WATER-FOOD-ENERGY-HEALTH: THE IMPORTANCE OF ENVIRONMENTAL SUSTAINABILITY IN THE CIRCULAR ECONOMY

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ABSTRACT

Water, food, and energy are considered necessary segments to achieve the sustainable development goals. Urbanization, population growth, international trade, economic development and climate change will significantly increase the need for these three segments, which is why it is necessary to focus on equal access to water, food and energy, while adhering to the principles of the circular economy. Water is used along the entire agri-food chain, while the generated energy is needed for the production, transport and distribution of food, as well as for the extraction, pumping, lifting, collection, transport, and treatment of water. Urbanization, industrial development, and the general population of citizens also require gradually more water, as well as land for food production and expansion, which entails the need for more and more energy resources. This results in environmental degradation and impairment of environmental sustainability, which leads to the scarcity of resources and impairment of the health of living organisms.
Given the importance of the topic related to the knowledge of biowaste and its management, a survey was conducted to gain insight into whether the general population of citizens is aware that by throwing food, other resources represented in the "water-energy" chain also get wasted, which leads to the disturbance of ecological stability. As expected, the results showed that our society needs further education to be able to manage waste in a sustainable way.

***Keywords*:** *agriculture, circular economy, food waste, water*

INTRODUCTION

Changing people's diets, rapid urbanization, world population growth, and economic development are just some of the factors that result in increased demand for water, energy, and food in today's world. The water, energy and food sectors are interconnected, and any change leads to interdependent relationships. Today, agriculture is the largest consumer of the world's freshwater resources, and more than a quarter of the energy used in the world

is spent on food production and supply. Feeding the global population, which is expected to reach 9 billion people by 2050, will require, according to estimates, an increase in food production by as much as 60 % [1]. In parallel, it is predicted that global energy consumption will increase by approximately 50 % by 2035, and the total amount of water withdrawn for irrigation will increase by 10 % by 2050 [2, 3].

More precisely, the agricultural sector accounts for 70 % of the total global freshwater withdrawal, making it the largest user of water. Water is used for agricultural production, forestry and fishing, along the entire agri-food supply chain, and is used for the production or transport of energy in various forms [3]. At the same time, the production and supply chain of food consumes about 30 % of the total energy consumed at the global level [4]. Energy is needed to produce, transport, and distribute food, as well as to extract, pump, lift, collect, transport, and treat water. Cities, industry, and other users are also demanding more water, energy, and land resources, while also facing the problems of environmental degradation and, in some cases, resource scarcity.

"WATER-FOOD-ENERGY-HEALTH" CHAIN

The food-water-energy chain is a useful concept for describing and understanding the nature of interconnected resource systems that are used to achieve the various social, economic, and environmental goals that constitute sustainable development. In other words, the mentioned chain represents a conceptual approach for the systematic analysis of interactions between the natural environment, human activities, and the use of natural resources in different sectors. The interactions within the chain are complex, dynamic, and interconnected, which is why they cannot be effectively resolved unless they are seen as fully interconnected and interdependent entities. The framework for defining such a single chain with three links [5] focuses precisely on achieving climate protection and ensuring equitable access to water, food, and energy, while at the same time encouraging sustainable growth of the green economy in today's urbanizing world. A better connection of the links in this chain is shown and explained in Figure 1.

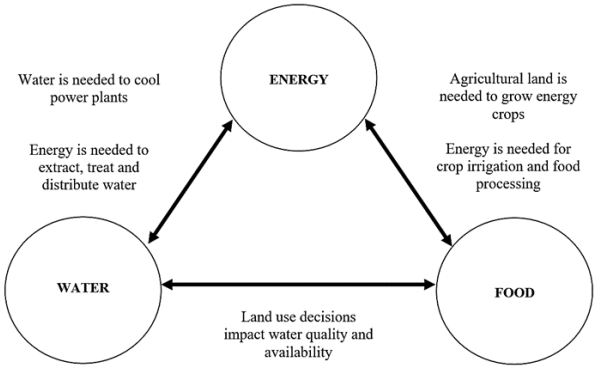


Figure 1. Water-food-energy nexus: modified from [6]

THE IMPORTANCE OF THE CIRCULAR ECONOMY IN ENVIRONMENTAL SUSTAINABILITY

The concept of circular economy is gaining more attention every day and represents an alternative to today's dominant linear system, which boils down to the "take-make-discard" principle. The new European Action Plan for the Circular Economy states that a circular economy is an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimized" [7]. Such an approach has the potential to break the current linear economy of unsustainable production, consumption, and waste generation by encouraging system innovation that designs waste, increases resource efficiency, keeps materials in use and decouples growth from consumption of limited resources. The aforementioned actually helps achieve a healthier balance between the economy, the environment and society, i.e., ecological sustainability, which has as its ultimate goal the establishment of a regenerative circular system.

Therefore, ecological sustainability is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and to ensure long-term quality of the environment, which will lead to long-term balance of the system [8]. Although the above may be considered common sense and perfectly logical, there is very little understanding or application of this in today's politics and decision-making processes. Sustainability is far more complex than simply focusing on the preservation of environmental components, choosing assumed environmentally friendly options or switching to alternative energy sources.

FOOD WASTE

It is safe to say that the currently applied food system is not good for the environment. The modern industrial agriculture has turned this industry into a leading source of greenhouse gas emissions and pollution and is driving species to extinction [9]. The way the food is produced today cannot work in the long term. In today's world, when almost 10 % of the world's population is starving, we are facing a situation where almost 1/3 of the produced food is thrown away [10]. A linear economy traditionally follows a "cradle to grave" system where products are created and used once and then disposed of as waste (most often in landfills) leading to a decrease in the value of materials and products, unstable prices due to resource scarcity and an unstable supply of raw materials due to excessive consumption [7]. The aforementioned also creates huge amounts of waste and generates greenhouse gas emissions, causing environmental degradation and climate change [7]. However, in a circular economy, the food value chain somehow "restores" the overall health of the system in a way that provides ecological and economic benefits, preserves and maintains raw material sources, and reduces the environmental impacts of production and consumption [7]. The process of reusing and recycling waste materials into useful products also increases market competitiveness, adding value to materials that were previously considered waste, which can create new business and innovation opportunities [7]. In addition to useful products, energy can also be obtained. The simplified display of difference between linear and circular economy is shown in Figure 2.

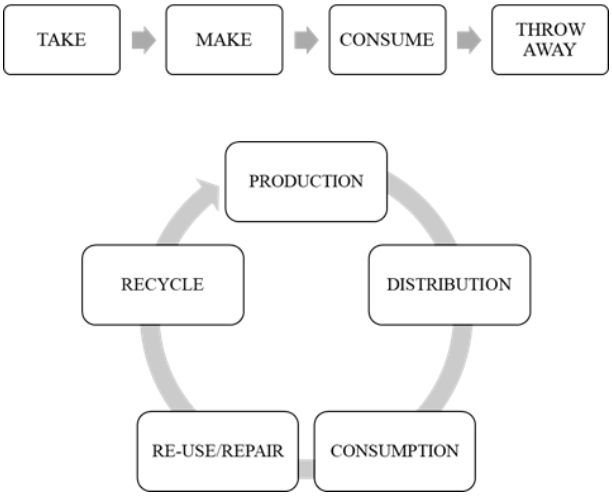


Figure 2. Simplified display of linear (top figure) and circular economy (bottom figure)

According to the available data, households discard approximately 11 % of the total available food at the consumption stage of the supply chain while globally per capita, 121 kg of consumer food is wasted each year, of which 74 kg occurs in households [11]. The transition from a linear system to a circular system is crucial, given the predictions that by 2050 a total of 2/3 of the world's population will live in cities [12] and consume 80 % of all food [13], making urban areas massive producers of waste. Because of the above, stakeholders and entrepreneurs must play a central role in enabling education about waste, as well as developing solutions for rural and urban waste. Globally, it is estimated that a total of 2.5 billion tons of food is lost or wasted annually, of which 1.2 billion tons are wasted by farms [14] and 931 million tons by retail establishments, food services and households [15]. The above leads to the fact that approximately 40 % of all produced food is thrown away [14, 15], and this data suggests that it is necessary to make drastic changes to the current system.

MATERIALS AND METHODS

For the purpose of this paper, the scientific survey method was used to obtain answers for research based on opinions or beliefs. Considering the general importance of the topic related to the knowledge of biowaste and its management, the analysis of the responses obtained provided the relevant answers used for the purpose of this research. The procedure for conducting the research included several stages: questionnaire preparation, questionnaire implementation, transcription, and data analysis. The preparation of the questionnaire included a detailed analysis of the literature and available research on the research problem, as well as the analysis of other secondary information. Based on the analysis, a questionnaire was developed, and the SurveyMonkey platform was chosen because it enabled the inclusion of larger number of respondents. Respondents were randomly selected from higher education institutions - students and employees, from utilities - employees and general population, participants of the Tehnoeko and Water for all conferences, and by invitations through the social networks Facebook and LinkedIn.

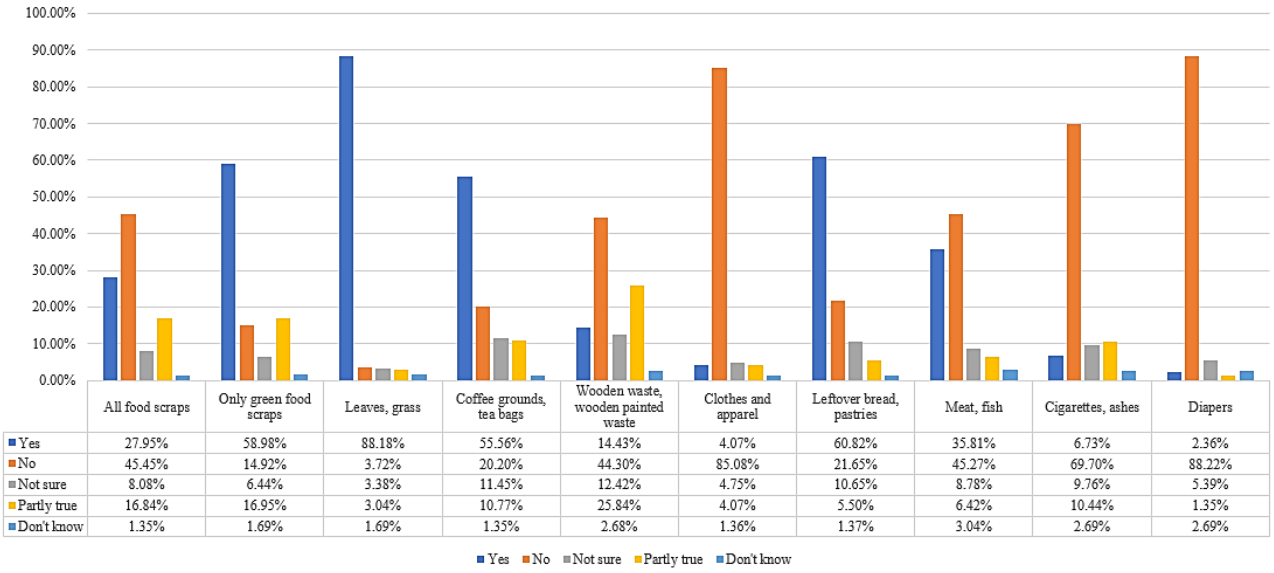
The survey was conducted from March to June 2022. The questions in the survey were of the closed type with offered responses and on individual responses with multiple response options. The entire survey included 28 questions, and for the purposes of this paper, a subset of the questions was selected and those responses relevant to the paper itself were analysed. In addition to the survey, the following scientific research methods were used in writing the paper: analysis and synthesis, inductive and deductive methods, descriptive methods, classification and compilation methods.

The aim of the survey was to determine the level of knowledge about biowaste and the importance of successful management.

ANALYSIS, RESULTS, AND DISCUSSION OF THE CONDUCTED RESEARCH

With the aim of collecting the most reliable data possible, 305 people participated in the research and correctly filled out the questionnaire. The distribution in terms of gender is: men 57 % and women 43 %. As for the age structure, three answers were offered, representing the age range of the respondents. Thus, 50 % of the respondents who filled out the questionnaire fall into the range 18 - 30 years of age, the respondents in the range 31 - 50 years of age account for 35 %, and those in the range 51 - 80 years of age account for 14 % of the respondents. The reason for this distribution is the sample selected for the analysis, which refers to the population of students and respondents who are more motivated in completing this and similar surveys. Since the survey was conducted in several counties, the distribution of respondents by county was determined. The highest percentage of responses, 38 %, was given in the city of Zagreb and 22 % in Zagreb County. Out of the answers with the possibility of registering the county, 20 % were from Međimurje, Zadar and Osijek-Baranja counties.

Regarding the household biowaste separation procedures, 80 % of respondents answered “yes” to the question, while 20 % of respondents answered that they do not separate waste. Comparing this answer with gender, we obtained a result that indicates that, based on the sample studied, 57 % of the female population separates organic waste, while 43 % of the male population does the same. Since a large percentage of respondents answered that they separate organic waste, the next question was whether they know the types of organic waste (Figure 3).



	All food scraps	Only green food scraps	Leaves, grass	Coffee grounds, tea bags	Wooden waste, wooden painted waste	Clothes and apparel	Leftover bread, pastries	Meat, fish	Cigarettes, ashes	Diapers
Yes	27.95%	58.98%	88.18%	55.56%	14.43%	4.07%	60.82%	35.81%	6.73%	2.36%
No	45.45%	14.92%	3.72%	20.20%	44.30%	85.08%	21.65%	45.27%	69.70%	88.22%
Not sure	8.08%	6.44%	3.38%	11.45%	12.42%	4.75%	10.65%	8.78%	9.76%	5.39%
Partly true	16.84%	16.95%	3.04%	10.77%	25.84%	4.07%	5.50%	6.42%	10.44%	1.35%
Don't know	1.35%	1.69%	1.69%	1.35%	2.68%	1.36%	1.37%	3.04%	2.69%	2.69%

Figure 3. Respondents' familiarity with biowaste [N = 305]

For the analysis of their knowledge about biowaste, which is crucial to obtain a suitable sample for further processing with biogas or composting, respondents were offered types of biowaste to answer on a scale from "No" to "I do not know". The results obtained in this way show that there is still some lack of knowledge when it comes to identifying biowaste. Thus, as many as 27.95 % of the respondents answered that biowaste includes all food scraps, which is not true. As for the identification of leaves or grass as bio-waste, 88.18 % are sure that it is bio-waste. As for whether meat and fish belong to organic waste, the distribution of responses is as follows: 45.27 % deny it, while 35.81 % consider it as bio-waste and 8.78 % are not sure. 20 % of the respondents do not consider coffee grounds and tea bags as bio-waste, although public communication on the territory of the Republic of Croatia clearly emphasizes that exactly this type of waste can be disposed of as bio-waste. In the case of clothing and diapers, over 80 % of respondents recognize that it is not bio-waste.

The answers to this question highlight the need to further educate citizens in order to achieve the best possible results in terms of organization and reduction of bio-waste generation. Since the paper shows a clear link between natural resources threatened by, among other things, the irresponsible behaviour of individuals, the distribution of responses to the question of how much waste affects the environment is extremely interesting. With the segment "presence of biowaste in municipal waste" the aim was to see if the respondents were aware of how much biowaste is in municipal waste itself. This question is of great importance because the biowaste fraction plays an important role in recycling and in the circular economy. In the end, 53 % of the respondents answered “less than 50 %” which is precise and proves that general population is very aware of how much biowaste is in municipal solid waste. Only 10 % of respondents answered “I can’t estimate” and only 3 % answered “more than 80 %” (Figure 4).

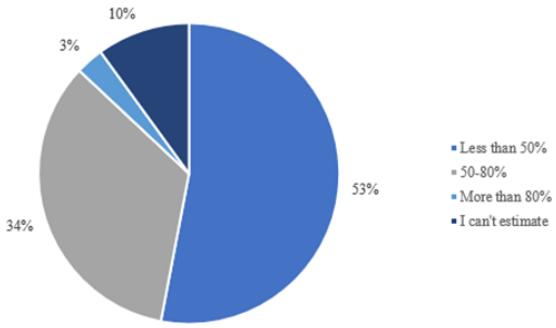


Figure 4. Respondents' assessment of the presence of biowaste in municipal waste [N = 305]

From the responses received, it seems that 73 % of respondents believe that biowaste has a significant impact on the environment. When asked about the impact of biowaste on the environment, i.e., which greenhouse gasses are produced during its decomposition, the response was that 44.92 % of the respondents were aware of the decomposition products of biowaste - methane, carbon dioxide, etc. - while 28.52 % do not know and 26.56 % are not sure about this answer (Figure 5).

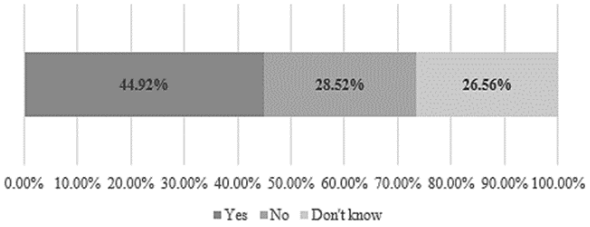


Figure 5. The respondents' familiarity with the phenomenon that the decomposition of biowaste causes the formation of harmful gases such as methane and carbon dioxide [N = 305]

Regarding the efficient disposal of biowaste and the knowledge of the concept of circular economy, the respondents had the opportunity to answer some questions about the processing of biowaste through composting. Thus, the answers to the question about the connection with composting as the oldest method of circular economy were obtained. The answers show that 72.13 % of the respondents consider composting as one of the oldest methods of circular economy, while 20 % are not sure and the rest gave a negative answer (Figure 6).

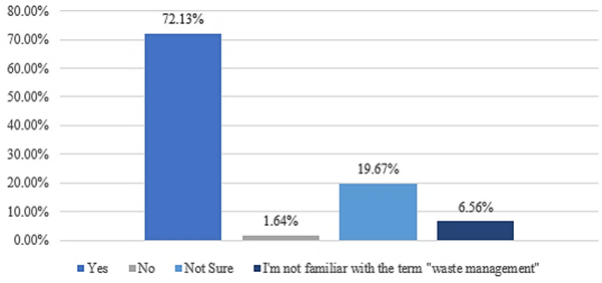


Figure 6. Respondents' answers regarding the opinion on whether the separation of biowaste is the oldest example of circular economy [N = 305]

All respondents who answered that they did not separate organic waste were asked about the reasons and motivation for that. A total of 54 % of the respondents think that they need additional infrastructure (bags or bins), 20 % think that they need additional education, and 18 % are motivated. The rest of the distribution of answers is shown in the Figure 7.

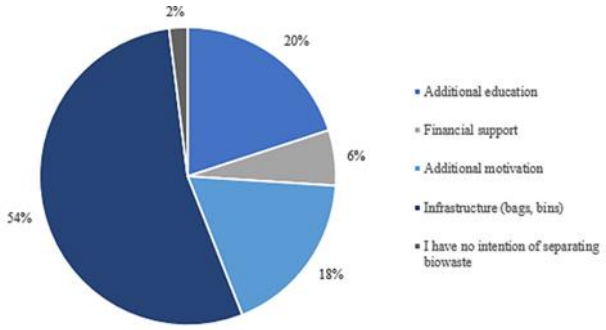


Figure 7. Respondents' answers about their opinion regarding the proper separation of biowaste [N = 305]

CONCLUSION

In today's world, sustainability should be a priority in all aspects of society, so it is important to consider the relationship between basic parameters such as food, energy, and water as the achievement of the sustainable development goals.

The "food-water-energy" chain is the central point for sustainable development and its goals. These three components are closely connected links in a chain in which one component affects the other two, and all three have a direct impact on the health of the ecosystem and all living beings. Agriculture is the largest consumer of the world's freshwater resources. Annually, about 70 % of the world's water is used for agriculture, and more than a quarter of the energy is used for the production and supply of food. As resource constraints become more apparent with climate change, it is necessary to understand the link between the "food-water-energy" chain where waste from one sector becomes a material input for another.

Therefore, the circular economy allows us to reuse resources (and very often even several times) and reduce the need for constant exploitation of new resources.

The paper focuses on research on the treatment of biowaste, i.e., food waste. Since it is a type of waste that can easily be included in the chain of sustainable management within the circular economy, it is important to analyse how familiar people are with it and to what extent it is a priority for them. There is no doubt that people use all available natural resources for food production, and at the same time they do not recognize their limits and importance. The research results show that in the Republic of Croatia there is still a lack of knowledge when it comes to identifying biowaste and that additional education is needed in our society to raise awareness and motivate all stakeholders in the chain of production, supply, and consumption so that the waste can be managed in a sustainable manner.

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