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DISTRIBUTION OF RADIOACTIVITY IN THE ALLUVIUM OF A DISPOSAL AREA AT LOS ALAMOS, NEW MEXICO

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Abstract.—Fine particles in alluvial material in a disposal area for liquid radioactive wastes at Los Alamos have greater affinity for radionuclides than coarse particles; however, most of the radioactivity is in the coarse material, which is more abundant. The radioactivity in the alluvium is dispersed by waste water and storm runoff and decreases with distance from the point of effluent outfall. Most of the radionuclides are retained in the upper 3 feet of the deposits, resulting in very little change in the quality of the ground water perched in the alluvium.

Liquid industrial wastes produced at the Los Alamos Scientific Laboratory, in north-central New Mexico, contain small but undesirable amounts of radioactivity. These wastes are treated by chemical processes and by ion exchange to reduce the radioactivity to less than 10 percent of the MPC (maximum permissible concentration), as recommended by the International Committee on Radiation Protection, before discharge to a disposal area in Mortandad Canyon, about 2 miles southeast of the community of Los Alamos. The effluent, diluted by waste water and storm runoff, infiltrates a small perched ground-water body in the alluvium (Abrahams and others, 1962). Some radionuclides in the effluent become bound to particles of the alluvium, thereby reducing the amount of radioactive contamination of the perched water.

This report is based on data collected in a preliminary study to determine possible areas of further investigation of transport of radionuclides on sediment. Samples of alluvium were collected from the surface to a depth of 3 feet at the point of effluent outfall and at locations 3,500 feet and 5,800 feet downstream. The samples were air dried and mechanically separated into seven fractions ranging in particle size from silt and clay to granules. The seven fractions were analyzed for gross alpha, gamma, and beta radioactivity and for radioactive strontium. The short duration of counting ($\leqq$ 30 minutes per sample) precludes a quantitative interpretation of the data, but the data are believed to indicate qualitatively the distribution of the radionuclides within the various fractions of the alluvium samples.

PARTICLE-SIZE DISTRIBUTION

The particles constituting the alluvium were derived from weathering of the Bandelier Tuff. The granules are composed principally of tuff and pumice, and contain minor amounts of quartz and sanidine crystals. The fractions from fine to very coarse sand consist mainly of quartz and sanidine crystals and fragments with minor amounts of tuff, pumice, and mafic minerals. The silt and clay fraction is composed mainly of the clay minerals montmorillonite and illite, which are the major end products of weathering of the tuff.

A cumulative curve (fig. 1) of particle-size distribution in the alluvium near the point of effluent outfall from the treatment plant shows that 95 percent of the material, by weight, is in the size range from medium sand to granules, and that 5 percent is in the size range from clay and silt to fine sand. The largest percentage of alluvium, by weight, is very coarse sand, and the smallest percentage is fine sand.

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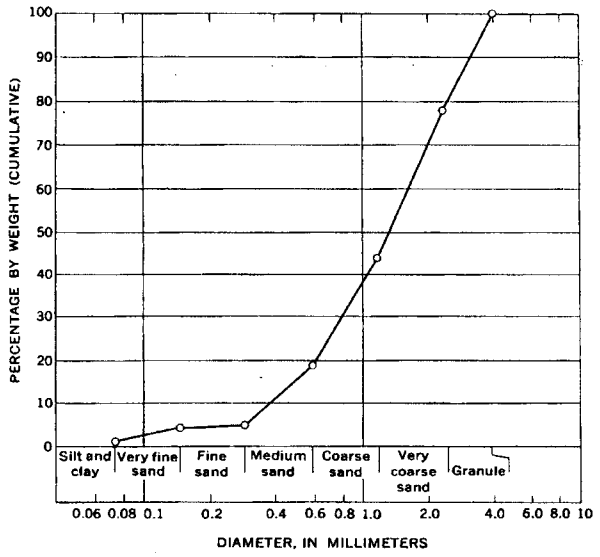

FIGURE 1.—Cumulative curve of particle-size distribution in alluvium near the point of effluent outfall from the waste-treatment plant.

RELATION OF RADIOACTIVITY TO PARTICLE SIZE AND MINERAL COMPOSITION

The distribution of the radioactivity is correlated with both the size and the mineral composition of the particles. On a unit-weight basis more radioactivity was found in the silt and clay, very fine sand, and fine sand than in the coarser fractions (table 1). The largest proportion of the radioactivity was in the silt and clay, and the proportion decreased with increasing particle size. The silt and clay, very fine sand, and fine sand are composed of clay minerals or of materials that are rapidly weathering into clays. The clay minerals montmorillonite and illite, derived from weathering of the tuff, have a relatively high ion-exchange capacity, and adsorb and retain radionuclides from the liquid wastes.

Of the larger particles, the granules have a higher concentration of gross gamma and beta radioactivity, and more radioactive strontium per unit weight than the more siliceous medium, coarse, and very coarse sand particles. This may be due to the fact that granules are primarily tuff and pumice of high microscopic porosity with large surface areas. Since the tuff and pumice are in the process of weathering, the pores contain some clay which tends to bind radionuclides.

DISTRIBUTION OF RADIOACTIVITY IN THE ALLUVIUM

A greater quantity of radionuclides was found in medium sand, coarse sand, very coarse sand, and granules than in the clay and silt, very fine sand, and fine sand. This is shown graphically in figure 2. The range from medium sand to granules makes up 95 percent of the alluvial material and, though the ability of the particles in this size range to bind radionuclides is less than that of the particles in the range from clay and silt to fine sand, the material of medium-sand to granule sizes contains more radioactvity simply because there is more of the coarse material available.

The radioactivity decreases with depth in the alluvium. Gross alpha activity decreases about 70 percent, gross gamma activity about 98 percent, and gross beta activity about 99 percent between the surface and a depth of 3 feet. Nearly all the radioactive strontium is retained within the upper foot of the alluvium.

The radioactivity also decreases with distance from the point of effluent outfall. Table 2 indicates the concentration of radioactivity at the point of outfall and at two distances downstream.

A buildup of radioactivity was expected in the alluvium near the point of effluent outfall; some radioactivity did accumulate, as noted in table 2, during the first 2 years of discharge. Primarily, dispersion of the radionuclides from the outfall area is due to flushing of alluvial particles from the area by periodic discharge

TABLE 1.—*Gross alpha, gamma, and beta radioactivity, and radioactive strontium, per unit weight of fraction*

[Analyses by the Los Alamos Scientific Laboratory, Group H-7]

Fraction	Particle diameter (millimeters)	Weight percent	Cumulative weight percent	Counts per minute per gram (dry weight)			
				Type of radioactivity			Radioactive strontium
				Gross alpha	Gross gamma	Gross beta	
Silt and clay	Less than 0.074	1.0	1.0	45	128	1,751	42
Very fine sand	0.074– .147	3.5	4.5	33	75	799	49
Fine sand	.147– .295	.5	5.0	24	61	771	27
Medium sand	.295– .589	13.5	18.5	15	33	396	23
Coarse sand	.589–1.17	25.5	44.0	8	32	414	17
Very coarse sand	1.17 –2.36	34.0	78.0	5	24	239	15
Granule	2.36 –3.96	22.0	100.0	4	35	425	31

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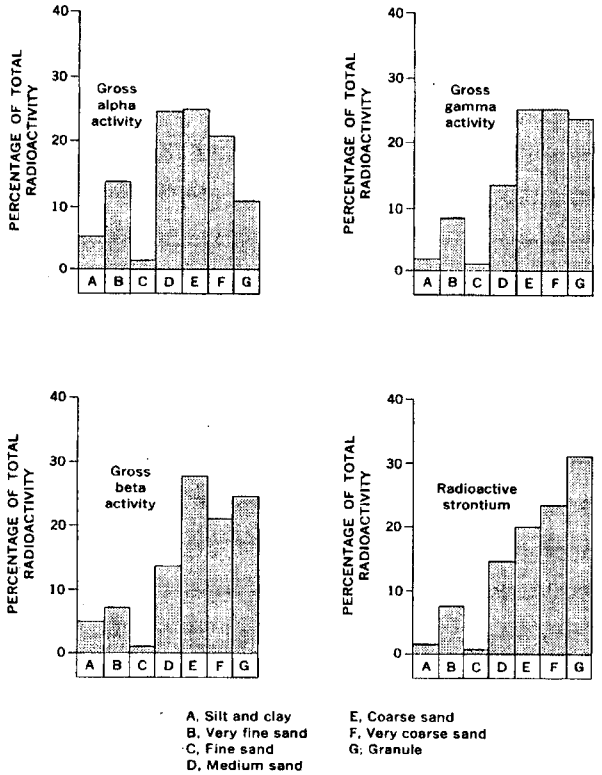

FIGURE 2.—Gross alpha, gamma, and beta activity, and radioactive strontium, in particle-size fractions of alluvium at the point of effluent outfall from the treatment plant (in percentage of 100-gram samples).

TABLE 2.—*Radioactivity of surface alluvium at the disposal area*

Type of radioactivity	Counts per minute per gram (dry weight)		
	At point of outfall	3,500 ft. from point of outfall	5,800 ft. from point of outfall
Gross alpha	9	4	2
Gross gamma	80	4	4
Gross beta	482	22	0
Radioactive strontium	25	2	4

of effluent, other waste water, and storm runoff. Radionuclides dislocated by flushing are redeposited with the translocated sediment. Radionuclides chemically dislocated are transported to an environment favorable for reprecipitation or for attachment to other alluvial materials.

The quality of the perched water in the disposal area has changed very little as disposal operations have continued. The negligible changes noted can be credited to an initial treatment of waste such that radionuclides are reduced to a level well below the MPC. Further, dilution of the treated effluent by nonradioactive waste water and storm runoff, as well as retention of radionuclides by the particles which constitute the alluvium, combine to produce a "waste stream" that is of high quality in itself. Thus, the infiltration of such a waste stream has had little effect on the quality of the perched water.

REFERENCE

Abrahams, J. H., Jr., Baltz, E. H., and Purtymun, W. D., 1962. Movement of perched ground water in alluvium near Los Alamos, New Mexico: Art. 37 *in* U.S. Geol. Survey Prof. Paper 450–B, p. B93–B94.