Cost Comparisons of Alternative Methods for Processing Recycled Waste Newspapers into Farm-Animal Bedding

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The United States is facing a seemingly overwhelming problem of how to dispose of its solid waste. For disposal solutions to be viable, they must be environmentally sound and economically viable. Processing waste newspapers for farm-animal bedding offers a successful partial solution that meets both criteria. Centralized newspaper chopping is found to cost less than on-farm chopping. Both chopped and unchopped waste newspapers can be economically transported considerable distances. The use of waste newspapers for animal bedding is economically attractive at the farm level and can provide a partial solution to the solid-waste disposal problem.

The United States is facing a seemingly overwhelming problem of how to dispose of a growing volume of solid waste. Between 1970 and 1984 the quantity of solid waste in this country grew by 20.5%. It is expected to grow by another 19.4% by the year 2000 (Franklin Associates). Landfills, because of their low cost, have traditionally been the favored site for solid-waste disposal. Landfills typically handle about 80% of the nation's municipal solid waste, with the remaining 20% being evenly split between incineration and recycling (U.S. Environmental Protection Agency February 1989). While the volume of municipal solid waste has grown, the number of landfills in the U.S. had declined to approximately 6,000 in 1987 (Beck). The decline in the number of landfills is the result of nonreplacement when landfill sites are filled and closed. It has become increasingly more difficult to construct new landfills because of stringent environmental regulations and growing political opposition from citizens and businesses located nearby.

Pennsylvania is confronted with many of these same disposal problems. Ninety-five percent of the 9.46 million tons of municipal solid waste estimated to be generated in Pennsylvania in 1990 is buried in landfills, with 3% incinerated, 1% converted to energy, and 1% recycled (Pennsylvania Dept. of Environmental Resources December 1988; Abdalla, Stotler, and Panichella). From 1970 to 1988 the number of landfills in Pennsylvania decreased from 1,100 to 75 (Pennsylvania Dept. of Environmental Resources May 1988). As a consequence, the Pennsylvania Department of Environmental Resources estimated in 1988 that the state's average landfill life expectancy was 4.5 years and only 2 years in the more densely populated southeastern portion of the state. As a consequence, tipping fees tripled between 1985 and 1988, with the statewide average now above $30 per ton (Pennsylvania Dept. of Environmental Resources May 1988). In some parts of the state, tipping fees more than doubled between 1989 and 1990 alone and are likely to rise another 20% in 1991 (Lloyd).

New solid-waste disposal methods are needed that rely less on landfills. The U.S. Environmental Protection Agency (EPA) has established a hierarchy for the disposal of municipal solid waste as part of its integrated waste-management program that seeks to reduce the flow of municipal solid waste by 25% by the end of 1992 (U.S. EPA February 1989). The first priority is source reduction (i.e., better product design, packaging, etc.); the second is recycling; and finally, combustion and landfilling. The EPA believes that landfilling is best left for those items that are nonrecyclable and noncombustible.

The objective of this paper is to examine the cost differences of methods for processing recycled waste newspapers into farm-animal bedding. More specifically, this paper examines the incremental costs

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associated with the processing and delivery of waste newspapers until they are ready to be used for bedding on a Pennsylvania dairy farm. Centralized and on-farm processing of newspapers are examined.

Typically, the discussion of new disposal methods focuses heavily on technical merits, with little attention given to cost. Yet for any disposal program to be successful, it must be both environmentally sound and cost-effective (U.S. EPA November 1989). Thus far, the technical evidence surrounding the use of waste newspapers for animal bedding indicates that it is an environmentally sound way to recycle this type of solid waste. While concern still exists surrounding the potential toxicity of the inks and dyes used in glossy inserts, regular black-and-white newsprint has not been shown to have any detrimental effects on livestock or livestock products (Shipp and Temple; Comerford).

Newspaper bedding can be handled on the farm with existing manure-handling equipment. Additional storage might have to be purchased for farmers wishing to process unchopped newspapers on-farm. Farmers wishing to use baled, processed newspapers, however, can store these bales in any facility currently used to store baled bedding. The only perceived disadvantage over traditional forms of bedding is that some farmers feel that chopped newspapers blowing around will detract from the appearance of their farms. This is typically a short-run problem, however, because the paper becomes less visible after it gets wet. The remaining question is whether waste-newspaper bedding can be priced competitively with other forms of animal bedding (e.g., straw, sawdust, wood chips).

Background

To extend the life of its existing landfills, the Commonwealth of Pennsylvania passed legislation in 1988 that requires nearly all communities to begin mandatory recycling of at least three of the following items before the end of September 1991: clear glass; colored glass; aluminum, steel, and bimetallic cans; high-grade office paper; newsprint; corrugated paper; and plastics (Pennsylvania Dept. of Environmental Resources 1988). Because paper and paperboard are the largest (37.1%) and fastest-growing part (1.1% per year) of municipal solid waste, many communities have chosen them as one of their first three items to be recycled (Franklin Associates). Waste newspapers, which accounted for 19.8% of the tonnage in this waste category and 7.34% of all municipal solid waste by weight (Franklin Associates), are thus popular recycling choices.

While there appears to be a well-established market for metal cans and glass, the market for recycled newspapers is somewhat less established. By many accounts, it is a market where supply greatly exceeds demand at current prices, with little relief in sight (*Pennsylvania Township News*; Shaw and Park; Beck; U.S. EPA November 1989). A Pennsylvania Department of Environmental Resources market-development study projected the likely supply and demand in 1991 at prevailing market prices for each of the eight items on the recycling list given above. The projected supply of old newsprint from the Commonwealth is estimated to be nearly four times the projected demand from Pennsylvania plus New Jersey, New York, and Maryland (Pennsylvania Dept. of Environmental Resources 1988). Because of this imbalance, many communities in the Commonwealth are searching for alternative ways to dispose of the waste newspapers they are collecting for recycling.

Currently, approximately 1.085 million tons of newspapers are disposed of each year in the Commonwealth (Pennsylvania Dept. of Environmental Resources December 1988). Under the assumption that newspaper replaces traditional bedding on a pound-for-pound basis and that normal bedding practices are followed (e.g., three pounds of bedding/animal/day) for all forms of livestock on farms, it is estimated that these animals could use 1.7 million tons of bedding each year. These calculations do not include the pet-owner and kennel markets. Regardless, this would result in a sizable reduction in the volume of solid waste going into landfills in Pennsylvania. As a result, the use of newspapers as animal bedding is of great interest to Pennsylvania's local-government officials.

Problems encountered in Pennsylvania are also being encountered in other states. Thus, the solutions developed here may have implications beyond Pennsylvania as other states deal with their mounting environmental problems during the coming decade.

Methodology

To facilitate the analysis, several assumptions are made. First, the cost of the waste newspapers is assumed to be zero. This is done to provide a clear measure of the cost of preparing and delivering waste newspapers for use as animal bedding. While it is recognized that this may not be true in every case, it does provide a standard starting point for the analysis. If a situation arises where it is necessary to either pay or be paid for the waste newspapers used, or to build in a profit, it is a simple

matter to adjust the figures. Second, the analysis begins with the centralized collection of the waste newspapers and ends when the waste newspapers are processed and ready to be used as bedding. This ending point is selected because it simplifies the comparison of the cost of waste newspapers to the delivered cost of other forms of bedding. This also means that regardless of the type of bedding used, the amount of time and effort required to place it in a stall is assumed to be the same (Comerford).

Third, the processes examined are assumed to require the purchase of new equipment. This assumption is conservative and may understate any cost advantage from using newspapers when either used equipment is purchased or existing equipment is utilized. Fourth, there is evidence that because of the greater absorbency of newspapers relative to traditional bedding material, less than a pound of newspaper can replace a pound of traditional bedding (Comerford). The analysis here, however, uses a conservative assumption that newspapers replace traditional bedding on a pound-for-pound basis. This may understate any cost savings that may occur when newspapers replace traditional bedding. Fifth, it is assumed for on-farm processing that chopping newspapers is a new activity on the farm that requires additional work on the part of the farmer.

Sixth, given current production practices on Pennsylvania dairy farms, the shift from growing bedding to purchasing waste newspapers is assumed to have little effect on farm revenues and expenses, or on the market for bedding. The normal production practice on Pennsylvania dairy farms is to devote a minimum amount of acreage to the production of bedding. In addition, farmers typically have a variety of sources from which to purchase bedding (traditional straw as well as wood chips, sawdust, etc.), so that a total shift to purchased bedding is not likely to have any serious impact on farm revenues and expenses. Bedding markets in Pennsylvania tend to be thin and local in nature, and therefore the introduction of newspapers is not likely to have much impact on the market for bedding.

The costs of processing waste newspapers for animal bedding are evaluated in three steps using incremental cost analysis (Beierlein, Woodruff, and McSweeny). First, the basic cost structure is established by determining the total cost per ton for newspaper bedding and then comparing it to the cost of alternative forms of bedding (e.g., straw, sawdust). Second, an alternative configuration of the system is examined to determine whether it is less expensive to process the newspapers at a central site before trucking to the farm or to ship the waste newsprint to the farm and carry out the processing there. Third, sensitivity of the solution to changes in major cost components of the processing system is examined by (1) changing transportation costs, (2) determining maximum distances that waste newspapers can be economically transported, and (3) determining the cost of operating the centralized processing center at various levels of output.

The processing and transportation costs are calculated separately so that each cost component can be evaluated on its own before arriving at a total delivered cost per ton. This is done to simplify cost comparisons for situations where the users provide the transportation of the bedding material.

The data on the costs and operating expenses come from a variety of professionals who either work with this type of equipment or who have operated pilot newspaper chopping plants. On-farm and centralized chopping systems were selected for comparison because they not only represent the extremes of the processing/delivery spectrum, but they are also the most likely options to be considered by potential users. While the values in any particular situation may differ from those used here, these values should help determine the general cost structure of using newspapers for animal bedding.

The on-farm system is assumed to have the raw waste newspapers delivered from a centralized collection point to the farm, where one person chops the paper on an as-needed basis using a free-standing or portable gasoline-powered chopping unit that costs $1,935 (Fisher). The variables used in the determination of on-farm chopping costs are given in Table 1.

The second system is a centralized processing facility comprised of two electrically powered chopping units, one baler, and supporting materials-handling equipment that receives the waste newspaper. The paper is chopped and formed into 48-pound bales that are placed on a truck and delivered to farms on a full-time year-round basis. The centralized center is assumed to employ four workers, one manager, and one truck driver. The operation has an initial capital cost of $80,000 and yearly nonwage overhead of $36,000 (Karakash). The variables used in the determination of centralized chopping costs are given in Table 2.

The delivery vehicle used in both systems is a tractor with a 45-foot trailer. The truck costs are derived from the U.S. Department of Agriculture's "Fruit and Vegetable Truck Report." These costs have been adjusted to reflect a typical situation for this type of recycling center where the average daily delivery mileage is 160 miles. This results in

Table 1. Variables Used in the Calculation of Total Cost of On-Farm Chopping of Waste Newspapers for Use as Farm-Animal Bedding, 1990

Assumed values of the input variables	
Number of dairy cows in herd	100.00
Pounds of newspaper/animal/day	3.00
Chopper through-put (pounds/minute)	7.00
Chopper cost/machine	$1,935.00
Depreciation life (years)	3.00
Salvage value	$0.00
Chopper repair & maintenance/year	$400.00
Fuel consumption (gallons/hour)	0.50
Fuel cost/gallon (gasoline)	$1.10
Farm wage rate/hour	$6.00
Farm wage fringe rate percent	25.00
Days of bedding needed/year	365.00
Incremental overhead cost/year	$100.00
Calculated total chopping cost/hour	
Depreciation	$2.47
Fuel	$0.55
Repairs & maintenance	$1.53
Overhead	$0.38
Labor-wage	$6.00
Labor-fringe	$1.50
Total cost/hour[a]	$12.44
Calculated total chopping cost/pound	$0.0296
Calculated total chopping cost/ton	$59.25

Source of assumed values of input variables: Fisher.
[a]Totals may not sum due to rounding.

Table 2. Variables Used in the Calculation of the Total Cost of Centralized Chopping of Waste Newspapers for Use as Farm-Animal Bedding, 1990

Assumed values of the input variables	
Center operation (hours/year)	2,080.00
Through-put (pounds/hour)	420.00
Salvage value	$0.00
Depreciation (years)	7.00
No. of operators	4.00
Wage rate of operators/hour	$4.50
No. of truck drivers	1.00
Wage rate of truck driver/hour	$8.00
No. of managers	1.00
Wage rate of manager/hour	$7.00
Wage rate fringe benefits percentage	25.00
Equipment cost	$80,000.00
Overhead/year	$36,000.00
Electricity cost/chopper/hour	$1.50
Total chopping cost/hour	
Depreciation	$ 5.49
Fuel	$ 1.50
Repairs & maintenance	$ 3.08
Overhead	$17.31
Labor-wages	$25.00
Labor-fringe	$ 6.25
Total chopping cost/hour[a]	$58.63
Total chopping cost/pound	$ 0.0070
Total chopping cost/ton	$13.96

Source of assumed values of input variables: Karakash.
[a]Totals may not sum due to rounding.

a transportation cost of $2.05 per mile. When chopped paper is hauled, the 45-foot trailer is completely filled at a weight of 23,040 pounds (480 bales). When unchopped paper is transported, the trailer reaches its weight limit of 60,000 pounds before it is completely filled. The variables used to determine the cost of transportation are given in Table 3.

Results

The Basic Cost Structure of Processing Newspapers for Animal Bedding

The first step in the analysis was to determine the cost of transporting and chopping newspapers on-farm and to compare this cost per ton to that of other types of bedding materials. The total cost per ton of on-farm chopping is $64.77, which includes $5.52 for transportation (Table 4). The cost per ton for chopping paper is high because of the limited amount of time (43 minutes) the chopping equipment is used each day and the extra time required to complete the new farm task of newspaper chopping. Transportation costs per ton are fairly low because of the large amount of paper that is transported in each trailer load.

The total cost per ton for on-farm chopping compares favorably with the price of other forms of animal bedding, where the low end of the price range in Pennsylvania is typically $65–$70 per ton but can range above $100 at various times during the year (Gingrich). Thus, it would appear that using waste newspapers as farm-animal bedding is economically attractive. The strength of this conclusion is reinforced by the anticipated steady supply of newspapers and the insensitivity of this supply to weather, economic, or biological factors that typically influence the supply of other forms of bedding.

The Comparison of On-Farm versus Centralized Chopping of Newspapers

The total cost per ton for centralized chopping is $28.21, including a transportation cost of $14.25 (Table 4). This figure is 56.4% less than the cost of on-farm chopping. The cost of transportation exceeds the cost of chopping. The rise in delivery cost per ton reflects the reduced density of the

Table 3. Variables Used to Determine the Transportation Cost of Delivering Waste Newspapers to Be Used as Farm-Animal Bedding, 1990

Assumed values of the input variables	
Miles driven per day	160.00
Fixed costs/year	$37,500.00
Variable cost/mile (except fuel & driver)	$0.3750
Fuel consumption rate (gallons/mile)	4.00
Fuel cost/gallon	$1.10
Driver wage rate/hour	$8.00
Driver fringe rate percentage	25.00
Trailer size (cubic feet-usable) (45′ L × 8′ W × 8′ H)	2,880.00
Unchopped newspaper weight/cubic foot (pounds)	35.00
Bale weight (pounds)	48.00
Bale size (cubic feet) (3′ L × 1.32′ W × 1.5′ H)	5.94
Bales/load	480.00
(80 per layer × 6 layers)	(23,040 lbs)
Unchopped newspapers/load (legal load limit is 60,000 lbs)	59,500.00 lbs
Calculated transportation cost/mile/ton (chopped bales)	$ 0.1781
Calculated transportation cost/mile/ton (unchopped bales)	$ 0.0690

Source of assumed values of input variables: U.S. Department of Agriculture; Karakash.

chopped, baled paper coming from the centralized facility (23,040 pounds/trailer load) versus that of the unchopped paper (60,000 pounds/trailer load) being delivered for on-farm processing. The rise in cost of delivery per ton ($8.73), however, is more than offset by the decline in chopping cost per ton (−$45.29). The efficiencies from specialization in chopping more than offset the additional transportation cost per ton. Thus, centralized chopping, rather than on-farm chopping, appears to be the lower-cost way to provide newspaper bedding for farm animals.

Furthermore, if the centralized processing center is run as a profit-making enterprise where the goal is a 10% return on investment, the price per ton of processed newspapers for bedding would only increase by $1.76 to $29.97. A 15% return on investment would require an increase of $2.64 per ton to a price per ton of $30.85. Both of these per ton figures still compare favorably to the costs of traditional forms of bedding.

The sensitivity of this solution to the level of output produced at the centralized chopping facility is examined by decreasing the number of hours of its operation until the total delivered cost equals the low end of the typical price range for other forms of bedding and the cost of on-farm chopping (approximately $65/ton). This occurs when the centralized chopping unit is operated 10.08 hours per week (Table 5). At all levels of operation above this point, centralized chopping costs are less than the cost of on-farm chopping and alternative forms of bedding.

Table 4. Comparison of Costs per Ton of On-Farm and Centralized Chopping of Waste Newspapers for Use as Farm-Animal Bedding to the Estimated Cost of Alternative Forms of Bedding, 1990

Alternatives	Chopping Cost	+ Delivery Cost	= Total Cost
		$/Ton	
On-Farm	59.25	5.52	64.77
Centralized	13.96	14.25	28.21
Traditional bedding (estimated)			65.00–70.00

Impact of Changes in Petroleum Prices

In light of the recent events surrounding world energy supplies, it is important to examine the impact of changes in petroleum prices on the transportation component of the cost structure. For this reason, two transportation-related changes are examined: (1) doubling the cost of transportation and (2) determining the maximum distance that newspaper can be transported and remain competitively priced with traditional forms of bedding.

Doubling the Cost of Transportation. The impact of rising petroleum prices on fuels and the general cost of goods and services is examined in the extreme case where the cost of transportation is doubled to $4.10 per mile. This results in a rise in the cost per ton of 8.5% for on-farm chopping, which is enough to remove the cost advantage enjoyed by newspapers and makes it approximately equal to the lowest price of other bedding sources

Table 5. Total Cost of Chopping and Delivering Waste Newspapers When the Centralized Processing Center Operates at Less than Full Time

No. Hours of Operation Per Week	Chopping Cost	+ Delivery Cost	= Total Cost
		$/Ton	
40	13.96	14.25	28.21
32	15.50	15.81	31.31
24	18.07	18.42	36.49
16	23.20	23.64	46.84
10.08	32.25	32.83	65.08
8	78.61	39.29	77.89

(assuming that the cost of alternative bedding is not significantly affected by increases in energy costs). The increase in the cost per ton for centralized chopping is a much more dramatic 50.5% and reflects the relative greater importance of the cost of transportation to this form of chopping. Yet despite this cost rise, centralized chopped waste newspapers continue to enjoy a 34.5% cost advantage ($22.54/ton) over other forms of bedding if their price remains unchanged.

Maximum Delivery Distance. To determine the maximum delivery area that a single waste-newspaper center could service, daily route mileage is expanded for the on-farm chopping system until the total delivered cost per ton equals the lowest expected price ($65/ton) for alternative bedding. For centralized chopping, distances up to 500 miles from the distribution center are examined.

For on-farm chopping, the maximum one-way distance from the central distribution center is 91 miles. At the maximum distance of 500 miles from the distribution center, the total cost for centralized chopping becomes $51.90 per ton. Thus, even if the higher-cost on-farm chopping option is used, it is still economically attractive to transport the recycled newspapers relatively long distances. This means that it is economically possible for urban areas' waste newspapers to be used to meet the bedding needs of fairly distant farm livestock.

Conclusions

Based on the results presented, it can be concluded that (1) the use of waste newspapers for animal bedding is economically competitive; (2) centralized chopping is less costly than on-farm chopping; (3) transportation is an important cost element in this recycling program; (4) the cost advantages associated with using waste newspapers for animal bedding are not likely to be jeopardized by foreseeable changes in transportation costs; and (5) it is economically possible to transport waste newspapers a considerable distance for use as farm-animal bedding. It appears that using waste newspapers as animal bedding offers a viable long-run partial solution to the United States' solid-waste disposal problems because it is both environmentally sound and economically feasible.

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