Technical feasibility of the incorporation of rice husk ash, sludge from water treatment plant and wood ash in clay for ceramic coating

Viabilidade Técnica na Incorporação de Cinza de Casca de Arroz, Lodo de Estação de Tratamento de Água e Cinza de Lenha em Massa Cerâmica para Revestimento

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Abstract

This paper presents a technical feasibility analysis of the incorporation of Rice Husk Ash (RHA), Sludge from Water Treatment Station (SWTS) and Wood Ash (WA) in clay for the mass used in ceramic coating. The methodology involved analyzing the technological properties of various compositions. Samples were prepared for pressing, with compositions from 0 to 50% waste and 50 to 100% clay. The sintering was carried out in a muffle furnace. The properties studied were: solubility and leaching (environmental characterization), water absorption and rupture strength modulus. It was concluded that the best condition was the use of up to 25% of the residuals at temperatures of 1000 °C, 1100 °C and 1150 °C.

Keywords: wood ash, rice husk ash, sludge from water treatment, ceramic coating

Resumo

Este trabalho tem como objetivo a análise da viabilidade técnica na incorporação de Cinza de Casca de Arroz (CCA), Lodo de Estação de Tratamento de Água (LETA) e Cinza de Lenha (CL) para massa cerâmica utilizada para cerâmica de revestimento. A metodologia consistiu na análise das propriedades tecnológicas de várias composições. Foram confeccionados corpos-de-prova por prensagem, com composições de 0 a 50% de resíduo e 50 a 100% de argila. A queima foi feita em forno tipo mufla. As propriedades analisadas foram solubilidade e lixiviação (caracterização ambiental), absorção de água e módulo de ruptura a flexão. Como resultados, concluiu-se ser viável a utilização de até 25% dos resíduos nas temperaturas de 1000°C, 1100°C e 1150°C.

Palavras Chave: *cinza de lenha, cinza de casca de arroz, lodo de estação de tratamento de água, cerâmica de revestimento.*

1. Introduction

Preoccupation with environmental impacts related to the lack of adequate solutions for industrial residuals has stimulated researchers to seek feasible uses for these residuals in the production of material for civil construction. Residual recycling contributes to a better environment and economizes prime material.

According to MEDEIROS; SPOSTO et al (2010), the incorporation of residues in new products can be transformed into new opportunities, if their good performance is proven. As examples, cited can be the use of chamotte, glass, rock dust, wood ash and rice husk ash incorporated in the ceramic mass for blocks.

In this work, three types of residues as an additive to ceramic mass were investigated for the production of ceramic coating. The residues studied were: rice husk ash (RHA), sludge from water treatment station (SWTS) and wood ash (WA), see Figure 1.

Figure 1
a) rice husk ash;
b) buckets with sludge from water treatment station;
c) wood ash from a ceramic industry.

Regarding estimates for the generation of these residues: for the RHA, IBGE (2009) lists a production of 13 million tons annually, a volume of around 20%; for the SWTS, Cordeiro (1999) states that around 2.000 tons/daily of untreated sludge are launched in waterways; and for the WA, Borlini (2005) states a monthly generation of approximately 300 tons in Campos dos Goytacazes, a city situated in the northern part of the State of Rio de Janeiro.

This article has the objective of presenting the analyses performed regarding the use of the RHA, SWTS and WA residuals for ceramic coatings. The following properties were determined: solubility, leaching, water absorption (WAbs) and bending rupture module (BRM), according to the scheme proposed by MEDEIROS; SPOSTO et all (2010), using experimental design and optimization techniques to evaluate the simultaneous effects of the characteristics, clay content, and residuals on the properties of the compositions destined for red ceramic.

For the analyses, used was the Brazilian standard ABNT NBR 1004 (2009), which considers as Class I, residuals that are dangerous and as Classes IIa and IIb, residuals that are not inert and inert, respectively.

2. Materials and methods

2.1 - Residual leaching

The leaching process consists in separating certain substances contained in the industrial residuals by means of washing or percolation processes. For the results presented herein, the samples were screened through an ABNT N° 200 (0.074mm) sieve and later submitted to tests according to the ABNT NBR 10005:2004 standard.

The chemical analysis of the solution was performed in an atomic absorption spectrophotometer.

2.2 - Residual solubilization

The solubilizing process involves adding deionized or distilled water to the residual, followed by agitation and filtration.

Once again, the residual samples were screened in an ABNT N° 200 (0.074mm) sieve and afterwards submitted to tests according to the ABNT NBR 10006:2004 standard.

The chemical analysis of the solution was performed in an atomic absorption spectrophotometer.

2.3 - Water absorption (WAbs) and bending rupture module (BRM)

After sintering, the samples were submitted to tests to determine water absorption (WAbs). Their results were obtained from the arithmetic averages of three replicates with their respective deviation standards. Afterwards, the values were compared with the results obtained by Souza Santos (1992) and those established by ABNT NBR 13818 (1997).

The bending resistance tests were performed in a universal SHIMADZU model AG-X50 machine. The results were obtained from the arithmetic averages of three replicates with their respective standard deviations.

The mechanical properties were determined in the Ceramic Laboratory of the Federal University of Campina Grande (UFCG). The technological tests referring to WAbs and BRM were performed according to the scheme proposed by Souza Santos (1992).

The samples were molded into prismatic blades with dimensions of 6.0 cm x 2.0 cm x 0.5 cm, by uniaxial pressing in a SCHWING SIWA press at 27.0 MPa. Then, they were dried in an oven at 110°C for 24 hours and later sintered at temperatures of 1000°C, 1100°C and 1150°C with a heating rate of 10°C/min and a burning time of 30 minutes. Cooling was done naturally during the night.

The tests were performed in the Ceramic Laboratory of the Federal University of Campina Grande (UFCG).

3. Results and Discussion

3.1. Residual leaching

Table 1 displays the leaching test results of the studied residuals performed in accordance with the Brazilian standards ABNT NBR 10004 and NBR 10005 (2004). Observing the values in Table 1, it can be concluded that the residuals are not dangerous and pertain to Class I.

Solubility tests were performed to determine their classification.

Analyzed Parameters (mg/L)	Leachate Concentrations (mg/L)			NBR 10004 Maximum Limit (mg/L)
	CCA	ETA	Lenha	
Nickel	< 0,10	< 0,10	0,12	25 [3]
Iron	0,30	0,21	0,18	30 [2]
Aluminum	2,34	< 0,10	< 0,10	20 [2]
Copper	< 0,10	< 0,10	0,11	200 [2]
Cobalt	< 0,10	< 0,10	0,39	5 [3]
Chromium	< 0,10	< 0,10	0,39	5,0 [1]
Cadmium	< 0,05	0,22	< 0,05	0,5 [1]
Zinc	< 0,10	0,19	< 0,10	500 [2]
Manganese	< 0,10	3,91	< 0,10	10 [2]
Sodium	67,1	652	229	20000 [2]
Lead	< 0,10	< 0,10	0,21	1,0 [1]
Barium	< 1,00	-	< 1,00	70,0 [1]

Table 1
Residual leaching test resulst

Sources: ABNT NBR 10004 (2004) [1]; Ruling 518 MS: Potability Standards (value multiplied by 100) [2]; Resolution 357 CONAMA, 2005 (value multiplied by 100) [3]

3.2 - Residual solubility

Table 2 presents the results of the residual solubility tests in accordance with the methods established by the standards ABNT NBR 10004 and ABNT NBR 10006 (2004).

When observing the values given in Table 2, it can be verified that RHA was classified as Class IIa (not inert) with values for sodium and manganese above the maximum limit. The SWTS was also classified as Class IIa (not inert), with the iron, chromium, cadmium and manganese and lead values above the maximum limit.

The WA was classified as Class IIa (not inert) with the values of the chromium, cadmium, and lead above the maximum limit.

Analyzed Parameters (mg/L)	Soluble Concentration (mg/L)			NBR 10004
	CCA	ETA	Lenha	Maximum Limit (mg/L)
Nickel	< 0,10	< 0,10	< 0,10	-
Iron	< 0,10	1,92	< 0,10	0,3*
Aluminum	< 0,10	< 0,10	< 0,10	0,2*
Copper	< 0,10	< 0,10	< 0,10	2,0*
Cobolt	< 0,10	< 0,10	< 0,10	-
Chromium	< 0,10	< 0,10	0,16	0,05*
Cadmium	< 0,05	0,05	< 0,05	0,005*
Zinc	0,50	0,14	< 0,10	5,0*
Manganese	3,34	1,50	< 0,10	0,1
Sodium	576	67,0	99,1	200,0*
Lead	< 0,10	< 0,10	0,11	0,01*
Barium	-	< 1,00	-	0,7*

Table 2
Residual solubility test results
Source * ABNT NBR 10004 (2004).

3.3 - Absorption

Table 3 presents the results for the physical-mechanical properties of the ceramic samples with dimensions 6.0 cm x 2.0 cm x 0.5 cm, containing residuals of RHA, SWTS and WA, molded by pressing after drying at 110°C and sintered at temperatures of 1000°C, 1100°C and 1150°C.

The following compostions were used:

a) A: 95% clay and 5% SWTS;
b) B: 75% clay and 25% WA; and
c) C: 83.33% clay, 8.33 WA, and 8,33% RHA.

The maximum WAbs value was 18% (mass incorporated with 25% WA at 1000°C), while the minimum BRM value was 8.81 MPa (mass incorporated with 25% WA 1000°C).

Composição	Temperatura (°C)	AA (%)	MRF (MPa)
A	1000	10,20	20,45
	1100	0,90	30,31
	1150	0,07	30,55
B	1000	18,00	8,81
	1100	17,32	9,49
	1150	12,05	11,05
C	1000	13,54	13,74
	1100	4,69	16,24
	1150	1,72	18,95

Table 3
Physical-mechanical properties of the ceramic samples after being press molded

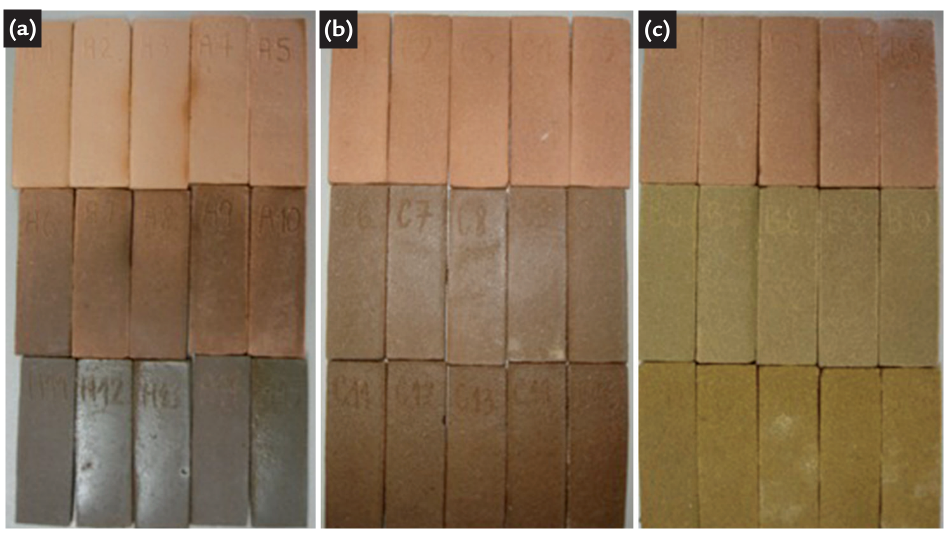

Figura 2
Visual aspects of compositions A, B and C for temperatures of 1000°C, 1100°C and 1150°C.

Comparing the values of the physical-mechanical properties with the ABNT NBR 13818 (1997) specifications previously presented in Table 3, it was verified that: for Composition A at a temperature of 1000°C and Composition C at a temperature of 1100°C, the ceramic samples were classified as porous material (Group BIII) because they presented water absorption values inferior to 20% and a bending rupture module between 15 MPa and 20 MPa. For the temperatures of 1100°C and 1150°C, the classification obtained for the ceramic samples of Compostion A was stoneware (Group BIb) because the water absorption values were inferior to 3% and the bending rupture module was between 30 MPa and 45 MPa. Composition C at a temperature of 1150°C was classified as a semi-porous material (Group BIIb) because it presented water absorption values inferior to 10% and a bending rupture module between 18 MPa and 22 MPa.

Figure 2 presents the visual aspects of the compositions utilized.

4. Conclusions

The results obtained display the importance of feasibility studies about incorporating residuals in ceramic mass so that the compositions obtained have satisfactory mechanical behavior and are in accordance with the specifications actually required for the production of ceramic coatings.

In regards to the environmental analysis, it can be concluded that RHA, SWTW and WA were classified as Classe II A (Not Inert).

The compositions that presented the greatest potential for utilization were: Composition A at temperatures of 1100°C and 1150°C and Composition C at a temperature of 1150°C, since they presented high mechanical resistance and low water absorption for ceramic coatings and as such, were classified as stoneware and semi-porous material, respectively.

In conclusion, it was observed that the residuals analyzed herein could reduce industrial processing costs from the origin to the final destination (ceramic factory). In addition, they present an adequate environmental solution because their usage in this manner guaranties lower negative environmental impacts generated by degraded areas.

5. References

ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 10004. Resíduos Sólidos.** Rio de Janeiro, 2004.

__________ ***NBR 10005. Lixiviação de resíduos.*** Rio de Janeiro, 2004.

__________ ***NBR 10006. Solubilização de resíduos.*** Rio de Janeiro, 2004.

__________ ***NBR 13818. Placas Cerâmicas para Revestimento - Especificação e Métodos de Ensaios.*** Rio de Janeiro, 1997.

BORLINI, M. C., SALES, H. F.,VIEIRA, C. M. F. et al. Cinza da lenha para aplicação em cerâmica vermelha, parte I: características da cinza. ***Cerâmica***, v. 51, n. 319, p. 192-196, 2005.

CONAMA - Conselho Nacional do Meio Ambiente. (2005). Resolução nº 357, de 17/03/2005. Dispõe sobre a classificação dos corpos d'água e diretrizes ambientais para seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes. **Diário Oficial da República Federativa do Brasil, Poder Executivo.** Brasília, DF, 18/03/2005.

CORDEIRO, J. S. Importância do tratamento e disposição adequada dos lodos de ETAs. In: ***Noções gerais de tratamento de disposição final de lodos de ETA.*** Rio de Janeiro: ABES/PROSAB, 1999. p. 1-19.

MEDEIROS, E. N. M., SPOSTO, R. M., NEVES, G. A., MENEZES, R. R. ***Cerâmica,*** Out/Nov/Dez, v. 56, n. 340, p. 399-404, 2010.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). Disponível em:http://www.ibge.gov.br/home/estatistica/indicadores/agropecuaria/lspa/lspa_20090 _7.shtm. Acessado em: 17/03/2009.

MS - Ministério da Saúde. (2004). Portaria nº 518, de 25/03/2004. Estabelece os procedimentos e responsabilidades relativos ao controle e vigilância da qualidade da água para consumo humano e seu padrão de potabilidade e dá outras providências. *Diário Oficial da República Federativa do Brasil*, Poder Executivo. Brasília, DF, 26/03/2004.

SOUZA SANTOS, P. ***Tecnologia de argilas, aplicação às argilas brasileiras.*** São Paulo: Edgard Blucher, 1992. v. 2, 340 p.

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