THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 2 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.2.02

THE IMPACT ASSESSMENT OF THE MINERAL AGGREGATES' DEPOSITS ON THE STORAGE AREA

Anca ȘERBAN, Adrian LEOPA
“Dunarea de Jos” University of Galati, Faculty of Engineering and Agronomy in Braila,
Calarasilor Street, 29, RO-810017, Braila, Romania
e-mail: adrian.leopa@ugal.ro

ABSTRACT

The construction sector is vital for our modern society such that most of the modern activities are dependent on constructions. The demographic increase and the longing of our times to better living conditions are the main exponents of unprecedented development in the construction field. The consequence of this phenomenon is the continuous growth of waste from construction and demolition. The management of these waste according to the sustainable development principles involves recycling or where not possible their storage considering the environmental tasks. This paper marks out the management of the two construction and demolition wastes, gas-formed concrete and concrete, taking account of the chemical composition of the leachate resulted from the waste drainage in the ground due to precipitation.

KEYWORDS: construction wastes, storage, soil pollution, leachate

1. Introduction

According to the report "Our common future" (Bruntland Report) issued by the World Commission on Environment and Development (WCEF) the definition of sustainable development is the following: “the sustainable development is the development that aims to meet the needs of the present without compromising the possibilities of future generations to meet their own needs” [1]. In the category "their own needs" the primary resources are also included (most of them), since these are exhaustible, even if up to the present time there have not been discovered all the existing reserves. Thus, we realize that today's generations have the moral obligation not to consume at an accelerated rate (or even run down) the primary resources presently available.

The possibility of a judicious management of primary materials is the use of waste as a secondary raw material. In support of it, the directive 2008/98 CE imposes a waste hierarchy which sets the order of waste management priorities as follows: waste prevention, preparation for reuse, recycling, recovery, and disposal. The protection of primary resources stems from the waste hierarchy as a direct advantage of recycling.

Consequently, the activity designed to protect primary resources, and which is also a principle of sustainable development is the waste recycling.

Regarding the recycling of mineral waste from construction and demolition (CD) both at national and European level, there are legislative norms regulating this domain.

At European level the Directive 2008/98 CE imposes that “by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight”.

Another important step in this direction is the EU Protocol on Building and Demolition Waste Management (EU Construction and Demolition Waste Protocol) (concluded in November 2016) which aims to increase the confidence in the CD waste management process as well as in the quality of waste generated by this field [2]. For this purpose, the structure of the protocol is based on five components, which are as follows:

- identification, source separation and waste collection;
- waste logistics;
- waste treatment;

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 2 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.2.02

- quality management;
- politics and the framework conditions [3].

2. The recycling of CD waste in European countries

In the European Union there is, at least at a legislative level, the optimum framework of a sustainable management of construction and demolition wastes.

At the European Union level, the amount of construction and demolition waste is around 20-30 of the total waste [2]. In a report made in 2008, the Umweltbundesamt (Environmental Federal Agency from Germany) estimates that 200 million tons of CD waste are generated annually at EU level (without considering the excavated soil), that is over 0.5 tons per capita. In the same context, the FEAD estimates for the same indicator a value ranging from 1.5 to 2 tons per capita [2]. According to the experts in the field, the disparities between these reports are due to differences between the definitions and reporting mechanisms as well as uneven levels of control and data reporting [2]. Therefore, a major problem in the management of construction and demolition waste is the exact estimation of the quantities collected.

This problem is also faced by Romania due to the absence of a regulated market for construction and demolition waste, and there are no recent and accurate statistical data on their management. In 2017, at the level of the Ministry of Environment, a legislative act is in the process of being prepared, concerning the management of the waste from construction and demolition waste which has as main objective the transition from a linear economy to a circular one [5].

Another objective of the European Union is the transition from a linear economy to a circular one according to which the waste will no longer be disposed of by incineration or stored but will re-enter into circulation. In this context, at the level of 2012, 5 billion tons of raw materials were consumed at the level of the 28 Member States. 80% of these were from primary resources, and the remaining 20% came from secondary raw materials, which meant a 20% recirculation rate. At the same year, 2.5 billion tons of waste were disposed of, out of which 42% was stored [6].

Even if at national level there is no centralized situation of construction and demolition waste, these waste fractions exist and the evidence of this is the statistical data regarding the construction development in Romania provided by the National Institute of Statistics. Based on these statistical data, the graphs of the monthly progress of the construction developments were represented regarding the construction objects (Figure 1) and the construction elements (Figure 2) related to the period from 2010 to 2018 [7].

Statistical data of the histogram in Figure 2 notes the following aspects:

- the volume of developments at the new constructions exceeds the reference value (year 2015) in 2010, 2011, 2012, 2015, 2016, 2017 and 2018;
- the volume of major repair developments exceeds the reference value (year 2015) only in 2013 and 2015;
- the volume of current repair and maintenance developments exceeds the reference value (year 2015) in 2011, 2013 and 2016.

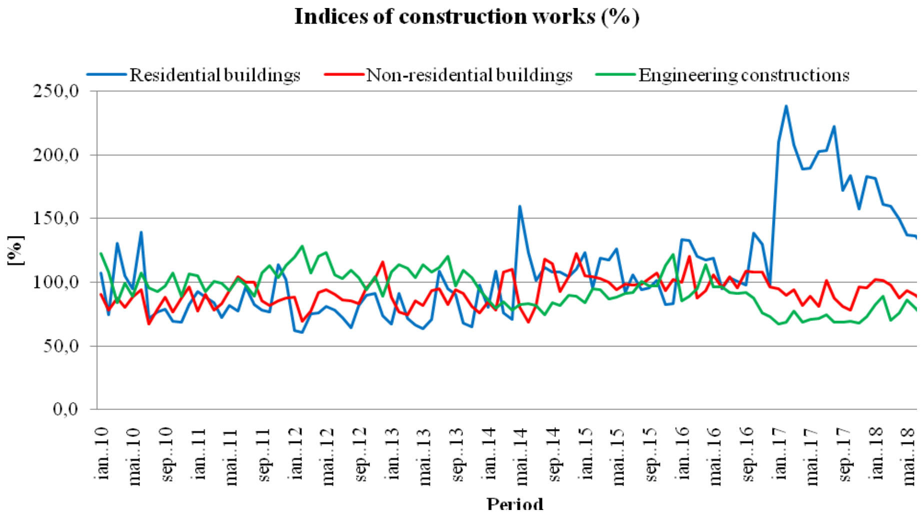

Fig. 1. *Indices of construction development (%) on construction objects; adjusted series according to the number of working days and seasonality. Stated as an index where 2015=100* [7]

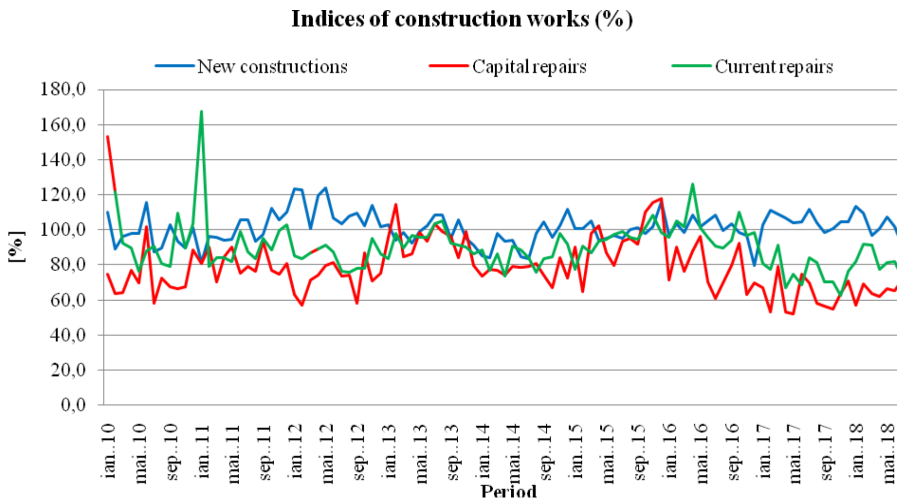

Fig. 2. *Indices of construction development (%) on construction elements; adjusted series according to the number of working days and seasonality. Stated as an index where 2015=100* [7]

The analysis of the two histograms of the evolution of construction development shows that at national level there are activities in the construction field which generate significant quantities of waste. Most of these waste fractions are disposed of in dump sites for inert waste.

3. Results

The humidity of the test materials was very low, namely 0.753 % for AAC and 0.233 % for concrete. The reaction of the eluates was moderately alkaline at the eluate from the two-stage batch leaching test (Table 3) and strongly alkaline at the eluate from one stage batch leaching test (Table 2).

The Total Dissolved Solid Materials is very high in both tests and for both materials, and yet exceeded the limit value at eluate from AAC for L/S = 2+8 L/kg. The high content of minerals is also reflected in the conductivity values, which were higher at the eluates from AAC in both tests.

The values of eluates hardness do not show an important content of calcium and magnesium salts. The calcium ions have higher concentration in the eluates from L/S = 10 L/kg for both test materials, while the magnesium ions are generally low, but recorded the highest value at AAC eluate from L/S = 2+8 L/kg.

The cations content in the eluates refers to the hydrogen carbonates HCO_3^-, chloride Cl^- and sulphate SO_4^{2-}. The hydrogen carbonates have higher values in the eluates from L/S = 10 L/kg for both test materials. The limit value of chloride is not exceeded in both cases of eluates and materials, but the value of eluate from concrete at ratio L/S = 10 L/kg is particularly remarkable. The sulphate ions are present in concentrations exceeding the limit value except for the one from the eluate from concrete at ratio L/S = 2+8 L/kg.

Table 1. *The results of eluates analysis for L/S = 10 L/kg*

Indicator and measure unit	The values for AAC eluate	The values for concrete eluate	Limit values for leachability of inert waste (Ordinance 95/2005)
Conductivity mS/cm	2.305	1.087	-
TDS mg/kg	3290	3055	4000 mg/kg
pH	9.0	11.36	-
Temporary hardness °d	1.792 °d	1.456 °d	-
HCO_3^-, mg/kg	390.4	317.2	-
Cl^-, mg/kg	132,93	453.76	800 mg/kg
SO_4^{2-}, mg/kg	3552	1248	1000 mg/kg
Ca^{2+}, mg/kg	480.09	729.4	-
Mg^{2+}, mg/kg	47.8	27.7	-

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 2 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.2.02

Table 2. *The results of eluates analysis for L/S = 2+8 L/kg*

Indicator and measure unit	The values for AAC eluate	The values for concrete eluate	Limit values for leachability of inert waste (Ordinance 95/2005)
Conductivity mS/cm	1.874	0.838	-
TDS mg/kg	5200	2140	4000 mg/kg
pH	8.25	8.11	-
Temporary hardness °d	1.764 °d	1.372 °d	-
HCO_3^-, mg/kg	277.69	147.05	-
Cl^-, mg/kg	430.35	369.75	800 mg/kg
SO_4^{2-}, mg/kg	2358.5	708.4	1000 mg/kg
Ca^{2+}, mg/kg	289.6	394.3	-
Mg^{2+}, mg/kg	127.4	12.3	-

4. Materials and Methods

In Romania, the wastes are governed by the Law 211/2011concerning the waste regime and by the HG 856/2002 concerning the waste classification and management.

To be stored and accepted in deposits, the Romanian legislation states that the wastes must meet certain chemical characteristics according to Ordinance 95/2005 The determination of the criteria of acceptance and preliminary procedures for the acceptance of waste from storage and the national list of wastes accepted in each class of waste deposit.

The first leaching test will be performed according to the standard SR EN 12457-2/2003- The waste characterization. Levigating. The conformity assessment test for granular waste and sewage sludge levigating. Part 2: One stage batch leaching test at liquid-solid ratio of 10 L/kg for material with particle size less than 4 mm.

The Romanian Ordinance 95/2005 provides for the leaching tests according to SR EN 12457/1-4:

- Part 1: L/S = 2 L/kg, particle size < 4 mm.
- Part 2: L/S = 10 L/kg, particle size < 4 mm.
- Part 3: L/S = 2 + 8 L/kg, particle size < 4 mm.
- Part 4: L/S = 10 L/kg, particle size < 10 mm.

According to the European legislation, the batch leaching test EN 12457/1-4 consists of 4 parts:

1. EN 12457-1: Performed at L/S 2 L/kg on material < 4 mm (1 step).
2. EN 12457-2: Performed at L/S 10 L/kg on material < 4 mm (1 step).
3. EN 12457-3: Performed at L/S 2 L/kg and L/S 8 L/kg on material < 4 mm (2 steps).
4. EN 12457-4: Performed at L/S 10 L/kg on material < 10 mm (1 step).

The test material 1 was the autoclaved aerated concrete (AAC) and it was part of a construction completed in 1987. The material was not exposed to the elements and was not held in inadequate conditions. The test material 2 was concrete from pavement of a country area and after being extracted from the pavement it has been kept in the same conditions as AAC (Figure 3).

(a) (b)

Fig. 3. *The test material: (a) Autoclaved Aerated Concrete AAC; (b) Concrete*

The granular material with dimensions d < 40 mm (Figure 4) derived from aggregates of AAC and concrete and was considered part 2 and 3 for the batch leaching test according to EN 12457-2 respectively EN 12457-3. The part 2 consists in one stage batch leaching test, where the liquid-solid ratio is L/S = 10 L/kg, while the part 3 consists in two stage batch leaching tests, where the liquid-solid ratio is L/S = 2 L/kg in the first step and L/S = 8 L/kg in the second step.

(a) (b)

***Fig. 4.** The test granular material with d < 40 mm: (a) Autoclaved Aerated Concrete AAC; (b) Concrete*

The single stage batch leaching tests were performed with distilled water on two types of material with particle size < 4 mm and at an L/S-ratio of 10 L/kg. The distilled water and the construction material remained in contact for 24 hours (Figure 5). At the beginning of the contact period the solution of material and distilled water was stirred for 30 minutes and left in contact for 23 more hours after which it was stirred for another 30 minutes and thus it was completed the 24-hour contact period. After the leaching test, the solutions were filtrated through a 0.45 μm filter and the resulted eluates were analysed for a wide range of parameters.

The two steps batch leaching tests were performed with distilled water on two types of material with a particle size < 4 mm and at an L/S-ratio of 2 L/kg followed by an L/S-ratio of 8 L/kg which corresponded to an accumulated L/S-ratio of 10 L/kg. In the first leaching step (L/S 2 L/kg) the contact time was 6 hours and in the second leaching step (L/S 8 L/kg) the contact time was 18 hours corresponding to a total contact time between the solid material and the leaching of 24 hours.

***Fig. 5.** The construction materials in contact for 24 hours at L/S = 10 L/kg*

In the first leaching step (L/S 2 L/kg) at the beginning of the 6-hour contact period (Figure 6) the solution was stirred for 30 minutes and left in contact for 5 more hours after which it was stirred for another 30 minutes and thus it was completed the 6-hour contact period. After the leaching test the solutions were filtrated through a 0.45 μm filter and thus resulted the eluates corresponding to the 6-hour contact time.

In the second leaching step (L/S 8 L/kg) at the beginning of the 18-hour contact period the solution was stirred for 30 minutes and left in contact for 17 more hours after which it was stirred for another 30 minutes and thus it was completed the 18-hour contact period. After the leaching test the solutions were filtrated through a 0.45 μm filter and thus resulted the eluates corresponding to the 18-hour contact time.

(a) (b)

***Fig. 6.** The construction materials in contact at L/S = 2+8 L/kg: (a) for 6 hours; (b) for 18 hours*

THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 2 - 2024, ISSN 2668-4748; e-ISSN 2668-4756
Article DOI: https://doi.org/10.35219/mms.2024.2.02

The eluates corresponding to the 6-hour contact time and 18-hour contact time were mixed and resulted the eluates for two-stage batch leaching test, which were analysed for a wide range of parameters.

The two sets of eluates were subjected to physic and chemical analysis, namely electrical conductivity, TDS (Total Dissolved Solid Materials), reaction (pH), temporary hardness, anions HCO_3^-, Cl^-, SO_4^{2-}, cations Ca^{2+}, Mg^{2+}. The analysis was carried out according to current standards, as shown in Table 3.

Table 3. *The standardized methods of analysis*

Indicator and measure unit	The analytical method
Conductivity μS/cm	potentiometric
TDS ppm	potentiometric
pH	potentiometric
Temporary hardness, ºd	titrimetric
HCO_3^-, mg/L	volumetric
Cl^-	titrimetric
SO_4^{2-}	volumetric
Ca^{2+}	titrimetric
Mg^{2+}	titrimetric

5. Conclusions

The test materials AAC and Concrete have a high Dissolved Solid Materials in eluates, but in case of AAC the two-stage batch leaching test lead to an increase with about 2000 mg/kg, while for Concrete lead to a decrease of about 900 mg/kg. Thus, in order to reduce the leaching of Dissolved Solid Materials from Concrete, the two-stage batch leaching test is appropriate.

The two-stage batch leaching test also led to the decrease of the eluates reaction (pH) for both materials, from strongly alkaline to moderately alkaline.

Although the concentration of sulphate ions is very high for both materials, the two-stage batch leaching test reduced them with about 1000 mg/kg for AAC and about 500 mg/kg for Concrete.

The HCO_3^- and Ca^{2+} ions had lower concentration in the two-stage batch leaching test. As for the Mg^{2+} ions and Cl^- ions, their concentration was lower in the two-stage batch leaching test for Concrete but was higher in the two-stage batch leaching test for AAC.

The two-stage batch leaching test was generally more beneficial for Concrete due to the decrease of all indicators value and less for AAC because the TDS indicator had a very important increase which may affect the ground of the landfill for inert waste. Thus, the leaching of solvable elements differs depending on the materials composition and their behavior in the leaching tests.

The solution for reducing the ground impact of the inert waste leachate is the three R – Reuse, Reduce, Recycle involving different methods such as reducing the CD waste by implementing installations for recovery of material fractions as close as possible to the generation source.

The future directions for research may consist in the analysis of the chemical characteristics of the test materials for different contact time and different number of leaching steps. According to these specific characteristics one can identify for which test materials the contact time and the number of leaching steps have major influence on the chemical elements' concentration in the leached amount. The topic of the study is very current and there is a great potential in terms of environmental impact evaluation. Some authors emphasize reducing the environmental impact of CD materials by reducing, recycling, incinerating with energy recovery and less by storing them on landfill.

References

[1]. *******, http://apmgl.anpm.ro/ro/dezvoltare-durabila.

[2]. *******, Policy Learning Platform, *Construction and demolition waste*, https://www.interregeurope.eu/policylearning/news/1770/construction-and-demolition-waste/.

[3]. *******. *Protocolul UE pentru gestionarea deşeurilor din construcţii şi demolări*, Septembrie 2016, http://ec.europa.eu/DocsRoom/documents/20509/attachments/1/translations/.

[4]. *******, *Service Contract on Management of Construction and Demolition Waste – SR1*, Final Report Task 2, February 2011, A project under the Framework contract ENV.G.4/FRA/2008/0112, European Commission (DG ENV), 2011.

[5]. *******, https://www.zf.ro/eveniment/reciclarea-deseurilor-din-constructii-si-demolari-in-romania-nu-exista-o-piata-totul-este-dezorganizat-unul-duce-la-groapa-altul-ascunde-16771877.

[6]. *******, *Towards a circular economy, Waste management in the EU*, STUDY Science and Technology Options Assessment, EPRS | European Parliamentary Research Service Scientific Foresight Unit (STOA) PE 581.913, http://www.europarl.europa.eu/RegData/etudes/STUD/2017/581913/EPRS_STU%282017%29581913_EN.pdf.

[7]. *******, Comunicat de presă, nr. 270, 15.10.2017, Institutul naţional de statistică din România, http://www.insse.ro/cms/ro/content/lucr%C4%83rile-de-construc%C8%9Bii-43.