Recycling and Sustainable Development

www.rsd.tfbor.bg.ac.rs

RSD

Online ISSN 2560-3132
Print ISSN 1820-7480

Assessment of construction and demolition waste management in the city of Aveiro, Portugal

Nikola Karanović [a,#], Ana Paula Gomes [a], Nemanja Stanisavljević [b]

[a] University of Aveiro, CESAM, Aveiro, Portugal
[b] University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia

ARTICLE INFO

Received 06 June 2018
Accepted 13 August 2018

Research Article

Keywords:
Waste
Construction
Demolition

ABSTRACT

Quantification is very important for construction and demolition waste management. Estimation of C&D can be reached by establishing waste quantification model for C&D waste that is applicable in urban areas. In this paper, it is presented model for quantification of C&D waste considering Aveiro. The analysis is done for single-family urban sector. In this paper, it is combined empirical data given from Portuguese Statistical Bureau (INE) considering construction activities and C&D waste. Estimations provide data and yearly estimation for C&D waste generation for a period 2015 until 2020 in Aveiro. LCA tool is applied in order to calculate environmental impact of certain C&D waste materials.

1. Introduction

Construction industry is the third-largest CO_2 emitting industrial sector, and representing 10 % of the total anthropogenic CO_2 emissions in the European Union (EU) (Habert et al., 2009). Waste stream from the construction and demolition processes was identified as a priority waste stream by the EU, as it constitutes one of the largest waste streams, since it represents approximately 49 % of the total waste generation in the EU. It is estimated that 887 million tons of construction and demolition waste is generated in the EU in the year 2008 (Eurostat, 2011).

Only small amount of construction and demolition (C&D) waste is recovered in EU (in general), despite the fact that C&D waste has a very high recovery potential (it is assumed that 80 % of waste can be recycled) (Ortiz et al., 2010).

The amount of waste at construction site is in extent. In Brasil, the amount of waste in the Brazilian construction materials on site (Pinto and Agopayan, 1994). In the Netherlands an average is 9 % of the construction materials ends up as site waste in the Netherlands (Bossink and Brouwers, 1996). Besides waste which is found on the construction sites, there is waste generated from the process of renovation and demolition (Table 1). Construction authorities have to implement new regulations in order to stimulate the use of low-waste building technology, to adopt better waste management (WM) practices, recording quantitative data, and make useful guidelines and measures in order to a more manageable and minimized construction waste generation (Jaillon et al., 2009).

2. Objective

The objective of this paper is to present a model for quantification of C&D waste yearly in urban areas for a period 2015-2020, particularly analyzing single-family residential areas in Aveiro, which also provides current

[#] Corresponding autor: nikola.karanovic83@yahoo.com

doi: 10.5937/ror1801009K

Table 1
Percentage of waste generated per activity (Bossink and Brouwers, 1996; Vanderley, 2000; Statistics Norway, 2006)

Type of activity	% of waste per activity		
	Western Europe	Norway	USA
Construction	20	20	8
Renovation	80	44	44
Demolition		36	48

and comprehensive information concerning the characterization and management of C&D waste using tools such as material flow analysis (MFA) and life-cycle assessment (LCA). The aim of this paper is reflected in the following:

- Detailed elaboration of the basic theoretical postulates considering C&D waste,
- Development of a theoretical model for determining the amount of C&D waste in urban areas of Aveiro,
- Estimation of C&D waste in Aveiro,
- Development MFA approach,
- LCA approach concerning environmental impacts of C&D waste.

3. Available methods for C&D quantification

Recent research trend in this field signalize that surveys and case studies are the main methodologies for data collection (Yuan and Shen, 2011). By Associates (1998), sampling and weighing at landfills, would be the most appropriate method for this study if sufficient time and funds were available. However, even on the local level there may be significant barriers to this method. Early efforts to estimate C&D waste have employed the same methods used to estimate municipal solid waste, which is by using *per capita* multipliers (Yost and Halstead, 1996). *Per capita* multipliers, do not reflect C&D activity.

Characterization of C&D waste is the initial stage of data collection and it is crucial (Gheewala and Kofoworola, 2009). This process consists of identifying type of waste materials being generated. Most authors conducted detailed study for characterization of various types of C&D waste materials. Most studies (Associates, 1998; Fatta et al., 2003; Bergsdal et al., 2007; Cochran et al., 2007; Gheewala and Kofoworola, 2009; Martinez Lage et al., 2010) focus on the major type of C&D waste with significant amount, such as concrete, bricks, timber, steel and drywall. Data gathered from C&D sites are described as '*waste assessment data*'.

These data were utilized to produce the average C&D waste generation rate per area, which is usually expressed in unit of amount (weight or volume) per area of activity.

The outcome is the quantity of national C&D waste generation in particular year.

The methodology should be well prepared for updating or predicting (Associates, 1998).

Yost and Halstead (1996) and Associates (1998), used National Statistical data and C&D waste assessment data from different sites in the USA. Yost and Halstead (1996), carried out a case study concerning gypsum wallboard waste generation in the USA, in order to assess the feasibility of wallboard recycling program, while Associates (1998) carried out a study for national C&D waste generation rate.

Total waste generation of certain year (tons/year), presents the product of total area (m^2) multiplied by the average waste generation (kg/m^2), given from the waste sampling. Estimation accuracy is related to the data accuracy (Cochran et al., 2007).

Model of quantification for C&D waste, which is also presented by Cochran et al., (2007) and Bergsdal et al., (2007), is given below: Waste produced in a region = [Activity level of construction; demolition or renovation in a region] x [Waste produced per activity].

By Associates (1998), an average C&D waste rate of generation for residential construction, non-residential construction, residential demolition, non-residential demolition, and non-residential renovation are 21.38 kg/m^2, 18.99 kg/m^2, 561.47 kg/m^2, 844.66 kg/m^2, and 86.27 kg/m^2.

The surveys conducted at the sites present main source of data for waste assesment in this case. By Bergsdal et al., (2007), concrete, bricks and wood are the main waste materials for new construction projects in Norway with 67 % and 15 %, and for demolition projects, 85 % present concrete.

Gheewala and Kofoworola (2009), presented results for new residential and non-residential projects in Thailand. This model is not taking into account demolition and renovation process. Quantification model presented in this case was developed to evaluate the capacity of national C&D waste recycling program. Gheewala and Kofoworola (2009), found that waste generation rate for new residential and non-residential projects were 21.38 kg/m^2 and 18.99 kg/m^2.

The quantification model:

$$Qx = A \cdot Gav \cdot Px \tag{1}$$

Qx = quantity in tons; A = area of activity in m^2; Gav = waste generation rate; Px = percentage of waste material. Fatta et al., (2003), presented the model with waste generation rate and density of C&D waste which shows the average value from Greek Statistical Bureau.

Quantification model is expressed as:

$$CW = [NC + EX\,] \cdot VD \cdot D \qquad (2)$$

CW = construction waste in tons; *NC* = new construction in m^2 (from NSSG); *EX* = extension infrastructure in m (from NSSG); *VD* = volume of generated waste per 100 m^2 = 6 m^3/1000 m^2 (national average); *D* = density of waste = 1.6 ton/m^3 (national average).

$$DW = ND \cdot NF \cdot SD \cdot WD \cdot D \qquad (3)$$

DW = demolition waste in tons; *ND* = No. of demolitions (from NSSG); *NF* = mean value of no. of floors that building has = 1.3; *SD* = surface of each building being demolished = 130 m^2 (national average); *WD* = generation rate of each demolition = 0.8 m^3/m^2 (national average); *D* = density of waste = 1.6 ton/m^3 (national average).

Martinez Lage et al., (2010), presented a model of the generation and composition of C&D waste in any region. Martinez Lage et al., (2010), used historical data concerning new constructions, renovation and demolitions. This model was applied in the case of Galicia. Several presumptions were considered in this case:

- The number of construction, renovation, and demolition works may be adjusted to a theoretical function (linear, parabolic, exponential) that varies over time (if data from a time series is known),
- Construction activities distribution in the whole region is assumed to be the same every year,
- Surface area of construction, renovation, or demolition project can also be adjusted for a variable function over time,
- Quantity of waste generated per area is assumed to be the same for each type of construction.

Quantification model is presented as:

$$R_{build} = \sum_{counties}(R_{Ci} + R_{Ri} + R_{Di}) = \sum_{counties}(C_C \cdot S_{Ci} + C_R \cdot S_{Ri} + C_D \cdot S_{Di}) \qquad (4)$$

R_{build} = C&D debris generated during a given year or horizon year (HY) distributed over counties; *RC* = waste from new construction; *RR* = waste from renovation; *RD* = waste from demolition; *SC* = total surface area for new construction; *SR* = surface area for renovation; *SD* = surface area for demolition; *CC* = waste quantity per surface area of new construction; *CR* = waste per area for renovation; *CD* = waste per area for demolition.

Minimum data needed includes the number of buildings constructed in the whole area over sufficient number of year to be able to establish correlation between year and number of building constructed, and an indicator on which to base the calculation of the mean area of existing construction. In this study, new construction work generates 80 kg of waste per m^2, which is equivalent to 0.11 m^3 of waste per m^2 (density = 700 kg/m^3). Demolition work generates 1350 kg of waste per m^2, while renovation process generates 90 kg/m^2.

Llatas (2011), is using method which involves: identifying building elements of the project and their construction processes, waste classification system (including remains, soil, and packaging) and modeling. Suggested model is presented as:

$$CW_B = \sum_j CW_{SBEj} = \sum_{ji} CW_{BEi} = \sum_{ji} CW_{Pi} + \sum CW_{Ri} + \sum_{ji} CW_{Si} \qquad (5)$$

CWB = volume of waste expected; *CWSBEj* = volume of waste expected in the system building element '*j*'; *CWBEi* = volume of expected waste from building element '*i*'; *CWPi* = volume of expected packaging waste element '*i*'; Σ*CWR*i = volume of remains expected from building element '*i*'; *CWSi* = volume of expected soil in building element '*i*'.

$$CW_{Pi} = \sum_k (EWL)_{pk} \cdot Q_i \cdot F_P \cdot F_C \cdot F_I \qquad (6)$$

$$CW_{Ri} = \sum_k (EWL)_{Rk} \cdot Q_i \cdot F_R \cdot F_C \cdot F_I \qquad (7)$$

$$CW_{Si} = \sum_k (EWL)_{Sk} \cdot Q_i \cdot F_S \cdot F_C \cdot F_I \qquad (8)$$

(*EWL*)*pk* = code of packaging; (*EWL*)*Rk* = code of remains (*EWL*)*Sk* = code of soil; *Qi* = amount of building element '*i*'; *FP* = packaging waste factor; *FC* = conversion factor; *FR* = remains factor; *FS* = soil factor; *FI* = increased volume factor.

Waste generation rate (without soil) is assumed to be 0.1388 m^3/m^2 in this case.

Hsiao et al., (2002), consider dynamic model of materials flow (waste from concrete fraction) in Taiwan. This model quantifies concrete waste output as the major component of C&D waste from national C&D activities.

The data required for calculation were given by statistical bureau of Taiwan. Hsiao et al., (2002), established the model to estimate relevant values. Model by Hsiao et al., (2002) is presented as:

$$W_c = d_{cc} \cdot [\sum A_{ij} \; x \; F_{ci}] \cdot P_{cc} \qquad (9)$$

$$W_d = d_{cd} \cdot [\sum A_{ij} \cdot F_{ci}] \qquad (10)$$

WC/D = generation of waste concrete from construction/ demolition (tons); *dcc/d* = specific gravity of C&D waste concrete (1.8 tons/m^3 for construction, 2.2 tons/m^3 for demolition); *Aij* = total floor area on use permits built

(m^2); *Fci* = volume of waste per area (m^3/m^2); *Pcc* = percentage of waste concrete in construction waste (21.17 %).

Martinez Lage et al., (2010) model can be regarded as the most accurate and comprehensive. The model uses reasonable assumptions, taking account C&D waste from all activities, density of waste, detailed waste assessment data from all counties of the region, and supported by strong data for building permits from a number of governmental sources.

4. Methodology

Aveiro is located in the northwest of Portugal within the central region of the country which encompasses around 1/3 of the continental coastline (around 275 km). Aveiro is the main municipality of the Baixo Vouga sub-region (NUTS III) which is integrated within the Portuguese Central Region (NUTS II).

Aveiro city is the sub-regional centre as is also the most populated of all municipalities (72,919 inhabitants – INE, 2010). Other sub-regional major cities include Águeda, Ílhavo and Ovar. The sub-region covers an area of 1807 km² and has a total population of 394,393 inhabitants for an overall density of 218 inhabitants/km².

Minimum data needed includes the number of constructed buildings in the whole area over sufficient number of year to be able to establish correlation between year and number of building constructed.

The procedure involves the calculation for: number of buildings (construction, renovation, and demolition), distribution of activities in Aveiro, quantity per area of activities and total waste generated from 1994 to 2014.

Data considering new construction, renovation and demolition activities for Aveiro are obtained from Portuguese Statistical Bureau (INE).

Model for quantification of C&D waste in Aveiro is presented in this paper. Model presented, is focused on C&D waste quantities from construction, demolition, and renovation process which is focused on single-family housing sector.

According to the data and analysis of single-family house from Aveiro which is used as a sample, it is known that 1,155,140 kg of construction materials were used for construction. This single-family house is used as a reference in order to acquire values for C&D waste in Aveiro.

Considering construction waste, data from new construction activity are used in order to estimate quantities. In Table 1, percentages of generated C&D waste per activity are presented. It is estimated that 20 % of construction materials used for new constructions represent waste according to Table 1. Model for calculating the amount of generated construction waste is:

$$QCW_{(20\%)} = NRO \cdot RVO_{(20\%)} \qquad (11)$$

QCW - Quantity of generated construction waste,
NRO – Number of residential objects,
RVO – Referent value for object (amount of construction materials).

Table 2
Construction activities in Aveiro concerning single-family housing sector in a period 1994-2014 (INE, 1994-2014)

Activity/Year	New construction	Renovation	Demolition
1994	39	39	23
1995	118	36	11
1996	183	35	10
1997	173	24	10
1998	260	36	22
1999	278	18	21
2000	226	20	29
2001	306	19	25
2002	347	55	25
2003	340	43	5
2004	375	31	2
2005	281	43	4
2006	233	35	12
2007	229	48	26
2008	172	47	10
2009	138	27	8
2010	116	25	5
2011	104	25	4
2012	89	24	4
2013	68	20	2
2014	39	14	3

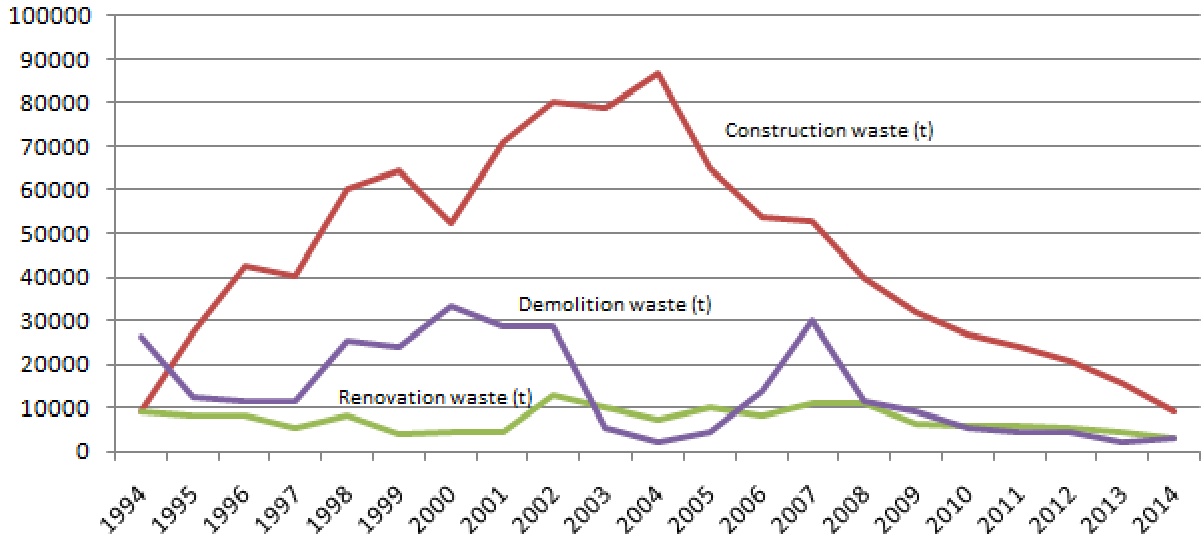

Figure 1. Amount of generated C&D waste (tonnes) in Aveiro considering single-family housing sector from 1994 until 2014 (excavation materials are not included)

It is estimated that waste derived from the process of renovation of residential objects represent equal amount as the amount of construction materials needed for reconstruction of residential objects (input=output) in this case. Analyzing current situation in Aveiro and data from Table 1, considering percentage of waste activity derived from renovation process, it is assumed that 20 % of waste is generated compared with the amount of used construction materials in the process of renovation.

Model for calculation of the amount of waste derived from the process of renovation:

$$QRW_{(20\%)} = NRO \cdot RVO_{(20\%)} \quad (12)$$

QRW – Quantity of generated waste derived from the process of renovation

Considering demolition waste in this case, it is assumed that the process of demolition is performed conventionally (with no extraction of recyclable materials), and all the waste from demolition process remains in situ.

Model for calculation of the amount of demolition waste:

$$QDW = NRO \cdot RVO \quad (13)$$

QDW – Quantity of generated demolition waste

According to the Figure 1, it is visible that construction waste has larger share in generation of C&D waste then the waste generated from the processes of renovation and demolition.

It is interrelated with the fact that in period processes of renovation or demolition in single-family sector.

5. Results

5.1. MFA Approach

Material flow analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time (Brunner et al., 2004). MFA is applied in this study and it shows yearly estimation of groups of construction materials and C&D waste from a period 2015 until 2020 in Aveiro.

In Portugal, data considering generation and treatment of construction and demolition (C&D) waste are recorded every year, and those results are presented in the "Integrated Map for Waste Registration (MIRR)" of the "Integrated Registration System developed by Portuguese Environment Agency (SIRAPA)". Considering this platform, data regarding quantities of C&D waste generation and treatment, are obtained from two sources: Portuguese statistical bureau (INE) and Portuguese Environment Agency (APA). In this case, Portuguese statistical bureau presented data between 2008 and 2013.

In the following table, results of C&D waste management in Portugal are presented. Also, in Table 2, data from two different sources in Portugal are collected (European Commission, 2016).

According to the data given by the Portuguese statistical bureau (INE) and Portuguese environmental agency (APA) concerning generated and treated C&D waste in Portugal from 2008-2013, MFA scenario for Aveiro is developed comparing the values from Table 2, representing the actual state of managing of C&D waste in this city.

This MFA scenario considers projection of generated and treated C&D waste of single-family residential sector

Table 3
C&D waste generation and treatment data 2008-2013 in Portugal (European Commission, 2016)

C&D waste (tonnes)	Source of data	Year 2008	2009	2010	2011	2012	2013
Generated	INE	2,096,475	2,146,524	2,195,128	2,522,541	1,224,861	1,746,652
	APA	-	1,647,795	-	-	-	-
Treated	INE	1,411,280	1,221,147	925,687	1,620,559	657,744	1,038,039
	APA	-	1,276,060	-	-	-	-
Recycled C&D waste	INE	250,657	299,312	362,721	851,608	429,746	845,930
Backfilled C&D waste	INE	-	-	-	-	-	-
Landfilled C&D waste	INE	1,160,102	918,843	556,310	762,068	227,288	190,158
Energy recovery	INE	522	2,993	6,656	6,883	711	1,951

Table 4
Quantities of treated C&D waste (single-family residential sector), current status of generated C&D waste in Aveiro

C&D waste fraction	Share (%)	Quantity (t)	Recycled (t)	Landfilled (t)
Minerals	92.2 %	21,140	incl.in minerals	incl. in minerals
Copper	0.35 %	80	35	45
Steel	1.5 %	343	150	193
Metal framework	0.15 %	35	incl.in minerals	incl. in minerals
Wood	3.5 %	802	353	449
Isolation materials (Foam)	0.1 %	23	incl.in minerals	incl. in minerals
Polymer material	0.1 %	23	incl.in minerals	incl. in minerals
Plastic materials	2.00 %	459	202	257
Glass	0.1 %	23	10	13
Minerals + Foam + MF + Polymer material	/	21,221	9,337	11,884

from 2015 until 2020 in Aveiro. Data given for a period 2008-2013, show that in average 44 % of C&D waste is recycled in Portugal, while 56 % is landfilled in the case of single-family residential sector.

Part of the C&D waste which is used for energy recovery represents share that is non-accountable in this case. In this MFA scenario, all fractions which are considered as C&D waste, as well as construction materials have equal share of recycling/landfilling treatment ratio in percentages, 44 % for recycling option, and 56 % for landfilling option.

Results calculated for treated C&D waste according to the data given for Portugal for a period 2008-2013 are presented in Table 3. Software STAN 2 is used as a tool in order to perform modeling for material flows of C&D waste in this case. Software STAN 2 is developed and published by the Institute for Water Quality, Resource and Waste Management of Vienna University of Technology.

5.2. LCA (Life Cycle Assesment) considering certain C&D waste materials in Aveiro

In this study, it is performed life cycle assessment (LCA), according to the international standards (ISO, 2006 a, b). One of the aims of this paper was to assess the environmental performance of C&D waste materials in Aveiro with the focus on C&D waste management where the results given from MFA are applied (Figure 2).

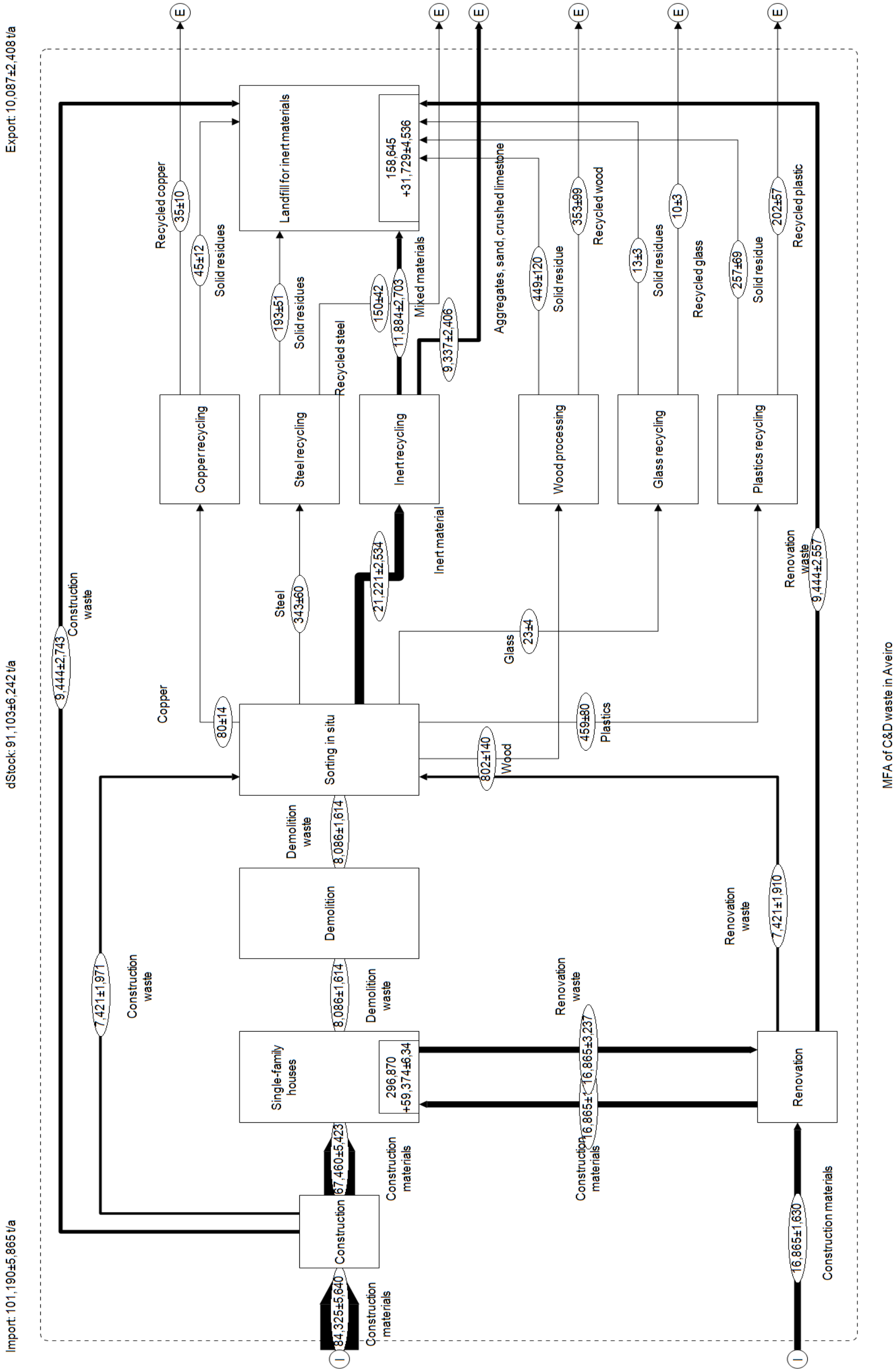

Figure 2. MFA of C&D waste management system in Aveiro (tonnes/year) from 2015 to 2020

Emissions of treatment and transport regarding different C&D waste materials are considered by applying LCA impact assessment IPPC 2013 and CML 2001. CO_2 emissions to the atmosphere and human toxicity are observed. Initial values regarding C&D waste materials were taken from the database Ecoinvent 3.2. Software openLCA is used in order to perform calculation considering environmental impact of certain C&D waste materials.

In this case, life cycle analysis is performed only for C&D waste in Aveiro, not including construction materials. In Table 5, there are presented calculated values concerning environmental impact of calculated values from MFA model in Figure 2 on a yearly level.

Table 5
Initial values of certain processes (values extracted from Ecoinvent 3.2) per 1 tonne of C&D waste treatment in Aveiro

Process	**Initial values**	
	IPCC 2013 (GWP 100a) (kg CO_2_eq)	CML 2001 (Human toxicity 100a) (kg 1.4 DCB-Eq)
Transport (Lorry 3.5-7.5 m^3)	0.525	0.127
Scrap copper (market)	0.018	0.318
Scrap steel (market)	0.015	0.08
Waste wood (market)	0.013	0.0049
Waste glass (market)	0.022	0.012
Waste plastic (market)	0.013	0.0064
Waste C&D inert fraction (market)	0.011	0.0057

Table 6
Calculated values of certain processes of C&D waste treatment in Aveiro

Process	**Calculated values**	
	IPCC 2013 (GWP 100a) (kg CO_2_eq)	CML 2001 (Human toxicity 100a) (kg 1.4 DCB-Eq)
Transport (Lorry 3.5-7.5 m^3)	3,210	776
Scrap copper (market)	6,300	11,130
Scrap steel (market)	2,250	12,000
Waste wood (market)	4,589	1,730
Waste glass (market)	220	120
Waste plastic (market)	2,626	1,293
Waste C&D inert fraction (market)	102,707	53,221

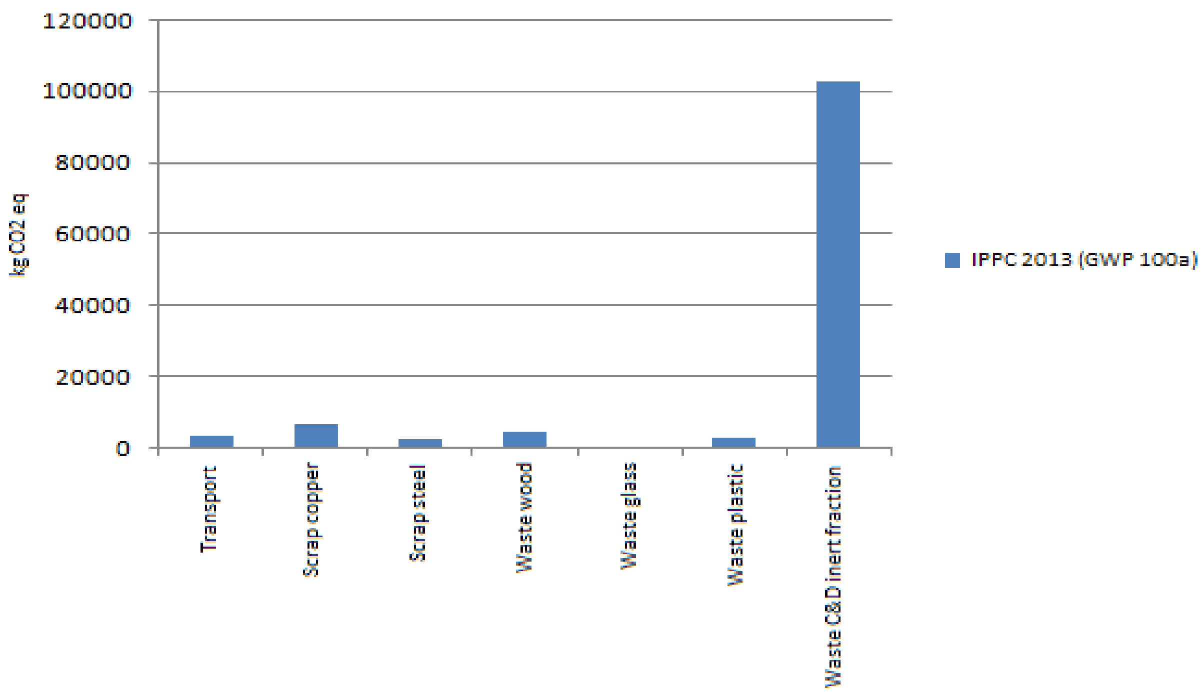

Figure 3. Impact assesment IPPC 2013 (GWP 100a) (kg CO_2 eq) according to the MFA model for C&D waste in Aveiro

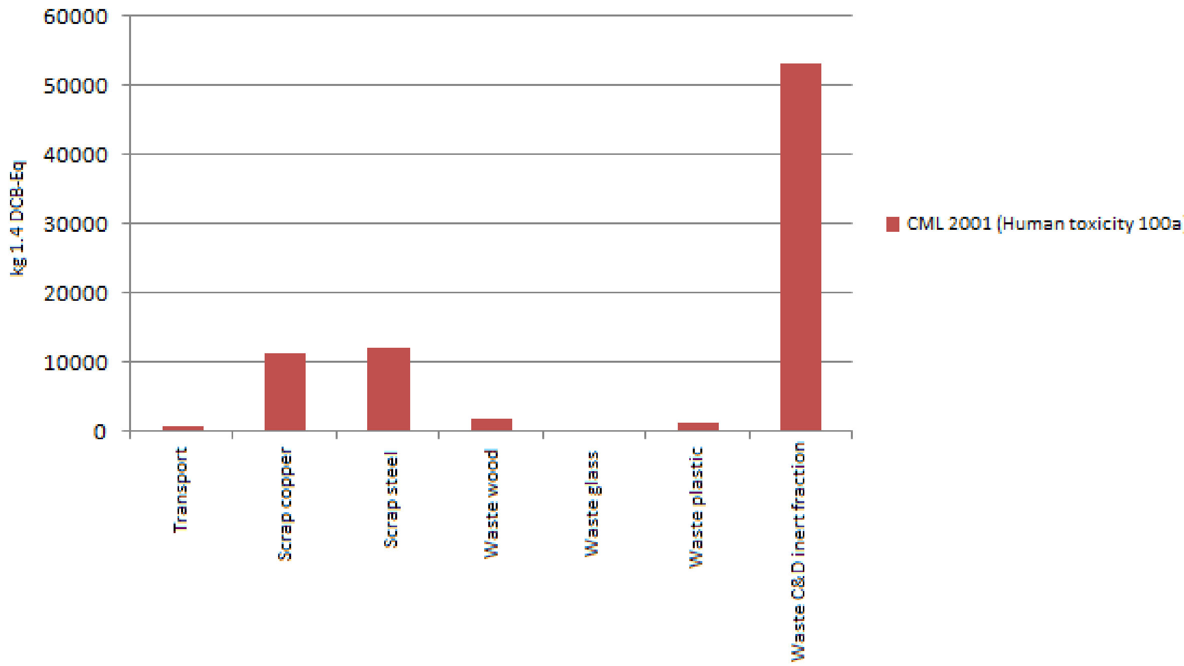

Figure 4. Impact assesment CML 2001 (Human toxicity 100a) (kg 1.4 DCB-Eq) according to the MFA model for C&D waste in Aveiro

6. Conclusion

In this paper, different methods of quantification of C&D waste are shown. It is very important to underline the fact that quantification of C&D waste is crucial in order to make proper waste management plan for a city such is Aveiro.

Life cycle assessment investigated and quantified the environmental impacts occur at the end-of-life phase of C&D waste materials in Aveiro.

The analysis included the waste from new construction, renovation and demolition process, defining and quantifying the material flows between the different processes. The estimated results to the overall environmental impact of the investigated C&D waste management in this case, show a crucial role of the recycling of different waste streams, in particular C&D inert fraction, copper and steel. The results show that C&D waste materials (inert fraction, copper, steel) with higher recycle potential could be better managed in order to reduce environmental impact in Aveiro.

In order to reduce environmental impact of different C&D waste materials, prevention, reuse, and recycling of C&D waste materials should be increased. Also, end-markets for recycled C&D waste materials are one of the crucial factors in order to increase recycling of C&D waste materials.

In order to increase recycling efficiency, state and local government should provide benefits to the recycling companies in order to correlate economical and environmental benefits.

References

Agencia Portuguese do Ambiente (APA), overtaken 2016,

Associates F., Characterization of Building-related Construction and Demolition Debris in the United States, U. S. Environmental Protection Agency, Municipal and Industrial Solid Waste Division, Office of Solid Waste, Report No. EPA530-R-98-010, 1998, 94,

Bergsdal H., Bohne R. A., Brattebø H., Projection of construction and demolition waste in Norway, Journal of Industrial Ecology, 11 (3), 2007, 27-39,

Bossink B. A. G., Brouwers H. J. H., Construction waste: quantification and source evaluation, Journal of Construction Engineering and Management, 122 (1), 1996, 55-60,

Brunner P. H., Rechberger H., Practical Handbook of Material Flow Analysis, Lewis Publishers, A CRC Press Company, Boca Raton, 2004, 318, ISBN 1-5667-0604-1,

Cochran K., Townsend T., Reinhart D., Heck H., Estimation of regional building-related C&D debris generation and composition: case study for Florida, US, Journal of Waste Management, 27 (7), 2007, 921-931,

European Comission, The EU in the world, 2016, 179, http://ec.europa.eu/eurostat/documents/3217494/7589036/KS-EX-16-001-EN-N.pdf/bcacb30c-0be9-4c2e-a06d-4b1daead493e , overtaken 2018,

European Commision, Assessment of the status, development and diversification of fisheriesdependent communities – Case study of Aveiro, 2010, 34, https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/aveiro_en.pdf , overtaken 2018

Eurostat regional year book 2011, General and regional statistics Collection: Statistical books, European Commission, Luxembourg, Publications Office of the European Union, 2011, 235, http://ec.europa.eu/eurostat/documents/3217494/5728777/KS-HA-11-001-EN.PDF, overtaken 2016,

Fatta D., Papadopoulus A., Kourmoussis F., Mentzis A., Sgourus E., Moustakas K., Loizidou M., Estimation methods for the generation of construction and demolition waste in Greece, Proceedings of the International Conference, Sustainable Waste Management and Recycling: Construction Demolition Waste, London, September 2004, 28-33, Editors: Limbachiya M. C., and Roberts J. J., Publisher: Thomas Telford, London,

Gheewala S. H., Kofoworola O. F., Estimation of construction waste generation and management in Thailand, Journal of Waste Management, 29 (2), 2009, 731-738,

Habert G., Billard C., Rossi P., Chen C., Roussel N., Cement production technology improvement compared to factor 4 objectives, Journal of Cement and Concrete Research, 40 (5), 2009, 820-826,

Hsiao T. Y., Huang Y. T., Yu Y. H., Wernick I. K., Modeling materials flow of waste concrete from construction and demolition wastes in Taiwan, Resources Policy, 28 (1-2), 2002, 39-47,

Instituto Nacional de Estatistica (INE), 1994-2014, Statistical Yearbooks 1994-2015, 1-300, https://ine.pt/xportal/xmain?xpgid=ine_main&xpid=INE, overtaken 2016,

ISO, 2006a, Environmental Management - Life Cycle Assessment-Principles and Framework, second ed.; ISO 14040; 2006-07-01; ISO: Geneva, 2006,

ISO, 2006b, Environmental Management - Life Cycle Assessment-Requirements and Guidelines, first ed.: ISO 14044; 2006-07-01; ISO: Geneva, 2006,

Jaillon L., Poon C. S., Chiang Y. H., Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong, Journal of Waste Management, 29 (1), 2009, 309-320,

Llatas C., A model for quantifying construction waste in projects according to the European waste list, Journal of Waste Management, 31 (6), 2011, 1261-1276,

Martinez Lage I., Martinez Abella F., Vazquez Herrero C., Perez Ordonez J. L., Estimation of the annual production and composition of C&D debris in Galicia, Spain, Journal of Waste Management, 30 (4), 2010, 636-645,

Ortiz O., Pasqualino J. C., Castells F., Environmental performance of construction waste: Comparing three scenariosfrom a case study in Catalonia, Spain, Waste Management, 30 (4), 646-654,

Pinto T. P., Agopayan V., Construction wastes as raw material for low-cost construction products, Sustainable construction: Proceedings of the First International Conference of CIB TG 16, Tampa, Florida, USA, November 1994, 335-342, Editors: Kibert C. J., Publisher: University of Florida, Gainesville, Fla.: Center for Construction and Environment, ISBN 0964388618,

Statistics Norway, Waste from building activities, 2004. Preliminary figures, Statistical Yearbook 2013, 63-64; 331-335, http://www.ssb.no , overtaken 2018,

Vanderley M. J., Reciclagem de resíduos na construção civil: contribuição à metodologia de pesquisa e desenvolvimento, (Tese), Universidade de São Paulo, Escola Politécnica, São Paulo, 2000, 113,

Yost P. A., Halstead J. M., A methodology for quantifying the volume of construction waste, Waste Management & Research, 14 (5), 1996, 453-461,

Yuan H., Shen L., Trend of the research on construction and demolition waste management, Journal of Waste Management, 31 (4), 2011, 670-679.

Analiza upravljanja građevinskim otpadom i otpadom od rušenja u gradu Aveiru, Portugalija

Nikola Karanović [a, #], Ana Paula Gomes [a], Nemanja Stanisavljević [b]

[a] Univerzitet u Aveiru, CESAM, Aveiro, Portugalija
[b] Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Srbija

INFORMACIJE O RADU

Primljen 06 jun 2018
Prihvaćen 13 avgust 2018

Originalni rad

Ključne reči:
Otpad
Izgradnja
Rušenje

I Z V O D

Kvantifikacija građevinskog otpada je veoma važna u kontekstu upravljanja građevinskim otpadom. Procena količina građevinskog otpada može se postići uspostavljanjem modela kvantifikacije građevinskog otpada koji se primenjuje u urbanim područjima. U ovom radu predstavljen je model kvantifikacije građevinskog otpada koji se primenjen u Aveiru. Analiza se odnosi na urbani sektor sa porodičnim tipom stanovanja. U radu su korišćeni empirijski podaci dobijeni od Portugalskog zavoda za statistiku (INE), u kojima su predstavljene sve građevinske aktivnosti i podaci koji se odnose na građevinski otpad. Procena koja se odnosi na količinu građevinskog otpada, doprinosi podacima o građevinskom otpadu, kao i podacima koji se odnose na procenu generisanja građevinskog otpada za period 2015 - 2020 u Aveiru. LCA softver se primenjuje kako bi se odredio uticaj određenih materijala iz građevinskog otpada na životnu sredinu.