Construction and demolition waste in Portugal: actual situation and future perspectives

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Abstract

In 2008, Portuguese national legislation was created to regulate construction and demolition waste (CDW). The present work intends to show how CDW management has been conducted in Portugal since then. To do so, a case study at the North Interior Region of Portugal was selected to be analyzed. The work was conducted during 2012 and the methodology involved construct sector characterization and analysis of actual CDW management practices. A survey was conducted to municipalities and construction companies, and interviews were made to private waste operators. Other entities were also invited to collaborate. The main results highlighted problems related with the integration of the several stakeholders, dissemination of legal information and legislation issues. Concerning the stakeholders' integration, it was notorious that CDW could be used often to recover old quarries and mines at the region. In terms of legal information diffusion, small construction companies do not have technical support to answer to the regulation requirements. In relation to legislation issues, companies up to 10 workers are not obligated to participate at national registration system, making difficult to quantify CDW generated by such producers. At the end, a list of proposal to help stakeholders to implement legislation and legislation improvements are suggested. The Portuguese experience can be an example of the challenges to implement and control CDW management.

Keywords: construction and demolition waste (CDW) management, survey, municipalities, construction companies, private waste operators, illegal disposal, registration.

1. Introduction

Around 850 million of tonnes (metric tons) of CDW are generated every year in European Union (EU), which represents 31% of all waste (ETC/SCP, 2009). Although the amount of CDW, the EU has not published a specific directive for this type of waste. Only the Waste Framework Directive 2008/98/EC is mentioning measures to deal with CDW. It is predicted that, by 2020, the preparing for reuse, recycling and other material recovery (including backfilling operations to substitute other materials) should be increased to a minimum of 70% by weight, excluding natural occurring material.

In Portugal, for year 2004, the amount of CDW estimated was around 11.4 million tonnes, where 5% were reused or recycled (Monier et al., 2011). Such results indicate that CDW management in Portugal was not being properly conducted, nor even respecting waste hierarchy principle. For that reason specific legislation was created to regulate CDW management since 2008. The core regulation is the law decree 46/2008 (in

Portuguese: *Decreto-Lei n.º 46/2008, de 12 de Março*) where is established the CDW management operations, like transport, storage, treatment, recovery and elimination (Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional, 2008). Who has the responsibility to manage CDW is its producer (or owner if the producer is not identifiable), but other stakeholders have also responsibility on their management. Only CDW from private construction works with license exempt is managed by municipal waste management systems, corresponding to municipalities associations where municipal solid waste presents a shared management. CDW producers/owners (the construction companies) can transfer their responsibility to private waste managers. Other legislation affecting CDW management are:

- Law decree 73/2011 (in Portuguese: *Decreto-Lei n.º 73/2011, de 17 de Junho*): transposes Waste Framework Directive 2008/98/EC, and it was also added the goal to incorporate at least 5% of recycled CDW in public construction works (Ministério do Ambiente e do Ordenamento do Território, 2011);
- Law decree 26/2010 and amendments (in Portuguese: *Decreto-Lei n.º 26/2010, de 30 de Março*): obligates the CDW owner from private construction works (with mandatory license) to keep record on CDW generated (Presidência do Conselho de Ministros, 2010);
- Law decree 18/2008 (in Portuguese: *Decreto-Lei n.º 18/2008, de 29 de Janeiro*) establishes the elaboration and implementation of a CDW prevention and management plan for all public construction works (Ministério das Obras Públicas, Transportes e Comunicações, 2008);
- Ordinance 417/2008 (in Portuguese: *Portaria n.º 417/2008, de 11 de Junho*): defines the documentation which certifies CDW transport and reception at private waste manager (Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional, 2008);
- Ordinance 335/97 (in Portuguese: *Portaria n.º 335/97, de 2 de Setembro*): regulates the transportation of CDW (Ministérios da Administração Interna, do Equipamento, do Planeamento e da Administração do Território, da Saúde e do Ambiente, 1997);
- Ordinance 209/2004 (in Portuguese: *Portaria n.º 209/2004, de 3 de Março*): transposes Decision n.º 2000/532/EC and its amendments concerning the European List of Waste (ELW) (Ministérios da Economia, da Agricultura, Desenvolvimento Rural e Pescas, da Saúde e das Cidades, Ordenamento do Território e Ambiente, 2004).

Concerning CDW reuse, the law decree 46/2008 stands that uncontaminated excavated soils and other naturally occurring material should be reused at the construction site or another construction works, in backfilling operations, sanitary landfill covering and other municipality licensed locations. CDW which cannot be reused has to be sorted at construction site to be recovered or recycled. If sorting at construction site is not possible, the producer has to deliver it to a private waste operator. Concerning CDW recycling, it is allowed to incorporate recycled CDW in construction works (just have to comply with technical norms or specifications). Landfilling is only possible after sorting (at construction site or by private waste manager) and it has to pay a tax (4.27€ per tonne) (Agência Portuguesa do Ambiente, 2013). To increasing recovery and recycling activities, a simplified licensing scheme exists.

To collect information concerning CDW generated and managed, CDW producers, private waste managers and waste management systems need to report data through the Integrated Registration System of the Portuguese Environment Agency (in Portuguese: *Agência Portuguesa do Ambiente*) electronic platform, called SIRAPA. However, if any private CDW producer has less than 10 workers it has no obligation in reporting waste.

Although the legislation is implemented since 2008, it is not known which has been the consequence in the field and the effects in how CDW is being managed. The present work intends to show how CDW management has been conducted in Portugal since the release of national legislation. To better analyze it, a case study at the North Interior Region (NIR) of Portugal was selected (Martinho et al., 2013), where the perspectives from the different stakeholders will be known, namely waste management systems and municipalities, construction companies and private waste operators. Through the analysis of the collected data, it is intended to point out suggestions to improve the environmental practices currently applied in CDW management in order to ensure a better performance. Legal requirements will also be analyzed to suggest improvements to the Portuguese CDW management.

2. Material and methods

To study CDW management in Portugal a case study was selected, the Portuguese NIR. The NIR has 15,027 km^2, with 1,100,000 inhabitants (Instituto Nacional de Estatística, 2012). The region includes 48 municipalities. The construction activity contributes to 12.5% to the total business in NIR. Between 2000 and 2010, the new construction activity is the one with more variation, having been reduced in 50%. Remodeling and demolition have been constant in this period. The construction companies represent 11.2% of all companies in the region and the average number of workers by company is only five, inducing that such companies are small and family-based.

In Portugal, the construction companies are divided in nine levels, depending on the maximum amount (in euros) of business license, which limits the construction work size (by its cost) that the construction company can conduct. Companies from level 1 are the ones which can conduct construction works up to 170,000 €, and level 9 can conduct above 17,000,000 €. In the region, the most significant companies are companies of level 1 (62%), level 2 (15%), level 3 (11%) and level 4 (6%). The rest of companies, levels 5 to 9, correspond to 6%. Companies from the higher levels are the ones which conduct licensed construction works, public or private, being smaller companies working in smaller construction works, including the ones exempted from license, and also conduct works for the bigger companies. It can also be affirmed that the bigger companies are the ones dealing with higher amounts of CDW, instead of smaller companies.

CDW management is divided in three main pillars: construction companies, who need to prevent and sort CDW at construction site; municipalities, who manage CDW from population, resulting from license exempted constructions; and private waste operators, who receive CDW from licensed construction projects.

In the area, municipalities are grouped in two municipal waste management systems, the *Resinorte*, with 35 municipalities, and Resíduos do Nordeste, with 13 municipalities, being their areas presented in Figure 1. These two waste management systems are responsible for the reception of CDW from municipalities and small construction companies (up to 10 workers). Private waste operators existing in the area conduct recycling, recovery and elimination. Concerning recovery, there are five quarries which receives CDW as backfilling material, and there is also one nonhazardous industrial waste landfill which has one cell only for inert waste. There are also other companies capable to produce recycled aggregates.

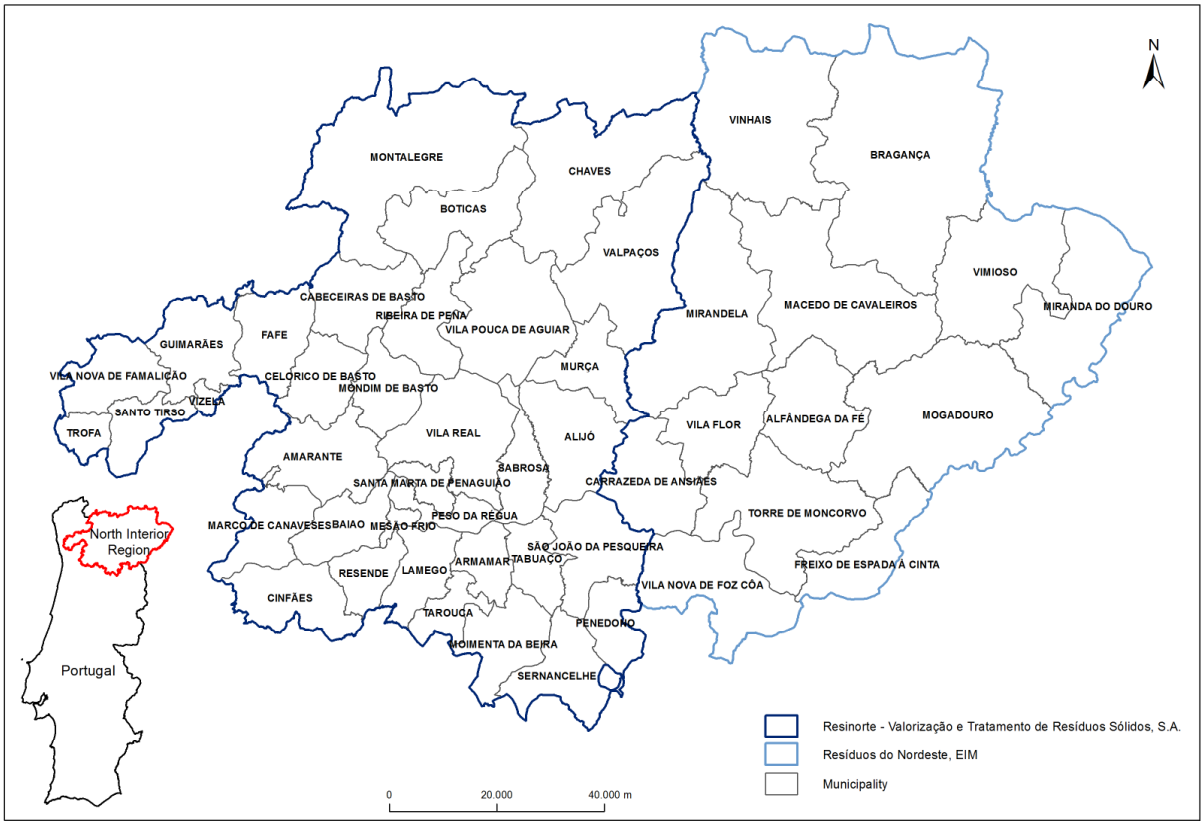

Figure 1. North Interior Region municipalities and waste management systems delimitations.

To assess CDW management and legislation a methodology was developed. The methodology was divided in two steps:

- The characterization of CDW management stakeholders: waste management systems and municipalities, construction companies and private waste operators. To conduct this step several research methods were applied, such as literature review and inquiries made to stakeholders involved in the CDW management. Concerning CDW managers, inquiries were sent to the two waste management systems and for each municipality. Both waste management systems answered to the inquiry and from municipalities only 27 answered. Concerning private waste managers, interviews were made for the companies which agreed with participating in the study, including also companies who produce recycled aggregates. Concerning CDW generators, the construction companies, it was selected a random sample from 2,208 construction companies operating in the area, which were contacted by telephone to be invited to participate in the study, being reached 306 companies. Only 39 have answered to the inquiry. In Table 1 are presented the contacts made to construction companies during the project;
- Actual situation of CDW management at NIR: data collected from Environmental Portuguese Agency and data from other sources were used to know CDW sent for recycling, recovery and landfilling.

Table 1. Contacts made to construction companies.

Levels, depending on the maximum amount (in €) allowed to participate	Number of construction companies established in the study area	Number of sampled companies	Success rate of contacts with the sampled companies			
			Answered to the survey		Did not answered to the survey	
			N.º	%	N.º	%
9	7	7	7	100.0	0	0.0
8	5	5	4	80.0	1	20.0
7	14	14	10	71.4	4	28.6
6	19	19	6	31.6	13	68.4
5	104	42	9	21.4	33	78.6
4	121	44	1	2.3	43	97.7
3	236	53	0	0.0	53	100.0
2	325	57	1	1.8	56	98.2
1	1,377	65	1	1.5	64	98.5
Total	2,208	306	39	12.7	267	87.3

3. Results and discussion

In this section will be presented the results from the assessment made to CDW sector and to stakeholders involved. The results are presented by each stakeholder analyzed.

3.1. CDW management stakeholders

The stakeholders analyzed have been construction companies, private waste managers, municipalities and waste management systems. From the analysis conducted it is notorious that stakeholders were not devoted to participate on the survey, being the exception the waste management systems. In terms of their structure, the municipalities from NIR are small, where human resources are scarce, not being primordial to answer to the inquiry. It was also noted that smaller municipalities were not informed concerning the changes in legislation and in their responsibilities. In the case of construction companies, the ones which have not answered are the smallest ones – levels 1 to 4. Again, their structure and specialized level is not enough to answer to the inquiry, being in majority reluctant in participating. Like small municipalities, small construction companies were not aware of their responsibilities concerning CDW, the classification rules, CDW transport guides or even final destinations for CDW generated during their construction works. To obtain information concerning private waste managers, interviews were made to few private waste managers like owners of CDW landfills, quarries and recycled aggregates producers.

3.1.1. Construction companies

The inquiry made to construction companies have resulted in a short number of respondents, mainly from companies of the levels 5 to 9, which are the ones generating higher amounts of CDW. These CDW generators need to handle CDW during the planning/project and construction phases.

Concerning planning/project phase, companies are dedicated to develop the CDW prevention and management plans mandatory for public construction works, waste management guidance, environmental management plans, waste management plans and construction site plans. Besides plans, also measures concerning construction methods which facilitates selective demolition, measures establish in contracts with sub-constructors concerning sorting waste in the construction site were also pointed out by respondents.

Regarding construction phase, all companies answered that some measure or action is implemented concerning CDW, being the results shown in Figure 2. The most relevant measures/actions mentioned were transportation into private waste manager, sorting at construction site, delivery of CDW into private waste manager including landfills, minimizing generation and hazardousness of CDW and reuse of uncontaminated excavated soils and other naturally occurring material.

Concerning how companies are reusing materials on site (excluding uncontaminated excavated soils) and incorporating recycled CDW, the companies mentioned that they reuse wood, cobblestone, granite / limestone, bricks, doors, railings and street furniture. Regarding recycling, companies report that the incorporation of inert material (e.g., bituminous mixtures, mixtures of inert and rocks) often occurs after physical handling of the material in landfills in the work itself, as base or sub-base pavement, in the execution of earthen floors or in accesses.

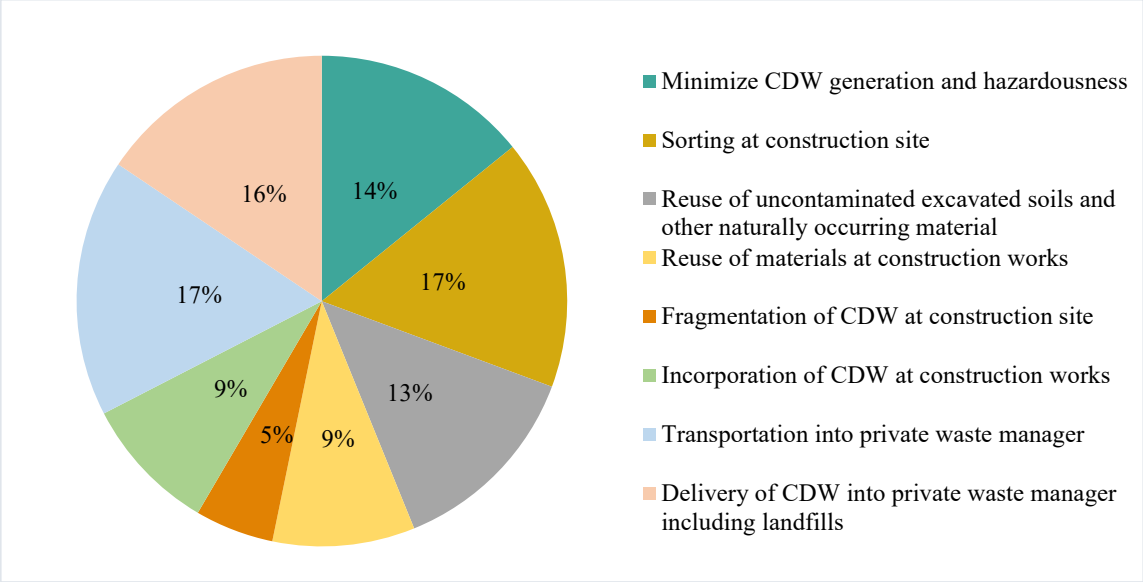

Figure 2. CDW management practices adopted by construction companies.

When asked about the costs related with the CDW operations, several companies provided data that focused mainly on the CDW management costs at construction site or mixed CDW by private waste managers, transport and sorting of the CDW. The costs provided are heterogeneous and are related to the type of the interventions, quantity generated, facilities proximity, as well to the contracts between companies and private waste managers. For sorting and packing, renting a container of 6 m^3 costs around 90 €; the fragmentation operation has a cost around 3 €/t; inert CDW and nonhazardous bituminous mixtures management costs 10 €/t; the management of bituminous mixtures containing hazardous substances costs around 115 €/t; metals management costs are normally free; mixed CDW management costs between 3 and 120 €/t; hazardous CDW management generally varies between 130 and 250 €/t; transportation costs can oscillate from 50 to 500 €/t. It is necessary to enforce that all these values are relative and dependent on the prices charged by different private operators involved in the process.

3.1.2. Private waste managers

This is the stakeholders group where legislation is more implemented. That is because these operators are already managing other types of waste, being registered at the SIRAPA, and with practice at documentation and protocols. The type of CDW received in 2010 by private waste operators is presented in Table 2.

Through contacts by phone made to the private waste operators, it was verified that the reception of CDW has decreased, a trend proportional to the slowdown of economic activity in Portugal in recent years and the consequent slowdown of the construction sector activity. Furthermore, the market is not attractive to recycled CDW, since this product cannot compete on price with virgin materials.

Table 2. CDW managed in the study area during 2010 by private waste operators.

Group [ELW]		**CDW treatment (operation R/D)**		**CDW quantification**			
				Tonnes		**% (for each ELW group)**	
Nonhazardous	ELW 17 01 (concrete, bricks, tiles and ceramics)	Disposal (D)	D1	17,268.2	17,446.5	D	90.9
			D15	178.3			
		Recovery (R)	R5	1,298.7	1,741.4	R	9.1
			R13	442.7			
		Total			**19,187.9**		**100.0**
	ELW 17 03 (bituminous mixtures)	Disposal (D)	D1	3,779.1	3,782.8	D	75.6
			D15	3.7			
		Recovery (R)	R5	934.0	1,218.6	R	24.4
			R7	262.0			
			R13	22.6			
		Total			**5,001.4**		**100.0**
	ELW 17 05 04 (soil and stones)	Disposal (D)	D1	3,767.3	3,767.3	D	97.3
		Valorização (R)	R5	103.2	103.2	R	2.7
		Total			**3,870.5**		**100.0**
	ELW 17 09 04 (mixed CDW)	Disposal (D)	D1	1,029.5	1,384.5	D	98.1
			D15	356.0			
		Recovery (R)	R13	26.5	26.5	R	1.9
		Total			**1,411.0**		**100.0**
	Others	**Total**			**6,097.1**		**100.0**
Nonhazardous		**Total**			**35,567.9**		**94.0**
Hazardous		**Total**			**2,278.2**		**6.0**
Total					**37,846.1**		**100.0**

Legend: ELW – European List of Waste (Ordinance 209/2004 - in Portuguese, Portaria n.º 209/2004, de 3 de março) / D1 - deposition into or on to land (e.g., landfill); D15 - storage pending any of the operations numbered D1 to D14 (excluding temporary storage, pending collection, on the site where the waste is produced); R5 - recycling/reclamation of other inorganic materials; R7 - Recovery of components used for pollution abatement; R13 - storage of waste pending any of the operations numbered R1 to R12 (excluding temporary storage, pending collection, on the site where the waste is produced).

In the NIR there is one landfill for inert waste and five quarries licensed to manage CDW included in their environmental recovery plans. The landfill has an estimated capacity of 800 t/year until 2020. For the quarries, an estimate was made, conducting to a value of fitting capacity between 200,000 and 220,000 t/year until 2020. However, technical elements informed by telephone that the landscape rehabilitation plans only allows the use of uncontaminated soils and rocks, although they consider being technically feasible to use inert materials to make the landscape recovery. The inert waste at these sites is being recorded mainly as a disposal operation, which explains the high percentage recorded for disposal operations in the NIR, shown in Table 2.

3.1.3. Municipalities and waste management systems

These stakeholders are related because both deals with CDW from license exempted construction works. Municipalities are near to population who conducts such kind of construction work, being the CDW delivered to waste management systems to be treated. Municipalities must have a regulation for population to know how they should deal with CDW. The municipalities in NIR have such regulation, where generic rules are presented, penalties for incorrect practices and the prohibition for illegal dumping.

Concerning the measures to implement the CDW legislation, the municipalities answered that prevention, sorting, reuse and recycling measures are applied. However, for recycled incorporation there are few municipalities which have confirmed the application of such measure. There are also municipalities who do not have municipal CDW regulation that have mentioned that CDW management measures are applied, as well as inspection actions and awareness campaigns to the population.

When municipalities were asked to describe the service provided for CDW, few municipalities have referred any kind of service available for their citizens. Only four municipalities affirmed that they have a collection and transport collection system of CDW into the recycling center, and only one mentioned that provides temporary storage of CDW, previous to be send to recycling center. The municipalities with recycling centers, which are managed by the waste management systems, are available to receive CDW. However, the owner / producer is responsible for its transportation in most cases.

In the survey there was an attempt to obtain further information on how the services mentioned may be required. The following responses were obtained: CDW delivery by the producer / owner to the nearest recycling center, entering in contact with the municipality responsible department, entering in contact with waste management system and entering in contact through e-mail or free telephone call. Only four municipalities have answered that is necessary to complete a credential to request services.

In cases of infringement, municipalities have similar procedures, like to apply penalties or suspension of constructions works, although such procedure is not included at the municipalities' regulation. Two municipalities have mentioned the penalties values applied: for a single person, a minimum value between 40 and 70 € and a maximum value up to 4,000 €; for a company the penalty is up to 40,000 €. When illegal dumping is detected, municipalities register their location. Then, they conduct several procedures to solve the environmental problem, like identification of the responsible of such dumping, contact authorities, and in cases when identification is possible penalties are applied as well mandatory cleaning of the illegal dumpsite.

Waste management systems are the entities who receive CDW from municipalities (Figure 1). The *Resíduos do Nordeste* has infrastructures to receive waste, specifically 14 recycling centers (one for each municipality, being one municipality with two), and one sanitary landfill for municipal solid waste, where CDW can be used. The municipalities inside this waste management system are lacking in terms of technology and infrastructure which could promote sorting and recovery, like a sorting plant or equipment to process inert waste. It can be expected that CDW is landfilled, without any known about sorting procedures at construction site.

The *Resinorte* waste management system has a considerable amount of municipalities, being difficult to uniform all CDW management practices. The existing infrastructures are 12 recycling centers and four sanitary landfills. CDW reception is made through recycling centers or directly by delivery into sanitary landfills. There is no sorting plant for CDW, however is made some sorting of recyclable materials, like packaging waste.

Regarding the CDW management costs, the value corresponding to the disposal in the sanitary landfill varies depending on whether is a municipality or a private entity. For a municipality, the amount range is between 30 and 34 €/t, to which is added the landfill tax. For a private entity, the value varies between 42 and 58 €/t, being added the landfill tax. Values for the CDW transportation from recycling centers to the landfill, the containers rental and transportation service available to private entities varies depending on the service provided.

Through the analysis of answer given by municipalities and waste management systems is verified that there is no clear relationship between the existence of waste management systems services and the provision of these services by municipalities. In fact it highlights a disorganized CDW management structure in the area under study from private works not subject to license, as well as works carried out by municipalities.

3.2. Actual situation of CDW management

The study developed in NIR (*Martinho et al.*, 2013) allowed the calculation for 2010 of an estimated CDW generation between 95,000 and 130,000 tonnes. These values were obtained considering two different types of data: data from SIRAPA related to licensed construction works and data from CDW generation estimated from license exempted construction works, being applied 40 and 70 $kg.inh^{-1}.year^{-1}$ CDW generation indicator obtained from Portuguese case studies.

The estimation was needed because reliable registration system is not implemented at waste management systems. Many recycling centers receive CDW without weighting and without registering their source or type of CDW. All CDW is classified as mixture. Also, it is missing appropriate CDW management solutions provided by municipalities, making population dispose CDW illegally, or dispose it at municipal waste collection containers.

Concerning CDW from licensed construction works, there is also a mismatch between amount generated and amount managed. The estimated amount of CDW generated from this source is around 50 thousands of tonnes for 2010, being the amount managed around 38 thousands of tonnes. Such discrepancy can be due to the CDW treated and recovered outside the area considered, illegal disposal, temporary storage and absence of CDW registration at SIRAPA platform.

Based on existing data and estimations made, only 12% of total CDW generated is send for recycling, 12% is send for other recovery, being eliminated 24%. The rest of CDW is expected to have an incorrect and/or unknown management. Concerning reuse there is no information compiled neither available to be analyzed. The same scenario occurs for incorporation of recycled material, and for that reason it cannot be quantified. Changes in legislation and how legislation is being implemented are needed to make NIR to comply with recycling targets, to reduce illegal disposal and incorporate CDW in construction sites.

4. Conclusion

The overall CDW management legislation published since 2008 have facilitated the organization of a national strategy to deal with this waste stream. However, after a few years of its entry into force, and based on the results of a study conducted in NIR at Portugal during the year 2012 (Martinho et al., 2013), it was found that operational and regulatory issues still exist, which need to be improved.

At the operational level, it was visible the missing of a correlation between the stakeholders and the procedures adopted in the area by institutions, for example at the level of municipal strategies. It was also noted the disinformation of many stakeholders in the CDW management process, as is the case of municipalities, but also for construction companies, especially smaller ones. It was also registered some illegal disposal of CDW at NIR.

Concerning treatment operations register, many CDW with considerable recovery potential are being classified as disposal operations, when it is understood that what is done is backfilling, with environmental benefits. This is the case of synergies with abandoned mines and quarries in landscape, during their recovery phase, in which it promotes the use of CDW. If the code attribution is not corrected at the short term, the recycling targets fulfillments can be compromised.

Concerning regulations, even after the publication of CDW legislation in 2008, there are still municipalities without updated regulations. This can lead to the difficulties and misleading of stakeholders in the implementation of practices for managing CDW.

Reporting is still needing adjustments because not all producers are required to register CDW quantities generated. Under current guidelines, also the registration of the CDW production place (e.g., municipality) is not included, what difficult the analysis of how CDW is being managed.

The application of a landfill tax for CDW has not shown to be capable to induce changes in stakeholders' behavior. Compared to the gate fees and management costs applied, the landfill tax practiced is too small to have a considerable effect in CDW recycling. However, if landfill tax is increased without affordable or free management options, the predictable effect will be the increase on illegal disposal for CDW in the area.

Given these findings, it is presented some recommendations for NIR, for Portugal or even for countries that are developing their strategists to manage RCD:

- Conduct awareness campaigns and training, with the aim of promoting behavior change, divided into two phases: the first, technically awareness and training of stakeholders in the CDW generation, management and control/registration; and second, directed to all citizens, potential producers of CDW, concerning their rights and duties;
- In terms of treatment, the inert fraction disposal on the soil, in order to carry out the environmental and landscape restoration (backfilling operation), must be recorded and accounted for as a recovery operation and not as a disposal operation;
- The CDW produced by small construction companies, employing up to 10 workers, should be accounted for, since the registration system currently is excluding them;
- The waste protocols for transportation should include the location of CDW generation, because currently the location is fulfilled with data from the head office of the construction company;
- Economic instruments that encourage the CDW recycling should be developed;
- Provide changes in SIRAPA in such way that could include reuse and incorporation of recycled material into the registration procedure;
- Update the municipalities' regulations concerning CDW, linking them with existing legislation.

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