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Life Cycle Assessment Approach for the Ship Recycling Industry

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Abstract. The recycling process is the end-of-life process in the life cycle of a ship. Ships that have served their purpose are repurposed at authorized ship recycling facilities. 85% of EU flagged ships are recycled in Turkey, the only country in the Mediterranean basin where ship recycling activities are conducted as a business. This study compared the environmental impact of various ship types in the global warming potential impact category by the life cycle assessment method. This method allows the calculation of environmental loads from a systematic and scientific perspective, taking into account all the inputs and outputs of a system, thus helping to compare options on an environmental basis. The data from industry and the life cycle analysis (LCA) inventory reveal the long-term environmental impacts of steel recovery from ship recycling facilities. In this study, the total annual recycling between 2009 and 2020 was analyzed comparatively indifferent ship types such as container ships, dry cargo ships, military ships, special-purpose platforms, and tankers. The results are obtained through improved material flow from "SimaPro" software, specially developed and designed for all material life cycle processes. These findings are presented for the benefit of stakeholders in the recyclers industry.
Keywords: *life cycle assessment, ship recycling, sustainability*

1. Introduction

The recycling process is carried out to economically repurpose ships that have served their purpose in various industries [1]. In place of the ships withdrawn from the expedition, new ships of new tonnage and high technology are being built, with increased operational efficiency and reduced risks of maritime operations. The Ship Recycling industry also has a place in the three major categories of a ship's life cycle (construction, operation, and recycling) [2,3].

Ship recycling is the polar opposite of shipbuilding. Steel accounts for 98% of scrap ships, and 95% of this is recyclable [4]. In terms of supplying raw materials to various industries, the ship recycling industry is an important sector for the entire world [5,6].

A ship contains various hazardous and toxic materials and recyclables at the end of its life cycle. Materials containing hazardous and toxic substances are closely monitored and strictly regulated in Europe and member states of the Organization for Economic Cooperation and Development [7]. The current Basel Convention on the Control and Disposal of Transboundary Movements of Hazardous Wastes, signed in 1989, classifies most of these substances aboard ships as hazardous and toxic.

It is essential to consider the environmental impacts a ship may have during its construction, service life, and recycling at the design stage. Life cycle assessment (LCA) for design for recycling is a decision-making instrument [8]. Using LCA, the environmental impact assessment of a ship still in the design phase can be conducted according to various cradle-to-grave scenarios. This evaluation will guide design, construction, operation, and recycling decision-makers [9].

A ship's LCA may not always be conducted from the cradle to the grave. Environmental impact studies can be accomplished within predetermined constraints by focusing on process enhancements. Inventory creation (LCI) is the most labor-intensive and time-consuming aspect of LCA studies [10]. Evaluating the data collected within the defined processes permits the development of focus areas within LCA studies that can yield results from the cradle to the grave.

1.1. Ship Recycling Overview

The global ship recycling industry is dominated by five countries. The ship recycling industry is dominated by Pakistan, China, Turkey, India, and Bangladesh, accounting for 97% of the total [11]. Meeting community needs and creating jobs from recycled steel are two of the ship recycling industry's primary benefits for these countries. In terms of energy consumption, Ship recycling saves approximately 74% of the energy required for steel production by providing recycled steel [4,12]. Aside from these benefits, ship recycling is regarded as a hazardous industry regarding occupational health and safety, and negative environmental effects result from various applications.

While certain countries created the Ship Recycling industry, it has evolved into an area of activity that all countries must closely monitor and plan for in today's world, when global warming, unemployment, and natural resource depletion are all on the rise [13]. Ship recycling is still practiced in several nations worldwide, especially those in the European Union.

International organizations such as the International Maritime Organization (IMO), the United Nations Environment Program (UNEP), the Basel Convention (BC), and the International Labor Organization (ILO) have all published ship recycling guides [14] and formed a joint working group dedicated to the subject as global awareness has grown.

Accepting the International Maritime Organization's Hong Kong Convention for the Safe and Environmentally Responsible Recycling of Ships represents a watershed moment for the industry [7]. The Hong Kong Convention, which has been widely accepted as a tool to regulate the industry on a global scale, has already begun to influence the regulations of the highest level governments, as well as ship recycling facilities, ship owners, shipbuilders, and that all key elements in the ship recycling process will soon have to adapt to this global regulation [12].

Ship recycling facilities have existed in an organized industrial zone on Turkey's Aegean coastline since 1976 and 50 kilometers north of Izmir on the Aliaga coast. Another nearby area, about 15 kilometers south of the peninsula, has steel mills that use mostly iron and steel scrap from ship recyclers as their main raw material. Other scrap metals and alloys, such as copper, bronze, brass, aluminum, and some equipment and machinery, are obtained from reused ships in the maritime sector and steel [15].

2. Methodology

Based on knowledge, LCA is a comparative environmental assessment and management tool for production systems [16]. This comparison is based on the concept of a functional unit, which represents the quantitative expression of the systems being compared to the equal payoff. This process is known as "Life Cycle Assessment" because it takes a "cradle to grave" approach, and its expansion from the cradle to the grave distinguishes it. From an environmental standpoint, LCA has numerous advantages. LCA can identify and track tradeoffs that represent the shift in environmental impacts from one environment to another or from one stage of the life cycle to the next. Because data must be carefully collected, evaluated, and validated, LCA studies take time to conduct reliable and substantial analysis.

To obtain accurate results from LCA studies, the data, results, or information obtained throughout the studies should be interpreted by controlling the relationship with other departments at all stages.

2.1. Goal and Scope

The study's overall goal is to compare the environmental impacts of ship recycling by year and ship type in different ship types such as container ships, dry cargo ships, military ships, special-purpose platforms, tankers, and total annual recycling between total annual recycling in 2009 and 2020.

The LCA methodology revealed environmental consequences to raise awareness among the ship recycling industry, decision-makers, and stakeholders. This research concentrated on cutting from steel processes.

2.2 Impact Assessment Method

The goal of this stage is to identify and quantify the environmental impacts of inventory or resource consumption emissions, as well as the impacts of all inputs from and outputs to the environment calculated during the life cycle inventory phase, and to aggregate them into a set of impact categories and specific indicators. During the analysis, the data were examined. The CML-IA method was used for classification and characterization [2].

The study's findings were compared in the Global Warming Potential (GWP) category. All quantities in the GWP impact category will be translated to "kg CO_2 Eq." This impact category's reference ingredient is CO_2. To convert each quantity to common units, multiply it by the characterization factor. Diverse scientific groups define the characterization variables based on different methodology and philosophical perspectives on environmental challenges.

In this study, the academic version of SimaPro 8.0.2 and the Ecoinvent v3.01 database has been used. All results calculated in kg CO_2 Eq represent GWP100 (Global Warming Potential in 100 years).

2.3 Use of Data

The data of ships recycled over the years at ship recycling facilities in Turkey's Aliaga region were evaluated in this study. Data sourced from ship recycling companies and the literature. It has been meticulously prepared item by item to address the recycling phase.

Table 1. Amount of Steel Recycled by Years [4,17]

Year	Steel (ton)
2009	298000
2010	423000
2011	653000
2012	927000
2013	802000
2014	587000
2015	602000
2016	604000
2017	818000
2018	602000
2019	654500
2020	855000

The recycling facilities provided data on O_2, LPG, diesel, and electricity consumption, which must be processed as inputs for the amount of recycled steel. Each process was handled by its code in the system, and calculations were performed within its processes. The assessment was based on the total tonnage of steel recycled between 2009 and 2020, as shown in Table 1. Table 2 shows the types of ships recycled between 2016 and 2020.

SimaPro, a professional tool for storing, analyzing, and monitoring the environmental performance of products and services, was used in this study as the LCA software. The ISO 14040 series recommendations allow for the systematic and transparent modeling and analysis of complex lifecycles using this tool.

Suitable data was discovered in the Ecoinvent v3.0.1 database for input and output materials. The obtained data is then entered. Industry data were obtained from ship recycling facilities in Aliaga (Turkey). As a result, the region was considered when selecting materials from the Ecoinvent database and determining the O_2, LPG, diesel, and electricity inputs.

Table 2. Ship Types Recycled by Years [17]

Ship Type	Year				
	2016	2017	2018	2019	2020
Barge	-	-	-	8377	8377
Dry Cargo	170000	260000	148000	158195	122000
Platform	186000	191000	219000	288401	213000
Tugboat	-	-	-	3937	34000
Tanker	62000	108000	34000	48936	95000
Cruise	-	-	-	-	162000
Heavy Duty	-	-	-	77054	-
Research V.	-	-	-	9329	-
Navy	22000	15000	-	13775	-
Ro-Ro	-	89000	62000	48330	-
Container S.	-	79000	-	-	-
Others	165000	58000	139000	-	220000

3. Results

As a result of the study, the environmental impact percentages of the total tonnage of ships recycled at the Aliaga ship recycling site by year and the total tonnage of ships by type were determined. The environmental impacts of recycled ship steel cutting operations in the Aliaga region are compared in Figures 1 and 2.

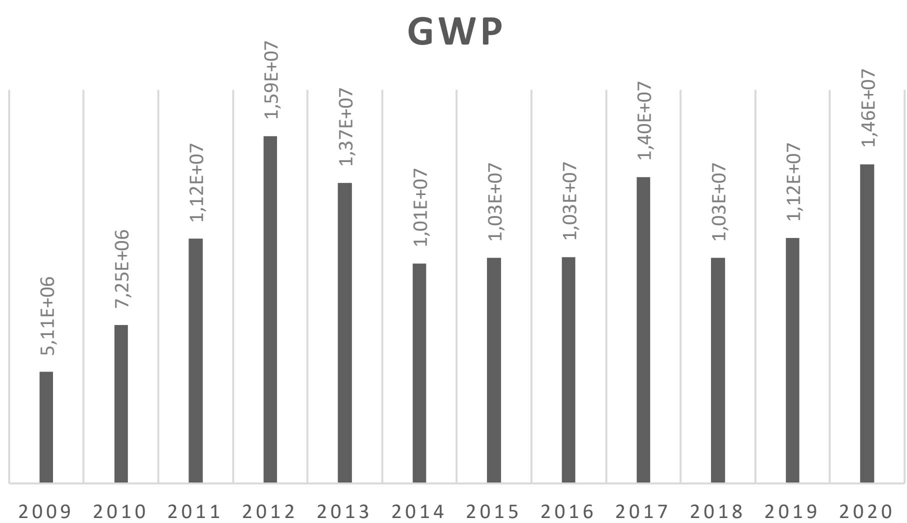

Figure 1. GWP Change by Years (2009 – 2020)

Figure 1 displays the potential global warming values (GWP100) of steel cutting by year of steel recycling between 2009 and 2020. Figure 2 depicts, in contrast, the potential global warming values (GWP100) of ship types recycled between 2016 and 2020, as determined by recycling processes.

Figure 1 shows that 2012 had the most significant environmental impact, with a high total recycling capacity. There was an increase in the GWP value between 2009 and 2012. The GWP environmental impact has increased by 1.28E+06 kg CO2 eq since 2020.

Figure 2 compares ship types recycled between 2016 and 2020: barge, dry cargo, platform, tugboat, tanker, cruise, heavy-duty, research v., navy, ro-ro, container ship, and the others. It is seen that platform and dry cargo ship types constitute 56% of the environmental impact. This effect is due to the recycling of specific ship types in higher tonnages at the Aliaga ship recycling site.

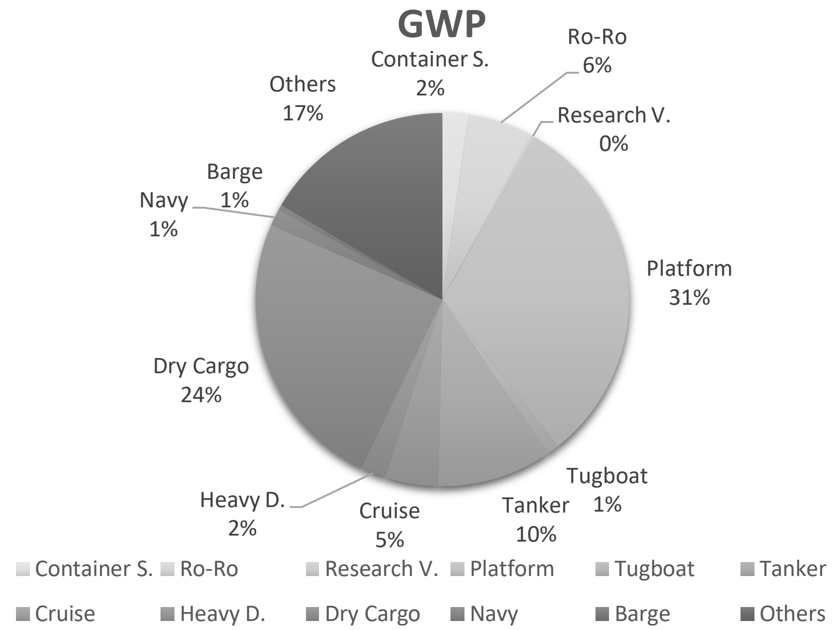

Figure 2. GWP Change by Ship Types (2016 – 2020)

4. Discussion and Conclusions

The goal was to show how the LCA approach can be used in the ship recycling industry. With the current situation analysis, the comparative results of the LCA, which is one of the management tools used to identify areas for improvement, and the environmental impacts resulting from ship recycling operations in the Aliaga region over time have been presented. This study performs calculations for the LCA system framework with the ship recycling operations constraint. It was thought in the Aliaga ship recycling region to compare both years and ship types. It will be possible to conduct new studies on scenarios that can be improved after revealing the current situation using a systemic approach.

The annual recycling tonnage fluctuations caused by the ship recycling industry's exposure to global economic processes should be evaluated alongside field capacity expansion studies and process improvement studies. Environmental impacts may be reduced due to improved use of the materials that comprise the steel cutting processes' inputs and alternative energy sources.

This study, which was conducted using data from the Aliaga region, revealed that process improvement studies conducted in areas where specific ship types are recycled could help reduce the environmental impacts caused by ship recycling operations.

References

[1] Neşer G, Ünsalan D, Tekoğul Nand Stuer-Lauridsen F 2008 *Journal of Cleaner Production* 16 350.

[2] Önal M, Neşer G and Gürsel K T 2021 *Ships and Offshore Structures* 16 1061.

[3] Sivaprasad K and Nandakumar C G 2013 *Ships and Offshore Structures* 8 214.

[4] Gemisander 2016 *Ship Recycling Industrialists Association 2016 Sector Report* (Ship Recycling Industrialists Association).

[5] Du Z, Zhang S, Zhou Q, Yuen K F and Wong Y D 2018 *Resources, Conservation and Recycling* 131 158.

[6] Rahman S M, Handler R M and Mayer A L 2016 *Journal of Cleaner Production* 135 963.

[7] Ignacio Alcaide J, Rodríguez-Díaz E and Piniella F 2017 *Marine Policy* 81 262.

[8] Cucinotta F, Raffaele M, Salmeri F and Sfravara F 2021 *Applied Ocean Research* 112 102705.

[9] Pryshlakivsky J and Searcy C 2021 *Journal of Cleaner Production* 309 127344.

[10] Suh S and Huppes G 2005 *Journal of Cleaner Production* 13 687.

[11] Rahman S 2017 *Procedia Engineering* 194 268.

[12] Ozturkoglu Y, Kazancoglu Y and Ozkan-Ozen Y D 2019 *Journal of Cleaner Production* 238 117907.

[13] Kaiser M J 2008 *Ocean Development & International Law* 39 178.

[14] Ocampo E S and Pereira N N 2019 *Journal of Cleaner Production* 224 981.

[15] Neşer G, Kontas A, Unsalan D, Uluturhan E, Altay O, Darılmaz E, Küçüksezgin F, Tekoğul N and Yercan F 2012 *Marine pollution bulletin* 64 882.

[16] Grubert E 2021 *Energy and Climate Change* 2 100061.

[17] Gemisander (B) 2020 *Ship Recycling Industrialists Association 2020 Sector Report* (Ship Recycling Industrialists).