SELECTED PROBLEMS OF REVERSE LOGISTICS IN POLAND

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Abstract: This paper presents the essence of reverse logistics and directions of physical and information flows between logistic network partners. It also analyses effects of implementation of the principles of reverse logistics in Poland in the years 2004-2007.

Keywords: reverse-logistics, waste, recycling, salvage

1. Theoretical background of reverse-logistics

Market globalization, increased number of entities cooperating with one another and increased scope of vertical and horizontal cooperation have led to a search for appropriate organizational configurations of the cooperating or competing entities. Logistic networks have become an alternative to the traditionally understood relations between suppliers and consumers dominated by mutual antagonisms and desire to make use of one's own strength. One of the elements of the logistic network environment are natural environment factors. The logistic network structure determines the level of costs and level of impact of the processes implemented within its scope on the natural environment. Logistic network partners undertake numerous activities leading to the implementation of the assumed goals. Thus it is of great importance to identify activities aimed both at reducing the costs and decreasing the negative impact on the natural environment. Some sample activities have been presented in Table 1. Figure 1. presents directions of physical flows between the logistic network partners.
Increasing environmental pollution has forced the economic entities to implement actions aimed at reducing the negative impact of their activities on the natural environment. Intensification of pro-ecological activities has especially been caused by [3.]:

1. legal requirements related to the responsibility of economic entities for manufactured products in the whole life cycle, obliging them mainly to dispose of or recycle the wastes in a proper way as well as to use recyclables in the production process,
2. ecological awareness of the customers, who are more willing to purchase environmental friendly products.

Drawing 1. shows that some physical flows have a reverse direction: from the consumption stage to the production stage. Such flows are characteristic of reverse logistics. Development of reverse logistics has been caused by an interest in re-using of used products and packaging. Reverse logistics is defined as a "process of recalling products from their usual final destination for the purpose of restoring their value or disposing of them in a proper way" [6.]. Reverse logistics is also „referred to as the process of logistics management involved in planning, managing, and controlling the flow of wastes for either reuse or final disposal of waste" [2.]. So the basic goal of reverse logistics is to increase the amount of disposables in production and consumption and thus to decrease the amount of used materials.

Table 1. Main activities influencing costs and environmental impact in logistic network

Type of factor	**Variables**
Transportation	- Transport from supplier to manufacturers and vice versa - Transport from supplier to consumers and vice versa - Transport from supplier to end-of-life facilities and vice versa - Transport from manufacturers to consumers and vice versa - Transport from manufacturers to end-of-life facilities and vice versa - Transport from consumers to end-of-life facilities and vice versa
Manufacturing	- Manufacturing at suppliers - Manufacturing at manufacturers
Product use	- Product use by consumers
Testing	- Testing
End-of-use alternatives	- Re-use - Refurbishing - Recycling - Energy production

Source: [9.]

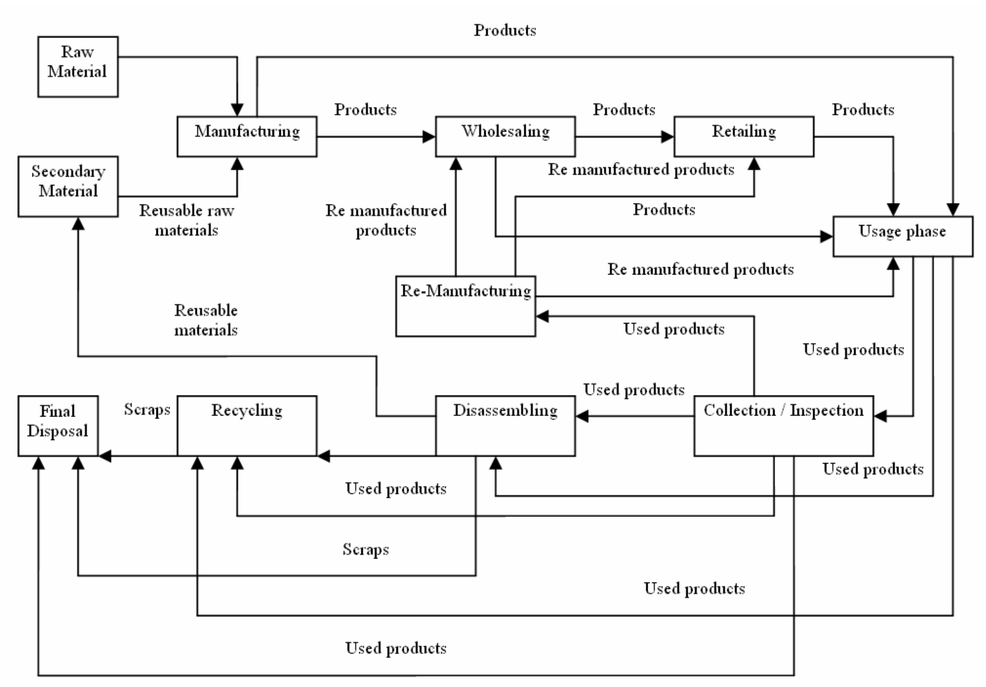


Figure 1. Framework for a sustainable logistic network.
Source: [9.]

Reverse logistics management is based on four basic principles [6.]:

1. limitation of production of new materials thanks to replacing them with recyclables,
2. usage of ecological materials,
3. re-usage of materials (e.g. packaging),
4. recycling of used materials and products.

Because of the implementation of the principles of reverse logistics, logistic networks become really closed systems, i.e. systems to which the wastes return in a part dependent on the level of their usage [1.]. And only such wastes, which cannot be re-used, enter the environment.
Owing to their goals and objects, the physical flows in the reverse logistics subsystems will take place in the so-called redistribution channels, while in case of other logistic subsystems we deal with distribution channels. Differences between these two channels have been presented in Table 2.

Table 2. Distribution and redistribution channels

Category	**Channel**	
	Distribution channel	**Redistribution channel**
Objects	• High-value final products • Highly diverse • Few producers	• Low-value wastes and pollution • Poorly diverse • Many consumers
Market	▪ Many consumers ▪ Diverse demand structure ▪ High diversity of consumers	▪ Few producers ▪ Poorly diverse demand structure ▪ Poor diversity of consumers
Tasks	▪ Sorting according to the type ▪ Distribution	▪ Sorting ▪ Collection

Source: [8.]

Reference books describe many models of reverse logistics. Most of them take into account four critical activities: collection, storage, treatment and distribution. Figure 2. shows a sample model of reverse logistics.
The concept of reverse logistics is characterized, similarly to the concept of logistics, by: [com. 5, 8.]:

- system-oriented thinking,
- general and total cost-oriented thinking,
- service-oriented thinking,
- effectiveness-oriented thinking.

Thinking in systemic terms includes dependencies between individual elements of the reverse logistics subsystem. It is also essential to analyse substantive and information processes which take place between the sites where the wastes are generated and sites where they are recycled. Three basic multi-level structures are distinguished in the structure of waste flows:

1. various groups of wastes are generated in the same site and thanks to transformation processes they are sorted and sent as uniform wastes to relevant storage, processing, recycling and similar sites,
2. the same groups of wastes generated in various sites are sent to recycling place,

3. there are many sources which generate wastes as well as many final destinations of wastes.

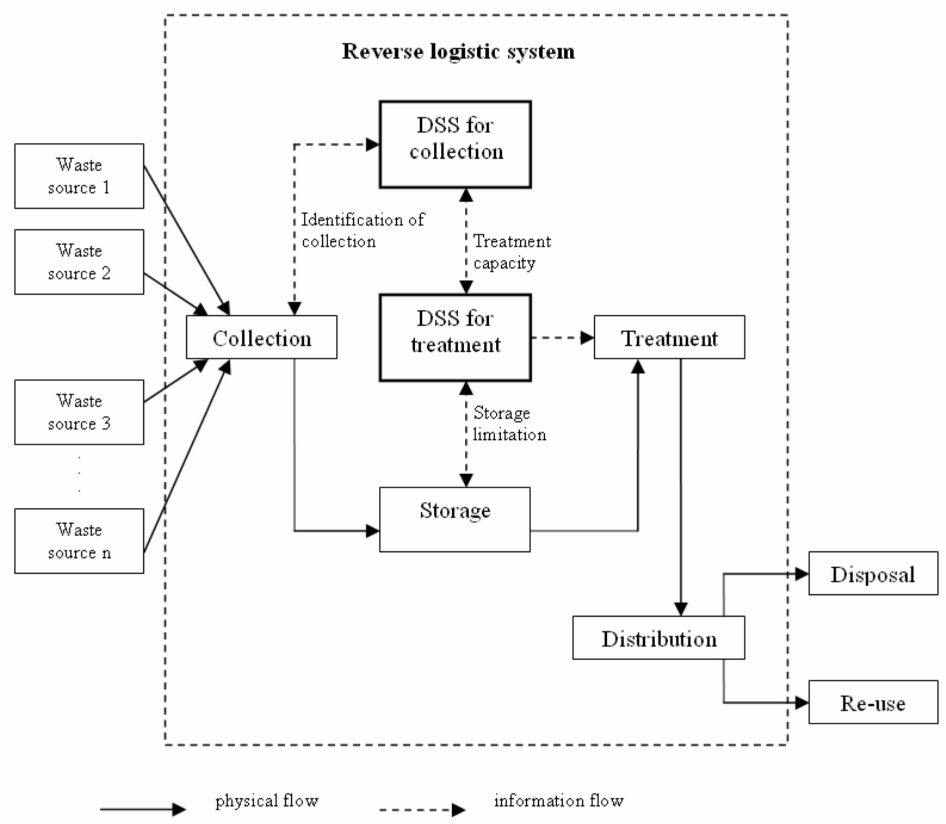


Figure 2. Conceptual model of the sample reverse logistics system.
Source: [2.].

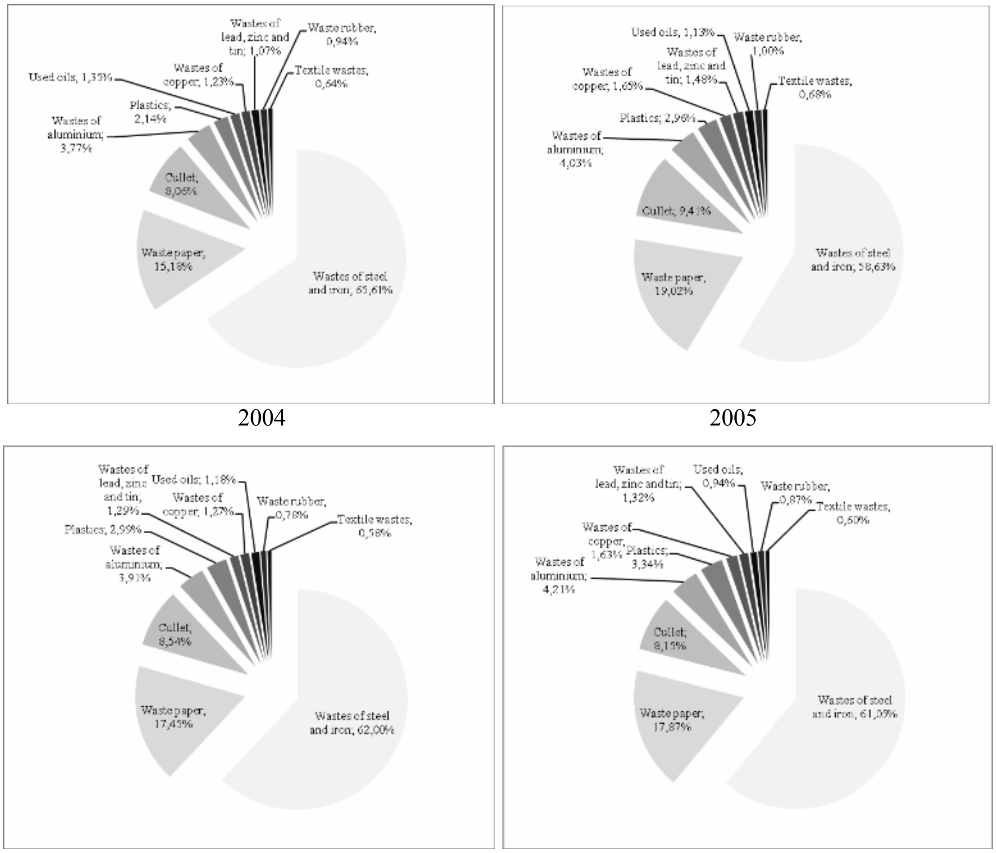
Thinking in systemic terms allows one to include the reverse logistics processes into each logistic network level. Thinking in terms of general costs aims at identifying all important cost elements connected with the reverse logistics processes. Thinking in terms of service is connected with delivery of the remains and wastes to recycling equipment and their removal from sites which generate them. Thinking in terms of efficacy covers aspects of economic and ecological efficacy. This efficacy can be measured by e.g. amount of the recovered material. In case of service-oriented thinking we can differentiate between two aspects [7.]:

1. if the wastes can be re-used following recycling processes, they must be adequately prepared in respect of type, amount, place and time, and the service level will be entry-oriented and calculated as a relation between the amount of the reported demand for wastes and the amount of the satisfied demand,
2. system exit-oriented service level (grade) is calculated as a difference between the amount of wastes generated upon the system entry and amount given in a specified time for elimination.

So efficacy of the reverse logistics will be expressed as the amount of recycled wastes or wastes given for elimination.

2. Analysis of the quantitative scale of usable wastes in Poland

To achieve a qualitative and quantitative reduction in the danger to the natural environment and inconveniences caused by the production of all kinds of wastes, the Polish companies, apart from pollution preventing actions, also undertake actions aimed at re-usage of the already produced wastes. Wastes generated in production processes (the so-called post-production wastes) and used products (the so-called post usage wastes) subject to processes restoring their utility for their manufacturers, keepers or other users are called recyclables. Structure of the sales of metallic and non-metallic recyclables in the production units has been presented in Figure 3. (supply) and Figure 4. (use).



2006 2007

Figure 3. Supply of secondary raw-materials in production units

Source: Own elaboration.

Structure of supply of recyclables in the years 2004-2007 is similar. In each analyzed year one generated or purchased the highest amounts of waste of steel and iron, and waste paper, and the lowest amounts of waste rubber and textile waste. Waste of steel and iron constitutes over half of the generated or purchased wastes.

Structure of use of recyclables in the years 2004-2007 is similar. In each analyzed year one used or sold the highest amounts of waste of steel and iron, and waste paper, and the lowest amounts of waste rubber and textile waste.

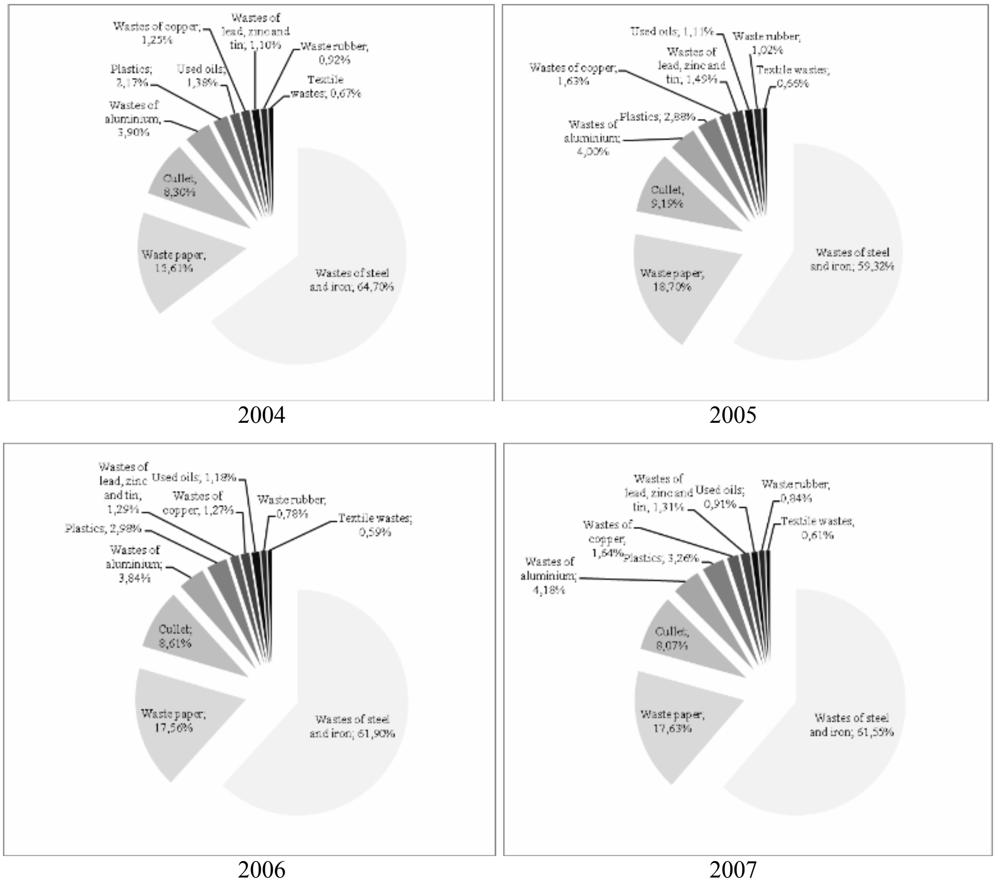


Figure 4. Use of secondary raw-materials in production units
Source: Own elaboration.

Table 3. outlines share of supply of recyclables from one's own activity in the total supply as well as consumption structure of recyclables for own needs in the total use

The majority of possessed recyclables come from purchasing centres. The recyclables came from one's own activity only in case of plastics and cullet in the years 2004-2005. plastics and textile wastes in 2006. and plastics and waste rubber in 2007. In each analyzed year. the following recyclables were most widely used for one's own needs: wastes of steel and iron (over 90%). wastes of copper. wastes of lead. zinc and tin. wastes of aluminium. used oils. cullet. waste paper.

Waste paper has a considerable share in recoverable material wastes. It is mostly used for the production of paper and cardboard. Consumption (recovery) of waste paper. understood as a number of kilograms of waste paper used for the production of 1 ton of paper and cardboard is indicated by the so-called consumption index. Dynamics of the consumption and stock of waste paper was presented in table 4.

In the years 2003-2007 consumption of waste paper increased considerably compared to 1995 and 2000. Single-basis dynamics indices show an increase in the waste paper consumption in each analyzed year:

– from over 40$ to over 80% compared to 1995. the increase showing an upward trend from one year to another,

– from over 29% to over 60% compared to 2000. the increase showing an upward trend from one year to another.

Table 3. Turnover of secondary raw-materials in production units

	2004		2005		2006		2007	
	supply from one's own activity / total supply	consumption for own needs / total use	supply from one's own activity / total supply	consumption for own needs / total use	supply from one's own activity / total supply	consumption for own needs / total use	supply from one's own activity / total supply	consumption for own needs / total use
Wastes of steel and iron	21.20%	95.01%	22.03%	95.35%	21.52%	95.02%	22.95%	94.48%
Wastes of copper	28.94%	74.64%	36.88%	67.50%	34.08%	74.96%	39.68%	74.90%
Wastes of lead. zinc and tin	24.64%	68.31%	19.08%	74.94%	19.84%	73.58%	18.79%	72.61%
Wastes of aluminium	39.61%	68.65%	36.93%	67.66%	38.22%	62.01%	35.81%	63.82%
Used oils	24.92%	70.31%	23.25%	68.61%	16.69%	63.68%	20.62%	64.64%
Plastics	66.52%	33.30%	64.26%	38.33%	65.32%	37.70%	63.54%	37.70%
Waste rubber	34.57%	52.96%	34.68%	56.53%	46.36%	47.55%	51.93%	43.80%
Cullet	55.55%	75.20%	48.81%	71.91%	47.26%	71.90%	49.44%	66.96%
Waste paper	29.85%	70.42%	30.60%	65.46%	36.02%	65.59%	35.33%	61.73%
Textile wastes	31.04%	35.30%	27.06%	31.13%	64.82%	28.16%	74.74%	25.82%

Source: Own calculation based on date from [4.].

Table 4. Use and stock of waste paper (in thous. t)

	1995 = 100%					2000 = 100%				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
Total use	140.89	153.99	170.01	178.35	188.82	124.19	135.73	149.85	157.21	166.43
Of which production of cellulose mass. paper and paper products	139.80	152.93	166.84	176.76	183.40	124.33	136.01	148.38	157.20	163.10
Total stock	86.18	102.64	89.02	79.07	128.46	110.13	131.17	113.77	101.04	164.16
Of which production of cellulose mass. paper and paper products	83.67	99.59	84.08	73.67	122.65	107.05	127.42	107.57	94.26	156.92
Factor of use of waste paper on 1 ton of paper and cardboard	100	100	100	100	100	100	100	100	100	100

Source: Own calculation based on date from [4].

In case of waste paper stock one can observe an increase in individual years compared to 2000. While analyzing the proportion of stock in individual years to the year 1995. an

increase could only be observed in 2004 and 2007. Index of waste paper consumption in the whole analyzed period remained unchanged and amounted to 0.4 for individual years.
Table 5. presents number of packaging and products introduced into the market and achieved levels of recovery and recycling of packaging wastes and post-usage wastes.

Table 5. Packaging and products introduced to the market and achieved levels of recovery and recycling of packaging and after-using products wastes

		An amount of on the market brought packaging and products subject to a duty of			Wastes exposed to		Achieved level of	
		total	salvage	recycling	salvage	recycling	salvage in percent	recycling
Packaging (in thous. t)	2003	2 579.9	–	2 535.2	–	677.9	–	26.7
	2004	2 890.2	–	2 640.6	–	941.0	–	35.6
	2005	3 174.1	–	2 878.4	–	1 342.8	–	46.7
	2006	2 982.5	3 254.2	2 655.4	1 772.9	1 659.3	54.5	62.5
	2007	3 133.7	3 122.5	2 561.1	1 874.8	1 235.5	60.0	48.2
Smear oil (in thous. t)	2003	201.7	169.0	144.0	88.3	48.9	52.3	33.9
	2004	211.5	211.5	241.0	89.5	73.6	42.3	30.5
	2005	196.8	196.7	190.6	99.8	65.1	50.8	34.1
	2006	185.6	185.6	179.5	96.6	69.7	52.1	38.8
	2007	181.6	181.6	179.2	102.8	76.0	56.6	42.4
Tyres (in thous. t)	2003	136.0	129.9	–	56.5	–	43.5	–
	2004	151.4	150.7	150.7	88.7	17.3	58.9	11.5
	2005	147.8	146.0	145.1	120.3	23.6	82.4	16.2
	2006	185.7	183.4	183.4	167.5	36.0	91.3	19.7
	2007	195.5	195.5	195.5	178.3	46.3	46.0	11.9
Nickel-cadm. accumulators (in pieces)	2003	2 593 041	2 490 986	2 490 986	317 001	329 191	12.7	13.2
	2004	3 193 357	3 191 932	3 191 932	1 119 651	1 256 070	35.1	39.4
	2005	2 021 458	2 009 182	2 020 460	1 711 732	2 158 155	85.2	106.8
	2006	3 215 207	3 214 127	3 214 127	2 213 755	2 205 955	68.9	68.6
	2007	4 531 476	4 531 476	4 531 476	2 695 798	2 635 359	59.5	58.2
Batteries and galvanic cells (in pieces)	2003	251 974 874	251 866 945	13 132 740	12 565 953	542 523	5.0	4.1
	2004	253 183 265	248 475 328	13 890 314	24 051 352	948 728	9.7	6.8
	2005	194 561 647	194 367 868	10 782 229	28 941 229	2 649 101	14.9	24.6
	2006	205 400 902	205 400 008	19 897 130	38 822 845	2 797 204	18.9	14.1
	2007	262 491 780	262 491 780	13 759 063	76 536 256	4 460 203	29.2	32.4
Discharge lamps (in pieces)	2003	18 050 529	18 026 336	18 009 536	2 381 385	2 391 506	13.2	13.3
	2004	8 456 760	8 456 727	8 456 727	1 542 339	1 566 116	18.2	18.5
	2005	22 190 958	22 190 958	22 190 958	5 789 843	5 786 085	26.1	26.1
	2006	22 516 842	22 513 246	22 513 246	8 705 245	8 644 043	38.7	38.4
	2007	6 891 422	6 891 422	6 891 422	4 917 499	4 741 647	71.4	68.8

Source: Own calculation based on date from [4.].

In the years 2003-2007 one could observe a slight average annual increase in the number of packaging, tires, nickel-cadm. accumulators and batteries. and galvanic cells introduced into the market by respectively 4.98%. 9.50%. 14.98%. 1.03% and average annual decrease in the amount of smear oil and discharge lamps by 2.59% and 21.39 % respectively.
Achieved level of recovery or recycling is calculated as a proportion between the amount of wastes given for recovery or recycling and the amount of wastes which are required to be recovered or recycled. Index of recovery and recycling level may also be calculated as a proportion between the total amount of wastes given for recovery or recycling and the amount of wastes introduced into the market. required to be recovered or recycled. It should be emphasized that the amount of wastes given for recovery and recycling in a given reporting year often includes the so-called surplus from the previous year. denoting an amount of recovery and recycling exceeding the level required in a given year. achieved by companies and organizations dealing with recovery. Because this. this index may achieve values of over 100%. Dangerous wastes are also given for recovery (Table 6.).

Table 6. Hazardous waste generated and salvaged during the year (in t.)

	Total	**Salvaged**	**% of salvaged waste**
1998	1 104 754	366 784	33.20%
1999	1 133 913	400 313	35.30%
2000	1 601 456	476 883	29.78%
2001	1 308 496	368 628	28.17%
2002	1 029 353	454 524	44.16%
2003	1 338 870	482 423	36.03%
2004	1 349 286	487 504	36.13%
2005	1 778 881	512 998	28.84%
2006	1 811 726	492 072	27.16%

Source: Own calculation based on date from [4.].

In the years 1998-2006 one could observe an average annual increase in the amount of the generated dangerous wastes as well as in the amount of dangerous wastes given for recovery by 6.38 % and 3.74% respectively. Share of the amount of recovered materials in the amount of generated wastes in individual years is similar and amounts to 28.17 % - 36.13 %. with the exception of 2002 when it reached over 44 %.

3. Summary

The end of the 20th century and the beginning of the 21st century can be characterized by a dynamic development of ecological concepts of economic systems functioning. A special attention given to the pro-ecological activity has caused by an increasing degradation of the environment brought about by the economic activity. Moreover. the ecological awareness of the customers is also developing and they often prefer to pay more for goods that do not pollute the environment at any stage of the life cycle. Wastes are pollution that is generated in almost every type of economic activity. The hierarchy of rules of dealing with wastes is clearly defined – the crucial action is to prevent their generation or to minimize the amount of the wastes. This action constitutes one of the principles of reverse logistics. whose basic aim is to increase the amount of recyclables in the production and consumption and thereby to limit the amount of consumed materials. These actions seem to be profitable due to the fact that the higher the number of cycles related to the re-usage of a given raw material. the smaller the usage value of the goods produced from them. Implementation and consistent putting into practice the principles of reverse logistics brings fruit in a form of reduced amounts of wastes. increased wastes given for recovery and increased amounts of recyclables used in the production process.

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