Microbiological and Chemical Survey of Beef Cattle Waste from a Nonsurfaced Feedlot

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Basic knowledge of the properties of beef cattle feedlot waste is essential if methodology is to be developed for the management or disposal of the manure. The 40,000 head of cattle in a typical feedlot produce 140 to 200 tons of waste per day on a dry weight basis. This accumulates as millions of tons of manure with the accompanying and as yet unsolved disposal and sanitation problems. The typical nonsurfaced feedlot uses the open pile method of disposal for solid wastes and lagoons for the liquid wastes.

Substantial information exists on the effects of the animal physiology, the feed ration and the environment on the chemical and physical characteristics of bovine wastes (TAIGANIDES and HOZEN 1966); but little information can be found on the biological properties. The wastes contain all of the ingredients of the feed, in their original or an altered form, providing ample nutrients for many different types of flora and fauna. Both the biological and chemical properties of these wastes are influenced greatly by feedlot practices such as the inclusion of antibiotics in the feed (ELMUND et al. 1971), and the frequency of waste removal. The bacteriological aspects of the lagooning of liquid manure have been considered (McCOY 1967), but only recently have the bacteriological aspects of surfaced feedlot waste been considered (RHODES and HRUBANT 1972). The nonsurfaced feedlot has received little attention.

This article describes a study of the average microbiological properties and selected chemical and physical properties of waste from a large nonsurfaced beef cattle feedlot in a semi-arid climate. The purpose was to define some of the major properties of the stockpiled manure prior to its potential use as a substrate for the production of single-cell protein.

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Materials and Methods

1. Collection of samples. Samples of manure were collected from a large feedlot (40,000 head) in which the same waste stack had been used for four years. A concentrated diet of grain sorghum, mostly milo processed by steam flaking with 15% roughage, was fed to the animals in the feedlot. The cattle were held in unsurfaced pens for approximately 150 days after which the manure was scraped from the pens and transferred to a large stack approximately 6.1 m deep covering two hectare. In order not to interfere with the operation of the feedlot and because of the great depth of this waste stack, duplicate samples of at least 250 g were collected at each depth by aseptic techniques. These samples were collected several meters apart at the face of the stack where it had been freshly opened by front end loaders. A shovel was used to cut into the face of the stockpiled waste to a depth of several cm to obtain a well mixed representative sample. Samples were taken approximately 0.3 m below the top, at the center and 0.6 m from the bottom of the stack. At each sampling period, freshly voided samples were collected from five animals selected at random. All samples were refrigerated from the time of collection primarily to prevent their possible exposure to much higher atmospheric temperature.

2. Media and culture conditions. Standard pour plate techniques were used with serial dilutions prepared from duplicate 10.0 g samples blended for three minutes in physiological saline. Five plates were prepared in replicate from each of at least three dilutions. Aerobic heterotrophs were assayed at 30 C on Standard Methods Agar (BBL). Coliform bacteria were assayed with Levine's Eosin Methylene Blue Agar (BBL) at 37 C. Anaerobes and facultative anaerobes were cultured in Anaerobic Agar (BBL) at 30 C after evacuation and replacement of the atmosphere with prepurified nitrogen. Fungi were cultivated on rose bengal streptomycin agar at 30 C (JOHNSON 1957). Spore-formers were assayed by heating the dilutions at 85 C for 20 min and plating the suspensions on Standard Methods Agar or Anaerobic Agar as appropriate. Thermophillic bacteria were assayed by incubation at 55 C using Standard Methods Agar.

3. Chemical analysis. Moisture determinations were made gravimetrically on duplicate 50 g samples by drying to constant weight at 105 C. Duplicate 5 g samples of

dried manure were ashed in tarred crucibles at 600 C. The total nitrogen content of each sample was determined in triplicate by the micro Kjeldahl procedure. Lipid content was determined by extraction of dried samples in the Soxhelet apparatus with anhydrous diethyl ether for 4 hr. A.O.A.C. procedures were used for ash, total nitrogen and lipid (HORWITZ et al. 1970). Chemical oxygen demand (C.O.D.) was determined by the procedure of Jeris (1967) on duplicate samples. Samples of 20 g were mixed with 50 ml of glass distilled water and the pH measured with an expanded scale meter. Ammonia nitrogen was determined by steam distillation and titration.

4. Sampling periods. The samples were obtained on the following dates: June 24, 1971; July 1, '71; July 8, '71; July 15, '71; July 29, '71; November 10, '71; March 11, 1972; March 27, '72; and July 6, '72.

Results

The averaged analyses of samples obtained during a one year period are reported in Tables 1 and 2. It would have been interesting to measure temperatures deep in the stockpiled manure. Surface temperatures taken by thrusting a thermometer deep into the manure at the sampling points did not differ significantly from atmospheric temperatures. The highest temperature recorded was 64 C at the mid-depth of the stack following several rains during July 1972. Higher temperatures must have been reached in this stack because it caught fire (presumably by spontaneous combustion) during January of 1972. Much of the stockpiled manure burned completely.

Forty culture isolates of the stockpiled waste were picked from typical colonies on aerobic Standard Methods Agar plates, cloned and identified. The following species were identified in the stacked manure: *Bacillus megaterium, Bacillus pulvifaciens, Bacillus cereus, Bacillus firmus, Bacillus lentus, Bacillus subtilis, Bacillus licheniformis, Staphylococcus* species (both coagulase positive and negative isolates), *Brevibacterium vitarumen, Brevibacterium tegumenticola, Brevibacterium incertum, Brevibacterium brunneum, Neisseria caviae* (2 isolates), *Alcaligenes faecalis, Escherichia coli, Escherichia aurescens, Flavobacterium ferrugineum* (3 isolates), *Flavobacterium harrisonii, Flavobacterium arborescens, Flavobacterium rhenanum, Flavobacterium diffusum, Achromobacter parvulus* and *Achromobacter superficialis.*

TABLE 1

Viable Microorganisms in Feedlot Manure. Number Per Gram Dry Weight.

	Freshly Voided Manure	Top Profile Stockpiled Manure	Middle Profile Stockpiled Manure	Bottom Profile Stockpiled Manure
Aerobic heterotrophs	3.7×10^7	4.4×10^6	1.7×10^8	7.7×10^6
Aerobic spore-formers	3.1×10^7	8.9×10^5	9.5×10^5	9.2×10^5
Coliforms	2.5×10^7	8.6×10^4	5.7×10^5	3.8×10^5
Aerobic thermophiles	6.2×10^7	3.7×10^5	8.9×10^5	4.9×10^5
Anaerobes or facultative anaerobes	2.4×10^8	5.1×10^6	3.4×10^5	9.5×10^4
Anaerobic or facultative spore-formers	2.5×10^6	3.0×10^5	1.8×10^4	5.2×10^4
Fungi	1.3×10^6	67	1.7×10^4	7.5×10^4
Number of Sampling Periods	5	3	5	4

TABLE 2

Chemical Composition of Feedlot Manure

Component	Fresh Manure		Top Profile Stacked Manure		Middle Profile Stacked Manure		Bottom Profile Stacked Manure	
	Average	Range	Average	Range	Average	Range	Average	Range
H_2O %	80.0	78.0-82.7	25.5	10.6-49.0	30.2	7.31-46.8	34.6	23.3-46.1
Ash %*	12.9	8.35-20.2	24.6	17.6-36.8	53.8	38.4-68.6	47.7	38.0-73.6
Lipid %*	6.64	2.05-9.60	5.30	2.62-9.69	4.01	2.67-6.18	5.16	1.69-10.2
Total Nitrogen %*	4.22	3.34-4.92	3.95	2.67-5.68	2.60	0.51-4.78	2.66	0.68-4.38
NH_3 %*	0.58	0.06-1.37	0.58	0.23-1.01	0.40	0.15-0.76	0.52	0.13-1.27
Crude Protein %*	26.3	20.9-39.2	24.7	16.7-35.5	16.3	3.18-29.9	16.6	4.22-27.4
C.O.D. mg/g*	1,344	911-1,747	1,109	865-1,345	901	480-1,258	730.5	415-1,087
pH	6.4	5.3-7.1	6.1	5.1-8.4	7.7	6.4-8.9	6.76	6.0-8.5
Number of Sampling Periods	8		6		9		8	

* dry weight basis

Discussion

Large numbers of bacteria were found in both the stockpiled and fresh manure. The experiments described above were designed to obtain preliminary information on the numbers and physiological types in the stockpiled waste. The data on fresh manure serves only as a reference. This study did not attempt to assay for nutritionally demanding anaerobes or those requiring CO_2 on isolation which would be expected to predominate in the fresh manure. The data does present some general trends which are of unknown significance at this time. As expected, the largest number of organisms found in the fresh manure were facultative or anaerobic species; this was true also in the top layer of the stockpiled manure. The manure in the stockpile was not expected to resemble the fresh manure since it was usually five months old when added to the stack. The high percentage of facultative or anaerobic organisms found in the top layer generally was not found at depths of 3 m and 5.5 m in the stockpile. Instead, at the greater depths aerobic facultative heterotrophs were present in the largest numbers. A high percentage of the total number of organisms found in the study were aerobic or anaerobic spore formers. The number of fungi cultivated from the fresh manure represented almost 10% of the total aerobic heterotrophs. The number of fungi in the stockpile represented a maximum of 1% of the aerobic heterotrophs. Since many farmers resist the use of stockpiled manure, fearing verticillium infection to their crops, this may be significant. Few of the fungal colonies cultivated appeared to be verticillum species. The average number did not exceed 1.3 per gram of manure.

The chemical analysis of this manure indicates that it is too low in nitrogen (2.6 - 3.95%) to make a good fertilizer. The ash content increased significantly from the time the manure was voided until it reached the bottom of the stockpile. This would indicate that if the manure were to be refed to the animals it should be collected in a different manner than used in this feedlot. The total C.O.D. value for the manure also decreased in the stockpiled manure representing a loss in total energy.

The bacterial counts obtained in this study (10^8/g) were much lower than those obtained by Rhodes and Hrubant (10^{10}/g) on samples of feedlot waste in pens with cement floors (1972). Rhodes and Hrubant (1972) also obtained higher counts (10^9/g) from an old

waste stockpile of about 20 cm depth. The reasons for the discrepancies between our data and theirs are probably due in part to the media used. They selected Eugon agar for the total counts which is a superior medium to plate count agar. Second and probably of equal importance, the samples obtained at the two feedlots are of entirely different types. The climate is very different; the average rainfall in Lubbock is 21 inches vs an average of 35 inches for the Rhodes and Hrubant site in Peoria. The temperature at the Lubbock site was a maximum of 40 C vs a maximum of 28 C at the Peoria feedlot. The feedlot practices were entirely different (cement surfaced vs dirt, a corn based feed at Peoria vs a milo based feed at Lubbock and other differences in operation).

The stockpile method of manure disposal in the Southwest is the prevalent practice and the data presented above may aid in developing a solution to the disposal and sanitation problems created by the manure.

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