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A study on the management of residuals in Alberta's agricultural and agri-processing industry

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Abstract: Agricultural and agri-processing industries generate appreciable quantity of residuals. Many of these residuals are biodegradable and can be processed to other value-added products, but a number of them require special handling. Today, there is a wide range of technologies that can be used by agricultural and agri-processing industries in processing these residuals to value-added products at various stages of the process lifecycle. Consequently, these processing technologies reduces the amount of residuals that is discarded as wastes. The purpose of this study was to identify types and sources of residuals in Alberta's agricultural and agri-processing industry. The study was also aimed at identifying commonly used residuals management technologies in the industry, factors affecting their choices, and the degree of importance attached to each factor in arriving at the final decision. The study involved a survey of twenty six farms and agri-processing companies all over Alberta. The survey was conducted by phone calls and by administration of questionnaire to the companies. Results from the study revealed that animal manure from feedlots is the major type of residuals from the industry. The manure is managed by applying it on farms for improved yield. In addition, the study revealed that residuals management decisions in the agricultural and agri-processing industry is a multi-criteria and multi-stage decision-making process. Moreover, provincial regulations, economic factor, and available technologies played significant roles in the choice of residuals management methods.

Keywords: Agri-Waste, Residuals Management, Waste Management, Waste Minimization, Waste Reduction

1. Introduction

Agri-waste consists of secondary materials such as rice husk and grain leftovers such as straws, wood chips. It is a significant portion of wastes generated from economic activities and households all over the world. Billions of tonnes of residuals are generated each year in the developing and developed countries from agricultural and agri-processing activities all over the world [1-12]. Figure 1 shows the consumption and pre-consumption food losses in various regions all over the world in 2010. It should be noted that pre-consumption loses dominated the agricultural and agri-processing wastes in developing countries of the world while consumption losses are dominant in developed countries. For instance, 39570000 tonnes of the 2638494000 tonnes of wastes generated in twenty seven European countries in 2010 is agri-waste [6]. Liu and Farmer (2010) also estimated an annual cotton gin waste generation of 1,424.28 thousand tonnes from Southern Plains of Texas [7]. These show that regardless of whether they are pre-consumption or consumption residuals, they are in significant quantities. Looking inwards, Alberta agri-industry has also been found to be a significant contributor to these large agricultural residuals' generation [2]. According to Alberta Environment [10], the high volumes of agricultural and agri-processing waste generation in the form of manure, straw and livestock processing waste are due to the province's having the largest confined feedlot operations and meat packing plants in Canada. Alberta Environment (2013) [10] revealed that current volume of agricultural residuals is largely made up of straw, manure and livestock processing wastes, and these residuals could have deleterious effects on human health and ecosystem welfare.

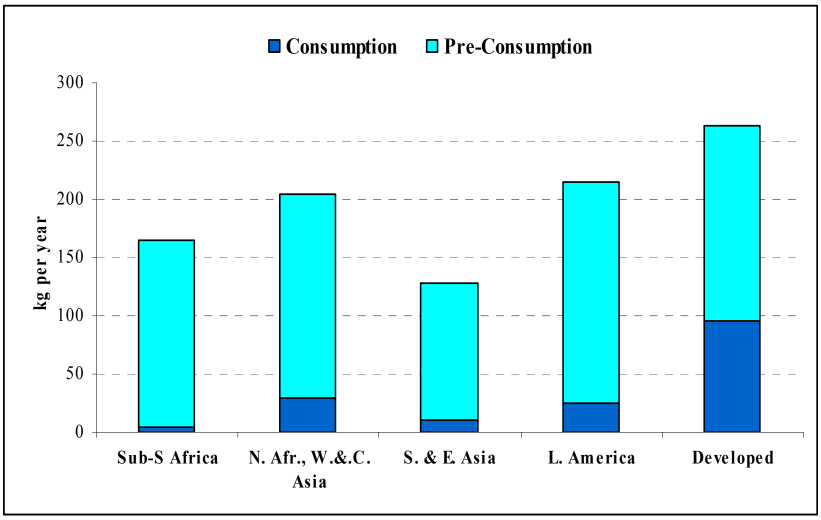

Figure 1*. World regional average per capita food losses and wastage (2010). Source: FAO, Agricultural Department. Available at http://www.fao.org/docrep/015/i2490e/i2490e03d.pdf*

There are several reports on residuals management problems and the potential consequences of agricultural and agri-processing residuals on our environment. Agricultural and agri-processing activities have been ranked as the most significant cause of impaired water quality in streams and lakes [1-5, 8-10, 12, 17]. For example, Cohen and Din (2013) reported that animal manure and agricultural residues are hazardous to the environment, causing air pollution; soil and groundwater contamination. In addition, agricultural and agri-processing wastes cause bad smells as well as insects, rats, and worms' infestation in the villages and towns located in the vicinity of agri-waste dumping sites [17]. Government of Alberta [2] also reported that crop and livestock production practices are associated with contaminants like sediment; agricultural chemicals like inorganic fertilizers, herbicides and insecticides; organic matter such as livestock wastes and decaying plant material; microorganisms from livestock wastes, and irrigation residues such as salts and trace metals. The report hinted that these contaminants are transported to surface and groundwater through various phases of the hydrological cycle. This contamination of water resources may result in impaired water quality which would consequently restrict such water from being used for irrigation, drinking water supplies, and recreation. Moreover, such contamination may also have significant public health and environmental impacts. The awareness of these potential problems is causing increasing concern among the Alberta's agricultural communities and the general public [1-5, 13-15].

Furthermore, reports from highly intensive agricultural regions of similar status with Alberta have alerted producers, regulating agencies, and the public in Alberta to the potential problems that could result from the expansion of the agricultural sector in the province. Consequently, the government, agricultural producers, and agri-food processors are taking proactive steps to avert the potential consequences of contaminations from agricultural operations in the province. This is being done by investing in and using modern residuals management practices and technologies that can help in reducing agri-industry's ecological footprints and thereby safeguarding the environment. Today, there is a wide range of technologies and practices that can be used by agricultural and agri-processing firms in processing their residuals to value-added products [8-31]. This would lead to reduction in the net amount of wastes that are generated at various stages of the agri-processing lifecycle. These value added products could be in terms of using these agricultural and agri-processing residuals as feedstock for bioenergy generation [8] and as construction bricks' material [9]. Agri-waste can also be used as raw materials for the production of various consumer products[10, 12], or as adsorbents of heavy metals and in water purification [26, 27]. For instance, Liu and Farmer (2010) estimated that 4,791 million kWh of electricity could be generated by using an estimated 1,424.28 thousand tonnes of cotton gin waste annually generated during ginning process in Texas [7].

Availability of variety of residuals management and waste reduction opportunities, many of which have unknown potentials and risks, poses a decision problem. A lifecycle consideration of some of these technologies may prove that they can be more environmentally injurious and/or wasteful than the waste stream they attempt to reduce [17]. Moreover, residuals management decisions in the agricultural and agri-processing industry as a multi-criteria and multi-stage decision-making process at the firm level may require process selection rethink, facility redesign, and changes in facility operations management. Making such crucial decisions is often characterized by a number of influence factors that are specific to individual firms and locations [18-34].

The recognition of the importance of these influencing issues led to this study on how residuals management technology decisions are made in the Alberta's agricultural and agri-processing industries, and factors affecting residuals management technology investment and utilization in the province. This study also included articulation of commonly used residuals management technologies in the Alberta's agricultural and agri-processing industry, identification of importance attached to factors affecting their selection for use, and why such level of importance was attached to each of them. The methodology used in data collection is discussed in the next section. Results obtained from the study are discussed in section three, while conclusions reached from the study are elucidated in section four.

2. Methodology

The approach taken in this research consists of a review of relevant literatures and data mining of a number of statistical databases. Some of the databases searched include statistical data from Food and Agricultural Organization (FAO), International Monetary Fund (IMF), World Bank, European Union (Eurostat), Statistics Canada, Agriculture and Agri-Food Canada, Alberta Environment, and Alberta Agriculture. Phone calls were also made to companies and questionnaires were administered to various companies contacted. Twenty six butcheries, meat packers, feedlots, rendering facilities, and farms all over Alberta were involved in the survey. They were asked the various types of residuals generated on their facilities and the percentage of each fraction on the total residuals generated. They were also asked the residuals management approaches, techniques and technologies that they are using to handle their residuals and reasons why they chose to manage those residuals in those ways. Furthermore, they were requested to rate the importance of their residuals decision criteria on the scale of 1-10, where 1 symbolizes "not so important" while 10 represent "extremely important." The outcomes are discussed in the next section.

3. Results and Discussion

The outcome of the survey revealed that there is a wide range of types of residuals that are generated at various agricultural facilities in Alberta. These residuals include leaves, straw and husks left in the field after harvest, as well as hulls and shells removed during processing of crop at the mills. Others are residuals like bagasse, husks, hulls, shells, residue, trimmings, and cut-offs from crop and animal processing. The results shown in Figures 2 - 4 are computed averages of each category of data provided by the companies researched. Figure 2 shows the percentage constituents of residuals generated by various agricultural companies in Alberta. The results showed that about 90% of the residuals generated is animal manure while chemical residue/containers, silage bags and refuse make up the rest.

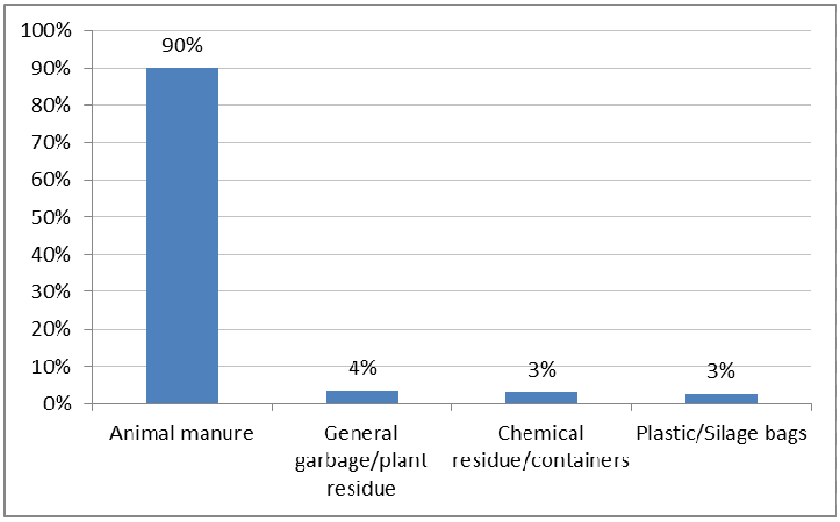

***Figure 2**. Characteristics of Residuals Generated on Alberta's Agricultural Facilities*

Figure 3 shows the proportion of different agri-wastes being managed through the use of various residuals management techniques. Most of the surveyed facilities indicated that they use landfills for refuse, silage bags and chemical residues/containers while the animal manure is applied on land to improve the soil fertility as specified in the relevant Alberta regulations. Rendering facilities included in the survey reported that fats that falls under the category of "specified risk materials" are also sent to landfills while other treatment fractions are sold to the relevant markets. The researched agri-waste management companies reported that wastewater constitutes the largest percentage of the residuals generated from their facilities and they handled their wastewater by pre-treating it before releasing it to the public sewage systems. They also indicated that odor is another major pollutant that comes from their facilities. They indicated the use of two approaches in handling the odors. They use "burner-thermo-oxidation technology" to handle high intensity odors while low intensity odors are treated by using "scrubbers that utilizes bleach solution".

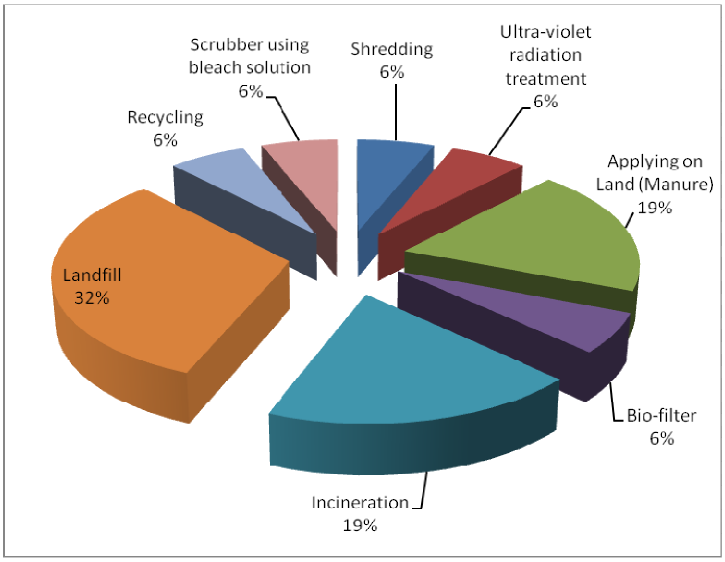

***Figure 3**. Types of Commonly Used Residuals Management Techniques*

Moreover, the survey revealed that government regulations, environmental impacts, economic benefits, and technology availability are the main factors that influenced their decision making on the type of residuals management technique to use for various types of residuals that are generated on their facilities. Figure 4 shows that most of the companies researched gave the importance rating of 10 to government regulations while majority of the twenty six facilities gave technology availability a score of 5. The importance rating of 10 is understandable as various facilities have to comply with government regulations guiding their activities. The 5 - 8.5 ratings for other factors showed that they are also very important in arriving at the final decision regarding which residual management technology or approach would be used.

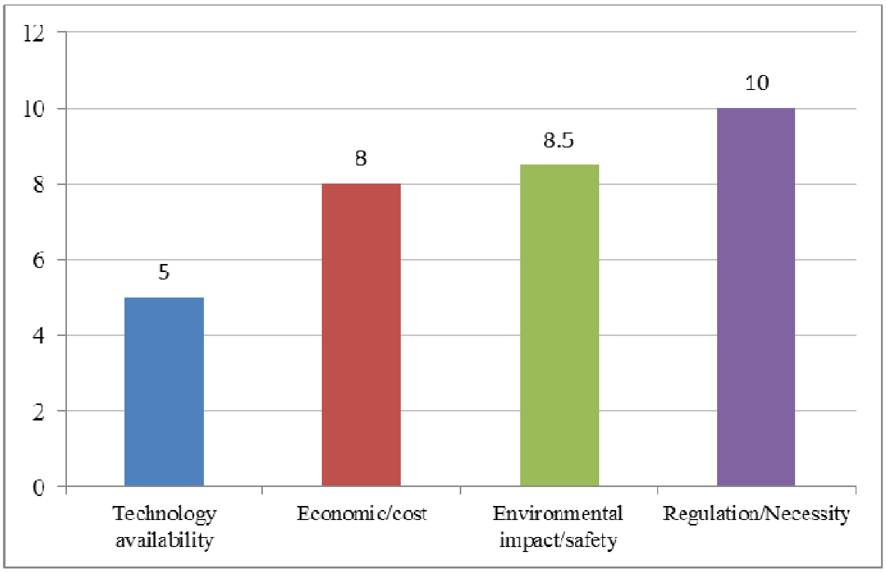

***Figure 4**. Agri-Residuals Management Decision Criteria and Importance Ranking*

4. Conclusion

This research looked into various types of residuals management techniques that are being used in the Alberta's agricultural industry and criteria that agri-based companies are using as basis for their choice of residuals management techniques. The study revealed that landfilling remains the most commonly used approach for agri-residuals management in Alberta. A number of agricultural facilities are making efforts to reduce the ecological footprints of their activities by minimizing the amount of residuals that ends up in the landfills through recycling. It was discovered that the main driving factors in the choice of agri-residuals management techniques being used by the researched companies in Alberta are government regulations, environmental impact/safety, economic issue, and technology availability. Further research in this area will look into how differences in company size, seasonal variation and trends in environmental awareness as well as changes in environmental regulation affect the choice of agri-residuals management techniques in the Alberta's agricultural and agri-processing industry.

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