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Removal of Radioactive Fission Products From Surface Water Supplies

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The long-lived Strontium 90 isotope produced in fission and distributed in fallout or waste disposal from nuclear fuels used in reactors, may enter the body through food or water and become part of the human bone. It is anticipated that the most serious effect of a high concentration of Strontium 90 in the skeleton will be the increased incidence of bone sarcoma and leukemia.

The short-lived fission isotope, Iodine 131, produced in fission and distributed in fallout or waste disposal from the nuclear fuels, also may enter the body and become part of the human system. The problem revolving around the metabolism of Iodine in man is associated with the fact that Iodine is accumulated by the thyroid gland. Iodine normally enters the body in the diet in the form of the elemental Iodine or organically-bound Iodine. However, since Iodine is soluble in water, it is entirely possible that highly contaminated water would be a source of radio-iodine after fission products had been distributed by fallout. During most normal circumstances the amount of radiation which would be delivered to the thyroid gland from amounts of radio-iodine reaching it from environmental contamination, is far below the level which will produce physiological effects. However, in case of a nuclear accident, or in case of fallout, the amounts could produce cancer in the thyroid gland.

In case of a nuclear accident or incident, shelter and food problems are not insurmountable if attacked in a practical and purposeful manner as described in the U.S. Department of Agriculture Farmers' Bulletin 2107, "Defense Against Radioactive Fallout on the Farm;" "The Family Fallout Shelter," Office of Civil Defense Mobilization, MP-15; and mimeographed material "The Combined Fallout Shelter, for Protection From Fallout, Storms, and for Food Storage" by Clarence Stevens, Marion W. Clark, and Ralph Ricketts, University of Missouri.

Human and animal food can be sealed in cans or dried and kept in airtight containers. Livestock can be kept under a roof of tight covering. But providing a supply of radioactive-free water for the family and livestock for a fallout period may be more difficult, particularly where the only adequate supplies of water are from surface streams, lakes, ponds, and cisterns. The problems occurring with underground water, deep wells, or properly protected, bacterially-safe springs are simple, compared with the problems associated with surface water supplies.

In many parts of Missouri, adequate water cannot be obtained from deep wells. People in these areas depend upon streams, lakes, and ponds for water for themselves and their livestock. The contamination of such sources of water with radioactive fallout could not be avoided. Thus, the problem in large areas of the country would involve some means of removing radioactive contaminants from surface water supplies.

A study, reported on the following pages, was undertaken by the University of Missouri Agricultural Experiment Station to determine some means of removing radioactive fallout from surface water supplies. Specifically, the problem involves some practical and adequate means of removing Strontium 90 and Iodine 131 from such surface waters as ponds, lakes, and streams.

Plan and Method of Investigation

The investigation consisted of three parts: (1) the removal of Strontium 90 from contaminated pond water, (2) the removal of Iodine 131 from contaminated pond water with sand filters, (3) the removal of Iodine 131 from contaminated pond water with activated charcoal filters.

Strontium Experiment

A 30 foot horizontal experimental sand-clay filter (Fig. 1) was selected for Strontium-removal tests. It had been used in bacterial studies with reference to the filtration of surface water of ponds and lakes on farms and ranches and had proven bacterially effective. Strontium is a positively charged cation. Sands and clays absorb cations so the assumption was made that the filter would absorb Strontium.

The surface water supply was spiked with short-lived, radioactive Strontium 89. Control samples were taken and counted to determine the concentration of radioactivity as counts per minute per mil.* The filter was arranged with special precautions against settling of the sand away from the top of the 30 foot tube. Should settling occur, it would leave a passage for unfiltered water to pass over the filter. Sand pressure above the filter furnishes protection against channeling of the sand. The removal of the radioactive isotope offered a check on the channeling of the filter as well as filtration efficiency. Sand channeling is a major problem with horizontal filters.

*ml – 1/1000 of a liter. The sample of liquid was dried on six 1-inch steel planchets and counted with a gas flow proportional counter.

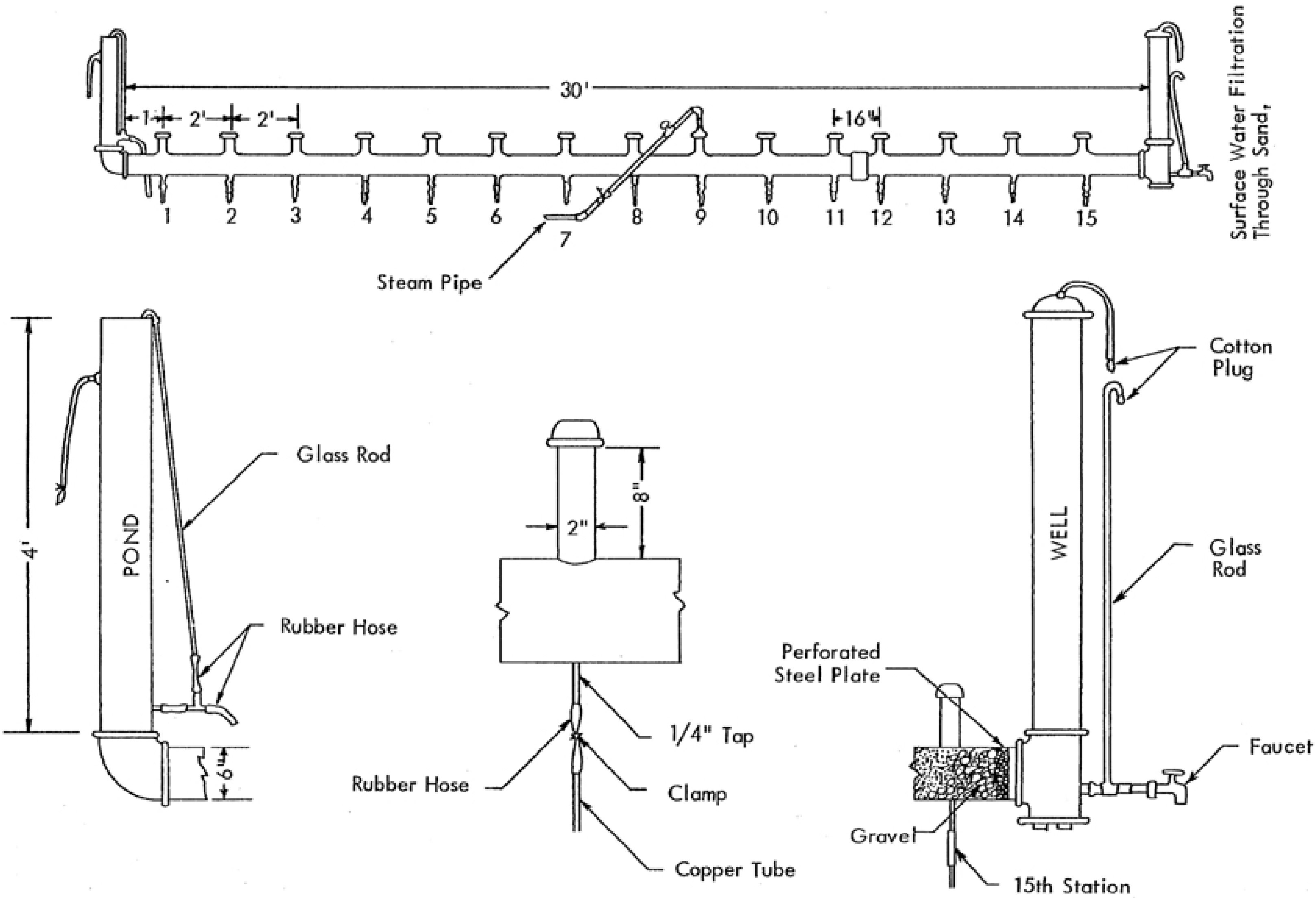

Fig. 1. Sketch of 30 foot horizontal sand-clay filter.

The filter used had ports every 24 inches along the 30 foot horizontal depth. The control activity of the pond water was from 2500 to 3000 counts per minute per ml. Since samples could be taken from the ports at 24-inch intervals along the filter, it was not difficult to determine the depth of penetration of the Strontium into the filter.

The capacity of the filter was checked and the speed of flow through the filter was calculated at approximately one foot per hour. Since the rate of flow of the filter was one foot per hour, and ports were two feet apart, it was decided to take samples from each port every two hours for a 30-hour period. Then, to further check the filter, another set of samples was taken after 12 more hours.

After the first two hours, while samples were being taken from each port, a sample was taken from the end port, or No. 15 Station, as a check for any possible channeling of sand in the filter.

Samples were prepared by filling planchets with 8 ml of solution from the filter ports. The planchets were taken to dryness under infrared light in the presence of moving air. The activity contained in the planchets was determined with the proportional gas flow counter. After all the water samples had been collected, the filter was taken apart and a core of the first foot of sand was removed and placed on X-ray film for an autoradiograph of the radioactivity held in the filter.

Iodine 131 Experiment

The experiment described above was repeated, using radioactive Iodine 131 instead of the cation Strontium 89. The sample Iodine used was procured from Oak Ridge National Laboratory. Since Iodine has a short half-life (8 days), the radioactivity is very high per gram of Iodine. Therefore, a very small amount of water-adsorbed Iodine would result in high activity as counts per minute, per ml of solution.

The filter was cleaned to the first port by removing the sand, and replacing it with clean sand. This served as a cleaning of the filter. Normally, the clay floc is removed from the surface of the sand which results in speeded flow and increased capacity. The pond was again filled and inoculated with the pond culture. The filter was allowed to operate for about two weeks to acquire at least some floc on the surface.

The pond was then spiked with 77 microcuries of radioactive Iodine 131. Samples were taken from the filter at four-hour intervals and analyzed for radioactivity. The gamma ray spectrometer was used for counting, since Iodine 131 is a gamma emitter.

Anticipating the possibility that the sand-clay filter would not be as effective as a filter for Iodine 131 as it was against Strontium 89 or Stontium 90 cations, a search was instigated for a substance that would be effective. An exchanger or absorber for Iodine 131 that could be used in combination with a cation exchanger to give complete filtration for both types of radioactive isotopes would be most desirable. Radioactivity in water could be expected to be a cation as Strontium 90, an anion, or a water-absorbed gas as Iodine 131.

The materials used in commercial dechlorinators were thought to be possible aids for removing Iodine 131. The principal reason for this supposition was that iodine and chlorine are of the same chemical family; both might behave similarly during filtering action. The dechlorinators have been developed to a high degree of efficiency and are used to remove chlorine from excessively chlorinated water. Activated carbon is the principal substance responsible for the chlorine removal. An activated carbon filter, commercially available, was used for the study. This type of filter is not uncommon, but unless used with clarified water, it readily seals over and becomes ineffective as a filtration unit. Clay colloids and organic matter suspended in water will render the filter ineffective.

A solution containing Iodine 131 was diluted in one liter of water (final concentration 25 microcuries per liter) and run through the activated carbon filter. The filtered water was divided into samples of 100 ml each as the liquid came through the filter. A 1 ml aliquot was used for counting.

RESULTS

The sand-clay filter was effective in removing all Strontium 89 activity, as shown graphically in Fig. 2 and shown by radio autographs in Fig. 3. It is apparent that the Strontium 89 did not pass two feet of sand-clay filter.

Results of the Iodine 131 study with the sand-clay filters, are presented in Table 1. The sand-clay filter apparently was ineffective as a filtering material for water-held Iodine 131. The results after eight hours were surprising since port No. 15 revealed activity and not all the stations above revealed activity. This may be explained by that fact that Station 15 was open all the time, while the other ports were open only when samples were to be collected. This would move a larger volume of water to the end port 15, resulting in incomplete mixing and in no activity at some ports. To check this observation, port 12 was opened and allowed to run

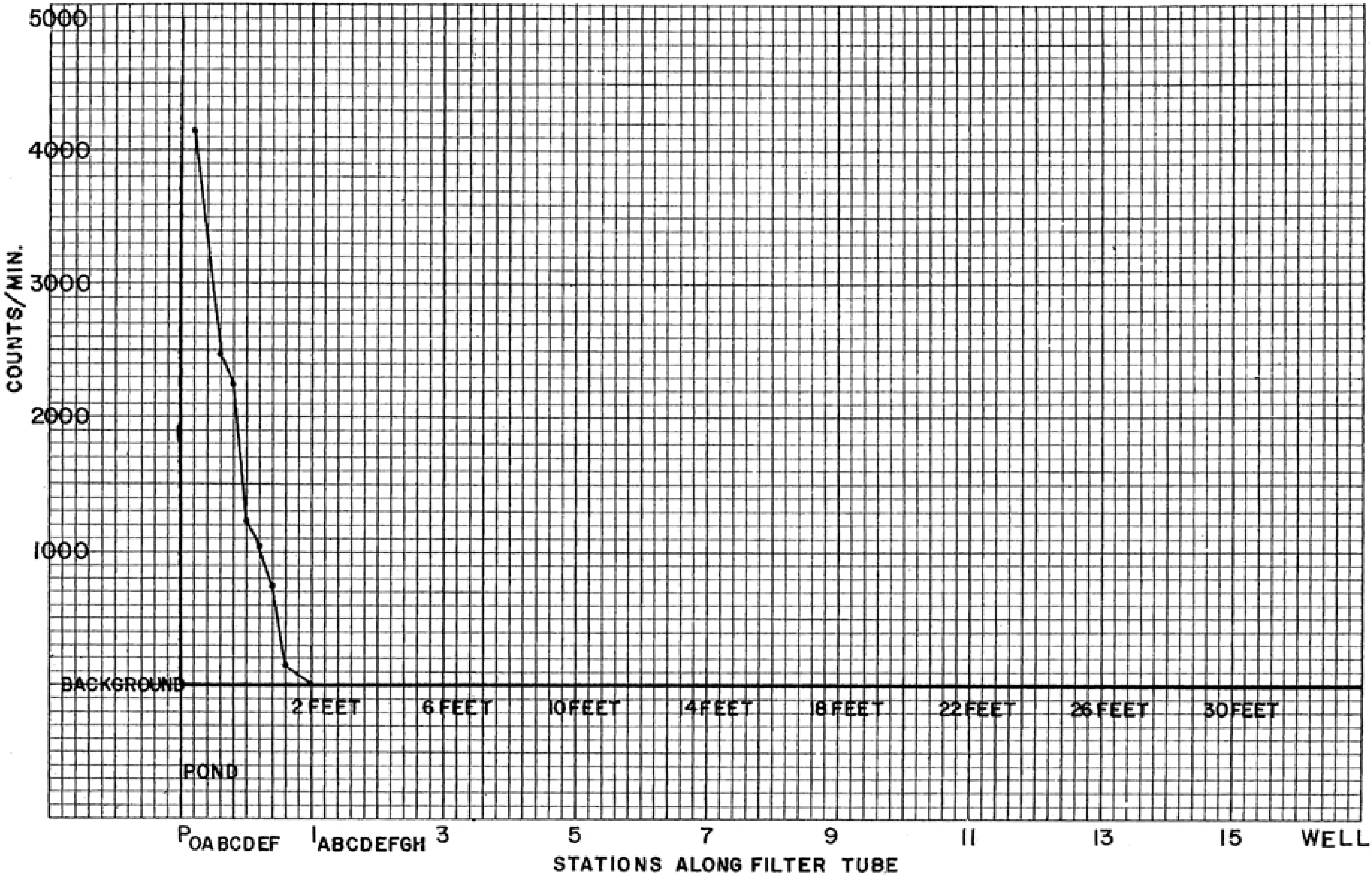

Fig. 2. Graph showing Sr^{89} removal from surface water by 30-foot horizontal sand-clay filter.

10 minutes after which a sample was taken. This sample revealed Iodine 131 activity of 239 c/m/ml. After 12 hours all ports revealed activity and the filter discharged Iodine 131 contaminated water.

Table 2 gives results of the study of removal of water-held Iodine 131 by filtration with activated carbon. The activated carbon filter was effective in removing the Iodine 131 activity.

TABLE 1-IODINE 131 ACTIVITY IN COUNTS PER MINUTE PER MILLILITER FOUR HOURS, EIGHT HOURS AND 12 HOURS AFTER RADIOACTIVITY HAD BEEN INTRODUCED TO THE FILTRATION COLUMN

Port Number	I 131 Activity After 4 hours	I 131 Activity After 8 hours	I 131 Activity After 12 Hours
1	155	229	263
2	303	320	248
3	48	443	265
4	10	494	341
5	21	297	338
6	Background	166	253
7	Background	73	431
8	Background	25	409
9	Background	Background	70
10	Background	Background	144
11	Background	Background	141
12	Background	10**	25
13	Background	Background	82
14	Background	Background	122
15	Background	104	153

*Background 15 c/m.
**After port 12 ran 10 minutes the second sample showed activity of 225 c/m/ml.

TABLE 2-IODINE 131 ACTIVITY IN COUNTS PER MIN. PER ML IN WATER SAMPLES FILTERED WITH ACTIVATED CARBON.

Sample	Net c/m/ml	Percent of I 131 activity removed
1st 100 ml	6	99.8
2nd 100 ml	6	99.8
3rd 100 ml	7	99.8
4th 100 ml	4	99.9
5th 100 ml	9	99.7
6th 100 ml	6	99.8
7th 100 ml	5	99.7
8th 100 ml	2	99.9
9th 100 ml	3	99.9
10th 100 ml	4	99.9

Back ground = 26 c/m.
Net Iodine 131 activity average of three unfiltered water samples = 2954 c/m/ml.

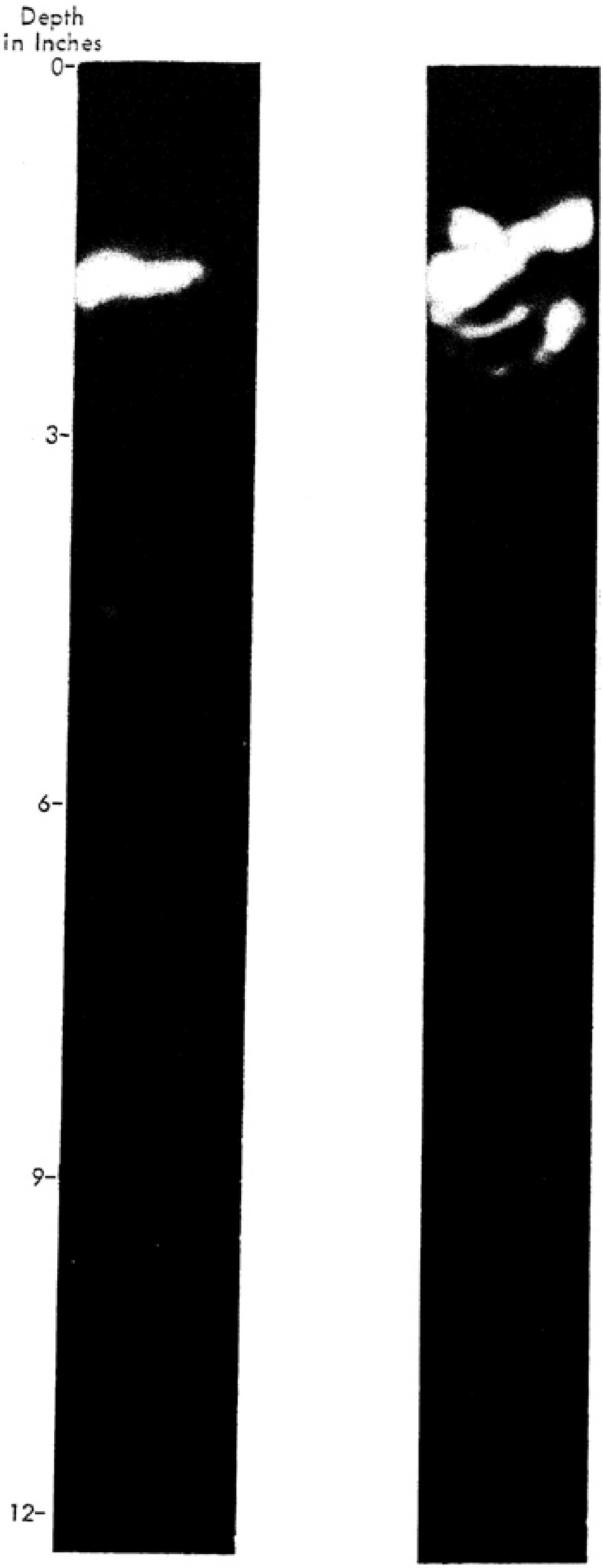

Fig. 3. Radio-autographs of sand-clay cores removed from the input end of the filter after filtration of Sr 89. The light areas show the concentration of the radio isotope.

SUMMARY AND CONCLUSIONS

Results of this study show that a properly constructed, 30-foot sand filter will remove such fallout as Strontium 89, Strontium 90 and other cations, possibly for any probable concentration, and for almost any length of time needed.

From the data shown, there was no channeling of the sand to let through the most minute quantity of water without proper filtering. Short-lived radioactive isotopes and the counting equipment could be used to detect any leak that would come in any open channel, and would be useful tools to test the effectiveness of a filter to be used for filtration of bacteria as well as radio-nuclides.

The sand-clay filter was not effective against water-held Iodine 131.

The activated carbon filter was effective in removing the Iodine 131 from sediment-free water. A comparatively small unit handling well-filtered and clarified water would be large enough for emergency use for any farm family and their livestock. The two filters combined would be a practical, economical, and very effective means of removing radioactive fallout from surface water for individual farm and ranch water systems.

It is suggested that the activated carbon filter be plumbed into the surface water system, including cisterns, as illustrated, so that if it isn't needed for regular use it will be immediately available for any emergency. Rural America can then be confident of the safety of its vital surface water supply against radioactive fallout in times of emergency.