

## RECOVERING AND REUSE OF SELECTED GROUP OF INDUSTRIAL WASTE

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### Abstract

The paper presents the level of recovering and reusing of industrial waste generated by the mining industry, power industry and metallurgy from 2000 to 2005. The data presented here shows that, the level of waste recovering and reuse in these years achieved about 80%. Within the period 2000-2005, the highest degree of recovering and reuse is noted for mining industry. This paper also shortly describes the methods of waste treatment within the period 2000-2005. Unfortunately the data shows that, the landfilling is the main disposal method of waste unutilized in Poland. Other methods are also used, but on a negligible scale.

### Streszczenie

Praca przedstawia poziomy odzysku i recyklingu odpadów przemysłowych z przemysłu górniczego, energetycznego oraz hutniczego w latach 2000 do 2005. Z danych wynika, iż poziomy odzysku i recyklingu w minionych latach wynosiły około 80%. W okresie 2000 - 2005, największy poziom recyklingu i odzysku był notowany dla przemysłu górniczego. Praca również pokrótce opisuje sposoby postępowanie z tymi odpadami w tym okresie. Niestety z przedstawionych danych wynika, że składowanie jest głównym sposobem unieszkodliwianie niewykorzystanych odpadów. Inne metody również są wykorzystywane w niedużym stopniu.

Keywords: Mining industry; Power industry; Metallurgy; Waste treatment; Recovery; Reuse.

## 1. INTRODUCTION

In the 1960s the humorist Tom Lehrer sang about environmental contamination, and he advised the tourists coming to the United States not to drink the water and not to breathe the local air. At that time, it was considered funny, now, it is nothing to laugh at. Due to recent developments in human activities, environmental contamination is increasing sharply. Industries have traditionally managed their waste products by discharging them into the environment without previous treatment. This practice resulted in an increase of pollution and produced a negative environmental impact [1]. Although some industrial waste (IW), classified by the EPA as extremely dangerous, ought to be neutralized of in a special way, landfill is

still the main disposal method. In Poland, environmental contamination is diversified with regard to different regions. 10% of the country inhabited by 1/3 of the population was ecologically endangered. The Silesian region, and especially its industrialized part, was considered to be a degraded region both in Poland and in the whole of Europe. Industry concentration in the Silesian region, especially the mining and power industries, caused huge disproportions between industrial development and environmental protection. Consequently, serious degradation and irreversible changes in the environment have been noticed [2]. Altogether more than 4 billion tones of wastes are landfilled in Poland and every year this amount increases by 145 million tones. This include 133 million tones of industrial waste [2]. The issue of waste

increasingly topical in Poland, not only because of the increase in the amount, but chiefly because of an efficient system for its management, and the impact of wastes and their processing (utilization) on the environment [3,4,5]. This review presents the case in Macao [6], Spain [1], Portugal [7], southern Europe [8], New Zealand [9] and Sweden [10].

In Poland over the past several years, a number of technologies allowing of industrial coarse-grained wastes utilization have been developed. A part of wastes is delivered to processing plants where the raw materials contained in the wastes is recovered, another part is used in underground technologies (such as: hydraulic and dry stowage, mining wall fall backfilling, old gunis caulking and orogen void spaces backfilling) and for both industrial and non-industrial purposes on the surface (road building and hydrotechnical engineering, building materials production, ground shaping or its adjustment to particular needs as well as soil fertilizing or improvement, etc.). The remaining wastes are temporarily stored in plant dumps in order to be recycled or neutralised [11].

The aim of this paper is to shed some light on the state of industrial waste management in Poland from 2000 to 2005. Sections 2-7 present and discuss the levels of IW recovering and reuse. Section 8 contains summary. Finally Section 9 contains conclusions.

## 2. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2000

The data show, that 125.48 million tons of IW was generated in Poland [12]. 76.88 % of the total was used both in industry and beyond it, 20.20% was neutralized, the rest, i.e. 2.92%, was stored temporarily at the factory landfill sites. A great amount of IW being neutralized, i.e. 88.97% was landfilled. In 2000, 0.29% of waste was directed to biological recycling and 0.74% to incineration. The rest of neutralized waste was stored temporarily [13].

### 2.1. Major producers and methods of industrial waste treatment in the year 2000

Major sources of IW were as follows:

- Mining industry – in 2000, this sector generated 45.80 million tons of waste which constitutes 36.59% of the total amount of waste generated in Poland. Out of this waste 38.82 million tons which comprises 84.75 % were utilized and 6.73 million tons makes up 14.69% were neutralized. The rest 0.25 million tons i.e. 0.55% was stored temporarily. Out of the total quantity of waste being neutralized, 6.26 million tons i.e. 93.02% was landfilled and 100 tons (0.01%) were neutralized by incineration. The part of neutralized waste, 0.47 million tons i.e. 6.97% was treated with the use of other methods.
- Metallurgical engineering industry – in 2000, 37.01 million tons generated in the metallurgical engineering industry sector being 29.49 % of the total quantity of IW in Poland. Out of the total amount of waste produced by this industry about 27.77 million tons (75.03%) was utilized, 19.89%, i.e. 7.36 million tons was neutralized. The rest 1.88 million tons (5.1%) was stored temporarily. In 2000, the quantity of metallurgical engineering industry neutralized was 7.36 million tons, 6.68 million tons (90.76%) of which was landfilled, 2.1 thousand tons (0.02 %) was directed to incineration. The rest of neutralized waste (9.23%) i. e. 0.68 million tons was treated in other methods.
- In 2000, 19.83 million tons generated in the power industry sector which comprises 15.80% of the total amount of IW in Poland. In 2000, 71.46% of the total amount of waste, i.e. 14.17 million tons, were utilized, 25.92%, i.e. 5.14 million tons, were neutralized. The rest 2.62%, i.e. 0.52 million tons was stored temporarily. 5.01 million tons (97.47%) of waste being neutralized were landfilled, 25.9 thousand tons (0.50%) was incinerated. The part of neutralized waste 2.03%, i.e. 104.1 thousand tons was treated in other ways [12]. Quantities of industrial waste generated by the major producers in the

**Table 1.**  
Major producers, quantities and treatment methods of industrial waste management for the year 2000 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			Total
				Incinerated	Landfilled	Other methods	
Mining industry	45.80	38.82	0.25	0.0001	6.26	0.47	6.73
Metallurgy	37.01	27.77	1.86	0.0021	6.68	0.68	7.36
Power industry	19.83	14.17	0.52	0.0259	5.01	0.10	5.14

year 2000 are shown in Table 1 and Fig. 1.

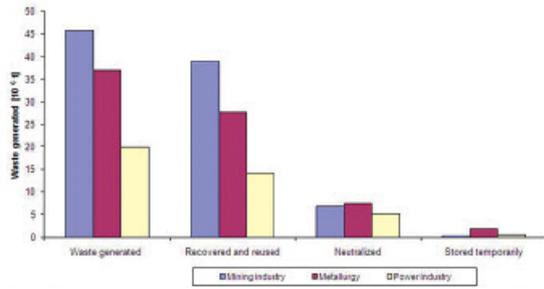


Figure 1. Waste generated and treatment methods of IW in the year 2000

### 3. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2001

In 2001, out of the 123.81 million tons of the total quantity of IW generated [4]. 78.26 % was used both in industry and beyond it, 19.27% was neutralized. The rest was stored temporarily. 85.96% of waste being neutralized was landfilled, 0.20% was directed to incineration and 0.36% was exposed to biological recycling [13].

#### 3.1 Major producers and methods of industrial waste treatment in the year 2001

With regard to the following data, in 2001 the major sources of IW were such branches of industry as:

- The mining industry – in 2001, this sector generated 43.73 million tons of waste which comprises 35.32% of the total amount of waste generated in Poland. In 2001, 38.96 million tons of the total quantity of waste was utilized which constitutes 89.10%, 4.69 million tons were neutralized which constitutes 10.70%. The rest 0.18%, i.e. 81.6 thousand tons was stored temporarily. Out of the total quantity of waste being neutralized, 4.36 million tons (92.96%) was landfilled and 100 tons (0.002%) was incinerated. The rest of neutralized waste

7.03%, i.e. 0.33 million tons was treated in other ways.

- Metallurgical engineering industry – in 2001, 37.5 million tons generated made up 29.49 % of the total quantity of IW in Poland. Out of the general amount of waste produced by this industry and beyond it 76.53%, i.e. 28.7 million tons, was utilized. 7.37 million tons (19.65%) was neutralized of. The rest 3.81%, i.e. 1.43 million tons was stored temporarily. Like in the previous years, a great amount of waste which was neutralized of, i.e. 6.78 million tons (91.99%), was landfilled, 1.9 thousand tons (0.02%) was neutralized by incineration. The rest 8%, i.e. 0.59 million tons was treated in other ways.
- The power industry generated 21.37 million tons which comprises 17.26% of the total amount of IW in Poland. 14.27 million tons (66.78%) of waste was utilized, 6.32 million tons (29.57%) was neutralized. The rest 0.78 million tons (3.65%) was stored temporarily. In 2001, out of the total amount of waste being neutralized, 5.7 million tons (90.31%) was landfilled and 35.3 thousand tons (0.56%) was incinerated. The rest 0.58 million tons (9.13%) of neutralized waste was treated in other methods [14]. Fig. 2 and Table 2 show quantities of industrial waste and treatment methods of industrial waste generated by the major producers in Poland in the year 2001.

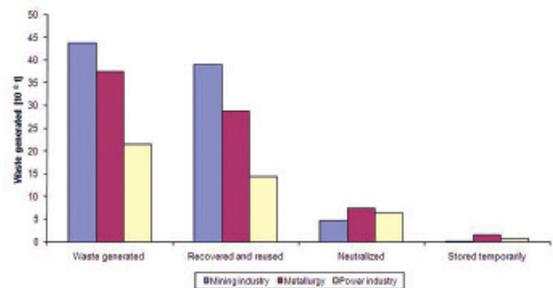


Figure 2. Waste generated and treatment methods of IW in the year 2001

Table 2. Major producers, quantities and treatment methods of industrial waste management for the year 2001 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			Total
				Incinerated	Landfilled	Other methods	
Mining industry	43.73	38.96	0.08	0.00001	4.36	0.33	4.69
Metallurgy	37.50	28.70	1.43	0.0019	6.78	0.57	7.37
Power industry	21.37	14.27	0.78	0.0353	5.70	0.58	6.32

**Table 3.**  
Major producers, quantities and treatment methods of industrial waste management for the year 2002 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			Total
				Incinerated	Landfilled	Other methods	
Mining industry	40.86	37.38	0.41	0.0006	2.93	0.15	3.08
Metallurgy	36.58	27.92	1.70	0.0007	6.35	0.61	6.96
Power industry	19.91	13.73	0.72	0.0376	4.43	0.99	5.46

#### 4. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2002

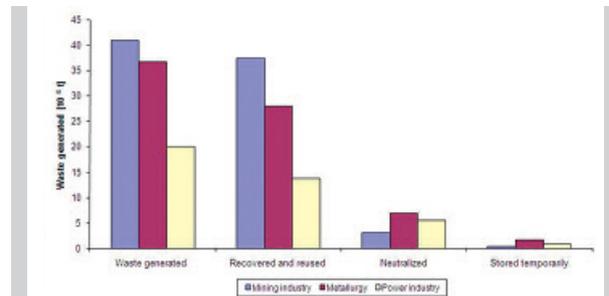
According to the Statistical yearbook [15], 117.89 million tons of IW was generated in 2002 (GUS, 2003). 79.03% was utilized for the sake of industry and beyond it, 17.6% was neutralized. The rest, i.e. 3.37%, was stored temporarily. What is more, 82.11% of waste being neutralized was landfilled, 0.40% was biologically neutralized and 0.26% was neutralized by incineration [13].

##### 4.1. Major producers and methods of industrial waste treatment in the year 2002

In 2002, the major producers of industrial waste were such branches of industry as:

- The mining industry. In 2002, this sector generated 40.86 million tons of waste which comprises 34.66% of the total amount of waste generated in Poland. In 2002, the mining industry contributed most to the total quantity of IW. 91.48%, i.e. 37.38 million tons of the total quantity of IW was utilized, 3.08 million tons (7.54%) was neutralized. The rest 0.98%, i.e. 0.40 million tons was stored temporarily. Out of the total quantity of waste being neutralized, 2.93 million tons (95.13%) was landfilled and 600 tons (0.02%) was neutralized by incineration. The rest 4.87%, i.e. 0.15 million tons of neutralized waste was treated in other methods.
- Metallurgical engineering industry – in 2002, this sector generated 36.58 million tons, 31.02% of the total quantity of IW in Poland. Out of the general amount of the produced waste 27.92 million tons (76.34%) was utilized. 6.96 million tons (19.02%) was neutralized. The rest was stored temporarily. Similarly to the previous years, 6.35 million tons (91.24%) of waste was landfilled and 700 tons (0.01%) was incinerated. The rest of neutralized waste 8.76%, i.e. 0.61 million tons was treated by the use of other methods.
- The power industry generated 19.91 million tons

which comprises 16.89% of the total amount of industrial waste in Poland. In 2002, 13.73 million tons (68.96%) of energetic waste was utilized, 5.46 million tons (27.42%) was neutralized. The rest 3.62%, i.e. 0.72 million tons was stored temporarily. Out of the whole amount waste being neutralized, 4.43 million tons (81.14%) was landfilled. 0.69%, i.e. 37.6 thousand tons was treated by incineration. The rest 18.18%, i.e. 0.99 million tons was treated in other methods [15]. Table 3 and Fig. 3 show quantities and treatment methods of industrial waste generated by the major producers in Poland in the year 2002.



**Figure 3.**  
Waste generated and treatment methods of IW in the year 2002

#### 5. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2003

In 2003, there were 120.55 million tons of IW generated out of which 79.15% was utilized and 18% neutralized. The rest, i.e. 2.85%, was stored temporarily. 74.70% of IW being neutralized was landfilled, 0.53% was directed to biological recycling and 1.93% was exposed to combustion [13].

##### 5.1. Major producers and methods of industrial waste treatment in the year 2003

On the basis of statistical data [16] in 2003, the major producers of IW were such branches of industry as:

- The mining industry – in 2003, this sector generated 39.34 million tons of waste which comprises 32.63% of the total amount of waste generated in Poland. Out of the total quantity of IW, 96.82%, i.e. 38.09 million tons, was recovered, 3.05%, i.e. 1.2 million tons, was neutralized. The rest was stored temporarily. Most IW being neutralized, i.e. 0.82 million tons (68.33%), was landfilled, 800 tons (0.07%) was thermally neutralized. The rest of neutralized 31.67%, i. e. 0.38 million tons was treated by the use of other methods.
- Metallurgical engineering industry – in 2003, this sector generated 37.88 million tons, 31.42% of the total quantity of IW in Poland. On the basis of the data (GUS 2007) in 2003, 28.92 million tons, i.e. 76.35%, was utilized, 7.14 million tons (18.85%) neutralized. The rest 4.8%, i.e. 1.82 million tons was stored temporarily. Most of the waste neutralized, i.e. 6.4 million tons (89.64%) was landfilled, 500 tons (0.007%) was neutralized by combustion. The rest of waste neutralized 10.36%, i.e.0.74 million tons was treated by means of other methods.
- The power industry generated 22.9 million tons which comprises 18.99% of the total quantity of IW. In the power industry sector, 14.83 million tons was utilized making up 64.76% of the total, 7.61 million tons (33.23%) was neutralized. The rest 2.01%, i.e. 0.46 million tons was stored temporarily. 5.68 million tons, i.e. 74.63%, landfilled, 31.3 thousand tons (0.41%) was incinerated. The rest 24.97%, i.e.1.90

million tons was treated in other ways. Table 4 and Fig. 4 present those branches which generated most of IW and methods of waste treatment in 2003.

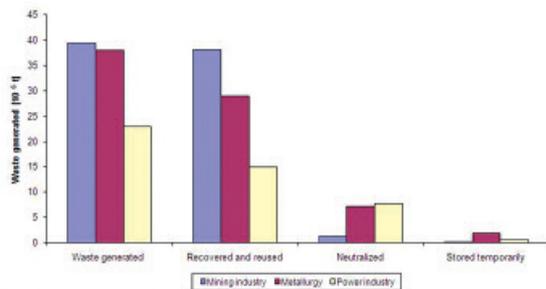
## 6. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2004.

According to data [17] in Poland in 2004, 124.03 million tons of IW were generated, out of which 78.4% was utilized and 18.20% was neutralized. The rest, i.e. 2.85%, was stored temporarily. 75.88% of IW being neutralized was landfilled, 0.70% was directed to biological recycling and 1.16% was exposed to combustion [13].

### 6.1. Major producers and methods of industrial waste treatment in the year 2004

According to statistical data in 2004, the major producers of IW were such branches of industry as:

- The mining industry – in 2004, it generated 40.05 million tons of waste which comprises 32.29% of the total amount of waste generated in Poland. 37.97 million tons (94.81%) was utilized, 2 million tons (4.99%) was neutralized, The rest 0.2%, i.e. 0.08 million tons was stored temporarily. Out of the total quantity of waste being neutralized, 1.9 thousand tons (0.09%) was incinerated and 1.96 million tons (98%) was landfilled. The rest 1.91%, i.e.38.1 thousand tons was treated by the use of other ways.
- Metallurgical engineering industry – in 2004, this sector generated 39.38 million tons constituting 31.75% of the total quantity of IW in Poland. On the basis of GUS in 2004. 29.4 million tons, i.e. 74.66%, was utilized, 8.08 million tons (20.52%) was neutralized. The rest 4.82%, i.e. 1.9 million tons was stored temporarily. Most of waste being neutralized, i.e. 7.24 million tons (89.60%), was landfilled, 4.1 thousand tons (0.05%) was neutralized by incineration. The rest 10.39%, i.e.0.84 million tons was treated by means of other methods.



**Figure 4.**  
Waste generated and treatment methods of IW in the year 2003

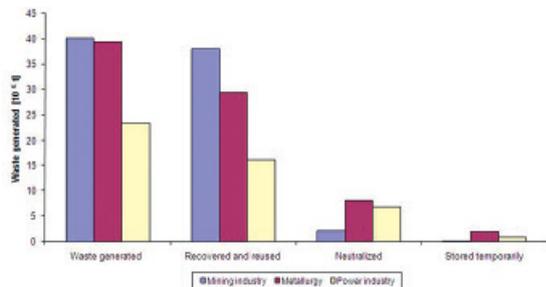
**Table 4.**  
Major producers, quantities and treatment methods of industrial waste management for the year 2003 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			Total
				Incinerated	Landfilled	Other methods	
Mining industry	39.34	38.09	0.05	0.0008	0.82	0.38	1.20
Metallurgy	37.88	28.92	1.82	0.0005	6.40	0.74	7.14
Power industry	22.90	14.83	0.46	0.0313	5.68	1.90	7.61

**Table 5.**  
Major producers, quantities and treatment methods of industrial waste management for the year 2004 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			
				Incinerated	Landfilled	Other methods	Total
Mining industry	40.05	37.97	0.08	0.0019	1.96	0.04	2.0
Metallurgy	39.38	29.40	1.9	0.0041	7.24	0.84	8.08
Power industry	23.47	15.97	0.80	0.0134	4.65	2.04	6.70

– Power industry generated 23.45 million tons which comprises 18.92% of the total quantity of IW. In 2004, 15.97 million tons was utilized making up 68.1% of the total, 6.7 million tons (28.57%) was neutralized. The rest 3.33%, i.e. 0.78 million tons was stored temporarily. Out of the total quantity of waste being neutralized, 4.65 million tons, i.e. 69.4%, was landfilled, 13.4 thousand tons (0.2%) incinerated. The rest 30.4%, i.e. 2.04 million tons was treated by means of other methods [117]. The data is presented below.



**Figure 5.**  
Waste generated and treatment methods of IW in the year 2004

## 7. INDUSTRIAL WASTE MANAGEMENT IN POLAND IN THE YEAR 2005.

In Poland in 2005, 124.6 million tons of IW were generated [18]. According to the balance, 79.26% of waste was utilized by this industry and beyond it, 17.75% was neutralized. Out of the total amount of

waste being neutralized, 76.35% was landfilled, 1% was directed to biological recycling and 1.126% was exposed to heat treatment [13].

### 7.1. Major producers and methods of industrial waste treatment in the year 2005

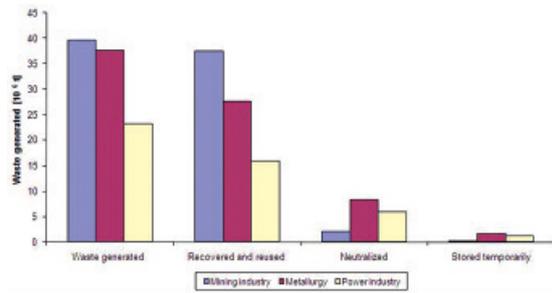
Major sources of IW were such branches of industry as:

- The mining industry – in 2005, this sector generated 39.62 million tons of waste which comprises 31.80 % of the total amount of waste generated in Poland. 37.45 million tons (94.52%) of waste was utilized, 2.02 million tons (5.1%) was neutralized. The rest 0.38%, i.e. 0.15 million tons was stored temporarily. Out of the waste neutralized, 2.01 million tons (99.5%) was landfilled, 800 tons (0.04%) was incinerated. The rest 0.46%, i.e. 9.2 thousand tons was treated in other methods.
- In 2005, Metallurgical engineering sector generated 37.65 million tons, 30.22% of the total quantity of industrial waste in Poland. In the metallurgy sector, 27.58 million tons of waste was utilized (73.25%), 7.65 million tons was neutralized (22.31%). The rest 4.44%, i.e. 1.67 million tons was stored temporarily. An enormous amount of waste being neutralized, i.e. 90.83% (7.63 million tons), was landfilled, 0.13 %, i.e. 10.7 thousand tons, was subjected to thermal utilization. The rest 9.04%, i.e. 0.76 million tons was treated by the use of other methods.
- The power industry generated 23.12 million tons which comprises 18.55% of the total amount of industrial waste in Poland. In 2005, out of the waste

**Table 6.**  
Major producers, quantities and treatment methods of industrial waste management for the year 2005 [million ton]

Major waste producers	Quantity of waste generated	Treatment methods					
		Recovered and reused	Stored temporarily	Neutralized			
				Incinerated	Landfilled	Other methods	Total
Mining industry	39.62	37.45	0.15	0.0008	2.01	0.01	2.02
Metallurgy	37.65	27.58	1.67	0.0107	7.63	0.76	8.40
Power industry	23.12	15.99	1.16	0.0308	3.96	1.98	5.97

generated by this sector, 69.16%, i.e. 15.99 million tons, was utilized, 3.99 million tons, i.e. 17.26%, was neutralized. The rest 13.58%, i.e. 3.14 million tons was stored temporarily. Out of the waste being neutralized 3.96 million tons was landfilled (66.33%), 30.8 thousand tons were subjected to combustion (0.51%). The rest 33.16%, i.e. 1.98 million tons was treated in other ways [18]. The data is presented in Table 6 and Fig. 6.



**Figure 6.**  
Waste generated and treatment methods of IW in the year 2005

## 8. SUMMARY

According to the statistics for the whole of Poland, in 2000, the mining industry generated the most industrial waste, i.e. 45.80 million tons, which comprises 36.50% of the total amount of waste generated in Poland. Metallurgical engineering industry produced 37.01 million tons being 29.49% of the total quantity. Last but not least, the power industry manufactured 19.83 million tons which makes up 15.80% of the total.

On the basis of statistical data, in 2001, the mining industry was the biggest producer of waste – 43.73 million tons which makes up 35.32% of the whole mass of generated waste. Metallurgical engineering industry takes the second place after the mining industry, it generated 37.50 million tons of waste which comprises 30.28 % of the total. Another branch in which a lot of waste is produced is the

power industry with its 21.37 million tons being 17.26% of the whole.

Similarly to the previous years, in 2002, the most waste, taking into account the whole mass of industrial waste generated in Poland, occurred in the mining industry. It produced 40.86 million tons, 34.66% of the total. Second place belongs to metallurgical engineering industry which collectively made 36.58 million tons of waste, which constitutes 31.02% of the total quantity. The power industry is in third place with its 19.91 million tons which makes up 16.89% of the total quantity of industrial waste produced in Poland.

The data shows that in 2003 the majority of waste was produced in the mining industry – 39.34 million tons, 32.63% of the total. Like in the previous years, second place belongs to metallurgical engineering industry which produced 37.88 million tons being 31.42%. The next branch, the power industry, generated 22.90 million tons.

The total quantity of waste generated in Poland in 2004 in such branches as the mining industry, metallurgical engineering industry, and the power industry, was 40.05 million tons (32.29% of the total), 39.38 million tons (making up 31.75% of the total), and 23.47 million tons (comprising 18.92% of the total), respectively.

In 2005, 39.92 million tons was generated in the mining industry which makes up 31.80% of the total amount of IW. This year, metallurgical engineering industry produced 37.65 million tons constituting 30.22% of the total. The power industry occupied third place with its 23.12 million tons generated, 18.55% of the total. The branches in which the most industrial waste was generated in Poland from 2000 to 2005 are represented in Table 7.

## 9. CONCLUSIONS

On the basis of statistical data. IW recovering and reuse in Poland keeps at a level of 80%. The highest degree of recovering and reuse is noted for mining

**Table 7.**  
Quantities of major waste producers from 2000 to 2005

Major waste producers	Years					
	2000	2001	2002	2003	2004	2005
Mining industry	45.80	43.73	40.86	39.33	40.05	39.62
Metallurgy	37.01	37.49	36.58	37.88	39.38	37.65
Power industry	19.83	21.37	19.90	22.90	23.47	23.12

industry. The data shows that landfilling is still the cheapest and most common method of industrial waste neutralization in Poland. Other utilization methods are applied on a negligible scale. Independently of the existing and future waste use possibilities, in case of waste generated by the majority of producers, the only rational method of disposal of most of them is landfilling given the existing knowledge, level of technology and market needs. Stored waste that are no longer used and which are known not to be economically useful, have to be reclaimed. Therefore, we have to put a pressure to implement Cleaner Production (CP) technology and standard of ISO 14001.

The use in underground mining technologies should be considered as one of the most effective methods of their utilization. Apart from placing wastes in post-mining workings, this method contributes to reducing extraction influences on the surface, improving ventilation conditions, and decreasing mining dangers such as fire, gas and burst hazard.

The industrial waste reuse in road building creates enormous possibilities of their rational management in the light of road and motorway development plan in Poland.

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