Economic Analysis of Manure Harvesting Equipment Utilized in Feedyards for Dust Control

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ABSTRACT

Large cattle production facility produces large amount of manure. One of the purposes of manure management is dust suppression, which becomes a greater issue in prolonged dry weather. Texas AgriLife Research and Texas AgriLife Extension Service personnel developed, compiled and analyzed a two-page written survey with the help of agricultural engineers. Survey data were utilized to determine the most frequently used manure harvesting equipment. Results showed that larger yards tended to own and operate the manure harvesting equipment themselves. Only 23% of medium-sized and 21% of large-sixed feedyards owned and operated an elevating scraper due to its high cost. The frequency for large, medium, and small-sized feedyards to hire manure-harvesting contractors were 71%, 39%, and 36%, respectively. The most frequently utilized manure harvesting implements identified in the feedyard manager survey, which were tractor-pulled box scraper, front-end loader and dump truck, had a combined hourly cost of $89.89.

KEY WORDS: dust control, manure harvesting, feed yards, particulate material (PM)

INTRODUCTION

Intensive cattle feeding operation is a major economic driver in much of the United States. In fact, feedyards under the Texas Cattle Feeders Association (TCFA) in Texas, Oklahoma and New Mexico [1] accounted for 30% of the nation's fed cattle production with a production of 7 million fed cattle in 2007. This equated to an about $7 billion industry and was a major regional stimulus. Furthermore, by the time the money circulated through regional residents and businesses, the total economic impacts were estimated at $19 billion (TCFA 2009). Feeding such a vast amount of cattle produces large quantities of manure. Manure contributes to atmospheric emissions, such as dust (particulate matter), hydrogen sulfide, ammonia, and volatile organic compounds.

Research by Sweeten (1979) revealed that beef cattle on high moisture concentrate rations excreted approximately 63 pounds of wet manure per day (at 85%

[1] TCFA represents the cattle feeding industry only in Texas, Oklahoma and New Mexico.

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moisture) per 1,000 pounds liveweight. An 850 pound steer produced eight pounds of manure solids per day. Natural processes of evaporation and biological decomposition decreased this to approximately two tons of manure (at 40% moisture) per animal per year that must be harvested from the pen surface. Quantities to be removed varied and depended on ration, animal density, feedyard surfacing material and cleaning procedures.

One of the purposes of manure management is dust suppression. According to Auvermann (2006), beef cattle receiving feed with a digestibility of 85%, 150 ft^2/hd animal spacing and a hypothetical uniform manure distribution produced over three inches of manure per year on the pen surface. Bench top experiments (Auvermann, 2006) supported conclusions drawn by Auvermann et al. (2000) that dust suppression became a greater issue as manure depth increases. Early implementation of dust control practices may reduce dust emissions. And typically a combination of techniques were implemented including: applying water to the pen surface, increasing the stocking rate in the pens, building sun shades, constructing windbreaks, and harvesting manure at optimal intervals.

This study focused on one method of dust control which is harvesting manure with equipment (Auvermann et al., 2000, Sweeten 1979). It was conducted to assist feedyard owners/managers in making informed decisions when purchasing implements. Specific equipment was identified by a survey developed and analyzed by Texas AgriLife Research and Texas AgriLife Extension, and administered by TCFA personnel.

The purpose of this study was to generate cost data for feedyard owners/operators to reference when making equipment purchasing and manure management decisions. The overall objective of this study was to identify and economically evaluate the most frequently used manure harvesting equipment. Examples of implements included: tractor-pulled box scraper, front-end loader, dump truck, spreader truck, elevating scraper, and tractor-pulled end-dump (Figures 1-4). The economic analysis was conducted by considering the following factors: 1) to determine the capital expenditure, salvage value, useful life in years, and normal annual hours of operation for 2010 model implements; 2) to establish the hourly fixed costs for interest, depreciation, insurance, registration, and taxes for each piece of equipment; 3) to identify the hourly operational costs for labor, fuel, maintenance and repairs, and lubrication of the machinery; and 4) to combine the fixed and operational costs to establish total hourly costs to own and operate the manure harvesting equipment.

Figure 1. Manure harvesting equipment (from left to right: elevating scraper, tractor-pulled box scraper, and front-end loader).
Source: Dr. Brent Auvermann, Texas AgriLife Research and Extension Center at Amarillo.

Figure 2. Manure harvesting equipment (spreader truck).
Source: Dr. Brent Auvermann, Texas AgriLife Research and Extension Center at Amarillo.

Figure 3. Manure harvesting equipment (dump truck).
Source: http://redwoodmetalworks.com/rmw-news/just-out-the-door/.

Figure 4. Manure harvesting equipment (End-dump tractor-trailer).
Source: http://talk.newagtalk.com/forums/threadview.asp?tid=146746&DisplayType=nested&setCookie=1.

MATERIALS AND METHODS

Texas AgriLife Research and Texas AgriLife Extension personnel developed, compiled and analyzed a two-page written survey that was reviewed by agricultural engineers. The survey was administered by TCFA personnel to 41 member feedyards during the first quarter of 2008. Major components of the survey focused on the manure harvesting equipment owned/operated by the feedyard and the manure collecting operations that were done by manure contractors. In the analysis, feedyards were stratified based on the number of head fed as follows:1) Small (less than 10,000 head capacity), 2) Medium (10,001 to 39,999 head capacity), and 3) Large (40,000 or more head capacity) to determine differences in operations utilized based on feedlot size[2]. The numbers related to large, medium and small-sized feedyards is 13, 14, and 14, respectively.

Survey data were used to determine the most frequently used manure harvesting equipment including: front-end loader, dump truck, spreader truck, elevating scraper, and tractor-trailer end-dump. The tractor-pulled box scraper was considered as one unit in this study because box scrapers are not self-propelled. After the most commonly used implements were identified, a cost analysis on an hourly basis was performed.

Six representative manufacturers in the Texas High Plains, South Plains, Dallas/Fort Worth, New Mexico and Oklahoma regions provided purchase price, salvage value, remaining value, useful life in years, and normal life in hours of operation for 2010 implement models. Hourly fixed costs for interest, depreciation, insurance, registration, and taxes were identified. A six percent discount rate was used to estimate cost streams in current dollars[3]. Depreciation was determined using the straight line-method with differing salvage values, dependent on each equipment. Insurance, registration, and taxes were calculated at one percent of the purchase price[4].

Hourly components of operational costs include labor, fuel, maintenance and repairs (M&R), and lubrication. Operator labor costs were assumed to be $10.70 per hour, based on the U.S. Farm Wage Rate: Quarterly Data (NASS 2009). Actual hours of labor exceeded machine time by 10%, because it included travel and time required to lubricate and service the equipment. Consequently, labor costs were estimated by multiplying the labor wage rate of $10.70 with 1.10, to establish $11.77 for the hourly labor cost. Current diesel fuel price was averaged at $1.98 per gallon based on information collected from three distributors. Average fuel consumption (in gallons per hour) was provided by industry representatives and differed by equipment. Several manufacturers described M&R and lubrication as important expenditures because these help to prevent wear and tear and possibly extend the useful life of the equipment. Annual M&R costs were provided by manufacturers and varied by equipment. Lubrication expenditures were estimated at 15% of the diesel fuel cost. Tire replacement was a large expenditure, dependent on individual machinery, and was not included in this analysis because it varied widely by source.

Total hourly fixed and operational data were combined to arrive at a total hourly cost for each implement including: the tractor-pulled box scraper, front-end loader, dump

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[2] This stratification is based on the responses from feedyards.

[3] 6% of discount rate reflects 3% of rate of return and 3% of inflation.

[4] 1% for insurance, registration and taxes are based on responses from six representative manufactures.

truck, spreader truck, elevating scraper, and tractor-trailer end-dump for feedyard dust control. The results of the feedyard manager surveys were compared with the calculated total hourly cost of the most frequently operated manure harvesting equipment to determine if a correlation existed between equipment operations.

RESULTS

Manure harvesting equipment used in feedyards. Categorization was done to identify similarities or differences in manure harvesting practices to control dust among small, medium, and large feedyards (Table 1). The tractor-pulled box scraper was used by 50%, 69%, and 93% of the small, medium, and large feedyard sizes, respectively. Larger yards tended to own and operate the manure harvesting equipment themselves. For example, 100% of the large feedyards surveyed owned a front-end loader and 93% operated their own tractor-pulled box scraper. Medium-size yards (10,001 to 39,999 head capacity) were also inclined to own manure harvesting equipment, but not to the percentage of the larger feedyards.

Only 23% and 21% of medium and large capacity feedyards, respectively, owned and operated an elevating scraper possibly due to its high cost. A manufacturer also stated the elevating scraper is becoming obsolete in manure harvesting because is not flexible and requires professional personnel for operation. Across all 41 feedyards surveyed, the predominant implements owned by feedyards were the tractor-pulled box scraper, front-end loader and dump truck at 71%, 68% and 61%, respectively.

Table 1. Percentage of Manure Harvesting Equipment Owned/Operated by the 41 Feedyard Managers Surveyed for Three Sizes of Feedyards.

Equipment Type	Small-sized	Medium-sized	Large-sized	Average
	Percent of feedyards using manure harvesting equipment			
Tractor-pulled box scraper	50	69	93	71
Front-end loader	50	54	100	68
Dump truck	50	85	50	61
Spreader truck	35	39	64	46
Elevating scraper	0	23	21	15
Tractor-trailer end-dump truck	14	39	64	41

Manure harvesting in feedyards. Survey respondents indicated that manure harvesting from pens was done either by a contractor, by themselves, or by a combination of both. Large-sized feedyards tended to hire contractors more frequently with 71% of the time, while medium-sized and smaller-sized feedyards harvested manure by feedyards themselves. Of the 41feedyards surveyed, less than 10% harvested manure by a combination of feedyard personnel and manure contractors. The percentage of manure

harvesting done by feedyards themselves, by hired contractor, or by feedyard/contractor combination for the three feedyard size categories is located in Table 2.

Table 2. Manure Harvesting by the Feedyard, Contractor or Combination of a Feedyard/Contractor.

Manure Harvested By	Small-sized	Medium-sized	Large-sized	Average
	Percent of feedyards using manure harvesting equipment			
Feedyard	58	54	29	46
Contractor	36	39	71	49
Combination	7	8	0	5

The capital expenditure, salvage value, useful life in years, and normal annual hours of operation for 2010 model implements. The purchase price used in the analysis of similar manure handling equipment was averaged over the manufacture's providing estimates. The elevating scraper was by far the most costly implement at $311,000. The least costly machinery was the box scraper alone at $7,000 with no salvage value at the end of seven years of useful life due to wear and tear. The purchase price of the tractor to pull the box scraper was estimated at $70,000 with a $10,000 salvage value after a useful life of ten years. The purchase price of the front-end loader and spreader truck were projected at $170,000 each. Purchase price, salvage value, projected useful life, and normal life of each equipment item can be found in Table 3.

Table 3. Purchase Price, Salvage Value, Remaining Value, Projected Useful Life in Years, and Normal Life in Hours for Manure Harvesting Equipment, June 2008.

Equipment Item	Purchase Price	Salvage Value	Remaining Value	Projected Useful Life (years)	Normal Life (hours)
Box scraper	$7,000	$0.00	$7,000	7	5,000
Tractor	$70,000	$10,000	$60,000	10	20,000
Front-end Loader	$170,000	$15,000	$155,000	15	20,000
Dump truck	$75,000	$1,500	$73,500	25	20,000
Spreader Truck	$170,000	$25,000	$145,000	10	20,000
Elevating Scraper	$311,000	$15,000	$296,000	20	20,000
Tractor-trailer end-dump	$145,000	$13,500	$131,500	25	30,000

The dump truck and tractor-trailer end-dump were the most likely equipment to travel on public highways and each had a useful life of 25 years[5]. The spreader truck was reported to travel short distances on public highways and was estimated to have ten years of useful life by industry experts.

The hourly fixed costs for interest, depreciation, insurance, registration, and taxes for each piece of equipment. Interest, depreciation, insurance, registration, and taxes constituted the total hourly fixed costs for 2010 model manure harvesting equipment and are located in Table 4. Because of the $311,000 initial capital expenditure for the elevating scraper, this implement had the largest hourly fixed costs of $2.26 of all equipment. Combining the hourly fixed cost of the box scraper at $0.45 and the tractor at $0.82, established a total hourly fixed cost of $1.27 for the unit. Even though the purchase price of the front-end loader and spreader truck were the same at $170,000, their hourly fixed costs were $1.49 and $1.97, respectively. This difference is due to the useful life of 15 years for the front-end loader and 10 years for the spreader truck.

Table 4. Purchase Price, Hourly Annualized Fixed Cost, Depreciation, Insurance, Registration and Taxes, where applicable, for Manure Harvesting Equipment, June 2008.

Equipment Item	Purchase Price	Hourly Annualized Fixed Cost	Hourly Depreciation	Hourly Insurance, Registration and Taxes	Total Hourly Fixed Costs
Box scraper	$7,000	$0.25	$0.19	$0.01	$0.45
Tractor	$70,000	$0.48	$0.30	$0.04	$0.82
Front-end Loader	$170,000	$0.88	$0.52	$0.09	$1.49
Dump truck	$75,000	$0.29	$0.15	$0.04	$0.48
Spreader truck	$170,000	$1.15	$0.73	$0.09	$1.97
Elevating scraper	$311,000	$1.36	$0.74	$0.16	$2.26
Tractor-trailer end-dump	$145,000	$0.38	$0.18	$0.05	$0.61

The hourly operational costs for labor, fuel, maintenance and repairs, and lubrication of the machinery. Operator labor, fuel, maintenance and repairs, and lubrication comprised the hourly operational costs for the manure harvesting equipment. Hourly diesel fuel ($1.98 per gallon) consumption costs ranged from $3.76 for the

[5] Both implements require higher hourly operational costs for labor, fuel, maintenance and repairs, and lubrication of the machinery.

tractor-pulled box scraper unit to $29.70 for the tractor-trailer end-dump. The tractor-trailer end-dump had the highest fuel consumption rate at 15 gallons per hour, causing the hourly fuel costs to be $29.70, compared to $19.80 for the dump truck and $6.14 for the front-end loader. Hourly fuel cost for the spreader truck was $15.84 (Table 5).

Table 5. Diesel Fuel Consumption and Hourly Diesel Fuel Cost for Manure Harvesting Equipment, June 2008.

Equipment Item	Diesel Fuel Consumption per Hour	Diesel Fuel Cost per Gallon	Total Hourly Diesel Fuel Cost
Box scraper	0.00	$1.98	$0.00
Tractor	1.90	$1.98	$3.76
Front-end loader	3.10	$1.98	$6.14
Dump truck	10.00	$1.98	$19.80
Spreader truck	8.00	$1.98	$15.84
Elevating scraper	5.40	$1.98	$10.69
Tractor-trailer end-dump	15.00	$1.98	$29.70

The hourly labor costs obtained from the U.S. Farm Wage Rate: Quarterly Data (NASS 2009) were $10.70. Because actual labor hours exceeded machine time by 10%, hourly labor cost was $11.77, and was the same for all implements. Surveyed manufacturers described maintenance and repairs (M&R) and lubrication as important expenditures because these items prevent or deter wear and tear, and possibly extend the useful life of the equipment. Annual M&R costs were provided by manufacturers and varied by equipment, and ranged from $1.05 per hour for the box scraper alone to $5.00 per hour for the elevating scraper and tractor-trailer end-dump. Lubrication expenditures were derived at 15% of the fuel cost and ranged from $0.66 per hour for the tractor pulled box scraper as a unit to $4.46 per hour operating the tractor-trailer end-dump. The tractor-trailer end-dump had the highest lubrication expense because this implement travels predominately on public roads at 15 gallons per hour and had the longest normal life at 30,000 hours. Even though the box scraper does not have an hourly fuel rate, the equipment still requires lubrication and was estimated at $0.10 per hour, according to industry standards. Combined hourly operational costs for the tractor-pulled box scraper were $30.26, since the two are considered one unit. Total hourly operational costs ranged from $20.71 for the front-end loader to $50.93 for the tractor-trailer end-dump (Table 6).

Table 6. Hourly Operational Costs for Labor, Fuel, Maintenance and Repairs, and Lubrication for Manure Harvesting Equipment, June 2008.

Equipment Type	Hourly Labor Cost	Hourly Fuel Cost($/hr)	Hourly Maintenance and Repairs Cost	Hourly Lubrication Cost	Total Hourly Operational Cost
Box scraper	$11.77	$0.00	$1.05	$0.10	$12.92
Tractor	$11.77	$3.76	$1.25	$0.56	$17.34
Front-end loader	$11.77	$6.14	$1.88	$0.92	$20.71
Dump truck	$11.77	$19.80	$4.38	$2.97	$38.92
Spreader truck	$11.77	$15.84	$2.00	$2.38	$31.99
Elevating scraper	$11.77	$10.69	$5.00	$1.60	$29.06
Tractor-trailer end-dump	$11.77	$29.70	$5.00	$4.46	$50.93

Total hourly costs to own and operate the manure harvesting equipment. Fixed and operational costs were combined to establish total costs per hour to own and operate the manure harvesting equipment. Total operating costs were greater than the fixed costs due to two factors: 1) operating labor at $11.77 per hour, and 2) fuel cost at $1.98 per gallon in association with the hourly fuel consumption of individual equipment. The most frequently utilized manure harvesting implements identified in the feedyard manager survey (Table 1) which are tractor-pulled box scraper, front-end loader and dump truck, had a combined hourly cost of $89.89 (Table 7). Across the 41 feedyards surveyed, 71%, 68% and 61% of the feedyards surveyed owned/operated a tractor-pulled box scraper, a front-end loader and a dump truck, respectively. 41% owned a tractor-trailer end-dump for which fixed and operating costs totaled $51.54 per hour over the 41 feedyards. At a total hourly cost of $31.32, only 15% owned/operated an elevating scraper.

Table 7. Hourly Fixed, Operational and Total Costs for Manure Harvesting Equipment, June 2008.

Equipment Type	Total Hourly Fixed Cost	Total Hourly Operational Cost	Total Hourly Cost
Box scraper	$0.45	$12.92	$13.37
Tractor	$0.82	$17.34	$18.16
Front-end loader	$1.49	$20.71	$22.20
Dump truck	$0.48	$38.92	$39.40
Spreader truck	$1.97	$31.99	$33.96
Elevating scraper	$2.26	$29.06	$31.32
Tractor-trailer end-dump	$0.61	$50.93	$51.54

Government Assistance Program. Manure harvesting is considered an expensive method to control dust in feedyards. Equipment purchase prices and operating costs, such as labor, fuel, and maintenance and repairs may add up to be prohibitive costs for some feedyards. However, there are government assistance programs that can help alleviate the total expenses.

The Environmental Quality Incentive Program (EQIP 2009) provides financial and technical assistance to agricultural producers who apply conservation practices on their land. EQIP funding is administered by the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS 2009). Reauthorized by the 2008 Farm Bill, new authorities were developed and funding was increased (Sokora 2009).

Commercial beef feedyards participating in the EQIP program must agree to meet specific technical criteria to insure their manure harvesting operations comply with current regulatory and environmental policies. These requirements are documented in a USDA-NRCS Manure Harvesting Management Plan developed specifically for each participating feedyard. Two operations known as "manure harvesting" and "manure cleanout" need to be undertaken to participate in the program. Manure harvesting is known as the "…removal of all loose, dry manure on top of the hard, compacted layer in the cattle pens. Manure cleanout is the "complete removal of the hard, compacted manure layer that is several inches thick… (Sokora 2009)."

There are three major Atmospheric Resource Quality Management (ARQM) schedules within EQIP in which a feedyard may participate. Each schedule has specific guidelines to follow and corresponding funding. For example, Schedule 1 requires one manure harvesting and one manure cleanout per year. When satisfactorily accomplished, the feedyard will receive government cost share payments of $165 to $330 per pen acre per year for a maximum of three years (Table 8). Schedules 1 and 2 were implemented with different manure harvesting dates to provide flexibility because some yards collect manure before or during the summer months (Schedule 1), while others, clean pens before the fall (Schedule 2). EQIP is a viable method to supplement manure harvesting

costs if the feedyard is willing to adhere to the guidelines set forth in the Manure Harvesting Management Plan. Additional and detailed information on EQIP can be reviewed on the Texas NRCS website: http://www.tx.nrcs.usda.gov/ Programs/EQIP /index.html.

Table 8. Texas Natural Resources Conservation Service (NRCS) 2009 Environmental Quality Incentive Program (EQIP) and Atmospheric Resource Quality Management Schedules (ARQM) Schedules for Manure Harvesting and Manure Cleanout and Corresponding Cost-Share Payments.

ARQM Schedule	Manure Harvest	Manure Cleanout	Payment Received
ARQM Manure Harvest Schedule 1	1 manure harvest of all pens between March 1 to May 31 time period	1 manure cleanout between November to February time frame	$165 per pen acre (maximum 3 yrs)
ARQM Manure Harvest Schedule 2	1 manure harvest of all pens between June 1 to September 30 time period	1 manure cleanout between November to February time frame	$165 per pen acre (maximum 3 yrs)
ARQM Manure Harvest Schedule 3	2 manure harvests of all pens between March 1 to May 31 & June 1 to September 31 time period	1 manure cleanout between November to February time frame	$330 per pen acre (maximum 3 yrs)

DISCUSSION

Cattle feeding in the High Plains is a critical component to the regional economy, but creates large quantities of manure that produce atmospheric emissions, such as dust. One manure management method is the use of implements for collecting manure including: tractor-pulled box scraper, front-end loader, dump truck, spreader truck, elevating scraper, and tractor-trailer end-dump. This equipment requires a significant amount of capital. This research found that, a tractor-pulled box scraper, which 71 % of 41 feedyards surveyed owned on average, had an average purchase price of $77,000, box scraper at $7,000 and tractor at $70,000. Fixed costs for this unit were $1.27 per hour and hourly operational expenses were projected at $30.26, or a total hourly cost of $31.53. Participating in EQIP can help in defraying some of these expenses.

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