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The Analysis of the Presence of Necrochorume in Communities in the Vicinity of the Cemetery Parque de Manaus and Nossa Senhora Aparecida

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Abstract— *This work aims to analyze the possible contamination in the water table, by the Necrochorume of the cemeteries Nossa Senhora Aparecida and Parque de Manaus, which are located on Avenida do Turismo nº 107, km 12, in the tarumã açu neighborhood, are the largest extension cemeteries and the only ones in Manaus to carry out burials. Necrochorume is the main contamination residue from bodies that are in a state of decomposition, this liquid that is composed of water, mineral salts and organic substances, are responsible for soil pollution and underground aquifers. Chemical, physical and microbiological analyses of 2 supply points were performed, one inside the cemetery and the other outside, in October, the results show a change in pH, turbidity and the occurrence of microorganisms having the potential to cause serious health and environmental problems.*
Keywords— ***cemetery, necrochorume, contamination.***

I. INTRODUCTION

Brazilian capitals are responsible for housing a majority part of the country's population, and the abrupt growth of these, can cause increased problems such as the lack of basic sanitation, degradation of preservation areas, soil pollution and resources (PESSOA et. al., 2016; ROCHA et. al., 2017). In addition, certain areas that in the early days of the development of cities were located outside the limits of the city, today they are in the urban perimeter, such as cemeteries. It was thinking about this problem that urban planning came to be considered as an efficient tool for the solution (CARNEIRO, 2008).

Around the 1970s, manaus necropolises became critical due to the high population growth caused by the emergence of the Free Zone. With this growth came the problem of cemeteries that soon ran out of room for new graves. In 1974, the Municipal Department of Works conducted a study to find new locations for a model necropolis (DUARTE, 2009).

However, cemeteries in fully urbanized areas are still frequent despite the implications such as groundwater and surface contamination (ROCHA et. al., 2017). These problems are still common even with the existence of bans on CONAMA resolutions 335/2003, 368/2006 and 402/2008, which regulate the environmental licensing of cemeteries (WEBER, 2010; KEMERICH et. al., 2014). Therefore, the choice of an appropriate place for cemeteries requires a rigorous and careful previous study, because in addition to contaminating the areas water resources, can change the process of decomposition of cadavers (CAMPOS, 2007; JALOWITZKI, 2011; LORENA et. al., 2018).

The study the rain and surface waters are essential because, the rainwater when they penetrate the soil flows through the graves, coming into contact with the decomposing bodies. But on the other hand, this decomposition process can take months to years, depending on the type of soil and room temperature, which can pollute water resources in the same year (BARROS, 2008; JALOWITZKI; 2011). Yet, Lorena et. al., (2018) and Pacheco and Mendes (2000) showed that during the decomposition of the corpse there is proliferation of microorganisms that despite difficult conditions of survival can cause tetanus, gasgangrene and food toxinfection. In

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addition, viruses such as hepatitis that when coming into contact with water can cause serious harm to the health of consumers (PACHECO e MENDES, 2000).

In addition, carneiro's study (2008) showed that contamination of underground aquifers are more difficult to remedy, as it is at great depths, which compromises the spring with viruses and bacteria more resistant, making water unfit for consumption. The resulting of human putrefaction is called necrochorume characterized by being a viscous solution, composed mostly of water, rich in mineral salts and degradable organic substances, being released around 30 to 40 liters per human.

Necrochorume has as main characteristics, viscosity greater than water, average density of 1.23 g/cm³, polymeizable, brownish or grayish color, strong and unpleasant odor, pH between 5 and 9, at a temperature of 23 to 28ºC, varied degree of pathogenicity (MATOS, 2001).

Despite the legislation, the areas of ancient cemeteries do not present any kind of planning, usually built in places where the underground is quite vulnerable. In most of them the drainage of rainwater is precarious, with flooding of some graves that are often in precarious consumer status (PACHECO, 2000). Rainwater, after crossing the cemeteries, falls into the urban rain network, and then channeled into bodies of water contaminating the surface waters with the substances present in the necrochorume. In cemeteries located where the water table is shallow, the chances of groundwater contamination are great (CARNEIRO, 2008).

The Parque de Manaus and Nossa Senhora Aparecida Cemeteries, located in the West Zone of Manaus municipality on Avenida do Turismo, n. 107, Km 12 – Tarumã, are chosen for the new burials. The original plan for the Cemetery Parque de Manaus was shallow field with gardens different from conventional crosses and grave of traditional cemeteries, while Our Lady of Aparecida arose by an emergency that the other cemeteries were no longer able of receiving new graves (DUARTE, 2006).

Therefore, this work aims to evaluate the possible impacts caused by cemeteries through the decomposition of cadavers thus harming public health, and through the results compare whether these fit with the potability standard of Ordinance No. 2914/11 Art. Second. This Ordinance applies to water destined for human consumption from a system and alternative water supply solution. Thus, this work will show an analysis of the physicochemical conditions of groundwater in the area of a cemetery located in the urban area of the city of Manaus / AM. This project is justified by the fact that the population around the area of the cemetery studied, use water for consumption.

II. MATERIALS AND METODOS

The study was delimited in the Cemetery Nossa Senhora Aparecida and in the Cemetery Parque de Manaus, located in the Tarumã neighborhood, which is administered by the Municipal Department of Urban Cleaning. This cemetery is located in the region of the Giant basin, which integrates seven neighborhoods of the city in an area of 105,433 hectares (Figure 1a). The Cemetery Nossa Senhora Aparecida has as activity new burials, since the Cemetery Parque de Manaus serves only burials in family grave (SEMUSP, 2019).

First, a survey of the watershed and the neighborhoods adjacent to the cemetery (Figure 1a and 1b) it was possible to observe the path of the bodies of water that are part of the basin and their respective levels. Because as Almeida (2005) showed the presence of cemeteries in slope areas, increase the chances of contamination by Necrochorume.

Based on this analysis, it was possible to determine the areas to which the water samples would occur, and two points were chosen within the delimited area, as shown in Figure 1b.

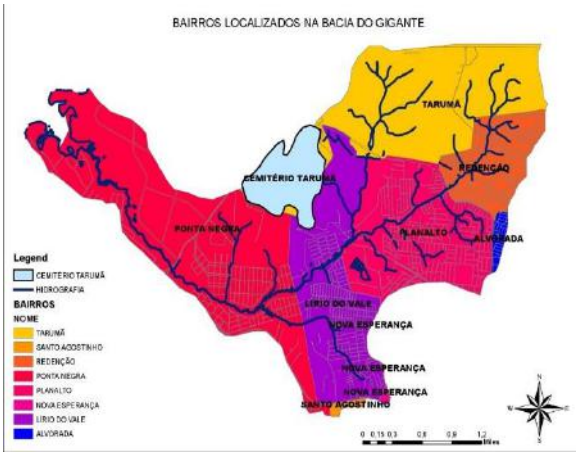

Fig.1: a) Neighborhood Location Map;

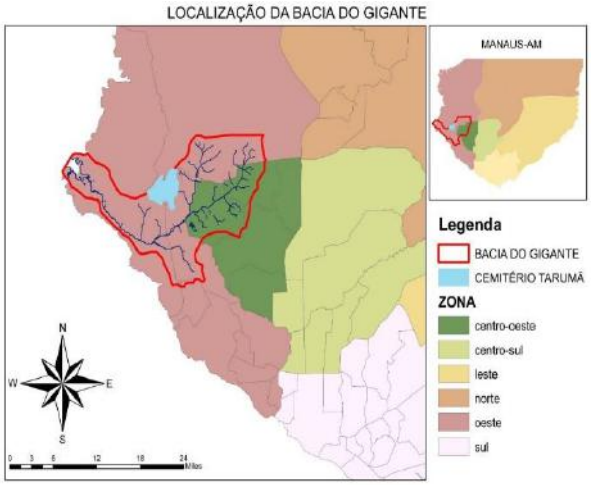

Fig.1 b). Location of the Giant Basin

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After delimiting the study area and collection points, the parameters that will be analyzed were determined to identify the presence or not of Necrochorume. Thus, only the parameters shown in Table 1 were analyzed.

Comparison was made with reference values and potability parameters according to the methodology in which they are contained, meeting national and international standards, such as the Standard Methods of Examination of Water and Wastewater 23rd ED. analyzed were:

Table 1: Parameters analyzed

Parameter Analyzed	
pH	Recommended for human consumption, between 6.0 and 9.5.
Temperature	Recommended for human consumption, between 6.0 and 9.5.
Total solids	Indicator capable of evaluating the total weight of mineral constituents present in water by volume unit, granting up to 1,000 mg/L
Turbidity	Difficulty measure of a beam of light crossing the water sample, as well as suspended solid materials; up to 5.0 UNT.
Calcium	Granted up to 250 mg/L, excess of this element in water can cause problems such as kidney stone.
Chlorides	Determines the degree of water mineralization or indications of pollution. Allowed up to 250 mg/L
Nitrite	It is indicative of recent contamination in water, from organic plant or animal material. Amounts granted up to 1.0 mg/L
Nitrate	It is indicative of recent contamination in water, from organic plant or animal material. The standard of potability that is 10 mg/L.
Sulfates	Determined by Decree-Law No. 306/07 of August 27, as parametric value 250 mg/L in water for human consumption.
Heterotrophic bacteria	Heterotrophic bacteria feed on organic molecules from other living beings and depending on origin, should not exceed 500 Colony Forming Units per milliliter (CFU/mL)
Total coliforms	The mere presence of bacteria in this group in water intended for human consumption discards water as non-drinking, with NMP/100 ml allowed.

In this work the methodologies used in the determination of analytical parameters, were the same used in Cunha (2008). Samples were collected on 10/29/2019 at 14:10, which basically is an Artesian well located inside the Cemetery, and a second collection point in a commercial establishment a few kilometers from the first sample, but outside the boundaries of the cemetery. Although rainfall indices are very low at this time of year, which allows for lower surface flow and necrochorume infiltration in the deeper areas of the soil, and water table, during the day of collection rain showers.

Table 2: List of used equipment.

Equipment	N. Série
Phmetro Digital PG 2000	17041055001012
Conduimeter HI 2300	08456546
Digital Turbidimeter HI 98703	08393410
Digital Spectrophotometer DR 3900	1585105

III. RESULTS AND DISCUSSIONS

In this section will be shown the results of the research carried out in the Parque cemetery of Manaus, which sought to identify the presence of necrochorume in groundwater. The research is of essential relevance, in view of its location in a fully urbanized area, and still being a source of supply for human consumption.

The results of the water analysis inside (Table 1) and outside (Table 2) of the cemetery presented a low pH in both samples, where the limits are between 5.51 and 5.90, respectively. These values are characterized as a body of water of considerable acidity, which indicates the presence of some polluting agent in the water body or evidence of the presence of necrochorume, as indicated by the limits set by the legislation. Despite this, Amorim (2017) shows that water in the northern region is originally acidic and should not be used initially as an indicator of pollution.

Furthermore, analyzing the other indicators it was possible to verify that most of them presented acceptable limits, maintaining the criteria determined by Consolidation Ordinance No. 5/2017.

However, the levels of turbidity analyzed in sample 1 presented values around 4.00 UNT, very close to tolerated, while sample 2 (Table 2) these values are even lower presenting values around 1.00 UNT. Although both samples have turbidity levels below 5.00 UNT (limit tolerated by legislation) a longer period of operation of the cemetery is easily exceeded. Also, for Campos (2007) and Carneiro (2007), the presence of suspended solid materials (silt, clay, calloids), finely divided organic and inorganic matter, microscopic organisms and algae are the main influencers of increased turbidity in a body of water.

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Table 1: Results of parameters analyzed in groundwater well inside the cemetery.

PARAMETERS	CONSOLIDATION ORDINANCE N° 5/2017	RESOLUTION CERH No. 01, OF 19 JULY 2016	SAMPLE 01
pH	6,0 a 9,50	**	5,51
Temperature (°C)	**	**	25, 6°c
Total Dissolved Solids	Up to 1.000 mg/L	**	66,00 mg/L
Turbidity (UT)	Up to 5,0 UNT	**	4,00 UNT
Calcium (Ca)	Up to 250 mg/L	**	0,35 mg/L
Chlorides (Cl)	Up to 250 mg/L	**	0,200 mg/L
Nitrates (N-NO_3)	Up to 10 mg/L	**	0,900 mg/L
Nitrates (N-NO_2)	Up to 1,0 mg/L	**	0,600 mg/L
Sulfates (SO_4)	Up to 250 mg/L	**	0,300 mg/L
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Parameters	**Unidade**	**Amostra**	**V.M.P**
Bacteria Heterotrophic	u.f.c/ml	47	500
Coliforms Total	NMP/100 ml	Out	Out

Regarding the parameters of potability and their respective limits, it is known that the potability of water is essential to the life and maintenance of human health, because the consumption of improper water can cause several consequences human health.

Temperature has an influence on biological processes, chemical and biochemical reactions occur in water and other processes, such as solubility of mineral salts and dissolved gases cause reaction with acids (CAMPOS, 2007). For Oliveira (2009) it is essential to emphasize that temperature interferes with microbiological progression, so that each microorganism has an ideal temperature area to develop.

The temperature values observed in samples 1 and 2 presented very close values, remaining around the range of 25.6° C in sample 1, while the show 2, presents a temperature of 26.6ºC. However, the high values of groundwater in this region are normal, due to high temperatures in the city of Manaus/AM that have annual averages around 24º to 26 ºC.

The values obtained in the analyses of dissolved solids performed in the 2 wells met the limit tolerated by the legislation, which the maximum allowed is 1,000 mg/l (VMP). Nevertheless, it was noticed that the solid content dissolved in well 1 was considerably higher than that found in sample 2, this is due to the high amount of sand granules in the well area.

Calcium is an element that is present in large quantities in most waters, and just as calcium carbonate (CaCO3) is common to find it in waters with pH above 8.2. Silva (2012) shows that the presence of calcium in groundwater is frequent and its association with carbonates is also used to determine alkalinity in groundwater and surface waters (BIGUELINI et al., 2012). The calcium concentrations detected in the analyzed samples showed values at the limit of the standard required by legislation in both samples 1 and 2, that is, values that are in accordance with the Consolidation Ordinance 5/2017.

In addition, chlorides are very soluble compounds and tend to enrich themselves along with sodium in groundwater. Contents above the M.S reference pattern (250 mg/L) are contamination indicators, in the results of the analyses show that it is well low.

Nitrate is a highly soluble salt characterizing organic matter contamination, usually present in landfills (COSTA, 2002). Biguelini and Gumy (2012) in studies conducted in Australia and Canada found a significant increase in congenital malformation "every defect in the constitution of some organ or set of organs that determines a structural morphological anomaly present at birth due to the

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environmental or mixed genetic cause" (BARROS, 2008). However, it was found that in sample 1 nitrate values were around 0.900 mg/L, while in sample 2, nitrate was around 0.001 mg/L, as shown in Tables 1 and 2.

Regarding nitrite all the results were satisfactory, because in the two wells analyzed, did not exceed the maximum limit allowed by consolidation ordinance No. 5/2017, which is 1 mg/l. It was verified that in well 1 the amount is around 0.600 mg/L, while in well 2 it has lower values, around 0.001 mg/L. Still, Santos (2015) shows that the presence of nitrite can cause damage to human health because, when present in the water in demasia.

The results obtained show an increase in pH and temperature results, which indicate a possible change from the decomposition of the cadavers. According to the World Health Organization (WHO) man is subject to an average daily consumption of about 500 mg/L of sulfates from water, because if ingested above this limit can cause gastrointestinal disorders.

Regarding microbiological results, heterotrophic Bacteria is shown to be worth 500 u.f.c/ml which is requiring for human consumption, while total Coliforms were absent. The amounts of parameters analyzed are few for the size of contaminants coming from the decomposition of this pollutant.

Table 2 - Analysis of Drinking Water Analytical Report.

PARAMETERS	CONSOLIDATION ORDINANCE No. 5/2017, ANNEX XX-MS/GM	RESOLUTION CERH No. 01, OF 19 JULY 2016	SAMPLE 02
pH	6,0 a 9,50	**	5,90
Temperature (°C)	**	**	26, 6°c
Total Dissolved Solids	Até 1.000 mg/L	**	30,00 mg/L
Turbidity (UT)	Até 5,0 UNT	**	1,00 UNT
Calcium (Ca)	Até 250 mg/L	**	0,010 mg/L
Chlorides (Cl)	Até 250 mg/L	**	0,100 mg/L
Nitrates ($N\text{-}NO_3$)	Até 10 mg/L	**	<0,001 mg/L
Nitrites ($N\text{-}NO_2$)	Até 1,0 mg/L	**	<0,001 mg/L
Sulfates (SO_4)	Até 250 mg/L	**	0,175 mg/L

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Parameters	Unit	Sample	V.M.P
Bacteria Heterotrophic	u.f.c/ml	03	500
Total Coliforms	NMP/100 ml	Out	Out

IV. CONCLUSION

This work showed an analysis of artesian wells, being the first located inside the Cemetery Parque Tarumã, and the second well in the external area. The choice of the well of the external area followed the flow of the first point analyzed. Water samples from sites where the groundwater level is closer to point 1 of collection, from the surface have higher pH, greater turbidity, less amount of dissolved oxygen than well 2 samples where at a distance of approximately 600 meters outside the cemetery. However, the number of samples collected is small to statistically evidence the risks, even if there is evidence of contamination, although the results indicate good groundwater quality.

Given the current legislation, it was contacted that a change in turbidity in the two collection points where the results of 4.00 UNT and 1.00 UNT show difference being this change due to the presence of particles suspended in the samples, such as sand, clay and microorganisms present, pH was shown in the first collection with low acidity of 5.51 and the second with 5.90 acidic waters for human consumption.

REFERENCES

[1] ALMEIDA, M.D. Parâmetros físico-químicos de caracterização da contaminação do lençol freático por necrochorume. Seminário de Gestão Ambiental: um Convite a Interdisciplinaridade. Instituto Viana Junior. Juiz de Fora; Minas Gerais, 2005.

https://dx.doi.org/10.22161/ijaers.611.67 *ISSN: 2349-6495(P) | 2456-1908(O)*

[2] AMORIM, X. T, Climatologia, Mudanças Climáticas, Desmatamento, trabalho de conclusão de curso Bacharelado em Ciências Ambientais: Impactos do Desmatamento Progressivo da Amazônia na Precipitação Do Brasil, 2017.

[3] BARROS, Y. J.; MELO, V.; et. al., Teores de metais pesados e caracterização mineralógica de solos do cemitério municipal de Santa Cândida, Curitiba (Pr). In Revista Brasileira de Ciência do Solo. Vol. 32, n. 4 Viçosa – MG Julho/Agosto. 2008.

[4] BIGUELINI, C. P.; GUMY, M. P. Saúde ambiental: índices de nitrato em águas subterrâneas de poços profundos na região Sudoeste do Paraná. Revista Faz Ciência, Cascavel, v. 14, n. 20, p. 153-175, 2012.

[5] BIGUELINI, C. P.; GUMY, M. P. Saúde ambiental: índices de nitrato em águas subterrâneas de poços profundos na região Sudoeste do Paraná. Revista Faz Ciência, Cascavel, v. 14, n. 20, p. 153-175, 2012.

[6] BRASIL. Agência Nacional de Águas (ANA). Lei de nº 9.433 de 8 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do art. 21 da Constituição Federal, e altera o art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989. Água subterrânea.

[7] BRASIL. LEI Nº 9.433, DE 8 DE JANEIRO DE 1997. Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos.

[8] BRASIL. MINISTÉRIO DO MEIO AMBIENTE. RESOLUÇÃO CONAMA Nº 357, DE 17 DE MARÇO DE 2005. Classificação dos corpos de água e diretrizes ambientais para o seu enquadramento.

[9] CAMPOS, A. P. S. Avaliação do potencial de Poluição no Solo e nas Águas Subterrâneas decorrente da atividade cemiterial. Universidade de São Paulo. Faculdade de Saúde Pública – São Paulo, 2007. Dissertação de pós-graduação em saúde pública.

[10] CARNEIRO, V. S. Impactos Causados por Necrochorume de Cemitérios: Meio Ambiente e Saúde Pública XV. Congresso Brasileiro de Águas Subterrâneas, Universidade Federal da Bahia. Departamento de Engenharia Ambiental, 2008.

[11] CARNEIRO, Victor S. Impactos Causados por Necrochorume de Cemitérios: Meio Ambiente e Saúde Pública XV. Congresso Brasileiro de Águas Subterrâneas, Universidade Federal da Bahia. Departamento de Engenharia Ambiental, 2008.

[12] CUNHA et al. Avaliação da Qualidade da Água do Aquífero Livre na Região do Cemitério Bom Jesus dos Aflitos, RUSSAS-CE, Brasil. Águas Subterrâneas, 2008.

[13] DUARTE, P.B. Microrganismos indicadores de poluição.52f. Monografia – Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Belo Horizonte, 2011.

[14] KEMERICH, P.D.C.; BORBA, W. F. A questão ambiental envolvendo os cemitérios no Brasil. Revista do Centro do Ciências Naturais e Exatas - UFSM, Santa Maria Revista Monografias Ambientais - REMOA e-ISSN 2236 1308 - V. 13, N. 5 (2014).

[15] LIMA. W. P. L. Parque Natural Municipal de Cabedelo: atividades humanas e impactos ambientais. Monografia apresentada a Universidade Federal da Paraíba, 2015.

[16] LIMA. W. P. L. Parque Natural Municipal de Cabedelo: atividades humanas e impactos ambientais. Monografia apresentada a Universidade Federal da Paraíba, 2015.

[17] LORENA, E. M. G.; Bezerra, A. P. X. G.; Sobral, I. G.; SANTOS, R. M. M.; Rolim Neto, F. C.; HOLANDA, R. M. Cálculo da evolução temporal de área degradada às margens do rio Tapacurá na Zona da Mata de Pernambuco, Brasil. Journal of Environmental Analysis and Progress v. 03 n. 01, 173-180, 2018.

[18] MATOS, B. A. Avaliação da ocorrência e do transporte de microrganismos no aqüífero freático do cemitério de Vila Nova Cachoeirinha, Município de São Paulo. São Paulo, Instituto de Geociências, USP, 2001.

[19] OLIVEIRA, B. R. F. Cemitérios: Impacto nas águas subterrâneas. 2009.120p. Dissertação (Mestrado em Engenharia do Ambiente) – Departamento de Ambiente e Ordenamento, Universidade de Aveiro, Aveiro, Portugal, 2009.

[20] PACHECO, A.; MENDES, J. M. B. Cemitérios e Meio Ambiente. Revista Tecnológica do Ambiente. Lisboa, Portugal, ano 7, n.33, p.13-15. 2000.

[21] MELO, F. P.; SOUZA, R. M. Modelagem Geofísica: Subsídios para Gestão Ambiental em Garanhuns-PE. In: MELO E SOUZA, R.; SANTOS, S. S. C.; SANTOS, E. A. (orgs.) Vivências e práticas socioambientais: metodologias aplicadas em comunidades São Cristóvão, SE. GEOPLAN/CNPQ/ UFS, 2015.

[22] ROCHA, C. M.; SANTOS, E. C. P.; SILVA, C. O. Espaço Urbano e Recursos Hídricos: Uma Análise dos Impactos Ambientais Causados pelo Cemitério Campo Santo José Augusto na Cidade de Ibateguara/AL. Geografia, Ensino & Pesquisa, v. 21, n.2, p. 174-187, 2017.

[23] ROCHA, R. Contaminação da água subterrânea por cemitérios: estudo de caso no Cemitério Municipal de Osório. - Porto Alegre: IGEO/UFRGS, 2017.

[24] ROSA, E. T. A relação das áreas de cemitérios com o crescimento urbano. Dissertação de Mestrado, Programa de Pós-Graduação em Geografia. Universidade Federal de Santa Catarina. 2003.

[25] SANTOS, A. G. S.; MORAES, L. R. S.; NASCIMENTO, S. A. DE M. Qualidade da água subterrânea e necrochorume no entorno do cemitério do Campo Santo em Salvador- BA. Revista Eletrônica GESTA, v. 3, n. 1, p. 39-60, 2015.

[26] SILVA, F. V. D. Avaliação da contaminação das águas subterrâneas por atividade cemiterial na cidade de Maceió, Biblioteca Digital Brasileira de Teses e Dissertações, 2012.

[27] WEBER, D. P. Análise da normatização acerca da implantação de cemitérios. 2010. 39f. Dissertação (Especialização em Gestão Ambiental) – Área de Ciências Naturais e Tecnológicas, Centro Universitá - rio Franciscano, Santa Maria, 2010.