of about 300 pCi/m^2sec.

The annual ore production rate[4] is shown in Fig. 3. The peak mining activity in 1960-1961 was only recently exceeded as U_3O_8 prices increased significantly making it economical to process lower grade ore.

The present annual radon release rate from U mill tailings is about $2x10^5$ Ci, if no radon attenuating measures are instituted. It is the major source of radon from all the tailings included in Table I. With the uniform institution of the proposed Nuclear Regulatory Commission Regulations on Uranium Mill Tailings Reclamation,[6,7] radon emissions would be reduced by about a factor of 150.

The large volumes of tailings generated in the uranium milling activity make it prohibitively expensive to transport a tailings pile any considerable distance. Proper selection of a tailings site is important in planning a milling activity. Parameters to consider include: isolation from population, geology and groundwater and surface hydrology.

The Nuclear Regulatory Commission has projected the uranium ore requirements to the year 2000, and this projection has been used to generate the curve in Fig. 4. With this projection the total accumulated amount of uranium mill tailings will increase from 120 million MT in 1977 to 600 million MT by 2000.

GRADE AND AMOUNT OF U ORE PRODUCTION

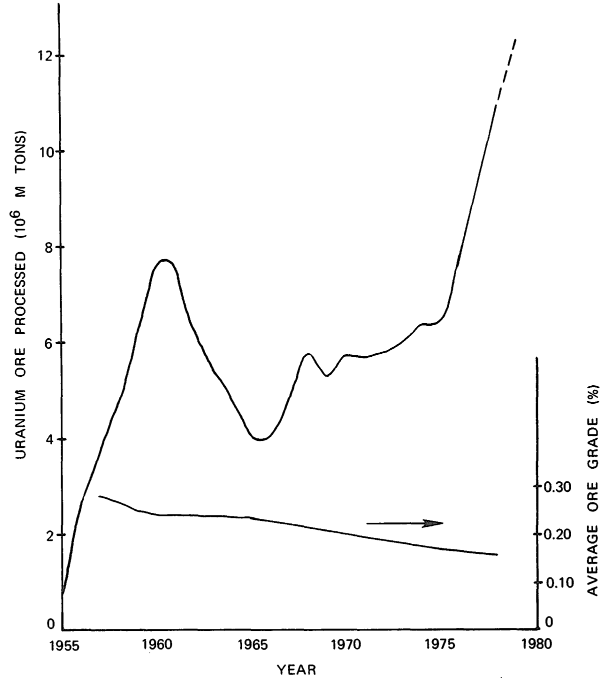


FIGURE 3

Phosphate Mining and Processing

Uranium and its daughter products have been associated with phosphate mining and processing. The uranium recovery process is based upon solvent extraction from a 30% phosphoric acid stream normally produced at or near the phosphate rock mine. By 1979 this process is expected to account for about 5% of domestic uranium production.[8]

Phosphate ore is comprised of about one-third recoverable

PROJECTED ANNUAL U MILL TAILINGS GENERATION

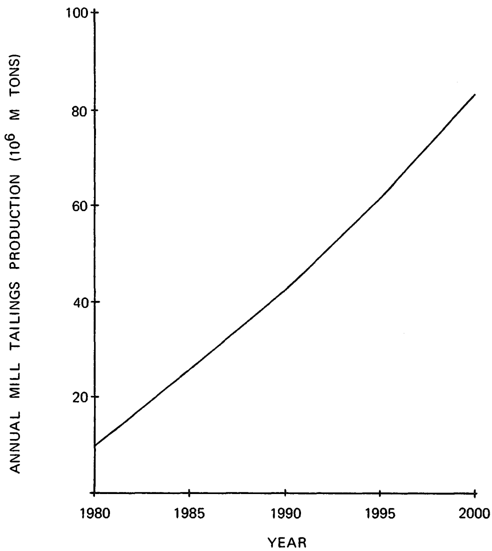


FIGURE 4

phosphate rock, one-third quartz sand and one-third clays. After separation from recoverable phosphate rock, sand tailings are pumped back onto the land for rapid dewatering, while the clays are pumped to impoundments where dewatering to a reclaimable state may require 15 to 20 years.

Florida produces about 91% of the phosphates in the U.S.; hence, the largest tailings piles are present in that state. Approximately 143 million m^2 of land containing this material has been reclaimed.[9] Johnson[9] reported an average surface radon flux of 8 pCi/m^{2}sec from reclaimed lands.

Phosphate is also mined in Idaho, and the tailings slag has been used in road construction in several cities, resulting in elevated gamma and radon levels.

Coal Ash

The amount of coal ash generated annually is 55 million MT, with about 16% of it being utilized for other purposes.

No uranium has been produced from coal combustion in power plants, but in the early 1960's lignite was burned to recover uranium.

Most coals contain uranium in concentrations ranging from 0.1 to 43 ppm. When the coal is burned, a beneficiation occurs which increases the concentration of uranium[10] and radium in the residual ash by a factor of 2 to 3. Although average U and Ra-226 concentrations in the ash are about 3-5 pCi/g, they can range up to 45 pCi/g.

COMPARISON OF RISKS

Potential population doses from radionuclide leaching and transport through an aquifer yield about 100 man rem for mill tailings, 0.1 man rem for U mine tailings and 0.01 man rem for coal ash.[11] The values for phosphate slag are significantly lower because it is assumed that the leached thorium and radium reach the ocean with very little entering a potable aquifer or surface stream.

Radon emission rates from these sources are given in Table III, as are population doses.[3] For comparison other major sources of Rn-222 are listed. These other sources comprise 99.9 percent of the estimated population dose, so that, on a population dose basis, these tailings piles are negligible. The major adverse health impact is the maximum individual doses that people would receive if they built dwellings on or adjacent to the piles, a situation that has occurred in several different locations.

TABLE III. Estimated Risks From

Sources of Radon

Source	Annual Release(ci/yr)	Population Dose(man rem)	Percent of Total P.D.
U Mine Tails	2×10^4	4.8×10^3	0.007
U Mill Tails	2×10^5	1.9×10^4	0.029
Phosphate Tails	4×10^4	8×10^3	0.012
Coal Ash	1×10^2	3×10^3	0.004
Natural Soil	1×10^8	3×10^7	40
Evapotran-spiration	9×10^6	2×10^6	3
Building Interiors	3×10^4	4×10^7	55
Soil Tillage	3×10^6	7×10^5	1
Natural Gas	1×10^4	4×10^5	0.9

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