TEXAS WATER DEVELOPMENT BOARD

REPORT 9

USE OF SEWAGE EFFLUENT FOR PRODUCTION OF AGRICULTURAL CROPS

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FOREWORD

This report was prepared under provisions of the General Research Agreement between Texas Technological College and the Texas Water Development Board. It is one of five reports by various members of the Texas Technological College staff arranged for as a direct contribution to the development of a State Water Plan. The Texas Water Development Board gratefully acknowledges the cooperation extended and the staff time and expense incurred by Texas Technological College in developing this information. The Board also thanks the authors for providing valuable and useful data important to water planning.

Texas Water Development Board

Joe G. Moore, Jr.

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TABLE OF CONTENTS

TABLES

APPENDICES

USE OF SEWAGE EFFLUENT FOR PRODUCTION OF AGRICULTURAL CROPS*

INTRODUCTION

The use of sewage effluent for the production of agricultural crops is an accepted practice in many areas of the United States. This paper summarizes the results of a survey conducted in Texas in 1965 on agricultural use of effluent. Discussions of the suitability of sewage effluent for crop production and cost considerations are included. This study was part of an overall assignment of the Texas Water Development Board to prepare a statewide water plan for Texas.

Water, like weather, is a subject many people are talking about. Many Texans believe something can be done about water problems.

According to President Johnson (13), "by the year 2000 more than 300 million Americans will require about 888 billion gallons of water per day. This is three times the present consumption." Finding adequate sources of good quality water to meet the growing needs will be one of the great challenges confronting scientists.

The water problems of Texas are more complex and acute than in many of the other states. Texas has undergone a transition from being primarily a producer of raw materials to a major manufacturing and industrial State. This change has been accompanied by a rapid increase in population. These growth patterns cannot be sustained without adequate sources of water.

The reclaiming of municipal waste water for re-use affords one of the great opportunities for water conservation. It has been estimated that only 5 percent of the total water used nationally by municipalities is consumed and thus not available for re-use (10). The re-use of water could have a significant effect on increasing the life of the water sources of a community as well as contribute to the economy of the area.

SURVEY OF AGRICULTURAL USE OF EFFLUENT

An attempt was made by the authors of this report to make a statewide survey of the use of sewage effluent for agricultural and recreational purposes.

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The questionnaire method was used because the survey had to be conducted on limited funds. A two-page questionnaire (Appendix A) was mailed to the city engineer of cities having a population of more than 1,000 according to the 1964-65 Texas Almanac (17). A shorter, one-page questionnaire (Appendix B) was mailed to the other towns with a population of more than 100. Of 1,200 questionnaires mailed out, 450 replies were received. Our survey was supplemented by IBM pull-sheets supplied by the Texas State Department of Health. Although the percent response was much greater than usually expected from questionnaires, conclusions must be drawn from samples within the population. The report is therefore liable to error but should provide a reasonably good evaluation of the agricultural use of sewage effluent. The investigators also made personal visits to sites at San Saba, Llano, Burnet, San Marcos, San Antonio, Fredericksburg, and Junction. According to the questionnaires returned, all of these were using effluent for agricultural purposes.

From the sources of information available, 135 towns and cities in Texas utilize sewage effluent for irrigating some type of agricultural crop. Eight other towns use effluent for watering parks, golf courses, or cemeteries. The number using effluent for recreational purposes is so small that this aspect was not further pursued and evaluated. It is recognized that use for recreational purposes may expand rapidly in the future.

Ten municipalities not at present using effluent indicated they are planning to do so in the near future. About 15 towns are planning to expand usage.

San Antonio is the largest city in the State that directs a significant portion of its effluent to agricultural use. During the summer its daily output is about 90 to 95 million gallons, of which 20 to 30 percent is used for growing crops. This portion is diverted to a canal which meanders several miles across the landscape. What is not removed from the canal is deposited in Lake Mitchell. The lake also has outlets by which farmers or ranchers may irrigate land. Quantities diverted to agricultural use are increased or decreased at the city plant according to requests from the farmers.

The bulk of this resource at San Antonio is applied to Johnson grass pastures and meadows. Much of it is applied to Coastal Bermuda grass and there is a small patch of St. Augustine grass. More than 4,000 acres of these crops is irrigated with effluent.

Amarillo, Abilene, and Lubbock are the other major cities that are making agricultural use of effluent.

One of the smallest towns making use of this resource is Quitaque. It has a population of about 600 and produces an average of 47,000 gallons of effluent per day.

SUITABILITY OF EFFLUENT FOR AGRICULTURAL USE

It is reported (7) that domestic sewage effluent is ordinarily more than 99.9 percent water. A considerable part of the remaining 0.1 percent is the same mineral content that was originally present in the water. The increase in solid content because of use actually is only a few hundred parts per million (ppm). Therefore, it should be considered an excellent substitute for or supplement to irrigation water. If the municipal water supply is suitable for

irrigation, its sewage effluent would also be suitable unless industrial or chemical wastes are dumped into sewage lines.

Normal rainfall is not sufficient for maximum crop production over much of Texas. Sewage processing plants can produce a clear effluent known to be usable and safe for irrigation purposes. Sewage irrigation can make use of water that is usually wasted, can contribute to the economy of the area, and reduce pollution in waterways. In many instances the sludge is sold for fertilizer.

Examples of Its Use

The utilization of sewage effluent for agricultural purposes dates back to Biblical times (12). One hundred years ago experiments were conducted in Paris, Berlin, and other European cities to determine the value of sewage effluent for agricultural production.

Sewage plant effluents have been approved in Texas for the irrigation of field crops grown for animal feed (9). Day and Tucker (3), in Arizona, obtained winter pasture yields equivalent to 12 tons of green forage per acre from small grains irrigated with sewage effluent with no additional fertilizer. Day and co-workers (4) produced higher yields of barley, wheat, and oats with effluent than from the use of well water plus 200 pounds of nitrogen, 150 pounds of phosphorus, and 100 pounds of potassium. Bushel test weight and total protein of grain produced with effluent was comparable to the fertilized grain. The use of sewage sludge to grow agricultural crops has been reported by a number of workers (1, 2, 6, 14, 15, 16). Sewage irrigation was started in Lubbock in the early 1930's and is still being practiced on the same land. Its use on the Agronomy Farm of Texas Technological College was initiated in 1965.

Sewage effluent that has had the standard activated sludge treatment can be handled like regular irrigation water. It may be applied by flood-irrigation, furrow-irrigation, or by a sprinkler system according to the topography of the land.

Nutrient Properties of Effluent

California workers (16) analyzed effluents from 15 cities and found that an acre-foot contained 60 to 100 pounds of nitrogen, 60 to 100 pounds of phosphorus, and 20 to 40 pounds of potassium. Effluent used in studies at Tucson (4) contained approximately 65 pounds of nitrogen, 22 pounds phosphorus, and 26.5 pounds of potassium per acre-foot. According to Dye (5) many minor elements including sulfur, magnesium, calcium, iron, manganese, boron, zinc, and copper are present to some degree in sewage effluents. The fertilizer value of sewage has been estimated by some (11) to be somewhat greater than its water value. This viewpoint was not shared by men who used the effluent on Coastal Bermuda grass at Llano and Fredericksburg, Texas. At Llano, sewage effluent was considered to have very little more fertilizer value than well water. There was a marked difference in greenness between fertilized (90 pounds of nitrogen) and unfertilized plots at Fredericksburg where the effluent was used.

Salt Accumulation

In Israel (11) soil irrigated with sewage effluent showed an accumulation of salts, especially chlorides, which were concentrated to a large extent in the upper layers of the soil. These salts were leached out during the rainy season and the soil returned to its pre-irrigated state. A question was asked on the questionnaire as to whether long-term use of effluent appeared to increase or decrease yields. All replies were that yields had been increased, even where used up to 40 to 45 years. Essentially, all studies have shown sewage effluent to be a suitable and valuable resource for the production of agricultural crops. Frank Gray of Lubbock, one of the senior users, has said (8), "We want to stress that we should all promote and encourage the use of our reclaimed water."

Most sewage treatment plants depend upon plant life in the form of bacteria and fungi to digest the solids in raw sewage. Materials that would not be lethal or destructive to these lower forms of plant life could hardly be expected to be toxic or lethal to the higher forms such as domestic crops.

ESTIMATED QUANTITY PRODUCED

Of the 135 municipalities reporting the use of effluent for irrigation, 92 (those on the IBM sheets) produced an average of 57,462,000 gallons per day. This does not include Amarillo and San Antonio, of which San Antonio alone produces about 90 million gallons per day.

Ten cities selected at random and shown in Table 1 had an average population of 28,200 and produced an average of 2,861,700 gallons of effluent per day. At this rate, a city of about 4,800 would produce an acre-foot of effluent per day.

Table 1.--Population and effluent of 10 cities and towns selected at random

City	Population	Effluent (gallons/day)
Dalhart	5,000	600,000
Seminole	6,300	448,200
Lamesa	10,600	952,000
Abilene	90,400	6,000,000
Dumas	8,500	900,000
Brownfield	9,400	661,500
Falfurrias	6,500	350,000
Lubbock	128,700	11,000,000
Snyder	13,900	1,200,000
Kerrville	8,900	750,000
Total	288,200	22,861,700
Average	28,200	2,861,700

With an estimated Texas population of 10,650,000 (17) in 1965, about 10,756,500 gallons of effluent is produced per day. The same reference

estimates a 75:25 urban to rural ratio. Annual effluent in urban areas, where central sewage systems would be expected, would approximate 1,317,375 acre-feet per year. "Rural" as used above means all areas with a population less than 2,500. Many towns included in that category have central sewage systems and are using effluent.

VALUE OF SEWAGE EFFLUENT FOR AGRICULTURAL USE

The economic contribution that could be made to the State through efficient use of 1,317,375 acre-feet of effluent would be difficult to estimate. An estimate that has had wide distribution in the literature and often quoted by speakers is that agriculture returns $44 to $51 per acre-foot of water used. The value would vary greatly with crops and the influence that increased acreages of some crops might have on prices. The estimated value of an acre-foot of water varies from a net of $16.50 for an average of several crops to $78.50 for cotton. In any case the value is sufficiently high to justify expenditures necessary to properly distribute it over productive soils.

In Israel (16) sewage effluent is considered of sufficient value to justify transporting it 60 miles from the point of origin.

A ranch operator using San Antonio sewage effluent states that his ranch will support two cows per acre compared with one cow per 30 acres on local non-irrigated land.

CROPS AND ACREAGE

Data available on crops being irrigated and the specific acreage of each is scant. Many respondents indicated that a certain crop was being irrigated but failed to estimate its acreage. Information available is summarized in Table 2.

Table 2.--Major crops irrigated with sewage effluent

Crop	Acreage
Wheat	1,610
Cotton	1,580
Grain Sorghum	1,609
Alfalfa	365
Rye	20
Corn	60
Oats	100
Pasture grasses	5,801
Not specified	1,011
Total	12,157

Included in "Pasture grasses" in the table are Johnson grass, Coastal Bermuda grass, and native or related species. This type of vegetation is normally adjacent to sewage disposal plants and represents minimum cost to the user in

seedbed preparation, seeding, tillage, harvesting, etc. Also this cover is present the year-round and provides erosion control superior to most row crops. Johnson grass is a low-value crop and would generally represent less than maximum or optimum utilization of the resource.

Irrigation with water or effluent may be questionable in areas with annual rainfall in excess of about 25 inches. This amount of rainfall if evenly distributed throughout the growing season would nullify many benefits of supplemental irrigation. There are very few areas in Texas that receive rainfall in this manner, and moisture deficiencies are commonplace throughout most of the State.

COST TO USERS

Information about the cost of effluent to the user is scant. The most common arrangement appears to be one in which the effluent is donated to the user if he will defray costs involved in removing it from the disposal plant or some area of deposit. In other cases the user pays a stipulated sum for the use of the effluent. Others are charged on a quantity basis such as so much per 1,000 gallons. Figures made available are summarized in Table 3.

Table 3.--Cost of effluent to user

City	Charge
Amarillo	$ 0.01 per 1,000 gal.
New Braunfels	300.00 per year
Hale Center	.25 per 1,000 gal.
Edinburg	.50 per acre irrigated
Coahoma	150.00 per year
Snyder	.05 per 1,000 gal.
Muleshoe	500.00 per year
Midland	.03 per 1,000 gal.
Burnet	.10 per 1,000 gal.

As water resources become more acute it is probable that higher charges will be demanded of users. Engineers at San Antonio calculate the cost of producing a million gallons of effluent at $35--including chlorination. A million gallons equals 3.07 acre-feet.

It was surprising to the authors of this report to find a general lack of understanding or appreciation for the value of effluent. Its use was discontinued at San Marcos and Burnet after having been used 15 years or more. The vocational agriculture teacher and his FFA members recently took over the Burnet project. The Lorenzo FFA also utilizes the effluent of that town. This appears to be a very fine arrangement for the smaller communities.

ODORS

Properly treated sewage effluent does not possess objectionable odors or other undesirable characteristics. The authors visited several fields where effluent was being used and noted the absence of offensive odors. No odors were

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APPENDIX A

QUESTIONNAIRE MAILED TO CITIES WITH POPULATION MORE THAN 1,000

APPENDIX A: QUESTIONNAIRE MAILED TO CITIES WITH POPULATION MORE THAN 1,000

SEWAGE EFFLUENT SURVEY

1. If you are not now using sewage effluent, is serious consideration being given to such use? _____
   If so, about when will such usage begin? _____

If you are using sewage effluent to produce crops, water city parks, golf courses, cemeteries, or other uses, please complete the questionnaire.

2. Name of city _____ 3. Population _____

4. What treatment is given the raw sewage in converting it to effluent?

_____

_____

_____

5. B. O. D. of effluent _____

6. Soluble salts (in parts per million) of effluent _____

7. Sodium to calcium ratio of salts in effluent _____

8. Other information available on chemical composition of the effluent

_____

9. Volume of effluent produced (1964) _____

10. Has the use of effluent helped solve some community problems, such as odor, aesthetic, health, others? _____

_____

_____

11. Approximate cost of effluent to the user (per 1,000 gals) _____

_____

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12. Is consideration being given to increased use of effluent? _____

_____

13. By what method is the effluent used?
    (a) Flood or furrow irrigation _____
    (b) Sprinkler irrigation _____
    (c) Ground-water recharge _____
    (d) Pumped from lake (lagoon) _____

14. What would you suggest as satisfactory levels of the following characteristics:
    (a) B. O. D. _____
    (b) Soluble salts _____
    (c) Others (specify) _____

If effluent is being used to produce crops, please answer the following:

15. How long has effluent been used on agricultural land? _____

16. Have crop yields increased or decreased from the use of effluent?

_____

17. Acres on which effluent is used:

Cotton	_____	Grain sorghum	_____
Alfalfa	_____	Corn	_____
Vegetables	_____	Sugar beets	_____
Others (specify)	_____		

If effluent is being used to water city parks, golf courses, cemeteries, or other purposes, please answer the following:

18. (a) Purpose for which used _____
    _____
    (b) Value of effluent (water or fertilizer saved, etc.) _____
    _____
    (c) Acres involved _____
    (d) Have specific problems of use arisen? Describe briefly _____
    _____
    _____

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APPENDIX B

QUESTIONNAIRE MAILED TO TOWNS WITH POPULATION MORE THAN 100

APPENDIX B: QUESTIONNAIRE MAILED TO TOWNS WITH POPULATION MORE THAN 100

SEWAGE EFFLUENT SURVEY

City _____ Population _____

Do you have a central sewage system? _____

If so, is sewage effluent being used to produce crops, for watering city parks, golf courses or other purposes? (Please indicate which)

_____

_____

_____

_____

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