Groundwater quality:Study of the Nitrate(NO3-) concentration in the Urban Area of the Brazil/Bolivia Border

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Abstract— *Objective: To analyze the quality of groundwater potentially impacted by nitrate (NO3-), before and after the flooding of the Madeira River, in two urban areas of Rondônia on the Brazil / Bolivia border. Method: Data and water samples were collected according to Standard Methods for the Examination for Water and Wasterwater (APHA, 1998) together with the methodology proposed in the Water Sample Collection and Preservation Environmental Sanitation – CETESB. The place were georeferenced using the Global Positioning System (GPS). For nitrate measurement, the spectrophotometry method was used using the Spectrophotometer, brand Micronal B495, the chemical reagents used were made by Alfatecnoquímica and available in two vials called reagents 1 and 2 (nitrate reagent). Results: In the first large area of risk in 100% of samples, high levels of N nitrate (NO3-) were detected. > 10 mg / L. In the second area in 30% of the samples were detected NO3 content higher than 10mg / L. Conclusions: The population is consuming water with a high degree of nitrate contamination. It alerts itself to a public health issue.*

Keywords— *Groundwater quality, Nitrate, Contamination.*

I. INTRODUCTION

In the State of Rondônia, groundwater represents an important resource in human supply. Of the total water that the Water and Sewage Company of Rondônia (CAERD) produces, 35% originates from the underground spring. Groundwater, as it is a low-cost alternative, is accessible to all, especially the low-income population, both in daily supplementation and in the total

replacement of water provided by the public and private service (CAMPOS, 2003).

Another aspects that are highlighted are: Inefficiency of basic sanitation services and lack of sanitary sewage in the urban area. The inefficiency of these services forces the local population to build black and septic tanks for effluent deposition within the immediate vicinity of their land (MELO JUNIOR et al., 2006), which in practice, this process translates into contamination of groundwater.

According to Barbosa (2005), the lack of a sewage collection network leads the population to adopt the use of septic tanks or sinks. The inadequate fate of domestic and industrial sewage causes the degradation of the underground spring by the leaching of organic and inorganic contaminants. Most of these contaminants reach the shallow water table, and can also reach the deep or artesian water table.

Nitrate occurs naturally in groundwater, but its presence in high concentrations is a result of human activities, mainly to the use of in situ sanitation systems, the nitrogenous substances of organic waste are oxidized by chemical and biological reactions and the result is the presence of nitrate in soil. Nitrate is extremely soluble in water and can move easily and contaminate the aquifer at long range due to its persistence and mobility. It is observed the power of contamination present in this chemical agent, once present in the soil or directly in the water has very easy to contaminate the groundwater.

Nitrate (NO_3^-) is a colorless, neutral, strong, oxidizing and water soluble ion, corresponding to the final ratio of biological stabilization of nitrogenous organic matter. It is the most common contaminant found in groundwater. Like Foster & Hirata (1993) cite, its concentration rarely exceeds 5 mg / L in non-polluted waters and concentrations above 10 mg / L represent a strong indication of contamination in the waters. In addition to the use of agricultural fertilizers and livestock, in situ sanitation systems, whether by septic tanks or rudimentary pits, are another important source of nitrate in groundwater. Due to the hazardous nature of this chemical agent, the lack of planning in the construction of each individual sanitation system (well x pit), allows the contact of the effluent from the well with the well water.

Baird; Cann (2011) corroborates the findings when they state that the inorganic contaminant of greatest concern in groundwater is the nitrate ion NO_3^-, which normally occurs in aquifers in rural and suburban areas. Nitrate in groundwater originates mainly from four sources: fertilizer application with nitrogen, as well as inorganic and animal manure, in plantations; soil cultivation; sewage deposited in septic systems and atmospheric deposition.

The legislation on the quality of drinking water in Brazil, at Ordinance no. 518/2004 of the Ministry of Health and the World Health Organization is exhaustive: "Water containing concentrations greater than 10 mg / L of nitrogen (N) in the form of nitrate (NO_3^-) is unfit for human consumption".

Concentrations above 3 mg/L of nitrogen in the form of NO_3^- are indicative of contamination due to anthropogenic activities, also indicators of bacterial contamination and fertilizers. A safety alert for the health of people who are subjected to such a situation.

At concentrations above than 10mg/L NO_3 -N, may cause methemoglobinemia and cancer. Nitrate, in particular, can reach groundwater and watercourses, causing diseases by the consumption of contaminated water (infant cyanosis or methemoglobinemia and stomach cancer) and environmental damage, such as eutrophication. For Baird and Cann (2011), excess nitrate ion in drinking water is worrisome in causing newborns to blue baby syndrome; and in adults, according to research, may be responsible for causing stomach cancer, and increasing the likelihood of breast cancer in women (BAIRD, CANN, 2011).

Like previously stated, in high concentrations, nitrate is associated with methemoglobinemia or blue-baby syndrome, which makes it difficult to transport oxygen into the bloodstream of babies, which can lead to asphyxia. In adults, internal metabolic activity prevents the conversion of nitrate into nitrite, which is the agent responsible for this disease. It is now known that nitrites, under certain conditions, can be combined with secondary amines, forming nitrosamines, products which are considered carcinogenic, teratogenic and mutagenic according to experimental tests performed on animals. Some studies relate statistically to gastric cancers and cervical cancers with excessive nitrate intake (BRASIL, 2008).

II. METHODOLOGY

Data and water samples were collected according to Standard Methods for the Examination for Water and Wasterwater (APHA, 1998) along with the methodology proposed in the Guide to Collection and Preservation of Water Sample of the Company of Environmental Sanitation Technology - CETESB.

The wells and water collection points were registered and some important variables such as age of the well, depth, hygiene conditions, cesspools, sewage, animals and others were registered.

The points of water collection for analysis were given in the urban area of two Amazonian municipalities, one state capital and another in the border area with Bolivia. 10 collections were made in each pre-defined area. The first area of risk of flooding and that appeared

with high concentration of nitrate and the second area far from the area propitious to flood. We will not puncture the exact places of water collection, so as not to stigmatize or stereotype the inhabitants of these places with higher nitrate concentration, according to the ethical principles of the research. These data are preliminary. Other elements that are being analyzed in the research: fluoride, chloride, nitrite, phosphate, sulfate and still can be extended to lithium, sodium, ammonium, potassium, calcium and magnesium. In addition, the wells and water collection points for analysis after flood and flood were the same as previously collected.

III.   RESULTS AND DISCUSSION

In the first large area of pre-flood / flood risk in 50% of samples, high levels of N nitrate (NO3-) were detected, above 10 mg / L, characteristic of waters with a high degree of impaction. Water not suitable for human consumption. 40% had a content> 3 mg / L, at 50%> 10 mg / L, the total contamination of the aquifer becomes evident. And after the flood / flood of the area the degree of contamination rose in a frightening way.

As shown in Table 1, high levels of N nitrate (NO3-) were detected in 100% of samples > 10 mg / L were detected 80% of the wells and collection points. PA57 calls attention with levels of 156.74, PA 51, with 70.08; PA54 at 67.36; PA59 at 63.27 and PA56 at 56.67. All characteristic of waters with high degree of impaction. The selected sites for water collection are urban areas of environmental risk for human health, a public health issue. Just to elucidate some points of reference, the surrounding graveyards, health units, streams that became an open pit, accumulation of houses in poor infrastructure conditions, the use of Amazonian well water and tubular wells without maintenance and near the black and septic septic tanks are conditioning and / or determinant for this scenario.

Table.1: NO3 concentration before and after flood (Situation I) Cadastral data of wells and water collection points and N-NO3 content (mg / L).

Amostral Point	Before	After
PA51	16,31	70,08
PA52	2,98	5,66
PA53	9,96	10,77
PA54	10,36	67,36
PA55	7,89	11,27
PA56	12,74	56,67
PA57	43,68	156,72
PA58	9,94	14,66
PA59	23,27	63,27
PA60	3,6	4,96

According to Table 2 in these points of water collection that did not have a direct influence by the flood / flood, the levels of nitrates did not undergo significant variations. In this area, 30% of the samples detected NO3 content higher than 10mg / L. Water not suitable for human consumption. In 70% of the samples, water content higher than 3 mg / L was detected, which characterizes water with a high degree of impaction, although it is not close to the results found in the areas of situation I, area affected by flooding.

Table.2: NO3 concentration before and after the Flood (Situation II) registration data from wells and water collection points and NO3-N concentration (mg / L)

Amostral Point	Before	After
PA21	5,54	**5,58**
PA22	5,56	**5,52**
PA23	1,27	**0,97**
PA24	**10,9**	**10,7**
PA25	2,45	**2,52**
PA26	**14,54**	**13,47**
PA27	**16,36**	**16,22**
PA28	4,5	**4,2**
PA29	2,77	**2,79**
PA30	3,27	**3,31**

Lima (2008), when investigating the groundwater of the aquifer Free Jaciparaná, in zone 3 of Porto Velho, before the event flooding of the Madeira River and consequently flooding of some urban areas of the city of Porto Velho, found it partially contaminated by nitrate.

In thirty of the ninety wells surveyed, that is, 33% of the water samples detected nitrate levels above or very close to the limit of 10 mg / L, the maximum value allowed in Brazil for water intended for human consumption, according to Administrative Rule #518 of March 25, 2004 from the Ministry of Health. In 68 wells, representing 68% of the samples, levels higher than 3 mg / L were identified, indicating changes in the chemical composition of the water by anthropogenic activities. The sampling points, the shallow wells, used in this study, 100% have depth up to 12 meters.

According to Lima (2008) this situation is identified with the concepts proposed by Hirata et al. (1997) on densely populated areas with an on-site sanitation system. This practice constitutes the main sources of nitrogen in the environment, due to the large number of pits. Campos (1999) em pesquisa em Mirante da Serra, também em Rondônia, found the predominance

of high levels of nitrate (NO3-) in the most densely populated areas. The low depth of the wells, the situation of sub-outcropping and predominance of latosols, extremely porous material; and, due to the high rainfall in the region, favors the leaching process. In addition to the precarious protection, the wells are susceptible to varying surface influences.

According to Varnier & Hirata (2002), even the pit being far from the well, around ten meters, commonly observed length, does not differentiate the degree of impaction in groundwater.

It is important to consider that, in case of presence of nitrate in the water, even in low concentrations, besides indicating that the contamination is old in the environment, it reveals the presence of organic matter associated with bacteria, viruses and parasites, alive or in some of the stages of decomposition. These agents cause several diseases, especially acute diarrhea and, in the form of nitrate, is a carcinogenic indicator (LIMA, 2008).

In part, this high contamination index was expected to be found in almost all of its totality, considering that these areas are used as effluent receptors, do not have a sewage collection network and the effluents produced by the population are released into the soil, streams and in septic and black septic tanks.

The studies by Alaburda & Nishihara (1998) are references regarding the population's health concern, especially the health of children and the elderly, because they are more susceptible to the development of methemoglobinemia due to exposure to water with a high concentration of nitrate and in adults the stomach cancers. Health impairments such as diarrheal diseases and gastroenteritis are commonly reported and recorded in the health care system of the counties surveyed.

IV. FINAL CONSIDERATIONS

Therefore, it can be stated that the sites surveyed are largely contaminated with nitrate. The main constraints are as sources of contamination to the anthropic and multi-point action of the in situ sanitation system, type septic tank and black cesspits, exposure and precariousness of the wells, exposure of solid waste, sewage disposal of all nature. Allied to all these conditions the flooding / flooding in this case were determinant to aggravate the contamination of the water table. The population is consuming water with a high degree of nitrate contamination. It alerts itself to a public health issue.

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