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Environmental life cycle assessment of septic tanks in urban wastewater system – a case study for Poland

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Abstract: Results of life cycle inventory (LCI) and life cycle assessment (LCA) for septic tanks collecting domestic sewage were presented. The study included the whole life cycle: construction, use and end-of-life stages of septic tanks. The analyses were conducted basing on actual data concerning performance of 793 septic tanks in Żory. Environmental impact assessment of the life cycle of septic tanks was conducted with TRACi and ReCiPe methods. Greenhouse gas (GHG) emission, eutrophication, fossil fuel depletion and metal depletion indicators were calculated and determinants of LCA of septic tanks were analysed. The system boundary was from cradle to grave. It was concluded that at the construction stage, GHG emission and fossil fuel depletion indicators are determined by the amount of concrete, steel, polyester resin, polyethylene, cast iron and PCV. At the use stage, GHG emission is determined by the amount and type of electricity used to treat sewage in a wastewater treatment plant (WWTP). Untreated wastewater, introduced into the environment (leaking tanks and users discharging sewage), is a determinant of influence on eutrophication. Life cycle inventory and environmental assessment of septic tanks with life cycle perspective are presented in the literature for the first time. The results highlight the importance of including each stage in the environmental assessment of elements of the urban wastewater system.

Introduction

Septic tanks are elements of the urban wastewater system (UWS) in Poland. The elements of the system of collecting, transporting and treating sewage in a given area are (Zdebik and Zawartka 2015) (Fig. 1):

- septic tanks, where sewage is collected in areas without sewerage system (outside the urban agglomeration) and transported with vacuum tankers to a wastewater treatment plant (WWTP),
- individual wastewater treatment plants (IWWTP), where sewage is treated in areas without sewerage system (outside the urban agglomeration), and sewage sludge they produce is transported with vacuum tankers to a WWTP,
- sewerage system together with accompanying facilities, transporting sewage to WWTP,
- WWTP treating sewage from sewerage system and sewage transported with vacuum tankers from septic tanks, as well as sewage sludge from individual wastewater treatment plants.

The wastewater treatment plant and the sewerage system are located within the area of the agglomeration, while septic tanks and individual wastewater treatment plants are located outside the area. They are the most common configuration solution of the system. Replacing a sewerage system and a wastewater treatment plant with septic tanks and individual wastewater treatment plants requires substitute infrastructure to treat sewage sludge from individual sewage treatment plants and treating sewage collected in septic tanks.

Septic tanks collect sewage from households or buildings generating domestic sewage which requires treating. The very basic quality of septic tanks is their ability to keep sewage separated from soil-water environment i.e. their leakproofness is a critical parameter. A leakproof tank requires systematic and costly cleaning and transporting sewage to a wastewater treatment plant where it is treated. Polish experiences show that few tanks remain leakproof, which results in constant emission of uncontrolled amounts of pollutants into the environment, causing significant damage (Stadnik 2015). In the literature the term of holding tanks is also used, which means a tight tank with no outflow. Septic tanks in Poland (as in the analyzed city area) are made mainly of reinforced concrete, more seldom of High-Density Polyethylene (HDPE) and polyester resins reinforced with glass fiber (GRP – Glass-Reinforced Plastic) (Burchart-Korol et al. 2019).

In recent years there have been few publications concerning environmental assessment of septic tank. Literature research showed that hitherto works have concerned the issue of soil pollution, and resulting groundwater pollution, caused by leaks or wrong use of septic tanks (Meile et al. 2010, Richards et al. 2016, Schaider et al. 2016, Swartz et al. 2006, Wilcox et al. 2009, 2010). Existing sanitation practices in the majority of developing countries rely mainly on on-site waste treatment approaches (Wang et al. 2014), including flush and waterless latrines connected to pit or septic tanks as a basic treatment of the waste (Anastasopoulou et al. 2018). According to Somlai et al. (2019) septic systems used for on-site wastewater treatment are potential sources of groundwater and atmospheric pollution. The study (Somlai et al. 2019) demonstrated that there are distinct spatiotemporal patterns for both CO_2 and CH_4 fluxes observed over a septic tank soakaway driven by both environmental factors and subsurface effluent dispersal. Onsite wastewater treatment is a potential source of greenhouse gas (GHG) emissions. Considering the large number of onsite septic tank systems in use internationally, potentially constituting a significant source of GHG emissions, there has been a surprising lack of direct field measurements of these fluxes to the atmosphere. Most of the existing septic system emission models rely on load-based calculations or estimated emission factors. The IPCC provides guidelines on national GHG inventories following an organic load-based approach to estimate septic system emissions. These guidelines only consider CH_4 emissions from anaerobic degradation in septic tanks. Direct CO_2 emissions from septic systems are omitted in the GHG inventories as they are of biogenic origin. Numerous recent studies on septic systems are focused mainly on the attenuation of chemical and biological pollutants and the risk for contamination of groundwater (Keegan et al. 2014), wells or surface waters (Dubber and Gill 2017, Ockenden et al. 2014, Withers et al. 2012) from septic systems. However, there is a limited number of studies with a scope on quantifying gas emissions from septic systems.

Determinants of environmental assessment of Polish individual wastewater treatment plants in a life cycle perspective were presented by Burchart-Korol and Zawartka (2019). Environmental life cycle assessment of wastewater treatment plant under Polish condition was shown by Burchart-Korol et al. (2017a). Nevertheless, there are still only few studies presenting results of an environmental analysis for the life cycle of septic tanks, which are a significant element of water and sewage management in Poland, especially in the areas of scattered site housing (Burchart-Korol et al. 2017b, Zawartka 2017).

The aim of the research was to assess environmental impacts of construction, use and end-of-life stages of septic tanks with life cycle perspective. The article is the first one to present results of potential environmental impact throughout the life cycle of septic tanks in urban wastewater system.

Materials and methods

Goal and scope of analysis

The aim of the article was LCA of septic tanks from construction stage, through use stage to end-of-life stage, considering Polish conditions where septic tanks are one of elements of water and sewage management system. The basic function of the analyzed system is to neutralize sewage from a given area, through treating it before reintroducing into the environment. The area where the system operates includes an administrative unit with an urban agglomeration covering part of the area. A basic unit of the system function, i.e. a functional

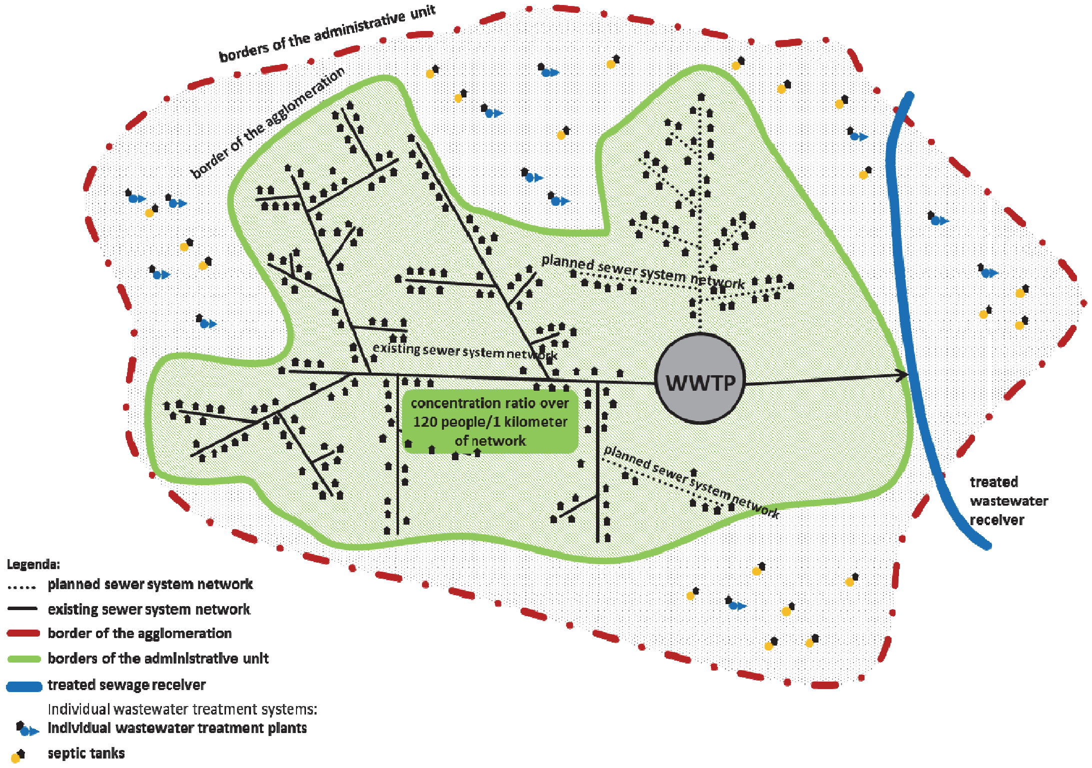

Fig. 1. Configuration of sewage management system

unit (FU), is population-equivalent (1 PE), which, is defined as load of biodegradable organic substances expressed as 5-day biochemical oxygen demand (BOD_5) of 60 g oxygen per day (Burchart-Korol and Zawartka 2019). The functional unit of the analysis is 1 PE as a parameter which is universal for each urban wastewater system considering its diversity.

The study was performed for an operating system of collecting, transporting and treating sewage in the city of Żory, Poland; including the area of the agglomeration of Żory with wastewater treatment plant (WWTP Żory) located in the catchment area of the Ruda river. The system consists of septic tanks which were analyzed. The system was accepted as the reference for analyses due to:

- importance of tanks in the system of collecting, transporting and treating sewage in Żory (793 pieces),
- differences in location, technology (material) and age of septic tanks,
- plans to expand the system due to the development of residential housing and manufacturing and service facilities and the need to provide information to decide the best configuration of the system.

At the end of 2015, in Żory there were 793 operating septic tanks: 567 concrete ones, 155 HDPE ones and 71 GRP ones (UM Żory 2016). Average capacity of a tank is 10 m^3 which allows a typical household to collect sewage for a month. Septic tanks in Żory serve 2,379 PE and are located mainly in the suburbs, in scattered site housing area where there is no sewerage system. Sewage from the tanks is transported in vacuum tankers to Żory wastewater treatment plant (WWTP Żory). There is a full placement inventory of septic tanks in the city, which are placed mostly in a few districts. The distance between septic tanks and treatment plant has been set as an average length of way which vacuum tanker transports the waste to treatment plant and it does include the way to the septic tank and from septic tank to treatment plant. The most common real life scenario has been taken under account that vacuum tanker drives out from the treatment plant and comes back. The average distance between a tank and the plant is approximately 8 kilometers.

The system boundaries for given life cycle stages of septic tanks are presented in Figure 2.

Life cycle inventory

For given life cycle stages of septic tanks, Life Cycle Inventory (LCI), necessary to conduct life cycle assessment, was performed. The main data sources were:

- data from registers of septic tanks (amount, material, capacity, users, frequency of sewage disposal, data for sewage balance) obtained from the City Hall of Żory (UM Żory 2016),
- data concerning use of the tanks (consumption of materials, fuels, energy to transport and treat sewage, qualitative and quantitative parameters of sewage) – obtained from the operator (PWiK Żory 2015),
- data from manufacturers of the septic tanks,
- research and own analysis data concerning construction and use of septic tanks.

Data identification and inventory concerned the whole life cycle of septic tanks. It was assumed that, in accordance with the facts, the EU's and common practice in the water and sewerage sector, the objects are built for a life span of 30 years and within the period their operating as intended is guaranteed.

Data inventory for the construction stage of septic tanks considers consumption of materials and resources and earthworks, both for the tank itself and a section of Ø160 PVC pipe transporting sewage from a building to a tank. The inventory stage of construction septic tanks included also the impact on the environment of assembly works and earthworks with the use of machinery and equipment (diggers, trucks), to perform excavations and the reuse of unnecessary excess of land near the construction site. The data inventory also employed own research associated with implementation of the

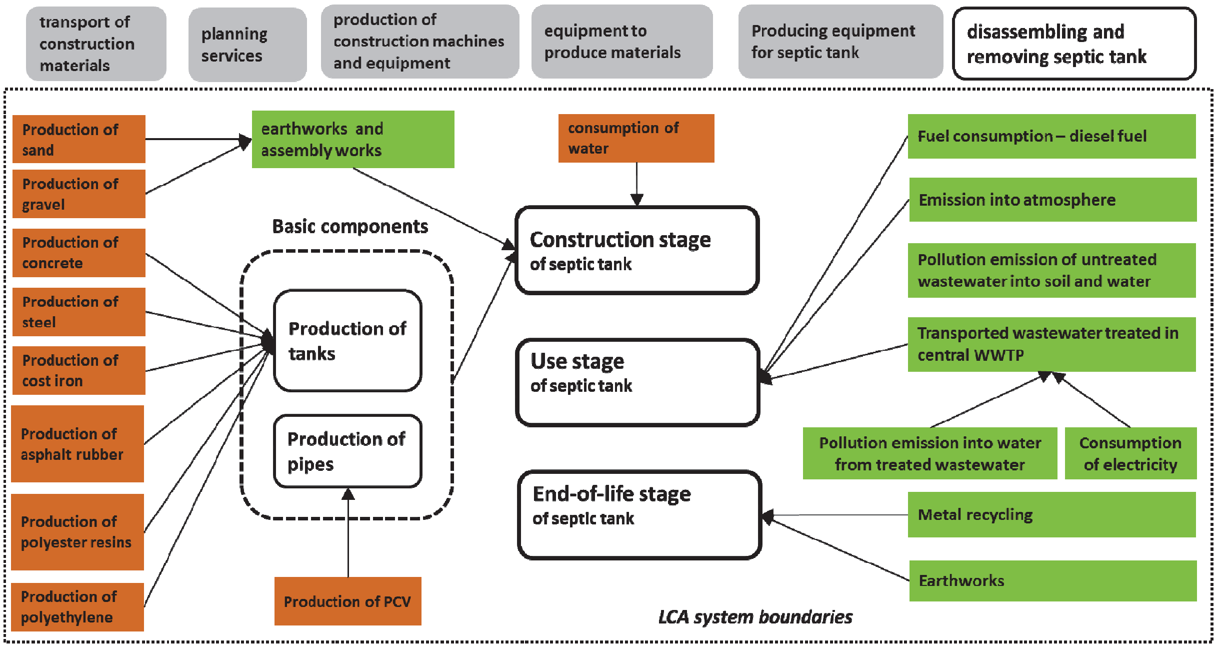

Fig. 2. System boundaries of life cycle of septic tank

investments. The collected input and output data inventory for stage of construction of septic tanks, are presented in Table 1.

The data analysis for the use stage of septic tanks considers transporting sewage to WWTP Żory, GHG emissions from the tanks into the atmosphere, pollutant emission into water after treating sewage transported to WWTP Żory, energy necessary to treat the sewage, as well as pollutant emission from untreated sewage into water and soil. GHG emission from the collected sewage into the atmosphere is an unbalanced factor in environmental impact assessment of the tanks. To assess GHG emission into the atmosphere Water Environment Research Foundation's research results were used (Leverenz et al. 2010). Use of septic tanks in Poland is associated with significant uncontrolled untreated sewage pollutant emission into the environment. Pollution balance was made basing on qualitative and quantitative data of sewage transported and treated in WWTP Żory (Table 2) (treated sewage), as well as guidelines (sewage collected in tanks and introduced into the environment in an uncontrolled way). The available literature (Withers et al. 2012), which indicates the level of emission of 1.3 kg P/household per year, enabled verification and confirmation of the value of uncontrolled phosphorus emission from the tanks into the environment. Data inventory for stage of use are collected in Table 3.

The end-of-life stage occurs when tanks are no longer used, most often when a property is connected to a sewerage system, more seldom when an individual wastewater treatment plant is constructed. The processes associated with the stage include recycling metals and backfilling the tank. The scope of work was determined on the basis of the authors' own experience during participation in the investment process of the construction of sewerage system in connection with the liquidation of the septic tanks.

The impact on the environment was determined on the basis of the scope of identified works related to the liquidation of the cesspool. The scope of work was determined on the basis of the authors' own experience during participation in the investment process of the construction of sewage network in connection with the liquidation of the cesspool.

The data inventory for end-of-life stage of septic tanks are presented in Table 4.

LCA method

LCA was selected for environmental assessment of septic tanks due to the fact that it enables considering the whole life cycle and showing many various environmental aspects. LCA was conducted following the requirements of ISO 14044:2006 International Standards. The phases of the LCA applied in the paper included: goal and scope definition phase, Life Cycle Inventory (LCI), Life Cycle Impact Assessment phase (LCIA) and interpretation phase. LCA was performed using LCA software package SimaPro v.8 and Ecoinvent 3 database within the program. The study performed an environmental evaluation following ReCiPe method (Goedkoop et al. 2013). For environmental assessment of septic tanks four impact categories were selected: GHG emission, eutrophication, depletion of metals, depletion of fossil fuel. The categories were detailed described by Burchart-Korol and Zawartka (2019). Influence category of GHG emission is converted into kilograms of carbon dioxide equivalent (kg CO_2 eq). The

Table 1. Input-output data inventory for septic tanks, stage of construction

Process	INPUTS/OUTPUTS	Value	Unit
Consumption of materials and resources	Production of sand	2596.345	kg
	Production of gravel	902.210	kg
	Production of concrete	1.976	m^3
	Production of steel	92.609	kg
	Production of cast iron	36.005	kg
	Production of PVC	19.669	kg
	Production of asphalt rubber	15.853	kg
	Production of polyester resins	17.040	kg
	Production of PE	32.550	kg
	Consumption of water – leakproofness test	5551.000	kg
Earthworks	Earthworks – excavations	23.219	m^3

Table 2. Average concentration of pollutants in sewage transported to WWTP Żory

Parameters	Value
BOD_5, g/m^3	1,235.0
COD, g/m^3	2,826.8
Suspension, g/m^3	3,984.3
TN, g/m^3	284.8
TP, g/m^3	36.4

amount of greenhouse gases produced to directly and indirectly support human activities were expressed using the reference unit, kg of CO_2. The GHG emission factor is calculated based on the global warming potential (GWP). Eutrophication is expressed in kg N eq unit. Category of fossil fuel depletion was converted into oil equivalent (kg oil eq) basing on the lower calorific value of 42 MJ/kg. Metal depletion is converted into iron equivalent (kg Fe eq) (Goedkoop et al. 2013).

The second chosen LCIA method was TRACI (Tool of Reduction and Assessment of Chemical and other environmental Impacts). This method allows for analysis of influence of 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) nitrogen and phosphorus on eutrophication The LCIA method was developed by the US EPA (United States Environmental Protection Agency) (EPA 2013).

Results and discussion

GHG emission assessment for septic tanks life cycle

Table 5 presents the main sources of greenhouse gases emission for septic tanks at all the stages of the life cycle within the system of collecting, transporting and treating sewage. The unit kg CO_2 eq/FU means greenhouse gas emissions expressed using the reference unit (kg of CO_2) per functional unit (FU), which is a population-equivalent (1 PE).

It was shown that the main greenhouse gas is CO_2 emitted at the construction stage of septic tanks. It was concluded that the volume of GHG emission is also influenced by methane and nitrous oxide emission. Basing on life cycle assessment of septic tanks, it was concluded that at the construction stage the volume of GHG emission is determined by the volume of used concrete

Table 3. Data inventory for septic tanks, stage of use

Process	Inputs/Outputs	Value	Unit
Transport sewage to WWTP Żory	Consumption of diesel fuel	7.372	kg/year
GHG emission from tanks into atmosphere	CO_2	876.2	kg/year
	CH_4	51.6	kg/year
	N_2O	0.49	kg/year
Pollutant emission into waters after treating sewage transported to WWTP Żory	BOD_5	222	kg/year
	COD	1.992	kg/year
	Suspension	1.590	kg/year
	TN	452	kg/year
	TP	0.463	kg/year
Pollutant emission from untreated sewage	BOD_5	42.455	kg/year
	COD	84.909	kg/year
	Suspension	49.530	kg/year
	TN	7.783	kg/year
	TP	1.274	kg/year
Consumption of electricity in WWTP Żory to treat transported sewage	Total consumption of energy	10.888	kWh/year
	Consumption of energy from grid	5.404	kWh/year
	Consumption of energy produced from biogas	5.483	kWh/year

Table 4. Data inventory for septic tanks, end-of-life stage

Process	Inputs/Outputs	Value	Unit
Recycling metals	Recycling cast iron	36.004	kg
Earthworks	Backfilling	7.930	m^3

Table 5. Main emissions of greenhouse gases for septic tanks, kg CO_2 eq/FU

Greenhouse gases	Stages			Total
	Construction	Use	End-of-life	
CO_2	398.27	128.42	-19.80	506.89
N_2O	20.80	2.29	-0.04	23.05
CH_4	20.90	25.10	-1.78	44.22
Other gases	1.00	0.51	-0.06	1.45
Total GHG emission	440.97	156.32	-21.68	575.61

(49%), steel (18%), polyester resin (12%), polyethylene (8%), cast iron (6%) and PVC (4%). Concrete and steel are the most important construction materials of tanks, while resin and polyethylene are used less commonly. The share of other factors (including: earthworks, asphalt rubber, gravel and water) is 2%. Main sources of GHG emission at the construction stage of septic tanks are presented in Figure 3 and determinants of GHG emission for use stage are shown in Figure 4.

Environmental assessment of the use stage of septic tanks showed that the volume of GHG emission is determined by the amount and type of electricity consumed to treat sewage in a wastewater treatment plant (68%), amount of diesel fuel consumed to transport sewage to a WWTP (20%) (Fig. 4), and also direct emission of gases: CH_4 (7%), CO_2 (5%) and N_2O (1%).

At the use stage of tanks, it was concluded that energy produced from biogas to treat transported sewage constitutes 50% share, which contributed to lowering GHG emission for the use stage of septic tanks by 34%. When only electricity from the electrical grid is used, GHG emission for the use stage of septic tanks is 236.26 kg CO_2 eq/FU, with 159.61 kg CO_2 eq/FU due to the consumption of electricity from the grid, while applying biogas to produce electricity the emission indicators are respectively 156.32 kg CO_2 eq/FU and 79.22 kg CO_2 eq/FU.

Life cycle analysis of the end-of-life stage of septic tanks showed that earthworks (GHG emission is 1.77 kg CO_2 eq/FU) and recycling cast iron, which is an environmental benefit in form of avoided emission (GHG emission is -23.50 kg CO_2 eq/FU) are factors which influence the result of GHG emission.

Fossil fuels depletion assessment for septic tanks life cycle

Assessment of septic tanks showed main sources of fossil fuel depletion at the construction stage (Table 6) and use stage (Table 7). It was shown that septic tanks contribute to fossil fuel depletion, of total 240.01 kg oil eq/FU, at the stage of construction (110.31 kg oil eq/FU), at the stage of use (133.69 kg oil eq/FU), while at the end-of-life stage fossil fuel depletion indicator is -3.99 kg oil eq/FU (environmental benefit). It was shown that at the stage of construction, fossil fuel depletion indicator is determined by the amount of used polyethylene (23%), steel (21%), concrete (18%) and polyester resin (15%), which are directly involved in constructing tanks, as well as PVC (8%), asphalt rubber (7%) and cast iron (5%). The share of other factors (including: earthworks, water and gravel) is 2%.

Environmental assessment of the use stage of septic tanks (Table 7) showed that fossil fuel depletion indicator is determined by the amount of diesel fuel consumed to transport sewage (85%) and the consumption of electricity from the grid (15%). Main sources of fossil fuel for septic tanks at the use stage are presented in Figure 5.

Basing on the analyses of electricity consumption at the use stage of septic tanks, it was concluded that the consumption of electricity generated from biogas to treat transported sewage meant lowering depletion of fossil fuels by 20.74 kg oil eq/FU.

Life cycle assessment of the end-of-life stage of septic tanks showed that earthworks (0.59 kg oil eq/FU) and recycling

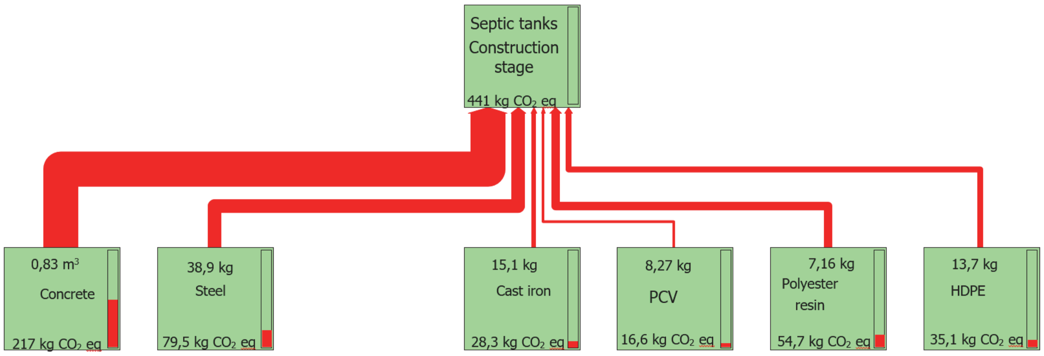

Fig. 3. Main sources of GHG emission for septic tanks – stage of construction, kg CO_2 eq/FU

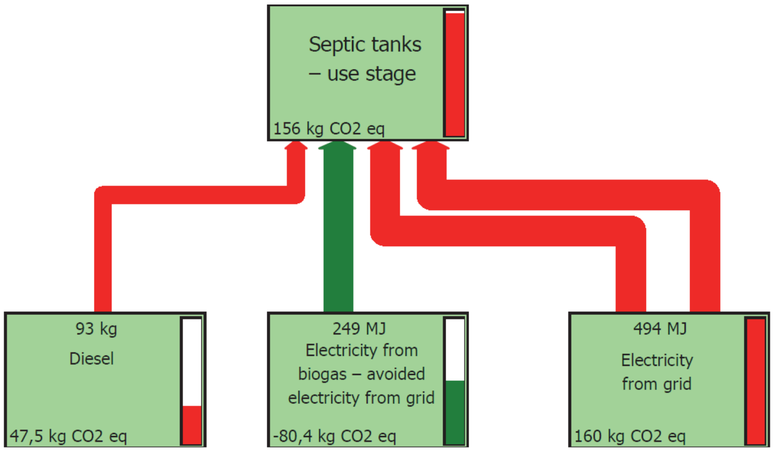

Fig. 4. Main sources of GHG emission for septic tanks, use stage, kg CO_2 eq/FU

cast iron (environmental benefit resulting from recycling tank lids), which contributes environmental benefit (-4.59 kg oil eq/FU), are factors which influence fossil fuel depletion.

Metal depletion assessment for septic tanks life cycle

Environmental analysis of the stage of construction showed main sources of metal depletion (Table 8). Septic tanks contribute to depletion of metals of 194.07 kg Fe eq/FU, at the construction stage with 205.69 kg Fe eq/FU (Table 8), at the use stage with 1.88 kg Fe eq/FU (Table 9). At the end-of-life stage fossil fuel depletion indicator is -13.50 kg Fe eq/FU. Metal depletion indicator at the construction stage is determined, most of all, by the amount of steel used to reinforce tanks (90%).

Table 9 shows that metal depletion indicator is determined by the diesel fuel consumed to transport sewage (66%) and the consumption of electricity from the grid (20%). Metal depletion is influenced by the production of electricity from biogas (14%). Main sources of metal depletion for septic tanks at the use stage are presented in Figure 6. Consumption of electricity generated from biogas to treat transported sewage meant lowering depletion of metals by 0.37 kg Fe eq/FU.

LCA study of the end-of-life stage of septic tanks showed that earthworks (0.08 kg Fe eq/FU) and recycling cast iron (-13.59 kg Fe eq/FU), are main sources of metal depletion.

Eutrophication assessment for septic tanks life cycle

Eutrophication is influenced mainly by sewage introduced into the environment, that is why the presentation of LCA results

Table 6. Fossil fuel depletion, construction stage of septic tanks

Factors	kg oil eq/FU	share, %
Gravel	0.33	0.30
Concrete	20.24	18.35
Steel	23.54	21.34
Cast iron	5.89	5.34
PVC	8.79	7.97
Asphalt rubber	7.74	7.02
Polyester resin	16.98	15.39
Polyethylene	24.88	22.55
Earthworks	1.73	1.57
Water	0.19	0.17
Total	110.31	100.00

Table 7. Fossil fuel depletion, use stage of septic tanks

Factors	kg oil eq/FU	Share, %
Diesel fuel	113.18	84.66%
Electricity from grid	20.45	15.30%
Electricity production from biogas	0.06	0.04%
Total	133.69	100.00

Table 8. Metal depletion, construction stage of septic tanks

Factors	kg Fe eq/FU	share, %
Gravel	0.22	0.11
Concrete	4.03	1.96
Steel	185.08	89.98
Cast iron	13.65	6.63
PVC	0.04	0.02
Asphalt rubber	0.07	0.04
Polyester resin	2.01	0.97
Polyethylene	0.30	0.15
Earthworks	0.25	0.12
Water	0.04	0.02
Total	205.69	100.00

Table 9. Metal depletion, use stage of septic tanks

Factors	kg Fe eq/FU	Share, %
Diesel fuel	1.25	66.1%
Electricity from grid	0.37	19.5%
Electricity production from biogas	0.27	14.4%
Total	1.88	100.00

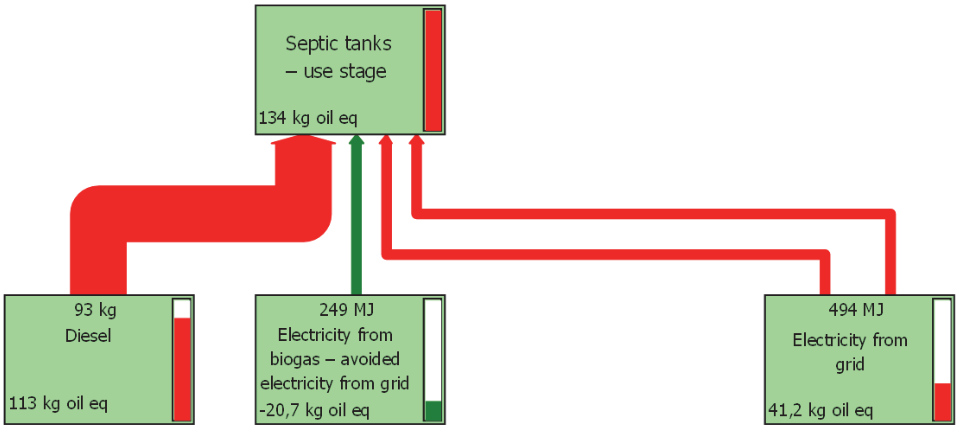

Fig. 5. Main sources of fossil fuel depletion for septic tanks, use stage, kg oil eq/FU

was limited to the use stage of septic tanks. It was shown that untreated sewage (294 kg N eq/FU which is 97% share) emitted into the soil-water environment due to leaking tanks and uncontrolled sewage discharge, has the greatest influence on eutrophication. Treated sewage has little influence on the level of eutrophication (7.06 kg N eq/FU which is 2% share), while diesel fuel to transport sewage and electricity is 0.3% share (Figure 7).

Eutrophication is influenced mainly by phosphorus of equivalent load of 117 kg N eq/FU (40% share), nitrogen which introduces 96.8 kg N eq/FU (33% share), COD responsible for 53.5 kg N eq/FU (18% share) and BOD_5 which introduces 26.8 kg N eq/FU (9% share) (Figure 8). Substances contained in sewage transported to and treated in a wastewater treatment plant also contribute to eutrophication (Figure 9). Nitrogen contained in treated sewage, which

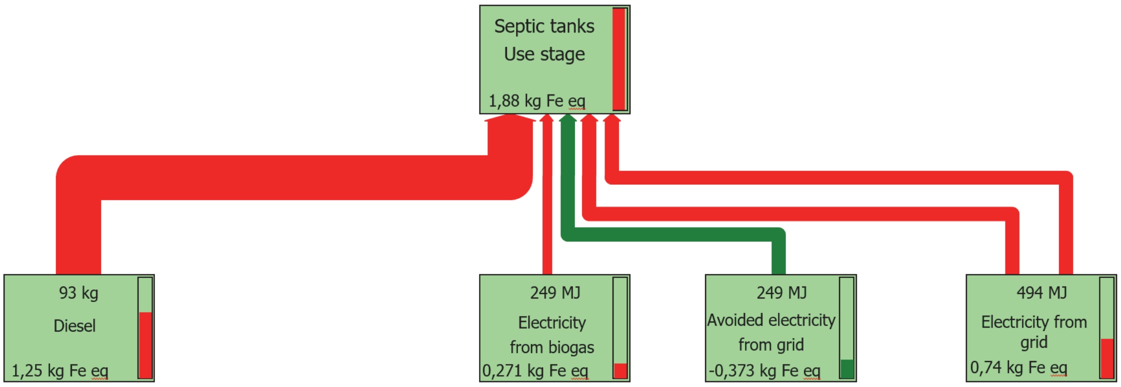

Fig. 6. Main sources of metal depletion for septic tanks, use stage, kg Fe eq/FU

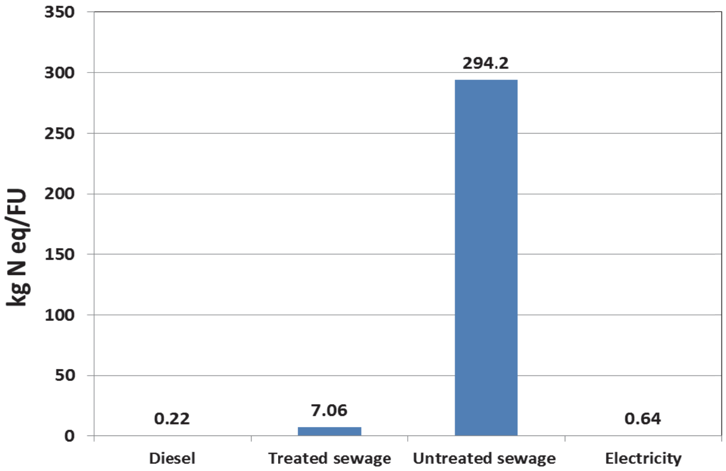

Fig. 7. Main sources of eutrophication for septic tanks – use stage, kg N eq/FU

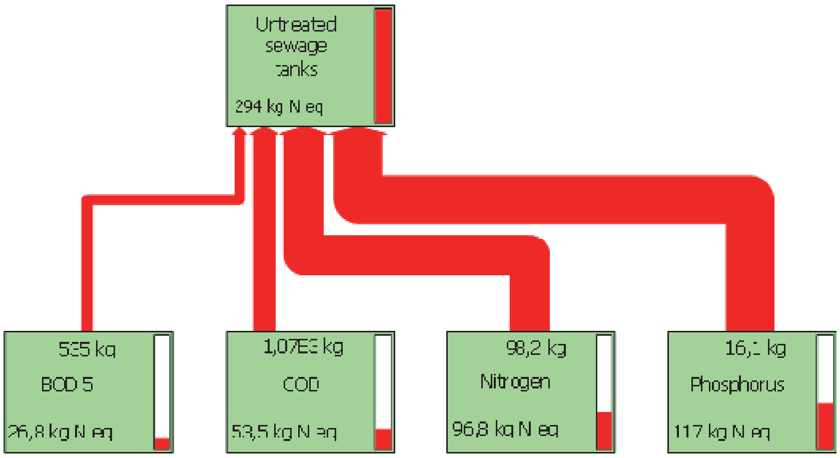

Fig. 8. Main sources of eutrophication in untreated sewage from septic tanks

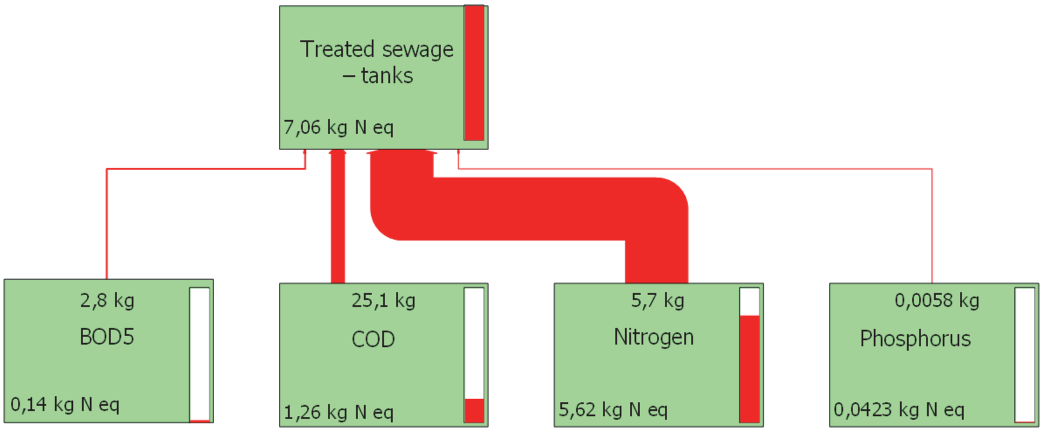

Fig. 9. Main sources of eutrophication in treated sewage from septic tanks

introduces 5.62 kg N eq/FU (80% share), influences eutrophication the most, while BOD_5, COD and phosphorus introduce a total of 1.442 kg N eq/FU, which results from high efficiency of processes in a wastewater treatment plant. Having analyzed the category of eutrophication, it was concluded that pollution load is a determinant in both treated and untreated sewage.

The conducted analysis shows that untreated sewage has crucial influence on eutrophication, especially phosphorus load (hundreds times bigger than in treated sewage) and nitrogen (several times bigger) introduced into the environment in an uncontrolled way.

Conclusions

This is the first attempt at a life cycle inventory and life cycle assessment of septic tanks in urban wastewater system. It was concluded that at the construction stage of septic tanks, GHG emission is determined by the amount of used concrete, steel, polyester resin, polyethylene, cast iron and PVC. Environmental assessment of the use stage of septic tanks showed that the main sources of GHG emission are: electricity used to treat sewage in a wastewater treatment plant, diesel fuel consumed to transport sewage to a WWTP and direct emission of gases (methane, carbon dioxide and nitrous oxide). The main sources of fossil fuel depletion at the stage of construction are: polyethylene, steel, concrete, polyester resin, PVC, asphalt rubber and cast iron. Septic tanks contribute to metal depletion mostly at the construction stage, where metal depletion indicator is determined by the amount of steel used to reinforce the tanks. Fossil fuel depletion and metal depletion indicators at the use stage of septic tanks are determined by the amount of diesel fuel consumed to transport sewage and the consumption of electricity taken from the grid and produced from biogas.

Recommendations and perspectives

Among all the elements of an urban wastewater system (UWS), septic tanks have the biggest influence on eutrophication of water with an influence determinant of untreated sewage introduced into the environment by leaking tanks and users discharging sewage.

Due to the significant influence which leaking septic tanks have on eutrophication, it is advised to take actions aimed at building a sewerage system, first of all in where there are no infrastructure limitations (existing wastewater treatment plant and its technological capacity), or sealing tanks and separating untreated sewage from soil-water environment.

The object of the research was a system functioning on a local scale, which was selected in such a way that due to its specificity (Figure 1) it could correspond to systems functioning at least on a national scale. Despite the fact that nowadays there are constructions of sewerage systems together with accompanying facilities, transporting sewage to WWTP, the septic tanks are commonly found on a global scale therefore it should be recognized that the test results can be universally applicable.

The obtained results form the basis for further development of environmental assessment towards selection of environmentally friendly materials at the construction stage, and limiting influence of individual solutions to neutralize sewage on eutrophication at the use stage. They also show the scale of influence such solutions have on the environment when errors are committed (leaks) and provide grounds to introduce system changes shaping the environmentally best solutions for areas of scattered site housing.

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Środowiskowa ocena cyklu życia zbiorników bezodpływowych w systemie gospodarki wodno-ściekowej – studium przypadku dla Polski

Streszczenie: Przedstawiono wyniki inwentaryzacji cyklu życia oraz oceny cyklu życia zbiorników bezodpływowych służących gromadzeniu ścieków bytowych w warunkach krajowych. Analizy obejmowały cały cykl życia: etap budowy, eksploatacji oraz etap wycofania z eksploatacji zbiorników bezodpływowych. Analizy zostały wykonane w oparciu o rzeczywiste dane dotyczące funkcjonowania 793 zbiorników bezodpływowych w Żorach. Ocena oddziaływania na środowisko została przeprowadzona metodą ReCiPe, oraz TRACI. Analizy obejmowały ocenę emisji gazów cieplarnianych, wpływu na eutrofizację, wyczerpania paliw kopalnych oraz metali. Granica systemu obejmowała cały cykl życia zbiorników. Stwierdzono, że na etapie budowy zbiorników emisje gazów cieplarnianych, wyczerpanie paliw kopalnych determinowane są ilością zużytego betonu, stali, żywicy poliestrowej, polietylenu, żeliwa i PCV. Emisja gazów cieplarnianych na etapie eksploatacji zbiorników determinowana jest ilością i rodzajem zużytej energii elektrycznej do oczyszczenia ścieków na zbiorczej oczyszczalni. Determinantem wpływu na eutrofizację są ścieki nieoczyszczone trafiające do środowiska, spowodowane nieszczelnością zbiorników oraz niekontrolowanymi zrzutami ścieków przez użytkowników. Inwentaryzacja cyklu życia zbiorników bezodpływowych oraz ich ocena środowiskowa zostały przedstawione w literaturze po raz pierwszy. Uzyskane wyniki podkreślają znaczenie włączenia każdego etapu do oceny środowiskowej elementów systemu oczyszczania ścieków komunalnych.