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WATER FOOTPRINT OF UNIVERSITY STUDENTS IN THE SEMI-ARID REGION OF NORTHEASTERN BRAZIL

PEGADA HÍDRICA DE ESTUDANTES UNIVERSITÁRIOS NA REGIÃO SEMIÁRIDA DO NORDESTE BRASILEIRO

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ABSTRACT: The water footprint deals with the accumulated and polluted water content resulting from the production of goods and services from which human being benefits. Due to its diversity, the university environment is composed of students that differ regarding parameters such as age, income, and, consequently, different eating habits. From this perspective, this study aimed to analyze the water footprint of students of the Interdisciplinary Bachelor's Degree in Science and Technology at the Federal Rural University of the Semi-arid Region (UFERSA) – Campus Mossoró/RN. The method used consisted of the application of semi-structured questionnaires adapted from the personal-extended Water Footprint calculator of the Water Footprint Network platform, where the data obtained from the questionnaires, collected as a sample source for convenience, were also inserted. The data collected included personal water consumption, food consumption, and water use within the domestic environment. In order to obtain the water footprint of the respondents, the value of the individual annual income was used together with the data on food consumption and domestic use of water, resulting in 1,664 m³/year for the total sample of university students, this value being higher than the annual worldwide per capita average and lower than the annual per capita average for Brazil.

Keywords: *water consumption, water resources, integrated management, virtual water*.

RESUMO: A pegada hídrica trata do conteúdo de água acumulado e poluído resultante da produção de bens e serviços dos quais o ser humano se beneficia e, por sua diversidade, o ambiente universitário é composto por estudantes que vão de diferenças como: faixa etária, renda e, consequentemente, hábitos de consumo alimentares diferentes. Objetivou-se, com este trabalho, analisar a pegada hídrica de estudantes do curso de Bacharelado Interdisciplinar em Ciência e Tecnologia da Universidade Federal Rural do Semi-Árido – Campus Mossoró/RN. A metodologia utilizada consistiu na aplicação de questionários semiestruturados adaptados da calculadora de Pegada Hídrica pessoal-estendida da plataforma Water Footprint Network, onde também foram inseridos os dados obtidos a partir dos questionários coletados como fonte de amostra por conveniência. Os dados coletados foram: pessoais, consumo de comida e uso da água dentro do ambiente doméstico. Para a obtenção da pegada hídrica dos respondentes, fez-se o uso do valor da renda individual anual juntamente aos dados acerca do consumo alimentício e uso doméstico da água, resultando em 1664 m³/ano para a amostra total de estudantes universitários, sendo este valor superior à média per capita anual mundial e inferior à média per capita anual do Brasil.

Palavras-chave: *consumo de água, recursos hídricos, gestão integrada, água virtual*.

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INTRODUCTION

While water is abundant in certain regions of the planet, others suffer from a lack of it, highlighting the inequality in terms water distribution around the world (BRASIL, 2020). Brazil is an example of that, as the Northeast region of the country suffers from the effects of a constant water crisis due to the local climate conditions, including low and poorly-distributed rainfall and high temperatures, which contributes to the scarcity of water resources (CARVALHO; CURI, 2016; DIAS; PESSOA, 2020).

Another important factor that highlights the need for efficiency in the management of water resources is the fact that the Brazilian semi-arid region, due to recurrent drought episodes, has suffered with desertification processes allied to socioeconomic fragility (TAVARES et al., 2019; MILHORANCE et al., 2019).

The water footprint concept is used in this scenario due to the need for efficiency and effectiveness in the management of water resources, defined as the total volume of water used during the production of goods and services, as well as the directconsumption of water by human beings (SILVA et al., 2013). The concept can be appliedto individuals, companies, nations, product production, and other individual processes (HOEKSTRA et al., 2011).

This broad picture includes universities, known as environments dedicated to the formation of future professionals, and for this reason playing an important role in raising awareness about the consumption of natural resources. In the university environment, there are people with different incomes, cultural aspects, and age groups, also representing several different consumption habits. Pinto et al. (2021), studying the water footprint of university students in the semi-arid region of Brazil, concluded that the introduction of this subject is very pertinent, given that there are not many regional studies on the issue, which justifies the need to evaluate the differences in consumption among these students, who are awareof water scarcity.

Just the fact that the coexistence of students who live in student housing facilities and those who live in their own houses already turns the university into a very complex atmosphere, requiring a more profound investigation into the influences of the university context on water consumption since the water footprint is directly proportional to the consumption pattern.

In view of the above, this study aimed to analyze the water footprint of students taking the Interdisciplinary Bachelor's Degree in Science and Technology at the Federal Rural University of the Semi-arid Region (UFERSA), Campus Mossoró/RN.

MATERIAL AND METHODS

Type of research

This is an exploratory study, consisting of field research focusing on expanding the researcher’s knowledge about the area of study through the development of hypotheses, thus enabling a more precise study (MARCONI; LAKATOS, 2003).

Instruments of research

The instrument of research is summarizedin the observation of the data obtained from the Google Forms tool, platform on which a semi-structured questionnaire was developed and applied to a convenience sample.

The questionnaire is a tool formed by sequences of arranged questions that must be answered in writing, in the interviewer’s absence, whereas observation is a technique that assists the researcher in recognizing and obtaining material related to objectives that guide behavior of individuals, even if they are unaware of it (MARCONI; LAKATOS, 2003).

Subjects and field of research

The research was conducted with a sample of 51 participants selected randomly from a pool of 418 students enrolled in the Interdisciplinary Bachelor's Degree in Science and Technology at the Federal Rural

University of the Semi-arid Region (UFERSA), Campus Mossoró. The data were collected from the Academic Records Department of the Pro-rectorate for Graduation.

The aforementioned municipality is located in a region suffering with water scarcity in which the population is supplied by surface reservoirs and underground reserves.

Data analysis

A semi-structured questionnaire was virtually applied for data collection. The questionnaire was adapted from the personal-extended water footprint calculator of the'Water Footprint Network' platform developed by UNESCO-IHE researchers, which was based on water needs per unit of product in the country of residence (HOEKSTRA et al., 2021).

The questionnaire was applied from September 21 to October 6t and consisted of questions about personal information, food consumption, and water use within the domestic environment, with Brazil being selected as the country of residency, aiming to analyze the Water Footprint of the interviewees.

The questionnaire was adapted to the reality of local university students and, therefore, questions such as pool use, car wash, electric showers, etc. were eliminated.

After the intervie wees' data were obtained, the analysis was carried out by observing the results collected from Google Forms and transformed into tables and graphs in a Microsoft Excel spreadsheet in order to, at a later moment, calculate their water footprint. Exceptionally for the individual gross annual income of the interviewees, it was necessary to convert the values to dollars for their insertion into the calculator by considering the exchange rate of 10/13/2021, when R$ 5.51 corresponded to US$ 1.00.

The comparative analysis between the global and national average per capita water footprint and the results obtained from the research was carried outusing the results of Giocomin and Ohnuma (2017), as it was a sample group from a higher education institution similar to the one in this study.

RESULTS AND DISCUSSION

Characterization of the sample

This research sample was made up of 51 university students, of which 35 were male (68.6%) and 16 were female (31.4%). The predominance of male responses in relation to female responses can be attributed to the predominantly male nature of the course under study, where the majority of participants are men. The age interval of the sample ranged from 18 to 49 years, as Figure 1 shows:

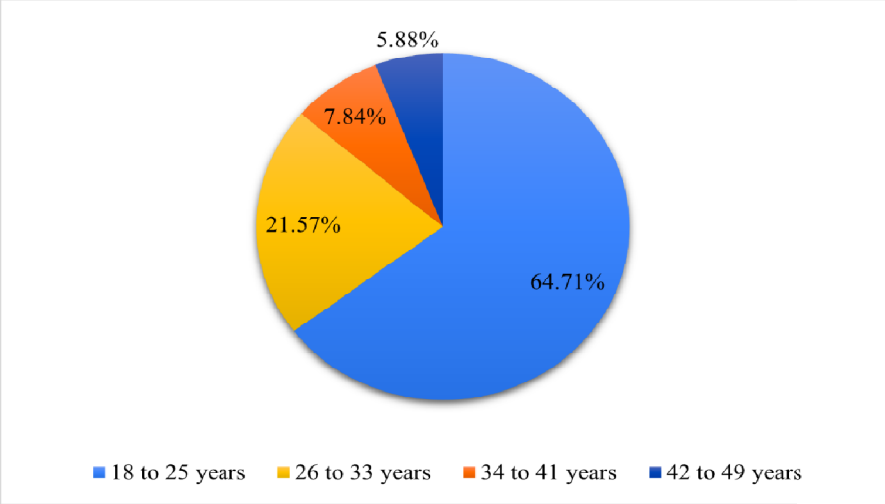

Figure 1. Age range of the sample analyzed (provided by the authors)

It stands out that most interviewees are aged between 18 and 25 years, which corresponds to 33 students (64.71%). However, the age of the total sample is quite varied, with 21.57% (26 to 33 years) corresponding to 11 students, 7.84% (34 to 41 years) corresponding to four students, and 5.88% (42 to 49 years) corresponding to three students. According to Maracajá et al. (2013) and Moreira & Mascarenhas (2019), income and water footprint are directly proportional since the higher the individual's income, the greater its water consumption. In addition to income, another factor that influences the WF value is gender. The results obtained regarding the average annual WF of university students depending on gender and the individual annual gross income are shown in Table 1:

Table 1. AverageWater Footprint of students according to gender and individual annual income.

Consumers				
Sex	Income (R$/year)	Income (US$/year)	Standard Deviation (Income R$)	WF (m³/year)
Male	10,797.77	1,959.67	10,389.23	1,863.00
Female	15,315.25	2,750.05	19,816.78	1,232.00
Average Total	12,215.02	2,216.88	13,988.91	1,664.00

Note: WF represents Water Footprint

The average water footprint of the male sample was 1.863 m³, whereas the average annual WF of the female sample was 1.232 m³, a result also found by Maracajá et al. (2013), Campos et al. (2017), and Moreira and Mascarenhas (2019), where maleshad a higher average annual WF than females in all classes and groups of consumers studied.

According to Moreira and Mascarenhas (2019), the class ofmen, young, low income, low years of formal education, single, and with a familiar income of up to 4 minimum wages, on average, has a higher water footprint.

In general, male income is inferior to females. However, the number of samples of both genders in not equal, therefore the average annual average WF of male students is higher, possibly due to the disparity between the number of interviewees of each sex and also dietary questions. As for the Standard Deviation (SD), males had the value of R$ 10.389,23, whereas females obtained R$ 19.816,78 as a result.

The total average considers the entire group of students, withthe average income amounting to R$ 12.215,02 and with a standard deviation of $ 13.988,91, entered into the calculator (converted into dollars) as US$ 2.216,88, which, associated with the collected data on food consumption and domestic use, resulted in an average annual WF of 1.664 m³. Based on the annual income, the average individual monthly income was estimated at R$ 1.017,91, a value below the minimum wage, which, in September 2021, was worth R$ 1,100.00.

Water Footprint analysis

The Water Footprint analysis was divided into three stages, consisting of the analysis of interviewees' personal data, represented by Table 1, water use in food consumption, and water domestic use within the household.

With regarding to water consumption based on nutritional habits, the interviewees were asked about the amount of food they consumed in kilograms (kg) per week, e.g., cereal products, meat, dairy products, vegetables, fruits, roots, and also food given in units, e.g., eggs and cups of coffee per day. Other information used consisted of the fat contentin the students' diet and the level of sugar consumption.

The analysis of domestic water uses within the household considered data related to the number of showers per day and week, as

well as the duration of each shower given in minutes. Another issue highlighted was daily personal hygiene, which includes brushing teeth, shaving, washing hands, as well as the habit of leaving the faucet open or closed during these actions.

Interviewees were asked about the weekly frequency with which clothes were washed and also the daily frequency and duration of dishwashing.

It is important to emphasize that the section referring to the personal-extended Water Footprint calculator dedicated to water use outside the household, the number of cups of tea per day and the shower flow, dishwashing with dishwasher machines, and the presence of a dual flush mechanism in the student bathrooms were not considered in this research as they are not part of the reality of most university students in Brazil, making the study faithful to the current context.

Food consumption

As seen in Table 1, male respondents had a higherannual average WFthan females, with food being an extremely relevant factor related to this result, making it necessary for individuals to be aware of the water footprint of the products they purchase, looking for options with lower WF values and adequate water consumption in domestic activities (SILVA et al., 2020).

It is known that men generally consume a higher volume of food than women, this being a natural factor, also mentioned by Miranda et al. (2017), who highlighted meat as one of the decisive factors for this difference sincemen are great consumers of meat, thus presenting an extremely high average WF, especially beef, given the water use in its production chain. The data analysis regarding the nutritional habits of university students in terms of sex is shown in Table 2.

Table 2. Analysis of food consumption among university students according to gender per week.

Food Consumption	Males	SD	Females	SD	Total Average	SD
Cereal products (kg)	2.94	2.74	1.51	1.09	2.49	2.43
Meat (kg)	2.08	2.35	1.03	0.53	1.75	2.02
Dairy products (kg)	1.60	2.07	0.85	0.89	1.36	1.81
Eggs (unit)	9	7	7	7	8	7
Vegetables (kg)	0.74	0.91	1.09	1.45	0.85	1.10
Fruits (kg)	1.24	1.17	1.23	1.89	1.24	1.41
Roots (kg)	0.70	0.57	0.62	0.73	0.68	0.62
Cups of coffee (unit)	2	3	1	1	2	2

Note: SD represents Standard Deviation.

The male sample showed higher consumption values than the female sample, except the vegetables, which shows that women consume more of this food, although the values are not so far apart, thus partly corroborating the results obtained by Silva et al. (2020), in whose study the consumption among the female public is higher for dairy products, fruits, and vegetables.

Two products stood out in the food consumption of male students, i.e., cereals and meat, the latter peaking the consumption ranking among all other products, with 2.94 kg/week, more than two times the amount consumed by the female sample. Meat is one of the animal products with the highest WF, with the WF of 1kg of beef being 56 times higher compared to the same amount of lettuce (KILIAN et al., 2021).

However, cereal products also needa large amount of water in their production, showing high WF levels among other agricultural products, as seen in Table 2. These results show the strong relationship between WF and nutrition habits since the male population had an average WF 51.22% higher than females. It is noted that, even in total mean values, the consumption of cereal products and meat still achieved higher values, followed by dairy products, fruits, vegetables,

and roots. A similar result was obtained by Strasburg & Jahno (2015) when they investigated the University Restaurant of the Federal University of Rio Grande do Sul (UFRGS). The authors observed that the WF of plant-based products represented only 22.1% of the complete menu. On the other hand, the products of animal origin were responsible for the other 77.9% of the WF, and beef cuts were separately responsible for 62.2% of this group. Food consumption also involves the fat content present in a person's diet. The preference of fat levels in the diet of university students can be seen in Figure 2:

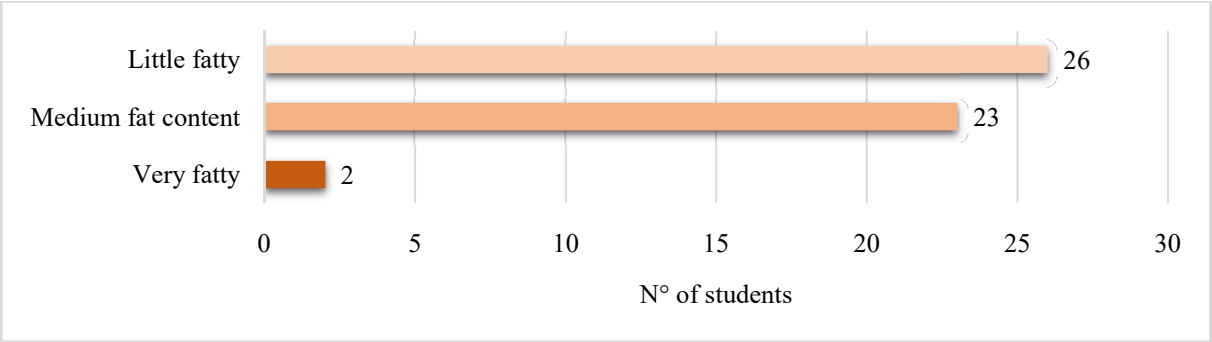

Figure2. Student preference regarding the levels of fat content in their diet (provided by the authors)

In this study, 26 respondents, of which ten were females and 16 were males, stated to prefer their food with low fat contents. Another group of 23 respondents, composed of five women and 18 men, declared preference towards a food with medium fat content, while only two interviewees, one woman and one man, defined their diet as very fatty.

It is noticeable that, of 51 respondents, 50.98% had a little fatty diet, revealing that approximately half of the interviewees opt for healthier nutritional habits. However, according to Barr and Broughton (2000), a great strategy to reduce fat consumption is through the exemption from meat consumption in the diet, which was not identified in the results of this research since no respondent abdicated meat consumption.

Another factor that interferes with the water footprint is the consumption of sugar and other sweets since sugar comes from agriculture, the sector that consumes the most water. The analysis of the consumption level of students regarding sugar and other sweets can be seen in Figure 3:

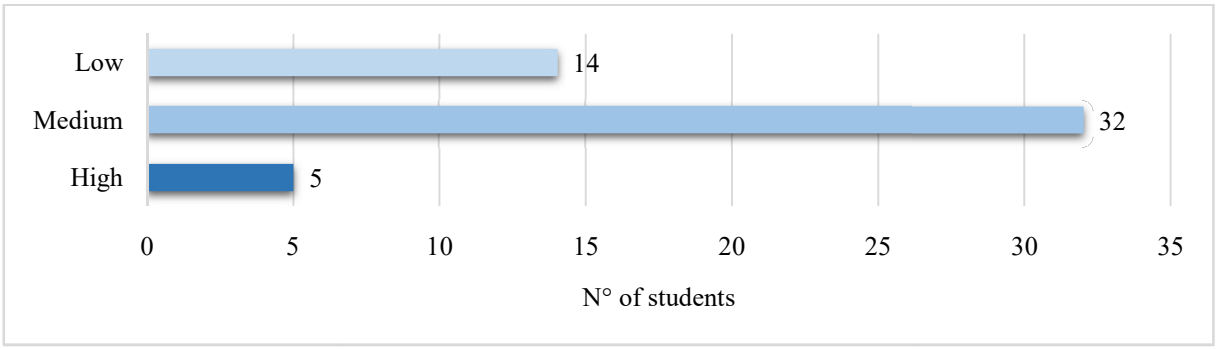

Figure 3. Students' consumption level regarding sugar and other sweets (provided by the authors)

Most respondents stated that they consumed sugar moderately, with the sample corresponding to 24 men and eight women. Another group stated that their sugar consumption level was low, being eight men and six women. Finally, only five students declared to consume high sugar levels, of which three were men and two were women. Most of the students (62.75%) have a diet ranging from medium to high levels of sweet consumption, corroborating the results obtained by Pinto et al. (2021), who analyzed the water footprint of students from the same university but from different courses, concluding that students had a medium level of sweet consumption.

3.2.2 Domestic water use

The domestic water use is related to water consumption within the household, not considering the consumption of nutritional products. The analysis of domestic water uses by university students according to sex in described in Table 3:

Table 3. Analysis of domestic water use by students according to gender.

Domestic water use	Males	SD	Females	SD	Total Average	SD
Shower (day)	2	1	2	1	2	1
Shower duration (min)	12.17	14.78	9.53	8.84	11.34	13.17
Shower (week)	15	8	15	7	15	7
Personal hygiene (day)	7	7	8	6	7	6
Clothes washing (week)	1	1	2	2	2	1
Dishwashing (day)	2	1	3	1	2	1
Dishwashing duration (min)	7.68	10.04	11.97	11.30	9.02	10.53

Note: SD stands for Standard Deviation.

At first, the number of showers per day and per week is the same for both genders, with shower duration differing by 2.64 minutes and with the male population consuming the most water in this regard. With regard to personal hygiene, including shaving, washing hands, and brushing teeth, women show a higher value than men. It is noteworthy that women showed to consume more water than men in domestic activities, as they perform these more frequently and for a longer time.

With regard to the personal hygiene of female respondents (caring for the body), the average frequency was seven times per day, the same value observed in the male sample. According to Table 3, dishwashing was performed twice a day, with an average duration of 9.02 minutes per wash.

The number of times of clothes washing was also evaluated, with the female sample corresponded to twice a week and the male sample to only on cea week. The average total domestic use, in general, was very similar in the male and female samples. The simple and common habit of leaving the faucet running when brushing the teeth, shaving, and washing hands contributes to increasing the average WF, in addition to being an unsustainable idea of water use. Among the 51 interviewees, Figure 1 shows how many of them did or did not turn off the faucet while performing their personal hygiene:

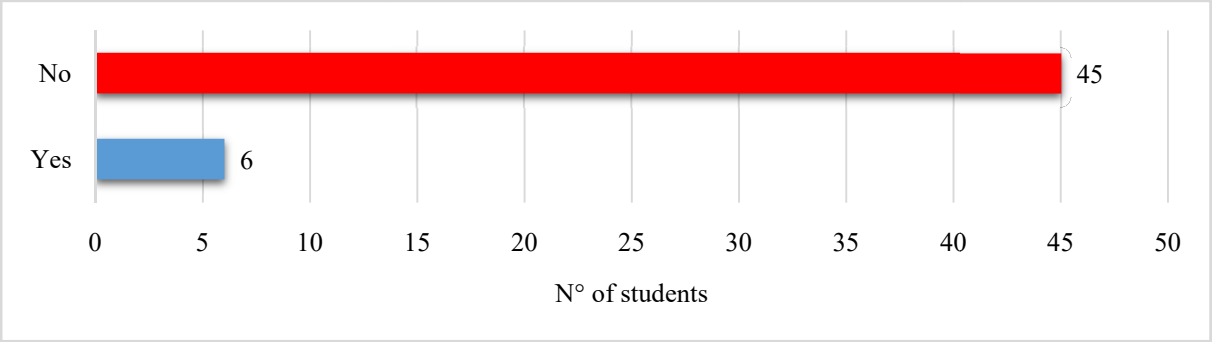

Figure 4. Students'daily practice of keeping the faucet open or closed while brushing theirteeth, washing hands, and shaving. No = Closed faucet, Yes = Open Faucet (provided by the authors)

It is clear that most of the students show awareness by simply turning off the faucet. Of the small number of six people that reported leaving the faucet open, five were men and only one was a woman, thus contributing to the high average WF shown by the male gender. In spite of that, 88.25% of university students were conscious about unnecessary water waste and that they live in a region suffering from water scarcity problems.

3.2.3. Overall analysis

As seen previously, in order to reach the average annual WF value, it is necessary to procure data on food consumption, domestic water use, and industrial water use (processed food) concerning only the individual's income. The average annual WF of the samples was estimated at 1,664 m³, and the influence of the data in question can be seen in Figure 5:

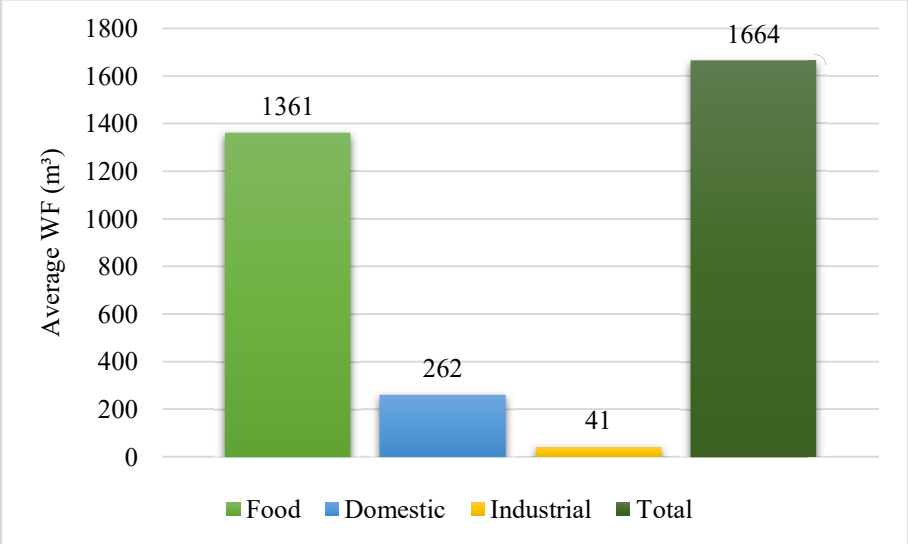

Figure 5. Characterization of the Water Footprint components of the total sample.

The average water footprint of university students living in the municipality of Grajaú, in the central-southernregion of the State of Maranhão, Brazil, was of 1,584.28 m³, and the largest contribution came from food consumption (77.35%) (CAMPOS et al., 2017). It is noted that, in this research, the food component influenced about 81.79% of the 1,664 m³ resultant value. This is followed by the domestic component, with 262 m³, and the industrial component (processed food), with 41 m³/year, which proves to have little influence in the result due to the individual income of the total sample being low. Since food consumption stands out among others, it is possible to observe which food products have the greatest influence on the food component in Figure 6:

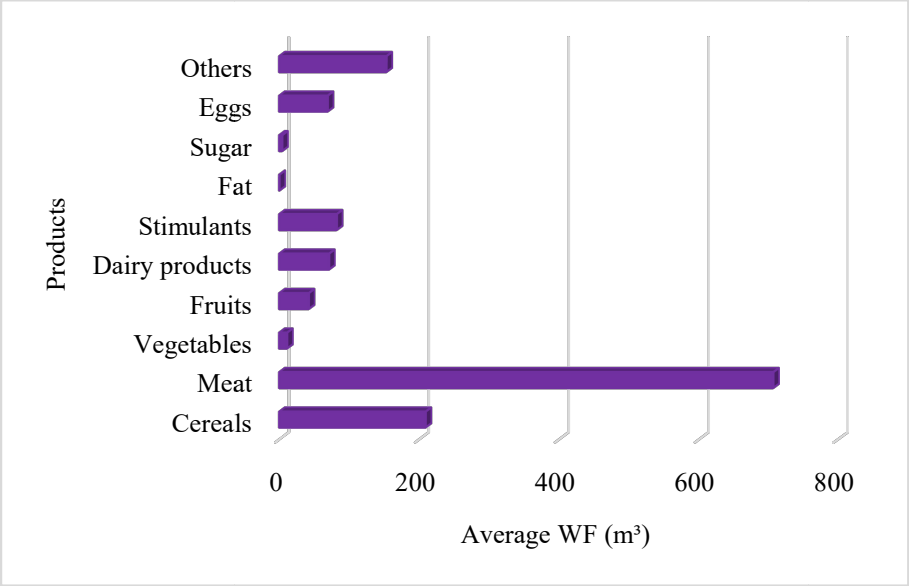

Figure 6. Contribution of each product to the food component.

Meat stands out with an annual average of 706 m³. According to Giacomin and Ohnuma (2017), if the meat is of beef origin, the higher its consumption, the higher the individual's WF. On the other hand, fat is practically insignificant in this case since most of the students opt for a diet with low or medium fat content, and those with a fatty diet are the minority. In order to have a better visualization of the results, a comparison was made between national and global data, as seen in Figure 7:

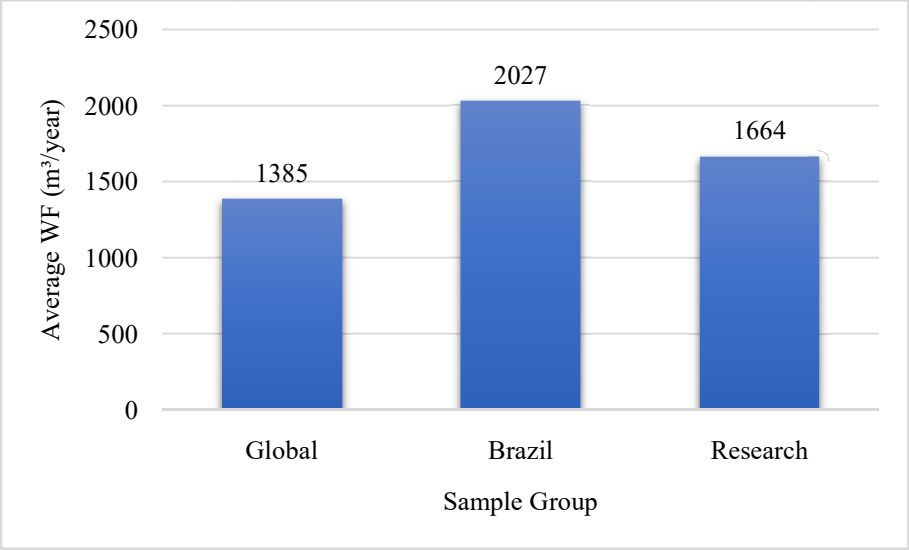

Figure 7. Comparison of the global, national, and the present research's per capita average water footprint.

According to Giacomin & Ohnuma Junior (2017), the global annual average WF is largely composed of the food component, corresponding to1.267 m³/year, followed by the domestic component, with 65 m³/year, and the industrial component (processed food), with 53 m³/year. Bringing it to the national level, Brazil has an annual average WF superior to the world's average and to this research's result, with the food component being the most influential in this value, with 1.926 m³/year, followed by the domestic

component, with 56 m³/year, and the industrial component (processed food), with 45 m³/year. The food and domestic components of this research are higher than the global average, and in the case of Brazil, the average WF in terms of food consumption is higher than that of this research, what does not happen in the world average. These observations can be related to the large beef consumption in Brazil, superior to this research, and the lower worldwide beef consumption, inferior to this research. The domestic component itself was higher than the Brazilian average, a result also observed by Giacomin & Ohnuma Junior (2017), who related this disparity to hygiene habits and even access to water.

The annual average WF of the university students at UFERSA was higher than the worldwide average by 34.51%, whereas the national average was superior to the student's average by 8.09%. For further comparison, it is possible to mention the values of the annual average WF of male and female samples (Table 1), where the male sample, with a value of 1,863 m³/year, is superior to the global and inferior to the national average. On the contrary, the female sample had an annual average WF of 1,232 m³/year, lower than the worldwide average and also than the national one, revealing that the female respondents consume less water than men.

CONCLUSION

The Water Footprint of students from the Interdisciplinary Bachelor's Degree in Science and Technology at UFERSA was estimated at 1,664 m³/year, a value higher than the global per capita annual average and lower than the Brazilian per capita annual average. The most influential component in this value was food, with meat being the product with the highest WF, whereas the industrial component (processed food) was the least influential, being associated with low income. Men had an average WF 51.22% higher than women, highlighting the importance of the gender factor being considered in studies about consumption.

The results obtained highlighted the poor awareness about unnecessary water waste. The water footprint indexes can be significantly reduced by changing habitual practices in terms of nutrition, which is the main component that increases the WF, and domestic water use, so that the consumption pattern of the population does not affect the quality and availability of water to future generations.

The calculation of the water footprint of other courses and even of the entire university is suggested for future research, considering the student's municipality of origin and other questions that may be related to consumption habits.

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