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GOOD WATER, BUT FOR WHOM? A STUDY ON THE PERCEPTION OF WATER QUALITY BY AMAZONIAN POPULATIONS

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ABSTRACT: In Brazil different regions have inadequate water and sewage treatment facilities, which can be made worse by the installation of large enterprises. The perception of these populations about the scenario in which they live is of great relevance in this context, the present study has the objective of analyzing the socioenvironmental profile and the perception of the water quality and its relation to health damage by populations resident from the area of Belo Monte hydropower plant. A cross-sectional study was conducted with 268 residents of two cities in the interior of Pará-Brazil and the data were obtained from the application of a semi-structured questionnaire. The results showed that the interviewees had minimal education and were low income. Most interviewees reported having running water in their home. However, 63.1% of the interviewees considered the water provided as organoleptically altered and of poor quality. Of the interviewees, 92.5% stated that their water is mainly from wells; 94.8% perceived a relationship between decreasing water quality and increasing health problems. Of these, 85.2% related to the decrease in water quality with renal problems, 75% with liver problems and 28% with hypertension. About 61.6% of respondents reported concerns about lack of basic sanitation. It is concluded that the populations studied understand the importance of quality water consumption and relate water quality to health problems. Therefore, these results serve as an alert to managers regarding the urgent need to improve the quality of life of this population.

Keywords: Pará, sewage systems, drinking water, health, chronic disease.

RESUMO : No Brasil, diferentes regiões têm instalações inadequadas de tratamento de água e esgoto, o que pode ser agravado pela instalação de grandes empresas. A percepção dessas populações sobre o cenário em que vivem é de grande relevância neste contexto, o presente estudo

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tem como objetivo analisar o perfil socioambiental e a percepção da qualidade da água e sua relação com danos à saúde por populações residentes da área. da usina hidrelétrica de Belo Monte. Um estudo transversal foi realizado com 268 moradores de duas cidades do interior do Pará-Brasil e os dados foram obtidos a partir da aplicação de um questionário semiestruturado. Os resultados mostraram que os entrevistados tinham educação mínima e baixa renda. A maioria dos entrevistados relatou ter água encanada em casa. No entanto, 63,1% dos entrevistados consideraram a água fornecida como organoléptica- mente alterada e de má qualidade. Dos entrevistados, 92,5% afirmaram que a água é proveniente principalmente de poços; 94,8% perceberam uma relação entre diminuir a qualidade da água e aumentar os problemas de saúde. Destes, 85,2% relacionaram-se à diminuição da qualidade da água com problemas renais, 75% com problemas hepáticos e 28% com hipertensão. Cerca de 61,6% dos entrevistados relataram preocupações sobre a falta de saneamento básico. Conclui-se que as populações estudadas entendem a importância do consumo de água de qualidade e relacionam a qualidade da água a problemas de saúde. Portanto, esses resultados servem de alerta para os gestores quanto à necessidade urgente de melhorar a qualidade de vida dessa população.

Palavras-chave: Pará, sistemas de esgoto, água potável, saúde, doença crônica

INTRODUCTION

Water is one of the most important elements of the planet and its presence is a determining factor for the biodiversity and organization of populations. The importance of water is invaluable and is considered an economic and social good that must be distributed equally to meet the needs of mankind [1,2]. According to Article 25 of the 1948 Declaration of Human Rights [3], all people have the right to an adequate standard of living to ensure their well-being and that of their family members. This right includes mandatory conditions for good quality of life such as drinking water and basic sanitation [4,5]. However, despite the importance of drinking water and basic sanitation in the environmental, social and public health spheres different countries have not yet been able to provide these conditions for their population [6].

In Brazil, different regions have a lack of basic sanitation and a lack of quality drinking water [7]. However, the northern and northeastern regions are the most affected [8], due to numerous factors such as the absence of water and sewage treatment systems, the presence of hydropower plants, unfavorable climatic conditions,

environmental contamination and low socioeconomic status in the region [9–12]. Exposure to all these factors can cause damage to resident populations at these sites such as kidney, heart and hypertension [13–16].

In the northern region of Brazil there is a large ecological and hydrological importance due to the presence of the Amazon basin, which is considered the largest river system in the world (7,008,370 km²) [17]. The Amazon Basin has a large variety of rivers [18] and among its main tributaries was the Xingu River. This river was characterized, until 2013, by having clear, transparent waters and containing high quality of surface water due to its high debugging power [17,18]. Therefore, with the construction of the Belo Monte hydroelectric plant [19], this quality scenario may have declined due to changes in the hydrological regime resulting in changes in the hydrossocial cycle and hydroeconomics of these areas [17,20]. These changes can directly influence and cause environmental and social vulnerability in the populations living in the impacted area [21,22].

In socio-environmentally vulnerable populations the perception about the surrounding environment is fundamental to expand positive discussions that promote the modification of the vulnerability scenario [23]. One of the factors to improve environmental quality of life may be related to the perception of the population about drinking water quality and its health implications [24]. The perception about the quality of water for human consumption has been the subject of countless studies in different countries [10,25–29]. In Brazil, the perception of water scarcity and quality was evaluated, and a large part of the interviewees showed a concern and distrust regarding the water quality received [30,31].

No study attempted to relate the perceived cause of disease among sick and non-diseased subjects and the perception of water quality. In addition, after the implantation of the Belo Monte Plant, few studies have analyzed the impacted area [21,32–35] and none of them attempted to relate the scenario before and after its insertion. Therefore, the objective of this study was to analyze the socioenvironmental profile and the perception of the water quality related to the health damages presented by the residents of the area of insertion of the Belo Monte hydropower plant, located in the interior of Pará - Brazil.

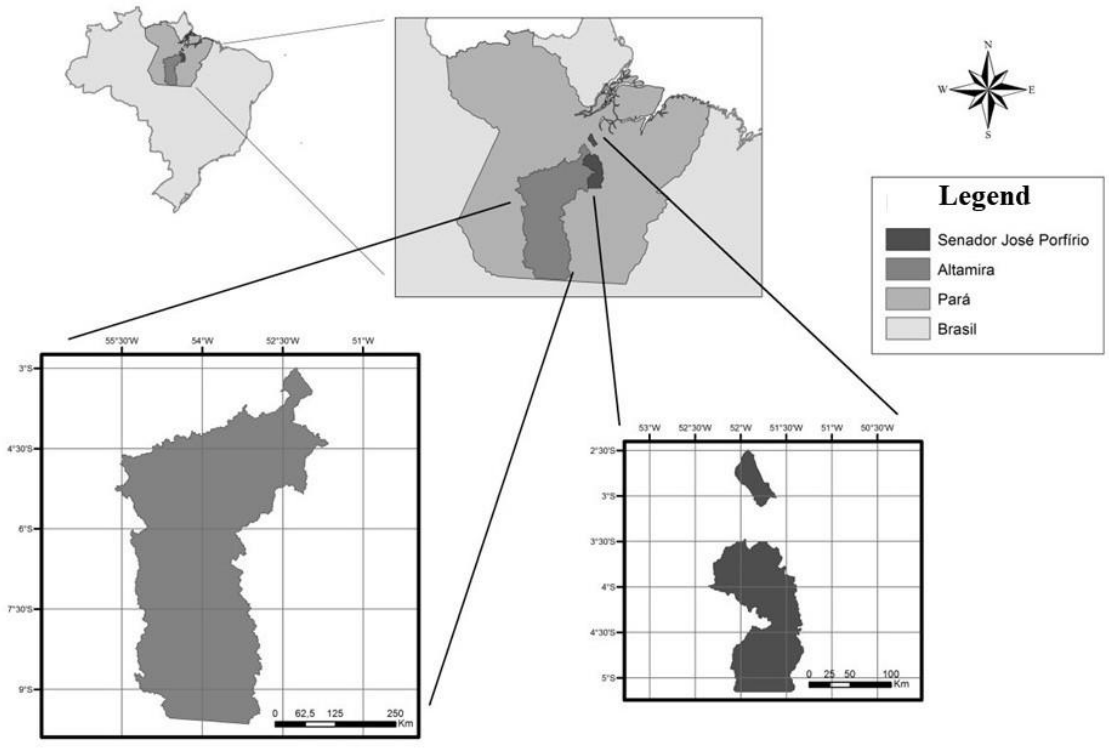
MATERIALS AND METHODS

Study area

The municipality of Altamira (Figure 1) is in the center-west of Pará, near the banks of the Xingu River, to which is inserted the 3rd largest hydroelectric plant in the world, the Belo Monte plant [36]. Altamira is considered one of the largest municipalities of territorial extension of Brazil, covering 159,533,730 km² and contains an estimated population of 106,768 thousand inhabitants [37]. Its human development index in the municipality is 0.665 [38].

The second county studied was Senador José Porfirio (Figure 1), also situated near the riverbanks of Xingu, and having a territorial area of 14,419,916 km² and a population of approximately 12,075 inhabitants [37]. According to the Brazilian Institute of Geography and Statistics (2010), the sewage collection and the human development index of this municipality (HDI) are 0.514 [38].

Figure 1. Location of the cities studied (Altamira and Senador José Porfirio).



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Individuals and sampling

This was an observational and cross-sectional study conducted in two neighboring municipalities located in the state of Pará, northern Brazil. The sample calculation for categorical variables with a significance of 5% resulted in a sample of 246 participants, however the total sample included 268 participants (N = 155 from Altamira and N = 113 from Senator José Porfírio). Eligibility criteria were: residents of the cities studied, 18 years of age or older and men and women with physical and mental ability to respond to the questionnaire.

Ethical aspects

This study was submitted and approved by the Committee of Ethics of the University Federal from Pará/Nucleus of Medicine Tropical (NMT), under number 811,807.09.29/2014.

Data collection

Data collection was carried out randomly in 2014, with municipalities divided into census tracts and the number of activities listed in each sector respected the representativeness of the population. Within each sector the houses were chosen at random. Only one inhabitant in each residence visited was interviewed. During the year of 2014, the collections were carried out during the months of May (days 29 and 30), June (days 04, 06, 07, 09, 25, 26 and 30), July (from days 1 to 08 and days 14 to 18), August (days 18, 19 and 26), September (days 20 to 26 and days 29 and 30) and October (days 1, 06, 07, 10, 14 and 15).

The instrument used was a closed and semi-structured questionnaire, following the method of [12]. Part of the structure questionnaire is in accordance with Brazilian Association of Companies of Research [39]. The instruments contained questions regarding socio-demographic, socioeconomic, health conditions and perceptions about water quality, basic sanitation and human health. In addition, the interviewees were questioned if they perceived a direct relationship between water quality with heart disease, renal and hepatic dysfunction, hypertension and diabetes.

Statistical analysis

The sample was calculated, and the questionnaire was coded in Epi Info 6.0 software. After coding, the data consistency check was performed on the frequency of

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the information collected to correct the errors. All the data collected in the two cities were analyzed together. For the analysis of the results, participants who did not answer a question or who did not have formed opinion were not considered. The chi-square or Fisher's exact test was applied to compare the differences between the municipalities regarding the perception of water quality and health conditions. Statistical analysis was performed using the STATA 14.0 software.

RESULTS

In according to Table 1 most of the respondents were female (74.6%) and in the age group between 30 and 59 years (81.0%). Among the survey participants, 66% lived in a stable environment with their spouse 79% were literate, or had at least some skill in reading and writing, although possessing a level of education less than or equal to 3 years (35.4%). 79% have elementary, middle, or upper level educations. Those participants indicating that their education was functionally illiterate' group, along with those who indicated they only knew how to sign their own name. A large part of the population was employed, whether formally, with a signed work permit, or informally – self-employed (86.9%), and living with an income that ranged from half to one-and-a-half the contemporary minimum wage, the Brazilian equivalent to US $236.30 - $354.95 (49.8%) in a month and compounding the economic class C1 (35.1%) according to Brazilian standards established by ABEP [40].

Still, it was observed that the families studied had more than three children (51.9%) and had been living for over 20 years in the municipality (45%), the majority (61.6%) in brick houses featuring bathrooms with drainage inside the houses (82.1%). A large number (96.7%) of the houses had pits and sinks in which to deposit waste, leaving 3.3% with neither pit nor sinkhole. Only 0.4% reported to have treated wastewater, 1.5% reported having to deposit their waste in creeks, and 1.4% used other means not specified. A large part of the respondents (98.1%) reported having water piped to the house originates from an artesian well (47.4%).

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Table 1. Socio-economic and socio-environmental characteristics

	N	%		N	%
Sex			**Married**		
Men	68	25.4	Yes	179	34
Woman	200	74.6	No	89	66
Age			**Spouse literacy**		
18 – 29	83	31	Yes	132	73.74
30 – 59	134	50	No	20	11.17
≥ 60	51	19	Just sign	21	11.73
Ethnicity			Can not answer	6	3.35
White	49	18.3	**Children**		
Mixed	187	69.8	No	30	11.2
Black	32	11.9	1 – 2	99	36.9
Education level (years)			≥ 3	139	51.9
			Time living in		
≥ 9	84	31.3	**the municipality** (months)		
4 – 8	88	32.8	0 – 59	27	11.3
≤ 3	95	35.4	60 – 240	104	43.7
Literacy			> 240	107	45
Yes	211	79	**House stuff**		
No	27	10.9	Brickwork	165	61.6
Just sign	29	10.1	Timber	103	38.4
Work			**Discharge toilet**		
Yes	233	86.9	Yes	220	82.1
No	35	13.1	No	48	17.9
Salary in R$			**Septic and non-septic tank**		
> 788,00	22	8.2	Yes	257	96.7
788 - 1.182	133	49.8	No	11	3.3
< 1.182	112	41.9	**Piped water**		
Economic class ABEP			Yes	263	98.1
Class A	4	1.5	No	5	1.9
Class B1	14	5.2	**Water suply**		
Class B2	49	18.3	Public company	9	3.3
Class C1	94	35.1	General well	121	45.1
Class C2	91	34	Artesian well	127	47.4
Class D – E	16	6	Others	11	4.2

In the cities of Altamira and Senador José Porfírio, most of the population reports having access to piped water ($p \leq 0.05$) (figure 2. A), with 67.4% of the water distributed by the Company for Public Water Supply. However, despite receiving piped water, the source of water offered in the two municipalities differs. The city of Altamira provides treated water supplied by a general network of supply. The use of water from

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artesian wells by less than half (47.4%) of its population was observed in the municipality of Senador José Porfírio ($p \leq 0.001$).

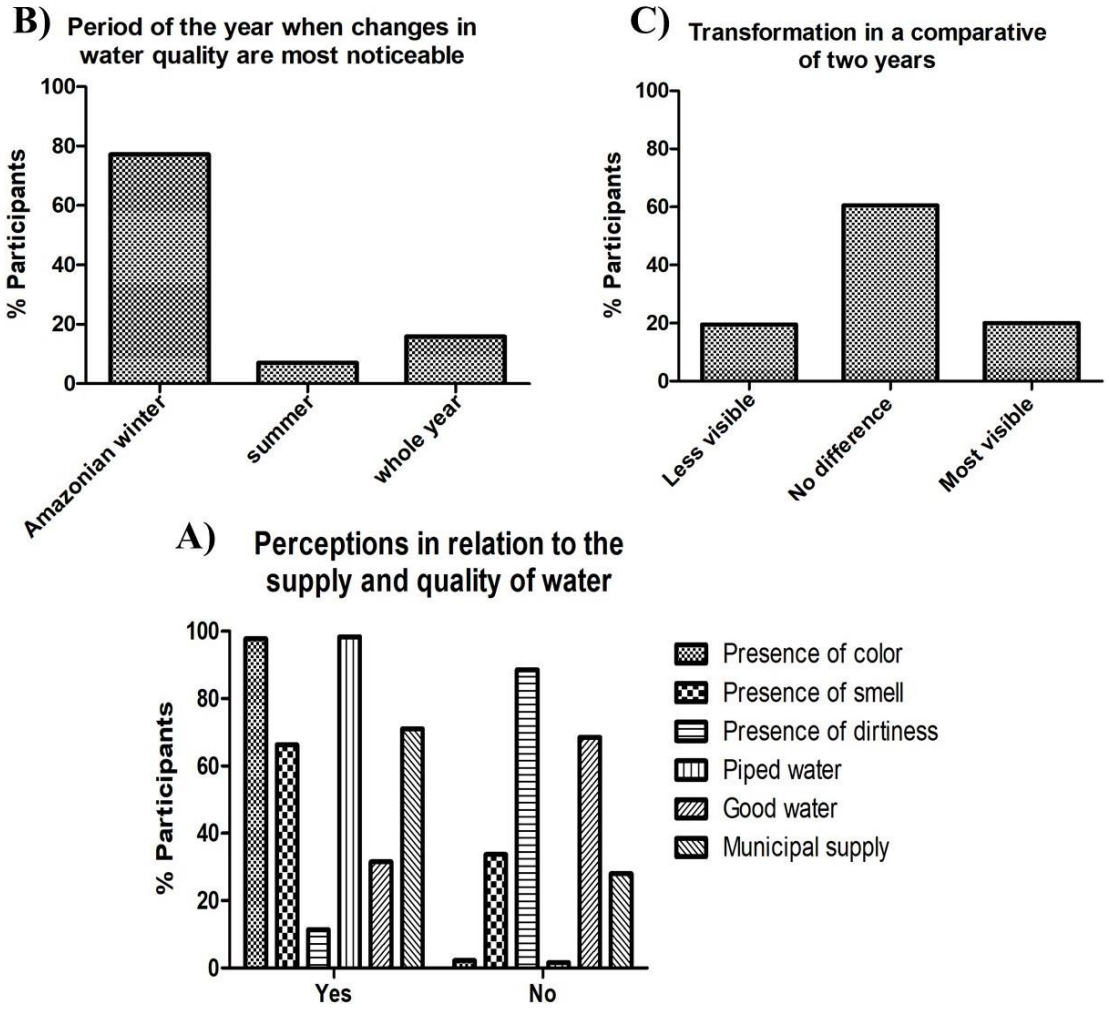
Table 2. Perceptions in relation to the supply and quality of water between the counties of Altamira and Senador José Porfírio.

	Altamira		Senador José Porfírio		P
	N	%	N	%	
Have Piped water					
Yes	150	96.8	113	100	0.07*
No	5	3.2	0	0	
Municipal supply					
Yes	69	44.5	111	99.1	< 0.001*
No	86	55.5	1	0.9	
Water quality					
Good	5	7.2	61	55.5	< 0.001
Bad	64	92.8	49	44.5	
Transformation in a comparative of two years					
less visible	4	11.1	12	27.9	< 0.001
No difference	26	72.2	21	48.8	
Most visíble	6	16.7	10	23.3	
Palate or color differentiated					
Yes	61	88.4	42	39.3	< 0.001
No	8	11.6	65	60.7	
Presence of color					
Yes	60	98.4	33	97.1	1.00*
No	1	1.6	1	2.9	
Presence of smell					
Yes	42	68.9	21	63.6	0.06
No	19	31.1	12	36.4	
Presence of dirtiness					
Yes	2	3.4	6	19.4	0.018*
No	57	96.6	25	80.6	
Period of the year					
Amazonian winter	36	63.2	51	91.1	< 0. 001
Summer	5	8.2	3	5.4	
Whole year	16	28.1	2	3.6	

P value considered through the chi-square test
* P value considered through the Fisher's exact test

The residents of the two municipalities stated that the water offered had changed in its organoleptic characteristics (Table 2), making the residents consider it unfit for consumption ($p \leq 0.001$) and of poor quality ($p \leq 0.001$) (figure 2. A) . During the time of year when the Amazon River is at its fullest (between November and March), the changes in the water quality are reported as more noticeable (77.0%, $p \leq 0.001$) (figure 2. B). The population perceived changes in color and in taste ($p \leq 0.001$), especially when referring to the taste or presence of dirt ($p = 0.018$) (figure 2. A). When residents compared the present quality of the water with that of the past 2 years, 58.2% did not realize a difference ($p \leq 0.001$) (Figure 2. C).

Figure 1. Perceptions in relation to the supply and quality of water



Also considered was the perception of the interviewed sick and non-diseased regarding the relationship between health problems and the quality of water

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(Table 3). In this context, the studied populations perceived that the changes evidenced in the water can bring health risks (94.8%, $p \leq 0.006$). The relevant percentage statistic of the respondents claimed that the quality of water was associated with hypertension, and 51% of those who had the illness not related the problem with the quality of the water ($p = 0.024$). Approximately 88% of the respondents with liver disease relate the problem with the quality of the water ($p = 0.011$). Most respondents (92.5%) related kidney disease to the quality of the water; 98% of those with renal diseases reported this association ($p = 0.005$).

Table 3. Relationship between the perception of health problems caused by water quality and prevalence of disease from the period up to 12 months prior to the data collection.

Variables of health	Water quality				P
	Relate		Don't relate		
	N	%	N	%	
Hipertension					
Yes	24	49	25	51	0.025*
No	50	30	117	70	
Heart diseases					
Yes	2	33.4	4	66.6	0.656
No	71	36.7	122	63.2	
Kidney diseases					
Yes	48	98	1	2	0.005
No	177	87	26	13	
Liver diseases					
Sim	22	88	3	12	0.011
Não	156	73.3	57	26.7	
Diabete					
Yes	5	38.5	8	61.5	0.540*
No	61	30.5	139	69.5	

P value considered through the Fisher's exact test

*P value considered through the chi-square test

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DISCUSSION

The development of the Belo Monte hydropower plant, despite the economic impact of the proposal, triggered social problems during and after its insertion [33,41]. This study, despite limitations such as the lack of multivariate analysis and the only survey of the participants reports, outlined a profile of the populations that coexist with the installation of an enterprise capable of causing socioenvironmental disorders. Therefore, in the results it is possible to identify the vulnerabilities of the studied population as the low levels of schooling and economic and the lack of treatment of water, sewage and adequate supply. In addition, the participants perceived poor water quality, changes in water quality between the evaluated periods and that these modifications can lead to damages to health. Due to the importance of the theme and the area studied this survey can be the starting point for the creation of public policies aimed at equity and quality of life of this population.

Some of the socio-environmental issues that occur in Altamira and surrounding municipalities are intrinsically related to deficiencies in public management, financial resources and population growth [35,42,43]. Samples of water from the urban area of Altamira and surrounding municipalities were evaluated in the period prior to plant insertion and had already indicated high contamination by *E. coli* and different ions [17]. However, the sum of these factors may have overlapped with the installation of the Hydroelectric Plant [22]. In addition, less than half (48.4%) of the population of Altamira had continuous water supply (every hour, every day) and the rest contained alternate supplies [44]. These past and present deficiencies may explain why a large part of the studied population consumes untreated well water (underground).

The use of groundwater by artesian wells is a medium used by the Brazilian population to consume water, due to its low cost and easy catchment, although it is vulnerable to contamination [45]. However, these wells can be improperly drilled, potentiating the contamination of the water by different ways [46,47]. As an aggravating circumstance the municipalities studied do not provide garbage collection services, adequate treatment of sewage and for this reason a large part of the population has septic systems in their residences. Due to this, the exposure scenario that this population is exposed shows even more worrying, since different studies have already reported that

septic systems can contaminate groundwater severely and cause damages to consumers' health [47–49].

The perception about water quality and preference as to its source are themes that are widely evaluated and discussed mainly in regions that present water scarcity or low economic and urban planning conditions [31,47,50]. The results of the present study were similar to those of the others studies, considering water as low quality and perceiving changes in the color and presence of odor, taste (similar to chlorine or metallic) and suspended solid particles [31,50]. Results contrary to those of Giatti.et al., (2010) who evaluated the population of Manaus, northern Brazil, which considered the water distribution as good quality. Also, in the formation of perception, the variation in the level of schooling between studies should be considered, since a low level, as in the studied population, may result in the lack of knowledge of their rights and duties in relation to drinking water [10].

The perception of the population about the impacts of hydroelectric projects on the quality of water for consumption and its relationship with health damage is still a poorly evaluated scenario [51,52]. Concern about health risks related to changes in water quality was evident in the municipalities studied. In addition, participants relate poor water quality to chronic diseases that cannot be transmitted, such as hypertension and kidney and liver disease. These perceptions are extremely positive from an epidemiological and environmental point of view, since knowledge of risks is an initial tool for risk management and planning of any type of intervention [53]. In addition, different studies associate poor water quality for consumption or its contamination by trace elements with the chronic diseases perceived and related by the study participants [14–16]. Therefore, the agreement between perceptions and experimental studies show the importance of perceptions mainly by socially and environmentally vulnerable populations.

In the Belo Monte hydroelectric power plant project there was an explicit description that its development would ensure rights such as water supply network, sewage network and sewage treatment plant in Altamira [54]. However, until the data collection period of the study, these demands had not been met for the population. Together with the collection of the rights provided for these populations, it should also reassess the availability of water resources in the territory of the Brazilian Amazon, due

to its wide available water resources [43]. Thus, quality water for consumption and basic sanitation is a duty and a commitment to public health, since populations without access to these services are at greater risk of developing health problems [11,23,29]. Also, consider that the responsible bodies have a duty to provide garbage collection and education for the social well-being of the population and environmental conservation.

CONCLUSION

It was concluded that the studied populations suggest the poor quality of the water for consumption and that the quality deteriorates according to the time of year. Despite low schooling and low income, the interviewees understood that water quality and basic sanitation are related to the appearance of diseases. Therefore, new studies are needed to verify the water quality of the artesian wells used for consumption by this population. In addition, the Critical Scenario on untreated water consumption and lack of sanitation serves as an alert and a duty for public managers and managers of the Belo Monte hydroelectric power plant. Thus, aiming at the health of the population, only through investment in the demands of water and sewage treatment, the precarious scenario demonstrated in the present study can be reversed.

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