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IMPACT WORLD+ A NEW METHOD FOR LIFE CYCLE ASSESSMENT

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Adam Idzikowski[1] – *orcid id: 0000-0003-1178-8721*
Tomasz Cierlicki[2] – *orcid id: 0000-001-7211-1197*
Patrycja Bałdowska-Witos[2] - *orcid id: 0000-0003-0547-4400*
Izabela Piasecka[2] - *orcid id: 0000-0003-4028-5146*
[1]University of Technology in Czestochowa, **Poland**
[2]University of Technology in Bydgoszcz, **Poland**

Abstract: With the IMPACT WORLD+ life cycle impact assessment methodology, the impact of a facility's life can be analysed. All midpoint scores are expressed in units of substance and refer to twenty-one damage categories. The distinctive feature of this method is its regionalized nature covering the whole world, which distinguishes it from other methods that deal with selected geographical regions. The IMPACT WOLRD+ method, like other methods, emphasises which factors have a high impact on human health and which factors have a negligible share. The new method also introduced new indicators that were not included in other methods.
Keywords: environment, life cycle assessment, sustainable development

1. INTRODUCTION

As it is commonly known, more and more people come from year to year in the world. The growth of the population and the increasing standard of living of the society contribute to the increased demand for broadly understood products, devices, machines and energy. As a result, there is a noticeable increase in food, machine and construction waste all over the world. The continuous exploration of natural resources is also visible, which contributes to their depletion - especially noticeable in recent years. Therefore, human activity has an impact on the biophysical world. Societies influence the biosphere by contributing to its transformation. The change of water relations, soil transformation, influence on the climate and the environment become clear. The influence of man on the environment disrupts its proper functioning. It manifests itself mainly in global warming, changes in the thickness of the ozone layer, reduction of the area of forests and arable land, the deficit of fresh water and the transformation of the environment. Therefore, for many countries, the idea of sustainable development is becoming important, with the aim of limiting human impact on the natural environment. I am looking for methods that will allow me to estimate the human impact on the environment. Based on these methods, measures can be taken

to reduce the impact of humans on nature while continuing to grow economically. The Life Cycle Assessment (LCA) method is becoming popular nowadays (Adamczyk 2005; Lewicki et al., 2011).

The use of LCA enables a global picture of the assessed technical object and its individual phases of its existence. When analyzing with a high degree of detail, the LCA method allows for the analysis of specific elements from which a given object has been produced. Thanks to the results, it is possible to choose a solution that will reduce or completely eliminate the negative impact of a technical object, element or material on the environment, while maintaining its appropriate quality and properties. Such conclusions are possible thanks to the detailed inventory of the examined object (Błazińska et al., 2020; Dąborwska and Dzikuć, 2012; Piotrowska, 2019).

The origins of the LCA took place at the World Energy Conference in 1963, when Herold Smith presented a report on the energy consumption of production systems. The presented assessment differed in structure from its present form, and the research on the improvement of the method conducted in the following years resulted in the fact that the Life Cycle Assessment method assumed its present appearance. It was not until 1990 that the name Life Cycle Assessment was introduced and established a theoretical basis for it. In 1993, the International Organization for Standardization published the ISO 1404x Life Cycle Assessment series of standards. Polish equivalents of LCAs have been developed based on ISO standards in Poland, they are: PN-EN ISO 14040: 2009 Environmental management - Life cycle assessment - Principles and structure, PN-EN ISO 14044: 2009 Environmental management - Life cycle assessment - Requirements and guidelines. These standards indicate the principles and structure of the Life Cycle Assessment and provide the requirements and procedures necessary for a proper Life Cycle Assessment. Since then, LCA has been recognized internationally as an effective tool for assessing the environmental impact of facilities (Grzesik, 2013).

Life Cycle Assessment is a technique that aims to analyze environmental hazard by identifying and determining the amount of used materials, energy and waste substances released into the natural environment in each phase of the life cycle of a technical facility. The analysis can cover global, regional and local aspects. During the analysis, methods are used to assess the impact of the facility's life cycle on the environment. The following methods are popular in Europe: EPS 2000, CML, Eco-indicator 99, IMPACT 2000+, ReCiPe, MIPS and the new IMPACT World + method. The above-mentioned methods are implemented in computer programs, eg SimaPro, GaBi, Umberto. Based on the data entered into the computer program and the selection of an appropriate method of analysis, the computer performs calculations that enable the assessment of the impact of products or processes on the environment. By comparing the obtained results with products or processes, you can estimate which product or process has a lower environmental impact (Dąbal and Łyszczarz, 2016; Żelazek, 2016).

Life Cycle Assessment covers the entire existence of a technical object, from the extraction of raw materials, through production, operation, processing, decommissioning, recycling and decommissioning of the tested object. That is why the discussed method is often called "cradle to grave". Thanks to this, LCA allows for the analysis of the environmental impact at individual stages of the life of a technical facility. The assessment is possible thanks to the identification and quantification of used materials and energy as well as waste and emissions released to the environment

(Piasecka and Tomporowski, 2018). The discussed methodology consists of four main steps:

- Goal Definition and Scoping
- Invertory Analysis
- Impact Assessment
- Interpretation

Defining the goal is related to the indication of the intended applications, the reasons for conducting the research and the recipient of the obtained results. In terms of research, it is important to define the system, its boundaries and the functional unit. The scope of the data should be defined in such a way as to ensure the greatest possible detail of the data. Inventory analysis involves collecting input data (materials and energy) and output data (waste substances) and creating a process tree. The task of the third phase is to determine the environmental relationships of all inputs and outputs covered by the LCA study and to determine the magnitude of their impact on the environment. Interpretation of the evaluation results is the last stage during which the obtained results are analyzed and recommendations are made to limit the environmental effects (Borowiec at al., 2009).

When analyzing the assessment of the impact of existence, the function and functional unit are of great importance. If possible, the time range should be specified in the functional unit. The functional unit is called the measure of the effects fulfilled by the functional outputs of the selection system. If the analysis covers the entire life cycle, it is proposed to select a functional unit from the use stage, because it best expresses the essence of the function (Braklee at al, 2009).

2. METHODOLOGY

The article uses the method of systematic literature review on IMPACT WORLD +, a new life cycle assessment (LCA) method. A systematic review of the literature is one of the methods of analysis that prepare the researcher for the later stage of research, which is a research experiment. This method is mainly characterized by theoretical considerations on a specific topic. Undoubtedly, it is worth emphasizing that the selected method is important in the subsequent stages of the research, because it affects the quality of conclusions and the correctness of the hypotheses put forward during empirical research. Therefore, this paper focuses mainly on describing and explaining the issues related to the IMPACT WORLD + method. IMPACT World+ is the update of the IMPACT 2002+, LUCAS, and EDIP methods and is based on a midpoint-damage framework. Most of the regional impact categories have been spatially resolved and all the long-term impact categories have been subdivided between shorter-term damages (integration of impacts before the 100 years after the emission) and long-term damages (impacts after the 100 years after the emission). During the analysis, the task was to review mainly foreign ones on a given topic, and then the searched publications were verified in order to select relevant articles. The aim of the analysis is to describe and explain what the IMPACT WORLD + method is in the life cycle assessment and what is the novelty of this solution.

3. METHOD IMPACT WORLD+

Many methods of assessing the impact of the existence of an object on the environment do not take into account its impact on the entire area of impact only on a given region

to which a given method applies. For example, the Eco-indicator 99, CML, ReCiPe, EDIP, IMPACT 2002+ and EPS methods are representative of Western European conditions, LIME 2.0 for Japanese conditions, TRACI for US conditions, and LUCAS for Canadian conditions. That is why the IMPACT WORLD + method was created, which is globally regionalized and allows the assessment of the facility's life cycle regardless of the geographic region. This method is an update of the IMPACT 2002+, LUCAS and EDIP methods. IMPACT WORLD +, like the above-mentioned methods, assesses the impact of the life cycle of a facility, taking into account emissions of substances and resource consumption, using characteristic factors at four hierarchical resolution levels: default, continental, national and native, taking into account regional impact factors and the accompanying uncertainty resulting from from spatial variability. It consists of eighteen midpoints level indicators and twenty one damage levels indicators, which guarantees the consistency of modeling and selection assumptions in different impact categories (web page).

Thanks to this approach, it is possible to calculate the environmental profile with less model uncertainty and greater environmental significance. All impact categories are divided into short-term damage (within 100 years after emission) and long-term damage. The method covers both midpoint indicators, damage to human health, ecosystem quality, as well as areas of conservation of ecosystem resources and services, and damage to water and carbon areas. This method analyzes the magnitude of global potential damage for each impact factor based on an estimate of total annual anthropogenic emissions and extractions (web page).

Figure 1 shows the general methodology of IMPACT WORLD + with different viewpoints, middle impact category (long-term climate change, short-term climate change, ozone depletion, freshwater acidification, soil acidification, freshwater eutrophication, salt water eutrophication, cancer-causing human toxicity , non-cancerous human toxicity, freshwater ecotoxicity, photochemical oxidant formation, particle formation, use of natural resources, ionizing radiation, fossil fuel consumption, water scarcity, land take, land conversion) and the impact category at the level of damage (climate change human health, change climate, ecosystem quality, ozone depletion, sea acidification, freshwater acidification, freshwater eutrophication, salt water eutrophication, carcinogenic toxicity to humans, does not cause human toxicity, freshwater ecotoxicity, photochemical formations non-oxidants, formation of particles, use of natural resources, ionizing radiation human health, ionizing radiation on ecosystem quality, biodiversity of land take, biodiversity of land transformation, water availability human health, water availability water ecosystem, water availability terrestrial ecosystem). Midpoint indicators characterize elementary flows that contribute to failure. The term midpoint is defined as the intermediate point between the LCI scores and the change. Which makes it possible to assign a midpoint category to the damage category that determines the change in the quality of the environment. The obtained results give a simplified model of complex reality, which does not change the fact that the obtained results facilitate taking actions aimed at reducing the negative impact of objects on the environment (web page).

The IMPACT WORLD + general framework is based on the midpoint change model that confirms four coherent and complementary viewpoints that allow the life cycle assessment profile to be defined:

a) midpoint viewpoint,

b) damage level viewpoint,

c) AoP damage point of view (area of protection) at the damage level, which groups the categories of impacts on the level of AoP damage: human health, ecosystem quality and raw materials and ecosystem services. Ecosystem services determine the potential impact on humans without directly affecting human health.
d) AoC point of view (area of interest) on damage level, expresses impact categories on damage level in terms of water-related damage, carbon-related damage and other AoP damage related to human health and ecosystem quality.
As a result, six levels are distinguished: human health related to carbon, human health related to water, remaining human health, quality of the carbon related ecosystem, quality of the water related ecosystem, remaining quality of the ecosystem (web page).

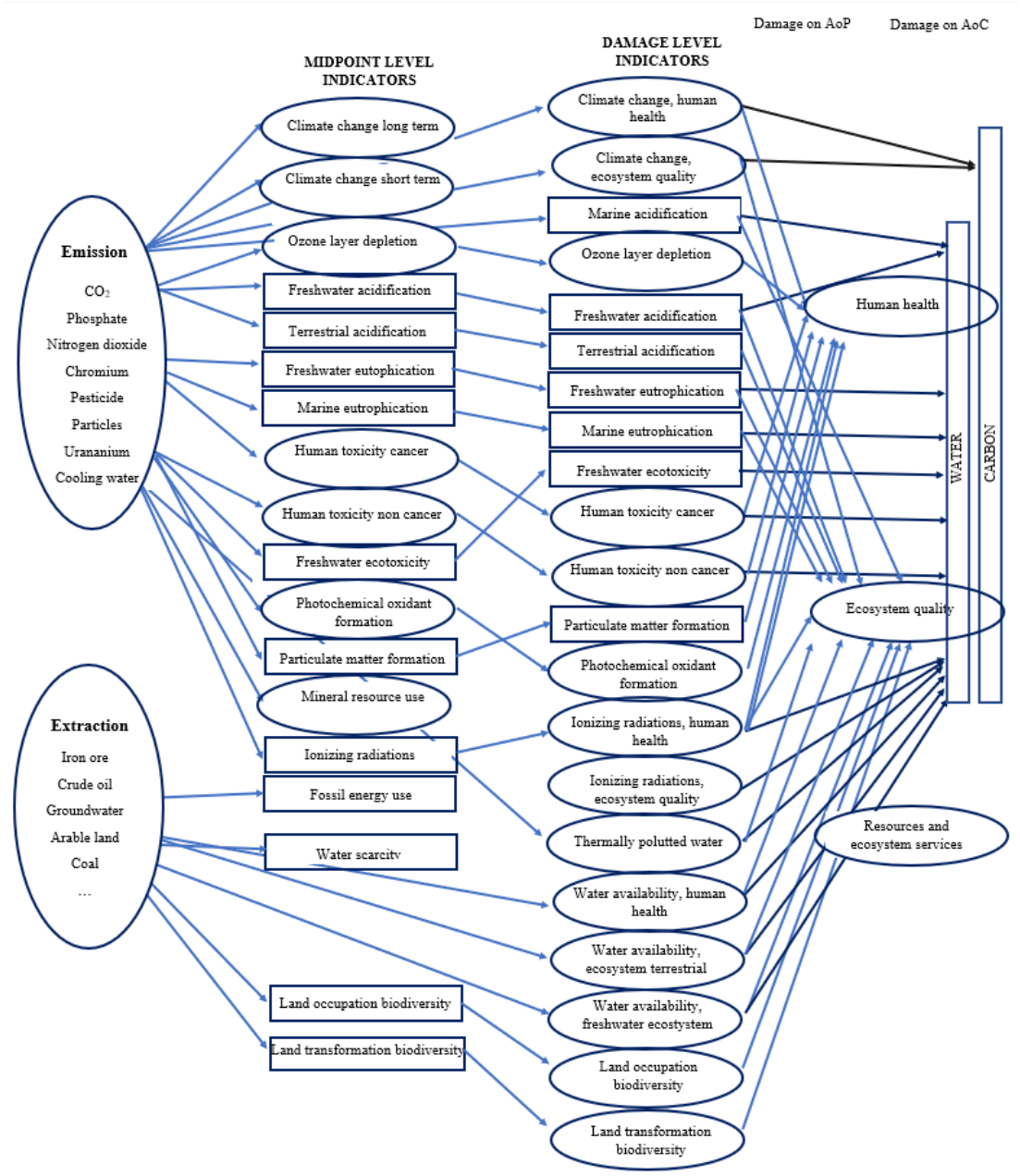

Fig.1.Diagram of methodology IMPACT WORLD+
source: www.impactworldplus.org - own elaboration

IMPACT WOLRD + also makes it possible to sum up the share of water and carbon damage indicators in a given protection area and to compare the results of water and carbon impact on human health and ecosystem quality, expressed in the scale DALY - Disability Adjusted Life Years, PDF·m^2·rok – Potentially Disappeared Fraction (web page).
The IMPACT WORLD + method, like ReCiPe and IMPACT 2002+, states the overriding contribution of climate change and the formation of particulate matter to human health, and the low impact of ionizing radiation, ozone depletion and the formation of photochemical oxidants on human health. Climate change and land use have a huge impact on the quality of the global ecosystem. IMPACT WORLD + introduced new indicators that were not included in ReCiPe and IMPACT 2002+, first of all, the impact of water consumption on human health and the long period of acidification and eutrophication of the seas on the quality of the ecosystem, which predominantly contributes to global environmental damage (web page).
IMPACT WORLD + likes other facility lifecycle assessment methods, has limitations. Many people criticize the LCA method for biased modeling because it is represented from a programmer's perspective. Therefore, it is said that the IMACT WORLD + method is a simplified and incomplete assessment of the impact of the existence of a technical object on the environment. It is emphasized that the results should be interpreted with caution, taking into account the adopted hypotheses and modeling limitations. Another limitation of the IMPACT WOLRD + method is the failure to take into account the categories of impact of factors such as the impact of photochemical oxidants on plants, noise, overfishing and unsustainable wood exploitation (web page).

5. CONCLUSIONS

The aim of the analysis was achieved thanks to the literature analysis of the IMPACT WORLD + method used to assess the impact cycle of objects. The main features of the method along with their limitations were described during the analysis. The discussed IMPACT WORLD + methodology is a new method helpful in assessing the impact of the existence of objects on the environment. The method is based on the LCIA structure and consists of eighteen midpoints and twenty-one failures, which guarantees the consistency of the modeling and selection assumptions in the different impact categories. The most important factors of this method are: climate change, land use, ecotoxicity of freshwater and soil acidification are the most important impact indicators. It gives the possibility to evaluate the emission and consumption of resources regardless of the geographic region. The IMPACT WORLD + method offers four different viewpoints to express the LCIA profile, midpoint level, damage level, AoP damage level, and AoC damage level. It is worth noting that the IMPACT WORLD + method introduced new indicators that were not taken into account in other methods, primarily the impact of water consumption on human health and the long period of acidification and eutrophication of the seas on the quality of the ecosystem, which is a major contributor to global environmental damage.
The IMPACT World+ method integrates developments in the following categories:

- Complementary to the global warming potential (GWP100), the IPCC Global Temperature Potentials (GTP100) are used as a proxy for climate change long-term impacts at midpoint.
- Marine acidification impact is based on the same fate model as climate change, combined with the H+ concentration affecting 50% of the exposed species.

- For mineral resources depletion impact, the material competition scarcity index is applied as a midpoint indicator.
- Ecotoxicity and human toxicity impact is based on consider indoor emissions and differentiate the impacts of metals and persistent organic pollutants for the first 100 years from longer-term impacts.
- Impacts on human health related to particulate matter formation.
- Impacts on ecosystem quality from land transformation and occupation are empirically characterized at the biome level.

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