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# REVERSE LOGISTICS

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Abstract		
<p>This thesis was focused on the analysis of the concept of reverse logistics and actual reverse processes which are implemented in mining industry and finding solutions for the optimization of reverse logistics in this sphere. The objective of this paper was the assessment of the development of reverse logistics in mining industry on the example of potash production.</p> <p>The theoretical part was based on reverse logistics and mining waste related literature and provided foundations for further empirical study. The history, relevance and structure of reverse logistics were considered in this part of the paper. The theory also included the analysis of industrial waste in the context of reverse logistics. In addition, the analysis of statistical data in the form of tables and diagrams were used in the theoretical part.</p> <p>The empirical part included the analysis of the implementation of reverse logistics in potash mining industry. The emphasis of the empirical part was on the description and consideration of reverse logistics with relation to a Belarusian company. Based on this information, the decision of further analysis of reverse logistics implementation in the companies “Belaruskali”, “PotashCorp”, “Mosaic”, “Kali&amp;Salz” and “Uralkali” was made.</p> <p>In conclusion, three solutions for the optimization of reverse logistics in mining industry were proposed. They are the implementation of an efficient reverse logistics management system, particularized marketing campaign and the attraction of investments for the development of reverse logistics innovations and their future realization. It is also important to note that the above-mentioned solutions can be implemented in any mining company. In sum, the main objective of the study was achieved.</p>		
Keywords		
logistics, reverse, sustainability, optimization		

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## 1 INTRODUCTION

Nowadays, the definition of “logistics” is becoming more and more concrete and covers a wide range of operations inside and outside a company. As Alan McKinnon (2010, p. 3) says, it is only over the past 50 years that logistics has come to be regarded as a key determinant of business performance, a profession and a major field of academic study. During this period, the dominant paradigm for those managing and studying logistics has been commercial. The prime objective has been to organize logistics in a way that maximizes profitability. The calculation of profitability, however, has included only the economic costs that companies directly incur. The wider environmental and social costs, traditionally excluded from the balance sheet, have been largely ignored — until recently.

Here it is worth noting that economic, environmental and social efficiencies are three core objectives for modern business companies in the implementation of their sustainable development. Reverse logistics is one of the methods which companies can use in achieving sustainability. Over the past decade, there have been many more theoretical and analytical contributions to the reverse logistics literature, reflecting a greater emphasis on the optimization of return flows of waste and other products. (McKinnon, 2010, p. 13). Actual problem is that there is still a great number of cases where reverse logistics needs to be not just analyzed, but involved and implemented. This thesis is dedicated to the precise analysis and assessment of reverse logistics and finding possible solutions for the optimization of reverse logistics in mining industry namely in “Belaruskali”, the most profitable enterprise in the field of mining industry in the Republic of Belarus and the third most profitable in the world. Also, four other companies, “PotashCorp”, “Mosaic”, “Kali&Salz” and “Uralkali” were studied. All these companies are world leaders in potash mining.

The main objective of this thesis is the assessment of the development of reverse logistics in mining industry on the example of potash production.

The other objective of this thesis is to determine the possible benefits companies may get from the implementation and development of reverse logistics.

In order to achieve the main objective, the next issues need to be considered:

1. Exploration of the theoretical aspects of reverse logistics;
2. Analysis of the performance of reverse logistics in mining industry and revelation of its weak points;
3. Analysis of actual situation in potash mining waste management;
4. Evaluation of the benefit from the implementation of reverse logistics in potash mining.

The analysis and description of reverse logistics and literature related to mining waste will be presented in the theoretical part. The empirical part will include materials from meetings with employees of the company “Belaruskali”, who possess the information about the implementation of reverse logistics there. The analysis of this company’s documentation, other data related to the realization of reverse logistics in “PotashCorp”, “Mosaic”, “Kali&Salz” and “Uralkali” and the suggestions for its development and optimization will also be studied in this part. In this way, the applied research methods, which help to find solutions to problems considering certain circumstances, will be used in the empirical part of the work. These methods are the most appropriate here because they ensure that fully objective information on the topic can be obtained and reasonable conclusions can be made.

The thesis consists of six main parts and 40 pages.

In regard to the key sources, the works of Alan McKinnon, David B. Grant, Alessandro Gandolfo, Robert E. Wright, N. Raj Kumar and R. M. Satheesh Kumar were used. In addition, Business Dictionary and the data of European Association of Mining Industries, Metal Ores and Industrial Minerals served as the basis of writing this paper.

## 2 REVERSE LOGISTICS

### 2.1 Definition

*“The term reverse logistics (RL), which has become only recently part of the current managerial/academic vocabulary, is a process by which a manufacturing company governs the return of its products, parts and materials from the consumption sites, in order to reuse them, recover their residual value, or to dispose of them”. (Gandolfo & Sbrana, 2008, p. 31-32).*

Reverse logistics combines two concepts: logistics activity and reverse process. It manages the tangible and intangible flows from the market to the production site, and at the same time it is a distribution channel, where the cargo route goes in the opposite direction unlike the normal one. (Gandolfo & Sbrana, 2008, p. 32).

Reverse logistics is a broader concept for overall supply chain optimization, which aims to support closed-loop supply chains by the improvement of such activities as product design, supply chain design, and product recovery. (Grant, 2013, p. 151).

In its turn, Business Dictionary gives the following definition of reverse logistics: *“Flow of surplus or unwanted material, goods, or equipment back to the firm, through its logistics chain, for reuse, recycling, or disposal”*. (Business Dictionary, 2016).

In addition to this, it is worth noting that many logistics companies also give their own definitions of reverse logistics. DHL, the company known as the global market leader in the logistics industry, defines reverse logistics as *“...the opposite of procurement, production and distribution logistics, all of which support product creation and distribution from the first supplier to the customer”*. (DHL, p. 1).

## 2.2 History

Reverse logistics implies the return of waste product and packaging for reuse, recycling and disposal, and today this activity is a crucial part of green logistics (Figure 1).

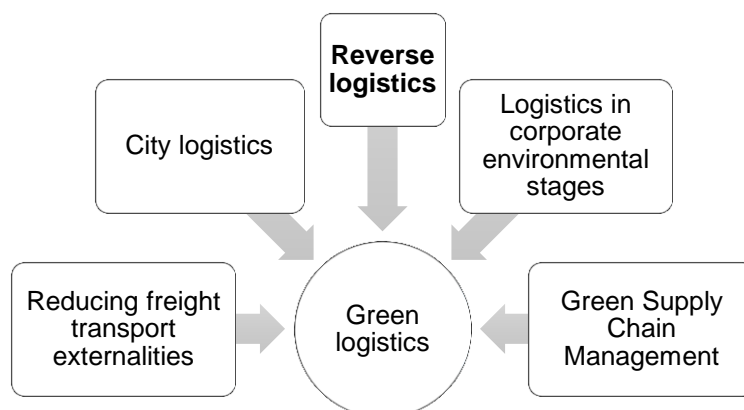


Figure 1 Reverse logistics as a part of green logistics (McKinnon, 2010, p. 6)

Reverse logistics is a new notion in the history of logistics and supply chain management. The US Army first paid its attention to reverse logistics operations in 1998. During the same year, the first commercial study of reverse logistics was made by Dr. Dale Rogers and Dr. Ron Tibben-Lembke. This study was published as “Going Backwards: Reverse Logistics Trends and Practices” and still remains the most comprehensive commercial study on reverse logistics.

Research interest in this topic developed in the early 1990s when governments and businesses began to reform the management of waste. This reorganization included reduction the proportion of waste material being dumped in landfill sites or incinerated and increase the proportion that was recycled and reused. Mainly this changed the logistics of waste management and stimulated research interest in the reverse flow of product back to the supply chain. (McKinnon, 2010, p. 13).

Nowadays, reverse logistics is developing rather fast because as the volume of waste being recycled and reused has grown, the range of new waste management systems is being expanded and government regulations are being intensified. (McKinnon, 2010, p. 13).

### 2.3 Relevance

The Council of Logistics Management has defined reverse logistics as referring to the “...*role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, and refurbishing, repair and remanufacturing...*” (Stock, 1998, p. 2). Today, all these activities are aimed not only at solving social and environmental issues, but they can also provide significant cost savings for a company. (Wright, 2011, p. 10).

Reverse logistics is one of the indexes which characterize sustainable development of the company. Economic growth of a company remains its strategic objective, but today it cannot be achieved without social and environmental care. The concept of reverse logistics is an integration of social and environmental aspects because people’s well-being and satisfaction and also the protection of the environment are main ideas of reverse processes.



Nowadays, there are many reasons for making a reverse flow going, e.g.:

1. Defects or malfunction of products;
2. Dissatisfaction of customers after having tried the product;
3. Defect or not correspondence to the order products returned by intermediate buyers (retailers);
4. Recall of products by the manufacturer to the factory by reason of revealed technical problems or defects in order to make the necessary changes and repairing on the products in order to reestablish their functionality and security;
5. Overstock of the warehouse;
6. Return of special packaging or containers after the product has been delivered or installed;
7. Products sent to the factory for future maintenance, development or usage;
8. Production waste recycling and usage. (Gandolfo & Sbrana, 2008, p. 32).

In addition, the most widely recognized benefits from the use of reverse logistics in a company can be:

1. Increase in revenue and profit from the selling of goods or services;
2. Increase in competitiveness and product or service availability;
3. Reduction of costs for purchasing of stock and spare parts;
4. Increase in effectiveness;
5. Reduction of response time to the request of retailers and buyers;
6. Growth of experience in troubleshooting;
7. Increase in the satisfaction of customers and retailers and loyalty. (Zueva & Shakhnazaryan, 2014, p. 142-143).

## 2.4 Structure

The structure of reverse logistics is presented by the analysis of its main elements and processes.

### 2.4.1 Elements

For proper understanding of the concept of reverse logistics, its main elements should be considered. Initially, it is necessary to know who (the actors) and what (the product) are involved in the reverse processes. Table 1 shows the constant actors involved in the implementation of reverse logistics.

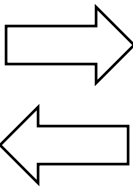
Table 1 Constant actors of reverse logistics (Grant, 2013, p. 152-154)

<b>Actor</b>	<b>Activity</b>
Retail companies	Management of product returns, repairs and warranties, including the resale and redistribution of unsold products and product warranties
Original equipment manufacturers (OEMs)	Management of product returns, repairs and warranties, but more often their activity involves outsourcing third-party logistics service providers or providing specialized channels for customers
Governmental agencies	Management of waste collection and disposal services to households and shops
Private waste management and product return companies	Third-party logistics service providers, which specialize in return management and other reverse activities
Traders	Purchasing and selling recovered products or recycled materials collected by government agencies, retail companies, waste management companies and scavengers
Reprocessors	Disassembling, repairing, remanufacturing, refurbishing, recycling and reprocessing products and materials from the 'disposal' market and transforming them into (re-)usable forms. In this way, this type of companies is one of the most important actors in the reverse process
Customers	The last but the most important actors because they form the 'reuse' markets. It means that without demand all the processes of reverse logistics will be economically inefficient

### 2.4.2 Processes

All the common reverse logistics processes or activities which suppliers implement are represented in Table 2. The goal of reverse logistics is achieved if a reverse material flow exists and also successfully operates.

Table 2 Reverse logistics processes in action (Rogers &amp; Tibben-Lembke, 1999, p. 10)

Customers		Suppliers
Products		Resell; Sell via Outlet; Salvage; Recondition; Refurbish; Remanufacture; Reclaim Materials; Recycle; Landfill
Packaging		Reuse; Refurbish; Reclaim Materials; Recycle; Salvage

## 2.5 Reverse Supply Chain

Obviously, all the reverse processes cannot exist separately from Supply Chain. They should be connected with other logistics activities such as manufacturing, purchasing, warehousing, transportation and controlled by

Supply Chain Management. When these requirements are observed, ordinary Supply Chain turns into Reverse Supply Chain or Closed Loop Supply Chain (Figure 2), which means that this logistics chain includes reverse processes and it is socially and environmentally responsible. Consequently, now it works under Closed Loop Supply Chain Management (CLSCM). (Kumar & Kumar, 2013, p. 156).

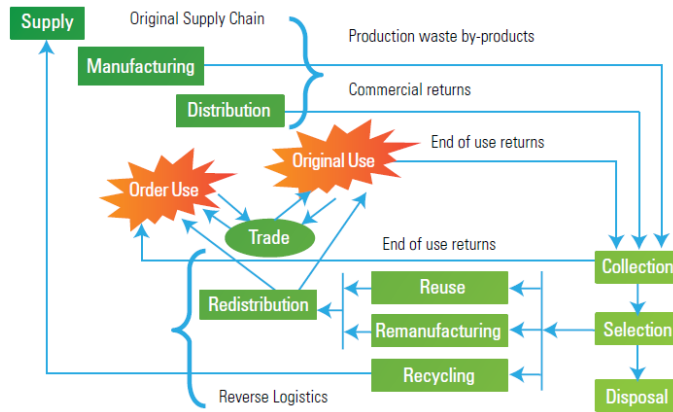


Figure 2 Reverse Supply Chain (Kumar & Chatterjee, 2011, p. 2)

Reverse Supply Chain is completely different from ordinary Supply Chain in many aspects, which is shown in Table 3.

Table 3 Difference between Reverse and non-Reverse Supply Chain (Kumar & Kumar, 2013, p. 156-157)

	Supply Chain	Reverse Supply Chain
Goal	Economic efficiency	Balance between economic benefits, social and environmental effects
Management	Lack of environmental impact's control	Social and environmental management is necessarily included
Business model	Less complete	More complete, because it has to consider green issues through the whole life cycle
Business process	"Cradle-to-Grave"	"Cradle-to-Reincarnation"
Consumption	Consumer interests, business activities	Government procurement, corporate social responsibility, sustainable consumption education and practices

In addition to this, there are two types of Reverse Supply Chain:

1. Centralized. The cost efficiency is reached by centralizing the testing and evaluation of the returned products at a central facility. The retailer or reseller does not participate in any product evaluation. Shipping costs are minimized by shipping the returns to the vendor in bulk;
2. Decentralized. The unused products can be restocked immediately in such kind of Reverse Supply Chain. Testing can be performed at the point of return by the reseller or retailer, but it needs to be technically feasible and

requires special knowledge of this technology from resellers. (Kumar & Chatterjee, 2011, p. 5-6).

### 3 INDUSTRIAL WASTE AS THE OBJECT OF REVERSE LOGISTICS

Nowadays, the world is developing very fast and all the processes and phenomena change immediately one by one. In this way, it becomes more and more complicated to control them efficiently. Increase in waste is one of the successful confirmations of this. As society has grown wealthier, it has created more rubbish. A high level of life quality means that people are buying more products. Consumption also has changed drastically. Today, people have much more choice and products which have shorter lifespans than earlier. There are also many more single-use and disposable products. Technological development means that people own and use many personal devices, and update them more often. These lifestyle changes may have improved the quality of human life, but they also mean we are generating more waste than ever before. (European Union, 2010, p. 2).

Business Dictionary gives several general definitions of waste. If all of them are combined, a more detailed definition will be obtained. Accordingly, waste is considered as unwanted materials left from a production activity which are often emitted to the environment and cause harmful changes, or as different processes which do not add value to a good or service (Business Dictionary, 2016).

Waste is an issue that concerns all of us. We all produce waste. According to the data provided by the European Union, on average each of the 500 million people living in the EU throws away approximately half a ton of household rubbish every year. These huge amounts of waste are generated mainly in manufacturing (360 million tons) and construction (900 million tons), while water supply and energy production generate 95 million tons. Altogether, the European Union produces up to 3 billion tons of waste every year. (European Union, 2010, p. 2). For example, in 2010 total waste production in the EU amounted to 2.5 billion tons. From this total, only a limited (albeit increasing) share (36 %) was recycled, the rest was landfilled or burned, of which some 600 million tons could be also recycled or reused. (European Commission, 2016).

Whether it is reused, recycled, incinerated or put into landfill sites, the management of waste requires a financial and environmental cost (European Union, 2010, p. 3). In this way, companies should take into consideration three important aspects of reverse logistics:

1. Not all used products are technically suitable for reuse, repair, remanufacture or recycling;
2. Companies should be sure that there is a constant supply of the products, which are going to be recycled or reused (supply from the 'disposal' market);
3. Companies should be sure that there is a constant demand for reprocessed products. In other words, they should be sure that it is worth developing a reverse logistics flow. (Grant, 2013, p. 159).

Reverse logistics systems involve many fragmented participants and experience a lack of supply chain leadership, so reaching the efficiency in this kind of logistics activity seems to be rather problematic. In this case, the role of product recovery management (PRM) becomes significant. In order to understand the economic value of PRM, Srivastava (2008) introduced a new concept called 'value recovery' (VR). Returns volume, timing, quality (grade), product complexity, testing, evaluation and remanufacturing complexities are the main characteristics of value recovery. Therefore, if all the recovery processes and aspects are carefully analyzed and then planned, the implementation of reverse logistics may lead to increased revenue, lower costs, improved profitability and enhanced level of customer service. (Grant, 2013, p. 161).

Within the framework of this thesis, industrial waste acts as the object of reverse logistics analysis because nowadays almost every kind of business requires specific materials which are usually obtained from mining and quarrying activities, and other various manufacturing processes. Thereby, there is an extremely large amount of industrial waste being produced every day and reverse logistics in this sphere must be implemented in order to prevent environmental pollution and achieve maximally efficient use of resources.

*"Industrial waste is solid, semi-solid, liquid, or gaseous, unwanted or residual materials (not including hazardous or biodegradable wastes) from an industrial operation"* (Business Dictionary, 2016).

The Collins English Dictionary offers another definition of industrial waste. It is “...*waste materials left over from a manufacturing process in industrial buildings such as factories and mines*” (The Collins English Dictionary, 2016).

We should also mention here that industrial waste includes:

1. Waste from commercial, industrial or trade activities or from laboratories;
2. Waste-containing substances or materials from industries, which are potentially harmful to human beings or equipment. (EPA Victoria, 2012, p. 1).

Waste from manufacturing industries includes different waste streams arising from a wide spectrum of industrial processes. For example, the production of basic metals, food, beverage and tobacco products, wood and wood products, paper and paper products generate the largest volumes of waste in Western and Central Europe. (European Topic Centre on Sustainable Consumption and Production, 2013).

In relation to the quantity of industrial waste, in 2012 the total waste generated in the EU-28 by all economic activities and households amounted to 2 514 million tons (Table 4). This was slightly higher than in 2010 and 2008 (2 460 million tons and 2 427 million tons), but lower than in 2004 (2 565 million tons). The relatively low figures for 2008 and 2010 may be the result of the financial and economic crises. (Eurostat, 2015).

Table 4 Waste generation by economic activity and households, 2012 (1000 tons) (Eurostat, 2015)

<b>Activity</b>	<b>Waste generation (1000 tons)</b>
Manufacturing	269 630
Mining and quarrying	733 980
Construction	821 160
Energy	96 480
Other economic activities	379 560
Households	213 410
<b>Total</b>	<b>2 514 220</b>

Figure 3 shows the share of each economic activity and of households in total waste generation in the EU-28 for 2012. Construction contributed for 33 % of the total and was followed by mining and quarrying (29 %), manufacturing (11 %), households (8 %) and energy (4 %). The remaining 15 % was waste generated from other economic activities. (Eurostat, 2015).

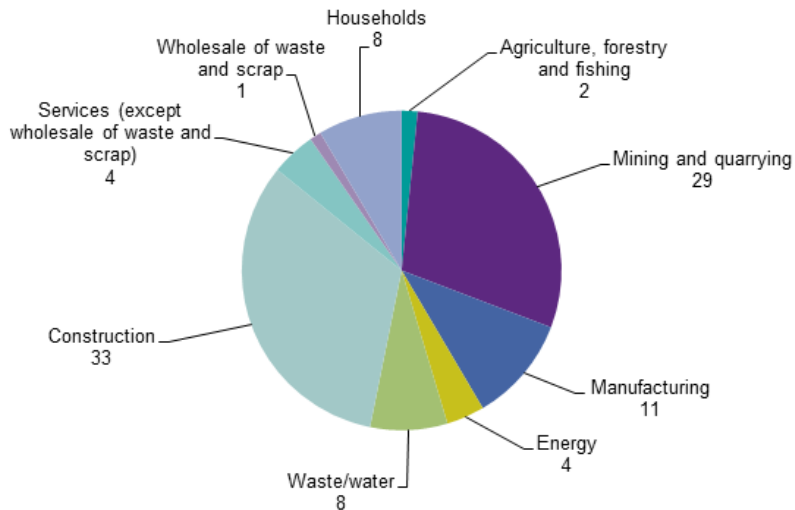


Figure 3 Waste generation by economic activity and households, EU-28, 2012 (%)

Today, industrial waste tends to increase despite national and international legislation and limitations, but at the same time innovative cleaner technologies, effective manufacturing practices and other waste minimization initiatives are developing. (European Topic Centre on Sustainable Consumption and Production, 2013).

### 3.1 Types of industrial waste

Today, various types of industrial waste exist. As was already mentioned, industrial waste is unwanted materials produced in or eliminated from an industrial operation and categorized under a variety of headings, such as liquid wastes, sludge, solid wastes, and hazardous wastes. (Environmental Glossary, 1998). These wastes come from such activities as manufacturing, mining process, oil and gas production.

#### 3.1.1 Solid waste

According to Business Dictionary, solid waste is “*solid or semisolid, nonsoluble material (including gases and liquids in containers) such as agricultural refuse, demolition waste, industrial waste, mining residues, municipal garbage, and sewage sludge*” (Business Dictionary, 2016).

Industrial solid waste is such type of solid waste which is produced by businesses and industries mainly because of their manufacturing activities. Here it is important to note that in any case industrial solid waste must be

evaluated in order to determine its proper disposal method. It is usually required by state laws and legislation and includes certain documentation of the characteristics of waste and/or laboratory testing.

Table 5 shows several types of industrial solid waste and corresponding examples.

Table 5 Common types of industrial solid waste and examples (Jinhui Li)

Type	Example
Industrial solid waste from...	
Mining industry	Waste stones, wall rocks
Metallurgical industry	Steel slag, red mud
Power industry	Coal fly ash, coal slag
Chemical industry	Empty chemical containers, waste pesticides from medicine and insecticide production
Oil chemical industry	Oil mud, oil contaminated wastes
Light industry	Animal residues and carcasses, sludge from food production, non-recyclable glass and plastic
Other industries	Construction wastes, electrical component wastes

### 3.1.2 Liquid waste

Waste can have non-solid form. Sometimes, solid waste can be converted into a liquid waste form in consequence of disposal. This includes storm water and wastewater. Wash water from homes, liquids used for manufacturing in industries and waste detergents are common examples of liquid waste. (EPA Victoria, 2012).

Industrial liquid waste is liquid waste resulting from an industrial or manufacturing process including food wastes from food product manufacturing, dairy wastes, and waste from all production steps within an industrial facility which includes vehicle maintenance areas where process waste and flammable waste trap wastewater are combined. (Metropolitan Council, 2013, p. 1).

### 3.1.3 Sludge

Sludge is known as “*semi-liquid residue from industrial processes and treatment of sewage and wastewater*” (Business Dictionary, 2016).

Merriam-Webster also defines sludge as “*a muddy or slushy mass, deposit, or sediment as precipitated solid matter produced by water and sewage treatment processes*” (Merriam-Webster Dictionary).



According to Business Dictionary, this kind of waste is generated in the treatment of industrial water or wastewater (Business Dictionary, 2016).

#### 3.1.4 Mining waste

Mining waste arises from different kinds of extractive operations (prospecting, extraction, treatment, storage) of mineral resources and they involve materials that must be removed to gain access to mineral resources, e.g. topsoil, overburden, waste rock and tailings remaining after minerals have been largely extracted from the ore. (European Commission, 2015).

Mining wastes are related to the products of two types. The first type is *“mining-and-quarrying extraction wastes which are barren soils removed from mining and quarrying sites during the preparation for mining and quarrying and do not enter into the dressing and beneficiating processes”*. The second one is *“mining-and-quarrying dressing and beneficiating wastes which are obtained during the process of separating minerals from ores and other materials extracted during mining-and-quarrying activities”*. (Glossary of Statistical Terms, 2001).

Nowadays, this type of industrial waste generates one of the largest waste streams in the EU. Some of the mining wastes are inert and do not represent any significant pollutant threat to the environmental safety. There is only one problem which might be taken into consideration here — these wastes occupy valuable land and cause harm to human life when they are deposited near the drainage area. (Glossary of Statistical Terms, 2001).

Unfortunately, there are also some types of mining wastes which are dangerous for the environment, e.g. waste from non-ferrous metal mining industry. They may contain large quantities of dangerous substances such as heavy metals. After the extraction and subsequent mineral processing, metals tend to become chemically more available, which can call the generation of acid or alkaline drainage. The management of tailings is also rather risky, often involving residual processing chemicals and elevated levels of metals. Other disadvantages of mining industry are the physical footprints of waste disposal facilities, loss of land productivity, effects on ecosystems, dust and erosion. These impacts were measured as rather costly to address through remedial measures. Accordingly, the production of mining waste and this kind

of industry itself must be controlled and highly managed. (European Commission, 2015).

In response, the EU has already proposed initiatives for the improvement of mining waste management (European Topic Centre on Sustainable Consumption and Production, 2013).

### 3.2 Hazard of industrial waste

As mentioned above, there are various types of waste. Obviously, a future increase of these wastes is not desirable because it appears rather onerous to find ways for their reuse, and their accumulation might cause dangerous effects on human health and the state of the environment, especially when this type of waste is determined as hazardous.

According to Business Dictionary, hazardous waste is *“solid, liquid, or gaseous by-product of industrial processes that possesses at least one of the four characteristics: corrosiveness, ignitability, reactivity, toxicity; and which may have to be handled stored, transported, and disposed of in a controlled manner”*. (Business Dictionary, 2016).

In 2012 in the EU, 99.9 million tons (4 % of the total amount of generated waste) were referred to hazardous waste. This was equivalent to an average of 198 kg of hazardous waste per one inhabitant in the EU-28. Overall, between 2004 and 2012, the European Union faced a 10 % increase in hazardous waste generation per one inhabitant. (Eurostat, 2015).

What is more important, in most cases hazardous waste comes from industrial and business activities (Dictionary.com, 2016). In this way, the study and research of the implementation of reverse logistics in industrial sphere needs close attention. Special legislation and management arrangements such as storage of hazardous waste separated from non-hazardous waste and strictly monitored treatment are already being performed not only in the EU, but also in the whole world. (European Topic Centre on Sustainable Consumption and Production, 2013).

### 3.3 Industrial waste management in the context of reverse logistics

The definition of management is very wide because nowadays this process is used in each sphere of people's life, beginning with our personal everyday arrangements and finishing with work on important projects, cases and other activities which require special attention and control.

Reverse logistics requires qualitative waste management which is the most essential part of developing a sustainable supply chain.

Business Dictionary states that waste management is the collection, transportation and disposal of different kinds of waste, which implies management of all processes and materials for proper handling of waste materials, taking into consideration human health codes and environmental regulations (Business Dictionary, 2016).

Glossary of Statistical Terms details the processes which are included in the concept of waste management and says that it covers such important processes as appropriate treatment of waste, control, monitoring, and regulation, prevention of waste production, reuse and recycling. (Glossary of Statistical Terms, 2003).

Based on the information above, a certain conclusion can be made. Reverse logistics will be efficient only if waste management is highly developed. At the same time, it is worth noting that all actual reverse processes are various, and the level of their complexity is increasing. Consequently, there is a need to address issues of sustainability and integration within the whole supply chain, not only to the post-consumption stage. (McKinnon, 2010, p. 243-244).

In this way, if each stage of supply chain minimizes waste production and reduces materials and energy consumption in order to create an environmentally friendly and qualitative product, sustainability of supply chain will be achieved, which is considered to be the main objective of reverse logistics (McKinnon, 2010, p. 246).

Unfortunately, this ideal concatenation of circumstances cannot exist in our real life. Nowadays, people have to solve problems concerning the environment and society as a whole with the help of reverse logistics. As it is shown in Figure 4, the implementation of reverse logistics is very important because it contributes to reaching sustainability in the modern world.

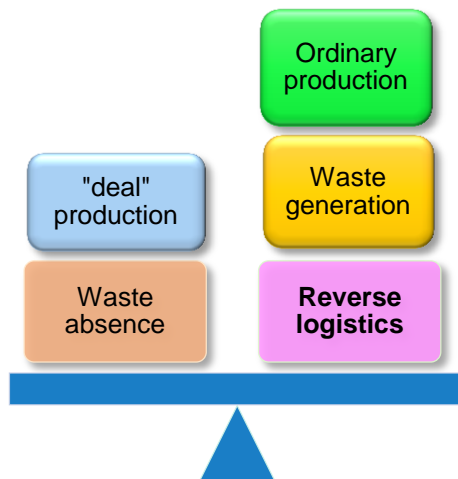


Figure 4 The role of reverse logistics nowadays

Nowadays, the European Union pays much attention to organizing efficient waste management. The EU waste policy has been actively developing during the last 30 years and today has its own strategy on waste. Some of the EU features of waste management are:

1. Performance according to waste hierarchy. Here prevention is considered to be the best solution, followed by preparing for reuse, recycling, other recovery and disposal;
2. Performance according to waste legislation;
3. Use of a life-cycle approach. (European Commission, 2010, p. 4-6).

In conclusion, it is worth saying that each manufacturing and mining industry should use and develop waste management because all that they manufacture today becomes the waste of tomorrow. Industrial companies should consider the impacts at the design stage of product creation, minimize material and energy use, reduce the use of hazardous materials, and manufacture products of long-term use which may eventually be reused or recycled. (European Topic Centre on Sustainable Consumption and Production, 2013).

### 3.4 Reverse logistics in mining industry

Today, the implementation of efficient logistics and supply chain management plays a crucial role in each industry. Mining industry is not an exception. But before proceeding to the analysis of reverse logistics here, the definition of the process of mining should be considered. Table 6 represents several definitions of mining process.

Table 6 Definitions of mining (The Free Dictionary by Farlex, 2016)

Dictionary	Definition
American Heritage Dictionary of the English Language	<i>"The process or business of extracting ore or minerals from the ground"</i>
Collins English Dictionary	<i>"The act, process, or industry of extracting coal, ores, etc, from the earth"</i>
Random House Kernerman Webster's College Dictionary	<i>"The act, process, or industry of extracting mineral substances from mines"</i>

Consequently, the result of mining industry is extracted minerals which are widely used nowadays and mining waste the use of which stands under the question. This chapter is devoted to considering mining waste as the object of reverse logistics in mining industry.

Today, mining industry is developing fast. Not only the process of mining is being improved and automatized, but logistics processes as well. Companies try to find the best logistical solutions and organize efficient logistics management, building a smart supply chain of the future. (Fleming Gulf, 2013).

As for Europe, there are many deposits of natural resources, so mining industry is highly important for the economic well-being of the continent. Minerals are widely used as construction materials for infrastructure and for industrial purposes (e.g. metals, lime, kaolin, silica sand, talc) in the production of cars, computers, medicines, human and animal foodstuffs and fertilizers (e.g. potash). (European Association of Mining Industries, Metal Ores & Industrial Minerals, 2014).

European metals and minerals mining industry is represented by the association called "Euromines" which aims to promote the industry and to maintain its relations with European institutions at all levels. (European Association of Mining Industries, Metal Ores & Industrial Minerals). Environmental responsibility and social care are one of numerous functions of this organization. According to the information presented in the Annual Report 2014 of "Euromines", the European mining industry provides waste management, water and biodiversity protection and reduction of air emissions. Also, it aims at "industrial renaissance", developing resource efficiency and the Circular economy (Figure 5). The main idea is that resources are used better and more efficiently at processing, design and recycling stages. ("Euromines", 2014, p. 18-21).

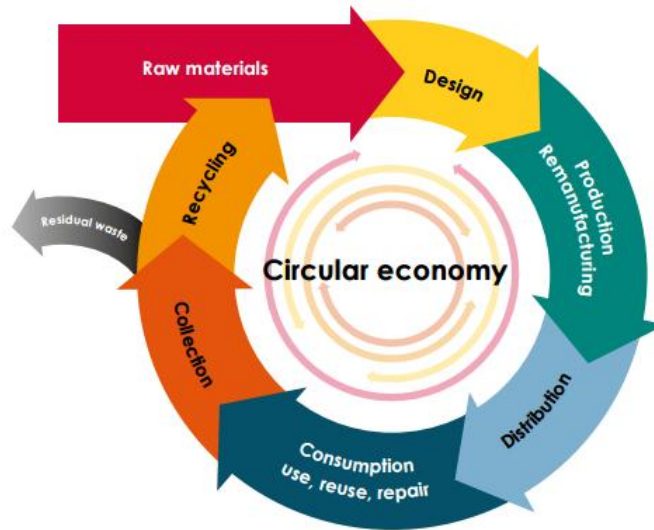


Figure 5 Circular economy (“Euromines”, 2014, p. 21)

As revealed in Figure 5, this type of supply chain is practically a closed loop despite residual waste production, which, unfortunately, cannot be reused.

On the other hand, this problem might be solved by achieving resource efficiency and subsequently a sustainable closed loop supply chain in the future. This is a key objective of European mining industry nowadays. Table 7 represents actual opportunities and bottlenecks of resource efficiency implementation in mining industry.

Table 7 Opportunities and bottlenecks of achievement mining industry’s resource efficiency (Euromines, 2011, p. 1-3)

Opportunities	Bottlenecks
Meeting minimum EU demand for the jobs, metals and minerals	Inadequate pricing policy
Further de-coupling of economic growth from resource use	Inadequate legislation in the EU
Increased competition for resources and therefore increased supply risks	Lack of canals and water infrastructure
Remaining relevant in a global economy (“having something to sell to the world”)	Skills shortages

In this way, the idea of sustainable or reverse supply chain seems to be really feasible, taking into consideration resource efficiency, the Circular economy, environmental protection and waste management. Figure 6 clarifies the required contributions from each stage of supply chain in achieving sustainability.

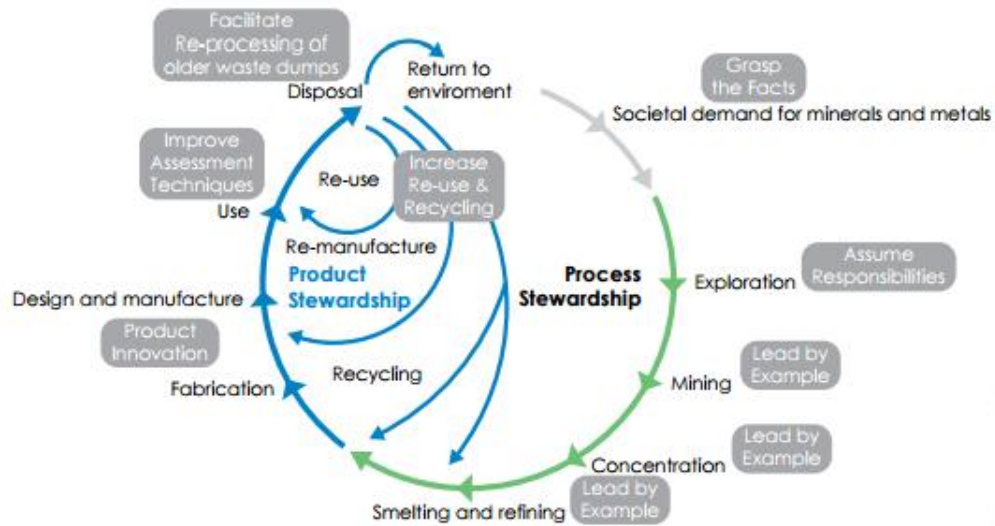


Figure 6 Closed loop supply chain in mining industry (Euromines, 2011, p. 3)

If not to look so far, it is worth noting that the actual situation in European mining industry leaves much to be desired. This is due to oversupply and weak markets. Specialists say that the situation will not change till the next pick-up in global economic growth. It means that mining companies do not have sufficient funds to develop reverse processes and, unfortunately, reaching sustainability in such conditions does not seem possible in the near future. (Cecilia Jamasmie, 2015).

#### 4 REVERSE LOGISTICS IN ACTION

Speaking of today's level of reverse logistics development, mining industry, particularly potash mining, will be taken as the object of the analysis. This choice can be explained by several reasons:

1. The state of mining industry has a great influence on the whole European economy;
2. The problem of mining waste accumulation remains actual and needs new solutions (especially, in the Republic of Belarus where the author of this thesis comes from and where this type of industry is leading and, actually, makes the largest contribution in the development of national economy on the whole);
3. Salt Association states that mining waste (sodium chloride) is not classified as dangerous to the environment, but together with that influences it to a

certain extent (Salt Association). Soil salting can be set as the example of this.

Nowadays, mining industry is developing rather fast paying attention to the use and improvement of various mining techniques. Mining technique is a crucial element without which Europe would not be in a position to benefit from its mineral wealth. Innovative mining techniques necessarily involve sustainable mining elaboration under technically and economically viable conditions and meet environmental standards. (European Association of Mining Industries, Metal Ores & Industrial Minerals).

Considering the present state of world mining industry, it is worth noting that such countries as Canada, the United States of America, the Republic of Belarus, Germany, and Russia are leading producers of such important industrial mineral as potash (Figure 7). Table 8 shows the latest data on potash production in these countries.

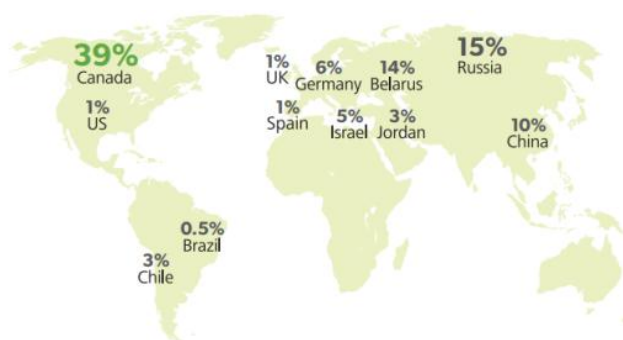


Figure 7 World potash capacity by region ("PotashCorp", 2015, p. 51)

Table 8 Production by mineral, tons (potash) (European Association of Mining Industries, Metal Ores & Industrial Minerals)

Country	2000	2003	2006	2009	2012
Canada	9,107,000	9,145,000	8,528,000	4,613,327	8,984,000
United States of America	1,300,000	1,100,000	1,100,000	840,000	900,000
Belarus	3,372,000	4,230,000	4,605,000	2,485,000	4,831,000
Germany	3,407,467	3,563,000	3,625,000	1,825,139	3,149,386
Russia (Europe)	3,680,000	4,650,000	5,274,100	3,730,000	6,128,100

As stated in Cambridge Advanced Learner's Dictionary & Thesaurus, potash is white powder containing potassium that is put on soil to make crops grow better (Cambridge Dictionaries Online, 2016).

Since the middle of the 19<sup>th</sup> century, this mineral has been actively used as a fertilizer. Potash or potassium plays the role of regulator, which helps plants to use water effectively and to avoid stress. Nowadays, potash mining has a



significant meaning in human life because all the plants need additional nutrients such as potassium, nitrogen, and phosphorus, especially after years of growing crops on the same land when soil begins to lack of them. The process of potash mining itself is rather complicated and includes several stages:

1. Extraction of potash or potassium chloride;
2. Separation of potash (crushing and rinsing the ore);
3. Squashing tiny particles of hot potassium chloride in a roller press;
4. Gathering potassium chloride crystals and processing them into granular fertilizer. (Nutrients4Life, 2013).

As the result of this complex process, large quantities of mining waste are generated as revealed in Figure 8.



Figure 8 Potash mining industry in Belarus (Available at: <http://belnp.org/wp-content/uploads/2012/01/%D0%91%D0%9A7103002.jpg> [Accessed: 10 March 2016])

Further analysis includes the consideration of the implementation of reverse logistics in potash mining industry on the example of such companies as “Potash Corporation of Saskatchewan”, “Mosaic”, “Belaruskali”, “Kali&Salz”, and “Uralkali” because precisely they represent this type of industry on the global arena. The problem of accumulating mining waste remains actual and needs new solutions.

#### 4.1 PotashCorp

“PotashCorp” is the world’s largest fertilizer company by capacity and produces the three primary crop nutrients: potash (K), nitrogen (N), and phosphate (P). PotashCorp’s Canadian operations represent one-fifth of global capacity. The company also has investments in four potash-related businesses in South America, the Middle East, and Asia. All in all,

“PotashCorp” does business in seven countries and plays an important role in helping the world grow the food it needs. (“PotashCorp”, 2016).

As described in 2015 Annual Integrated Report of “PotashCorp”, the company uses standardized systems, implements best practices at all its facilities, manages mining risks such as ground collapses and flooding through the development of world-class geological technology and mining techniques and aims at minimizing waste and increasing recovery rates. (“PotashCorp”, 2015, p. 54).

According to the statistical data of the company, the amount of waste is increasing year after year, which contradicts to the strategy of sustainability of “PotashCorp” (Figure 9). Obviously, the company increases the quantity of production, but it can also be proposed that reverse logistics is not implemented efficiently in this company. In addition, “PotashCorp” does not provide information on waste utilization.

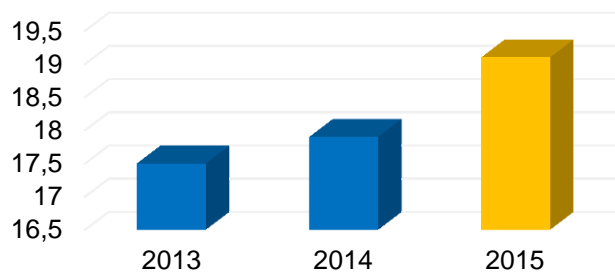


Figure 9 Waste generated by “PotashCorp” on years: potash performance (million tons) (“PotashCorp”, 2015, p. 57)

## 4.2 Mosaic

The Mosaic Company is the world's leading producer and marketer of concentrated phosphate and potash. It employs approximately 9,000 people in six countries and participates in every aspect of crop nutrition development.

“Mosaic” mines phosphate rock from nearly 200,000 acres of Mosaic-owned land in Central Florida, and the company mines potash from four mines in North America, primarily in Saskatchewan. The products of “Mosaic” are processed into crop nutrients, and then shipped via rail, barge and ocean-going vessels to the customers around the world.

In terms of potash production, “Mosaic” is one of the world leaders in this industry with annual capacity of 10.5 million tons. (The Mosaic Company).

What is important here is that the Mosaic Company in fact practices reverse logistics. The reduction of waste by increasing reuse and recycling of resources is one of the main sustainability targets of the company. All in all, more than 15,000 tons of waste was recycled across business units in 2014. (The Mosaic Company, 2014, p. 3-5).

Mining wastes generated from potash production are used in the production of potassium hydroxide, snow and ice melting formulas (the product is White Fine Untreated 0-0-62), water softeners, oil-well drilling muds, metal electroplating, aluminum recycling, and they are also used by food processors and pharmaceutical manufacturers. (The Mosaic Company).

It is also worth noting that the excess salt generated from potash mining is processed and then used for such commercial purposes as road salt, water softener salt and for use in food grade products and industrial uses. Figure 10 reveals the latest data on the quantities of mining waste from potash production which were processed and disposed. Disposal methods are storage and recycling for commercial use.

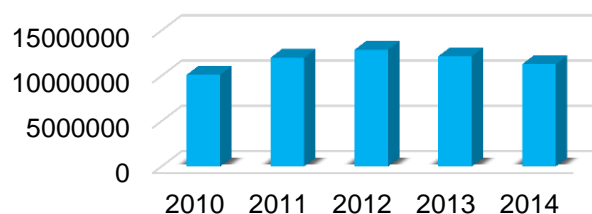


Figure 10 Mining Processing Waste Generated on years (tons) (The Mosaic Company)

Consequently, the following conclusion on the implementation of reverse logistics in “Mosaic” can be made: the company not only sets the objective of sustainable development, but also achieves it by developing effective waste management and focusing on continuous improvement to minimize the generation of waste. (The Mosaic Company).

### 4.3 Belaruskali

Open Joint Stock Company “Belaruskali” is one of the most influential manufacturers and exporters of potash fertilizers in the world. According to the

International Fertilizers Association data, it accounts for one seventh part of the world's potash production. (“Belaruskali”).

The rock salt extracted using the selective method of mining is classified according to the insoluble residue content in technical and edible salts for further treatment and manufacture of products of standard quality. Precisely technical salt represents mining waste created in this Belarusian company. This type of salt is rated as sodium chloride technical and mineral concentrate (halite). (“Belaruskali”).

In the course of further investigation, the data on mining waste generation and the implementation of reverse logistics in Production Unit 4 of “Belaruskali” is analyzed. Each Production Unit (in total, “Belaruskali” has four main Production Units) consists of a mine to extract potash ore (Production Units 2 and 4 include two mines each) and a factory to process the mined mineral and manufacture potash fertilizers (“Belaruskali”). Table 9 represents the quantity of ore mined, sylvite (KCl) obtained and mining waste halite (NaCl) generated in years 2013, 2014, and 2015.

Table 9 Quantity of ore mined and wastes generated in Production Unit 4 of “Belaruskali” on years, tons

	2013	2014	2015
Mined ore	8,010,809	11,727,964	12,159,570
Sylvite (KCl)	1,942,362	2,872,001	2,909,178
Halite (NaCl)	5,864,460	8,548,820	8,924,530
<b>Waste transfer and utilization</b>	<b>912,020.75</b>	<b>650,888.46</b>	<b>692,043.96</b>
<b>Waste transfer and utilization of the total waste generation, %</b>	<b>15.6 %</b>	<b>7.6 %</b>	<b>7.8 %</b>

Based on the information shown in Table 9, the next conclusion can be made. Year after year, the Belarusian company is improving its production of potash extracting and processing more ore compared to the previous year, but does not implement reverse processes efficiently. The transfer and utilization of waste has a tendency to reduce and, undoubtedly, requires new investigations and solutions.

In any case, the company cares about sustainability issues and reuses halite and suggests that it can be used:

1. In heat and power stations to produce deicing agents;
2. As an icemelter;
3. In other technical purposes. (“Belaruskali”).

The Republic of Belarus, Russia, Lithuania, Poland, and Moldova are in the number of countries where halite is delivered and used.

As regard to the transportation of halite, it is implemented on gondolas by rail. In addition to this, a gondola is equipped with a large bag made from special material in order to protect its content from external impacts such as rain and humidity. After halite is loaded into this bag, it is tied and a cargo is ready for delivery.

#### 4.4 Kali&Salz

“Kali&Salz” (K+S) is a world-known German resource company which has been mining and processing mineral raw materials for more than 125 years. All the products of “Kali&Salz” are used in agriculture, food and road safety and play an important role in numerous industrial processes. K+S is the world’s largest salt producer and one of the top potash providers worldwide. Nowadays, with more than 14,000 employees, the company achieved about € 4.2 billion as revenue in financial year 2015. (“Kali&Salz”).

Taking into account that “Kali&Salz” is a mining company, the question of waste generation arises by itself. It was found that most of the solid waste of K+S can be characterized as mining waste (solid residues). The crude salt in potash mining contains a limited proportion of recyclable materials (30 %). The other part is residues which cannot be economically exploited and need appropriate disposal. Solid residues from the potash industry can be accommodated underground as backfill material, the rest is piled up above ground (Figure 11). (“Kali&Salz”).



Figure 11 Mining waste stockpiling in K+S (Available at: <http://www.k-plus-s.com/de/gewaesserschutz/produktionsverfahren.html> [Accessed: 15 March 2016])

Considering the Annual Report 2015 of the company, it can be concluded that, in fact, “Kali&Salz” implements pile management. In 2015, K+S piled up 27.3

million tons of solid residues (2014: 26.9 million tons) and accommodated 1.9 million tons as backfill underground (2014: 1.8 million tons). On the other hand, the company only accumulates large quantities of mining waste on the ground, obtains permissions to expand its piles and displaces small and medium-sized ones not aiming at the practice and elaboration of reverse logistics. The only reverse operation which is used in this German company is that it is making research on creation of suitable covering materials for piles which allow for revegetation. (“Kali&Salz”, 2015, p. 48).

#### 4.5 Uralkali

“Uralkali” is one of the world’s largest potash producers and exporters. The company includes 5 mines and 7 ore-treatment mills situated in the towns of Berezniki and Solikamsk (Perm Region, Russia). “Uralkali” employs approximately 11,000 people in the main production unit. (“Uralkali”, 2016).

The question of sustainability in this Russian company takes an important place and attracts much attention. Minimizing the impact on the environment is set as one of the main objectives in achieving sustainability. The company uses not only advanced treatment systems, but at the same time it is looking for new ways of waste disposal and possibilities of recycling. (“Uralkali”, 2016).

As an example, Russian halite waste is used for the production of saline solution which is used in the production of soda, industrial sodium chloride and mineral concentrate “halite”. Halite waste and clay-salt slurries are also used for filling the mined-out areas of mines. (“Uralkali”, 2014, p. 45).

Actually, an important point is that “Uralkali” implements reverse logistics efficiently. The latest data on waste generation and its disposal confirms this fact. Table 10 reveals that the company is engaged in the development of reverse processes by waste delivery to other enterprises for its further reuse.

Table 10 Total weight of waste by type and disposal method in “Uralkali” (“Uralkali”, 2014, p. 10)

	Uralkali Group Total	
	Year 2014	Year 2013
<b>Hazard class I-IV (hazardous waste)</b>		
Waste at the beginning of the year	38,4	36,0
Waste generation	28,122.8	18,872.3
<b>Waste utilisation</b>	<b>95.9</b>	75.2
Waste neutralisation	0.0	1.0
<b>Waste transfer to other enterprises:</b>	<b>28,045.3</b>	18,790.1
– for utilisation	248.0	714.5
– for neutralisation	21,021.7	10,909.8
– for storage	44.4	249.7
– for disposal at dumps (burial)	6,731.2	6,916.2
Waste disposal at facilities operated by the company	0.0	1.7
Waste at year-end	20.1	40.4
<b>Hazard class V (non-hazardous waste)</b>		
Waste at the beginning of the year	540,870,485.9	523,064,933.7
Waste generation	34,745,236.9	28,130,560.6
<b>Waste utilisation</b>	<b>10,432,746.3</b>	10,231,285.6
Waste neutralisation	0.0	0.0
<b>Waste transfer to other enterprises:</b>	<b>70,808.2</b>	88,449.3
– for utilisation	38,756.6	52,484.2
– for neutralisation	0.0	0.0
– for storage	0.0	999.0
– for disposal at dumps (burial)	32,051.6	34,966.1
Waste disposal at facilities operated by the company (for storage at salt and slime dumps)	25,102,050.5	18,662,131.0
<b>Waste at year-end</b>	<b>565,112,169.0</b>	<b>540,875,757.0</b>

#### 4.6 Optimization

Optimization of reverse logistics is worth development provided that there is a constant demand for reprocessed products.

Nowadays, mining waste is rather demanded and widely used in such fields as ice melting, power system, water treatment, plastic production and building. In this way, new solutions for the optimization of reverse logistics in mining industry is worth consideration and future realization:

1. **Reverse logistics management.** The issue of sustainable supply chain is important to each modern business company. The implementation of effective management implies a highly educated specialist in reverse logistics and continuous work on the reverse strategy of a company;
2. **Marketing.** The analysis of markets is the second step which a company should undertake. If an accurate reverse strategy is created, a reverse logistics department should analyze demand. As it has already been mentioned, mining waste has a wide use and, actually, has not a high price. In this way, there will not be a difficulty in finding customers. In case

of the company “Belaruskali”, it should negotiate with at least neighboring countries (Ukraine, Latvia) and aim at setting long term relationships on constant supply of halite with them. The same idea can be applied in another mining companies as well;

3. **Investment.** Additional financial support can help Research & Development department to launch new investigations and studies in this field, e.g. with relation to the creation of suitable covering materials which would allow for revegetation of piles, in order to find better solutions of reuse of mining waste.

## 5 CONCLUSION

The main objective of this thesis was the assessment of the development of reverse logistics in mining industry on the example of potash production. In order to achieve this objective, important questions needed to be answered such as what possible benefits companies may obtain from the implementation and development of reverse logistics. The second and the third chapters of the study provide theoretical foundations for empirical study. The reverse logistics related topics such as reverse supply chain, industrial waste and its types, hazard of industrial waste, industrial waste management were discussed. The analysis of statistical data in the form of tables and diagrams was used as the main method in the theoretical part.

The empirical part includes the analysis of reverse logistics implementation in potash mining industry. Here it is important to note that the role of reverse logistics in potash mining industry is growing together with the development of mining industry itself. The question of sustainability attracts much attention from mining companies today, but the problem of waste generation and its accumulation remains intractable and requires more research and investment. Resource efficiency and the circular economy still continue to be only logical theoretical models which definitely require more research to answer the question: “How to achieve that?”

The study proposes three methods for future improvement and optimization of reverse logistics. The first one is efficient reverse logistics management system which companies should engage. The second one is particularized



marketing campaign. The third method is the attraction of investments for the development of reverse logistics innovations and their realization.

From the author's point of view, modern industrial companies which use natural resources should think not only about meeting demand and obtaining more profit, but also about taking care of nature itself and future generations. Companies should undertake concrete actions, not only saying beautiful words to the world. It is high time to not only consume, but to create and contribute.

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