Methodological proposal for the site selection of a borehole repository for disused sealed sources in Brazil

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Abstract. According to the Brazilian regulation for site selection for low level waste repositories, areas of interest and preliminary areas steps must encompass a bibliographic review, followed by a systematic study of natural characteristics and infrastructure. Using a GIS platform, a methodology based on spatial and geochemical/hydrochemical databases for porous and fissural domains, along with selection/exclusion criteria, were proposed to select possible sites of a borehole repository for sealed sources. After this selection, technical, logistical and juridical features was also considered. Applying this methodology for Brazil, 209 counties were selected as preliminary areas. The lack of necessary databases can be a difficulty for applying this approach.

Key Words: disused sealed sources, borehole repository, site selection

1. Introduction

Site selection for a borehole repository is one of the key components of site assessment. Together with engineered barriers, the site must provide radiological protection, meeting all the requirements established by the regulatory bodies [1]. This paper proposes a methodology for site selection of borehole repositories using geoprocessing tools and applies it for the Brazilian case, using public domain databases.

2. Methodology

This work follows the three-stage methodology proposed by [2]: conceptual and planning, area survey and site characterization, focusing only on the first and second stages. Three different topics were addressed: overall plan for the site selection process, identification of desirable features for the survey and data evaluation.

Using GIS tools, the desirable features described for each attribute related to the available databases were selected. Considering the type of featured data, databases comprise Terrain Features (geology, hydrogeology and geochemistry/hydrochemistry) and Technical, Logistical and Juridical Features, also named TLJ (distance to source cities, indigenous areas, main drainages, environmental conservation unities, mining areas, high altitude areas and highways, and a maximum limit for demographic density). For each database, the key aspects and desirable characteristics for best overall performance of the repository were selected, based on [2], [3] and [4]. The interception of the results of the several considered characteristics resulted on a list of possibly suitable areas.
Due to the natural differences in the hydrodynamic behavior of groundwater pathway, groundwater evaluation in terrain features was divided in fissural and porous approaches. Each approach generated partial results, which were evaluated after by TLJ aspects (man-induced aspects, in accordance to [5]).

Geochemical characteristics of the water at the near field play an important role in the behavior of engineered barriers, since they are suitable to corrosion and degradation through the interaction with water and geological environment. Although there are no guidelines for the limit values for hydrochemical parameters for a best performance of the engineering barriers, a range of values was established based on geochemical characteristics of the Water Sample no. 5 [6] for pH (>8.46) and sulphate concentration (<10.66 mg/L) and on the Water no. 6 [6] for chloride concentration (<100 mg/L). For this evaluation, it was used geochemical database available in [7]. Water boreholes were chosen when they were within 1 km from the areas selected on the preliminary results for the corresponding domains used in the evaluation of fissural and porous sites.

The simplified work flowchart for site selection methodology is presented in (see FIG. 1.)

![FIG. 1. Simplified work flowchart for site selection methodology](image)

3. Results of the selection process

For the Fissural Approach, the following databases were used in successive rounds of analysis: geodiversity [8], lithology [9], hydrogeology [10], geochemistry/hydrogeochemistry [11]. The intersection of the results obtained is presented in (see FIG. 2).

For the Porous Approach, it was adopted the following order: hydrogeological, geodiversity, geochemistry/hydrogeochemistry. Numerical data for the hydrodynamic characteristics of porous aquifers are available in the hydrogeological database, making it be more relevant in the analysis compared with the fissural approach. Geodiversity database was used with the same criteria adopted for the fissural approach. The results intersection is presented in (see FIG. 3).
For the geochemical/hydrogeochemical feature, none of the available water borehole data were located close enough of the already selected sites to add any information to the site selection about their suitability.

For the TLJ features, six criteria were defined: distance to source cities, indigenous areas, main drainages, environmental conservation unities, mining areas, maximum limit for demographic density. These criteria were selected based on having the largest impact of land use, database availability and compliance to the aspects determined by [12]. For each parameter, an area of inclusion or exclusion was defined with the same methodology applied for the site selection of the Brazilian Low and Intermediate Levels Waste Repository Project (RBMN Project) [13]. Result of this analysis is shown in (see FIG. 4.), and the final results including all the criteria are shown in (see FIG. 5.).

4. Conclusions

The evaluation lead to a list of 209 counties that contains areas the meet the requirements according to the methodology proposed. The site selection using geospatial analysis from multiple database may provide significant results especially due to the possibility of correlating different variables and parameters. However, the results must be treated with precaution due to the tendency of rejecting sites based on false premises as the result of lack of appropriate databases, different scales used in the interrelation, eventual data inconsistencies and subjectivity of some criteria and/or numerical parameters.
As result of the robustness of the engineering barriers of the BOSS concept, it is well established in the reference literature that only few requirements of the site must be satisfied, mainly related to hydrogeological and geochemical conditions. This work has shown that, for using the geoprocessing methodology for site selection, it is a requirement that more complete and reliable database addressing this features are made available.

References


