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Neutronic Activation of Amazon Technogenic Deposit Soil Used as Raw Material in Brick Manufacture

Ativação Neutrônica de Solo de Depósito Tecnogênico Usando como Matéria Prima para Fabricação de Tijolos

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Abstract

Considering the extraction of soil from Technogenic Deposits, may result in the risk, this article investigated whether in the brick making process, there is a possibility that chemical elements, considered linked to human illness, may have evidence of release to the environment. The adopted strategy was to subject both the soil, as well as the brick manufactured with this soil, to the Neutronic Activation test, later, through the mass balance, to verify the variations in the global concentrations of chemical elements. The results show that of the 27 elements analyzed, 25 showed a reduction in their concentrations after the burning of the soil. As the systematic literature review points out, the release of these chemical elements to the environment, is intrinsically linked to the decrease in the environmental quality of the built environment, therefore, it is an indication of possible risks for human health.

Keywords: Soil; Technogenic deposits; Brinks

Resumo

Considerando que a utilização de solo de Depósitos Tecnogênicos pode envolver risco, este artigo investigou se no processo de fabricação do tijolo existe a possibilidade de elementos químicos, considerados ligados a doenças humanas, apresentam indícios de liberação ao meio ambiente. A estratégia adotada foi submeter tanto o solo, quanto o tijolo fabricado com este solo, ao ensaio de Ativação Neutrônica, posteriormente, por meio do balanço de massa, foram verificadas as variações nas concentrações globais dos elementos químicos. Os resultados mostram que dos 27 elementos analisados, 25 apresentaram redução em suas concentrações após a queima do solo. Conforme aponta a revisão sistemática da literatura, a liberação desses elementos químicos para o meio ambiente, está intrinsecamente ligada à diminuição da qualidade ambiental do ambiente construído, portanto, é um indicativo de possíveis riscos à saúde humana.

Palavras-chave: Solo; Depósito tecnogênico; Tijolo

1 Introduction

The modus operandi of development in Brazil has produced an uneven urban fabric and a reduced quality of life for the majority of the population. Considering the medium-sized Amazonian cities, such picture can be even more dramatic.

The soil, near subnormal agglomerates, and even close to urbanized areas, can present contamination since, after all, the collection and treatment of wastes remains a limitation at the national level (Schueler; Kzure; Racca 2018). The indiscriminate use of soil, addressing only the criteria of granulometry, can pose a threat to human health (Ko et al. 2003).

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In the study by Scarpelli (2003), it is possible to visualize the negative impact on human health resulting from the use of materials in civil construction, when their chemical and mineralogical characteristics are minimally known. The author highlighted the inherent implications in the use of soil containing tailings from the exploration of manganese, from Serra do Navio (Amapá-Brazil), like a landfill. Following the reasoning expressed in Peloggia (2018), that deposits with disturbances, alterations and anthropic influences, can be considered Technogenic Deposits, this article considers that the soil comes from a deposit of this type, since, some deposits are located near areas undergoing lawsuits filed by the State Public Ministry (Brazilian state justice body). It was possible to discover, through the forensic techniques of the Renato Chaves Center of Forensic Sciences, that several of these areas exhibit heavy metal contamination, a fact widely reported by the press in 2017. However, the national academic literature lacks research on what impacts would exist in their use in the Civil Construction Industry. Even when considering international literature, such focus remains scarce.

To assess whether the use of soil from technological deposits for the manufacture of bricks can result in the possibility of releasing chemical elements, with the risk of damaging human health, this article performs a mass balance between two specimens: the soil of the deposit and the brick (produced from this soil). After submitting the specimens to the neutronic activation test.

2 Methods

Favaro et al. (2000) defined that neutronic activation comprises a non-destructive technique that consists of bombarding the target material of the study and measuring the induced radioactivity. The recognition of isotopes, according to the authors, is possible since each one has peculiarities in its emission. Thus, adopting a reference standard renders it possible to make quantitative determinations of concentration.

The experiment was carried out at the Neutronic Activation Laboratory of the Nuclear Chemistry and Radiochemistry Unit, of the Nuclear Technology Development Center (CDTN). The used Standard was a neutral flux monitor, Al-Au certified alloy (0.1%), adopting the Reference 530 of the Reference Materials and Measurements (Belgium). The Quality Control of the reference sample is certified by the Join Research Centre (JCR), Brussels, Belgium. The formula described by Favaro et al. (2000) to obtain the concentration of the elements.

The Neutronic Activation Laboratory of the Nuclear Chemistry and Radiochemistry Unit/CDTN adopts the *k0* method, as explained in the study by Menezes and Jaćimović (2008, 2011).

The elements of interest were Arsenic (As), Barium (Ba), Bromine (Br), Cerium (Ce), Cobalt (Co), Chromium (Cr), Cesium (Cs), Europium (Eu), Iron (Fe), Hafnium (Hf), Potassium (K), Lanthanum (La), Sodium (Na), Neodymium (Nd), Rubidium (Rb), Antimonium (Sb), Scandium (Sc), Selenium (Se), Samarium (Sm), Tantalum (Ta), Terbium (Tb), Thorium (Th), Uranium (U), Tungsten (W), Ytterbium (Yb), Zinc (Zn), and Zirconium (Zr).

The mass balance calculation was adopted to measure the variation in the concentration of chemical elements, considering the value initially identified in the soil, and the value subsequently measured in the brick, right after the burning of the soil.

3 Results

The Table 1 presents the results of the neutronic activation carried out in the soil of the Tecnogenic Deposit, as well as in the brick manufactured with this soil. It is worth mentioning that, when testing batches of bricks (at least in Brazil), only one brick is subjected to tests.

Of the 27 chemical elements found in the soil, 19 of them showed a concentration reduction greater than 50% after burning, which may mean that this material has chances of having been released to the environment via the atmosphere.

The scientific literature is indicative that there is a correlation between increased concentration of these elements in the environment and increased environmental degradation and human illness (Mehr et al. 2017; Mizutani et al. 2016; Tubino & Simoni 2007; Wen et al. 2017), and even those elements that have a concentration reduction of less than 50%, such as Zr, there is the possibility of human sickness due to the increase of their presence in the environment (Daldon & Arruda 2007). Therefore, it is necessary to verify how the dispersion of these elements is occurring in the vicinity of the brick factories, as this possible release of these elements can interfere in the surroundings (Xia et al. 2011), even causing compromises to human health (Wardrop & Le Blond 2015).

Table 1 Neutronic Activation Results.

Element	Soil (mg/kg)	Brick (mg/kg)	Reduction after burning (%)
Ba	168	57	66.07
Br	4.5	0.64	85.78
Ce	41	12	70.73
Co	5.8	2.8	51.72
Cr	57	48	15.79
Cs	2	0.9	55
Eu	0.71	0.28	43
Fe	27643	25357	8.27
Hf	7.5	4.1	45.33
K	7068	2890	59.11
La	21	8.1	61.43
Na	1514	126	91.68
Nd	18	0	100
Rb	36	15	58.33
Sb	0.36	0.31	13.89
Sc	7.8	6.5	16.67
Se	0	0	0
Sm	3.4	0.94	72.35
Ta	1.1	0.42	61.82
Tb	0.46	0.13	71.74
Th	8.1	4.7	41.97
U	2.3	1.09	52.61
W	1.5	0.7	53.33
Yb	2	0.81	59.5
Zn	48	39	18.75
Zr	305	176	42.29

Source: authors, 2020.

4 Considerations

Even if this raw material does not compromise the conformation quality of the construction components, it is crucial to consider that in the manufacturing process adopted (artisanal) there is a possibility that chemical elements are released and their accumulation in the surroundings needs to be investigated.

Elements such as Neodymium, Cerium, Barium and Bromine, have signs of being related to illness, according to the scientific literature, and have a significant decrease in concentration after burning, likewise Tory, Uranium and Zirconium, thus they can represent potential risk of exposure, and are known to be linked to illness.

It is worth noting that in the Amazon context, urbanization is progressing intensely in the last century, a process that followed in these first two decades of the 21st century, so human occupation close to areas of soil extraction is a reality, in the same way, that precarious housing close to the brick factories, which are increasingly populated, therefore, there is a potential risk for the coming decades with the intensification of these releases, and an increase in the population density of the surroundings.

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Author contributions

Antonio Carlos Santos do Nascimento Passos-de-Oliveira: conceptualization; formal analysis; methodology; validation; writing-original draft; writing – review and editing; visualization. **Alcebíades Negrão Macêdo:** methodology; validation and supervision. **José Antonio da Silva Souza:** methodology. **Dênio Ramam Carvalho Oliveira:** writing – original draft.

Conflict of interest

The authors declare no conflict of interest.

Data availability statement

All data included in this study are publicly available in the literature.

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