Urban gardens and the risk to human health: Possibilities of contamination through irrigation water

Hortas urbanas e o risco a sáude humana: Possibilidades de contaminação por meio da água de irrigação.

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1 INTRODUCTION

Considered the most abundant compound on our planet, water is indispensable for the survival of living beings (SELBORNE, 2002).

Great civilizations rose on the banks of the waters. Sumerians, between the Tigris and Euphrates rivers, Egypt, whose lands were fertilized by the waters of the Nile River, the Indus Valley Civilization where India and China are located, watered by the waters of the Yellow River.

Privileged by the proximity of water, rivers allowed these civilizations fertile lands, irrigation and the use of water for the most varied activities and needs of man.

Abundant but finite, water on the face of the earth has been gradually penalized over the centuries by human action, contributing to the reduction of quality water on the planet.

For Gonçalves (2008), the advance of cities towards the banks of rivers, streams, springs and aquifers puts both the quantity and quality of water at risk.

The human activity of exploitation of the planet as industries, urban growth and disordered cities and the advance to the banks of rivers, deforestation of riparian forest, mining, extensive livestock, agribusiness, exploit, pollute and undermine the amount of water on earth making it scarce and unsuitable for human health. (PHILIPPE JR, 2008).

Sometimes the scarcity, the increase in production and the high cost of water requires the use of water of dubious quality in activities that require special care, such as food production (ALMEIDA, 2010); (UNESCO, 2017).

2 OBJECTIVE

The present study was motivated by the hypothesis of contamination of vegetables by irrigation with water from urban streams of dubious quality. In this context, the objective was to investigate the possibility that the water used in the irrigation of urban vegetable gardens in Araguaína does not meet the quality standards stipulated by the legislation, and may cause health problems to the population consuming vegetables.

3 METHODOLOGY

The methodology consists of collecting water samples used in irrigation of vegetables from urban gardens of Araguaína near streams impacted with domestic sewage discharges. Water samples were collected from streams and wells; main sources of irrigation through properly sterilized glass containers and subsequent analysis of the material in the laboratory by the *Standard Methods for the Examination of Water and Wastewater* for the determination of biological indicators in drinking water using the Presence and Absence (P/A) method with LST broth.

. For microbiological analysis parameter was used reference of Total and Thermotolerant Coliforms, presence of *Escherichia coli.*

The samples were collected on 11/26/2018 at 08:00 am and then sent for analysis, which took place in the early afternoon hours of 11/26/2018.

A water sample was collected from each of the defined garden points: P1 and P2. The samples were collected in stream and well type cacimba that are formed by slope, rain or water table. For the collection procedure, sterilized glass vials were used and handled with protection of procedure gloves.

Point P2 consists of a shallow cacimba type well with 3m depth and 2m diameter and P1 is the Jardim/Maracanã stream (Figure 04 and 05).

Figure 4: P2 - Shallow well, cacimba type

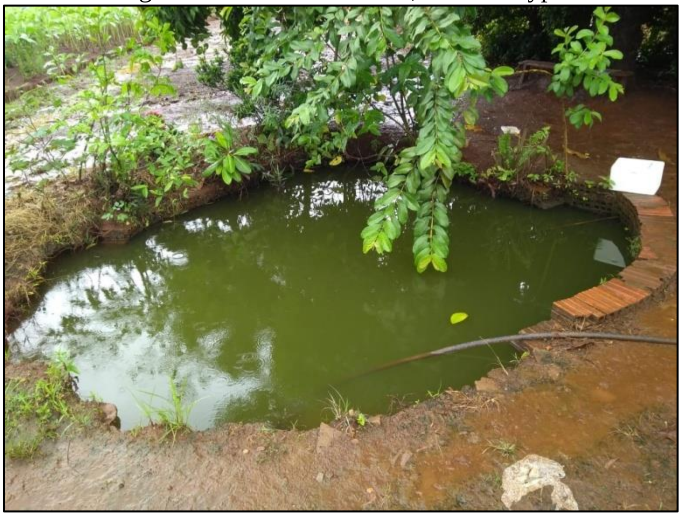

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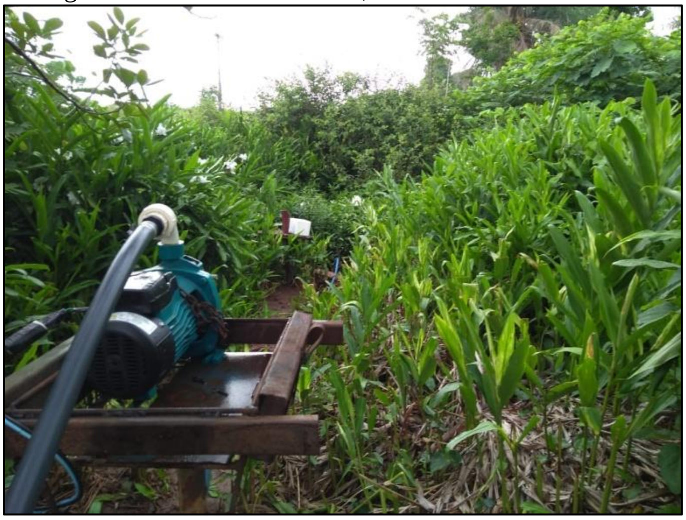
Figure 5: Water catchment P1, Jardim/Maracanã stream.



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The samples collected were stored in a previously sanitized Styrofoam box with ice cubes to keep the samples stable. The time between collection and analysis was 6 hours.

Two samples of irrigation water were collected, one from each half of the main irrigation source of each enterprise. The collected waters are intended for irrigation of vegetables, and the main buyers of these products are the residents, passers-by of the neighborhood and neighborhood fairs and the municipal market of Araguaína-TO.

After collection, the samples were packaged and transported to the laboratories of the Federal University of Tocantins - UFT, Araguaína-TO Campus for analysis.

The method for the assessment of microbiological water quality was based on the Standard Methods for the Examination of Water and Wastewater for determination of biological indicators in drinking water by the Presence and Absence (P/A) method with LST broth.

3.1 QUANTIFICATION OF TOTAL COLIFORMS (TC)

Total coliforms were quantified using the multiple tube technique with the determination of the most probable number (MPN), with a series of 10 tubes according to the Practical Manual of Water Analysis - 2013 and Ministry of Health Ordinance No. 2,914 of December 12, 2011.

3.2 PRESUMPTIVE TEST

It consists of inoculating 10 portions of 10 mL of the water sample into tubes containing Lauryl Sulphate Broth (CLT). After inoculation, incubate the samples at 37º C for 24/48 hours. Acidification of the medium with presence or absence of gas in the Duran tube is the presumptive result for the presence of coliform bacteria.

3.3 CONFIRMATORY TEST

It consists of transferring each tube of the positive presumptive test to 2% Brilliant Green Bile Broth (VBBL). After inoculation, incubate the samples at 37°C for 24/48 hours. Gas production is a confirmatory result for the presence of coliform bacteria.

3.4 TEST FOR DIFFERENTIATION OF THERMOTOLERANT COLIFORMS (*E. COLI)*

It consists of transferring each positive presumptive test tube into EC Broth. After inoculation, incubate the samples at 44°C for 24 hours.

3.5 ISOLATION OF *E. COLI*

Samples positive in the differentiation assay are streaked onto plates containing Macconkey agar and incubated at 37º C for 24 hours. After inoculation, typical colonies are transferred to tubes containing TSI agar and further incubated at 37º C for 24 hours. positive results for *E. coli* are submitted to confirmatory biochemical tests: citrate, indol/SIM, methyl red, urea, glucose, lactose and sucrose.

3.6 FACULTATIVE AEROBIC MESOPHILE COUNT

The standard plate count technique is used, where 1 mL of each water sample and their respective dilutions (10-1, 10-2,10-3,10-4,10-5 and 10-6) are transferred to individual petri dishes and then added to pre-melted PCA agar. After homogenization and solidification, the samples are incubated at 37º C for 24 hours and then the colony count is performed. The number found is multiplied by the dilution factor, and the result expressed in Colony Forming Units per milliliter (CFU/mL).

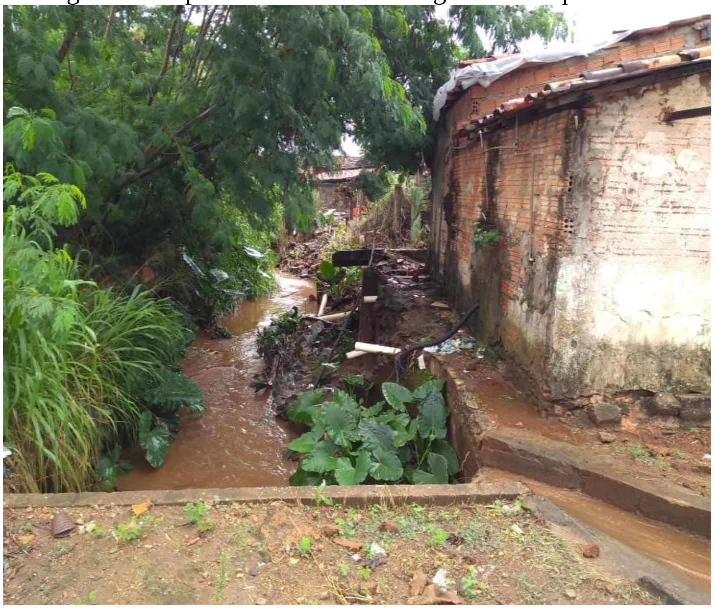
4 DEVELOPMENT

Located in the northern region of the state of Tocantins, the municipality of Araguaína has an area of 4,000.416 km2. Created on November 14, 1958 by state law n0 2.125, located in the northern region of the state (figure 1), between the coordinates of 070 11'28 "south latitude and 48º 12' 26" west longitude, with an average altitude of 277 meters.

According to the 2010 census of the Brazilian Institute of Geography and Statistics (IBGE), the Municipality of Araguaína has 150,484 inhabitants with an estimate of 186,245 people for 2021. (IBGE 2021). Located on the banks of the Lontra River, Araguaína is intersected by several streams that also comprise the Araguaína Hydrographic Basin, including the rivers: Preto and Lontra; the streams Lavapés, Prata, Raizal, Xixebal, Cará, Jacubina, Tiúba and Jacuba; and the Ribeirão de Areia, all located in the perimeter of the city (PMAE,2013).

Among those already mentioned there are other small tributaries that make up the hydrographic network of Araguaína. We highlight the Tanque and Jardim streams, also known as Maracanã, object of this research. Araguaína's hydrographic network receives solid waste, domestic and industrial sewage, treated or not along its bed, which can contaminate surface water, groundwater and wells.

Figure 1: Disposal of domestic sewage into Tanque stream



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According to (SILVA and ARAÚJO, 2003, p. 1020.), "(...) domestic and industrial sewage industrial in cesspools and septic tanks, the improper disposal of solid urban and industrial waste, gas stations and washing and the modernization of agriculture compromise water quality."

On the banks of the streams of Araguaína there are several small enterprises in the field of vegetable production. These vegetable gardens are irrigated with water from adjacent streams and wells. The production of vegetables is marketed in free fairs and food businesses in the city of Araguaína-TO.

With the advent of the formation of cities, the challenge of water supply for the population also arises. There is evidence in Portugal about the use of water spaces since the eleventh century, but the first compiled on the subject dates from 1430, in this writing there are prohibitions and norms aimed at proper use, avoiding pollution, outlining policies that ensured the quality and sanity of water spaces in the city of Lisbon, therefore a speech focused on the cleaning of the urban space related to the control of pestilences (GONÇALVES, 2017).

The first action of the United Nations, in order to evaluate in a global and coordinated way the issue of the environment, seeking answers to existing problems and trying to define future lines of action, was at the United Nations Conference on the Human Environment, held in 1972 in Stockholm, Sweden. In 1983 the World Commission on Environment and Development was constituted, this Commission in 1987 presented its report entitled "Our Common Future", this became the basic reference for the organization of the United Nations Conference on Environment and Development (UNCED), which took place in Rio de Janeiro in June 1992 (BRAZIL, 2011).

The Federal Constitution of 1988, in its article 23, items II, VI, VII and IX establishes the common competence of the Union, the states, the Federal District and the municipalities to care for health, protect the environment, promote improvements related to basic sanitation, and combat pollution by preserving forests, fauna and flora. In Article 200, items II and VIII, it defines the execution of "Sanitary and Epidemiological Surveillance actions" to the Unified Health System (SUS), in addition to collaborating in the protection of the environment. And in article 225, it guarantees everyone the right of common use to the ecologically balanced environment, as well as the duty to preserve it for future generations (BRASIL, 1988).

The most relevant environmental problem in Brazil is undoubtedly water pollution, where 80% of total waterborne morbidities and approximately 30% of deaths are directly linked to contaminated, untreated and poor quality water (BRASIL, 2013).

We cannot treat natural water as an entirely pure substance, due to the presence of organic substances, atmospheric gases, traces of minerals and metals, for example, in rainwater. This precipitated water forms underground and surface springs, incorporating and dissolving organic substances, minerals and microorganisms (QUEIROZ, 2018).

Water is the imperative natural expedient for the maintenance of all living beings. Useful for human consumption if drinkable, because it will not offer risks to the individual in relation to his health, being used for personal and environmental hygiene, for the preparation of food and ingestion (BRASIL, 2011; SOUZA, 2000).

In large cities, there is a deficiency in the supply of piped water, of good quality for consumption and in sufficient quantity, transforming the habit of users and forcing them to ration or look for alternative sources, such as wells, streams, cisterns, cacimbas among others and even rainwater. In the rural area this reality is accentuated, because the public power does not reach them or even take note of the basic sanitation conditions, leading the residents of the region to seek alternatives, these being non-potable sources (QUEIROZ, 2018).

SUS managers emphasize the relationship between the health status of a specific community and sanitation actions as fundamental. Thus, it is essential to evaluate morbidities related to sanitation activities or the lack of an adequate structure, such as inadequate or lack of: sanitary sewage, final disposal of waste, water supply, housing, drainage and inadequate or non-existent sanitary conditions (BRASIL, 2011).

Specifically, the ingestion of contaminated, non-potable water is directly associated with the state of illness of human beings and communities. These diseases are commonly found in regions with low socioeconomic status, where there is a lack of sanitation (especially treated water and sewage), malnutrition, low level of education, and the quality of personal hygiene and food is deficient (PEDROSO; OLIVEIRA, 2007).

Waterborne, foodborne and sanitation-related diseases are as follows: Botulism, Cholera, Acute Diarrheal Disease (ADD), Foodborne Diseases (FBD), Typhoid Fever, Rotavirus, Verminosis, Teniasis, in addition to Viral Hepatitis A and E, most of these diseases have as mode of transmission the oral-fecal route (TOCANTINS, 2017).

According to (*SNIS 2016)*, more than 3.5 million Brazilians, in the 100 largest cities in the country, dump sewage irregularly, even though they have collection networks available. Generally the disposal of wastewater, gray is done in rivers streams and lakes.

The irregular dumping of domestic sewage into rivers and streams is not the privilege of the 100 largest cities alone. Araguaína enjoys the same reputation, after all becoming open sewage is the fate of every watercourse invaded by disorderly urbanization.(figure 2)

The Brazilian standard NBR 9648 (ABNT, 1986) defines sanitary sewage as the "liquid discharge consisting of domestic and industrial sewage, infiltration water and parasitic rainwater contribution". It also defines domestic sewage as the "liquid discharge resulting from the use of water for hygiene and human physiological needs (...)".

For Almeida (2010, p. 22) "The urban water veins are currently configured in degraded spaces. Moving from historically attractive spaces to become receptacles of excrement of society ". Still in this sense (MUCELIN and BELLINI, 2008) state that the "river is used as a place of final disposal of garbage, an existing and reprehensible cultural habit".

In Brazil, it is estimated that 60% of hospital admissions are related to basic sanitation deficiencies, which generate other consequences with an extremely negative impact on the quality and life expectancy of the population.

The proof of transmission of infectious diseases by water dates back to 1849, when Snow demonstrated its role as a contaminating agent in a Broad Stret well, in the spread of diseases among people who used it. (BORGES and BERTOLIN, 2002).

According to BOVOLATO (1998), shallow wells combined with the absence of sewage networks and the local culture of local sewage disposal, are preponderant factors for the contamination of the water table and shallow can by pathogenic microorganisms.

In this sense, a study conducted by Bovolato (1998) shows contamination of 94% of shallow wells by total and fecal coliforms in the urban area of Araguaína.

For Santos, (2013), many diseases can be transmitted by water, through pathogenic microorganisms from animal or human intestine. According to Conama resolution No. 375 of March 17, 2005 waters contaminated by feces and sewage as waters with the presence of bacteria of the type *Escherichia coli bacteria* and some bacteria of the genus *Klebsiella, Citrobacter* and *Enterobacter,* can trigger gastrointestinal disorders characterized by watery diarrhea. (BRASIL, 2005).

Escherichia coli (E. coli) is a bacterium whose presence in water is a worldwide reference for water contamination by pathogenic microorganism of enteral origin.

The World Health Organization (WHO, 2016), defines Escherichia coli (E. coli) as a bacterium found in the human and animal intestine, used as a reference for fecal contamination of water, which can characterize it as unsuitable for various activities and use. (WHO, 2016).

The disposal of solid waste and domestic sewage into rivers, a common practice in urban streams, ends up contaminating the waters with infectious agents such as bacteria, viruses, protozoa and helminths. Contamination is usually through ingestion, either directly by drinking contaminated water or by consuming raw food irrigated or washed with infected water.

The waters used for irrigation are generally of surface or groundwater origin. Coming from the rains, these waters take for themselves the most different physical/chemical substance with also residues of human and animal activity when in contact with the soil (ALMEIDA, 2010).

The surface waters of urban regions according to (MAROUELLI et all, 2008),(MATTOS,2003), are usually contaminated by agents that spread diseases.

In this same sense, Pacheco et al (2002) states that water intended for irrigation is an original source of contamination since it contains large amounts of pathogenic microorganisms such as fecal coliforms, aeromonas, salmonella, intestinal parasites and others.

Thus, leafy vegetables such as cabbage, lettuce, arugula and other types consumed raw become a vehicle for transmission of diseases such as amoebiasis, giardiasis, typhoid fever and cholera when irrigated mainly by sprinkling.

Sprinkling is the main method of irrigation of vegetable crops in Brazil, about 90% of vegetables grown in Brazil use it. However, it is not ideal for all types of crops, as it can favor a greater incidence of diseases, since the contaminating matter in the water is retained in the foliage (MAROUELLI, et all, 2008).

Although it seems a new concept, the reuse or repurposing of wastewater is a common practice in the distant past. In ancient Greece sewage disposal was used for irrigation in agriculture. The increasing demand for water and calls for the conscious development and sustainable use of water has made planned water reuse a necessary and current topic for the growing demands of the population for water. (CARVALHO et all, 2014)

For each activity that uses water, there are requirements to be observed. For the microbiological standard of water intended for irrigation of vegetables that are consumed raw, the resolution of the National Council of the Environment - CONAMA of No. 357 of March 2005, Chap. III, Section IV, article 21 determines: The degree of contamination should not be exceeded the value of 200 thermotolerant coliforms per 100 mL. (BRASIL, 2005, 2011).

Studies show real possibilities of contamination of vegetables through irrigation water and the risks to human health when consumed raw.

Takayanagui et all, (2000) reports that laboratory analysis of 129 gardens surveyed revealed irregularities in 20.1% of them, highlighting high concentration of fecal coliforms in 17%, presence of Salmonella in 3.1% and various enteroparasites (Ascaris sp, ncylostomidae, Strongyloides sp, Hymenolepis nana and Giardia sp) in 13.1%.

In this same sense Ragazzi, (2011), points out; it is very common the studies developed focused on qualities of food irrigated by low quality water. and that usually finds some kind of contamination, is the case of vegetables and other foods consumed raw.

Lira et al. (2015), corroborates with Ragazzi (2011) by stating that the theme of wastewater and its use for irrigation is a widely studied and recommended practice.

The scarcity of the water resource, the growing demand in agriculture and the need to use it in a more rational way has motivated the search for sustainable and viable alternatives such as using waters that are classified as lower quality.

Hespanhol (2002) apud Lira et al. (2015) classifies as waters of inferior quality, those of sewage of domestic origin, agricultural drainage waters and brackish waters.

Studies such as Mattos, (2003), Mierzwa, (2004) and Carvalho et al, (2014) show feasibility of reuse of lower quality waters, but there are precautions to be observed.

For Mattos (2003) In cases of contamination with risk to public health in itself dealing with irrigation is of paramount importance the disposal of sprinkler irrigation or other type that comes to deposit water in the aerial part of the plants in this way the drip would be the most recommended for irrigation vegetables and fruits consumed raw and without skin.

Drip irrigation deposits water directly at the root of the plants. This method presents a lower risk of leaf contamination and minimizes soil contamination.

In general, medium-sized and large cities have green areas within the cities and usually near the stream, destined to the production of vegetables such as lettuce, coriander and leaf onions, cabbage and arugula that supply the consumer market.

The proximity of the vegetable gardens to the streams favors the use of their waters directly for irrigation or through wells near the streams or waterholes. In this sense Barros et al. (1999), highlights: It is a common practice to use water from streams and small rivers for irrigation of vegetables.

Barros et al. (1999) also states that this practice compromises the quality of the food produced, since at some point they receive human waste, compromising their quality; therefore, the food produced in these areas presents itself as an important route of infection by enteropathogens, through the oral route, assuming a fundamental role in the spread of diseases.

In this context is located the object of study of this work. Located in the Municipality of Araguaina-TO and consists of two distinct points of water collection for vegetable garden irrigation.

The gardens have asbestos boxes, buckets and cans for water storage and transportation and small water pump for water withdrawal from the stream. The study areas were identified as points P1 (7º10'50.1"S; 48°12'49.6"W) and P2 (7°09'26.9"S 48°12'14.1"W). Point P1, Jardim/Maracanã stream is located in Sector Belo Vista I, on the banks of BR 153. Point P2 is located in the Dom Orione sector, on the banks of Street 10, and bordered by the Tanque stream. For irrigation, water from the Jardim/Maracanã stream is used in the P1 vegetable garden and P2, water accumulated in a cacimbão dug in the soil adjacent to the Tanque stream.

5 FINAL CONSIDERATIONS

The results of this experiment to assess the potential risks of contamination of vegetables through irrigation suggest caution with the consumption of vegetables produced by the analyzed points.

The parameters analyzed exceed the recommendations of Conama, Anvisa and the World Health Organization for the use of water in irrigation of foods consumed raw, such as lettuce, cabbage and coriander and onion leaves.

All water samples collected presented some type of nonconformity for use in the irrigation of vegetables consumed in natura (Table 1). According to the resolution of the National Council of the Environment - CONAMA of No. 357 of March 2005, Chap. III, Section IV, article 21 for the microbiological standard of water intended for irrigation of vegetables. In this case the recommendation would be a maximum of 200 coliforms per 100 ml. Anvisa through Resolution-RDC No. 12 of January 2, 2001, ANNEX I - Sanitary microbiological standards for food establishes tolerance for indicative sample of 102 i.e. 200 coliforms per 100ml.

Table 2: Microbiological results of irrigation water

COLLECTION POINTS	TOTAL COLIFORMS (MPN1/Ml)	COLIFORMES THERMOTOLERANT (NMP/ML)	E. COLI (AUS./PRE.)	AEROBIC MESOPHILES (CFU2/ML)	VALUE OF REFERENCE3
P1	>23	>23	PRESENCE	101 X 10^2	200/100ml
P2	>23	>23	PRESENCE	18 X 10^2	200/100ml

All samples were positive for the presence of Escherichia coli (*E.Coli*), a bacterium belonging to the Enterobacteriaceae family characterized by the activity of the enzyme β-glycuronidase. It is the only species of the thermotolerant coliform group whose exclusive habitat is the human intestine and homeothermic animals, where it occurs in high densities. (BRASIL, 2005)

In addition to the escherichia coli (*E.Coli*) bacteria, the presence of Total Coliforms and Aerobic Mesophiles was also identified, but there is no established standard for irrigation water regarding total coliforms, mesophiles, only for thermotolerant coliforms, where a maximum limit of 200 coliforms per 100 ml is accepted (ENDLER et all, 2013).

Additional results should be sought by repeating the experiments, at different times of the year, in order to identify whether the process of contamination of irrigation sources persists throughout the year, a case of seasonality or chance.

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