



ANALYSIS OF THE USE OF CONSTRUCTION WASTE AS SOIL ACIDITY CORRECTIVE

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ABSTRACT

The construction and demolition waste (CDW) can be used as soil acidity corrective, which allow its final destination as an input of agricultural and environmental interest, beyond pollution control. This alternative of final destination makes possible the reduction on the amount of solid waste disposed in landfills, which will reduce the environmental impact and increase the useful life of the landfills. Therefore, the objective of this study was to evaluate the use of the construction waste to correct the pH of an acidic soil, typical of the southeastern region of Brazil. The CDWs used were collected in static buckets positioned next to building sites in Belo Horizonte, MG; sifted at less than 0.297 mm diameter and incorporated into an oxisol (red yellow latosol) collected on an exposed slope at Federal University of Minas Gerais (UFMG). Then, an incubation curve (after 21 days of incorporation of the waste to the soil) was performed varying the dose of the construction waste to the soil, aiming to obtain a pH x dose curve. Using logarithmic regression, the equation $\text{pH} = 0.5454 \ln(\text{Dose}) + 6.9646$ was defined as ideal to describe this relationship. Thus, for the agricultural use it will be necessary a dose of $1,71 \text{ t ha}^{-1}$, while, for pollution control, it will be necessary a dose of $46,28 \text{ t ha}^{-1}$.

Palavras-chave:

resíduos da construção civil
poluição do solo
acidez

ANÁLISE DA UTILIZAÇÃO DE RESÍDUOS DA CONSTRUÇÃO CIVIL COMO CORRETIVO DE ACIDEZ DE SOLO

RESUMO

Os resíduos da construção civil (RCCs) podem proporcionar correção da acidez dos solos e, com isso, possibilitar sua destinação final como insumo de interesse agrícola e ambiental e de controle da poluição. Essa alternativa possibilita uma diminuição na quantidade de resíduos sólidos dispostos em aterros sanitários, fazendo com que, além de diminuir o impacto ambiental, aumente a vida útil dos mesmos. Em vista disso, procurou-se avaliar o uso desse resíduo na correção do pH de um solo ácido, típico da região sudeste do Brasil, como forma de aproveitamento dos RCCs. Os RCCs utilizados neste experimento foram coletados em caçambas estáticas posicionadas próximas a obras localizadas em Belo Horizonte, MG; peneirados para separação da fração de diâmetro inferior a 0,297 mm e incorporados a amostras coletadas em um talude exposto de um Latossolo Vermelho Amarelo, no campus da Universidade Federal de Minas Gerais (UFMG). Após 21 dias de incubação das diferentes misturas de solo com doses de RCCs, foi medido o pH nas suspensões, preparadas com água do material das misturas, sendo obtida a curva pH x dose do resíduo misturada. Por regressão logarítmica, foi ajustada a equação $\text{pH} = 0,5454 \ln(\text{Dose}) + 6,9646$ para estimativa da dose de RCCs, para obtenção de um valor pretendido de pH no solo. Para o aproveitamento agrícola, recomenda-se a aplicação de uma dose de RCC de $1,71 \text{ t ha}^{-1}$, enquanto para fins de controle da poluição ambiental, a dose recomendada é de $46,28 \text{ t ha}^{-1}$.

INTRODUCTION

According to Law 12.305 / 2010, which instituted the National Solid Waste Policy - PNRS (BRAZIL, 2010), solid waste corresponds to discarded materials, substances, objects or goods resulting from human activities in society, whose final destination is, proposes to proceed or is obliged to proceed, in solid or semi-solid states, as well as gases contained in containers and liquids whose particularities make their release into the public sewer network or into bodies of water unfeasible, or require technical solutions for this or economically unviable due to the best available technology.

Construction and demolition wastes (CDW), according to the PNRS, correspond to those residues resulting from the construction, renovation, repair and demolition of civil construction works, including those resulting from the preparation and excavation of land for civil works. Such wastes will be the focus of studies in this work, as they represent 50 to 70% of the mass of solid urban waste in Brazil (BRASIL, 2011), besides being, many times, discarded in an irregular way. Irregular discharges have been made in depressions in the terrain, lowland areas and, especially at the margins of water bodies, bringing several problems in terms of contamination of flora, fauna, soil and water, beyond changing the landscape harmony.

ABNT / NBR 10.004 / 2004 presents the classification of solid waste, being divided into classes, which can be dangerous or non-dangerous. Among the non-dangerous are included inert and non-inert. CDWs can be classified as non-hazardous and non-inert (class II - A), because, although they are not dangerous, they may have solubilizable constituents, assigned programs exceed water potability standards when they come into dynamic or static contact with distilled or deionized water. These characteristics of CDWs, especially with regard to their non-hazardous nature, demonstrate that they can present less demanding treatment and disposal solutions than most other solid wastes, which facilitates the use of alternative methods of their final disposal.

Acidification is a natural process in Brazilian agricultural soils, occurring mainly due to the leaching of salts and the entry of acid rain water in this médium. This process can result in a decrease in the amount of available nutrients essential for the ideal growth of various plant species (RITCHEY, 1980). According to CFSEMG (1999), the ideal pH for an agricultural soil is 5.5-6.0, and should not exceed 6.5.

Soil pH directly influences heavy metal retention, adsorption and precipitation. Since pH 8.3 is the maximum value obtained when adding lime to the soil, it can be taken as a reference for the maximum dose to be applied, with the purpose of changing the pH of the soil (MATOS *et al.*, 1999; MATOS *et al.*, 2000).

The objective of this study was to verify the possibility of beneficial final destination for the CDWs, failing to lead them entirely to landfills. This purpose can provide an increase in useful life of a solid waste disposal landfill, beyond decreasing the costs of this service.

MATERIAL AND METHODS

The effect of CDW incorporation on soil pH, in a soil typical of the southeastern region of Brazil was evaluated to verify the possibility of using such waste as a corrective to the soil acidity. The CDWs sample was obtained from stationary buckets positioned close to building sites in Belo Horizonte, MG. From this material, the smallest material was selected visually, consisting mainly of concrete and ceramics.

Samples of the Red-Yellow Latosol used in this study were collected on a slope of the Federal University of Minas Gerais (UFMG). This area was chosen for collection, as it is a site dominated by highly weathered soil and naturally acidic characteristics, which would provide an interesting evaluation of the influence of the dose of CDWs on its pH. The physical, chemical and physicochemical characteristics of the sample collected in horizon A (0-20 cm surface layer) of this Red-Yellow Latosol used in the present study are shown in Table 1.

a) Determination of the granulometry of construction solid waste (CDWs)

The collected CDW samples were separated by granulometry, using ABNT # 10 (2.00 mm), # 20 (0.84 mm) and # 50 sieves. (0.297 mm). After 5 successive sieves of 200 g samples, the average granulometric distribution of the CDWs was obtained, according to the separation sieves mentioned (Table 2). Considering that, the finer the material, the greater its specific surface and exposure to reactions with the medium, a classification

called Relative Efficiency (ER) typical of each granulometric fraction was established (MATOS, 2014). Thus, the weighted average was obtained considering the participation, in terms of mass, of each granulometric range, to obtain the RE of the evaluated material (ERm).

In Table 2 we can observe that approximately 13% of the collected material passed through the # 50 sieve, which means that it consists of particles with a diameter less than 0.297 mm and fully reactive. As this granulometric fraction shows

Table 1. Physical, chemical and physicochemical characterization of the Red-Yellow Latosol collected at the Federal University of Minas Gerais and used in this experiment

Attributes	Value
Coarse sand (g g ⁻¹)	29.3
Fine sand (g g ⁻¹)	3.8
Silte (g g ⁻¹)	15.9
Silt (g g ⁻¹)	51.0
pH in H ₂ O	6.2
pH in KCl	4.22
P (mg dm ⁻³)	< 0.1
K ⁺ (mg dm ⁻³)	7.0
Ca ⁺² (cmol _c dm ⁻³)	2.59
Mg ⁺² (cmol _c dm ⁻³)	0.06
Al ⁺³ (cmol _c dm ⁻³)	< 0.1
H + Al (cmol _c dm ⁻³)	1.8
Mn (mg dm ⁻³)	5.54
Zn (mg dm ⁻³)	0.27
Total Fe (mg dm ⁻³)	5.54
Cu (mg dm ⁻³)	0.30
Total Nitrogen (mg kg)	458
Sum of Exchangeable Bases (cmol _c dm ⁻³)	2.67
Effective CTC (cmol _c dm ⁻³)	2.67
CTC at pH 7.0 (cmol _c dm ⁻³)	4.47
Base Saturation index (%)	59.7
Aluminum Saturation index (%)	0.0
Organic Matter (dag kg ⁻¹)	0.78
Remaining Phosphorus (mg L ⁻¹)	2.5
Organic Carbon (dag kg ⁻¹)	0.45

Source: Schlosser (2017).

Table 2. Particle size distribution and relative efficiency (RE) of the material collected from CDW

Sieve mesh opening (mm)	Mass (g)	Accumulated mass (g)	% Accumulated	RE (%)
> 2.00	71.6	71.6	36%	0
> 0.84	45.4	117.0	59%	20
> 0.297	57.2	174.2	87%	60
< 0.297	25.8	200.0	100%	100

100% effective reactivity and, in this research, the focus was to evaluate the effects of its incorporation into the soil in a very short term, to obtain the pH curve as a function of the CDW dose, only the fine fraction (< 0.297 mm) was used.

b) Assay Methodology

The CDW dose was varied, using its finer particle size fraction that was mixed with the samples of Red-Yellow Latosol, following the method presented by Matos (2015), in order to obtain a pH x CDW dose curve.

According to the aforementioned method, six samples of 0.5 liter of soil were used, passing through a # 10 sieve, which means, with aggregates with a diameter less than 2.00 mm. These samples were placed in individual plastic bags where they were mixed with 0 g, 6.25 g, 12.5 g, 25.0 g, 50.0 g and 100.0 g of CDW passed through # 50 sieve. After adding the CDW, the material contained in the plastic bags was stirred in order to obtain homogenization of the mixture. No repetitions were performed, considering that, in this type of soil test, a curve is generated and, traditionally, repetitions are not required.

In all plastic bags containing the different soil-CDW mixtures, 125 mL of distilled water were added, and the material was subsequently homogenized again to distribute the water in the mass. A volume of 10 cm³ of material was collected and placed in a 50 mL container and then 25 mL of water were added. After mixing, the suspension remained at rest for decanting for 30 minutes. Then, the peagameter electrode was inserted to measure

the pH in the suspension, characterizing the initial condition of the reactive process (MATOS, 2012).

The mixture was exposed to the environment (fully opened plastic bags), on a bench and in laboratory conditions, for 21 days, when the pH measurement was performed again, as previously described.

The pH x dose of CDW data pair made it possible to obtain the incubation curve (Figure 1). As already discussed, the value of 6.5 was considered as the maximum to provide adequate conditions, in terms of pH for agricultural soil and 8.3 for pollution control purposes, such as heavy metals. Thus, the CDW doses were estimated to obtain one and another final destination in the soil according to Equation 1.

$$\text{Application dose} = \frac{\text{Dose} \times V_s}{V} \quad (1)$$

Where, Application Dose is the dose of CDW to be applied per hectare of soil; Dose is the dose of CDW in the soil sample; V_s is the volume of soil contained in 1 hectare of area, considering 0.2 m of depth (2.0×10^6 L); and V is the volume of soil used in the experiment (0.5 L).

RESULTS AND DISCUSSION

The curve with its respective adjusted equation to estimate the necessary CDW dose to reach the soil pH suitable for agricultural purposes and for pollution control is shown in Figure 1.

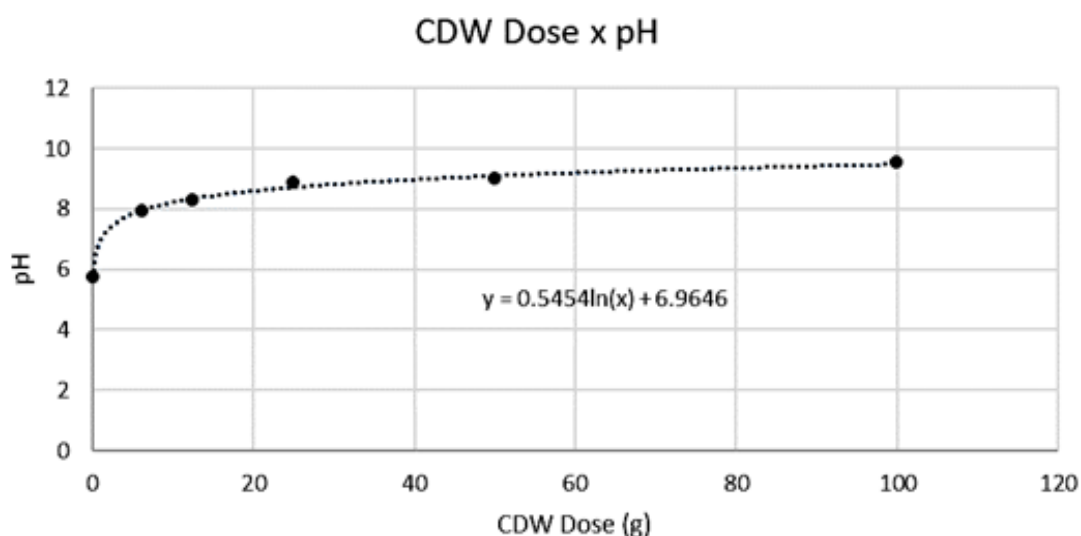


Figure 1. Graph showing the curve of pH x dose of CDW incorporated into the soil

Having adjusted the equation $pH = 0.5454 \ln(\text{Dose}) + 6.9646$ as the most appropriate (highest determination coefficient, which was 53.7%), the CDW dose of 1.71 t ha⁻¹ was estimated being able of raising the soil pH up to 6.5, considering an incorporation depth of 0.20 m. However, for the purpose of controlling environmental pollution, as in the case of an interest in creating of a “chemical barrier” below the compacted layer of a landfill or a waste dump, a dose of 46.28 t ha⁻¹ would be necessary to obtain pH 8.3, which is the maximum that can be achieved with the addition of this waste.

Based on the data presented in Table 2, it was possible to calculate, by weighted average, the Relative Efficiency of the evaluated material (ERm), whose value was corresponding to 34.4%. This result is indicative of the relatively low reactivity of the evaluated material, which is due to its coarse granulometry and, therefore, less ability to neutralize acidity in a very short time. For greater reactivity of the material, it becomes necessary that the raw material be subjected to an efficient grinding process, when it is treated before its final disposal in the soil.

Thus, we can verify that small doses of CDW are sufficient to raise the pH of agricultural soil such as the studied Oxisol. However, higher doses are required for the prevention or control of soil pollution. Although the dose of agricultural use is lower, it is estimated that its demand and application is higher. Therefore, we must consider making this sieved residue available to rural producers in areas surrounding the cities, minimizing the costs of transport.

CONCLUSION

- Considering the CDW application as an acidity corrective for an acidic soil, aiming its agricultural use, it is recommended to apply 1.71 t ha⁻¹; in the case of its application in areas where it is necessary to pollution control, the recommended dose is 46.28 t ha⁻¹.
- The CDWs showed great potential to be used as a soil acidity corrective, since they provided a considerable increase in soil pH, even when applied in low doses. Based on the results obtained, the final destination of CDW in the soil is foreseen, either for agricultural purposes or pollution control, an important technical and

environmental alternative for the beneficial use of CDWs.

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