Reclaiming Sewage Effluent

By L. G. Wilson and G. S. Lehman

To the layman, sewage effluent represents a necessary but aesthetically undesirable byproduct of community living. To the water conservationist, on the other hand, sewage effluent constitutes a valuable source for a water conservation and re-use program.

Of particular importance for this purpose are the relatively large quantities available in metropolitan areas on a continual basis. In Arizona, for example, sewage flows equal or exceed 50 percent of the total water requirements of the municipalities in the state. By 1975, according to data in an Arizona Town Hall on Arizona's water supply, the total sewage flow from the greater Phoenix area should be 423 ac ft/day (acre feet per day); and for the Tucson area, 111 ac ft/day.

At present a large portion of sewage effluent from treatment plants is being used for irrigation of non-edible crops (so-called sewage farming). Since effluent normally contains an abundance of the nutrients required for crop growth, the farmer reaps an additional benefit by utilizing this supply. Other re-use possibilities also exist, such as for industry, recreation, and for irrigation of edible crop varieties.

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To Upgrade Quality

One drawback to the use of sewage effluent for such purposes is the need to upgrade the quality to levels commensurate with public health safety standards. Two possible methods for "tertiary" treatment of sewage effluent prior to re-use are grass filtration and soil filtration.

Grass filters consist of grassed areas through which sewage effluent is passed. Apparently treatment is effected by the following mechanisms: (a) removal of settleable materials, by the filtering action of grass, and (b) reduction of organic pollution by oxygen at the water surface, and by a biologically active film on the grass surface.

Soil filtration, one of the oldest water treatment methods, consists of percolating sewage effluent through soil material either to a subsurface collector or directly to ground water. With proper management, the soil serves as an effective filter for both solid material and microorganisms.

Grass Filtration Studies

This paper presents data on preliminary studies, conducted cooperatively by the Water Resources Research Center, and the Sanitary District No. 1 of Pima County. Main purpose of these studies was to determine the effectiveness and durability of grass filters during tertiary treatment of sewage effluent under Arizona conditions. Auxiliary studies were made to determine intake rate and depth of penetration of percolating effluent to provide data for future soil filtration studies.

Three plots, each 25 x 1000 feet (0.3% slope) were constructed in 1965 near the outfall from the Ina Road Oxidation Pond operated by the Sanitary District. Each plot was seeded to common Bermudagrass. The outer checks served as guard strips, restricting lateral subsurface flow from the central test strip. An asbestos cement liner was installed in the head ditch to minimize leakage.

Effluent was by-passed to the head ditch through a four-inch pipeline. An earthen ditch was used to conduct tail water to the Santa Cruz River for disposal. Three-inch Parshall flumes were located in the head ditch and tail water ditch for measurement of inflow and outflow rates. Two 100-foot access wells, for use with a recording moisture logger, were installed at 200 feet and 800 feet from the head end of the strip.

Three Tests Used

Three trials were conducted on the test strip in 1966. The guard strips were well irrigated before each test in an effort to minimize lateral subsurface flow from the central strip during testing. For these trials all the water available at the by-pass line was applied to the strip. This was done so that we could observe treatment during maximum loading conditions. The principal analytical method for characterizing treatment during the first two trials was the B.O.D. test, conducted on inflow and outflow samples. (B.O.D. values provide a measure of the biologically decomposable material in a stream). In the third trial the Chemical Oxygen Demand (C.O.D.) test was used. (This

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with comparable numbers of livestock during the summer grazing period.

When increased numbers of animals were placed on the pastures to utilize additional forage obtained from fertilization, individual animal gains were similar to those on check pastures, but the gain per acre was approximately doubled.

Heifers lost weight on dry grass during the October 20 to December 20, 1966 grazing period and fertilization in July did not reduce this loss.

The full story cannot be determined from data from a single year. This study will continue next year to determine carryover effects of the 1966 fertilization.

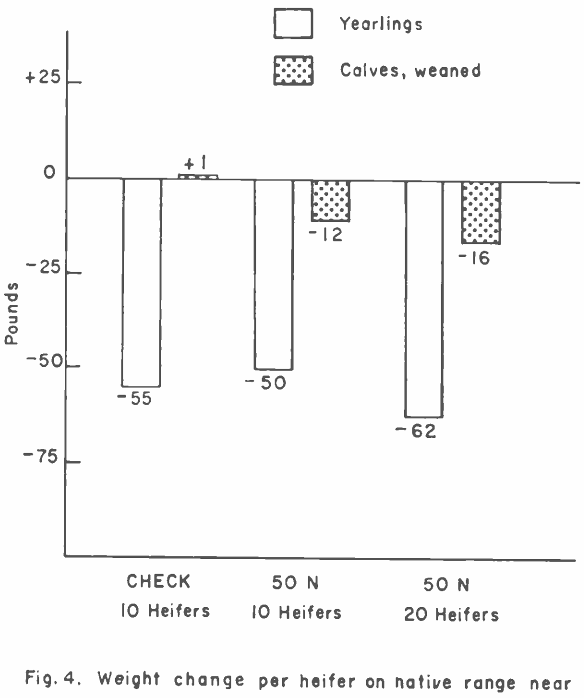

Fig. 4. Weight change per heifer on native range near Elgin, Arizona, Oct. 20-Dec. 20, 1966

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test measures the chemically oxidizable material in an effluent sample.)

Visual observations were made on changes in suspended solids concentration during grass filtration, and on the ability of the Bermudagrass to withstand prolonged flooding. Inflow and outflow rates were determined from Parshall flume data; results were used to estimate intake rates. Detention times (that is, time of residence of the effluent on the plot) were estimated for each trial from rate of advance data at the beginning of flooding. Subsurface moisture changes were monitored in the access wells using a recording moisture logger .

Algae Affect Results

For the first trial grass height averaged about four inches. Because of the shortness of the grass and the high hydraulic loading, 1.5 ac ft/ac/day, the grass was completely covered at several locations. Detention time was about 8½ hours. The total volume infiltrated during the nine days of testing was 3.8 ac ft, and average infiltration rate was 0.80 ac ft/ac/day. No definite conclusion could be made on treatment effectiveness from B.O.D. data since algae, entrained in samples, appeared to affect results. Visual observations on suspended solid concentration in inflow and outflow effluent showed that coarse particles were removed during filtration. In spite of prolonged inundation the grass recovered rapidly after water was turned off the plot.

Moisture logs obtained in an access tube on August 15, 24, 25, and 28, are shown in Figure 1. The log for August 15, illustrates the moisture profile the day before the test was started. Apparently pre-irrigation on the plot caused an increase in moisture content from about 25 to 35 feet below ground surface, and a rise in the water table level to about 45 feet.

The log for August 24, the last day of the test, shows the effects of flooding on the moisture content in the surface: a pronounced rise being evident from 0 to 10 feet below ground surface. The moisture bulge from 25 to 35 feet remained as in the earlier log, but a moisture increase was apparent in materials from 36 to 44 feet. This increase implies that accretion to ground water occurred during the trial.

Logs for August 25 and 28 were almost identical to that of August 24, except for a slight reduction in moisture content in the upper 10 feet, and continued increase in the region from 36 to 44 feet.

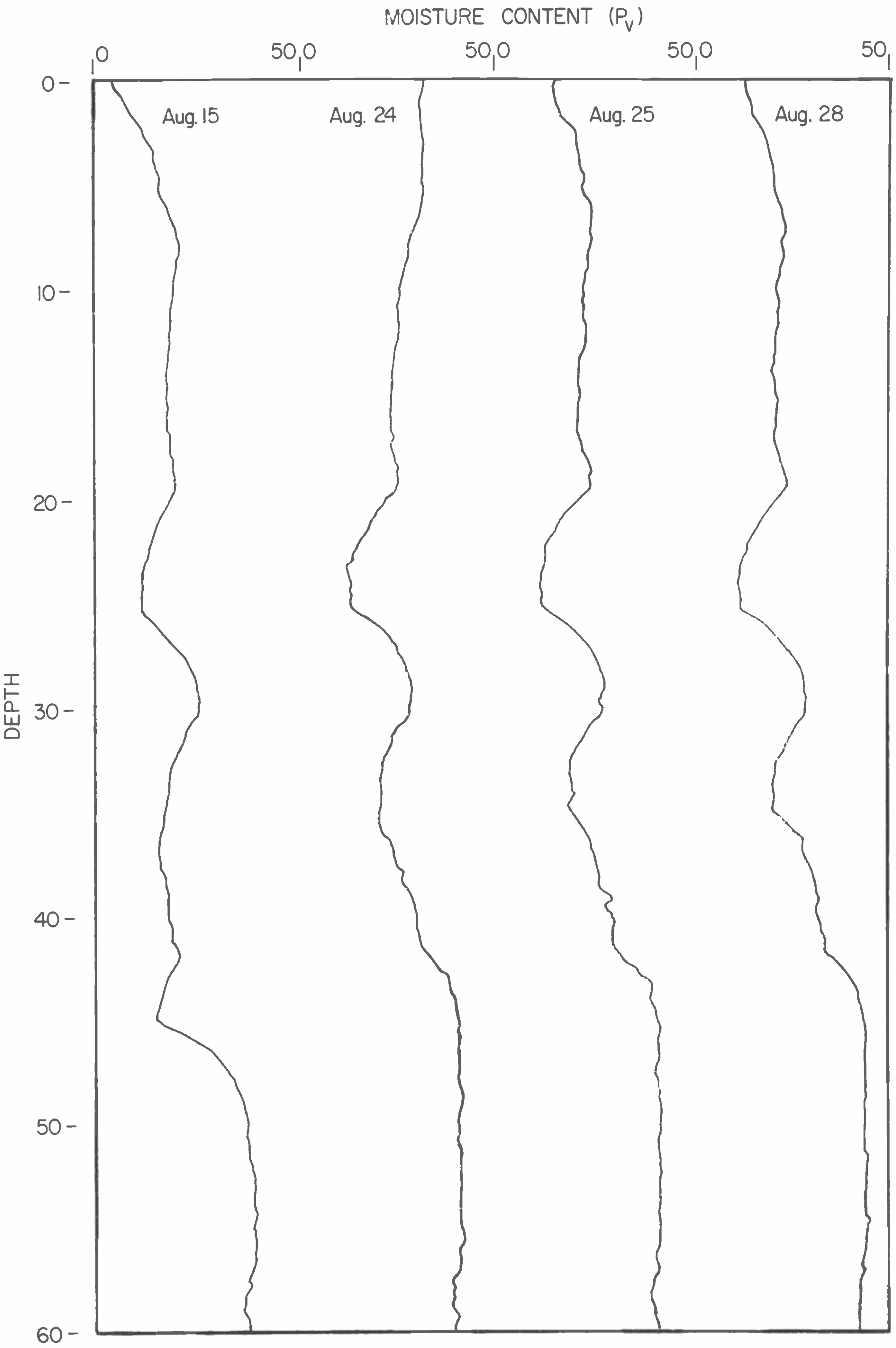

FIGURE 1 — Moisture Logs at Grass Filtration Plot Aug. 15-28, 1966.

Second Trial—Sept. 17-24, 1966

During the second trial grass height was about 14 inches and coverage was dense. Submergence was minimal and the test strip functioned more effectively as a filter. The average hydraulic loading was 1.4 ac ft/ac/day and detention time was again about 8½ hours. The total volume infiltrated during the eight-day trial was 2.6 ac ft and average intake rate was about 0.7 ac ft/ac/day. B.O.D. values, again, appeared to be unreliable. Coarse materials in the incoming effluent were reduced during filtration. Moisture logs were similar to those described above. The grass was not affected by flooding.

Third Trial—Oct. 1-18, 1966

It was evident from the two earlier trials that results of B.O.D. tests are affected by algal activity in the samples. During the third trial, therefore, we decided to use the C.O.D. test to characterize treatment. (C.O.D. is affected by number of alga but not algal activity). Duration of this trial

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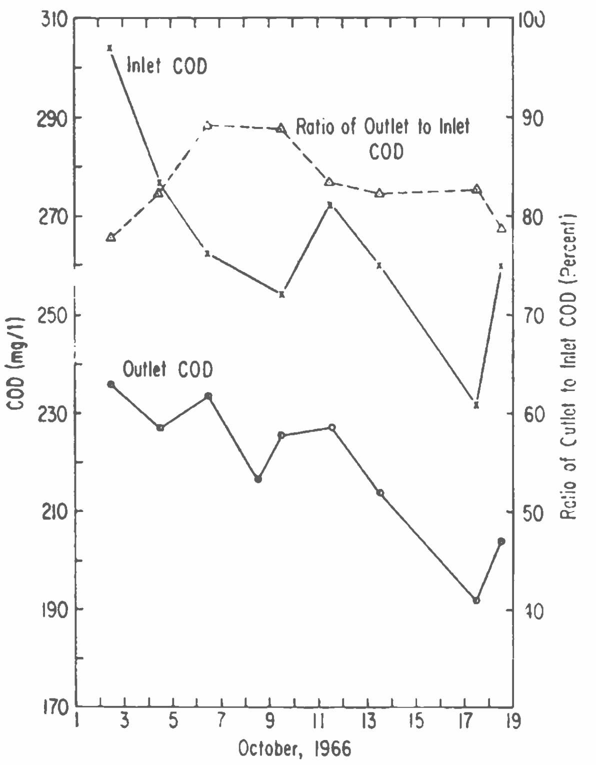

FIGURE 2 — Inlet and Outlet COD Values (mg/1) and Ratio Outlet to Inlet COD (percent) During Third Trial, Oct. 1-18, 1966.

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was longer than for the other two, so that we could determine if treatment improves with time.

Grass height was again about 14 inches and coverage was excellent. In spite of an increase in hydraulic loading to 1.7 ac ft/ac/day, submergence was not observed. Maximum detention time was about eight hours. Total volume infiltrated during the 17-day trial was almost 9 ac ft. Average infiltration rate was about 0.9 ac ft/day. Suspended solids were of colloidal dimensions and were not markedly reduced in concentration during flooding.

Outflow Values Consistent

Results of C.O.D. tests on inlet and outlet samples, together with the percentage of outflow to inflow samples, are shown in Figure 2. The data indicate that although inlet C.O.D. fluctuated during the test, outflow C.O.D. values were consistently lower. After an initial drop in percentage of outflow to inflow C.O.D., to 77.6 percent on Oct. 2, the percentage increased to a maximum value of 89.0 on Oct. 6. Thereafter, the percentage gradually decreased to a value of 78.7 on Oct. 18. It appears that treatment improves with time when inundation is avoided and the unit operates as a true grass filter.

Subsurface moisture changes during the third trial were about the same as those reported for the first trial. The grass showed no ill-effect from the prolonged flooding.

Cite Five Conclusions

On the basis of results from the three grass filtration trials, and particularly the third trial, we conclude:

(1) Only partial treatment was produced during the trials of 1966 because of the excessive hydraulic loadings and short detention times. The results of the third trial were encouraging enough, however, for us to anticipate producing a desirable effluent during future studies using lighter loadings.

(2) Grass height and density should be great enough to ensure operation of the grass plots as true filters.

(3) Water percolating downward during flooding eventually reaches the water table. Apparently the subsurface materials will serve as a soil filter. During impending studies water samples will be obtained in two wells, recently installed to 30 feet and 50 feet below ground surface, to determine changes in quality during soil filtration.

(4) C.O.D. is a more reliable method for characterizing treatment than B.O.D. in samples containing high algal concentrations.

(5) Bermudagrass tolerated prolonged flooding with sewage effluent.