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STUDY OF LEAK INTERFERENCE FROM THE RIO MADEIRA THERMOELECTRIC PLANT IN THE WELLS OF BAIRRO NACIONAL - PORTO VELHO/RO

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Abstract: Little is said about the constant occurrences of groundwater contamination by industries and plants, a fact that masks the reality of the families and the environment affected by them. This article aims to study contamination due to leakage of petroleum derivatives from the installations of the Rio Madeira thermoelectric plant located in the municipality of Porto Velho/RO, through collections of water samples from "amazonas" type residential wells and the carrying out of laboratory tests that allow the identification of the presence of such derivatives as well as carrying out a qualitative analysis of the water collected intended for human consumption. Through the study it was possible to identify a low concentration of petroleum derivatives, however with values outside the limit ranges for human consumption recommended by CONAMA number: 357 of March 17, 2005. This finding led the present study to propose alternatives for supply of the resident population and carrying out a bioremediation study to correct the problem of soil contamination.
Keywords: Groundwater, contamination, petroleum products, thermoelectric plant.

INTRODUCTION

Water is the most important means of subsistence for living beings, and everyone has the right to use it to supply basic needs in relation to the right to life advocated in article 5 of the 1988 Federal Constitution. However, the competent bodies of Each state or region has the role of responsibly managing the distribution and maintenance of the means used to supply drinking water to the population. Although the most used supply channels are carried out in surface mode, that is, through capture in rivers, lakes and dams, there is also the capture of groundwater, through artesian or semi-artesian wells, which are sources of use of less cost and necessary for some locations, aiming to make life easier for residents.

According to Silva (apud. Oliveira & Loureiro, 1998):

> "Groundwater has become an alternative source of water supply for human consumption. This is due to both the scarcity and pollution of surface water, making treatment costs, at potability levels, increasingly high. In general, groundwater is potable and does not require prior treatment, as the processes of filtration and purification of the subsoil promote the purification of water during its percolation in the environment, becoming a potential source of water of good quality and low cost, which can its exploration can be carried out in rural and urban areas."

Therefore, it is necessary to preserve groundwater, as once contaminated the cost will be higher and sometimes unfeasible for the sectors responsible.

A contaminated area is defined as a place, land or installation where there is a legitimate condition of pollution or contamination caused by the presence of quantities or concentrations of any substances or residues that have been deposited, disguised, concentrated, stored or infiltrated there accidentally, naturally or even even on purpose, waste that is in conditions that could cause harm to human health and the environment.

Milani, (2008) defines that the existence of contamination can cause problems in the following areas:

> "The existence of a contaminated area can generate problems such as damage to human health, compromising the quality of water resources, restrictions on land use and damage to public and private assets, with the devaluation of properties, in addition to numerous damages to the environment."

In a contaminated location there is a great possibility of pollutants concentrating in different physical environments causing great damage to the environment, such as in surface waters, soil, and even in the air we breathe. According to CETESB (2013), pollutants or contaminants have the capacity to be transported through different means, such as soil, air, groundwater and surface water, in order to modify the natural quality characteristics of the environment, bringing negative impacts and/ or risks to the assets to be protected, located in the area itself or in its surroundings.

It is important to highlight that the water components, their concentration and other parameters directly influence the type of treatment to be carried out. In the case of springs or wells, they are subject to local conditions regarding geology, climate and human activities. Therefore, the water treatment and analysis process must be adjusted according to its use, since the main concern with water quality is directly focused on human consumption. Therefore, the present work aims to study the area of hydrocarbon contamination that affects the quality of life of local residents, in order to classify the level of contamination of water from Amazon-type wells in homes in a limited region of the Nacional neighborhood of the municipality of Porto Velho.

METHODOLOGY

LOCATION AND STUDY AREA

The area of the present study is eminently urban and is located in the municipality of Porto Velho - Rondônia, in the Nacional neighborhood. At this point, facilities of the state's electricity distribution concessionaire, ENERGISA, are located, where the contamination occurs (Figure 1). It is worth mentioning that the contamination occurred prior to the administration of ENERGISA.

The Nacional neighborhood is classified according to the municipality's master plan as a ZPI2 (Igarapés Projection Zone), with a high population density, while the place where the contamination comes from is classified as a ZP (Port Zone). It is essential to highlight the importance of good quality of local groundwater due to the lack of water supply by the municipality in several parts of the neighborhood. Therefore, residents meet their basic needs by collecting water from Amazon wells, which are contaminated.

Figure 01. Rio Madeira Thermoelectric Power Plant in the Nacional neighborhood.

Source: Google Maps, (2021).

PHYSICAL, GEOLOGICAL, GEOMORPHOLOGICAL AND SOIL CHARACTERIZATION

The area in the immediate surroundings is the most affected as it receives all contamination, from this, the spread of contaminants will depend on the vehicles and media existing in the physical environment. To begin the study, it was necessary to determine the local characteristics, taking into consideration, the physical, geological and geomorphological aspects, since such aspects directly influence the way in which the polluting fluid behaves in the soil until it reaches the groundwater. Collecting the aforementioned information served as a crucial factor in determining sample collection points.

The Groundwater Information System – SIAGAS together with the well database in the State of Rondônia provided information that allowed structuring an action plan to collect water quality data from wells supplied by the water table contaminated by the leak, providing information such as chemical analyses, hydrogeological and geological information and the local construction profile, as shown in Figure 2.

DETERMINATION OF COLLECTION POINTS

The Porto Velho water supply system benefits 65% of the population, the municipality currently has 539,354 inhabitants (IBGE/2020), and the alternative used by residents is the use of groundwater, which is collected in Amazonian wells and tubular wells.

In order to find traces of contamination in the groundwater used to supply the population, a triangulation was carried out in order to capture 3 strategic ends around the leak, aiming to determine the points of greatest contamination and enable the study of the behavior of the polluting fluid.

Six sample collections were carried out, 5 (five) in Amazon wells and 1 (one) in a stream close to the affected properties. These collections were carried out in May/2021, a period falling within the Amazon winter. The previous assessment of contamination by the polluting fluid was based on the hydrogeological and geophysical characteristics of the local soil.

Figure 3 shows the location of the collection points, named as follows:

AS-1 - Surface Water from collection point1

AP-1- Well water from collection point 1

AP-2 - Well water from collection point 2

AP-3 - Well water from collection point 3

AP-4 - Well water from collection point 4

AP-5 - Well water from collection point 5

It is worth mentioning that the collection from nearby points is due to the local geomorphological difference, for example we have the AP-04 and AP-02 collection points, the AP-02 collection point is located at a higher altitude, making it Therefore, upstream of point AP-04, this choice was made in order to identify the possible percolation of the polluting fluid to higher locations. The same line of reasoning was adopted for points AP-01 and AP-05, considering point AP-01 upstream and point AP-05 downstream of the contamination.

Figure 03. Rio Madeira Thermoelectric Plant in the Nacional neighborhood.

Source: Google Maps, (2021).

LABORATORY ANALYSIS OF COLLECTED MATERIALS

The physical-chemical and microbiological analyzes of the collected samples were carried out in the FARO laboratory applying the procedures and standards in force for each parameter to be determined. Following water quality standards for human consumption and other areas (such as entertainment and industry) recommended by current regulations, oil and grease analyzes were carried out in the LAPEF laboratory - Laboratory Analysis of Water, Effluents, Soil and Petroleum Derivatives located in municipality of Porto Velho.

Field data were collected such as: Date and time of collection, occurrence of rain, geographic coordinates, nature of the well

Description:

Geological Formation:

Initial Depth(m):	Final Depth (m)	Type of Training:
0.00	48	Group Ji-parana

Lithological Data:

From(m)	Until(m):	Lithology:	Lithological description:
0	11.5	Sandy clay	Yellow sandy clay
11.5	43	Conglomeratic sand	Conglomeratic sand
43	48	Silt	Brownish gray silt

Aquifer at the point

Aquifer: Porous

Top(m)	
Base(m)	
Capture:	
Condition:	
Penetration:	

Water level:

Date:	08/03/1998
Water level(m):	6.3
Level Measured by Pumping(Y/N)	s
Flow rate (m3/h):	34.5

Figure 02. Report on geomorphological characteristics of the district: ``Nacional``.

Source: Groundwater Information System – SIAGAS

(Amazonian or tubular), static water level, name of the owner and address of the location. Among the physicochemical and microbiological parameters, the following stand out: pH, electrical conductivity, color, turbidity, and fecal and total coliforms. For oil and grease detection analyses, BTEX content and hydrocarbon index (TPH) tests were carried out).

To collect the samples in the field, sterilized plastic bottles (1L) were used, which were dropped to the static level of the well with the help of a nylon line in order to immerse it, allowing the water to enter the container, thus 1 liter of water sample was collected from each point studied and transferred to collection bottles made available by the laboratory. To check non-standard parameters, the limits adopted by CONAMA resolution: Fresh water, Section I – Art. 4, Class I – CONAMA RESOLUTION Number: 396, of April 3, 2008, which provides for environmental classification and guidelines, will be observed. for framing groundwater.

POPULATION SURVEY QUESTIONNAIRE

As a research tool, a questionnaire was used with open questions to residents of the homes selected for the study of their wells, aiming to collect informative data regarding the current condition of such local residents in relation to losses resulting from contamination. To this end, the following questions were asked:

1) How long have you lived there?

2) Are the residents of the residence aware of the oil leak?

3) Did you notice the presence of smell, color or flavor in the water?

4) Is there a history of flooding in the region?

5) How is the residence's water supply supplied? CAERD, Amazon-type well,

6) Artesian well, others…

7) Are there any histories of infectious diseases? (Vomiting, nausea, diarrhea, etc…)

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RESULTS AND DISCUSSIONS

According to the Ministry of Health Ordinance number: 2,914 of December 12, 2011, potability criteria are a set of values used as parameters for determining the quality of water supply for human consumption. The current work is of an investigative nature, determining the potability of the water samples analyzed and the pollutants derived from petroleum or coliforms present in them, as the parameters analyzed are sufficient to determine such quality and the risks to local planting and human health. The presence of inorganic chemicals in water samples was not analyzed as they were not relevant to the study.

Physicochemical parameters

Through tests carried out in the FARO laboratory, the following results were obtained (Table 1) regarding the physical-chemical parameters, namely: pH, electrical conductivity, color and turbidity.

PH (HYDROGENION POTENTIAL)

pH is a very important parameter, as it indicates the acidity or alkalinity of solutions. Through it, one can get a sense of the quality of industrial waste thrown into the water, as taught by SANTOS, 2013 (apud. Macedo, 2000).

The parameters adopted for the pH of water can vary from 0 to 14, identifying the acidity, neutrality or alkalinity of an aqueous solution, with a pH <7.0 being considered for acidic aqueous solutions, pH = 7.0 for neutral solutions and pH >7.0 for alkaline solutions. From this, a pH range between 6 and 9 is defined as a parameter for human consumption, as recommended by CONAMA N° 357, OF MARCH 17, 2005. *

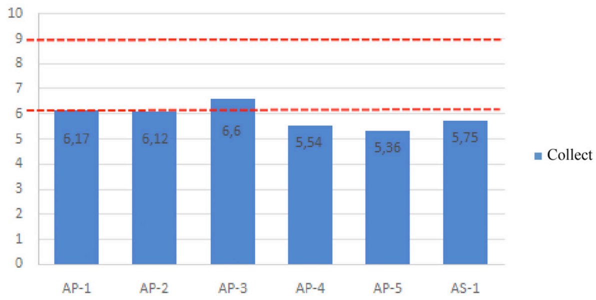


Figure 04. pH limit ranges as predicted by Conama and the respective results obtained

Source: Author (2021)

Regarding the pH of the collected samples, the results obtained indicate that the AP-04, AP-05 AND AS-01 samples are outside the pH range indicated in current legislation as shown in figure 4, presenting themselves in the acidic range below 6,0. The other samples analyzed comply with the pH range indicated in current legislation, these being samples AP-01, AP-02 AND AP-03, where they obtained a pH between 6.0 and 9.0. However, an average pH of 5.92 was obtained among the samples analyzed, consistent with the pH of groundwater in the Porto Velho region (CPRM, 2011).

Although practically all stages of water treatment depend on the pH obtained, such as in the processes of neutralization, disinfection, precipitation, among others, it is not decisive in classifying water as potable or not, as it does not present short-term harm to human health.

ELECTRIC CONDUCTIVITY

Electrical conductivity is the ability of an aqueous environment to conduct electrical current and is entirely linked to the content of salts dissolved in it in the form of ions. Although it is not possible to detect dissolved salts using this parameter, it is an indicator of the presence of polluting sources in the water. Electrical conductivity does not pose

PARAMETERS	UNID	AP-1	AP-2	AP-3	AP-4	AP-5	AS-1	CONAMA number: 396/2008
pH	-	6,17	6,12	6,6	5,54	5,36	5,75	6,0 - 9,0
ELECTRIC CONDUCTIVITY	µs/cm	75	113	125	29	112	72	-
COLOR	ppm	2,5	< 3	< 3	5	< 3	3	15
TURBIDITY	NTU	357	0,02	0,02	249	0,02	187	100

Table 01. Results of physicochemical parameters.

Source: Author (2021)

risks to human health, however it is through this parameter that it becomes possible to determine the concentration of total dissolved solids, where these can present health risks, since in excess, in addition to making the water unpleasant to the taste, It also allows the formation of kidney stones due to the accumulation of salts in the bloodstream.

Regarding the electrical conductivity resulting from the collected samples, there is no normative reference to be adopted for this parameter. In view of this, it is understood that the lower the electrical conductivity, the greater the possibility of the presence of organic materials (oils, greases, alcohol, phenols), as they do not conduct electrical current, and the higher the electrical conductivity, the greater the presence of salts in the sample.

It is verified that the AP-04 sample presented the lowest electrical conductivity (29 µS/cm), characterizing the sample with the greatest possibility of presence of organic materials when compared to the others, since such organic materials do not have electrical conduction capacity, being considered insulators. The samples AP-02, AP-03 and AP-05 obtained the highest electrical conductivity results, exceeding the range of 100 µS/cm, representing the samples with the highest concentration of salts and consequently the lowest presence of organic matter. Among the samples, an average of 87.66 µS/cm was obtained.

COLOR

Color is an aesthetic parameter of acceptance or rejection of the analyzed water, which aims to indicate the presence of substances dissolved in the water. According to Ordinance 2914/11 of the Ministry of Health, the maximum permissible color value in distributed water is 15.0 U.C. Therefore, all water samples analyzed are within the range indicated by current legislation, indicating an acceptable presence of organic matter or metals as shown in figure 5 below.

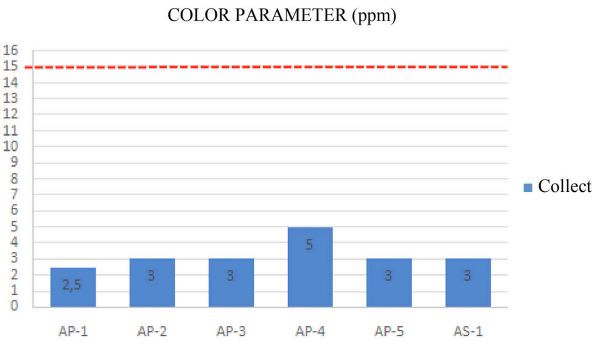


Figure 05. Limit range of the color parameter as predicted by conama and the respective results obtained.

Source: Author (2021)

TURBIDITY

Turbidity has broad importance in environmental monitoring, functioning as an indicator of pollution. According to Ordinance number: 2,914/011, the maximum value allowed for the turbidity of drinking water is 5.0 NTU. The greater the intensity of the scattered light, the lower the turbidity of the sample analyzed.

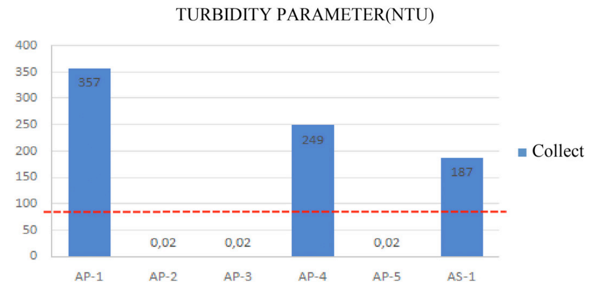


Figure 06. Limit range of the color parameter as predicted by conama and the respective results obtained.

Source: Author (2021)

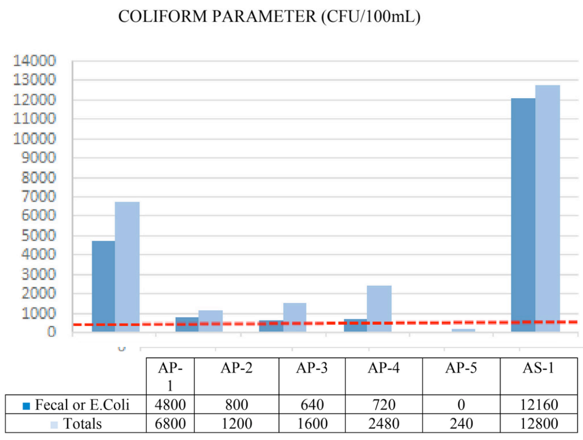
With regard to the results obtained in the analyzes it is possible to verify that the samples AP-01, AP-04 and AS-01 obtained values above those permitted by standard, this indicates that in these samples there is the possibility of a greater presence of solid matter in suspension in water, as well as clays, silts, and also the presence of organic materials, which is the focus of the present study. Samples AP-02, AP-03 and AP-05 have results within the limit range recommended by CONAMA, as shown in the table.

MICROBIOLOGICAL TESTS

Total coliforms are the most important indicators of water pollution, where such microorganisms are quickly detected by techniques that consist of the addition of enzymatic substrates for the detection of β-D-galactosidase, which indicates the presence of total coliforms, and ß-Dglucororonidase, which indicates the presence of E. coli. (Silva et al., 2013).

Total coliforms are considered environmental microorganisms, and indicate that the water may be in contact with some type of organic matter, which may occur due to the permeability of the walls of the collection wells, which are lined, for the most part, with conventional masonry without the presence of plaster, or waterproofing treatment on them. Although it is considered an indicator of water pollution, its use for evaluating fecal contamination is very limited. This is due to the fact that there are also bacteria of non-fecal origin in this SILVA group, (apud. BARBOSA; 11 LAGE; BADARÓ, 2009; DA SILVA et al., 2013).

Escherichia coli is a microorganism found in human and animal feces, commonly present in soil with fecal contamination, water and sewage. The presence of E. coli in the samples suggests that this water is unsuitable for human consumption, as these bacteria is an important cause of gastroenteritis SILVA, (apud. ALVES et al., 2008; SIQUEIRA et al., 2010; DA SILVA et al., 2013).



	AP-1	AP-2	AP-3	AP-4	AP-5	AS-1
Fecal or E.Coli	4800	800	640	720	0	12160
Totals	6800	1200	1600	2480	240	12800

Figure 07. Graph of microbiological analysis results

Source: Author (2021)

Of the total of 6 samples collected, all showed a large load of heterotrophic bacteria except sample AP-05, where there was no detection of fecal coliforms or E. Coli, however, in all samples, contamination by total coliforms was detected. Ordinance Number: 2,914/2011 establishes the microbiological standard of water for human consumption and determines the absence of positivity for total coliforms and Escherichia coli per 100

PARAMETERS	UNID	AP-1	AP-2	AP-3	AP-4	AP-5	AS-1	CONAMA number: 357/2005
COLIFORMS FECAL or E. Coli	UFC /100 ml	4800	800	640	720	0	1216 0	1000
TOTAL COLIFORMS	UFC / 100 ml	6800	1200	1600	2480	240	12800	-

Table 02. Results of microbiological analyzes.

Source: Author (2021)

PARAMETERS	UNID	AP-1	AP-2	AP-3	AP-4	AP-5	AS-1	CONAMA number: 396/2008
Benzene	mg/L	0,091	< 0,001	< 0,001	0,071	< 0,001	< 0,001	0,005
Toluene	mg/L	0,042	< 0,001	< 0,001	0,012	< 0,001	< 0,001	0,17
Ethylbenzene	mg/L	0,021	< 0,001	< 0,001	0,061	< 0,001	< 0,001	0,2
Total Xylene	mg/L	0,03	< 0,002	< 0,002	0,068	< 0,002	< 0,002	0,3

Table 03. BTEX analysis results.

Source: Author (2021)

PARAMETERS	UNID	AP-1	AP-2	AP-3	AP-4	AP-5	AS-1	CONAMA NUMBER 357/2005
Phenanthrene	µg/L	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	SVR / µg/L
Benzo anthracene	µg/L	0,002	< 0,005	< 0,005	0,001	< 0,005	< 0,005	0,05
Benzene pyrene	µg/L	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,05
Indene (1,2,3- cd) pyrene	µg/L	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,05
Styrene	µg/L	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,02
Dibenzo pyrene	µg/L	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	SVR / µg/L
Nastalene	µg/L	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	SVR / µg/L
Dibenzo anthracene	µg/L	0,01	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,05

Table 04. Results of hydrocarbon index analyzes.

Source: Author (2021)

mL of water samples analyzed. Therefore, with regard to microbiological analyzes, the water from these wells cannot be considered drinkable, according to Ordinance Number: 15 2914, of December 2011 (MS), since high values of fecal and total coliforms were detected. in all samples analyzed, exceeding the values set out in current legislation, as mentioned above.

BTEX CONTENT

As can be seen, the water samples analyzed presented values below the maximum limit of CONAMA resolution N°396, dated April 2008. However, concentrations of BTEX compounds were detected in all samples. Such results lead to the understanding that the situation regarding water contamination is not worrying, from an analytical point of view, however it is possible to visually identify a large presence of oils or greases on the surface of the water in the collection sites, as shown in figure 8, this presence of surface oils or grease prevents the entry of light and oxygen into the water, which can cause the death of aquatic species since their development and survival depend on sunlight. Correct inspection by the federal government and the responsible state agencies and continuous monitoring of pollution are extremely important to guarantee the integrity of the local environment, since the contamination under study by the Public Ministry was confirmed in 2020.

Figure 08. Visual detection of the presence of oil or grease on the surface of the collected samples. Source: Author (2021)

TOTAL TPH

Oils and greases are organic substances of mineral, vegetable or animal origin. These substances are generally hydrocarbons and their presence reduce the contact area between the surface of the water and the atmospheric air, thus preventing the transfer of oxygen from the atmosphere to the water.

As for the hydrocarbon index, there was detection in all samples and the results indicated low concentrations so that all analyzed samples are within the limit allowed by CONAMA, this shows that as well as the results obtained in the BTEX analyzes the situation regarding The contamination of water by hydrocarbons is not a concern, in terms of analysis, however, it is necessary to observe the occurrence of infectious diseases and neurological problems in families affected by contamination due to the detection of hydrocarbons, even if they fall within the limit ranges recommended by CONAMA.

QUESTIONNAIRE

Through the questionnaire, it was possible to inform residents about the history of contamination, from how it occurred to how it affects their lives. Questions were raised regarding residents' awareness of pollution, the incidence of flooding in the region, the presence of smell or taste in the water, the type of water supply used by the residence and the possibility of a history of infectious diseases (vomiting, nausea, diarrhea, etc...).

For the most part, the responses were similar. In all residences, residents were aware of the contamination and only one resident did not report the presence of a smell or taste similar to fuel in the well water. Furthermore, residents reported a long history of infectious diseases in the families affected after contamination., the fish that lived in streams close to the affected area died and local planting became deficient, causing great damage to the local area, due to it being considered a farmland area with a strong incidence of planting to support local families. Regarding the water supply by the local concessionaire, it is non-existent, where, according to the residents, the initial installations for the water supply were carried out, but the connection to the residences was not made.

SUGGESTIONS FOR MITIGATING RESIDENT PROBLEMS

The survey of water quality conditions in wells shows the impossibility of safe consumption. Therefore, this work evaluated the following mitigation proposals:

Drilling of artesian wells - Through a local survey of residents of the region who already had artesian wells on their properties and with confirmation of the veracity of the information by companies specialized in drilling of artesian wells in the municipality, it was found that the depth average water reach, +50m in depth in order to capture water that falls within the parameters foreseen for human consumption according to CONAMA Number 357 of March 17, 2005, is on average. Given this, quotations were obtained from municipal companies specialized in drilling artesian wells and the average cost for drilling per housing unit for the desired depth and study area varies between R$14,000.00 (Fourteen thousand reais) to R$16,000.00 (Sixteen thousand reais).

Interconnection of the concessionaire's distribution network, existing in the neighborhood, since they already have water distribution installations carried out by the local concessionaire (CAERD) but unfinished. There is also a reservoir installed in the neighborhood with a capacity of 3.5 million liters. Works to distribute water to the local population were suspended in 2018 and will resume in 2021.

III) Soil remediation for future use: after stopping the leak and removing the source of contamination, it is suggested to proceed with the recovery of the contaminated soil through bioremediation. In general, bioremediation is based on the biochemical degradation of contaminants through the activity of microorganisms present or added to the contamination site (Bernoth et al., 2000). According to Andrade (2010), soils naturally contain numerous microorganisms with varied metabolic capabilities and may become capable of efficiently degrading different contaminants, such as oil and its derivatives. However, in some cases, soil contamination by these substances has become a global problem, mainly due to the difficulty of rehabilitating the contaminated area. The high cost of carrying out such a study and implementing it must be taken into consideration, as the minimum period for obtaining valid positive results can take years.

FINAL CONSIDERATIONS

Regarding the form of household water supply, of the five wells monitored, Amazonian wells are the only form of water supply in 100% of the residences used for the study, with no water supply from the public network. It is worth mentioning that to meet the needs of residents, the company responsible for the spread of pollution has temporarily provided drinking water from its facilities to local residents through a temporary installation. The condition of the building, sanitation and location of the well are important factors directly related to the health of final water consumers, especially children who are more susceptible to water-borne diseases.

Data analysis regarding BTEX did not present values that exceed the potability limits imposed by CONAMA number: 396, with the worst contamination situations being found in the AP-01 and AP-04 samples and the most favorable situations being found in the AP samples. -02, AP-03, AP-05 and AS-01, such differences in values in nearby locations are due to local geology, since samples AP-02,03,05 and AS-01 are located at points of higher altitudes, making it difficult for the polluting fluid to percolate as it is unfavorable to gravity.

Even if values above the limit predicted for the analyzes of BTEX content and hydrocarbon index were not detected, this is the focus of the present study, and in addition to the possible visual detection of the presence of oils and greases in the surface layer of the collected waters, through the other parameters analyzed, it was possible to conclude that there are several sources with polluting potential that allow the water from the wells studied to be characterized as unfit for consumption. In a macro view of all the parameters studied, the collection points AS-01, AP-01 and AP-04 are determined to be the most critical in terms of microbiological, physical-chemical and the presence of petroleum derivatives.

To this end, based on the results obtained, it is possible to carry out a long-term study regarding the feasibility of using bioremediation processes on site, aiming at natural soil correction. However, if there is a need for rapid intervention, the proposed solution is the drilling of artesian wells for the affected families, resulting in an average cost of R$14,000.00 to R$16,000.00 reais. Furthermore, Amazon-type wells must be deactivated and grounded, making it impossible to use water unfit for human consumption.

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