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Definition of Critical Risk Factors in an Effluent Drainage Network Project Using AHP: A Case of Study

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Abstract High population growth and water quality are directly related to some critical factors in treatment plants and are often not perceived or ignored for prevalent economic reasons. The present study aims to present the risk factors that can influence the decision-making process in an effluent drainage network project. The available literature on risk analysis for this type of process is limited. Through questionnaires responses by specialists in the area in social networks. As a result, the most critical factor is a) possibility of reusing treated effluents, odor generation, interaction with the neighborhood and regional environmental legislation b) know the local legislation as the first condition for an effluent treatment project, it is important to note that differences in legislation often make it impossible to implement a treatment project that is successful in one state to another. c) study of interaction with the neighborhood must consider so that there are no problems with the existing Environmental Legislation to minimize the problems with people living near the effluent treatment plants. The conclusion is that the proposed method is an invaluable source for environment professionals and decision makers, in the sense that it augments their information on drainage network projects and help to identify critical risks factors and allow the implementation of actions to avoid project failure.

Keywords: Treated effluents; Reuse; Water Resources Management; Affinity diagram; AHP

1 Introduction

Effluent is waste from human activities, such as industrial processes and the sewage network, which are released into the environment, in the form of liquids or gases. Much of the existing drainage system in Brazil is obsolete and outdated. These systems were designed for an old reality, where they were less urbanized and waterproofed. The projects were not created based on the changes that could occur in society and, consequently, the networks that were designed are shown to be insufficient and unable to drain this flow of sewage and garbage in general. In this sense, errors or inconsistencies in the drainage network can harm the project or cause this project to be achieved by compensating the externalities parameter values. The process of drainage nets has been intensively studied in recent times (Fernández, 2013). From an economic point of view, it is also important to highlight the influence that the increase in treated volumes, due to excess risks, may represent in the management of treatment. Generally, the operating costs involved can turn out to be much higher than those expected values (Almeida, Monteiro, 2004).

After the decline of the Roman Empire, the population of countless cities in Europe and Asia decreases causing the abandonment of municipal services, and consequently, their deterioration (Saldanha, 2003). In the following centuries, strategies related to the design of urban drainage and sanitation networks have not undergone any relevant progress. In sanitary terms, a certain regression is allowed during the Middle Ages, as personal hygiene and cleanliness are not at all a concern of the population (Burian and Edwards, 2002).

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Only from the eighteenth century "being clean" assumes a distinguishing status, being only available for some very specific social classes (Burian and Edwards, 2002).

From the 1950s, Brazil went through an accelerated urbanization process. In the mid-2000s, 138 million Brazilians lived in urban areas (IBGE, 2000). Urbanization was carried out disproportionately across the Brazilian territory, so that only nine metropolises concentrate about 40% of the urban population in the country (IBGE, 2001). In the field of sanitation, the National Sanitation Plan (PLANASA) was created in the military regime in 1970. PLANASA's main guidelines were the centralization of the sector around the State Water and Sewage Companies (CEAEs), which are properly concessionaires contracted or agreed with the municipalities for water distribution and sewage collection and final destination. However, favelas are regions of municipalities that, throughout Brazil's history, have not been prioritized by these public basic sanitation policies (Gomes, 2009). Recently, there has been a new attempt to mobilize public opinion to stimulate public power to intervene repressively against favelas, controlling their expansion, or even, as has been seen in some cases, proposing their removal so that problems, as basic sanitation were reduced (Compans, 2007). Another curious fact is that the municipalities assisted by FUNASA (Fundação Nacional de Saúde), have resources from the Ministry of Health. However, in 1993, it assisted 625 localities, that is, 6% of Brazilian municipalities, serving about only, 5 million people (Costa, 2003).

The convergent aspect of the situation of basic sanitation in the favelas refers to the presence of vectors or reservoirs of diseases, such as rats, cockroaches, among others. This finding suggests that the lack of integration between basic sanitation actions that involve all related services, namely, water supply, sanitation, public cleaning, rain drainage and vector control of communicable diseases, have implications from a practical point of view. No matter how much progress is made in addressing the deficits in one of these services, deficiencies in another can cause the persistence of the problems to be tackled, such as the risks to public health resulting from the unhealthy environment (Gomes, 2009). For Heller (1989), the area of basic sanitation lacks an approximation with the public health perspective, visualizing its ends and not the means to achieve them and, thus, increasing the effectiveness of its actions. Drainage channels are the lines along which river processes act to transport water and mineral material from a local region, allowing gravity processes on the slopes to continue to diminish landscapes. Drainage networks are the basis for defining drainage basins, an essential component in hydrological models and resource management plans (O' Callaghan, Mark, 1984).

According to Collares (2000), the drainage system is an important indicator of the alterations occurred in the composition of the hydrographic basin environment, either due to changes in their structure and shape or due to channel loss and gain. The management entities responsible for the control, insertion and monitoring of the current drainage networks, have faced serious problems, associated with the occurrence of infiltrations, of an economic, structural and environmental (Coelho, 2013). For Coelho (2013), currently, infiltrations into drainage networks play an important role in the dimensioning of drainage network, including specific regulations for estimating these volumes, in case there are no real registers. The affluences are of particular concern improper or not accounted for at the time of the project. To assess the quality of drainage networks, quantitative parameters of both networks and reference drainage networks are necessary for their evaluation, in addition to the overlap of both networks for visual analysis (Fernández, 2013). The drainage network of a geographic region defines the drainage paths for water from rain according to the relief of the region (Santos, Francisco, 2011). Within the scope of water resources management, there is a shortage of globally applicable systems that reference, indicate and identify, in a unique and efficient way, the spatial organization of hydrographic basins and respective drainage networks (Silva, et al., 2008).

Unless the terrain is rugged, the derived water channels tend to flow in parallel lines in the preferred directions generated by grid orientation sampling. In addition to the presence of noise that creates artificial wells (Fairfield, Leymarie, 1991). There are problems that prevent the successful design of fully connected drainage networks, with a single line width: the positioning of the ends of the drainage networks; and the allocation of drainage directions, in particular the allocation of drainage directions through flat areas and in closed depressions in the wells (Tribe, 1992). Sanitary use generates waste that is mostly separated into specific treatments. Wastewater contains liquid and solid human excreta, various cleaning products, food waste, disinfectant products and pesticides. Human excreta, mainly, derive microorganisms present in the waste. Characteristics of industrial effluents are inherent to the composition of raw materials, supply water and the industrial process. The concentration of pollutants in effluents is a function of losses in the process or water consumption (Von Sperling, 1996).

The treatment processes to be adopted, their constructive forms and the materials to be used are considered based on the following factors: the regional environmental legislation, the climate, the local culture, the investment costs, the operating costs, the quality of the treated effluent, operational safety related to leaks of used chemicals or effluents, generation of odor, interaction with the neighborhood, possibility of reusing treated effluents (Giordano, 1999). The treatment systems must be used not only with the minimum objective of treating the effluents, but also to meet other premises. An important point to be noted is that unnecessary waste should not be generated by using the treatment (Giordano, 2003).

The sensory characteristics of the effluents are very important and may be the object of the authorities' attention. The odor in industrial effluents may be due to the exhalation of organic or inorganic substances due to fermentation reactions resulting from mixing with sewage, aromas, solvents and ammonia from the leachate. The color of the effluents is another characteristic confusingly controlled by the legislation (Giordano, 1999). The color in the environment is the apparent color, composed of dissolved substances and turbidity (Giordano, 2003).

According to Archela et al. (2003), Unless the terrain is rugged, the derived water channels tend to flow in parallel lines in the preferred directions generated by grid orientation sampling. In addition to the presence of noise that creates artificial wells (Fairfield, Leymarie, 1991). There are problems that prevent the successful design of fully connected drainage networks, with a single line width: the positioning of the ends of the drainage networks; and the allocation of drainage directions, in particular the allocation of drainage directions through flat areas and in closed depressions in the wells (Tribe, 1992). Sanitary use generates waste that is mostly separated into specific treatments. Wastewater contains liquid and solid human excreta, various cleaning products, food waste, disinfectant products and pesticides. Human excreta, mainly, derive microorganisms present in the waste. Characteristics of industrial effluents are inherent to the composition of raw materials, supply water and the industrial process. The concentration of pollutants in effluents is a function of losses in the process or water consumption (Von Sperling, 1996).

Pollution can be defined as any form of alteration of natural properties, whether physical, chemical or biological, that may occur in the environment. Thus, we must distinguish pollution from contamination, as this represents a potential risk to nature, and is therefore more harmful to the environment and human health. In several ways, water can affect human health: through direct ingestion, in food preparation; personal hygiene, agriculture, environmental hygiene, industrial processes or leisure activities (Fundação Nacional de Saúde, 2006). The pathogenic bacteria found in water and / or food constitute one of the main sources of morbidity and mortality in our environment. They are responsible for numerous cases of enteritis, childhood diarrhea and epidemic diseases, which can result in lethal cases (Fundação Nacional de Saúde, 2006). According to Mannarino et al. (2003), a well-known example of public health disorders that may result from the lack of good effluent treatment is the cholera epidemic that hit London in the 19th century. In addition, pathogenic substances, such as sulfates, have laxative and toxic properties, other elements, such as zinc, arsenic and cyanides, can cause serious problems to human health (FUNASA, 2004).

2 Objectives

Previous work listed important factors for the treatment processes to be adopted, their constructive forms and the materials to be used, however, none of the previous works listed response to the following question. RQ1: What are the critical factors for the treatment processes to be prioritized considering their externalities? This study can be a guide for professionals working in the process of treating effluents in different sectors on how to prioritize process factors. This work aims to define the critical factors that can influence the sewage treatment processes and the population and the environment around them and provide an assessment of them.

The methodological structure of the research was composed of the following steps: in Section 1 (Introduction) a bibliographic review was made on the chosen theme, in Section 2 (Methods) it is explained how the selection of critical factors was and there is an explanation of how the questionnaires developed to collect information from the interviewees and what was the criterion for determining the interviewees. Once the structure was established, it was possible to carry out a case study, shown in Section 3 (Results) of the participant observation type, using previously prepared questionnaires. Finally, in Section 4 (Conclusion) an analysis of the collected data and conclusions was carried out.

3 Methods

A literature search was done to identify the critical factors that could cause the effluent treatment process to be adopted and a field study was done to validate these factors with the professionals currently working with these processes. The research carried out for this study, carried out with Google Docs forms, was answered by experienced professionals in the field. This study aimed to obtain the degree of importance on the perspective of each professional on each of the externalities mentioned by Giordano (1999), the externalities were: the regional environmental legislation; the weather; the local culture; investment costs; operating costs, the quality of the treated effluent; operational safety related to leaks of used chemicals or effluents; odor generation; the interaction with the neighborhood and the possibility of reusing the treated effluents and the degree of importance varied between it was important, it has high importance, medium importance, low importance, being the “it is important” considered something that should not be left aside in any project and the other three (high importance, medium importance, low importance) expressed that it was important but not essential. Due to the elicitation of probabilities with specialists, one hundred questionnaires were answered and selected by different professionals (workers in different areas of the effluent treatment industry), these professionals were selected on the LinkedIn social network, taking into account the branch of the company they work or worked with, more than 10 years in the effluent treatment business and if they had an understanding of the treatment process.

4 Results

Based on the work of Giordano (1999), the critical factors considered were: regional environmental legislation; the weather; the local culture; investment costs; operating costs; aquality of the treated effluent; operational safety related to leaks of used chemicals or effluents; odor generation; the interaction with the neighborhood and the possibility of reusing treated effluents, it is worth mentioning that this study is of importance, both when making a project, and for a study of a project already ready and in operation. Due to the elicitation of probabilities with specialists, one hundred questionnaires were answered and selected by different professionals (workers in different areas of the effluent treatment industry), these professionals were selected on the LinkedIn social network, considering the branch of the company they work or worked with, more than 10 years in the effluent treatment business and if they had an understanding of the treatment process. According to them, with more than 76% of participants working in large companies, 20% in medium and 4% and in small companies and, as shown in Figure 1.

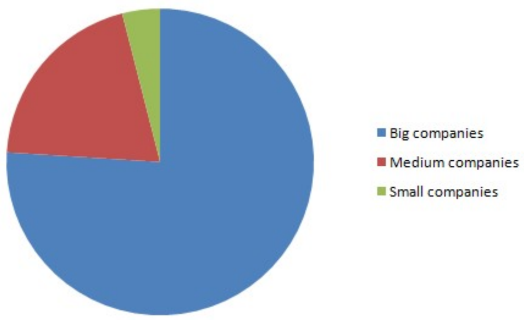

Figure 1: Percentage of employees in each company size
Source: The author

One hundred experts responded to the survey, they should answer whether each listed factor was important, it is of high importance, medium importance, low importance, the “is important” considered something that should not be left out of the project and the other three (high importance, medium importance, low importance) expressed that they were important, but not essential. The result, in percentage, can be seen in Table 1.

Risk Factors	s important	High Importance	Medium Importance	Low Importance
Regional Environmental Legislation	74	26	0	0
Climate	15	85	0	0
Local culture	5	26	34	35
Investment costs	27	16	42	15
Operational costs	61	22	0	17
Occupational Safety Relating to Leaks of Chemicals Used or Effluents	67	30	3	0
Odor Generation	88	11	1	0
Interaction with the Neighborhood	78	10	7	5
Possibility of reusing treated effluents	95	4	1	0

Table 1: Percentage of results
Source: The author

A graph was generated to better illustrate which of the factors were most important and should be prioritized in the effluent treatment process in Figure 2.

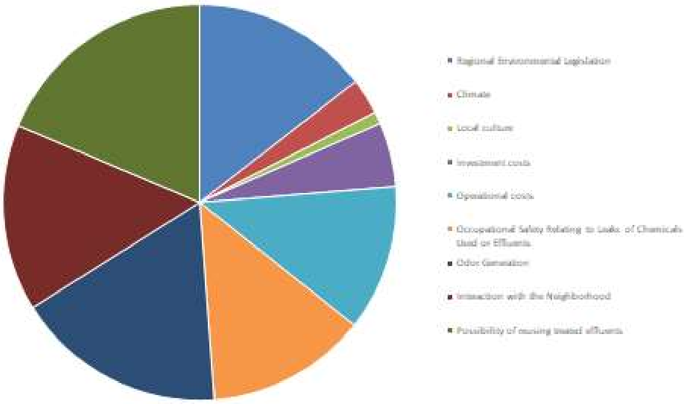

Figure 2: Percentage of results
Source: The author

For this study, only factors with percentages above 70% were considered to be of paramount importance in the “is important” column (first column of the percentages). The most important factor considered was the possibility of reusing treated effluents. The reuse of effluents can occur in potable and non-potable purposes. Drinking reuse generates high costs and can generate risks to human health and its practice is conditioned to situations of scarcity. Reuse for non-potable purposes occurs in the following activities: Agricultural (irrigation of edible plants or not); Urban (fire prevention, sanitary discharge, street washing, cooling towers, among others) (Giordani; Santos, 2003). The second factor considered as the most important was the generation of odor. Regarding odor, people's response to odors is variable, as shown in this research. This variability is the result of different odor perceptions (the perception varies due to different classes of odorant compounds). Furthermore, the fact of accepting or rejecting an odor depends a lot on previous experiences, on the circumstances in which it is felt, on the age, health and attitudes of the human recipient (Liliamtis; Mancuso, 2003). Care must be taken to choose the materials that will make the treatment, as they can influence the odor more than the effluents themselves. Another factor considered important was the interaction with the neighborhood. A good study of interaction with the neighborhood should consider: the establishment of parameters in case reforms are necessary for the feasibility of the project and environmental impact studies presenting proposals for environmental adjustments to make the project is feasible. Son after, the factor considered the most important was the Regional Environmental Legislation. Legislation is the first condition for an effluent treatment project, it is important to note that the differences in legislation often make it impossible to copy a treatment project that is successful in one state to another. A sewage treatment plant (ETE) may be sufficient to comply with the legislation of one state, but it does not meet all limits established by another state.

The parameters for controlling organic load are applied very differently, between some states. In the State of Rio de Janeiro, the assessment is made using the parameters of biological oxygen demand and chemical oxygen demand. Regarding the biological oxygen demand, efficiency is directly linked to the organic load in two ranges: up to 100 kg BOD / d 70% and above 100 kg BOD / d 90%. In relation to chemical oxygen demand, control is carried out by concentration, with a table in which the industry typology is the indicator (Giordano, 2003). With regard to metals, what varies between different state laws is the concentration of parameters.

5 Conclusion

In answer to the question, we have: the possibility of reusing treated effluents, odor generation, interaction with the neighborhood and regional environmental legislation as the most critical factors, considering externalities. Effluent reuse can occur in potable and non-potable purposes. Drinking reuse generates high costs and can generate risks to human health and its practice is conditioned to situations of scarcity and reuse for non-drinking purposes occurs in several areas and for different purposes. We can see that non-potable reuse may be more viable for companies that want to use this effluent reuse methodology.

Regarding odor, it is a more complex case due to the variable perception for everyone, depending on pre-existing experiences. A good study of interaction with the neighborhood must consider so that there are no problems with the existing Environmental Legislation and aiming at possible works or in case of accidents in order to minimize the problems with people living near the effluent treatment plants.

Knowing the local legislation is the first condition for an effluent treatment project, it is important to note that differences in legislation often make it impossible to copy a treatment project that is successful in one state to another. A sewage treatment plant may be sufficient to comply with the legislation of one state, but it does not meet all limits established by another state. The contribution to the scientific community is the detection of the most critical factors in the introduction of an effluent treatment plant. Each sector will be able to carry out the necessary actions prioritizing the most important factors. A future work would be a detailed study of each of the factors in different treatment plants.

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