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Reverse Logistics Systems of Empty Packings of Agricultural Pesticides in Brazil

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Abstract:

This paper presents an understanding of RLSs in Brazil for empty packings of pesticide. it describes and analyzes these RLSs, in order to identify the processes of return and recycling and the market viability for recycled products. The work described in this paper studied the connections or relationships with focus on the recycler of 1st level, decomposing the studied RLS into two subsystems or stages: collection and post-collection system

Keywords: *Reverse Logistics System, Packings of Pesticides, Brazil.*

1. INTRODUCTION

The concern of society with the environment has increased considerably in recent times. The signs of environmental degradation, evidenced by climate change caused by global warming has touched everyone. Governments, businesses and people initiated action to preserve the environment, seeking to decrease the impacts of human activities.

Conceptually, logistics includes managing the flow of materials, stocks in manufacturing processes, finished goods, distribution and information from the origin of raw materials to the point of consumption, in order to meet customer requirements (BALLOU, 2001). However, from the society's concern with the deterioration of the environment and its resources due to population explosion, unprecedented industrialization and unbridled market competitiveness of the last decades, companies have realized that logistics management should go beyond the point of final consumption. Everyone should understand that the business strategy for "gaining" consumers must include environmental issues. Within this approach, reverse logistics management is considered an extension of the traditional logistics concept.

In a business perspective, while logistics management is deals with the flow of materials and information to the downstream production chain, reverse logistics management is related to the return of waste products (making them inert in the environment); empty packagings and accessories for recycling in the productive process.

A Reverse Logistics System (RLS) is therefore a system that encompasses all stakeholders, their activities and relations involved in the recovery of assets or value of products in end of life. The performance - effectiveness and efficiency - of Reverse Logistics Systems (RLS´s) is usually evaluated in terms of reduction of costs.

The growing interest in RLS's is partly due to the pressure of new laws, which have forced producers to be responsible for the collection and final disposal of their products, putting the most complex challenges in supply chain management of their products. Thus, the company should no longer be concerned only in manufacturing, selling and distributing, their goods. In other words, they should not only take care of conventional logistics.

The trend of Brazilian legislation, which goes towards making companies increasingly responsible for the entire life cycle of their products, will make the companies responsible for the packagings of their products after delivered to final consumers. This is being achieved through the collection, treatment and recycling of their products, as it has occurred in the agrochemical industry.

Pesticides are chemicals used to plant crops. In order to ensure the collection and disposal of empty pesticide in an environmentally correct way, Brazilian environmental legislation distributes responsibilities for all parts involved in the pesticides supply chain.

In accordance to what was stated, this article aims to provide an understanding of the RLS's adopted in Brazil for managing the recovery of empty containers/packings of pesticides. More specifically, it describes and analyzes RLS's packaging of pesticides, identifying the responsibilities of actors in the supply chain; the process of returning; recycling feasibility and market for recycled products. For that we made a review of the literature produced on the subject through various publications, public and private research into the various participants in the RLS of empty packings of pesticides in Brazil.

2. REVERSE LOGISTICS

2.1 DEFINITIONS AND BOUNDARIES

Reverse logistics studies material flows ranging from end-user logistics process original (or another previous point, if the product does not come to that) to a new point of consumption or reuse. Examples of reverse logistics processes are the collection of bottles of bottles, the return of goods and the restoration and / or recycling of materials.

The main activities in reverse logistics are a collection of products to be recovered and its distribution after reprocessing. Although the problem resembles the classic problem of distribution, there are some differences: typically there are many points where the goods must be collected, the collection of packaging of products is generally a problematic issue, the cooperation of the sender is, in many cases, much needed, and the goods tend to have a low

value.

The differences between direct and reverse logistics are not limited only in the direction of material flow, ie the movement of customers to suppliers, but go much further. Otherwise you can simply say that these flows are "normal" starting the client (in this case playing the supplier) and ends at the beginning of any other logistics flow, a supplier who will take these inputs (in this case, a client of process).

Over the past decades, reverse logistics has become an issue both in academia and in business. In the early nineties, the Council of Logistics Management (CLM) published two studies on LR. The first study (STOCK, 1992) recognized in a general way the LR as relevant to society and for business. The second was developed by Kopicki (1993) and has pointed to the benefits of recycling and recovery of products. Jahre (1995a, 1995b) discussed the management of reverse channels and explored the concept of postponement applied to the problem of waste disposal. Rogers and Tibben-Lembke (1999) presented an extensive collection of best practices LR, giving special attention to the American experience. In 1992, Stock has introduced new approaches to LR, as the logistics of returning the products, resource reduction, recycling, and actions for material substitution, recycling, waste disposal, reuse, repair and remanufacturing of materials.

Rogers and Tibben-Lembke (1999) defined reverse logistics in the economic outlook as the process of planning, implementing and controlling the flow of finished goods and related information from the point of consumption to the point of origin in order to recapture value or suit your destination.

Earlier this century, the reverse logistics is to be associated with more operational issues. Several studies have been devoted to the optimization and management of reverse logistics, such as the work of Guide et al. (2000) on the characteristics of the LR for remanufacturing systems. More recently, Davies (2004) explores the issues of LR applied to the planning and production control.

To characterize reverse logistics, Rogers and Tibben-Lembke (1999) are based on the concept of logistics, and for them:

> "Logistics is the process of planning, implementation and efficient control (including cost) of raw materials, materials in process, finished goods and related information from point of origin to point of consumption to meet customer needs."

Then:

> "Reverse logistics is the process of planning, implementation and effective control (including cost) of raw materials, materials in process, finished goods and related information from the point of consumption to the point of origin to meet the needs of recovery and value or get correct deposition / controlled. "

It should be noted that the information flow in both directions in both cases. Furthermore, remanufacturing operations extras like some kind of preparation for deposition and even changes in the logistics or the direct product design to facilitate or reduce costs later (in the reverse) are usually included in the field of reverse logistics.

Because reverse logistics an area of research for new and practical nature can be found in the literature other terms, such as logistics return, reverse logistics, distribution, reverse logistics, and retro. They all say roughly about the same subject.

According to Leite (2002), the reverse distribution channels (CDRs) can be divided into:

a) CDR-sales: they consisted of different ways and means of returning a portion of products flowing in the opposite direction of the consumer to the retailer or manufacturer, retailer and the manufacturer, between companies, motivated by various types of problems;

b) CDRs post-consumer: are goods originating in the disposal of finished products after their original usefulness. Among them two subsystems: reverse channels for recycling and reuse reverse channels. There is also the possibility of a portion of those products from post-consumer is directed to systems of disposal.

It is important to note that there is a difference between reverse logistics and waste management. This refers primarily to the collection and processing of products or materials that are deposited. The point here is the definition of waste. This is a crucial issue, since the term waste entails legal consequences, for example, with regard to the regulation of import/export of waste.

Reverse logistics focuses on streams where there is some value to be recovered from products and materials and these can enter into a new supply chain. It also differs from green logistics. It considers the environmental aspects of all logistics activities and is more directly focused on logistics. The most important issues for green logistics are the consumption of natural non-renewable resources, emission of pollutants, usage of roads, noise pollution and waste disposal.

The boundary between the forward logistics (from raw materials to final consumer) and reverse logistics (from the end use until the recovery of value) is not strictly defined. A product that reaches its end of life or use in a supply chain may become a component or raw material in another supply chain. As an example, it can be mentioned the case of products such as glass bottles and paper, which are both essential for the production of other types of glass and paper, respectively.

Finally, reverse logistics can be viewed as part of sustainable development. This was defined in a report to the European Union as it "meets the needs of the present without compromising the ability of future generations to meet their own needs" (BRUNDTLAND, 1987). In fact, one can consider the reverse logistics as the implementation at the business processes that ensure that the company uses and reuses, efficiently and effectively, all the value that is put in products.

2.2 RELEVANCE

For years, Europe encourages sustainable development. Thus, practice has included recovery of materials through environmental legislation and the extension of producer responsibility. Recent developments show that the law and its consequences have increased. The products of highest priority include: vehicles (Directive 00/53/CE), electronics (Directive 02/96/CE) and packaging (Directive 94/62/EC).

Table 1.1 summarizes these policies with respect to recycling quotas for France, Germany and the Netherlands (European Environmental Agency, 2004; Auto Recycling Netherlands, 2004; Europe, 2004).

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European Directive (quotas to be reached)	Germany (shares held)	France (shares held)	Netherlands (shares held)
Cars			
85% (2006)*	85%	-	85% (2002)
95% (2015)*	-	-	95% (2007) *
Electronics			
60%-90% (2006)*	-	-	45% - 75% (2002)
Packaging			
50% (2001)	65% (1998)	45% (1998)	60% (1998)
60% (2006)*			
70% (2011)*			

Table 1: Shares Recycling in Europe (2004)

Although member states of the European Union (EU) are encouraged to introduce systems to prevent the use and recycling of materials, several have some freedom in the establishment of recycling quotas (Greece, Ireland and Portugal may adjust the quotas to lower levels). With respect to waste with packaging, for example, Belgium, Spain and the Netherlands, have set targets for prevention (through agreements and covenants). On the other hand, Germany, Denmark and Portugal have introduced targets for the reuse of packaging. Austria and Finland set as targets for recycling and reuse of packaging.

Regarding economic activities related to reverse logistics have not yet been carried out further studies. It is known that some recovery activities, such as recycling, require labor-intensive. Some studies indicate that recycling activities create five to seven times more jobs than incineration and more than 10 times the operations of landfilling (EUROPEAN ENVIRONMENTAL AGENCY, 2004).

Besides this fact, the European Commission estimates that the recovery activities provide an opportunity to create new work areas (EUROPE, 2004). These new studies may also prove to be in a situation for the employees' working life, which can mean a great benefit, especially in developing countries.

In conclusion, reverse logistics can set up a tripod important for sustainable development because it provides environmental benefits, economic and social.

3. THE PROBLEM OF PACKINGS OF PESTICIDES

The “green revolution model” has raised the overall productivity of the Brazilian agricultural sector during the last decade. At the same time that productivity of the 15 larger cultures has increased in 16.8%, the use of insecticides, fungicides and herbicides increased

by 233.6%, 584.5% and 5414.2% respectively. The intensive use of pesticides (a tonic in this productive model) has caused countless negative impacts, from natural enemies of insects' elimination as well as the resistance development to pesticides for insects and herbs (FERRAZ, 2000).

Brazil produces seven times the world average of poison per inhabitant. Within this context, Brazil is the fifth largest user of pesticides, consuming a total of 300 tons/year. The national demand for those substances grows, according to several Brazilian scientists at a rate of 6,5%, per year, being larger than the combined volumes of the 4 countries that precede it. The indiscriminate use of pesticides affects not only the soil, but also rivers and oceans, to where 25% of these residues are drained. Besides the toxicity of the pesticides, inadequate use of equipments and lack of protection for workers result in harmful effects to the workers' health and population in general (PINHEIRO & ADISSI, 2004).

In 2003, agrochemical sales were approximately $ 3.1 billion, equivalent to 170 tons. This sales volume represented a growth of 63% over the previous year and, over the same period, imports grew by 55% (ABIQUIM, 2005). According to the same source, Brazil is a country of average consumption, equivalent to 3.2 kg of pesticides per hectare. To get a preview of what this index represents, in Table 2 shows the consumption of pesticides per hectare in various countries of Europe.

Country	kg / h	Country	kg / ha
Netherlands	17,5	United Kingdom	3,6
Belgium	10,7	Brazil	3,2
Italy	7,6	Luxembourg	3,1
Greece	6,0	Spain	2,6
Germany	4,4	Denmark	2,2
France	4,4	Portugal	1,9

Source: Sindag (2005).

Table 2 - Consumption of pesticides (kg / ha), 2003

The toxicity of products coupled with inadequate equipment and lack of protection for workers result in deleterious effects to health of workers and the general population.

Another serious environmental/health problem is generated by the reuse of discarded packings of pesticide by small farmers. Some types of empty packings, due to its size and resistance, are attractive for being reused as deposit of water, grains, manioc flour, among other uses (FERRAZ, 2000).

3.1. LEGISLATION ABOUT EMPTY PACKINGS OF PESTICIDES

Due to pressure from environmental NGOs, and associations of agricultural engineers, some states have stepped forward and drew up laws regulating the sale, use and disposal of pesticide containers. O Estado de Sao Paulo in 1984 published his 1st Law on Pesticides, the Law 4002 on 05/01/84, repealed by Act 5032 of 11/04/86 in some of his articles, and regulated by Decree 10/10 of 30.5645 / 89 and 31,132 on 05/01/90.

A milestone in relation to pesticides was the issue of federal law 7802 of 11/7/89 creating the obligation of Agronomic Prescription for the sale and use of all pesticides, belonging to any toxicological class. Decree No. 4074, of 04 January 2002 regulates Law 7802/89, provides for research, experimentation, production, packaging and labeling, transportation, storage, marketing, commercial advertising, the use , import, export, waste disposal and packaging, registration, classification, control, inspection and surveillance of pesticides, their components and related products, and other provisions;

Law 9974 of 06 June 2000 amending Law No. 7802, requires producers and distributors of pesticides, their components and the like, are responsible for disposal of empty containers of products they manufacture and market after the back from users. It also determined that users of pesticides, their components and related services shall file the return of empty containers of products to retail outlets in which they were purchased within one year following the date of purchase, the return may be mediated by vacancies and collection centers, and before returning to the rigid packaging that contain formulations miscible or water dispersible conducting the operation of triple washing.

The triple washing consists of washing with water three times in a row, rigid packaging, and this water will be spilled into the tank of application equipment along with the syrup. After proper washing, should be destroyed (by making holes in the bottom of the pack) to prevent any attempts to re-use, but taking care to preserve enough of the label.

The new wording of the 7802 law establishes a penalty of imprisonment from two to four years plus fines for those who produce, market, transport, apply, serve, give and waste disposal of empty agrochemical packaging, components and related services in compliance with the requirements stated therein.

CONAMA Resolution 334/2003, sets forth the procedures for environmental licensing of establishments for the collection of empty pesticide ANTT and Resolution 420/2004, kime empty pesticide as hazardous waste for purposes of transportation across the country, provided that subject for washing.

3.2. TYPES OF PACKINGS SOLD IN BRAZIL

According to the National Association of Plant Protection (ANDEF), the most common packages contained therein pesticides are:

a) rigid packaging

– metal drums - 50, 100, 200 L, buckets - 10, 20, 25 Kg

– plastic cylinders - 20 L bottles,

– glasses, bottles - 1/4, 1/2, 1 L

– fibrolatas, packs of 5 and 20 kg

b) Flexible Packaging

– plastic bags-1/2 - 30 Kg

– paper bags-1 - 30 kg

– cartridges, paper - 1/2 - 2 Kg

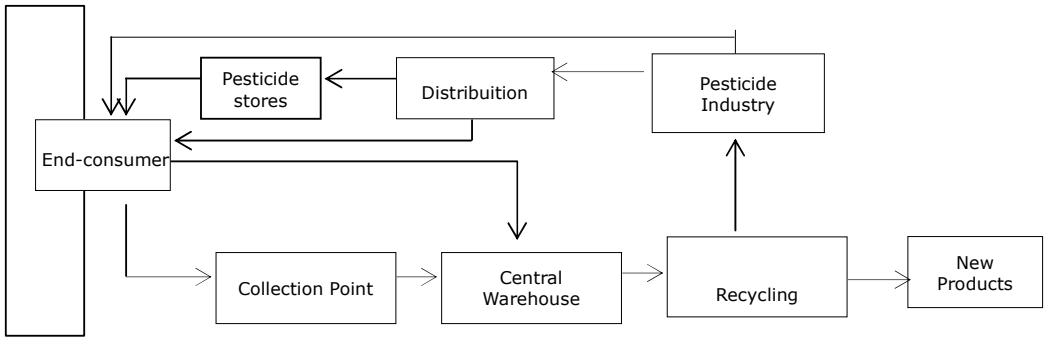
– collective cardboard boxes - 1 - 50 units

Besides these, there are large packages such as "FARM-PACK" returnable containers for fixed supply in bulk, type "BULK", contains up to 50,000 liters, and water soluble packaging. The rigid plastic containers can be manufactured in, high density polyethylene (HDPE), polyethylene co-extruded (COEX), or polyethylene terephthalate (PET) plastic covers of the containers are usually of polypropylene (PP).

3.3. THE RLS OF EMPTY PACKINGS OF PESTICIDES

Before the legislation previously mentioned, every sold product arrived to the farmer's hands with a simple guide that mentioned ways of conditioning the packings in rural areas. The most common “treatment” was to bury (following a series of technical procedures applied by the farmers) and incineration. At the present time, the logistics process of

destination and treatment of empty packings of pesticides follows the flow presented in the figure 1.



Source: Adapted from LIMA FILHO et al. (2006).

FIGURE 1: Reverse Logistics for empty packings of pesticides.

The process of reverse logistics of empty packings begins with the farmer, who has the legal obligation of, packaging, or three times pressure wash and return them within one year of purchase or six months after the due date of the validity of the product. Washing under pressure is used only in the case of rigid packaging, such as high density polyethylene and metal, which represent 85% of the material on the market. The advantage of the washing process is to make the packaging into common due to the reduction or elimination of contamination, ensuring that the farmer also earn that respect, since it can take about 3% more product, which previously had as waste packaging. The washed packages must be delivered to a reception given by the dealer on the invoice. The lids of the containers must be with holes. The packaging should never be carried along with people, animals, food, medicine or inside closed vehicles, when it is not washable. As for flexible, like paper bags, and aluminized low density polyethylene, which represent about 15% of total packaging circulating in the market because they are difficult to wash, are destined for incineration.

The construction of the collection center is the responsibility of dealers of pesticides. Moreover, it is up to them to indicate on the invoice, the address of the nearest receiving property of the farmer, guided the choice of form and time for delivery. Packages returned by farmers are inspected one by one, by trained staff at the reception, to establish the conditions for return, washed and unwashed, sending, after verification, proof of delivery for inspection purposes. Some of these units have received larger areas and can perform an operation to reduce the volume, facilitating transport to the final destination. They are called central

receiving stations or units that receive and sort the packages to be delivered in bulk units within their catchment area.

At the other end of the process of reverse logistics are the manufacturers of pesticides. As of central receiving, it is the industry the legal responsibility for coordination of transport, by incineration, the recycling facility for the manufacture of goods that use as raw material, packaging material from washed and returned, although it is up to their social responsibility to educate retailers and farmers, both on the use of the product and on the importance of reverse logistics process (SATO, CARBONI, MOORI, 2006).

The measure aims to prevent chemical residues return to nature and the inadequate reuse of the material. Without proper collection, packaging are dangerous sources of environmental pollution can contaminate soil, groundwater and still reach directly to human health (inpEV, 2006).

The RLS introduced in the previous figure can be broken down into various actors and their relationships, leading to a chain. In this study, the connections or relationships with a focus on recycled or recovered the first order, breaking the SLR into two subsystems or stages: data collection and system of post-collection (Figure 2).RLS into two subsystems or stages: collection and post-collection system (figure 2).

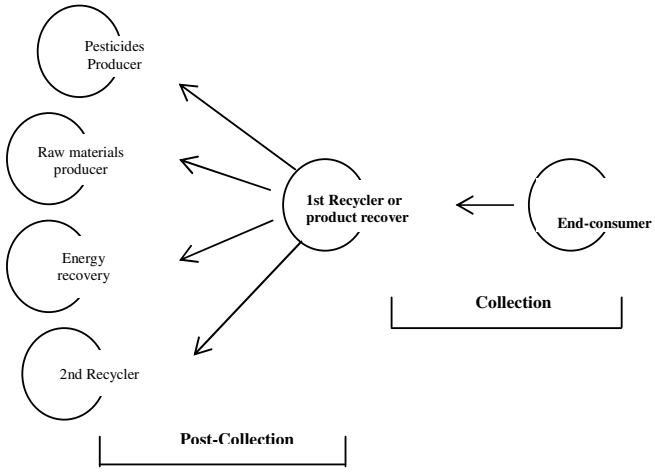


Figure 2: The studied RLS and its subsystems: collection and post-collection.

Mandatory since June 2002, returning empty containers of pesticides has increased in the country. With this, Brazil is already the country that collect pesticide containers in the world. The mesh of receiving empty now has 350 units managed by 185 associations, cooperatives and 40 dealers representing more than 2,200 distributors in 23 federal states,

elevating Brazil to the world leader in collection and disposal of empty containers of pesticides, surpassing the 30 largest countries with similar systems for the collection together, including: Germany, Australia, USA, Canada and France (inpEV, 2006).

The reverse logistics using the same truck that carries the full pesticide containers for distributors and cooperatives to bring empty containers (bulk or packaged), for storing it in the collection centers is more efficient in terms of costs. Before this process, the truck used to return empty. This process has advantages such as safety for the environment and health, as it uses a carrier capable of performing this type of transport and economy, since the truck has some of the costs paid when he took full containers. In four years of operation of the disposal, have been handled 15,981 trucks (equivalent to the truck), without any accident. Starting from a generic model of circular flow of materials (Figure 2), the system studied is positioned between the end consumer and supply chain, traditional or direct.

The system of post-collection can end with a producer of raw material, a manufacturer of final product (if parts are reused), an exploiter of energy (using fractions of a product as fuel) or other recyclers. The system of post-collection starts after the selection and removal of products to be recycled. After these processes, the system of post-collection is to be treated as a regular supply chain.

According to Kumar and Tan (2003) apud Sato, Carboni, Moore (2006), some factors have forced companies to adopt reverse logistics as a management strategy, such as:
a) Government legislation - legislation regulates the disposal of empty pesticide and defines the responsibilities of the farmer, dealer, manufacturer, and the government, the issue of education and communication;
a) Life cycle of products - reverse logistics must be considered within a broader concept, which is the life cycle of the product, which the logistical point of view, does not end with delivery to the customer. Products become obsolete, can be damaged or defective and must return to its point of origin to be properly discarded, repaired or reused. From the financial point of view, besides the cost of purchasing raw materials, manufacturing, warehousing and storage, life cycle of a product also includes other costs that are related to the entire management of its reverse flow;
b) New distribution channels - new distribution channels such as ecommerce, have been exploited to provide faster and better customers. These new direct distribution channels

should be prepared to manage a network of reverse logistics as the market becomes globalized;

c) Market forces - retailers believe that customers value the companies that have more liberal policies of product returns. This is a perceived advantage, and in this context, the suppliers or retailers assume risks for the existence of damaged products. It is a trend that is reinforced by the existence of laws that protect consumers by guaranteeing them the right to return or exchange;

d) Changes in the forces within the supply chain - according to Lacerda (2004), factors such as good control of entry, standardized processes and mapped, and cycle times, information systems, planning and logistics network between clients and suppliers can contribute positively to the performance of reverse logistics management.

Another important aspect for Sato, Carboni, Moore (2006), the adoption of reverse logistics management is to increase environmental awareness of consumers, who expect companies to reduce the negative impacts of their activity on the environment. This has led shares of some companies in order to communicate to the public an institutional image "green".

The adoption of a procedure for dealing with the disposal of empty pesticide is complex and requires the effective participation of all those involved in manufacturing: marketing, use, licensing, inspection and monitoring activities related to handling, transport, storage and processing of these packages.

In the 90´s the Brazilian industry began to seek a solution for the problem of empty packings of pesticides. By that time a partnership among ANDEF (the General office of Agriculture of the state of Sao Paulo), AEASP (the Association of the Agricultural Engineers of the State of São Paulo) and COPLANA (the Association of Sugar Cane Producers of Guariba District) was created in order to study the flow of empty packings of pesticides. Through this initiative it was implemented the first unit of reception and primary treatment of packings of pesticide. Recycling alternatives were created through an agreement with a small company of the pesticide industry.

An important and critical step for conducting this project was the contribution of the Brazilian Association of Technical Standards (ABNT) for the development of standards and procedures for the treatment and washing process of empty packings of pesticides. The establishment of these procedures has permitted that the packings of pesticide could pass to a dangerous residue to be considered common dejections, which made possible its recycling.

On December of 2001 the National Institute of Processing of Empty Packings was founded (inpEV). In March of 2002 the inpEV started to operate with the support of 22 pioneering companies. By the end of 2002 inpEV has collected 3.700 tons of empty packings of pesticides. After 4 years of operation, inpEV already processed a total of 56.000 tons of empty packings of pesticides. Now the Brazilian system of final destination of empty packings of pesticides is world reference in the subject when destining more packings than the sum of 30 countries that possess similar programs. Nowadays, the institute operates with 66 companies and 7 associated entities. The structure of the RLS operated by inpEV is formed by 365 processing units (collection points, central warehouses and recycling plants), which meant 19.634 tons of packings by the end of 2006.

4. MARKET VIABILITY FOR EMPTY PACKINGS OF PESTICIDES

After four 5 years of operation of INPEV, some Brazilian states continue presenting significant growths in the indexes of devolution of packings, with prominence for Mato Grosso do Sul, that increased their devolution indexes in 49% (it passed of 646 tons in 2004 and 965 tons by the end of 2005), Rio Grande do Sul, increased 47% (it passed of 996 tons for 1.464 tons) and Bahia, increased 42% (it passed of 683 tons for 969 tons of returned packings).

States of Paraná and Mato Grosso continue in the leadership in the collection of the empty packings of pesticides in Brazil, since in 2005 it has been returned in these States 4.006 tons and 3.891 tons, respectively. The state of São Paulo occupies the third position, with the processing of 2.597 tons of empty packings, what represents 12% of growth in relation to the year of 2004 (inpEV, 2007).

Besides 2 companies that practice energy recovery, in terms of final destination, the RLS for packings of pesticide in Brazil has 8 companies certified by inpEV that receive and recycle these packings. Only those companies are capable to deal with the recycling of these packings. These companies are strategically located in 5 Brazilian States (figure 3).

Figure 3. Location of the recycling companies in Brazilian territory.

The products resulted from the recycling of the packings are: cardboard barrels, tubes for sewer, packings for lubricating oil, boxes of automotive battery, and covers for packings of defensive agricultural, among others. The covers of the packings of pesticides are the first products returned for original use through recycling. The final products are produced by consent of inpEV, which prioritizes products for industrial use.

Figure 4. Recycled products

Now the priority of the actors of this system is the search for mechanisms that make the program sustainable, since today it is integrally financed by farmers, distributors, cooperatives and manufacturing industries, each one of them with a quota of responsibility. The program does not seek profit but the execution of the legislation with benefits to the environment.

5. FINAL CONSIDERATIONS

Besides contributing for the preservation of the atmosphere for future generations, the management of the RLS for packings of pesticide develops an important socio-economic function in Brazil. It generates more than 2.500 direct jobs along the whole chain

(associations of distributors, cooperatives, collection points, carriers, recycling companies and services providers).

One of the main goals of the legislation is to direct the material flows in packings of pesticide chains in an economical way towards environmentally friendly disposal options. Therefore, it is necessary for legislators to understand the structure of the supply chains for packing sod pesticide, technologies and markets. The primary goal of a legislator is to develop competitive markets by turning the negative value of packings of pesticide into a positive one. This can be done by encouraging research and development for new products derived from packings of pesticide and for better methods to process those packings.

In line with this discussion, this paper has identified two research topics that are of importance for scrap tire supply chain management:

- How to set the budget for empty packings management programs and how to allocate it to different markets?

- How to organize the collection of empty packings?

These issues can also be applied to other industries for which landfilling poses a heavy environmental burden. For example, the End of Life Vehicle Directive of the EU stipulates that starting from January 2007 drivers will be able to leave ELVs at an authorized treatment facility without incurring a charge.

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