PROBLEM OF BRAZILIAN CEMETERIES AND ENVIRONMENT – REVIEW OF STUDIES

O PROBLEMA DOS CEMITÉRIOS BRASILEIROS E O MEIO AMBIENTE – ESTUDO DE CASOS

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Abstract: The Cemeteries in Brazil are considered by the legislation in force as activities that may be subject to environmental licensing. This condition is based in the interaction in which the cemeteries have with natural resources. The main types of cemeteries are the traditional horizontal and parks or gardens, and more recently, vertical. Authors portray the socio-environmental reality of traditional cemeteries based on technical studies conducted in different states. This work aims to analyze each study and synthesize the main information such as applied methods, results obtained and conclusions. Most of the studies analyzed identified degrees of contamination of water and soil, putting the health of living beings at risk. The main methodologies and results evaluated were highlighted and technical and legal recommendations, such as the environmental regularization of Brazilian cemeteries through environmental licensing were pointed out as the conclusion of this work. At last, a diagnosis on the problem of Brazilian cemeteries in relation to the environment was carried out.

Keywords: Cemetery. Necrochorume. Natural Resources. Environmental Pollution. Environmental Impacts.

Resumo: Os Cemitérios no Brasil são considerados pela legislação vigente como atividades sujeitas a licenciamento ambiental. Esta condição é baseada na interação em que os cemitérios têm com os recursos naturais. Os principais tipos de cemitérios são os tradicionais horizontais e parques ou jardins e, mais recentemente, os verticais. Autores retratam a realidade socioambiental dos cemitérios tradicionais com base em estudos técnicos realizados em diferentes estados. Este trabalho tem como objetivo analisar estudos de caso e sintetizar as principais informações, como métodos aplicados, resultados obtidos e conclusões. A maioria dos estudos analisados identificou graus de contaminação da água e do solo, colocando em risco a saúde dos seres vivos. As principais metodologias e resultados avaliados foram destacados e recomendações técnicas e legais, como a regularização ambiental de cemitérios brasileiros através do licenciamento ambiental, foram apontadas como a conclusão deste trabalho. Por fim, foi realizado um diagnóstico sobre o problema dos cemitérios brasileiros em relação ao meio ambiente.

Palavras-chave: Cemitério. Necrochorume. Recursos Naturais. Poluição Ambiental. Impactos Ambientais.

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1 INTRODUCTION

The burial of dead bodies is being practiced since the middle ages, having different practices and rituals according to the place and people's culture. In Brazilian colonial period was common the burial of families in their rural places, and in church fields those who were used to celibacy, politics and from rich families.

Numerous epidemics happed at humanity history, as a typhoid fever, yellow fever, hepatitis A, among others, the majority disseminated, in main part, because a fault of hygienic and sanitation. In XVIII century, in the water around Berlin and Paris, there were registers of numerous cases of typhoid fever, coming from dead bodies victims having these diseases, contributing to the proliferation of it in that zone.

The epidemiological risk of the cemetery leads the society to a change in the form and place of burial. Private cemeteries were closed and the mortal remains transferred to a central cemetery of the community or city.

These places were far from the civilization, and this isolation was a guarantee of safety to society. With the time and growth of cities, the expansion of urban places without planning made zones with high concentration of people settlement around the cemetery. This approximation replaced cemeteries zones inside the urban perimeter, and next to the neighbourhoods and commercial zones of the city.

In Brazil, according to Kemerich et al (2014) there are vertical cemeteries, traditional ones, crematories and the parks or gardens. The vertical cemeteries and the crematories are considered something new, which creates resistance with application of these methods upon religious, social and cultural issues. Vertical cemeteries increased exploitation of space and grew the capacity of burial per area when you compare with the traditional method, which have problems with expansion because the city area around.

The vertical cemeteries and the crematories have more protection to environment and more control of pollution. These cemeteries are built with planning, in appropriate places, controlled conditions, licensing and inspection of environmental institutions.

The traditional cemeteries and parks or gardens are common and used around the country for all religions, ethnicity and social classes. The burial in these places are

performed for decades, on the soil in concrete graves or brick built, usually, without a correct protection. These condition gets a harder implantation of systems to control, collect and treatment of generated effluents, so important to reduce environmental impacts.

This kind of burial have some disadvantages, as the ones told by Kemerich et al (2014): groundwater and surface's water contamination; occupation of large areas; high cost of building and maintenance; interference in the urban aesthetics; proliferation of insects which can transmit diseases like mosquitoes, scorpions and cockroaches. All of these aspects can clearly impact soil, wind and water.

After the burial, the dead bodies, when not cremated, go thought decomposition process. This process, human components and some other elements are liberated, for example, varnishes, paint, metal from hinges and handles and preservatives used in bodies like formaldehyde (FINEZA, 2008).

Bortolotti (2009) identified radioactivity in a 200 meters radius becoming by people that when alive, were submitted to radiotherapy or received cardiac pacemaker supplied with radioactive energy. These radioactive elements have risks to human health. Moreover, the author salient that the right destination of this bodies should be cremation and the ashes placed to sanitary landfill able to atomic waste.

About a decomposition of organic material of bodies, the main sub product of this process is the Necrochorume, characterized as a grayish-brown and viscus liquid, containing, according to Kemerich et al (2012) approximately 60% of water, 30% of mineral salts and 10% of organic substances degradable, consequently being an environmental poisoning.

After the 1950's decade some authors cited about some problems that cemeteries could make and guided a need of geological studies, hydrogeological and sanitarian which would evaluate the possible poisoning of soil and waters of cemeteries areas and adjacent (BÉRGAMO, 1954 *apud* FINEZA, 2008).

In 2011, the geologist Lezíro Marque da Silva concluded a research in which involves over than a thousand cemeteries in BRAZIL, public and private, and in an interview to Maciel (2012) cited that more than 75% of public cemeteries have problems with environmental and sanitary issues. According to Silva, there are problems on soil surface with a proliferation of diseases vectors, and subsoil with poisoning of groundwater table. The author explains that the Necrochorume can infiltrate in the soil

and with a water contact, can spread by the area creating a sheet of pollution which can reach wells and rivers.

According to Oliveira (2017), the management of cemeteries belongs to the city government, or to individuals by delegation. The civil responsibility about environmental impacts caused by Necrochorume and Necrowaste caused by burial activities should be designated to the city hall, as well as to the person in charge of its administration.

Cemetery activity is considered a potential environmental pollution, subject to environmental licensing, according to the resolution of the National Council of the Environment - CONAMA, nº 335 of April 3, 2003, which provides for the environmental licensing of cemeteries, to be approved by the environmental agency protection.

The situation is worrisome throughout the national territory, from the point of view of the control and solution of the contaminants generated by the burial in traditional cemeteries and gardens, on this account it has been installed for decades and is still a common practice.

It's worrisome, as well, a lack of knowledge of the population in general about the environmental damages caused from cemeteries. Dantas et al (2015) conducted an interview in Natal-RN with popular visitors to a city cemetery and 74% answered "no" to the question "Do cemeteries cause environmental damage?".

In this scenario, the present literature review in an article form, is aimed to gather knowledge, methodologies and results reached in case of studies carried out in the Brazilian cemeteries, as well as analyze the state of this activity.

2 METHODOLOGY

The article itself synthesizes information from studies that evaluate soil and / or water contamination caused by Necrochorume. The methodology used in this bibliographic review consisted in the following items:

a) Read and to identify the methods and evaluation strategies of the environmental impacts adopted by the authors;
b) Describe in a summarized way the main methodology applied by the authors in their respective studies;
c) Prepare a table containing the main information of the analysed studies as: author, year, city, cemetery, parameter and places evaluated;

d) Correlate the work and interpret the results in order to identify standards in the way to assessing the impacts of cemeteries in the environment;
e) Conclude from the studies analysed considering the particularities of each one of them, as well as the global scenario of cemeteries in Brazil.

3 RESULTS AND DISCUSSION

The presentation of the information of the studies starts with the characterization of the study area and the history of the cemetery and region, with data referring to the year of foundation, the number of tombs, the ways of burial used, and secondly, complementary studies such as geological studies, hydrogeological, hydrological, topographic and sanitary surveys, revealing data such as groundwater flow direction, ground altimetry, groundwater level, soil and rock typology, pluviometric indexes, among others.

The data, information and complementary studies applied in the studies analyzed were relevant to conclude on the impact of the cemetery in the environment. The main points for primary data collection, used to support the authors' technical studies, were the existing tubular wells and/or perforation to collect water and soil samples. Monitoring points internal and external to the study area allowed for a more representative evaluation.

The allocation of at least one point of analysis in the external area and upstream of the cemetery in relation to the flow of the groundwater was a fundamental strategy used by most authors to isolate the contribution of the cemetery in the pollution of natural resources. The analysis of physical, chemical and biological parameters of soil and water upstream of the study area makes it possible to identify if other polluting sources are acting in the studied region, as well as to evaluate the natural characteristics of the soil.

Despite of both authors, Silva et al (2009) and Zanato (2016) have evaluated only the physical parameter, Electrical Conductivity of water and soil, most of the authors made use of microbiological and physicochemical laboratory tests that allowed to diagnose the contamination of the environment by Necrochorume.

Table 1 - Summary of the information of the analyzed studies

Author (year)	City-State	Cemetery analyzed	Studied Element		Parameters analyzed	Has studied element been Contaminated ?
			Soil	Water		
Enetério (2009)	Bonito - MS	Cemitério Municipal de São João Batista.	No	Yes	Thermotolerant coliforms, hete rotrophic and proteolytic bacte ria, mesophilic aerobic microo ganisms, pH and 20 chemica elements, including barium an lead.	Yes
Silva et al (2009)	Piracicaba - SP	Cemitério Municipal de Vila Re-zende – 1976.	Yes	Yes	Electric conductivity.	Yes
Silva (2012)	Maceió - AL	Cemitério Nª Srª Mãe do Povo - 1940; Cemitério São José – 1918.	No	Yes	Temperature, pH, turbidity, dis solved solids, electrical condu ctivity, chlorides, nitrates, sulfa tes, total and fecal coliforms, heterotrophic bacteria and tota proteolytic bacteria.	Yes
Amorim e Cruz (2014)	Cachoeira - BA	Cem. Mun. da Piedade – 1874.	No	Yes	Total nitrogen and phosphorus	Yes
Conceição (2015)	Silva Jardim - RJ	Cemitério Rural de Bananeiras (Cemetery with 40 graves).	No	Yes	Thermotolerant coliforms; Che mical Oxygen Demand (COD) Dissolved oxygen; turbidity; pH; nitrates; phosphorus; dis-solved solids and temperature	No
Dutra et al (2015)	Lages - SC	Cemitério Nª Srª da Penha.	Yes	No	pH, organic matter and soil texture.	Yes
Santos et al (2015)	Salvador - BA	Cemitério do Campo Santo – 1844.	No	Yes	turbidity, pH, apparent color, Escherichia coli e Clostridium perfringens.	Yes
Neckel, et al (2016)	Carazinho - RS	Cemitério Municipal - século XIX; Cemitério Católico/ Evangélico Jardim da Paz - 1966; Cemitério Martin Lutero – 1982.	Yes	No	Parameters of CONAMA: cop per, zinc, iron, manganese, lead and chromium.	Yes
Tormen, et al (2016)	Erechim - RS	Cemitério Municipal Pio XII; Cemitério Jardim da Saudade.	No	Yes	Chemical Oxygen Demand (COD), Total Coliforms and Thermotolerant.	Yes
Zanato (2016)	Caçapava do Sul - RS	Cemitério Santo Antônio – 1837.	Yes	Yes	Electric conductivity.	Yes
Neckel, et al (2017)	Marau - RS	Cemitério Central de Marau and other 43 rural cemeteries.	Yes	No	Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), organic car-bon; pH, heterotrophic, total and fecal coliforms.	Yes

The evaluation of the electrical conductivity of water and soil by Silva et al (2009), Silva (2012) and Zanato (2016), can be justified since the increase in the amount of water-soluble minerals from the decomposition of organic matter of corpses, increases the value of this parameter, which can be related to Necrochorume contamination.

Parameter such as: presence of heterotrophic bacteria, proteolytic bacteria, *Clostridium perfringens,* total coliforms, fecal and thermotolerant, enterovirus and adenovirus, BOD-biochemical oxygen demand, DO-dissolved oxygen, nitrogen, total phosphorus, sulfur, pH, turbidity, among others are commonly used by the authors.

In the study of Dutra et al. (2015) the soil texture was evaluated through the method of Day (1965) and Gee & Bauder (1986), which is based on separating the sand and clay fraction from a soil, and through formulas determine the percentages of fine and coarse sand, silt and clay. The soil texture classification is divided into coarse, moderately thick, medium, moderately thin and fine.

The soil texture influences the percolation rate of the soil, being an important attribute for the control of the pollution. For example, clayey soils act as a natural physical barrier to the detachment of the effluents from the soil. Clay soils are recommended for sanitary landfill sites, in order to prevent contamination of the groundwater and aquifer in cases of leachate leakage. The same study applies to cemeteries in relation to the Necrochorume.

In the aquifer vulnerability assessment study, Kater and Oliveira (2016) used the empirical theory of Foster and Hirata (1988) that defines a flowchart that relates the groundwater occurrence and depth condition and the lithography of the area, in which results in the vulnerability index of the aquifer studied.

Aquifers of the Karstic, Fractured, Free or Groundwater and Porous type offer greater risk of contamination by effluents when you compare to the Confined or Artesian aquifer. This last one presents a natural confinement condition that prevents the contamination of its water reservoir by effluents

Kater and Oliveira (2016) evaluated the vulnerability of the Aquifer Beberibe responsible for a large part of the water supply for the Metropolitan Region of Recife-PE. The authors verified that the aquifer presents high vulnerability to the contamination by Necrochorume, although, its greater extent, at depths of 100-150 meters and covered by thick layers where there are intercalations of clayey layers.

Silva et al. (2009), in Piracicaba-SP, used the Eletroresistivity Method to evaluate the contamination of groundwater by Necrochorume. It obtained interesting results as to the depth and area of probable contamination by the Necrochorume. It showed that the contamination is probably reaching depths of approximately 10 meters.

Conceição (2015) carried out a case study with the purpose of evaluating the possible contamination, by the cemeterial activity, of a spring used for water supply in

the district of Bananeiras in the city of Silva Jardim-RJ. For such study, he evaluated the surface and groundwater of internal and external points of the district's rural cemetery, this one having 40 graves. The results did not present contamination in the superficial or subterranean waters, which was attributed to regional geological characteristics - granitic and the absence of formation of sinks, subterranean rivers or caves.

Amorim and Cruz (2014) evaluated the groundwater contamination in the city of Cachoeira-BA, and the results related to the total nitrogen and phosphorus parameters showed that the area is not totally protected from the action of the Necrochorume.

The studies of Enetério (2009), Silva (2012) and Santos et al (2015) evaluated the parameters listed in table 1 at different periods of the year and observed a significant difference in the results. For example, Enetério (2009) evaluated the water quality in wet and dry periods in the city of Bonito-MS, and found that in the first period the values of the evaluated parameters occurred in a lower concentration or in a negligible concentration in relation to the second period, confirming the hypothesis of dilution of the contaminant in the wet period.

According to Silva (2012), in the Cemetery Nª Srª Mãe do Povo in Maceió-AL, there is a presence of total coliforms and fecal in the dry periods, while in the wet periods the values were absent, with absence of proteolytic bacteria. The presence of proteolytic bacteria are indications of contamination by Necrochorume and its absence is attributed to the fact that this cemetery does not carry out direct inhumation in the soil, so the author verified that there is no contamination by Necrochorume, but urban pollution contamination by coliforms.

In Salvador-BA, Santos et al. (2015) analyzed points upstream and downstream of the Campo Santo Cemetery, during wet and dry periods, and verified the absence of *E. Coli* in both periods, implying that there is no urban pollution; and presence of *Clostridium perfringens* in two seasons of the year, with more significant values in the dry season, indicating the contamination by Necrochorume.

Silva (2012) also analyzed São José Cemetery, an old cemetery in Maceió-AL, which used for decades the direct burial in the soil. In this area, there was presence of total heterotrophic and proteolytic bacteria, suggesting the contamination of the aquifer by Necrochorume, which puts at risk the health of the population and the tourists, since São José Cemetery is located 250 m from the central beach in Maceió and 1,250 m of Mundaú Lagoon.

Enetério (2009), analyzed 8 artesian wells in the tourist city of Bonito - MS, known for allowing water sports in its various "natural aquariums", rivers and lagoons, with crystalline waters and abundant aquatic life. The artesian wells analyzed were used to supply the residences until 2007, since there was no public water supply, and until the year of Enetério's study they were used for the irrigation of vegetables. With the study of Enetério (2009) seven of the eight wells analyzed were condemned due to the high presence of total coliforms and thermotolerant.

The samples evaluated by the author showed that 75% of the samples presented, on average, nitrate values 209% higher than the Allowed Maximum Value - AMV; in the well of analysis closest to the graveyard, the author identified the increase in the electrical conductivity generated, probably due to the increase in the concentration of mineral salts in the water, from Necrochorume, which is in line with the findings of Silva et al (2009), Silva (2012) and Zanato (2016). In addition, the potassium index related to the decomposition of the bodies, were close to the upper limit normally found in groundwater.

Enetério concluded that such results found in the wells near and upstream of the cemetery suggest the contamination of the groundwater by Necrochorume. In the other wells, sanitary sewage contamination was confirmed. The same occurred in the study of Tormen, et al (2016) in the city of Erechim-RS.

Neckel, et al (2016) evaluated the soil of three graveyards in the city of Carazinho-RS and found that heavy metals such as: Cu, Zn, Fe, Mn, Pb, Cr vary in greater intensity and concentration in the internal limits of the cemeteries in relation to the external area, identifying the concentrations reduction of contaminants as the monitoring points move away from the cemeteries analyzed.

The author observed that in the oldest cemetery evaluated, the concentration of the lead element (Pb) exceeded the toxicity prevention limits established by the law. The concentrations of lead in the internal part of the cemetery were about 4 times higher than the measurements on the outside. However, in the other two cemeteries, the new Pb samples were within the range of prevention, although close to the upper limit.

Neckel et al 2017 argues that the high risk of contamination of the environment by traditional cemeteries, due to the difficulty of implementing a pollution control structure generated by it, makes its practice unfeasible. The opposite is observed for vertical

type cemeteries, which architectural and sanitary conception favors the implantation and control of pollution.

The use of landmarks in areas upstream of the study area in relation to the direction of flow of the groundwater, is an important strategy and it was widely used by the authors.

The monitoring of parameters over a period of at least one year, aiming to identify seasonal effects, reveals the concentration variation of a parameter in time, which may be sometimes in unconformity with current legislation, sometimes not. In order to obtain representativeness in studies it is essential that the monitoring is continued.

The authors analyzed parameters contained in the resolutions CONAMA n ° 357/2005, n ° 410/2009 and n ° 430/2011, which proposes the classification of surface water into classes quality, as well as Portaria n ° 2914/2011 of Ministério da Saúde (Brazilian Health Department) which propose ratings to evaluate the potability of water for human consumption. The comparison of the values obtained by the analyzes showed in the studies, when compared to the reference values defined in the current legislation, allows to identify the degree of contamination of the natural resource.

4 CONCLUSION

Necrochorume is a potential contaminant of natural resources, especially water and soil. The main source of this contaminant are cemeteries, which, arranged in urban areas and without environmental control measures, impact the environment and the health of living beings.

The studies discussed in this study show that there are environmental problems resulting from poor management of cemeteries in different Brazilian states.

It is important to note the studies with parameters and variables monitoring in a continuous form, in order to represent the seasonal behavior of the parameter and guarantee its validity.

For the analysis of the contamination of natural resources, it is evident the need to analyze physical, chemical and biological parameters, in a correlated way, to obtain a representative conclusion of the impacts of the Necrochorume in the soil and water.

The local and regional lithology has an effective influence on the propagation of the Necrochorume contaminant in the soil.

The contamination of aquifers with 10 meters of depth identified by Silva et al. (2009) and the vulnerability of aquifers from 100 to 150 meters of depth reported by Kater and Oliveira (2016), highlights the importance of the analysis of lithology in areas of new cemeteries installation.

The awareness of water users located around cemeteries, not served by the public water supply system, is the responsibility of the public power in order to guarantee these users well-being.

This bibliographic review showed that different regions of Brazil face health and environmental problems involving cemeteries, as evidenced by most of the studies analyzed.

It is imperative and urgent the environmental regularization of Brazilian cemeteries through environmental licensing.

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