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Reservatórios de água para uso doméstico no Brasil: qualidade microbiológica e química e manutenção de condições sanitárias

Storage tanks for household water usage in Brazil: Microbiological and chemical quality, and maintenance of sanitary conditions

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RESUMO

Introdução: Os reservatórios domésticos de água garantem comodidade e segurança para os consumidores em relação à intermitência de água. Negligenciar os cuidados mínimos para os reservatórios pode transformá-los em uma fonte de água imprópria para consumo. **Objetivo:** Avaliar a qualidade físico-química e microbiológica da água dos reservatórios domiciliares, destacando a necessidade de ações individuais para garantir a qualidade da água consumida em casa. **Métodos:** Foram selecionadas 217 residências, onde os moradores responderam um questionário para o levantamento das condições de armazenamento e manutenção dos reservatórios de água e para coleta de amostras. As dosagens de cloro, pH e temperatura foram realizadas in situ e as de metais por espectrometria de massa com plasma indutivamente acoplado. A presença de parasitos foi avaliada pela técnica de sedimentação espontânea e a de bactérias dos grupos coliformes (totais e fecais) pela técnica de tubos múltiplos com substrato cromogênico. **Resultados:** Os resultados mostraram que 115 (53%) participantes conheciam o período correto de manutenção dos reservatórios e 109 (50%) indivíduos relataram que não executam a manutenção na frequência recomendada. Os valores médios de cloro, pH e temperatura foram de 1,34 mg/L, 6,5 e 25,4 ºC, respectivamente. As concentrações médias de metais apresentaram-se abaixo dos valores máximos permitidos e não foram detectados parasitos e bactérias. Os testes indicaram que as amostras de água se encontram de acordo com os padrões de potabilidade recomendados pela legislação nacional. **Conclusão:** Embora os resultados não mostrem contaminação microbiológica nas amostras estudadas, a população precisa ser regularmente informada sobre a importância da higienização do reservatório. Atualmente, existe uma preocupação crescente com o desenvolvimento de ações individuais direcionadas à saúde humana e prevenção de doenças relacionadas ao acesso e uso da água. Portanto, são necessários programas de educação em saúde para orientar a participação da comunidade, com fins de promover melhor qualidade de vida.

Palavras-Chave: Qualidade de água; Reservatórios de água; Técnicas microbiológicas; Características físico-químicas da água; Promoção da saúde.

ABSTRACT

Introduction: *Storage tanks for household water usage guarantees convenience and safety for consumers in relation to water intermittency. Neglecting a minimal care for storage tanks can turn them into a source of water unfit for consumption.* ***Objective:*** *To evaluate the physical, chemical, and microbiological quality of water in household tanks to highlight the need for individual actions to guarantee the quality of water consumed at home.* ***Methods:*** *Residents of 217 homes answered a questionnaire to gather information about the water storage tank conditions and maintenance. Chlorine dosing, pH and temperature measurements were performed in situ and metal analyses were made using an inductively coupled plasma mass spectrometry (ICP-MS). The presence of parasites was evaluated using the spontaneous sedimentation technique and presence of bacteria from the coliform groups (total and fecal) were made using the multiple-tube technique with the chromogenic substrate.* ***Results:*** *Results showed that 115 participants knew the correct storage tank maintenance period and 109 participants did not perform the storage tank maintenance at the recommended frequency. Mean values of chlorine, pH, and temperature were 1.34 mg/L, 6.5, and 25.4 ºC, respectively. Average concentrations of metals were below the maximum values allowed. Parasites and bacteria were not detected. Tests indicated the water samples were in accordance with the potable water quality standards endorsed or recommended by the Brazilian legislation.* ***Conclusion:*** *Results did not show microbiological contamination in study samples. Nevertheless, it is necessary to keep the population regularly informed about the importance to maintain storage water tanks clean. Currently, there is a growing concern with the development of individual actions aimed at human health and prevention of water-related diseases concerning its access and use. Therefore, we need health education programs to guide community participation into the promotion of a better quality of life.*

Keywords: *Water quality; Household tank; Microbiological techniques; Water physicochemical characteristics; Promotion of health.*

INTRODUCTION

Worldwide, approximately 785 million people still lack access to safe water and 2.4 billion, almost half the population of developing countries, do not benefit from adequate sanitation. It is estimated that approximately more than 800,000 people die per annum from gastrointestinal problems related to watering supply, sewage, and inadequate handwashing practices, of which 361,000 are children under the age of five[1]. In fact, good quality, safe, and clean water supplies are some of the main policies for human health promotion in developing countries[1].

In many regions of Southern Africa, Asia, and Latin America the water supply remains intermittent. This factor leads residents to adopt alternatives for water transportation and storage at home in different sorts of containers. Residents must ensure daily water amount considered sufficient to their individual and collective needs, such as food preparation, personal hygiene, and maintenance of house cleaned. Household water is not always stored in appropriate containers[2].

In Brazil, homes have a reservoir, known as a water tank, which serves to maintain water sufficient for the family daily supply. Historically, since the 19th century, the goal of improving water supply systems has led to enlarging and improving the water-quality distribution networks. Interruptions in service, though, have continued. Thus, it proved necessary to install a household tank to ensure the availability of the daily amount used by the population[3].

For the most part, household water tank ensures convenience and safety for consumers in relation to the continuity of their water supply. The presence of running water leads to a reduced incidence of waterborne diseases. However, neglecting the minimal care to maintain the tank clean can turn it into a source of water unfit for consumption. Negligence to keep the tank clean, allows the deposit of impurities brought by the water distribution network itself, lack of cleaning, sealing or other protections. A household tank is considered part of the whole water treatment system, and it should work in harmony with the entire system. It cannot be considered as an isolated element. Even properly installed and easily accessed, it is not free of risks[4].

Most Brazilian cities have not yet established a policy for the water quality monitoring for household tank. Consequently, population is unaware of serious health problems related to the consumption of improperly treated and stored water, which represents a serious challenge for public health. The provision of safe drinking water is one of the main requirements of municipal supply infrastructure. However, at home, the quality of water in the storage tank is the responsibility of the owner.

Ordinance 05/2017 of the Ministry of Health of Brazil establishes d*rinking water* quality *standards* for human consumption and defines the maximum allowed values (MAV) for microbial agents, and physical and chemical parameters of importance to the quality of drinking water for human consumption. Among those recommended are chlorine and pH levels, which must conform to the values established by law[5].

In the last decade in several countries, studies have shown the importance of health and educational interventions to reduce the drinking water contamination stored in households, revealing, and measuring the impact on population health[6-7]. This study aimed to do a survey about the conditions of storage and maintenance of household reservoir and to evaluate physical-chemical and microbiological parameters of water of the household tank, highlighting the need for individual action to ensure the water quality being consumed at home, thus avoiding risks to health.

METHODS

Study Location

Ribeirão Preto is in the Northeast of São Paulo State, with an estimated population of 703.293 inhabitants[8]. Water is distributed to houses by the Department of Water and Wastewater of Ribeirão Preto, which is responsible for the uptake of groundwater from the Guarani Aquifer through 103 wells.

Sample definition

The number of households for the collection of water samples was defined according to standards regarding the size of representative water samples in relation to population density described in Ordinance 05/2017 of 2017 from the Ministry of Health[5], totaling 217 households. To select households, city and census tracts maps were acquired, totaling 642 sections, of which 217 were randomly selected and each one of them, drawn a home for the sample, using the Microsoft Office Excel 2016.

Ethical aspects

The residents were first informed about the ethical issues, objectives, and methodology of the study. They were also informed about the approval of the Ethics Committee for Research at the Ribeirão Preto College of Nursing (Protocol no. 0943/08). After clarification and in the presence of the researcher, the participants read the Terms of Consent, which was signed at the time of collection of water samples.

Survey of conditions of storage and maintenance of domestic water tank at home

A questionnaire was applied for participants. It was formulated with issues related to cleaning the tank and quality of domestic water consumed at home. The questionnaire consisted of 10 questions: 1) Does your home have a water tank? 2) Are you aware of the need to clean the tank of your home? 3) What interval do you consider correct for cleaning the tank of your home? 4) What products and objects do you consider appropriate for cleaning your home tank? 5) When was the last cleaning of the tank of your home? 6) How do you consider the quality of water supply system that arrives in your home? 7) Do you use the water tap? 8) How do you consider the water quality of the tank of your home? 9) Do you use water from the tank straight from the tap? 10) Which rooms in your home receive water from the tank? We conducted a descriptive analysis of data collected.

Collecting water samples

In each selected household, we collected water samples in glass vials previously sterilized from the tap for physical-chemical and microbiological analysis. Using direct reading equipment, chlorine and pH levels and water temperature were observed *in situ*. Water samples collected for parasitological (1 L) and bacteriological (100 mL) analysis was performed following Standard Methods for the Examination of Water and Wastewater[9]. Samples were transported to the Laboratory of Ecotoxicology and Environmental Parasitology at Ribeirão Preto College of Nursing, University of São Paulo, in a thermal box (4ºC), and analyzed in a period of less than 24 hours.

Physical-chemical analysis

Chlorine values were read with the colorimetric method. We used a meter model HI 93734 Hanna Instruments®, which enabled the measurement of free residual chlorine in the water. The pH test of the water analysis was performed using the potentiometric method, with a portable pH meter, model pH-100/pHTek calibrated with 4.0 and

7.0 pH buffers. The water temperature was measured using a Minipa MV-365 digital thermometer.

Samples for metal analysis (50 mL) were fixed with the addition of high purity nitric acid (HNO_3) and maintained at -18°C until the time of analysis. The metals considered in this study were arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), thallium (Tl), tin (Sn), vanadium (V), and zinc (Zn). Elements concentrations were determined by Inductively Coupled Plasma Mass-Spectrometry (ICP-MS), and the limits of detection was 0.20µg/L for As, Be, Cu, Hg and Ni; 0.50µg/L for Cr and Zn; 0.05µg/L for Cd, Pb, Mn and Tl; 0.10µg/L for Sn; and 1.00µg/L for V.

Microbiological analysis

Sedimentation method was used for the parasitological analysis. After collection, samples were homogenized and slowly transferred to a glass of 500 ml of sediment where they remained undisturbed for a period of 2 to 24 hours, with subsequent preparation for reading in a Sedgwick-Rafter chamber (Pyse-SGI Limited, Kent, UK), following the procedure of Standard Methods for the Examination of Water and Wastewater[6].

For bacteriological analysis, the multiple tube method with Colilert® chromogenic substrate was used. Results were read according to the Most Probable Number Technique, following the procedure recommended in Standard Methods for the Examination of Water and Wastewater[10].

RESULTS AND DISCUSSION

Conditions of storage and maintenance of household tank

Results revealed that individuals (97%) are aware of the existence of a domestic tank in their home and the need for cleaning it (86%), however, they are misinformed about the correct schedule to which this cleaning should adhere and do not keep domestic control of this maintenance since they do not keep track of when the tank is cleaned.

Regarding the appropriate frequency with which to clean the household water tank, 53% of the participants reported it should be every 6 months, which is the recommended interval to avoid sediment accumulation at the bottom of the tank according to recommendations of the National Health Foundation (FUNASA)[11], and to enable the removal of biofilm, a complex microbial ecosystem that clings to tank inner walls.

However, 47% of participants thought that the appropriate interval for cleaning the tank is one year, more than two years, or have no knowledge about the matter. This is a situation of concern, given that the interval of time is greater than what is recommended (6 months), which favors the proliferation of microorganisms in the tank[12].

Regarding the cleaning of the tank in the residence of each participant, only 12% said they clean their tank every six months. Among the rest, 1% said they never have it done; 41% have not had it done for over 2 years; 8% had it done a year ago; and 38% could not answer, saying they had recently rented the property. The information about cleaning tank reveals an important fragment of information, since only (12%) of respondents reported receiving information about the recommended cleaning period.

When asked about the objects and products deemed appropriate for cleaning tank, 82% indicated water, chlorine, and fiber brush as suitable material for maintaining the site for the storage of water (Figure 1). Only 18% of respondents indicated inadequate objects and chemicals that, according to the FUNASA[11] can cause corrosion, which can lead to the fixing of the chemical residue and impurities in the tanks, thus contaminating the water.

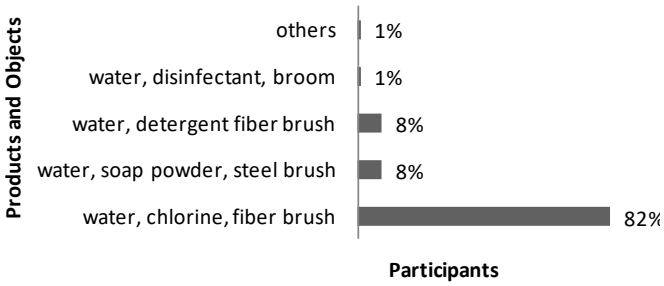

Figure 1. Products and objects appropriate for cleaning domestic water tanks according to the participants.

According to 63% of participants, the bathroom and the kitchen were the rooms of the house directly connected with household water tanks (Figure 2). Thus, the importance of the cleaning correct periods and maintenance are emphasized, since the bathrooms and the kitchens are places where personal hygiene and food preparation are carried out, in addition to direct water intake.

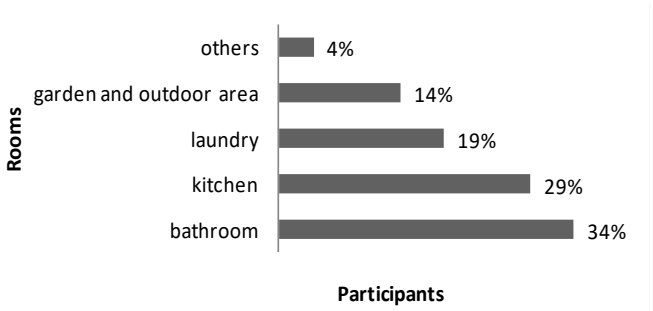

Figure 2. Rooms in the home that receive water directly from the household tank.

Almost all participants (95%) considered the water provided by the distribution system to be of good quality, though, a little more than half (55%) said they directly used this water for drinking, disregarding the use of filters and bottled mineral water. This study illustrated in a simplified way the perception of some residents regarding the need for cleaning and maintaining domestic water tanks, indicating the need to increase popular awareness about the quality of water consumed. Some authors found that people do not trust the quality of water coming to their homes, leading them to consume bottled water for direct ingestion, using tap water for hygiene and household cleaning[13].

Physical-chemical evaluation

The observed values of temperature, pH and chlorine from water samples collected from 217 households (Table 1) were in accordance with Brazilian legislation. This sets national drinking-water standards for human consumption, except in a residence that presented a chlorine value above the allowed value (2.32 mg / L) and in another residence, the pH value below the recommended value (5.5).

Table 1. Values of temperature, pH and chlorine of 217 water samples from the homes in Ribeirão Preto. Ribeirão Preto/SP, Brazil.

Value	Temperature (ºC)	pH	Chlorine (mg/L)
Minimum	18.6	5.5	0.15
Maximum	35.8	7.4	2.32
Average	25.4	6.5	1.34
Reference value	-	6.0 – 9.5	0.2 – 2.0

*Reference value by Ordinance 05/2017 of Ministry of Health, Brazil.

The maximum value of 35.8°C for the water temperature was justified using solar heaters in the home. The average value observed for the water temperature was analyzed at 25.4°C. In Ribeirão Preto, the mean climatic temperature in the sampling period was 22.8°C. The average temperature in wells where the water that supplies the county is collected is approximately 26°C[14]. The average pH values were within the limits recommended by Ordinance 05/2017, establishing the ideal range of pH between 6.0 and 9.5 throughout the distribution network[5]. The average pH of the water samples was 6.5 and the average value observed in the wells, in another study of 2009, was 5.9, which is slightly acidic[7].

According to the results of temperature and pH presented in Table 2, the averages of these parameters were within the limits recommended by the Brazilian legislation. The water temperature and pH can also change depending on storage time and the tank's physical condition, given environmental exposure and the type of material used in the tank's manufacture[2]. Temperature controls the behavioral characteristics of organisms, solubility of gases and salts in the water, while pH has an indirect effect on the precipitation of toxic elements such as heavy metals and interferes with the reactivity of chlorine, which decreases as pH increases[15].

Table 2. Average concentration, minimum and maximum values of metals (mg/L) in water samples (n = 217) from the homes in Ribeirão Preto. Ribeirão Preto/SP, Brazil.

Value	Cu	Cr	Mn	Ni	Pb	Zn
Minimum	0.0012	0.0002	<LOD**	0.0001	0.0001	0.0061
Maximum	1.5391	0.0246	0.0427	0.0197	0.0368	7.8591
Average	0.0629	0.0015	0.0010	0.0016	0.0026	0.1396
SD	0.1840	0.0019	0.0035	0.0029	0.0043	0.5797
Reference value*	2	0.05	0.1	-	0.01	5

*Reference value by Ordinance 05/2017 of Ministry of Health, Brazil. **LOD: Limit of detection.

Chlorine concentrations were between 0.15 and 2.32 mg/L, with mean values within the limits recommended by the Ordinance (Table 1). Compared to chlorine, according to the Ordinance 05/2017, after disinfection, the water must contain a minimum content of 0.5 mg/L of free residual chlorine, with a mandatory maintenance of at least 0.2 mg/L at any point distribution network. It is recommended that the maximum content of free residual chlorine at any point in the supply system not exceed 2.0 mg/L[3]. Chlorine is the most widely used chemical disinfectant in most plants treating surface water and groundwater because it can break down or oxidize the cell wall of microorganisms, interfering with their metabolism and destroying them[9,16]. In homes, chlorine is an effective agent for chemical decontamination of water that remains stored. However, you must maintain levels recommended not to cause health risks to the population and be able to prevent cases of diarrhea, especially in developing countries[9,16-17].

Regarding the metal analyzes, As, Be, Cd, Hg, Sn, Tl and V concentrations were below the limit of detection. Table 2 show the average concentration of Cu, Cr, Mn, Ni, Pb and Zn, as well as minimum and maximum values.

Except for the maximum values of lead and zinc (in two different residences), the mean concentrations of metals in water were within the values established by the Brazilian legislation. We also observed that the quality of water studied is perhaps related to the fact of Ribeirão Preto is supplied with water extracted from underground wells, receiving only the addition of chlorine and fluorine, a procedure recommended by Ordinance 05/2017. There is, therefore, no change in its characteristics. Moreover, there is daily monitoring of water quality supply, made by the company responsible for municipal service[5].

Microbiological evaluation

All samples showed negative results for growth of coliform bacteria and for the presence of eggs, cysts, and larvae of parasites. It should be noted that the results presented reflect the standardized techniques for water analysis. However, it is known that the uses of other techniques (conventional PCR, qPCR) are more sensitive and could provide more accurate results. Another factor that justifies the absence of coliforms in water samples is that it was observed an average free chlorine residual of 1.34 mg/L (Table 1), likely a factor inhibiting growth and/or facilitating the elimination of *Escherichia coli* and other microorganisms in stored water, corroborating with the negative microbiological results found[9,17-18].

Although the results show no microbiological contamination in study samples, the population needs to be regularly informed about the importance of cleaning their tank, making use of objects and products suitable for the removal of biofilm that forms there, thus ensuring the maintenance of good water quality to be consumed and used daily in rooms like the bathroom and kitchen.

Supply of quality water in sufficient quantity is essential to the prevention of several diseases related to watering. However, this process is only effective when there is monitoring of water quality so as to avoid potential risks to the health of consumers. Such monitoring exists and is performed by the Water-Treatment Plant, even up to the moment, it enters the houses. From that point on, though, water quality is the responsibility of the residents. The household water tank when it is properly installed and maintained in a hygienic and clean condition can minimize possible contamination of domestic water supplies, since no one is handling the water thus not allowing contamination through the introduction of objects and hands inside the container.

CONCLUSIONS

The quality of water supplied to households through a supply network and maintenance of recommended values of free residual chlorine in the tank home, explains the comforting results obtained during parasitological and bacteriological analysis of water samples from the public health standpoint. There is currently an increase concern over the development of individual actions directed at human health and disease prevention related to watering access and use. Therefore, health education programs are needed to guide the participation of the community in activities regarding environmental health with a view to promote a better quality of life.

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