

manure used as a seed covering gives varying results, depending on the amount and frequency of irrigation. Repetitive irrigations resulted in better emergence but did not lower the mean emergence period or increase the seedling size. The beneficial effect on emergence was probably the result of removing soluble materials from the manure, improving moisture relations around the emerging seedling, or both. Additional irrigations appeared to improve the effectiveness of stabilized vermiculite and to overcome some of the crusting effects where soil coverings were made. The emergence of seedlings covered with soil, however, remained very low regardless of irrigation frequency.

In the second 1974 test, leached steer manure was included as a covering treatment (see table 3). Leached manure equaled stabilized vermiculite in all of the evaluation factors except seedling weight. Seedling weight was less than that found in the stabilized vermiculite treatment.

Table 4 gives results of an experiment conducted in 1975. Leached manure increased the percentage of emergence, but did not shorten the emergence period. Stabilizing manure with petroleum mulch was of no observed benefit.

Summary

Leached steer manure, evaluated as a seed covering to prevent seedling losses due to soil crusting, was found to enhance lettuce seedling emergence under soil crusting conditions. This was not generally the case when manure was used without previous leaching to remove soluble materials. Manure was not as effective as stabilized vermiculite in the 1973 test, but it was comparable or better in the 1974 and 1975 tests. The 1975 test was conducted in August, whereas the 1973 and 1974 tests were conducted in the late spring. Stabilized vermiculite has sometimes been observed to be less effective under summer conditions, and this may explain its relatively poorer performance in 1975.

Further experiments to field-test leached steer manure, ascertain the amount of leaching necessary, define the irrigation regime necessary for best results, and find a satisfactory mechanical means of applying the material appear to be justified.

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Wastewater regulations in Santa Ana River Basin

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Concern over deteriorating quality of groundwater in Riverside and San Bernardino counties has led to dairy waste disposal regulations in California's largest Grade A milk-producing region, the Santa Ana River Basin (SARB). A study has been conducted to determine the effect of these regulations on the SARB dairy industry and to examine possible alternatives for dairies. The study concludes that milk production may be maintained in the near future if sufficient credit is available to dairymen; otherwise, the dairy industry may eventually leave the SARB unless new waste disposal technology can be implemented.

Dairies in the SARB produce three forms of waste: stormwater runoff from corral areas, washwater from cleaning cows and milking areas, and manure. These dairy wastes contribute tons of salts to SARB groundwater annually. To control dairy pollution, the California Regional Water Quality Control Board, Santa Ana Region, requires dairies to: (1) provide facilities to contain 1.3 times the runoff from a 10-year, 24-hour rainfall (a storm of 24-hour duration which yields a total precipitation of a magnitude that has a probability of recurring only once every 10 years); and (2) discharge no more than 3 tons of manure (1.5 times the annual waste produced by one cow) per acre each year. This rate of discharge results in an annual salt contribution to groundwater of approximately 0.3 ton per acre. The total acreage used for waste disposal in 1973 was approximately 12,000 acres. (This includes only disposal acreage owned by dairies; the extent of dairy waste disposal on nondairy land is not known.) A maximum annual salt contribution by the dairy industry of 3,600 tons per year (0.3 x 12,000) is thus the implicit goal of the regulations.

The typical method of compliance with these requirements consists of: (1) a system of pumps, culverts, and a pond to hold wastewater until it can be spread on disposal land; and (2) disposal of solid waste by hauling it to land that has available absorption capacity. Since

wastewater cannot be hauled away economically, the dairy needs surrounding land for wastewater disposal.

SARB dairymen have traditionally held strong preference for this region because of its proximity to the Los Angeles milk market. Hence, there is a reason to believe that most dairymen will continue dairying in this region as long as it is economically feasible. Using this behavioral rule, the effect of the Water Quality Control Board requirements has been derived by computer simulation of the SARB dairy industry.

Since little is known about the availability of financing for each dairy's waste disposal system, results were obtained for a wide range of credit levels—\$100, \$200, and \$300 per cow. As expected, the results vary, depending on credit availability and also on whether the discharge limit of 3 tons per acre includes the estimated 10 percent of total manure contained in washwater (table 1). If it does not, the pollution goal is apparently not achieved. If it does, then the pollution goal may be achieved but apparently at high cost to the industry. Indeed, expenses may be so great as to cause many dairies to migrate out of the SARB, which would lead to higher transportation expenses for milk shipped to Los Angeles.

An alternative solution is based on the following factors:

1. Total disposal acreage will be different under the requirements. For land prices in a neighborhood of \$6,000 an acre (an approximation of existing land prices in the SARB), disposal acreage may decrease if restrictions include manure contained in washwater but will increase if they do not (fig. 1 and 2).

2. Disposal of waste contained in liquid is very costly if additional land must be purchased.

3. The number of cows per disposal acre varies among dairies. The industry as a whole possesses enough land to dispose of washwater in accordance with either interpretation of the existing regulations.

TABLE 1. INDUSTRY RESULTS UNDER CURRENT REGULATIONS

Regulation	Credit per cow dollars	Cows*	Dairies number	Profit dollars	Waste [†] tons	Cost dollars
Preregulation	—	172,615	418	7,077,215	50,000 [‡]	—
Discharge limit includes manure contained in wastewater**	100 200 300	70,413 110,266 126,206	165 255 287	1,401,675 1,741,204 1,778,343	2,924 3,866 4,243	5,675,540 5,336,111 5,298,972
Discharge limit excludes manure contained in wastewater ^{††}	100 200 300	162,154 172,113 172,113	293 411 411	3,307,113 3,421,078 3,421,078	6,583 6,824 6,824	3,770,202 3,656,237 3,656,237

Sources:

For preregulation (waste) figure, see Albert A. Webb Associates, *Dairy Waste Management Plan*, Riverside, California, October 15, 1973, p. 139.

Computed using herd size data from California Regional Water Quality Control Board, Santa Ana Region, *1973 Dairy Report*, Riverside, 1973.

* Counting heifers as one-half cow and calves as one-fifth cow.

† Tons of salts contributed to groundwater.

‡ Estimated.

** Equivalent to restricting solid waste disposal to 1.5 cows per acre and washwater disposal to 15 cows per acre.

†† Equivalent to restricting solid waste disposal to 1.5 cows per acre and washwater disposal to 40 cows per acre.

Problems arise because of the distribution of the disposal acreage. Some dairies possess more than enough disposal land to meet the requirements; others, often with large herds, possess little or none.

There is a trade-off between cost to the industry and water quality. Tougher disposal requirements mean cleaner water but also greater expense. Clearly, it is desirable to obtain cleaner water in the least expensive way. In view of this goal and the previously listed factors, the disposal requirements might be formulated with separate restrictions for disposal of washwater and manure.

Cost-waste trade-off curves are derived in figure 3 for three credit levels by considering separate restrictions. The curves indicate the minimum cost possible for each waste level and vice versa. Any given water quality goal can apparently be achieved at lower cost through proper implementation of separate restrictions.

Table 2 shows the proper restrictions and the resulting effect on the industry for the ceiling of 3,600 tons of salt pollution per year. The cost of compliance is still great but improved from the single restriction case. A review of both tables 1 and 2 also shows that aggregate herd size varies directly with credit

TABLE 2. INDUSTRY RESULTS WITH SEPARATE DISPOSAL RESTRICTIONS

Credit per cow dollars	Disposal limit		Cows*	Dairies number	Profit dollars	Waste [†] tons	Cost dollars
	Solid waste cows per acre	Wash-water					
100	1	20	107,030	250	2,084,473	3,600	4,992,841
200	1	16	115,965	270	1,806,291	3,600	5,271,024
300	1	15	118,636	266	1,628,158	3,600	5,449,156

Source: Computed using herd size data from California Regional Water Quality Control Board, Santa Ana Region, *1973 Dairy Report*, Riverside, 1973.

* Counting heifers as one-half cow and calves as one-fifth cow.

† Tons of salts contributed to groundwater.

availability, but that this is not the case with industry profit.

In the preceding analyses, the method of waste disposal was limited to the hauling and pond procedures discussed earlier. However, other technologies are currently available. The most promising new waste disposal technology is the CERECO manure recycling process discovered by Auburn and Colorado State universities and developed by the Ceres Ecology Corporation of Sterling, Colorado. This process produces (1) a fermented roughage feed, (2) a high protein concentrate, and (3) a substance that may

be used as a potting mix from cow manure. It is possible that the revenue from the sale of the feed products would more than compensate for the expenses associated with the construction of a recycling plant in the SARB. This new process may offer a much better solution to the solid-waste management problems of the SARB dairy industry, because manure hauling expenses can be eliminated or greatly reduced for dairy farmers.

In summary, the conclusions of the study are as follows.

First, any level of water quality can

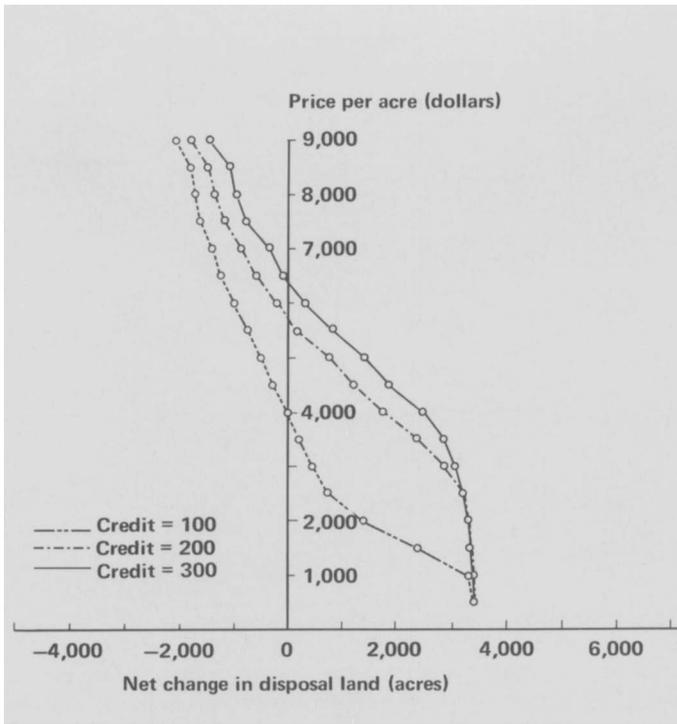


Fig. 1. Net change in disposal land, if discharge limit includes manure contained in washwater.

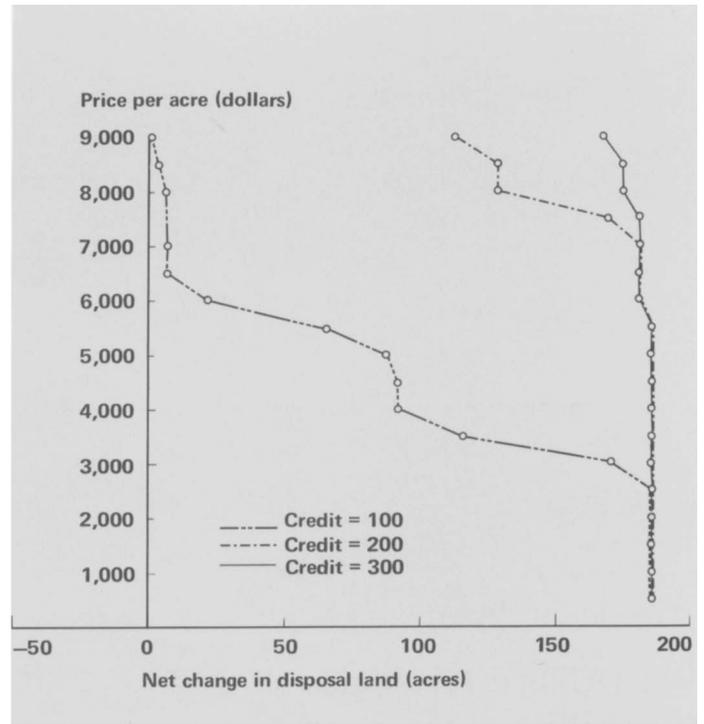


Fig. 2. Net change in disposal land, if discharge limit excludes manure contained in washwater.

be achieved at lower cost by using separate restrictions for the disposal of solid waste and waste contained in liquid. In particular, more strict regulation of solid waste relative to the disposal of washwater is suggested.

Second, production, as reflected by aggregate herd size, can be maintained in the short run if sufficient credit is available. However, this may not be the case in the long run, since profit and possibly future investment fall regardless of credit availability.

And finally, a better solution to the problem may be found in implementation of manure recycling processes.

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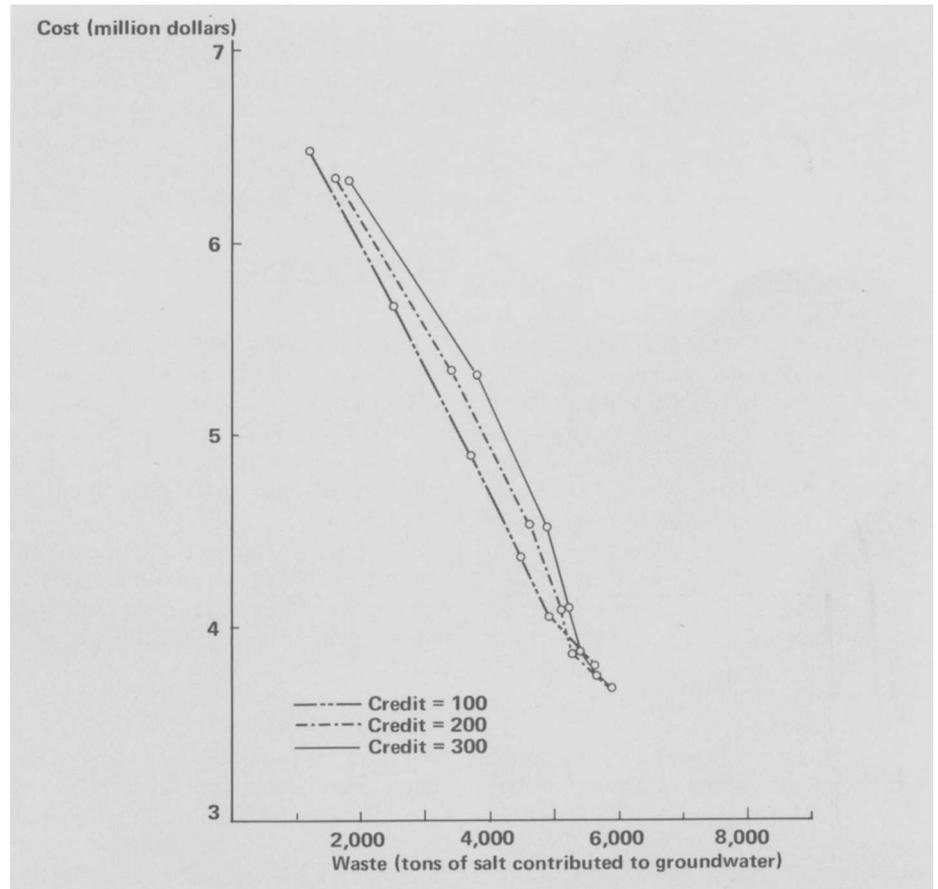


Fig. 3. Cost-waste trade-off curves with separate disposal restrictions.