# DAIRY WASTE TREATMENT BY HIGH-RATE TRICKLING FILTRATION, WITH PARTICULAR REFERENCE TO NITROGEN.

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by

RODNEY JACK BENNETT

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## ABSTRACT

The effective disposal of dairy factory waste is becoming increasingly important in New Zealand. Treatment by high-rate trickling filtration is a successful method in use overseas. For New Zealand conditions, a 'roughing' treatment removing 60 - 90% of the BOD of the waste should be adequate. One objective of this research was the development of a filter capable of providing this treatment. Another objective was the resolution of the controversies between the theoretical and empirical performance-prediction relationships available for trickling filtration. Because nitrogen is receiving a greater emphasis as a pollutant, a third objective was the study of nitrogen removal in dairy waste trickling filtration.

The experimental work primarily involved the use of a pilot-scale trickling filter. This was designed using conventional parameters. The filter column was an 18" diameter, 8' long concrete pipe, filled with river stone. An artificial waste compounded from whey and water was fed to the plant at a controlled rate, being diluted with flow from a 25 gallon recirculation tank prior to application to the column. The treated waste overflowed from the recirculation tank and was discharged. The plant was operated at the high organic loading intensities of 1.3 - 2.7 lb BOD/yd$^3$day, and at the high recirculation ratios of 20 - 55 : 1. The levels of BOD and organic, ammoniacal, nitrite and nitrate nitrogen were measured in the feed and settled effluent at different recirculation ratios. Aqueous suspensions of biomass collected from the plant were incubated under aerobic

and anaerobic conditions, in the presence of a variety of carbonaceous and nitrogenous additives. The nitrogen balance of these suspensions was studied.

The plant fulfilled its design function of providing a 'roughing' treatment, as it removed 60 - 85% of the feed BOD. The experimental data did not support the available performance-prediction relationships, and hence the controversies between these relationships were not resolved. The pilot plant performance could be described by the equation

$$Y = 17.778 + 3.079X - 0.0342\ X^2$$

where Y = % removal of applied BOD

X = recirculation ratio

This equation, specific to the pilot plant, predicts an optimum recirculation ratio of 45 : 1, which is considerably higher than the 10 : 1 ratio commonly used. Successful operation of the plant was achieved at BOD : nitrogen ratios in the feed of 21 - 27 : 1, which are higher than the 20 : 1 maximum generally recommended. Despite this high ratio, typically 30% of the feed organic nitrogen was present in the effluent. There was no evidence of nitrification. The nitrogen balance experiments provided evidence of net nitrogen loss from the suspensions, under aerobic conditions. Denitrification under anaerobic conditions followed normal routes.

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# INTRODUCTION.

The produce of New Zealand's dairy factories earns approximately twenty percent of its overseas exchange (N.Z. Dept. of Stats. 1969); the same factories produce at least ten percent of its biological industrial waste (Bennett 1969). The effective disposal of this waste is becoming increasingly important for a number of reasons. Firstly, dairy production is increasing and also, in general, is the waste production from both farm and factory. Because much of this material is water-carried, the greater waste production is increasing the loading of pollutants on waterways in dairying areas. Secondly, amalgamation of small factories into larger units is also causing higher pollution levels in streams which were possibly able to cope with the discharge from the smaller units. Thirdly, there is the recent upsurge in public interest in the pollution and conservation of the environment. This should tend to make public authorities more stringent in their enforcement of pollution regulations, and effective waste treatment, or disposal, more necessary.

Dairy factory waste can be disposed of or treated by a large number of methods, as outlined in Table 1. Disposal may be by dilution with large volumes of water, such as in rivers, lakes and the sea. Another method is spray irrigation, onto pastures or forest and scrub. Treatment may be by any of the methods used for domestic waste, and includes chemical precipitation, incorporation into domestic sewage for municipal treatment, aerobic processes such as the various forms of trickling filtration, activated sludge and oxidation pond, and

Table 1.

Dairy Waste Disposal and Treatment.

| Disposal Methods | Comments |
|---|---|
| Dilution into a large volume of water e.g. sea, lake, river. | Permissible only where effect on water is slight. |
| Spray irrigation on pastures, forest and scrub. | Can be beneficial if properly controlled according to conditions e.g. soil, weather. |
| **Treatment Methods** | |
| Chemical Precipitation | Can be successful, but high cost. |
| Incorporation into municipal treatment | Worthwhile if charges are reasonable. |
| Activated sludge process | Quite successful, requires little space. Sensitive to load variation. |
| Trickling filtration | Generally the most successful treatment method |
| Oxidation Pond | Large area required. Not common. |
| Anaerobic Treatment | Good for excess sludge from trickling filtration and activated sludge. Large volume and close control of raw waste required. |

anaerobic digestion. Trickling filtration is the most commonly favoured method of treatment, its virtues including greater stability under varying load than its closest rival, the activated sludge process.

The treatment of dairy waste by trickling filtration was chosen as the basis of this study. The investigation considered three main topics:

(a) The treatment of a compounded dairy waste by means of trickling filters operating at hydraulic and organic loadings greater than used in normal practice.

(b) A study of the many theoretical and empirical relationships for filter design and performance and the applicability of experimental data to these predictions.

(c) A study of nitrogen relationships in this type of trickling filtration.

Other topics briefly considered were oxygen transfer rates in the experimental units, the bacterial composition of the growth on the units, and the digestion of excess growth by anaerobic means. The literature relevant to each major section of the study is considered at the beginning of its respective chapter, although inevitably there is some overlap.