

SAVING WATER IN RESERVOIRS

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INTRODUCTION

From early 1950 through 1955 many central and southern Illinois communities experienced shortages in their water supplies due to a severe drought. By early 1954 there were 41 communities in the southern half of the state that faced serious water supply problems (Hudson and Roberts, 1955). Most of these towns depended upon impounding reservoirs, and runoff had decreased from the normal ten inches per year to approximately one per cent of normal.

Annual water losses due to evaporation are approximately 40 inches in the southern half of Illinois (Roberts, 1953). As water levels in reservoirs dropped, evaporation rose to values greater than municipal withdrawal. In one community which daily pumped one-third of a million gallons from the 65-acre municipal reservoir, local restrictions reduced this to 170,000 gallons per day during July, 1954. However, during that same month, evaporation accounted for 460,000 gallons per day or 2.7 times more than the city demand. Obviously evaporation is a big factor in municipal reservoir accounting, and any means for reducing this loss is worthy of attention.

RESEARCH IN EVAPORATION CONTROL

While Illinois was experiencing its drought, a more severe one was affecting the southwestern part of the United States and other parts of the world. In 1952 the Australian Commonwealth Scientific and Industrial Organization began testing an insoluble film to suppress evaporation from small water surfaces. W. W. Mansfield, for whom the Australian process has been named, is the first man credited with developing the idea of using hexadecanol, which comes from whale oil, for reducing evaporation losses from small ponds. In parts of Australia annual evaporation amounts to 10 feet. Mansfield found that on ponds up to two acres in area a coating of hexadecanol could reduce evaporation by at least 25%, and as much as 45%.

For more than 40 years physical chemists in the United States have been carrying on experiments with monomolecular layers. Their studies provide basic data for present evaporation suppression projects.

The drought in Texas caused the Southwest Research Institute to start a program early in 1956 to investigate means of retarding water evaporation. The United States Bureau of Reclamation and the United



FIG. 1.—Evaporimeters at Urbana, Illinois, evaporation station.

States Geological Survey have both made fundamental studies on energy balance and film spreading techniques and several laboratory studies of evaporation savings. A team of North Texas State College students in collaboration with six government agencies has conducted studies on physical and biological effects of hexadecanol in a five-acre lake near Oklahoma City. The Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, has made studies on the toxicity and biological oxidation of monomolecular films used in reservoir evaporation control.

The Illinois program.—The work of the Illinois State Water Survey in this field has been concentrated on the measurement of differences in evaporation rates from pairs of identical water containers where one surface is unprotected and the second surface has a coating of hexadecanol. These studies have also been applied to a 100,000-gallon capacity tank.

The Survey operates three evaporation stations in northern, central, and southern Illinois. These are Class A pan installations and Ste-

vens-Roberts evaporimeters (Roberts, 1954) which record water losses graphically from a three-square foot surface. In February, 1956, two identical evaporimeters (Fig. 1) were installed at the Survey's Urbana evaporation station. One milligram of hexadecanol was applied to one surface; the second had water without any protective coating. The water containers were approximately two feet in diameter and one-inch deep, with built-in overflows to waste excess precipitation. During the spring and early summer months the effect of the monolayer cover was negligible, but there were individual days during July and August when the pan with the hexadecanol cover had water loss of nearly 30% less than the pan without the chemical cover. Figure 2 shows the cumulative evaporation from both pans for a three-month period. The average reduction in evaporation was 10% for the period.

In June, 1956, two 55-gallon drums, with one end of each removed, were buried adjacent to each other at the evaporation station. The open ends of the drums extended two inches above the ground surface. Angle-iron supports for hook gauges were constructed across the open ends, and the pans were filled with water to the ground level. Thermocouples were inserted just below the water surfaces to give continuous measurements of water temperatures in each of the containers. One was filled with plain water and the second was given an application of one mg. of hexadecanol. Once-daily readings with hook gauges were made on both pans. Water losses from the two drums for the period

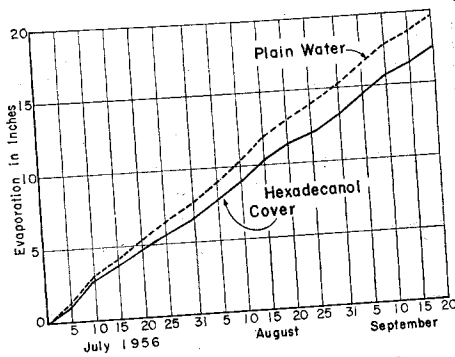


FIG. 2.—Cumulative evaporation from evaporimeter pans at Urbana, Illinois.

July 1 to September 20, 1956, differed by 27% as shown in Figure 4.

Although hexadecanol films are reported (Chem. Week, 1956) to allow free transfer of oxygen and carbon dioxide from the air through the film to the water, there was some evidence that the film had a retarding effect. Rust collected along the inside of the drum, filled with plain water, to a depth of six inches from the surface while less than one-inch of rusting was noted in the drum that had the monolayer covering.

In August, 1956, the University of Illinois made available for this project a 100,000-gallon capacity aerator tank located on the campus at Urbana. During August, September, and October, tests were made for water losses from this basin, using alternately plain-water surfaces and surfaces with monolayers. The water was changed before each treatment began.

Figure 5 shows the cumulative evaporation from the aerator tank and from a nearby Class A pan. During the period of record, August 15 to October 28, 1956, the Class A pan evaporation was 10.70 inches

while the aerator tank evaporation measured 8.22 inches or 23% less. Some of this difference might be accounted for by the sizes of the containers.

During the periods marked A, B and C the aerator water surface was treated with hexadecanol. For the week of August 30 to September 7, evaporation from the aerator tank was 56% less than that from the Class A pan. Subtracting from this amount the over-all average difference of 23% leaves 33% credited to the evaporation suppression effect of hexadecanol. Similar credits of 24% and 11% are shown for the periods, September 14 to 23 and October 11 to 18. It can be seen that the evaporation suppression effect of the chemical becomes less as summer ends and fall weather begins. Sampling of the interim periods indicates close agreement between pan and aerator tank evaporation rates.

Close examination of the lower curve shows that efficiency of the chemical was highest during the first two or three days of application and dropped considerably during the latter part of each period. This would indicate that the method

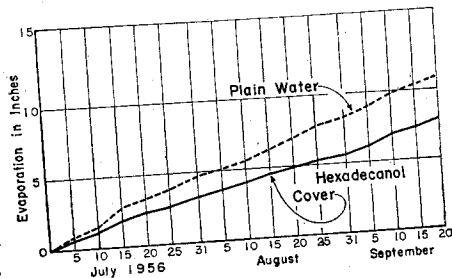


FIG. 3.—Cumulative evaporation from three-foot deep buried pans at Urbana, Illinois.

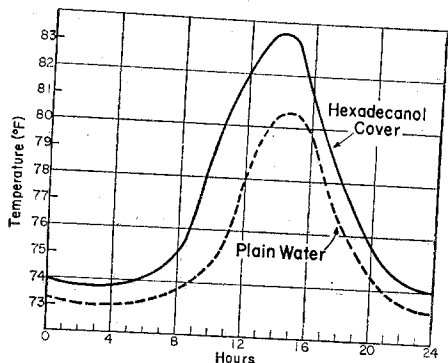


FIG. 4.—Surface water temperature curves for three-foot deep buried pans, one day after application of hexadecanol.

of applying the chemical needs to be greatly improved.

Figure 6 shows one section of the aerator tank including the hook gauge, temperature recorder, and the water level recorder.

Cost of retarding water evaporation.—The small quantity of chemical used so far in the Illinois research program has cost \$2.10 per 500 gms., roughly \$2.00 per lb. The Australians reported their cost for hexadecanol as 7s. per lb. or, at the present rate of exchange, 75 cents. The evaporation retardant material used in the Texas studies was reported to cost 40 cents per lb.

Dressler (unpubl. address, 1956) pointed out that the film-forming material accounts for two-thirds the cost of evaporation control treatment, with the remaining one-third charged to effort in getting the chemical on the water. The results of several research projects throughout the world indicate that the water saved is worth 20 or more times the cost of treatment, with indications that greatest savings could be effected if the treatment could be applied on larger water bodies.

Applying the film.—A total of four hexadecanol containers was used on the Illinois Water Survey's aerator tank. The containers had wooden bases 10" long and wooden ends 4" by 4". The sides and tops were made of fine copper screen wire. The wire-mesh, floating container, one anchored in each acre of water area, has been the popular means in Australia, Africa, and the United States for getting the film on the water. This method of propagation is probably unsuitable for large-scale control of evaporation from lakes where there is considerable boat traffic.

It is suggested that boats could be one means of applying the monolayer to Illinois lakes and water supply reservoirs. On most large lakes a police boat regularly patrols the waters. A simple attachment on the water pump of the boat engine would channel a stream of water through a vessel containing the chemical and into the lake. The chemical would be spread by the wake of the boat and the area and schedule of seeding could be adjusted to the needs of the individual lakes.

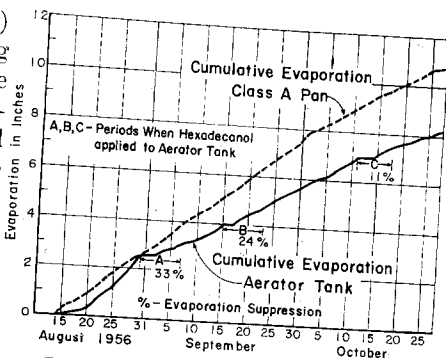


FIG. 5.—Evaporation from Class A pan and 100,000-gallon capacity aerator tank at Urbana, Illinois.

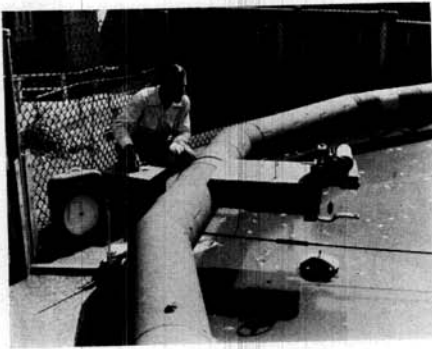


FIG. 6.—Aerator tank used to test monolayers at Urbana.

The program cost would be little more than the cost of chemicals. The labor expense would be absorbed in the cost of operating the patrol boat. A few floating containers may be necessary on the windward sections of the lakes to insure maximum effect of the monolayer. As the value of monolayer coverings becomes better known in the field of water resources management, the problems of developing practical and economical methods of producing the coverings will probably be quickly developed.

Toxicity and attrition of films.—According to Berger (pers. comm., 1957) film destruction by organisms in well-seeded natural water may be an important factor. Ludzack and Ettinger (1957) have found that emulsions of hexadecanol and pellets of the material suspended in baskets undergo biological destruction in laboratory test studies. They reported that, on two different runs at 20° C., suspensions of hexadecanol in very gently aerated carboys showed a weight loss averaging 3.5 and 4.3 lbs. per acre per week.

The statement (B. B. Berger, pers. comm., 1957) on toxicity of commercial preparations containing hexadecanol as prepared by the Robert A. Taft Sanitary Engineering Center has been accepted as a basis for Illinois tests, in the absence of direct evidence against hexadecanol as a hazard to health.

CONCLUSIONS

Although the Illinois State Water Survey evaporation suppression study has been in operation only a year, our experiences in this study confirm much that has been found experimentally elsewhere, although our findings appear to be generally more conservative. Most of the studies have been carried on in areas of the world where normal evaporation amounts are two or three times greater than those in Illinois. Under Illinois conditions the rate of natural water loss by evaporation may be reduced by a maximum of 33% during the warmest part of the summer and by about 11% during the cooler frost-free periods by application of hexadecanol. Many Illinois water supply reservoirs store nearly 50% of their capacity in the top 3 feet. Normal evaporation exceeds three feet per year in reservoirs in the southern half of the state where surface waters provide most municipal supplies. If evaporation could be reduced by one-third it would be equivalent to a 17% increase in Illinois reservoir storage capacity. During the summer of 1957, the program will be expanded to include studies on suppressing evaporation from larger water bodies and of problems encountered so far in our work in Illinois.

ACKNOWLEDGMENTS

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