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# Sustainable management of hazardous wastes in the electroplating sector according to Circular Economy rules

## Zrównoważone gospodarowanie odpadami niebezpiecznymi w przemyśle galwanotechnicznym w świetle założeń GOZ

*The electroplating industry sector generates of many problematic waste in the meaning of further recovery or recycling. Plenty of generated waste are the hazardous waste. The article focuses on the problem of hazardous substances use in the electroplating sector, in the context of the Circular Economy policy, requirements of the Industrial Emissions Directive (IED) and the revision of the relevant reference documents on the Best available techniques (BAT / BREF). This issue was addressed in the HAZBREF project, funded by the INTERREG Baltic Sea Region Program, in which the current situation was reviewed, and there were identified recommendations for good management practices for chemicals containing hazardous substances, and waste management.*
*This paper is based on review of twenty integrated permits issued for STM (Surface Treatment Of Metals and Plastics) facilities in Poland and in-depth interviews of the two case studies operators. The study allowed for an overview of the applied practices and analysis of solutions that can support safe waste management in Circular Economy (CE) context.*
Keywords: *electroplating, hazardous wastes, circular economy,*

*Sektor przemysłu galwanicznego generuje wiele odpadów problematycznych z uwagi na dalsze ich przetwarzanie w tym odzysk lub recykling. Wiele z wytwarzanych w sektorze odpadów to odpady niebezpieczne. Artykuł koncentruje się na problemie stosowania substancji niebezpiecznych w branży galwanotechnicznej w kontekście polityki gospodarki o obiegu zamkniętym, wymagań dyrektywy w sprawie emisji przemysłowych (IED) oraz rewizji odpowiednich dokumentów referencyjnych dotyczących najlepszych dostępnych technik (BAT / BREF). Kwestia ta została podjęta w ramach projektu HAZBREF finansowanego z Programu INTERREG Region Morza Bałtyckiego, w którym dokonano przeglądu obecnej sytuacji i sformułowano zalecenia dotyczące dobrych praktyk zarządzania chemikaliami zawierającymi substancje niebezpieczne oraz gospodarowania odpadami. Niniejsze opracowanie opiera się na przeglądzie dwudziestu pozwoleń zintegrowanych wydanych dla obiektów STM w Polsce oraz na pogłębionych wywiadach z dwoma operatorami instalacji przemysłowych. Badanie pozwoliło na przegląd stosowanych praktyk i analizę rozwiązań, które mogą wspierać bezpieczną gospodarkę odpadami w kontekście gospodarki o obiegu zamkniętym.*
Słowa kluczowe: *galwanotechnika, odpady niebezpieczne, gospodarka o obiegu zamkniętym,*

### 1. Introduction

Best Available Techniques in Surface Treatment of Metals and Plastics (STM) are indirectly supporting Circular Economy (CE) by creating durable and long-lasting surfaces through which the lifetime of metals, such as in automotive bodies, car components, covered polymers and construction materials can be extended. On the other hand, the variety of chemicals and metals used in STM processes hinders recycling from technical or economic point of view.

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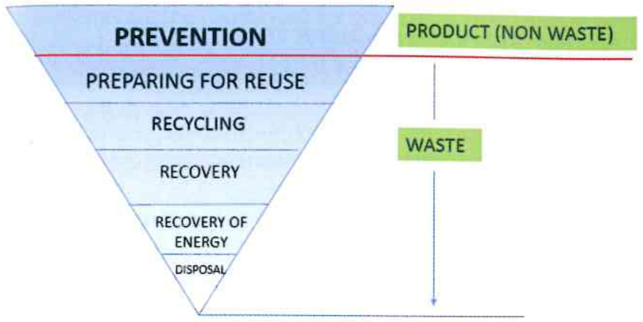


Fig. 1. Hierarchy of waste management [2]
Rys. 1. Hierarchia zarządzania odpadami [2]

The whole sector is a significant user of non-renewable resources (metals) although, where possible the good practice is to reuse of recycled materials such as metal substrates or electrolytes. Also, in-line recycling of electrolytes takes place (e.g. chromium-trioxide). Recovery processes are currently widely used for basic metals (such as Zinc, Copper and Nickel) from well-characterised waste streams). Processes are predominantly water-based, so the main waste streams are wastewaters from rinsing processes or postprocess spent solutions, sludges from wastewater treatment, and wastes from process maintenance. Another significant waste stream is packaging waste contaminated by chemicals. Depending on the process, liquid emissions may contain cyanides (although the historic trend is decreasing), as well as surfactants which often have low biodegradability and accumulative effects (e.g. fluorinated surfactants). Hazardous substances, and valuable metals end up in sludges from wastewater treatment. Closed water cycles are widely used by modern and well-developed STM plants. The majority of STM facilities do not recover their own process wastes themselves but send them to external treatment.

The EU Action Plan for the Circular Economy [1] establishes a substantial and ambitious programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials, and a revised legislative proposal on waste. The European Commission has adopted a new Circular Economy Action Plan - one of the main blocks of the European Green Deal, Europe's new agenda for sustainable growth. In practice the CE tackles the issue of responsible waste management based on waste hierarchy. This hierarchy was introduced to the legal system by Directive 2008/98/EC of the European Parliament and of the Council on waste (Waste Directive) [2] , and then transposed into national regulations. The hierarchy concerns hazardous waste and none hazardous waste as well. The hierarchy consists of six elements (Fig. 1):

- Prevention and avoidance of hazardous wastes generation
- Preparing for re-use
- Recycling
- Recovery
- Other Recovery, e.g. Energy recovery
- Disposal

### 2. Scope of analysis and methodology

Subject of the work is the management of hazardous substances and waste in the context of the Circular Economy policy and the Directive of European Parliament and the Council on Industrial Emissions (IED) [3].

Issues discussed in this article were the subject of the HAZBREF project - *Improving the management of Hazardous industrial chemicals in the IED BREF*. The project ended in January 2021 and was funded by the INTERREG Baltic Sea Region Program. One of the project activities was to analyze the existing conditions and good practices applied in the STM sector in relation to hazardous waste and the potential implementation of Circular Economy. The aim of the study is to indicate the limitations and possibilities to improve the management of hazardous waste based on the current practice in the industry and recommendations for process improvement.

For this purpose there was performed, an analysis of legal requirements resulting from the IED Directive [3], analysis of the BAT reference documents for the surface treatment of metals and plastics (STM BREF) [3] and waste treatment (WT BREF) [5], an analysis of selected integrated permits for installations in Poland and in-depth interviews of the operators. In the first step BAT Reference document for the sector was reviewed in the context of waste hierarchy and hazardous waste classification as defined by Waste Directive [2] and, based on that, these BATs were selected which promote the Circular Economy. In the next step the identified BATs were checked as to their performance in practice of IED STM installations with regard to waste management. The identified BATs supporting CE were analysed for the companies in Poland taking into account the criteria of robustness, effectiveness and further potential for improvement. As a basic source of the information on how the operators apply the relevant BATs, there were used the Integrated Permits issued according to IED Directive [3]. Twenty integrated permits issued for STM facilities in Poland were reviewed. They were selected as to cover various production profiles, scales of activities and management settings. The results were further scrutinized through in-depth reviews of operators in two case studies. Apart from these Directives other legal documents and literature was reviewed with respect to specific issues arose during the study. This included among others WT BREF [5], European List of Waste [6], Waste Directive [2] and Polish Waste Law [7]. Considering the surface treatment waste in the life cycle perspective the IED requirements [3] where checked in WT BREF [5].

### 3. Results

The STM BREF [4] contains 33 generic BATs and 25 specific BATs for the different processes in the STM sector: BATs are described in chapter 5 of the reference document. Aspects of CE and wastes were identified in generic BATs and in the specific BAT regarding substitution (table 1). The BATs structure corresponds with the waste management hierarchy. Unlike none hazardous wastes the issue of using hazardous substances is also important.

*Quality management system*

The analysed case examples show that improvements in hazardous waste management can already be achieved by implementing good housekeeping practices. In the advanced companies Management Systems are widely implemented. They address quality management, based for example on ISO 9001, the environmental protection, (e.g. ISO 14000) and Occupational Health and Safety (e.g. ISO 45001). The standards define requirements for internal operations and value chain responsibilities. In some cases the operators have implemented integrated systems such as: Environment, Health, and Safety (EHS) program. These systems have a strong impact on selection of chemicals, maintaining product quality, waste management issues and environmental responsibility. They require actions to reduce the amount of waste and waste management in the installations. The Quality Management Systems require also to some extent control in the waste management value chain of the waste processing. According to the case study operators, the good practice is development and implementation of annual internal plans to reduce the amount of waste generated and its negative impact on the environment. It should be underlined that proper conduct of the operators regarding the use of chemical substances waste manage-

**Table 1. Review of BATs identified as relevant to circular economy in the STM BREF [8].**
**Tabela 1. Przegląd technik BAT zidentyfikowanych jako istotne dla gospodarki o obiegu zamkniętym w dokumencie BREF STM.**

| STM BREF chapter/ subchapter | | Brief description of the content |
|---|---|---|
| **5.1 Generic BAT** | | |
| **5.1.1** **Management techniques** | *5.1.1.5* | *Process line optimisation and control* It is BAT to optimise individual activities and process lines by calculating the theoretical inputs and outputs for selected improvement options and comparing with those actually achieved |
| **5.1.2** **Installation design, construction and operation** | | It is BAT is to design, construct and operate an installation to prevent pollution by the identification of hazards and pathways, simple ranking of hazard potential and implementing a three-step plan of actions for pollution prevention |
| **5.1.5** **Waste minimisation of water and materials** | *5.1.5.1* | *Water minimisation in-process* |
| | *5.1.5.2* | *Drag-in reduction* |
| | *5.1.5.3* | *Drag-out reduction* |
| | *5.1.5.4* | *Rinsing (reduction of water consumption by using multiple rinsing)* |
| **5.1.6** **Materials recovery and waste management** | *5.1.6.1* | *Prevention and reduction.* |
| | *5.1.6.2* | *Re-use* |
| | *5.1.6.3* | *Materials recovery and closing the loop* |
| | *5.1.6.4* | *Recycling and recovery* |
| | *5.1.6.5* | *Other techniques to optimise raw material usage* |
| **5.1.7** **General process solution maintenance** | | It is BAT to increase the process bath life as well as maintain output quality, particularly when operating systems near to, or at, the closing of the materials loop |
| **5.1.8** **Waste water emissions** | *5.1.8.1* | *Minimisation of flows and materials to be treated* |
| | *5.1.8.2* | *Testing, identification and separation of problematic flows* |
| | *5.1.8.4* | *Zero discharge techniques (may not be BAT due to too high energy consumption and investment costs, but in certain, very limited cases it can be the best option, and case by case assessment is needed)* |
| **5.1.9** **Waste** | | BAT for waste minimisation are given in Section 5.1.5 and for materials recovery and waste management in Section 5.1.6. |
| **5.2 BAT for specific processes** | | |
| **5.2.5** **Substitution for, and/or control of, hazardous substances** | | It is a general BAT to use less hazardous substances. BAT to avoid or possible to replace the use of 7 main hazardous substances: |
| | *5.2.5.1* | *EDTA* |
| | *5.2.5.2* | *PFOS (perfluorooctane sulphonate)* |
| | *5.2.5.3* | *Cyanide* |
| | *5.2.5.4* | *Zinc cyanide* |
| | *5.2.5.5* | *Copper cyanide* |
| | *5.2.5.6* | *Cadmium* |
| | *5.2.5.7* | *Hexavalent chromium* |

ment and occupational health and safety is required by relevant national laws. Although, the law imposes obligations on entrepreneurs, irrespective of the Management Systems but on the other hand these systems help in fulfilling the legal requirements. These aspects, among others, are regulated by the Labor Code (art.221), which prohibits the use of chemical substances and their mixtures that are not clearly labeled, allowing their identification [9].

According to the interviewed operators, organization of production (BAT 5.1.2.) is an important aspect in the management of hazardous wastes. The operation plans concern waste management rules, use of appropriate risk prevention measures including spills and accidents, proper integration of environmental protection measures and production set ups.

The companies with Management Systems carefully select chemicals for use in the production processes, check and test appropriateness of their application focusing especially on possible impact on waste water and liquid waste treatment systems. The key aspect is systematic inventory and management of hazardous wastes. It is the common approach in the analyzed installations to segregate the wastes as far as possible for economic reasons. This is a key activity determining the recycling opportunities. This includes, implementing chemical awareness and adequate unloading, handling and storage of hazardous wastes within the production facilities.

*Avoidance of hazardous wastes*

Operators of the analysed companies focus on prevention of hazardous waste generation in the first place. Reduction of hazardous wastes generation is achieved through high efficiency of raw materials usage according to STM BREF [4]. Common approach found in the case studies is to use techniques for prolonging life of working baths. Most of the hazardous wastes are spent process solutions containing heavy metals (generated when raw materials are dragged out of process solutions with the workpieces, and into rinsing-waters), thus avoiding of dragging metals out of the bath and feedback of the dragged-out process solutions into the process tanks is one of key aspects for process optimization and further waste management. According to the operators of IED installations by retaining raw materials in process vats and by minimising water use help essentially to minimise material losses and generation of wastes. These practices, although reduce the amount of hazardous wastes but the potential for prevention of hazardous wastes generation is moderate.

*Baths regeneration*

In the analysed installations there are commonly used techniques for bath regeneration according to STM BREF (BAT 5.1.6) [4]. Application of this practice depends on the specificity of the process and the conditions for its efficient performance. Standard





procedures are the techniques for cyan baths regeneration of nickel planting baths, acidic metal etching solutions, Zinck, Nickel plating, phosphatising, anodising in sulphuric acids and chromium plating baths. The regeneration techniques cover: filtration on fabric, activated carbon, electrochemical treatment on low current density, carbonates freezing and crystalisation. This allows to remove pollutants such as dust, grease, hydrocarbons as well as precipitated sediments that may arise as a result of chemical reactions. The opportunities for prolonging baths life are limited and finally the working medium of coating is replaced (once – to a few times a year depending on the production volume). Examples of the HAZBREF case studies showed that for some processes carried out in a continuous system, galvanic baths do not become waste during whole its lifecycle. Due to conditioning operations (filtration, filling-up working metal) baths are infinitely used in close loop system.

Despite the successful approaches recovery of materials is, at the same time, limited for technical and economic reasons. Regeneration of baths generate hazardous wastes but in relatively small quantities. They include: liquid wastes classified as code 11 01 98* (Other wastes containing hazardous substances) and sludges from cleaning of galvanic baths of the code 11 01 09 * (Sludges and filter cakes containing hazardous substances). These waste should be delivered to authorized recipients for neutralization or utilization

*Substitution of substances classified as less hazardous and process changes*

According to HAZBREF case studies the companies and the sector as a whole undertake efforts to replace hazardous chemicals, although use of those is in the core of the technology. As result of the REACH Regulation [10] the following hazardous substances were substituted:

- Cr VI in decorative chromium plating according to REACH authorisation rules except for some applications (pickling of plastics, hard chromium plating, military, automotive and aviation).
- In hard chromium plating the use of PFOS (Perfluorooctanesulfonic acid) and nonylphenol.
- In degreasing processes use of natural biodegradable cleaning agents.

An essential factor is the fact that usually the customers ordering the components in electroplating plants specify the properties of coatings (substrate preparation, coating thickness, quality of finish) and by that determine the technological processes at the installation. This sometimes hinders the STM companies in making their own decisions.

Substitution of chemicals or their better use in many examples require substitution not only of chemicals but of the whole process or even technology. In the analysed case installations there were identified examples of processes substitution with those having lower environmental impact e.g replacement of cadmium plating with zinc – nickel plating. Although, substitution in general reduce environmental burden related to the substituted chemicals but does not necessarily change the balance of hazardous and non-hazardous wastes generated in the facility and improve the opportunities for recycling if other constituents still pose a problem.

*Packaging waste*

Due to wide range of chemicals used in STM processes and its huge amounts, packaging waste is an essential waste stream in the sector. Usually responsibility of this waste management is shifted to waste collectors. However, good practices of separation and storage of packaging for hazardous substances implemented at the STM plants are essential for the further handling of this waste. It allows to avoid recycling of packaging which, despite initial cleaning, may contain residues of hazardous substances. It concerns, among others plastic packaging that could in an uncontrolled way go to processors who produce recyclates for re-use in the production of polymers. Simultaneously the good practice is to extend the use of reusable packaging (containers, containers, barrels) where it is possible (e.g. in cooperation with regular suppliers and repeatable substances).

*Separation and pretreatment of wastes*

Recycling and recovery options depend on waste stream separation and the use of dedicated pre-treatment systems. The most important in this regard are advanced wastewater streams separation process prior to further treatment and selective collection and storage of waste. In HAZBREF project there were found measures to reduce waste/wastewater/waste gas streams such as collection of sub-streams for specific pre-treatment. The pre-treated wastewater streams are then jointly neutralized before discharge to external wastewater system. The wastewater treatment system often integrates similar process wastewater, wastewater generated in air treatment (wet scrubbers), spills from storage accidents and wastewater from waste treatment processes e.g. dewatering. The technical, economic and environmental aspects frequently limit – according to the operators, the application of more advanced solutions, especially in existing plants with diversified production and those with limitations in space.

In the considered case studies the main streams are cyanide wastewaters, chromium or nickel wastewater, acid and base wastewaters. The wastewater treatment system generates inorganic wastes of similar physical properties but of versatile chemical content depending on the technological processes and is transferred to external company for safe utylisation. This approach is typical for analysed IED installations. Separation of waste may be a key issue in regard of further treatment, for example, in non-ferrous metals industries. In this context (NFM BREF) has many BATs addressing recovery and separation of different materials [11].

*Re-use and recovery in installation*

Re-use of spent materials is very limited in the installations. The following practices were identified in the study:

- Recovery of valuable metals, Silver, Platinum used in specific processes,
- Where possible basic materials are recovered e.g. in anodising process. Aluminum hydroxide from anodising can be also precipitated and recycled, for example as a coagulant for sewage treatment.
- One of the case study operators is developing the technology of electrolytic recovery of Cu from the copper stripping baths (Cu is used in intermediate process operations to mask elements). The assumption is to implement a technology that will work directly in the electroplating plant, and the recovered copper will be reused in the process.
- It can also be a requirement for continued use of restricted chemicals as it is done in the Persistent Organic Pollutants (POPs) Regulation [12] where the use of PFOS is only allowed for hard chromium plating in closed-loop systems. Therefore, an advanced rinsing-cascade system with feedback to the electrolyte, scrubbers and evaporators must be used in order to keep the chromium trioxide and PFOS in the system. Similarly the operators use also closed cleaning systems based on chlorinated compounds,

It was observed in the case studies that the most advanced recovery methods are dedicated to water. Water is recovered as part of hazardous waste/wastewater treatment by closing the water circuit. A closed cycle will result in environmental benefits such as decreased water. The recovery processes generate additional hazardous wastes (spent filters, membranes) which has to be disposed. In most of the companies re-use of water from wastewater treatment

**Table 2. Example of the common waste types generated in the analysed STM installations, along with declared treatment processes**
**Tabela 2. Przykład typowych rodzajów odpadów powstających w analizowanych instalacjach STM wraz z deklarowanymi procesami ich przetwarzania**

| Waste code | Waste name | Waste treatment process |
|---|---|---|
| 06 01 06* | Other acids | R5, R6 |
| 06 02 05* | Other bases | R5 |
| 06 03 11* | Solid salts and solutions containing cyanides | R5 |
| 06 03 13* | Solid salts and solutions containing heavy metals | R4, R5, R12, R13 |
| 06 04 05* | Wastes containing other heavy metals | R4, R5 |
| 07 07 10* | Other filter cakes and spent absorbents | R3, R12, R13, D9, D10, D15 |
| 11 01 05* | Etching acids | R4, R5, R6, R13, D9, D15 |
| 11 01 06* | Acids not otherwise specified | |
| 11 01 07* | Etching alkalis | |
| 11 01 09* | Sludges and filter cakes containing hazardous substances | R4, R12, R13, D9, D10, D15 |
| 11 01 11* | Aqueous rinsing liquids containing hazardous substances | R5, R6 |
| 11 01 13* | Degreasing wastes containing hazardous substances | |
| 11 01 15* | Eluate and sludges from membrane systems or ion exchange systems containing hazardous substances | |
| 11 01 16* | Saturated or spent ion exchange resins | R7, R8 |
| 11 01 98* | Other wastes containing hazardous substances | R5, R6, R4, R12, R13, D9, D10, D15 |
| 11 02 07 * | Other wastes containing hazardous substances | D10 |
| 11 03 01* | Wastes containing cyanide | R5 |
| 16 03 03* | Inorganic wastes containing hazardous substances | R5, R6, D10 |
| 16 03 05* | Organic wastes containing hazardous substances | R3, R5, R6 |
| 16 05 06* | Laboratory chemicals, consisting of or containing hazardous substances, including mixtures of laboratory chemicals | R5, R6 |
| 19 08 06* | Saturated or spent ion exchange resins | R5, R12, R13, D9, D15 |
| 19 08 13* | Sludges containing hazardous substances from other treatment of industrial waste water | |

is hindered as it requires cleaning prior to its recycling but can have an essential impact on reduction of water inputs

It is a basic approach to use internally the liquid wastes in onsite wastewater treatment processes. e.g neutralize acids and base liquid wastes or neutralise the spent baths in wastewater treatment system. For this activity a separate Integrated Permit for waste management is required from the operators according to IED and WT BREF [5]. Some spent baths are used in other processes (BAT 5.1.6.2) - it has relatively small importance reducing the use of raw materials.

Good examples of BATs implemented in HAZBREF study are related to degreasing and cleaning, where a set of hazardous substances is used. There are applied pre-treatment of degreasing and cleaning wastewater in on-site designated wastewater treatment step (e.g. skimmer) or in separate auxiliary waste management installations based on advanced systems (e.g. reverse osmosis, dewatering). For this activity a separate Integrated Permit for waste management is required according to IED [3] and WT BREF [5].

*Applied waste treatment processes*

Hazardous waste processing is generally not carried out at the installation only by external entities. From the operator's point of view, the legal requirements related to hazardous wastes management have to be obliged in the first place. The implemented environmental management system obliging him to control the way of waste processing helps to fulfill the legal obligations but also provides a good basis for improvements. The recycling options for waste materials are limited by the composition and the amounts of waste generated.

Common waste generated by STM processes and its coding are presented in table 2 along with waste treatment process declared by waste collectors and further processors.

Recycling or recovery (R) and disposal (D) operations are defined by Waste Directive [2]:

- **R3** Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes
- **R4** Recycling/reclamation of metals and metal compounds
- **R5** Recycling/reclamation of other inorganic materials
- **R6** Regeneration of acids or bases
- **R8** Recovery of components from catalysts
- **R12** Exchange of waste for submission to any of the operations numbered R 1 to R 11
- **R13** Storage of waste pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where the waste is produced)
- **D9** Physico-chemical treatment not specified elsewhere which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
- **D10** Incineration on land

Processes R3-R5 includes preparing for re-use. R3 covering also gasification and pyrolysis using the components as chemicals and recovery of organic materials in the form of backfilling. If there is no other R code appropriate, R12 can include preliminary operations prior to recovery including pre-processing such as, inter alia, dismantling, sorting, crushing, compacting, pelletising, drying, shredding, conditioning, repackaging, separating, blending or mixing prior to submission to any of the operations numbered R1 to R11.





In practice, recycling of waste from the STM sector is limited and concerns mainly hydro and pyro metallurgical non-ferrous metal refining (recycling includes refining of copper, nickel, chromium and zinc from suitable electroplating sludge as metals or metal compounds) [13]. As a recycling can be also classified conditioning and reuse of certain types of baths. Preparation for recycling is the manufacture of usable metal concentrates.

Other STM waste treatment operations are recovery or disposal processes (eg. etching solutions recovery, preparation of waste composites for further treatment as stabilisation or solidification, as well as conditioning as waste fuels intended for combustion in specialized plants. Stabilisation and solidification may occur in the immobilisation process [5]:

**Stabilisation** (WT BREF, Section 5.1.2.1.1) changes the chemical state of the constituent of the waste input. With complete stabilisation, a hazardous waste can be transformed into a non-hazardous waste by means of specific chemical reactions that destroy organic hazardous contents and convert inorganic hazardous substances into non-hazardous compounds (for instance, the reduction of chromium (VI) into chromium (III) or the oxidation of cyanide).

**Solidification** (WT BREF, Section 5.1.2.1.2) changes the physical properties of the waste input by using additives. Partial stabilisation or solidification processes do not change the hazardous nature of wastes, and the classification of waste with regards to pollutant parameters is therefore not modified.

Sludges of high concentrations of $SiO_2$ may be treated under vitrification process which is thermal disposal process that is carried out conversion to glass and glassy materials at high temperatures of 1000-1600 °C [14], in which destruction of hazardous compounds in the waste and to ensure a safe immobilization of heavy metals. Glass material can be used in road construction. The drawbacks of this technology are: limited yield of the plant, very expensive technology because of the high energy consumption (much higher than for other types of furnaces) and frequent maintenance operations (duration of the torches is very limited, because of the consumption of electrodes). Moreover, the maximum water content in the waste to be treated must be less than 10 wt% and the net heat value of the waste must be at least 12–15 MJ/kg, otherwise the whole process becomes uneconomical [15].

## 4. General recommendations for improving CE aspects in STM processes

Currently many BREFs have references to the waste hierarchy but not that many elements to complement the objectives of the hierarchy. For example, the Waste treatment BREF (WT BREF) states "For instance, according to waste hierarchy, operations aiming for recovery prevail over disposal." This kind of vague references can be found in many BREFs, but they rarely provide any tangible provisions for operators or permit writers. Some of the recent BREFs as WT BREF [5] and Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (CWW BREF) [16] include an inventory BAT, which is however quite general. Especially in sector BREFs, the inventory BAT should be more specific in order to include relevant information on hazardous chemicals/substances used. This would improve the recovery, recycling and re-use of waste/by-products. The share of hazardous substances ending up in the product or waste should be investigated. Also, the content of hazardous substances in the incoming raw materials should be part of the inventory. According to BAT and good industrial practices avoiding of waste is a basic principle that can be defined for the STM sector and CE implementation. However, avoidance of waste generation at all is currently not an option, due to excessive environmental costs and high energy consumption. Findings of case studies, which can be identified as CE supporting activities and good practices are the following [17]:

- common practice is extraction of metals from the sludge of the STM waste water treatment
- etching liquids containing copper, can be utilized as copper source in e.g. fertilizer production,
- onsite use of common spent process liquids in the neutralization stage of the wastewater treatment system (such as acidic solutions from etching), is becoming more often applied as disposal costs rise,
- rinsing water is usually pretreated onsite prior to discharge to downstream wastewater treatment facilities,
- regeneration and maintenance of technological baths are widely used techniques. All these techniques extend the life of the bath, prevent the formation of waste and are also economically justified,
- in order to improve recyclability of the waste streams, certain waste and wastewater streams are collected/ stored separate.
- the impact of certain chemicals in wastewater mixtures on quality of wastes should be considered,
- good practice is to develop a process chart, which is connected to the chemicals used. It contains a list of all chemicals and their composition used in the installation and helps to determine which streams could be put together and which need to be kept separate.
- this also helps the external recyclers to optimize recycling since they will have better information on the composition of the sludge or liquid waste.

Challenges related to CE issues:

- due to the use of many hazardous substances, most waste from STM processes is classified as hazardous waste,
- extraction of metals from rinsing waters is not yet economically viable with some exceptions such as silver and gold due to their value,
- the problem for external waste treatment operators is the irregularity of liquid waste generation, the variable or unknown composition and the unpredictable quantities.
- the quality of chemicals used may vary greatly and may have an influence on product quality and recyclability as well as process waste management,
- the coating of metals and plastics have an influence of the recyclability of metals from postconsumer waste.
- reuse of packaging in the industry is limited,
- cooperation between waste producers (STM plants) and waste processors can improve recyclability of wastes,
- weak quality of safety data sheets (SDS) can results undiserable substances in STM processes. Finally this may hampers further recycling or recovery of postprocessing wastes.

## 5. Conclusions

According to operators (Polish installations) the use of simple risk management to design, construct and operate an installation according to BATs helps to protect the environment, particularly soil and groundwater. These measures are often limited by the historic context of the installation development and depends on business opportunities for changes of activities and modernisation of the installation (STM cases in Poland).

Common activities on STM plants for minimization and prevention of waste are the reduction of the amount of hazardous material in the waste by substitution [4] and extension of the service lifetime of the process solutions (Process Solution Maintenance).

Life cycle approach and the cross-media effects has to be considered in making the decisions This may also include the most important life cycle aspects from the production of raw materials, their use in the STM installation and the product, if it has an impact on the recycleability etc. For example, reducing hazardous substances in wastewater might increase emissions in air or make product less recyclable, durable etc. More ambitious goals can be achieved in specialized plants with larger production volumes.

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Konkursy SITPChem, PSK, PSMB

# Nowe edycje konkursów dla młodych (i nie tylko) korozjonistów

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W 2020 roku odbyła się już 52. edycja Kokursu SITPChem. Z edycji regionalnych do ogólnopolskiego Konkursu wpłynęło 10 prac dyplomowych przygotowanych w roku akademickim 2018/2019 z pięciu ośrodków akademickich (Bydgoszcz, Gliwice, Łódź, Toruń, Warszawa). **Do 31.12.2021** można składać prace z roku akademickiego 2019/2020.

Więcej informacji: http://sitpchem.org.pl/dzialalnosc/konkursy/

### Konkurs Polskiego Stowarzyszenia Korozyjnego na najlepsza pracę inżynierską lub licencjacką, magisterską i doktorską

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Konkurs prac z roku 2019 jest już rozstrzygnięty, prace obronione w roku 2020 można zgłaszać do nowej edycji konkursu do **31 marca 2021 roku.**

Więcej informacji znajdą Państwo na II stronie okładki a także na str. 54 oraz na stronie PSK: https://psk.org.pl/o-nas/konkursy

### Konkurs PSMB na wzorcowe wykonanie ekspertyzy lub prac osuszeniowych, naprawczych i antykorozyjnych

Polskie Stowarzyszenie Mykologów Budownictwa ogłosiło konkurs na wzorcowe wykonanie ekspertyz mykologiczno - budowlanych, mykologicznych oraz prac osuszeniowych, naprawczych i antykorozyjnych zrealizowanych w 2020 roku.

Celem konkursu jest wyłonienie najlepszych ekspertyz mykologiczno - budowlanych, mykologicznych oraz obiektów budowlanych, na których osiągnięto wyróżniające się wyniki. Konkurs stanowi promocję rzeczoznawców oraz wykonawców robót. Przedmiotem konkursu są ekspertyzy zrealizowane w 2020 roku oraz nowe lub naprawiane obiekty budowlane, w których prace zostały skończone w okresie od stycznia do grudnia 2020 r. Konkursem kieruje Zarząd Główny Polskiego Stowarzyszenia Mykologów Budownictwa.

Kryteria oceny: jakość i zakres merytoryczny ekspertyzy, jakość robót, organizacja budowy i czas jej realizacji, rozwiązania techniczno-technologiczne prac osuszeniowych, naprawczych i antykorozyjnych, koszty realizacji obiektu budowlanego.

Zgłoszenia do konkursu są przyjmowane **do 31 marca 2021 r.** Ocena zgłoszeń jest dwuetapowa (etap pierwszy – formalne rozpatrzenie dokumentów (do 30 dni od daty zgłoszenia), etap drugi – ocena i rozstrzygnięcie (o wynikach tego etapu organizator konkursu powiadamia uczestników do 28.06.2021). Wręczenie nagród przewiduje się 16.09.2021 r.

Więcej informacji: http://www.psmb.wroclaw.pl/