

## ORIGINAL RESEARCH ARTICLE

# Looking forward to a sustainable city through the management mode of Construction and Demolition Waste (CDW): A case study of Barranquilla

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### ABSTRACT

**Background:** The resulting large amount of construction and demolition waste (CDW) has become a global problem. To this end, Colombia's legislation seeks to guide its proper management and promote its transformation and reuse. **Methodology:** Based on the analysis of the national and local legislation of CDW management frontier cities in Colombia, this study puts forward an alternative to the formulation of a comprehensive management plan. Based on this analysis, the conditions and characteristics of medium-sized cities such as Barranquilla are studied and analyzed in order to provide a comprehensive alternative for the management and treatment of this kind of waste. **Result:** The prevention, storage, collection, transportation, use, and final disposal aspects that should be considered in the CDW integrated management plan most suitable for Barranquilla City are determined. According to these special characteristics and conditions, a scheme of treatment plants is proposed. **Conclusion:** In view of the rapid development of Barranquilla in recent years, Barranquilla needs to quickly adjust its CDW management mode. The city recognizes that the separation of source and use is at the core of the model needed to achieve sustainable management processes. In addition, the shortcomings of the current management system are found, and combined with the application of the linear economic model, a management model based on the principle of circular economy is proposed.

**Keywords:** sustainable cities; management plan; CDW; sustainable development

## 1. Introduction

In medium-sized cities some years ago, there was no emergency demand due to the existing supply of nonrenewable raw materials, so the reuse or recycling of construction and demolition waste generated in civil engineering was not considered.

However, many studies around the world have shown that some wastes in CDW can successfully replace natural stone aggregates, thus helping to transform the construction industry into a sustainable activity. Through the use of circular economy in waste<sup>[1-5]</sup>, the goal is to keep the value of products, materials, and resources in the economy for as long as possible, and minimize the production cost of new

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materials<sup>[6]</sup>. Specifically, in Colombia, CDW has little support for the development of laws, including in Barranquilla, Medellin, and Bogota. In recent years, each city has made significant progress in implementing policies and strategies to improve the integrated management of desertification/land degradation, so as to become an environmentally sustainable city. Therefore, it has developed its own desertification/land degradation management standards. Similarly, the national government headed by the Ministry of Environment and Sustainable Development adopted Resolution 0472 of 2017, which stipulates the overall management of CDW in the country and provides guidelines for all actors involved in the proper management of CDW, including the generation, transportation, disposal, and treatment of waste for use or reuse in infrastructure projects. This is part of the theory of circular economy, which has been applied to solid waste all over the world and now aims to integrate its practice into CDW management.

On the other hand, due to inadequate treatment of desertification/land degradation in inappropriate locations (such as river basins, wastelands, parks, and urban drainage ditches)<sup>[7]</sup>, ecosystems (urban and rural) and people are seriously affected by health effects, disease vectors (flies, rats, etc.), and floods. The latter is one of the main problems facing the city of Barranquilla, where CDW is placed on rainwater collection channels or streets, washed away by rivers, and blocked on the rainwater collection grids of newly built channels<sup>[8]</sup>. Therefore, the current CDW comprehensive management model of medium-sized cities must be planned, organized, and designed according to current local and national regulations and the latest transformation and transformation technology.

The method proposed in this book to solve CDW management problems is based on the concept of circular economy and involves management measures based on good practices of circular economy (source separation, recycling, reuse, and transformation), which aim to significantly improve the social, environmental and economic problems of

the city. This goes hand in hand with the goal of “strengthening inclusive and sustainable urbanization, medium-sized urban planning, and participatory, inclusive and sustainable waste management capacity”<sup>[6]</sup>, In addition, “reducing the per capita negative environmental impacts of cities, including special attention to air quality, urban and other waste management”<sup>[6]</sup>, is contained in goal 11 to build sustainable cities and communities.

On the basis of previous studies, this paper reviews the national and local legislative framework and management process of CDW through a comparison of Barranquilla City with Bogota and Medellin.

Therefore, the strengths, weaknesses, and characteristics of the city have been identified, and a proposal for a construction and demolition waste management plan (CDW) will be proposed as a model for the sustainable management process of Barranquilla City. Therefore, the purpose of this paper is to determine the best choice of comprehensive management scheme for a sustainable medium-sized city in the process of urban expansion. Taking Barranquilla City as an example, this paper puts forward a comprehensive CDW management mode based on the principle of circular economy. It must be pointed out that in order to implement the sustainable management strategy proposed in this paper, the characteristics of Barranquilla City will be taken into account. Barranquilla City is a medium-sized city (about 1.28 billion residents). Due to its characteristics and growth in the past 10 years, it has the following characteristics: lack of ownership of CDW management by construction companies and citizens, insufficient means of transporting such waste (animal tractors), lack of environmental entities, deep-rooted civic culture, and weak management of urban administration in the field of CDW control and monitoring. Concentrating on these aspects in one analysis is an important part of the research because, on the basis of these aspects, a comprehensive model can be generated and organized according to the actual problems of the city.

## 2. Legislative framework for construction and demolition waste in Colombia

### 2.1. National background

In Colombia, Chapter 3 of the constitution deals with collective and environmental rights. Article 80 stipulates that management must be planned from the beginning to reduce the use of natural resources in order to ensure environmentally sustainable development. In 1974, it stipulated that in creating new waste knowledge and applications, “scientific and technological research should be encouraged: 1. Reintegrate solid, liquid and gaseous wastes from industrial, domestic or general human activities into natural and economic processes.”

Improve and develop new methods for the treatment, collection, storage, and final disposal of non-reusable solid, liquid, or gaseous wastes<sup>[9]</sup>.

In 1994, Resolution 541<sup>[10]</sup> was established to regulate the loading, transportation, storage, and final disposal of construction waste, define some concepts (such as materials, loose aggregates, public space, and unorganized discharge), and formulate guidelines for transportation, storage, loading, unloading and final disposal. By 1996, under Law No. 142<sup>[11]</sup>, the national government regulated the

provision of public household toilet services and handed over responsibility for collection, transportation, and final disposal to CDW generators. It also gives the entities providing cleaning services the responsibility to coordinate these activities and ensure that CDW is separated from other solid wastes during implementation and that final disposal is carried out in tailings approved by local environmental authorities. Decree No. 1505<sup>[12]</sup> provides for an integrated waste management plan that aims to carry out activities for the appropriate and effective management of municipal solid waste. At the point of updating regulations, people began to see that waste separation is the basic basis of the concept of the green economy. Decree No. 1259<sup>[13]</sup> provides for the establishment and implementation of environmental comparisons as a cultural tool for the proper management of solid waste and CDW (so far referred to as debris). The implementation of such an environmental comparison is first to prevent the negative impact of bad behavior on the environment, emphasize the impact on human health, and impose educational and economic sanctions on natural or legal persons who violate the regulations. Subsequently<sup>[14]</sup>, it attempted to integrate all existing regulatory decrees issued so far into a single regulatory body. **Table 1** summarizes the legislation (decrees and resolutions, etc.) on solid waste management and final disposal.

**Table 1.** General and specific national standards for the treatment of CDW in the cities of Bogota, Medellin and Barranquilla

Anus	National	Bogota D.C.	Medellin	Barranquilla
1974	Act No. 2811 of 1974 Decree No. 2462,			
1989	Colombia, October November 26, 1989			
1994	Resolution 541, Colombia, 14 December 1994			
1996	Colombian Decree No. 605 of 27 March 1996			
2001	Law No. 685, Colombia, 15 August 2001			
2002	Decree No. 1713, Colombia, 6 August 2002		018 agreement, Part VII, Decree No. 151	
2003	Decree No. 1505, Colombia, 6 June 2003	Resolution 556, Bogota, 7 April 2003		
2004		Decree No. 190, Bogota SDA, 22 June 2004		
2005	Decree No. 838, Colombia, 3 March 2005 Decree No. 4741, Colombia, 30 December			

Anus	National	Bogota D.C.	Medellin	Barranquilla
2005				
<b>Table 1. (Continued).</b>				
Anus	National	Bogota D.C.	Medellin	Barranquilla
2006		Decree No. 312, Bogota SDA, 15 August 2006		
2007	Resolution 1362, Colombia, 2 August 2007	Decree No. 620, Bogota SDA, 28 December 2007		
2008	Decree No. 1259, Colombia, 19 December 2008			
2009	Law No. 1333, Colombia, 21 July 2009	Agreement No. 417, Bogota, 17 December 2009	Decree No. 0440, Medellin, 30 March 2009	
2010	Decree No. 2715, Colombia, 28 July 2010		Decree No. 0874, Medellin, 24 May 2010	
2011		Resolution 1115, Bogota SDA, 26 September 2012		
2012				
2013	Decree No. 2981, 20 December 2013	Resolution 715, Bogota SDA, 30 May 2013	Decree No. 1609, Medellin, 30 July 2013	Decree No. 0860
2015	Decree No. 1076, Colombia, 26 May 2015	Resolution 932, Bogota SDA, 9 July 2015		
2016	Resolution 0472, Colombia, 28 February 2017		Circular No. 100-0017, Medellin Conare, May 5, 2017	Resolution 1482, December 2017, Barranquilla Vader
2017				

## 2.2. Bogota case

In the case of Bogota, Decree No. 190<sup>[15]</sup> recognizes the proper management of regional solid waste. Decree No. 312 of 2006<sup>[16]</sup> adopted the master plan for the integrated management of solid waste in the city, supplemented by Decree No. 620<sup>[17]</sup>, with the aim of establishing a system, including appropriate waste treatment, transportation and final disposal projects, and warning of the need to control the generation of waste. Another area that attempts to provide guidance is the tariff section, which establishes a general solid waste recycling and utilization subsystem and specifies special equipment for the storage, recycling, and utilization of waste collected in private space<sup>[17]</sup>. Later, the concept of a tailings plant, crushing plant, or tailings treatment plant appeared. Subsequently, the regional environmental secretariat SDA issued Resolution No. 2397<sup>[18]</sup>, which aims to provide technical supervision for the treatment and/or utilization of debris in Bogota, and recommends that private or public debris generation companies working in Bogota start from the research and design stage, including: use

materials from the treatment center to seek the correct utilization of waste. In 2012, Resolution 1115<sup>[19]</sup> was issued, which proposed technical and environmental guidelines for construction and demolition waste treatment and treatment activities in the capital region. It also defines the concept of waste internationally as “waste to be developed and/or treated” and as “CDW construction and demolition waste”. Resolution 715<sup>[20]</sup> was drafted to make some adjustments and clarifications to the terminology and define non-recyclable CDW construction and demolition waste, recyclable materials contaminated with hazardous waste, and materials that cannot be recycled by the state as non-recyclable CDW construction and demolition waste. By 2015, the office of the mayor of Bogotá, within the framework of its human program for Bogotá, issued a document entitled “CDW integrated management”, which is intended to serve as a guide for the development of a construction site management plan.

## 2.3. Medellin case

In 2002, by Decree No. 151<sup>[21]</sup>, a regional

environmental secretariat was established in Medellin. Subsequently, an animal-driven vehicle replacement program was launched in 2008 to prevent the illegal collection of such vehicles by CDW. In 2009, according to the conditions of the region, how to manage the regional development plan was determined through the manual on social and environmental management of projects under construction<sup>[22]</sup>. In 2013, according to the implementation of national legislation, the mayor's office of Medellin issued guidelines for social and environmental management of public infrastructure construction<sup>[23]</sup>, including waste treatment, treatment, transportation, final disposal, and disposal.

#### 2.4. Barranquilla case

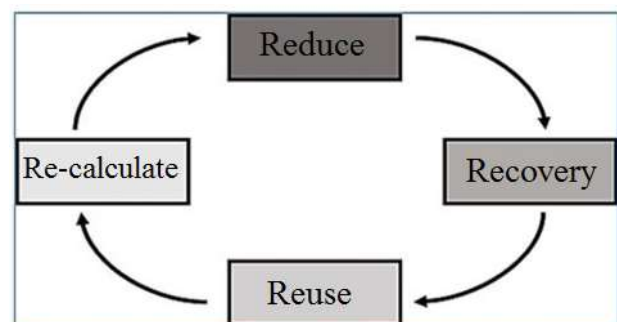
In Barranquilla, in March 2013, the regional mayor's office, through the government secretariat and the environmental police, implemented an environmental system in the city to punish natural and legal persons who committed crimes of coexistence of environment, ecosystem, and health within the jurisdiction of Barranquilla special industrial and port area through the disposal and/or management of solid waste or waste<sup>[24]</sup>. This is known as environmental comparison and was developed and implemented under Decree No. 1259<sup>[13]</sup>. In addition, transport-related activities and CDW provisions have been identified, which will be considered violations and deserve environmental comparison. 1. Encourage the transport of waste and debris in inappropriate or inappropriate environments; 2. Dumping garbage from moving or stationary motor vehicles or human or animal traction vehicles onto public roads, parks, or public areas; (3) Dumping solid waste and rubble in public places and unauthorized places; 4. Incineration of solid waste and/or debris without the control and authorization specified in the current regulations. The Municipal Environment Bureau drafted Resolution No. 1011<sup>[25]</sup>, which introduces the technology, environmental guidelines, and protocols for the management, treatment, transportation, and final disposal of CDW construction and demolition waste in Barranquilla district. In 2017, Resolution

1482<sup>[26]</sup> was issued to regulate the registration of generators and managers seeking to fully manage the CDW in the city.

### 3. CDW integrated management plan for sustainable cities: Barranquilla

#### 3.1. Barranquilla is a sustainable city

Guiding a city towards sustainability means taking waste management as the guiding principle of development and expansion methods. Its goal is to lead the comprehensive management of CDW to prevent its generation and maximize its utilization. Therefore, it is proposed to apply the concept of circular economy to the treatment of urban domestic waste, so as to shorten the life cycle of waste and realize the effective utilization of resources. As shown in **Figure 1**, the hierarchical order of properly managing CDW is: reduction, reuse, recycling and revaluation, minimizing environmental impact, and giving priority to sustainability<sup>[27]</sup>.



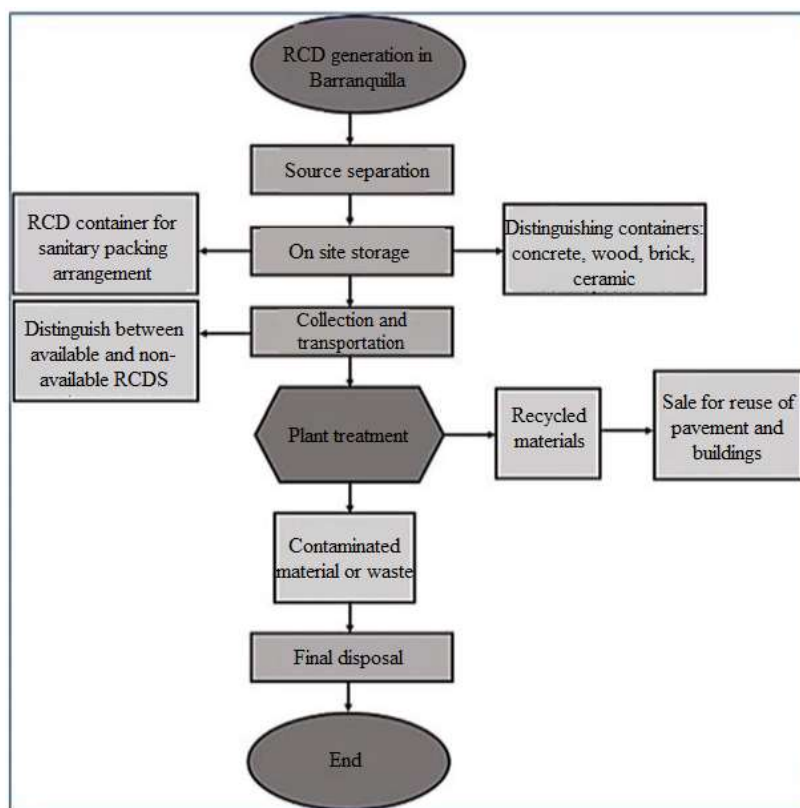
**Figure 1.** Principles of hierarchy in waste management (Barranquilla s.a.e.s.p., 2018).  
Source: Pacheco Bustos and Páez

In order to develop this part of the research, it was necessary to understand that Barranquilla has unique and differentiating aspects that make its management model suitable for certain particularities. Among these aspects are: the city's climate, the existence of only one company in charge of the collection and final disposal of the waste generated, few options of legally constituted areas for final disposal, low social appropriation of the

issue of CDW disposal at the construction site, as well as a low knowledge of the current regulations and lack of communication of the same by the environmental entities (very similar to other intermediate cities worldwide). Based on the above, an investigation was carried out and a general outline of the integrated management plan was proposed with emphasis on separation at source and treatment of collected waste (circular economy principles), which was improved as surveys were conducted with the main actors involved in the management and handling of CDW in the city of Barranquilla. Once the main characteristics of the city have been identified, the general outline of the integrated CDW management plan for Barranquilla can be proposed, based on the aforementioned hierarchy principle (**Figure 1**). Thus, once the CDW is generated at the construction site, a source separation

process must be carried out, which is based on a selective storage of the waste generated to facilitate its subsequent management: either its use or final disposal.

Therefore, it is necessary to use different containers for CDW and other separate waste containers (concrete, wood, brick, ceramics, etc.). To be arranged, because their characteristics may not be available. As shown in **Figure 2**, the collection and transportation of CDW are in progress to guide the available materials to the treatment and processing plant to produce new recycled materials. This figure shows the proposed scheme of the CDW integrated management plan for Barranquilla City. If any contaminated material appears, it shall be disposed of at a location determined by the environmental entity.



**Figure 2.** General drawing of CDW comprehensive management plan of Barranquilla City.

Source: self-compiled.

### 3.2. Prevention and reduction

In order to guide the sustainable management of urban construction and demolition waste

management, it is necessary to give priority to prevention and reduction measures on the construction site. Therefore, activities such as proper work arrangement, supply, and correct quantity

calculation may contribute to or affect the generation of waste. Keeping the workplace clean and orderly and having the equipment required to carry out activities may be the keys to minimizing waste generation and optimizing CDW production in urban engineering.

### 3.3. On site storage: Source separation

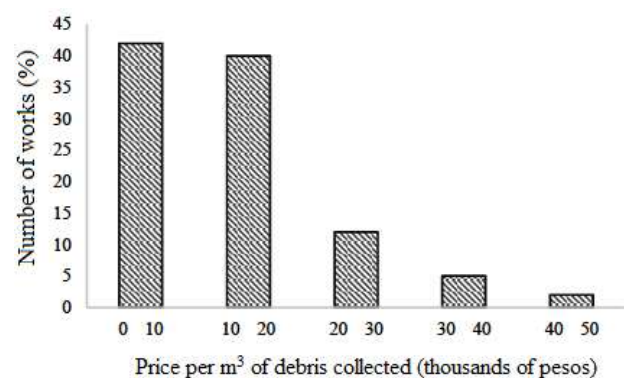
In Palanquin City, about 63% of the civil engineering projects active in the city do not separate the generated waste from the source<sup>[8]</sup>. Therefore, in order to improve the utilization rate of waste such as concrete, wood, brick, and ceramics (selected according to their applicability and product rate), it is recommended to manually separate the available and unusable materials on site. This is called source separation and is characterized by a selective collection of selected wastes by dividing them into the above two categories. Generally speaking, if CDW is found to be contaminated, dangerous, or ordinary waste, it is unusable; Otherwise, such waste can be classified as recyclable CDW and involves special treatment for recycling. In this article, it is recommended to use containers that distinguish available materials, such as concrete, wood, and organic materials, so that these materials can be collected according to the quantity produced by each material and transported to the relevant development center. Non-recyclable waste must be placed in a container called “miscellaneous”, where ordinary waste is mixed with nonhazardous waste for collection, transportation, and final disposal in sanitary landfills. Hazardous wastes shall be stored in separate containers and treated with special measures. Another option is proposed, that is, to assign different waste containers to each work by the regional administration, which is also responsible for socializing the correct method of waste separation and making the Construction Association aware of the environmental and economic benefits of using these containers in the project.

### 3.4. Collection and transportation

In terms of collection and transportation, due to

the lack of environmental awareness among construction workers, Barranquilla has an obvious problem that must be solved through a comprehensive construction and demolition waste management plan. In cities, a lot of work enables collection and transportation to be carried out by the lowest cost people, even if they are not registered as managers in urban environmental entities. In fact, a common practice is to use animal-driven vehicles for these activities<sup>[3]</sup>. In response, environmental entities must strengthen control, but they must also establish a tariff system to balance the costs of legally established management companies in the market. The comparison between the costs per cubic meter charged by the companies responsible for urban collection and consolidation directly illustrates an example of the imbalance of collection charges in Barranquilla.

In **Figure 3**, however, it should be noted that it should only be compared with private companies that have the right to collect and transport, as vehicles without logistics or regulatory costs should not carry out these activities in cities. Therefore, the collection and transportation costs of environmental entities should be assessed, and it is recommended to establish collection companies or cooperatives specializing in CDW, rather than just toilet companies as the only option. In the analysis of transportation cost per cubic meter of CDW, it is necessary to know the following quantities: materials to be recovered, materials reused in the same or other works, materials stored on legally constructed barges, and materials finally transported to the treatment process.



**Figure 3.** Barranquilla CDW collection price range.



Source: Pacheco *et al.*<sup>[8]</sup>

### 3.5. Utilize

One of the basic principles of the circular economy is to pay attention to the reuse of waste. The use of CDW is a stage to measure the possibility of extending the service life of waste, which is defined as “any activity seeking appropriate management of CDW through reuse, recycling, and revaluation to minimize the cost of final disposal”<sup>[28]</sup>. Therefore, Resolution 0472 of 2017 divides construction and demolition waste into “recyclable” and “non recyclable”. Civil works for the implementation of integrated CDW management should refer to Colombian regulations to determine the available wastes and propose reuse or revaluation alternatives to be provided for each waste.

In addition, it is recommended that regional administrations “encourage enterprises to adopt sustainable practices and include sustainability information in their reporting cycle”<sup>[6]</sup> as the goal of sustainable development goal 12 on responsible production and consumption.

### 3.6. Final disposal

With regard to the final disposal of construction and demolition waste, it is recommended to dispose of only unusable waste as far as possible, that is, hazardous or contaminated waste, ordinary, or those that cannot be utilized due to their characteristics. Like many other medium-sized cities, the current problem in Barranquilla is the lack of a treatment plant where waste can be revalued. Therefore, even CDW can be used as a substitute for aggregates such as concrete or asphalt, building ceramics, and ultimately as sanitary filler. The consequences of these practices affect not only the waste of treatable or reusable materials but also the underutilization of sanitary fillers.

## 4. Proposed treatment plant

Selection of intermediate urban treatment plants in the process of urban expansion

According to the need to deal with desertification/land degradation and drought, the treatment plant has four technical levels<sup>[2]</sup>.

**Level 1:** those who use manual handling of unwanted materials and selection of materials to be handled. It is recommended to install it at the CDW collection point in order to recover materials that are easy to recycle, treat or dispose of through a controlled arrangement.

**Level 2:** includes crushing, particle size grading, allowing immediate sale, and significantly reducing the volume of residues in sanitary fillers. It is recommended to produce proven recyclable materials in public and private works.

**Level 3:** it is conducive to the treatment of cleaning materials, such as structural concrete, track concrete, diaphragm and some selected ceramics. They are fixed type facilities, and the only problem is that the positioning point must be within the influence radius of the plant coverage, so that builders prefer recycled materials to new materials.

**Level 4:** Based on selective demolition<sup>[3]</sup> and wet classification. At this technical level, real application can only be realized before the regulation of dumping rate, recovery obligation and sales price are sufficiently attractive to the profitability of investors.

In terms of the level of treatment plant, current regulations, and the city’s current management of CDW, it is determined that the best plant to be implemented is the plant with technology level 2. These plants significantly reduce waste in sanitary fillers (concrete, wood, bricks, and ceramics) and enable them to be used in the production of new products<sup>[23]</sup>.

### 4.1. Operation process of treatment plant

After defining the floor plan, you can define whether the floor is semi-fixed or fixed. The advantage of the first method is that it can



temporarily locate gene quantitative sites (such as dismantling tracks and buildings) and move them to other CDW generation sites through the track or tire system without any unnecessary impact. On the other hand, fixed plants lack the ability to migrate to the power generation area, but they have very special characteristics, such as size, the possibility of handling heterogeneous materials, and the reduction of processing cost per ton of materials<sup>[2]</sup>. Therefore, in Barranquilla City, a fixed power plant with a superior location will achieve good results. Considering the pre-separation at the origin, the preprocessed CDW must be identified and stored in the product disposal area, which may hinder the subsequent processing steps. In these areas, CDW cleaning should also be carried out to avoid contamination by any organic matter or other attached waste, which may cause problems when reused as glass materials. In addition, magnetic separation must be carried out to obtain as many metal elements as possible to prevent them from following the grinding process<sup>[2]</sup>. Crushing shall be divided into two stages: the first stage is related to the expected number of years of CDW to be crushed, and the second stage is related to the particle size required for the final product (aggregate). During the crushing process, the materials shall be stacked in the battery and covered with surface protection to prevent air and soil pollution.

The physical, mechanical, chemical, and biological properties of the CDW to be crushed must be another aspect to be considered because, depending on its composition, CDW can be used to form new materials, asphalt mixtures, or special concrete. It is important to carefully study and understand the chemical composition of stone aggregates produced during crushing, as they may react with cement or asphalt, affecting the loss of required strength and other factors currently being studied.

One of the objectives of the management plan is to achieve the maximum utilization of CDW recovered per cubic meter. However, it is important to clarify that some of them must eventually be

treated in an appropriate manner, whether in sanitary landfills or in protected and appropriate locations.

## 4.2. General drawing of treatment plant

Figure 4 shows the overall schematic diagram of the process related to the selected alternative, which will be an ideal choice for the CDW treatment plant in Barranquilla City.

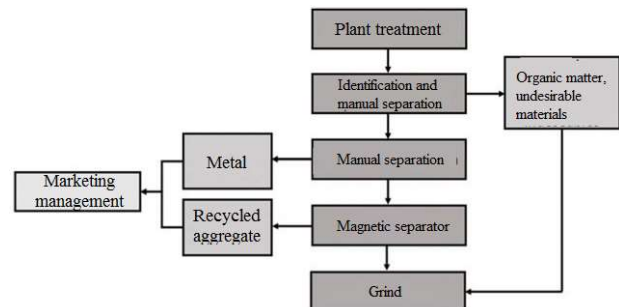


Figure 4. General drawing of Barranquilla CDW treatment plant.

Source: self-compiled.

## 5. Conclusions and recommendations

Taking Barranquilla as an example, this paper analyzes the implementation of a CDW management scheme in a medium-sized city twice. On the one hand, the current legislation of the city is analyzed and compared with the city with the most experience in such management in Colombia. In addition, according to previous studies<sup>[8]</sup>, an alternative to the management and treatment of CDW generated in Barranquilla City is provided. Therefore, this paper draws the following conclusions:

Barranquilla must begin to implement comprehensive management measures to manage CDW and follow the example of pioneering cities such as Medellin and Bogota in order to comply with existing local and national norms.

(1) Each CDW producer and/or manager shall develop and implement their own comprehensive management plan to propose specific measures for the proper disposal of waste in their respective work.

(2) Priority should be given to measures to

prevent and reduce CDW, which means a change in the environmental awareness of the Barranquilla Institute of Architecture to promote sustainability.

(3) It is important to take measures to utilize CDW with a reusable or recycling function. Therefore, the amount of waste in sanitary filler is reduced, and the service life of sanitary filler is prolonged.

(4) Source separation is the key to maximizing the use of waste generated during construction, as it can prevent pollution or mixing with waste, affecting performance for reuse or recycling.

(5) Cooperation between local authorities, such as mayors' offices, environmental policy and oversight bodies, and construction companies implementing resolution 1482/201 must be strengthened.

(6) In addition to economic benefits, the implementation of these new waste treatment technologies has also improved people's quality of life and the environment, as it has created jobs and reduced the exploitation of nonrenewable resources.

(7) In addition, after determining the scope of the document and the areas that need to be improved in Barranquilla City, the following suggestions can be made:

(8) In future studies, it is necessary to conduct an economic analysis to understand the market profitability of construction and demolition waste (such as recycled aggregate or steel) and determine the best rate for the collection, transportation, and sales of final products obtained from the treatment plant. In addition, it is recommended to conduct an economic comparative assessment of the costs incurred by the current waste management and the costs and revenues incurred by the implementation of integrated waste management measures.

(9) It is recommended to conduct a study to determine the location of the treatment plant and identify all CDW hotspots or occurrence points in the

city.

(10) It is necessary to consider different tests (physical, mechanical, chemical, and biological) to describe CDW to determine the size and capacity of crushers used in the treatment plant and the size of products to be put on the market for inclusion in the construction of roads and buildings.

(11) Finally, this paper aims to take the first step to correct and reduce improper practices in the city by implementing a comprehensive waste management plan that will ensure cultural, commercial, and political changes and provide tax incentives for the sale and recycling of stone aggregate.

Therefore, it is expected that Barranquilla will move towards sustainable development through the best management of construction and demolition waste.

## **Conflict of interest**

The authors declare no conflict of interest.

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