LCA STUDY OF ENVIRONMENTAL IMPACTS OF WWTP

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ABSTRACT

This article reviews the environmental impacts of the wastewater treatment plant. The wastewater treatment plant is evaluated using a simplified LCA analysis, as only negative environmental impacts are assessed. The analysis takes place in 4 phases, which is interconnect and interact with another. It is important to correctly specify input data such as a functional unit, reference flow, system boundaries. Subsequently, a characterization model of the product system is created, what presents the wastewater treatment process with all input parameters.

***Key words**: environmental impact assessment, wastewater, LCA analysis, LCI analysis*

1 INTRODUCTION

With the adoption of the Water Framework Directive 2000/60/EC, the SR has undertaken to establish an effective system of protection of aquatic ecosystems. The protection system of aquatic ecosystems also includes the creation of appropriate conditions for drainage and sewage treatment that the EU has established by Directive 91/271/EEC. Even though legislation sets limit values for the amount of pollutants discharged, a breach of the aquatic ecosystem of the recipient may occur. At present, mandatory tools are used to assess environmental impacts of objects. EIA or optional tools, for example, EMAS, GPP or LCA.

It is one of the optional tools of environmental management and can be used in almost every area of the economy. The main idea behind the usage of the LCA study is to limit or even eliminate the adverse environmental impacts arising from the increase in product quality. The main idea behind the usage of the LCA study is to limit or even eliminate the adverse environmental impacts arising from the increase in product quality.

2 DEFINITION AND METHODOLOGY OF LCA

2.1 Definition of LCA

Life Cycle Assessment is an analytical method for assessing the environmental impacts of processes and products. Evaluates their environmental impacts with respect to the life cycle (Kočí 2009, s. 263). The environmental impact of products or processes are reckoned together as an entire chain (Groen et al. 2016, s.1125-1137). LCA ascertains the environmental impacts of products or systems from cradle to grave (Bounocore et al. 2016, s.11).

The methodology of LCA is standardized within EU by ISO Standards 14000 and in Slovakia are most commonly used ISO 14040 and ISO 14044. According to this standard, the LCA is a comparative method that expresses the potential environmental impacts of individual products with respect to the life cycle (ISO 14040). The assessment consists from four phases, which are represented in ISO standards. In figure 1 are illustrated the four phases of LCA.

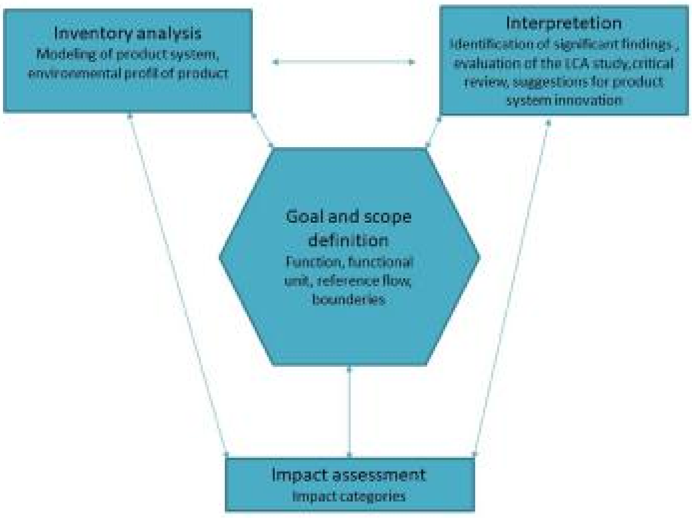

Fig. 1 Life Cycle Assessment phases (Kočí 2009)

2.2 Methodology of LCA

2.2.1 *The goal and scope definition*

The subject of the assessment and its scope is determined in the first phase of the LCA analysis. In particular, it is necessary to clearly identify the content of the study, the meaning, the target group and the conditions under which the analysis will be valid. Characteristics of technical parameters and requirements are closely related to the determination of the subject of the study. Within the characteristics of the technical parameters, the functional unit, the reference flow and the boundary of the system are determined (Kočí 2009, s. 263). The goal of the analysis is the assessment of the environmental impacts of municipal WWTP. It serves to monitor the current state of operation with its optimization forecast.

2.2.2 *Description of the WWTP under study*

The WWTP under study is a mechanically-biological treatment plant with low entrainment activation, anaerobic sludge stabilization and with gas management. It was designed for capacity of 80,000 p. e. but currently, it works just about half capacity (46 400 p. e.) because all communities are not connected to the WWTP. Nowadays, some communities that belong to the agglomeration have not built the sewer networks. In the future an increase of number the connected inhabitants and industrial activities, the increase amount of wastewater is expected.

2.2.3 *Functional unit*

The purpose of the WWTP is to remove the pollutants and reduce the emissions when the treated effluents are discharged to the aquatic ecosystem (Hospido et al. 2004, s. 261-271). Rate of fulfilment of the functional outputs is a functional unit used to measure the comparability of LCA results (Kočí 2009, s. 263). According to Hospido et al. the functional unit can be defined as quantity of removed pollutants, amount of treated wastewater or generated sludge. The amount of wastewater was determined as a functional LCA unit because it was based on the realistic data.

2.2.4 *System boundaries*

System boundaries define important life cycle processes that need to be included in LCA analysis. They greatly influence the outputs of the analysis, so their correct determination is very important (Bounocore et al. 2016, s.11). The boundaries of the system were defined by the potential impacts of sewage at purification levels, so the wastewater treatment system was divided into three subsystems (fig. 2). Subsystem 1 consists the raw waste water inflow and the mechanical treating level (pre-treatment, primary treatment). Subsystem 2 comprises the biological treating level and the discharge of the treated water into the receiving water. The subsystem 3 includes the last part of WWTP the sludge treatment. This subsystem counts the transport of the sludge and its application to the land.

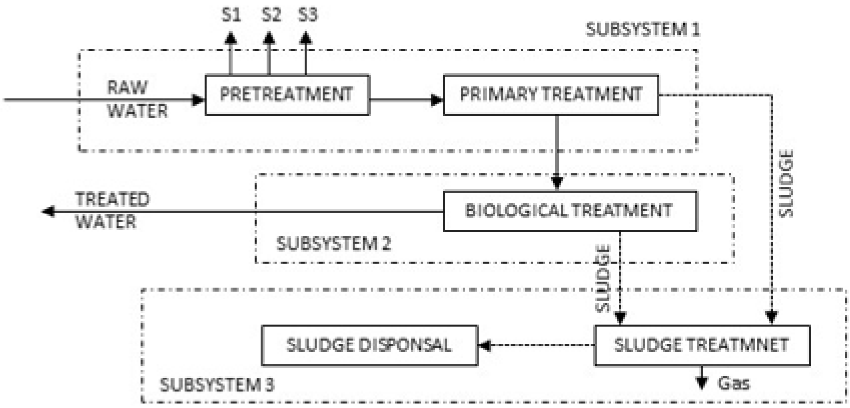

Fig. 2 Model of product system and subsystem defining

2.2.5 *Inventory analysis – Life cycle Inventory*

The Inventory analysis is concerned with data collection and calculation procedures necessary to complete the inventory (ISO 14040). According to Kočí LCI serves to determine the count of primary flows that are released into the environment during the product life cycle. The inventory function is to focus on environmentally relevant information about participating processes in the product system. The output of the inventory analysis is a set of data called the ecovector. The ecovector summarizes the material flows that enter and exit the system. They are presented in inventory tables – matrices (Kočí 2009, s. 263).

The inventory analysis is based on real measured data for the period of twelve months. All the data are presented in Table 1 and they showed the average measured values of the twelve months period and serve only to illustrate inventory tables. Extensive tables that contain of the amount of inert waste, municipal solid waste and emissions to air were used to perform the analysis.

2.2.6 *Life Cycle Impact Assessment*

The Life Cycle Impact Assessment is the LCA phase, which aims to convert the results obtained through inventory analysis. It is the conversion of the ecovector (elementary flows) into suitably selected units of impact categories. The basic step of the evaluation is the classification of the elementary flows that are assigned to the individual impact categories. The output of this phase is the characterization profile determined by the impact category indicators (Guinèe et al. 2001, s.19). In addition, the assessment used midpoint characterization model, which was based on the measurable properties of substances representing elementary streams. So, were used the ILCD 2011 impact assessment method, that was created by the Joint Research Centre (JRC) of the European Commission.

Materials	Inflow from the sewer system	To further v treatment	Emissions to the Environmnet
pH (-)	6,94	7,09	7,26
COD (mg/l)	267,19	164,43	11,09
BOD_5 (mg/l)	154,25	89,88	5,63
DS 105 (mg/l)	185,09	86,88	11,14
$N\text{-}NH_4$ (mg/l)	16,47	13,8	0,66
$N\text{-}NO_3$ (mg/l)	0,29	0,28	7,67
N_{total} (mg/l)	22,17	22,31	10,16
P_{total} (mg/l)	2,46	1,76	0,44
$PP\text{-}PO_4^{3-}$ (mg/l)	1,36	0,96	0,24
Elektricity (kWh/year)	1516733		

Tab. 1 Inventory data for subsystems 1, 2

The ILCD was developed by analysing several life cycle impact assessment methodologies to achieve a consensus on the recommended method for each environmental theme (Acero et al 2016, s.12). Consequently, the ILCD impact assessment method evaluates the eleven categories of impacts in the analysis i.e. acidification, climate change, resource depletion, ecotoxicity, eutrophication, human toxicity, ionizing radiation, land use, ozon layer depletion, particular matter and photochemical oxidation. Table 2 presents the results of impact assessment.

Impact category	Reference unit	Result
Acidification	Mole H+ eq.	9266,0
Climate change	kg CO2 eq.	1055379,2
Freshwater ecotoxicity	CTUe	41665,0
Ionizing radiaton - human health	kg U235 eq.	117829,5
Land use	kg SOC	207238,4
Particulate matter/Respiratory inorganics	kg PM2.5 eq.	592,9
Photochemical ozone formation	kg C2H4 eq.	3000,9
Resource depletion	kg Sb eq.	4246,0
Terrestrial eutrophication	Mole N eq.	10362,7

Tab. 2 Impact category values

3 RESULTS

The result of the LCA analysis is the large amount of data, which need to be sorted and, if necessary, complemented by advanced data. In general, the interpretation of the analysis based on layout data with respect to the most important processes, sensitivity analysis and the assessment of the uncertainties of the study, the final narrative summary and formulation of realistic recommendations. Although, the result of the analysis is a set of reference units, which is then converted into a percentage of the impact categories for a more transparent presentation.

Figure 3 shows the possible negative environmental impacts of the wastewater treatment process. The most significant negative impacts are reflected in the components of the global impacts (85,5%), which include the impacts of climate change (85%), exhaustion of mineral and fossil resources (0,3%) and photochemical ozone formation (of 0,2%). Smaller impacts are observed when the components of terrestrial eutrophication (0,8%) and acidification (7%), which form the components of the regional impacts. It was important to determine the magnitude of local impacts (freshwater ecoxicity 3,4% and ionising radiation of 9,5%) that describe the possible impacts on the environment in the direct vicinity of the pollution source.

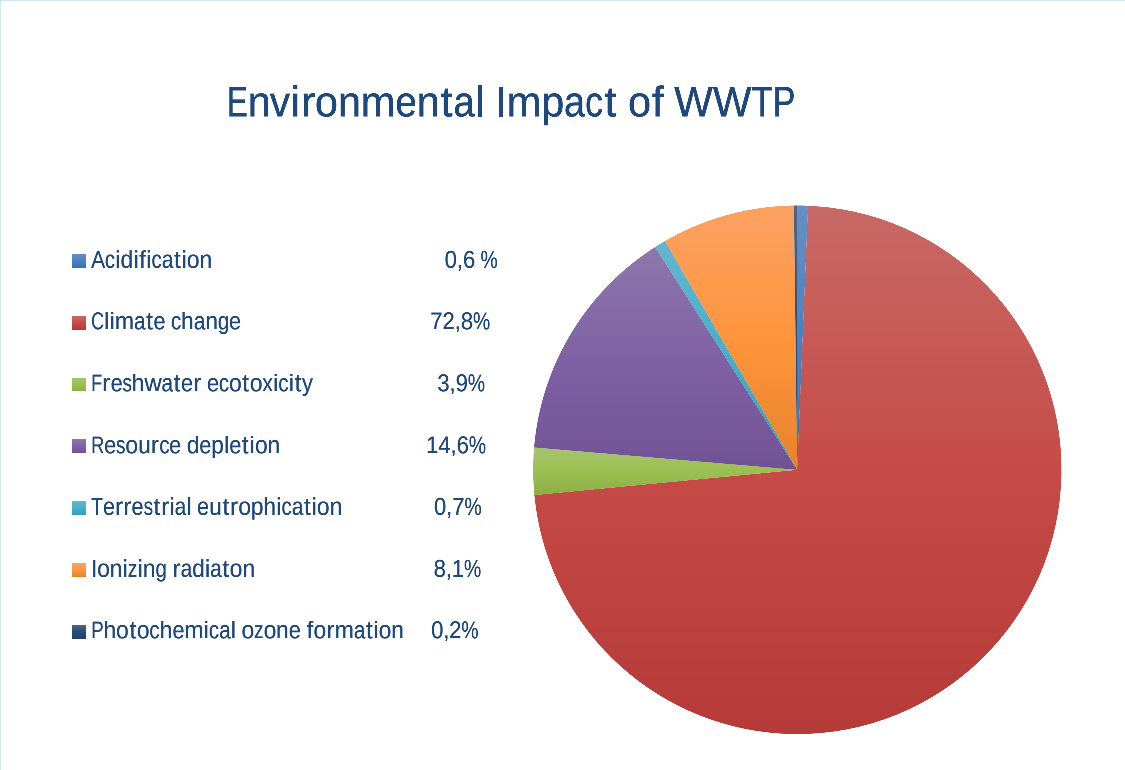

Fig. 3 Environmental impacts of the wastewater treatment plant

4 CONCLUSION

The objective of this contribution was acquainted with the methodology of LCA analysis and its use to assess the environmental impacts of the wastewater treatment plant Kútniky. Using the LCA analysis identified the potential adverse effects of the treatment process of wastewater on the environment. Impact assessment of the life cycle of plants is based on the correct determination of the functions, functional unit of the system, system boundaries and reference units. During twelve months period, thorough the inventory analysis were collected the impute data about wastewater inflow, sludge and discharge. Subsequently, were this data allocated to the impact categories. In the framework of the analysis considers the legislative requirements for emission limit indicator values of impact categories.

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