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Use of the Port Community System in Sustainable Ship-Generated Waste Management

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Agnieszka Deja[1], Magdalena Kaup[2], Marek Gróbarczyk[3], Wojciech Ślączka[4]

Abstract:

Purpose: *The main objective of the paper is to present the possibilities of using the Port Community System (PCS) as an integrated IT system in the area of ship-generated waste management in the context of sustainable circular economy in seaports.*
Project/methodology/approach: *The research carried out enabled the development of a model for ship-generated waste management in seaports using the PSC IT system. Such measures should contribute to the protection and improvement of the status of the environment, as well as result in measurable economic benefits in the future.*
Findings: *The PCS IT system presented in this paper enables sustainable waste management encompassing the circular economy approach. This platform optimises, manages, automates and improves the performance of a range of port processes through a single submission of data, connecting them in a coherent system and reducing the administrative burden.*
Practical Implications: *The PCS-based module to ship-generated waste management have been identified a continuous ship monitoring with regards to waste, provision of thorough control over waste movement (system tightening up), transparent information overview (permanent view of all activity stages). This interactive collaboration tool allows for optimal cooperation between port companies and European Union seaports.*
Originality/value: *Considering the concept of circular economy, which offers a great opportunity to improve business processes, a waste management model with the PCS may serve as the basis for the development of logistics chains for waste and for the elimination of undesirable incidents caused by poor management practices with respect to ship-generated waste and cargo residues in ports.*

Keywords: *Waste management, IT system, Port Community System, circular economy.*

JEL classification: *Q01, Q53, L91, M15.*
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[1]*Corresponding author, Maritime University of Szczecin, Faculty of Economics and Transport Engineering, ORCID ID:0000-0001-5988-788X, e-mail: a.deja@am.szczecin.pl.*
[2]*Maritime University of Szczecin, Faculty of Navigation, ORCID ID: 0000-0002-9384-8144, e-mail: m.kaup@am.szczecin.pl*
[3]*MSc Eng. marek.grobarczyk@gmail.com*
[4]*Same as in 3, ORCID ID: 0000-0003-3265-9726, e-mail: w.slczka@am.szczecin.pl*

1. Introduction

Considering the fast development of the maritime industry, the existing supervision and control of the work carried out both within maritime businesses and on water transport equipment itself are not always fully effective Oftentimes, human errors lead to undesirable emergencies that could be avoided if information flows between the people engaged in the performance of specific transport responsibilities in port areas were better managed (Deja *et al.,* 2021). Appropriate information flow in any processes and activities carried out in relation to ships, cargo and hinterland transport infrastructure is of critical importance in relations between ships and ports (Kaup *et al.,* 2019) and can only been sured by means of a single, harmonised and efficient IT system. The use of different systems by businesses operating within one industry may lead to duplication of efforts, data inconsistencies, and consequently errors or inaccuracies. Furthermore, the multitude of different applications results in wasted time due to, for instance, the need to operate several dialogue boxes across multiple applications, which obviously does not make the work done by port staff any easier.

One IT system that can be widely used for the purposes of comprehensive port management and services is the Port Community System (PCS). It plays the role of a 'single digital point of contact', while significantly contributing to the automation of logistics processes. The system has already been implemented by selected ports, also in Europe, where it operates as an individual solution tailored to the port's cargo handling capacity, its geography, as well as other considerations (Kuceli *et al.,* 2008). Taking into account the opportunities and advantages offered by the existing Port Community System solutions, as well as by expanding or modifying certain applications, additional PSC functions could be delivered in order to use the system for the purposes of sustainable management of ship-generated waste.

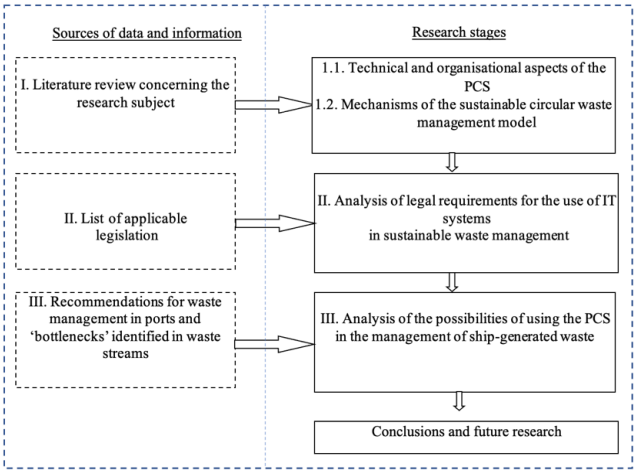
The circular economy model is on the rise today, also in the area of ship-generated waste management. This model has a clear focus on resources, and it attempts to consider all inputs and outputs of the production process, albeit with a strong emphasis on waste. The application of this model and its use in the operation of the PCS IT system could contribute to the protection of the environment and improvement of its status, while having a certain economic relevance as well.

The paper presents the possibilities and significance of using an integrated IT system, such as the Port Community System, in sustainable management of ship-generated waste in seaports. The first part of the paper discusses the underlying analysis and describes the research tools. The essence and working structure of the Port Community System have been analysed. This is followed by an overview of the circular waste management model and the legal requirements pertaining to the use of IT systems in sustainable waste management at seaports. The final part of the paper presents the possibilities of using the PCS in the management of ship-generated waste in seaports.

2. Materials and Methods

The main objective of the paper is to present the possibilities of using the Port Community System as an integrated IT system in the area of ship-generated waste management in the context of sustainable circular economy in seaports. With a view to achieving the study objective, three stages including analyses of the research subject have been identified, as presented in Figure 1.

Figure 1. *Research methodology schema*



Source: *Own elaboration.*

The first stage includes an overview and analysis of literature with respect to the structure and working principle of the Port Community System, with a particular focus on the organisational and technical considerations necessary to fully implement the PCS in seaports. This stage additionally includes an overview and analysis of sustainable waste management and circular economy model solutions discussed in literature.

The second stage involves an analysis of the legal requirements pertaining to the use of IT systems in sustainable waste management. This includes the key documents currently in force concerning the organisation of waste reception as well as the most recent documents relating to the implementation of digital data transfer platforms that play the role of 'single digital points of contact. The third stage consists in an analysis of the possibilities of using the PCS in the management of ship-generated waste in seaports. In view of the challenges of effective waste management in ports and poor information flow between the parties engaged in waste reception from ships and disposal, it is important to apply an integrated IT system, such as the PCS, to ensure full information flow and integration of all actors in the right time and place. Based on the experience and knowledge of the authors and a literature review, the challenges of full implementation of the PCS in waste management have been identified and collated.

The concept for an integrated waste management model with the use of the PCS is not developed here. However, this possibility should be pointed out, as it may contribute to a more efficient organisation of waste reception and processing activities. Furthermore, considering the concept of circular economy, which offers a great opportunity to improve business processes, the current model with the PCS may serve as the basis for the development of logistics chains for waste and for the elimination of undesirable incidents caused by poor waste and cargo residue management practices.

The final part of the paper presents the conclusions of the study and outlines the future research paths focusing on the possibilities of efficient adaptation and use of the Port Community System in sustainable ship-generated waste management in a seaport, depending on the waste type and disposal or recycling method

3. Selected Considerations of Sustainable Waste Management in Seaports

It is a key objective of the maritime policy of the European Union to have a broad range of international community efforts directly contributing to a high level of safety and protection of the marine environment. International regulations (conventions, resolutions, EU directives) are particularly relevant as regards the identification of the required action. The United Nations highlight the challenges of marine ecosystem pollution and place a special emphasis on the conservation of marine species (EU, 2018). The overarching goal in this context should be international community action focusing on sustainable development.

The international MARPOL 73/78 Convention is the most important international document governing the issues of protection of the marine environment (IMO, 1973). Its provisions were used, inter alia, as the basis for the development of Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities for ship-generated waste and cargo residues. In accordance with the Directive, all Community ports have been obliged to carry out environmental tasks focusing on waste management, both in the environmental and economic context. Environmental activities, which consist in appropriate routing of waste streams originating from ships, are aimed at protecting marine resources and reducing the discharges of pollutants into the marine environment (Deja *et al.*, 2018).

By properly tracking the waste streams from origin to disposal, it is possible to have adequate control over the process as a whole. Implementation of activities that should be carried out in advance follows as a natural consequence of the application of this model. It will give the possibility for both tackling the effects of environmental pollution and reducing the associated cost. MARPOL 73/78 is being continually improved with respect to the considerations of ship-generated pollution. Unfortunately, the recent modifications have not resulted in a total elimination of illegal pollution discharges from ships into the sea. As regards the arrangements for

reception and further handling of ship-generated waste, in 2018 IMO adopted new guidance for port reception facilities (IMO, 2018) which sets out standards pertaining to, inter alia, the provision of information on waste on board ships before they physically call at European Union ports.

The adoption of Directive 2000/59/EC, as amended (now Directive 2019/883 of the European Parliament and of the Council of 17 April 2019 (EU, 2019) resulted in more waste and cargo residues being transferred to the Community port reception facilities in the recent years. The meaning of the document for sustainable ship-generated waste management is also emphasised in Communication from the Commission of 2 December 2015: *Closing the loop* – An EU action plan for the Circular Economy, which states that it provides a foundation of the development of closed-loop activities (EU, 2015). Circular economy is a new line for environmental and economic action that promotes solutions relying on a transition from the existing linear model of economic activity to a closed loop (Prieto-Sandoval *et al*., 2018).

The circular economy concept is now widely debated by the scientific and business communities, building on and giving more structure to the concept of sustainable development. It is emphasised in particular that the system should be "restorative and regenerative" (Ghisellini *et al.,* 2016; Murray *et al.,* 2017). Already in 2007 Peters *et al.* (2007) defined circular economy in the following manner: "The central idea is to close material loops, reduce inputs, and reuse or recycle products and waste to achieve a higher quality of life through increased resource efficiency" (Ghisellini *et al.,* 2016).

Importantly, it is emphasised that it replaces the earlier 'end-of-life' concept and it should engage all actors on a macro and micro scale. In the recent years, the sustainability efforts of the European Union focus on the implementation of strategic plans that include the transition to circular economy, as it is particularly important to identify the challenges of efficient resource and pollution management and to respond to them. In the traditional model (linear economy), the environmental impact is marginalised, as the model does not consider such things as rational extraction of resources or a rational approach to products in use. This results in the generation of enormous amounts of waste and pollution which need to be managed appropriately. Such practices are based on the end-of-pipe approach that prevailed in late 1990s.

Currently, in circular economy settings, it is important to see the opportunities to achieve certain targets in advance. In 2016, the European Union took action to support and promote design solutions focusing on an environmental approach, which was fine tuned in 2019. With appropriate production planning, we are able to reduce the consumption of resources, primarily by leveraging ecodesign opportunities in production as well as logistics processes. The purpose of ecodesign is to minimise adverse environmental impacts. Capturing the opportunities offered by the closed loop is a key measure supporting the optimisation of natural resource consumption,

for instance by planning and subsequently reviewing product life cycles (Sauvé *et al.*, 2016). 2019 was a remarkable year from the perspective of action taken by the European Union to minimise the generation of waste (especially plastics). A range of documents was implemented to regulate this area. These include, but are not limited to, "*A European Strategy for Plastics in a Circular Economy and the Single-Use Plastics Directive*". The objective of the two documents was to minimise or completely ban single-use plastic products on the EU market, resulting in the reduction of plastic pollution (EU, 2018).

Late in 2019, the European Union adopted a key document highlighting the essence of sustainable development and its importance for the future development of the society, the European Green Deal, or EU's new economic strategy until 2050 final. The strategic message in the document is that Europe must achieve the status of a climate-neutral continent by 2050 (EU, 2019). Efforts in the industrial context are expected to focus on promoting circular economy solutions, which requires the delivery of environmentally clean processes. This is to be achieved by intensifying investment in research and adopting innovative solutions (EU, 2020).

The waste hierarchy, being a key element in the waste management process, plays a crucial role in circular economy. The priority order of waste management options is directly reflected in the cost of action incurred by the business operator. In accordance with European Union guidance on waste management, action should be primarily geared towards the prevention of waste, which practically means that appropriate arrangements must be made before a product is launched on the market. The second most favoured option is preparation for reuse, followed by recycling and recovery. The least favoured and least promoted option should be disposal by landfilling (Kaup *et al*., 2019).

Sound waste management enables the achievement of required recycling levels. Proper routing of waste streams in logistics terms allows them to be optimally used from the perspective of resources, which will be reflected in environmental as well as economic benefits (EU, 2015).

4. Technical and Organisational Aspects of the PCS in Seaports

The ongoing technological progress enables the use of new and improved IT solutions by maritime businesses, including seaports. Their proliferation is dictated or even forced by the need to access timely, reliable and thorough information, or the need to promptly carry out tasks and handle orders at different complexity levels as required by customers.

One such IT system is the Port Community System, which has a wide range of applications in the operations of logistics companies, improving the performance of their tasks, offering the opportunity to boost the performance of the existing processes, and ensuring the effective management of databases through data

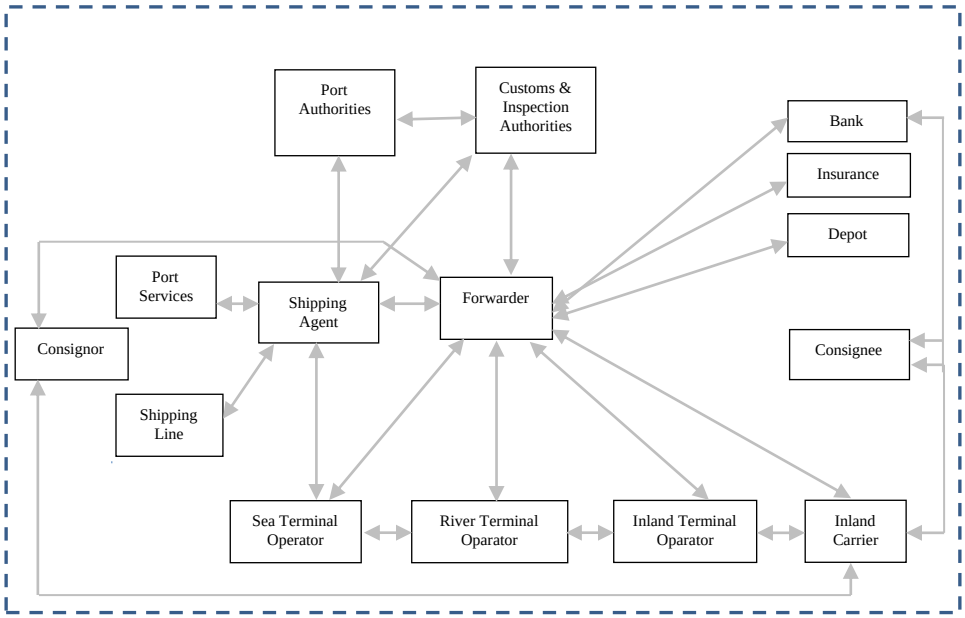
integration. Considering the widespread digitalisation of business operations, the PCS is a unique tool intended for handling of transport and logistics processes.

In the context of port operations, the PCS is a neutral and open electronic platform supporting smart and secure information exchange between public and private stakeholders to improve the cooperation between them. This platform optimises, manages, automates, and improves the performance of a range of port processes through a single submission of data, connecting them in a coherent system and reducing the administrative burden (Marek, 2016: Varbanova, 2017). The PCS designed as part of the operations of Polish ports enables extensive cooperation with state inspection authorities:

- integration of systems with the PCS – the primary process;
- provision of IT support for internal processes of port control authorities, such as waste handling;
- provision of IT support for cargo handling processes in seaports, with port operators and shipping lines within establishments;
- enabling the performance of their own functions with the use of the PCS platform with the external environment at large.

Figure 2 shows the PCS communication model between potential actors for various activities taking place in seaport areas.

Figure 2. *The PCS communication model*



Source: *Elaboration based on Van Baalen et al., 2009.*

5. Possibilities of Using the PCS in Ship-Generated Waste Management

Seaports are obliged to provide a wide range of services to ships, which include, without limitation, services relating to the reception of waste and cargo residues. By reason of their location, they operate as highly important nodes for environmental action. Port operations, which have an extensive technical and organisational structure from the environmental perspective, should be viewed from many angles. Seaports generate pollution from two main sources: from the industrial operations carried out on their premises and from the reception of ship-generated waste. In accordance with the applicable regulations, ports are obliged to respect national and international environmental protection laws (Jóźwiak, 2005).

The PCS mechanism is now being implemented by Polish ports, in particular its logistics and treasury modules. By reason of social sensitivity and UE law requirements, the implementation of the waste management module has been completed. It should be noted that this module is an integral part of the system and an essential component with an appreciable effect on the quality of port services. It provides considerable assistance in the management of waste reception in ports, integrates the declarations submitted in a single electronic checkpoint (NSW), enabling the automated management of the notified waste stream and – in an integrative approach – transmits information to waste management units. In consequence, this allows for the control of waste amount, type and landfilling location, thereby managing the electronic database of waste transferred by ships in a comprehensive manner. It is noteworthy that the implementation of the system will in practice fully eliminate the paper workflow, which has been used so far to handle the matters in question. The implementation of the PCS in Polish ports will be based on a structure containing the following system components:

- customs module;
- shipowner module;
- food safety inspection module, including veterinary;
- module for port operators;
- electronic records module;
- hinterland traffic handling module;
- dangerous goods handling module;
- module for forwarding agents;
- port gate services module;
- communications module;
- module for the port authority which includes a waste module.

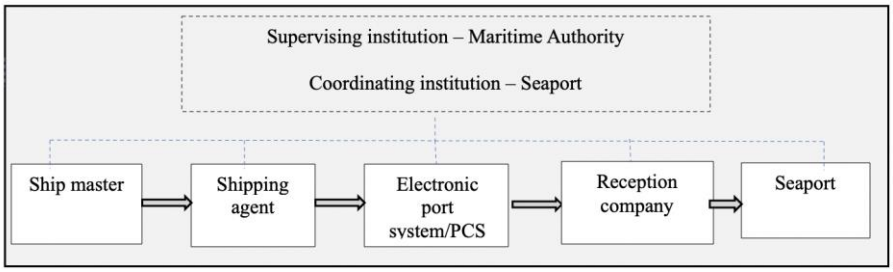
Considering the evolving nature of transport and logistics in seaport areas, as well as the European Union directives being adopted, the scope, type and method of implementation of the PCS were defined for each port. On the initiative of the following ports, Le Havre, France; MCP, Felixstowe, UK; Portic, Barcelona, Spain; Portbase, Rotterdam, Netherlands; dbh, Bremen, Hamburg, Germany. The International Port Community Systems Association (IPCSA) has been established to

integrate ports around the use of the PCS. The Association has developed a suite of recommendations and procedures, defined the scope of good practice and launched a central information exchange database with a view to unifying the PCS systems. In this way, a functional implementation model has been designed that set out recommendations with respect to the implementation of the PCS. The development of optimal organisational solutions in the area of waste management in seaports is very difficult due to, inter alia, the complex structure of undertakings, type of activities and a vast impact zone. The waste generated by ship operations pose a major environmental challenge as they may contain large quantities of pollutants harmful to human health (Balic *et al.,* 2019). In this regard, it is particularly important to take measures involving:

a) minimising waste 'at source', using the best available technologies;
b) control and evaluation of waste reception and downstream management procedures on the basis of the applicable international and national regulations;
c) minimising waste in ports based on integrated systemic action (Comtois and Slack, 2007)

Figure 3 presents the actors that are to be involved in the procedure of notifying waste before a ship calls at port with the use of the PCS system, and Figure 4 shows the proposed flow of the process.

Figure 3. *Actors involved in the process of waste reception from ships in a seaport*



Source: *Own elaboration.*

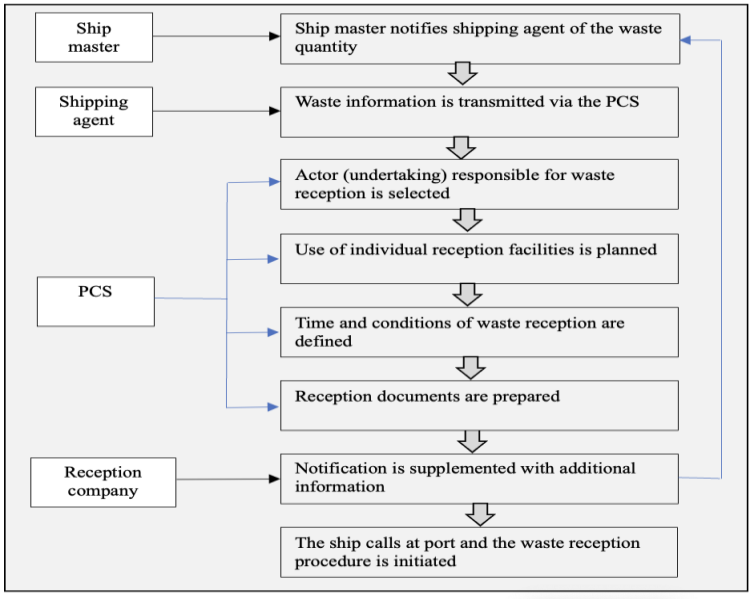
A ship heading towards a port is obliged to submit a notification form. Where the Port Community System (PCS) is in place, the notification is submitted to the Port by electronic means through that IT system. In view of the above, the notifying party should have an access code to the system. When a notification is made, coordination activities are planned for the reception and downstream management of the ship-generated waste. The assumption in the proposed scenario (created on the basis of existing solutions in EU ports) is that notifications are made by shipping agents, who are authorised to use the electronic port systems (Deja and Kabulak, 2017).

Therefore, the master of a ship heading to a port should inform the agent of the waste on board the ship by means of a copy of the completed notification form, from

which data can be retrieved by the system. From the perspective of the arrangement of reception of waste and cargo residues in ports, it is critical to be aware of the characteristics of pollution generated by ships and to specify the amount of that pollution (Slišković *et al.*, 2018; Ulnikovic *et al.*, 2012; Vaneeckhauteab *et al.*, 2020). If we receive accurate information about waste on board a ship heading to a port in good time, we are able to plan and arrange for the optimal performance of reception facilities. Then we can reroute the waste streams in an appropriate manner to undertakings that will handle them using the best available technology.

It should be emphasised that planning, steering, execution and control of logistics waste management processes are very important from the environmental and economic perspective (Deja *et al.*, 2018; Pereza *et al*., 2017*)*. The Port Community System (PCS) is a solution which enables coordination across all these processes, and most importantly, supports maritime administration authorities in supervision over waste streams moving between ships and places of final destination. This solution enables the elimination of systemic bottlenecks. It should be stressed that seaports are perfect locations for activities focusing around circular economy as a new concept of environmental action, which involves the performance of functions that are particularly important from the environmental perspective, while highlighting the critical role of proper coordination of individual logistics processes in environmental protection. The Port Community System (PCS) enables the linking of individual elements of activities within a sustainable logistics chain in maritime transport, which begins and ends in a port. This is the perfect place for the implementation of circular economy solutions.

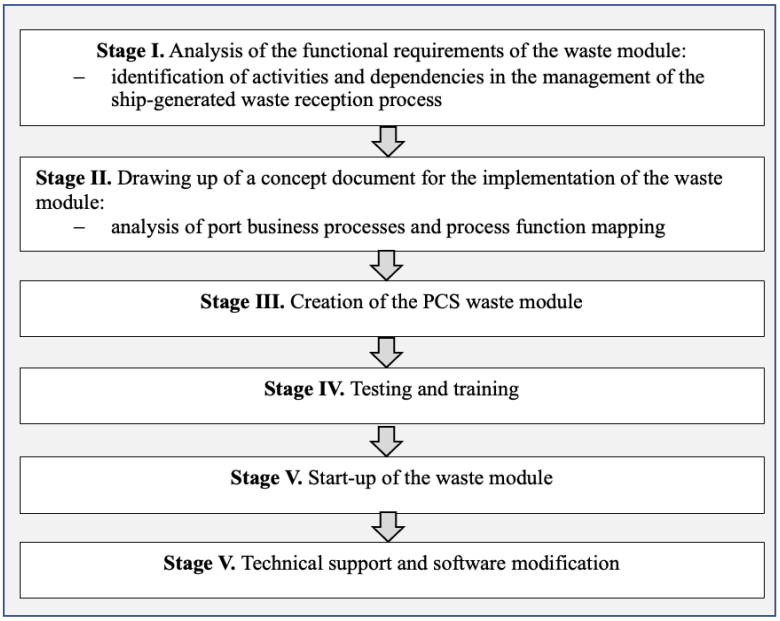
Figure 4. *Waste notification procedure using the PCS*



Source: *Own elaboration.*

The basic requirement for the implementation of the waste module of the PCS system is that waste reception services of adequate quality must be ensured, as well as acceptable costs, reliable service delivery, full supervision over waste management and complete reporting enabling the optimisation of the waste management process. For the Szczecin – Świnoujście Port Complex, the design and implementation process for the waste module is broken down into 5 stages, as shown in Figure 5.

Figure 5. *Design and implementation process for the PCS waste module at the Szczecin – Świnoujście Port Complex*



Source: *Own elaboration.*

In accordance with the presented design and implementation process scheme for the waste module at the Szczecin – Świnoujście Port Complex, stage I involves mainly the identification of activities and dependencies in the management of the ship-generated waste reception process. Stage II envisages the analysis of the functional requirements for the concept for the implementation of the waste module and process function mapping in the PCS based on consultations with key users, as well as creation of essential interfaces to support the functionality of individual processes. Stage III is to include the creation and implementation of the waste module, in accordance with the provisions of the concept document of the waste system, which will be subjected to functional testing at the next stage. The two final stages are the start-up of the waste module for the infrastructure selected by the port as well as technical support and adjustment of the waste module to the applicable legal regulations.

6. Conclusions

Both international and national legislation clearly specifies the waste management responsibilities of ships and seaports. Due to the growing importance of sustainable measures in this respect, we are observing legislative changes in this area every year. They are mostly geared towards promoting waste minimisation solutions, as well as further processing, which is the most favoured option from the environmental perspective. A seaport is a perfect place to implement a sustainable waste management concept, where the Port Community System (PCS) can play a particularly important role, as the interdependencies between logistics activities and sustainable development are constantly emphasised. The key is to look for sustainable solutions which should guarantee the conservation of natural resources as well as reduce pollution arising from the logistics processes involved in their disposal. Based on the research, the following opportunities offered by the PCS to ship-generated waste management have been identified:

- Continuous ship monitoring (advantage for the environment) – solutions could be proposed in the future to monitor ship movements within the EU area
- Provision of thorough control over waste movement (system tightening up). Full supervision over waste movement and choosing optimal management options.
- Transparent information overview (permanent view of all activity stages)
- The information collected in the PCS can be used to develop optimal solutions from the economical and environmental perspective for the existing waste management systems.
- The possibility of expanding the scope of services offered by a port (such as processing more waste within the port – in particular MARPOL Annex V);
- Improving the efficiency of utilisation of port reception facilities
- Optimisation of the workflow between the individual actors involved in the waste reception process
- An interactive tool for cooperation between port companies
- An interactive tool for cooperation between EU ports.

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