DEVELOPMENT OF RECOVERY LOGISTICS IN POLAND

Agata Mesjasz-Lech

University of Czestochowa

Abstract: The paper presents basic terms in the field of recovery logistics, with the special consideration of its methods, so like salvaging and the recycling. Effects of development of recovery logistics were exposed to the analysis in recent years in Poland.

Keywords: business system, waste, recycling, salvage, recovery logistics

1. Waste and contaminations as the effect of functioning of business system

Waste and contaminations are the consequence of processes realized in the business system. It takes energy and non-energy resources from the environment, processes them and deliveries the useful product in the form of specific goods and services to the environment as the result [1]. Waste and contaminations transferred to the environment are unfortunately the result of processing processes. Functioning of business system is presented on the figure 1.

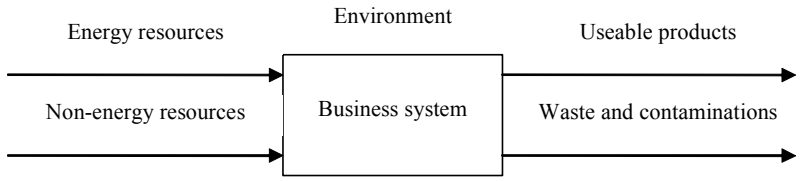

Figure 1. View schema of business system *Source: [1]*

The increase of importance of the environmental protection in the business activity has resulted in attaching the bigger and bigger weight to methods of dealing with waste. It turned out that waste was able to become the valuable raw material, finding the reuse in the business system. Waste can be included in repeated circulation after their earlier processing, in order to assign a utility value to such waste. Waste generated in given product (also raw materials, semi-finished products etc.) consumption as well as used disposable packaging can be processed in order to reuse. The real closed business systems have been created in this way. In such created systems waste is salvaged and returned towards the entrance of the system in most cases. The figure 2. presents functioning of the real closed business system.
The system presented on figure 2 was called real closed business system because waste returns to the systems only partly, because the mark of its usage is determined with level of the technology. Only waste which isn't able for reuse lands to the environment. Advantages of real closed business system are first of all:

- Reducing the degree of the environment impurity,
- Exploitation of significantly smaller quantities of natural resources from the environment,
- Reducing capital-output ratio and energy-consuming processes of secondary raw materials winning and processing [5],
- Economic efficiency improvement thanks to decreasing production costs,
- Realizing the principle of sustainable development.

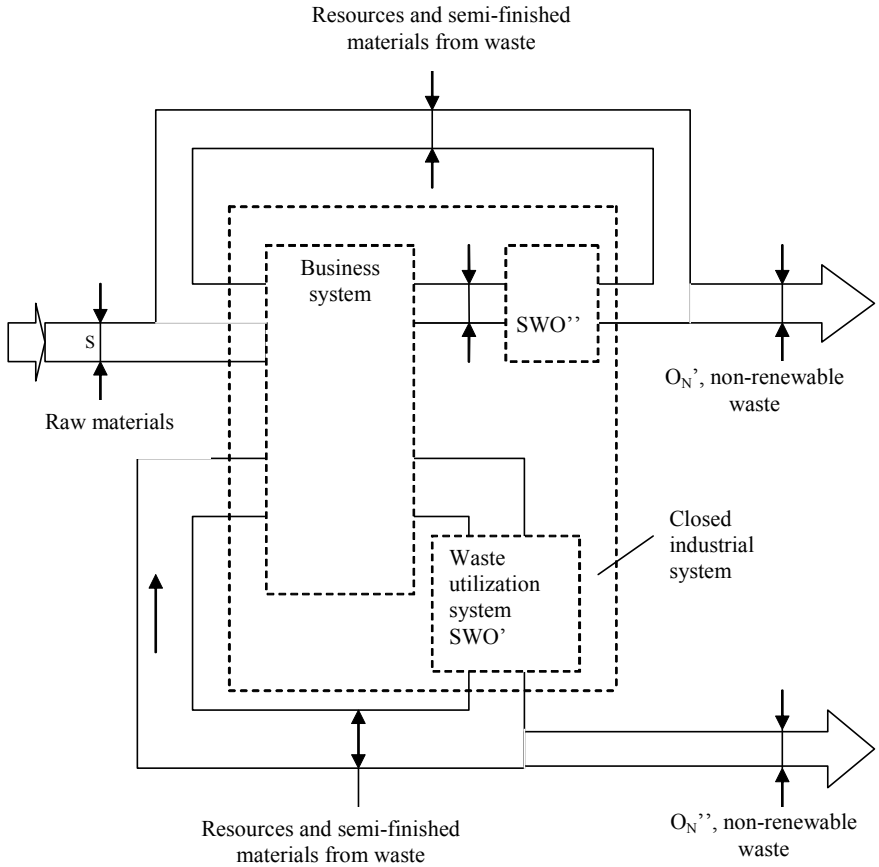

Figure 2. View of raw materials, products and waste flow in real closed business system; S – raw materials flow, P – products flow, O_N', O_N'' – non-renewable waste flows, SWO' – system of post-usage resources utilization, SWO'' – system of production waste utilization *Source: [1]*

2. Recovery and recycling as the basic processes in the real closed business system

Recovery and recycling are the basic processes which purpose is returning waste and used products to the entry of economic system. "Recovery shall mean any operations which do not endanger human life and health or the environment, consisting in the use of waste in whole or in part, or leading to extraction and use of substances, materials or energy"[3]. However the recycling is understood as such recovery "as consist in reprocessing of substances or materials contained in waste through a production process to recover substances or materials for their original or different uses"[3, 7].

The recycling is a stage process, which consists of following elements [8]:

- Proper state policy favoring the recycling,
- Proper designing of goods:
  - the broadest usage the materials suitable for the recycling for their production,
  - using homogeneous materials what simplifies disassembly and segregation processes,
  - joining various materials in such way, so that their future disconnection will be the simplest,
  - using component parts which are able to reusage without or at minimal processing,
- Development of the processing technology in order to use their biggest part,
- Waste, products and component elements of products signifying system in order to make the segregation process easier,
- Sort, assembling and the collecting of used products logistics,
- Proper waste preparing for the processing and raw materials processing and recovering.

For the sake of the waste kind and the possibility of further methods of dealing with waste three kinds of the recycling can be distinguished [8]:

- Reuse – recurrent usage of material or product in the same purpose (e. g. tyres retreading, replaceable bottle),
- Further usage – using waste for new applications after the proper physical, chemical or biological modification (e. g. granulation of used plastics and tyres, where granulate can be used as filler in building materials),
- Renewed consumption – recovery of chemical waste from total waste quantity and its renewed introduction into production process (using car wrecks in steel factory).

For the sake of the specificity of technology it is possible to determine three basic methods of recycling:

- Material (mechanical) – the most preferred form of the recycling. It depends on the renewed processing of waste to the product of the use value. It is usually product of other use than the original what creates the cascade system, in which every next stage has smaller requirements laid down for products. The suitable selection of composition permits the processing recyclable materials with big efficiency under the good quality of products. This method is technologically simple when concerns materials about the identical chemical structure.
- Raw materials (chemical) – depends on winning raw materials used for the production of given product. Raw materials can be reused for producing balanced materials and waste generated as a result of this method (petrochemical light and heavy fractions) can be use as admixture to fuels and lubricants. The basic advantage of this method is the possibility to modification the materials without their previous segregation.
- Energy (burning with energy recovery) – depends on partial winning of energy which was used for producing products which are collected on dumps (of which also packages).

Recycling has apart from positive results, unfavorable consequences, among which the following effects are the most often enumerated [5]:

- Increase of labour-consuming of processing recyclable materials compared with the processing of original raw materials, caused mainly by need to carry out additional

modification operations, decrease of efficiency of machines because of the worse quality of recyclable materials, increase of work costs,
- Contamination of post-usage waste contributing to the increase impurity of processing industry of recyclable materials,
- High investment outlays for the necessary infrastructure,
- Complexity of technological processes because of lower value of technological and quality indicators of recyclable materials,
- Worse technological characteristics of recyclable materials obtained from regeneration or processing what causes decrease of utilitarian and quality indicators of products which are produced from them,
- High costs of processing of recyclable materials in the relation to original raw materials.

3. Essence and meaning of recovery logistics in efficiency of functioning of real closed business system

Development of recovery logistics was caused by interesting of reuse of used products and packages. Recovery logistics can be defined as:

- "applying the concept of logistics in regard to the remainder and causing economicly and ecologically effective flow of the remainder, at the simultaneous space-time transformation, including the change of quantity and sort" [4],
- "process of withdrawing products from their common place of the final use in order to restore them the value or to disposal them using proper method" [6].

The basic purpose of recovery logistics is also increasing the quantity of recyclable materials in production and consumption and thus reducing quantity of used materials on condition that activities realized in this direction will be economical. It is necessary to remember, that the more cycles tied with the reuse of given raw material the smaller use value of products produced from them (fig. 3).

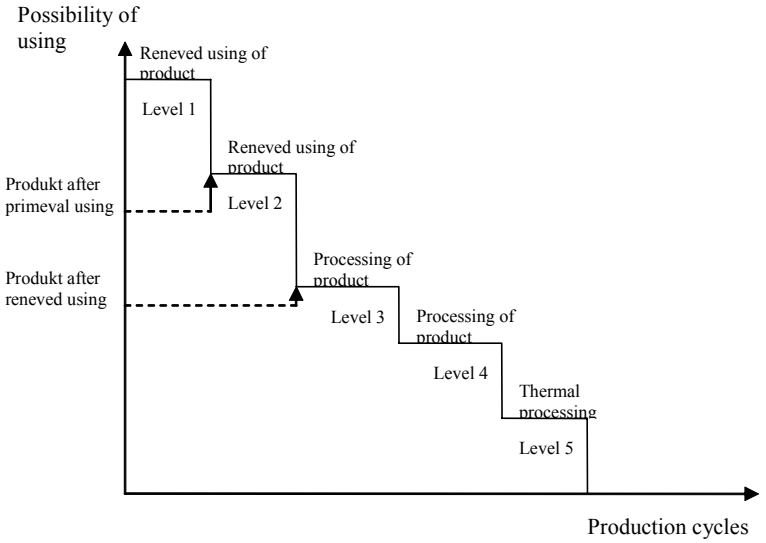

Figure 3. Dependence between production cycles and possibility of using
Source: [2]

Essence of recovery logistics is based on four basic principles [6]:

1. Reducing new materials in production thanks to replacing them with recycled materials else,
2. Usage of ecological materials,
3. Reusage of materials (e.g. packaging),
4. Recovery of used materials and products.

Recovery logistics is possible when:

- The product life cycle will be analyzed in order showing the impact of environment factors on its production, use and disposing,
- Products will be able to take to pieces and recycle,
- Producers will collaborate with deliverers in order delivering reusable and recyclable materials,
- Packages producers will take the possibility of their multiple-use or processing into consideration.

4. Effects of recovery logistics in Poland

The problem of waste and their negative influence on the environment is more and more noticeable. The new Act of 27 April 2001 on Waste (O. J. No. 62 item 628) which determines the basic principles of dealing with waste in order reducing their negative influence on the environment has bound in Poland since April 2001. Development of ecologically oriented concept of logistics, of which recovery logistics, has contributed to the fact that the right methods of dealing with waste must be not only ecologically, but also economic efficient.
The waste problem in Poland is still serious. The quantity of generated waste has kept on the constant level since 2000 (fig. 4.). Only in 2002 it was possible to watch their not large decrease about less than 5% in the relation to the year 2001.

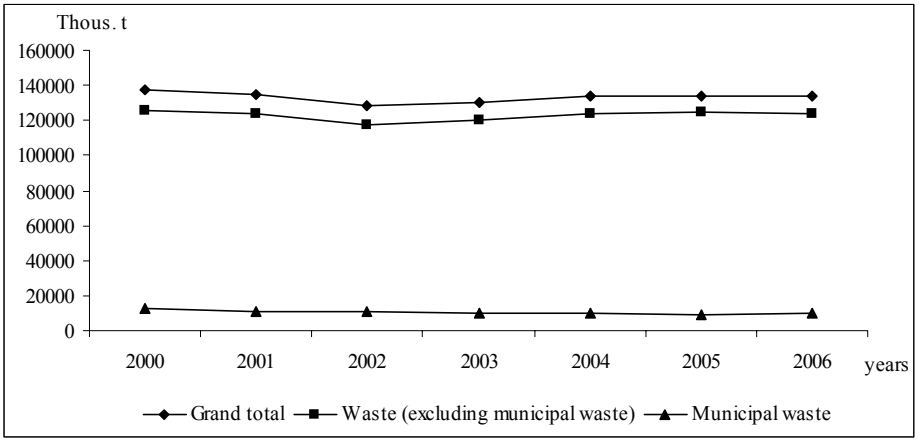

Figure 4. Waste generated during the year (in thous. t)
Source: Own elaboration based on [3]

Annual average rate of changes of all generated waste quantity was -0.27% in years 2000-2006. The bigger changes in this period it is possible to notice in the level of municipal waste, whose quantity has decreased average by 3.62% year in, year out.

Economic processes occurring in Poland, as well as change in pro-ecological behaviour of economic units have contributed to the changes in structure of plants generating waste (fig. 5.). Although their number grew – it was them about 360 more in 2006 than in 2002, they recovering and disposing than storing waste more often and more often.
Watching changes in the structure of companies generating waste in years 2002-2006 it was possible to notice that:

- Annual average increase of number of companies recovering waste came to 2.89%,
- Annual average increase of number of companies disposing waste came to 1.04%,
- Annual average increase of number of companies storing waste came to 1.16%.

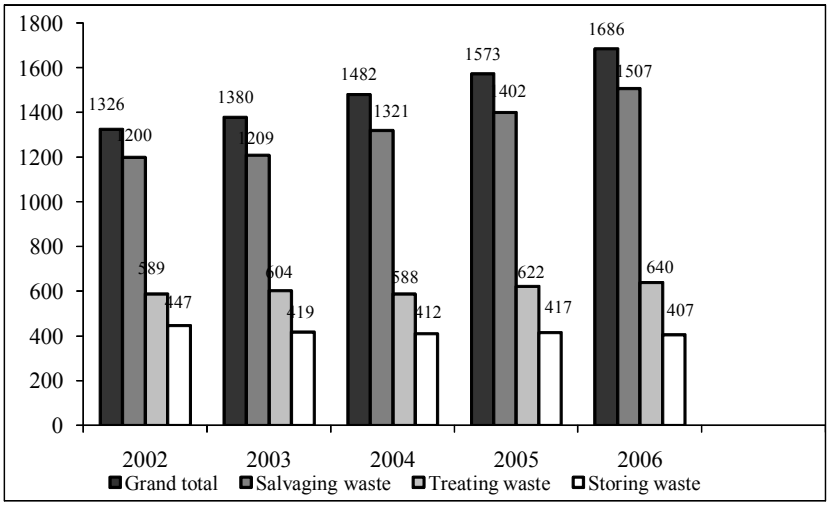

Figure 5. Plants generating waste
Source: Own elaboration based on [3]

The percentage of plants recovering, disposing and storing waste is presented on fig. 6.

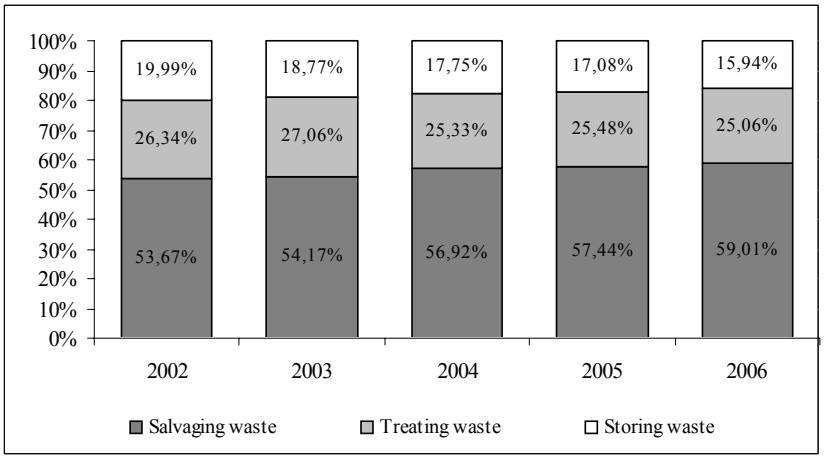

Figure 6. Plants generating waste
Source: Own elaboration based on [3]

Plants recovering waste presented bigger and bigger percentage in the structure of plants generating waste - in 2006 they posed over 59%, while in 2002 - around 54%. The percentage of plants storing waste decreased from 19.99% in 2002 to 15.94% in 2006.
In the table 1. data regarding plants generating waste by degree of waste salvaging, treating and storing in years 2002-2006 were presented.

Table 1. Plants generating waste *Source: Own elaboration based on [3]*

by degree of waste salvaging									
Years	5,0% and less	5,1-10,0	10,1-25,0	25,1-50,0	50,1-70,0	70,1-80,0	80,1-90,0	90,1-95,0	95,1% and more
2002	18	18	26	61	82	73	133	112	677
2003	18	20	30	60	80	71	109	94	727
2004	30	12	32	56	92	71	112	93	823
2005	25	16	35	70	75	67	136	90	888
2006	28	20	31	75	85	64	125	97	982

by degree of waste treating					
Years	5% and less	5,1-10,0	10,1-20	20,1-30	30,1 and more
2002	136	83	88	50	232
2003	133	67	79	42	283
2004	124	66	75	39	284
2005	123	73	80	43	303
2006	131	74	70	46	319

by degree of waste storing									
Years	5,0% and less	5,1-10,0	10,1-25,0	25,1-50,0	50,1-70,0	70,1-80,0	80,1-90,0	90,1-95,0	95,1% and more
2002	131	71	88	53	27	14	12	9	42
2003	115	67	77	57	23	13	7	10	50
2004	117	64	83	49	13	15	5	10	56
2005	125	67	84	45	21	9	8	8	50
2006	115	60	76	54	15	10	8	9	60

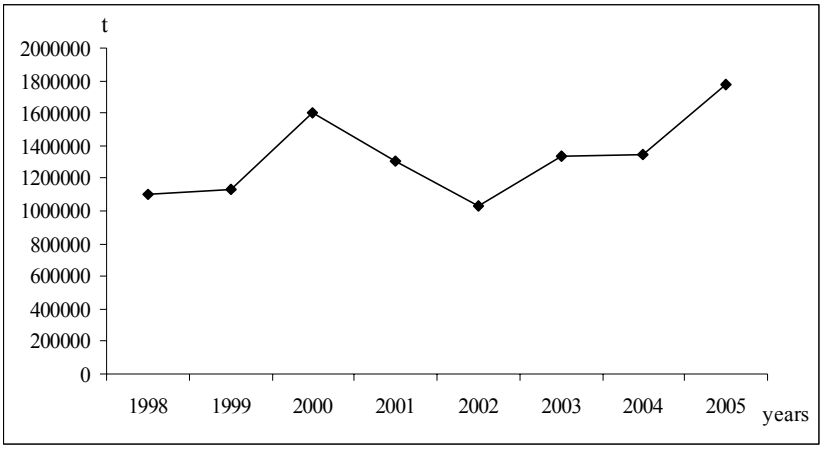

Figure 7. Hazardous waste generated
Source: Own elaboration based on [3]

Taking the percentage of waste which were salvaged, treated and stored into consideration, it is possible to say that:

- The number of plants salvaging more than 95% of generated waste has increased,
- The number of plants treating more than 30% of generated waste has increased,
- The number of plants storing more than 95% of generated waste has increased, though plants storing waste less than 5% have presented the biggest percentage.

Big fluctuations were watched regarding hazardous waste (fig. 7.).
The quantity of hazardous waste has increased since 2002 – there was it about 72.81% more in 2005 compared to 2002. Hazardous waste is generated chiefly in industrial plants and reduction of its quantity is difficult. Limiting of threats created by this waste consists chiefly in waste disposal. Record of hazardous waste hasn't included diverse energy sources in Poland, i.e. shops and households.
The percentage of waste salvaging or treating is presented on fig. 8.

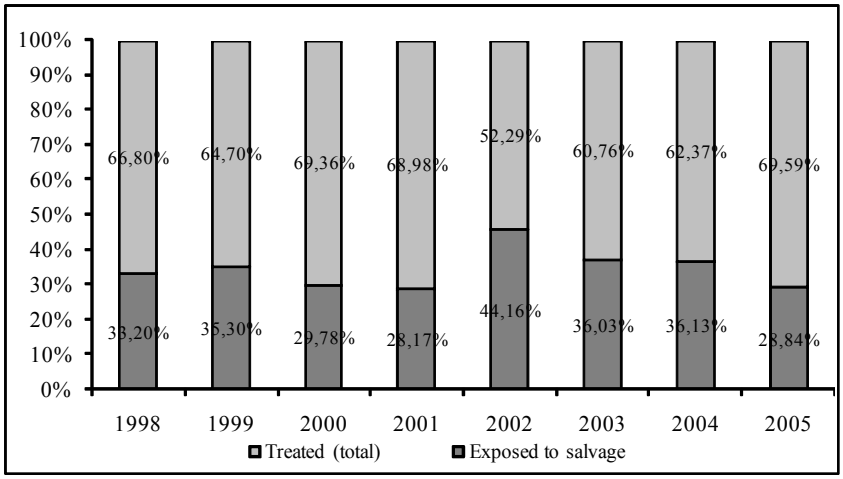

Figure 8. Hazardous waste generated
Source: Own elaboration based on [3]

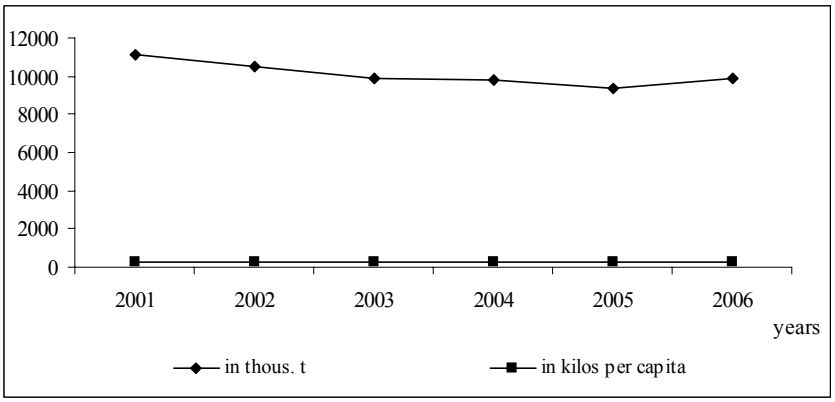

Figure 9. Municipal waste collected
Source: Own elaboration based on [3]

Treating (of which storing) is still the basic method of dealing with hazardous waste – it concerns more than 60% of total amount of hazardous waste. About 30% of hazardous waste is recovered and you can mention about annual average increase of the level of recovery about 3.76% in years 1998-2005.
The favourable phenomenon which could be observed in Poland in years 2001-2006 was decrease of amount of municipal waste (fig. 9.). The decrease of the level of municipal waste was observed per capita too.
A lot of waste industrial as well as municipal can be treated as raw materials. In the table 2. the quantity of packaging and products introduced into the market and reached levels of recovery and recycling of packaging and post-usage waste is presented.

Table 2. Packaging and products introduced to the market and achieved levels of recovery and recycling of packaging and post-usage products wastes
Source: Own elaboration based on [3]

		An amount of on the market brought packaging and products			Wastes exposed to		Achieved level of	
		subject to a duty of			salvage	recycling	salvage	recycling
		total	salvage	recycling			in percent	
Packaging (in thous. t)	2003	2579,9	–	2535,2	–	677,9	–	26,7
	2004	2890,2	–	2640,6	–	941	–	35,6
	2005	3174,1	–	2878,4	–	1342,8	–	46,7
	2006	2982,5	3254,2	2655,4	1772,9	1659,3	54,5	62,5
Smear oil (in thous. t)	2003	201,7	169	144	88,3	48,9	52,3	33,9
	2004	211,5	211,5	241	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
Tyres (in thous. t)	2003	136	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	145,1	120,3	23,6	82,4	16,2
	2006	185,7	183,4	183,4	167,5	36	91,3	19,7
Nickel-cadm accumulators (in pieces)	2003	2593041	2490986	2490986	317001	329191	12,7	13,2
	2004	3193357	3191932	3191932	1119651	1256070	35,1	39,4
	2005	2021458	2009182	2020460	1711732	2158155	85,2	106,8
	2006	3215207	3214127	3214127	2213755	2205955	68,9	68,6
Batteries and galvanic cells (in pieces)	2003	251974874	251866945	13132740	12565953	542523	5	4,1
	2004	253183265	248475328	13890314	24051352	948728	9,7	6,8
	2005	194561647	194367868	10782229	28941229	2649101	14,9	24,6
	2006	205400902	205400008	19897130	38822845	2797204	18,9	14,1
Discharge lamps (in pieces)	2003	18050529	18026336	18009536	2381385	2391506	13,2	13,3
	2004	8456760	8456727	8456727	1542339	1566116	18,2	18,5
	2005	22190958	22190958	22190958	5789843	5786085	26,1	26,1
	2006	22516842	22513246	22513246	8705245	8644043	38,7	38,4

Watched in years 2003-2006 tendencies of quantitative and qualitative waste (being secondary raw materials) changes informed about:

- Increase of quantity of packaging waste introduced into the market,

- Decrease of quantity of smear oil introduced into the market,
- Increase of quantity of tyres, nickel-cadm accumulators, batteries and galvanic cells and discharge lamps,
- Increase of the level of recovery and recycling for waste introduced into the market,
- Increase of the level of recycling reached in all analyzed waste groups.

Analyzing annual average change rate regarding all groups of waste introduced into the market in years 2003-2006 it was possible to affirm that annual average decrease could be observed in case of amount of oils and batteries and galvanic cells introduced into the market and annual average increase – in case of amount of remaining groups of waste introduced into the market.
Recovery and recycling of waste raw materials are the basic undertakings aiming at reduction of amount of waste in Poland. In the table 3. the structure of turnover of secondary raw-materials in Poland in years 2004-2006 is presented.

Table 3. Turnover of secondary raw-materials (in thous. t)
Source: Own elaboration based on [3]

	Supply			Use		
	2004	2005	2006	2004	2005	2006
Scrap and wastes: of steel and iron	65,20%	58,63%	62,00%	64,28%	59,32%	61,90%
of copper	1,22%	1,65%	1,27%	1,25%	1,63%	1,27%
of lead, zinc and tin	1,69%	1,48%	1,29%	1,74%	1,49%	1,29%
of aluminum	3,75%	4,03%	3,91%	3,88%	4,00%	3,84%
Used oils	1,35%	1,13%	1,18%	1,37%	1,11%	1,18%
Plastics	2,13%	2,96%	2,99%	2,15%	2,88%	2,98%
Waste rubber	0,93%	1,00%	0,78%	0,91%	1,02%	0,78%
Cullet	8,01%	9,41%	8,54%	8,24%	9,19%	8,61%
Waste paper	15,08%	19,02%	17,45%	15,51%	18,70%	17,56%
Textile wastes	0,64%	0,68%	0,58%	0,66%	0,66%	0,59%

Scrap and wastes of steel and iron had the biggest participation in supply and use of secondary raw materials – they made about 60% of total amount of secondary raw-materials. The second group of secondary raw materials as for level of reusage was paper - it made from 15% to 20% of turnover of secondary raw materials. Waste rubber was least subjected to recycling– its participation in supply and use made about 1%.

5. Summary

The first complex waste management systems (mainly with reference to recovery and safe waste storing) were the effect of the negative impact of hazardous waste introduced in the environment in large quantities. The basic act governing rules of waste management is at present the Act of 27 April 2001 on Waste in Poland. According to the Act the hierarchy of rules of dealing with waste is following:

1. Prevention of waste generation or minimizing the quantity of waste,
2. Safe waste removing,
3. Recovering or treating of waste whose avoidance was impossible.

These principles are consistent with principles determined in the Council Directive 75/442/EEC of 15 July 1975 on waste (as amended by Council Directive 91/156/EEC of 18 March 1991 so-called the Frame-Directive). According to the Frame-Directive following activities should be priority:

- Avoiding waste generation thanks to applying clear technology and effective technologies of final disposal of dangerous substances contained in waste destined for recovery,
- Managing generated waste by recycling of materials, reusing of recycled materials, regeneration or the other method making recovering secondary raw materials possible
- Using waste as unconventional energy source.

Undertaken pro-ecological activities resulted in numerous positive effects in waste management in Poland, among which it is possible to enumerate e.g.:

- Stopping the quantity of generated waste on the constant level and not allowing to its increase,
- Decrease of the level of municipal waste,
- Increase of number of plants treating and recovering waste,
- Decrease of quantity of waste stored in dumps,
- Increase of usage of secondary raw materials,
- Increase of quantity of waste intended for recovery and recycling.

The consistent realization of principles regarding waste managing determined in legal acts can result in the next ecological effects and development of recovery logistics – in economic efficiency of undertaken pro-ecological activities.

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