

CHAPTER 8

Zero Waste Approach and Recycling

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Introduction

The environmental problems threaten life as problems arising from factors such as unconscious use of resources, waste and pollution. The wasteful use of resources returns to the environment as waste materials, waste water and polluted air (Tseng et al., 2020). Plastic and electronic waste (e-waste) (Abalansa et al., 2021), microplastics causing bioaccumulation (Sol et al., 2020), excessive use of fossil fuels, deforestation and chemical pollutants (Choi et al., 2019) cause environmental problems in the form of water and air pollution, biodiversity loss and deforestation. Global climate change (Intergovernmental Panel on Climate Change (IPCC) [Intergovernmental Panel on Climate Change (IPCC)], 2018), which is one of the environmental problems with high sensitivity, is another main problem arising from these problems. All these negativities of anthropogenic nature are gradually surrounding us and bringing us closer to environmental bad scenarios that we think will never happen, but gradually we are being dragged step by step. The search for fast and effective solutions to these problems continues in different environmental ethical, rational, economic or oppositional variations. The zero waste approach is one of the perspectives adopted in reducing environmental problems, which is directly related to the problems and grounded in the logic of pollution, waste and recycling.

Zero Waste Approach

The concept of zero waste (ZW) (Connett, 2013a), a pioneering and alternative solution to the waste problem in recent years, is the goal and policy of many fields. The concept of waste can be classified as municipal solid waste (MSW) such as household garbage and organic waste, industrial waste including industrial waste, mining waste and hazardous

waste including radioactive or electronic waste (Zaman, 2015) and waste is generated as a result of all human activities in life (Brunner & Rechberger, 2015). The basis of zero waste is the recovery of waste by abandoning the storage and incineration of waste (Zaman, 2015). Although waste is associated with leftovers and worthlessness after use in the ongoing history of the world, wastes are actually very important as they are our secondary carbon source (Lee et al., 2020). With zero waste, an energy recovery based on reduction, separation and utilization is realized. Zero waste is a key to tackling this crisis, as waste is growing like an avalanche due to human extravagance and waste (Foster, 2021). In the concept of zero waste, it is also planned to minimize consumption and thus prevent the generation of waste in the first place. March 30th has been declared as International Day of Zero Waste by the United Nations. With zero waste, zero environmental/economic/social loss is targeted.

Figure 1.

Zero Waste Concept



With the zero waste approach, waste prevention/proper management is carried out in a flow of preventing waste, using resources more effectively, reducing the amount of waste, collecting it in appropriate systems and using procedures to recover it in order to target zero waste. Its main objective is to reduce waste as much as possible before it goes to landfill and to conserve natural resources. This approach also prevents external dependence on fossil resources (Lee et al., 2020).

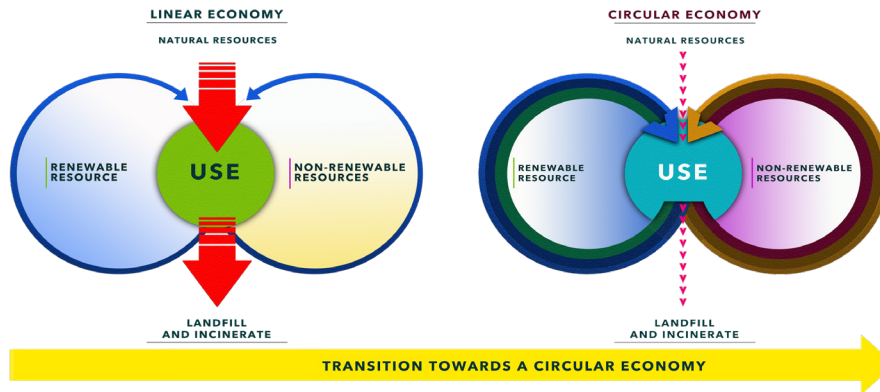
The benefits of the zero waste approach can be categorized under four main headings (Pietzsch et al., 2017):

1. Benefits for Society: Within the zero waste approach, there is an orientation for the public to implement this approach. This orientation indicates a positive effect on the attitude towards the environment. Consumption habits and the disposal/removal and collection of waste are tried to behave in accordance with the approach. This increases recycling and reduces risks to public health.

2. **Economic and Financial Benefits:** Profit increases in direct proportion to the decrease in waste with the zero waste approach. At the same time, environmental regulation costs and time wastage caused by waste are prevented with zero waste logic. Since recycling will occur naturally in zero waste, a profit is also made from these materials. Since zero waste will create new business areas, there is also an increase in income.
3. **Environmental Benefits:** The zero waste approach prevents waste generation and the damage it will cause. The lifespan of landfills is extended, productivity increases as waste will enter production processes as raw materials, and less raw materials are needed. Among the most important impacts of zero waste on the environment is the reduction in the emission of greenhouse gases. While energy is produced from waste, energy consumption is reduced thanks to eco-efficiency together with recycling processes. The zero waste approach ensures the protection of the environment and the reduction of the use of substances harmful to health.
4. **Benefits for Industry and Stakeholders:** Efficiency in the increase in energy and raw materials ensures maximum production with minimum resources, thus increasing the profit obtained. The make-use-dispose cycle for a product is abandoned and products with a longer life cycle are developed. The competitiveness of industry stakeholders increases and a sustainable way of sourcing products can be developed. Industrial symbiosis, the concept of companies in different industries sharing waste and side products with each other to increase resource efficiency and reduce environmental impact, is increasing.

The zero waste approach is closely associated with the economy in terms of its contribution to the economy and the financing of the approach. In particular, the approach is linked to the circular economy. This connection can be explained as zero waste production supports the circular economy, and the circular economy is attracting intense international attention (Kerdlap et al., 2019). The emergence of the circular economy is due to the fact that the linear economy, which made countries with a strong industry until the 20th century financially strong, ceased to function in the 21st century (Sariatli, 2017). Linear and circular economy models are shown in Figure 2 (Potting et al., 2017).

Figure 2.
Linear and Circular Economy



The “take-make-dispose” functioning of the linear economy has evolved into “reduce, reuse and recycle” in the circular economy. Therefore, the circular economy aims to eliminate waste and pollution caused by waste by keeping products and their components in long-term use. In the circular economy, recycling (transforming waste into products/materials for reuse), repair (fixing defects in the functioning/use of products to extend their lifespan), reuse and upcycling (transforming waste into products that are more valuable in material terms) are applied towards zero waste (Ministry of Environment, Urbanization and Climate Change, 2019a).

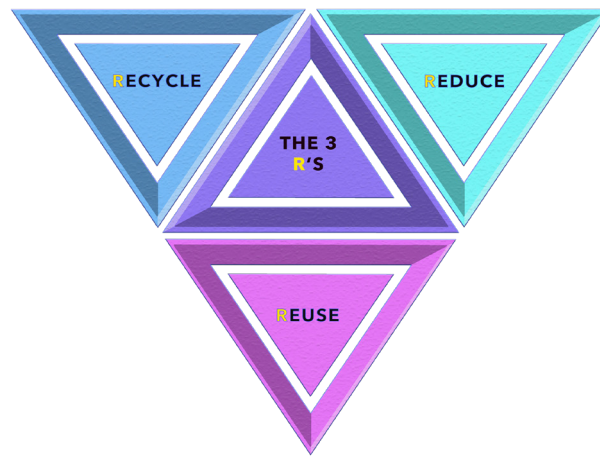
Zero waste management

Under the influence of circular economy in zero waste management, many rules or hierarchical order are applied and expressed by “R”. In the study, 3Rs, 5Rs and 9Rs will be mentioned in chronological order.

The 3Rs of zero waste

The 3R rule, also known as the Waste Hierarchy (Whitmarsh et al., 2018), is the most basic zero waste cycle. The acronym with the Reduce-Reuse-Recycle flow is a minimized path to follow in the zero waste process. Reduce means to first reduce the use of resources in production/consumption; Reuse means to reuse to reduce the amount of waste; Recycle means to return to nature. An illustrative visual for the 3R’s rule is presented in Figure 3.

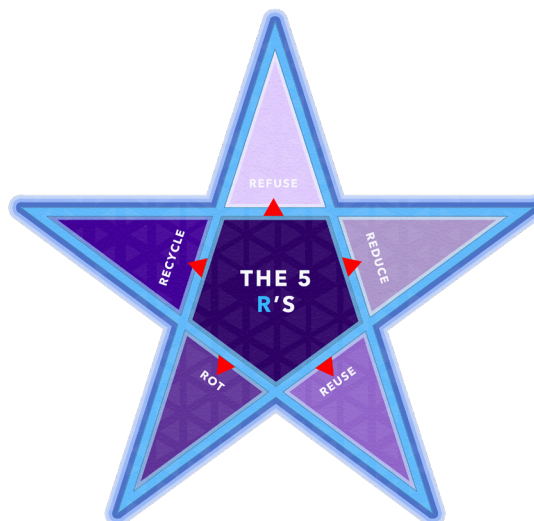
Figure 3.
The 3Rs of Zero Waste



5Rs of zero waste

The 5R rule is a complex flow of additions to the 3R rule's steps. It is widely adopted and provides guidance in transforming zero waste into a lifestyle. The 5R acronym stands for Refuse-Reduce-Reuse-Recycle-Rot flow. Refuse refers to consumption habits, considering the need for a product/material before purchasing it and refusing to consume it if it is unnecessary. Reduce is the simplification of life and reduction of waste. Reuse is avoiding single-use products and opting for long-lasting products. Recycling is the need to consider the possibility of recycling if the R's in the first three steps cannot be met. Rot is the composting of organic waste (Johnson, 2013). An explanatory visual for the 5R rule is presented in Figure 4.

Figure 4.
5Rs of Zero Waste

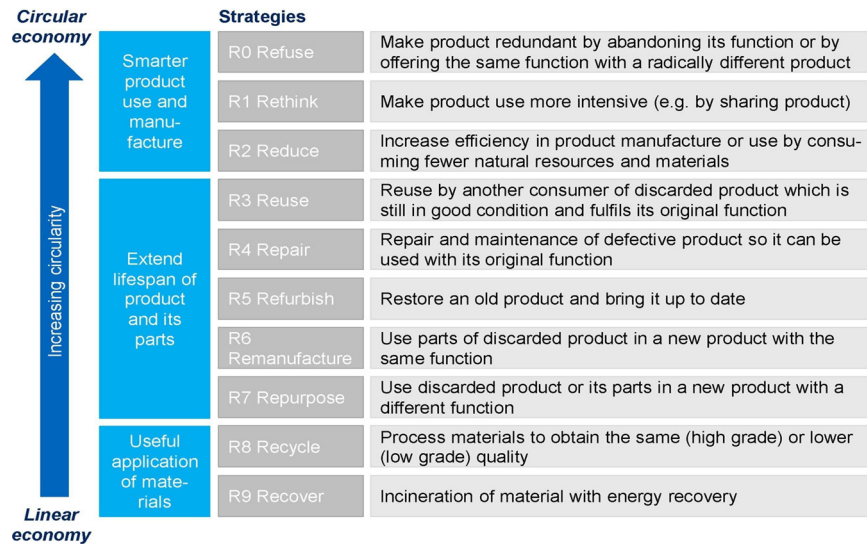


9Rs of zero waste

The fact that the 3Rs, the basic hierarchy in which zero waste is implemented as a progressive system, has been expanded to 5Rs shows that the 5Rs can also be expanded. One of these is 9R and 9R is also related to the circular economy model. In the 9R, there may be differences in the number and steps (Kirchherr et al., 2017; Potting et al., 2017; Van Buren et al., 2016). An explanation of the 9R framework is presented in Figure 5 (Kirchherr et al., 2017; Potting et al., 2017):

Figure 5.

9Rs of Zero Waste



History of Zero Waste Approach

It is considered that a general overview of the chronology of the zero waste approach may be useful in providing clarity. The idea that waste can be a resource that can be reused dates back to the 19th century (Bilgili, 2021). It is quite difficult to obtain precise information on how long the term zero waste has been used. According to Murray (2002), the term zero waste comes from Japanese Total Quality Management (TQM). The term zero waste was first used in 1973 by the American chemist Palmer when he founded ZeroWaste Systems Inc. In ZeroWaste Systems Inc, where the term was used in the public sphere, chemical products that were removed because they would not be reused were reused as raw materials. The organization was successful for the ten years it was in operation. In the late 20th century, the term was adopted by activists and began to be used widely (Warner et al., 2015).

The National Recycling Coalition (NRC) was founded in 1978 with the aim of bringing companies, managers and interested communities together to recycle solid waste (Rootes & Leonard, 2009). In the early 1980s, in the United States of America (USA), the effects of the habit of incinerating garbage on the environment and the health of people, an important part of the environment, were discovered and counter-actions were taken and a great impact was achieved on the way to zero waste approach (Bilgili,

2021). During the 1980s, Daniel Knapp developed the Total Recycling Concept (Connett, 2013b), which concretized that garbage collected in Urban Ore with the idea that it could only be incinerated could be reused.

Having developed the Total Recycling concept in the 1990s, Knapp expanded it abroad and became a major activist for the “Zero Waste No Waste” lifestyle. Assisted by an international network of people involved in zero waste in 1995, Lynn Landes initiated efforts to inform the public about environmentally friendly waste management. In the same year, the Grassroots Recycling Network (GRRN) was founded by the California Resource Recovery Association, the Institute for Local Self-Reliance, and members of the Sierra Club’s Waste Committee to take recycling one step further through education, collaboration and support. This organization became the pioneer of zero waste based practices in the USA (Izeman & Gokaldas, 2004). A major step towards zero waste was taken at the city level in Canberra, the capital of Australia, in 1996. The organization, sloganized as “No Waste By 2010” (Silva et al. 2016), became a milestone in the zero waste approach, with some municipalities in New Zealand and San Francisco adopting zero waste and other cities joining them.

The first significant zero waste milestone of the 2000s was the proposal of the Zero Waste International Alliance (ZWIA). The alliance, held its first official meeting in 2003 due to financial difficulties, has been working on zero waste and continues its activities for a waste-free world with The Eleventh Zero Waste Dialogue in 2022 (ZWIA, 2023).

As a requirement in the 2010s, the zero waste approach has become fashionable and started to be adopted as a lifestyle. It is aimed to internalize the practices and simple rules for the collection and separation of waste at the household level in architecture. Nowadays, the view that the future of the world can be shaped by choosing zero waste products is dominant. Johnson (2013) states that with simple rules, one year of non-recyclable waste produced by a family of four can be as much as a mason jar, and the popularity of this practice is increasing. On the other hand, zero waste activists agree that people gaining this habit and living their lives with zero waste awareness will have a positive impact on our common future (Müller & Schönbauer, 2020).

Fundamentals of Zero Waste Approach

Since the zero waste approach is an environmental protection-based approach that has found a place in many fields, many studies have been conducted in the literature. The zero waste approach has organic links with sustainable development, recycling and environmental awareness.

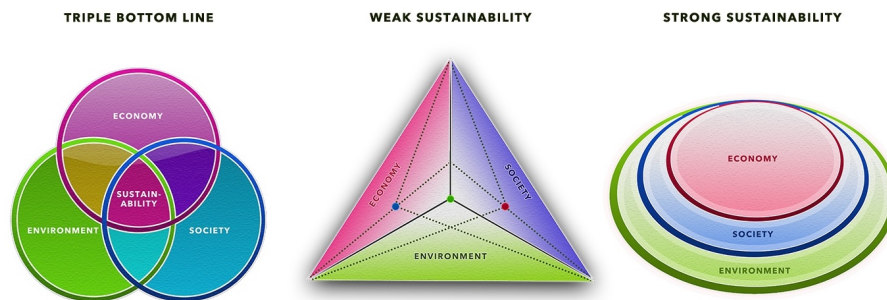
Zero waste approach and sustainable development

The formation of the sustainable development concept began in the 1970s and 1980s when people realized that their unconscious use of the environment and resources threatened

their lives (Bogutz et al., 2021). The idea of sustainable development was formed in the 1980s based on the development of economy, society and environment by supporting each other. The sustainable development concept was defined by The World Commission on Environment and Development (WCED) in the “Our Common Future” report published in 1987 as the use of today’s resources with future generations in mind. Equality between generations is considered. Currently, it has become an important variable in the management policies of states and companies at the international level (Shi et al., 2019). The implementation of sustainable development varies depending on who implements it. The sustainable development process, progressing subjectively rather than objectively, may vary depending on the size of the mass/region, where this mass/region is located in the world and the sector (Jiménez-Martínez & García-Barrios, 2020). Sustainable development consists of three dimensions as economic, social and environmental, and achieving sustainability is based on achieving all dimensions simultaneously (Wu, 2013). According to the positioning and relationships of these dimensions within the system, weak and strong sustainability models are formed (Neumayer, 2003) and an explanatory visual of these models is presented in Figure 6 (Wilson & Wu, 2017):

Figure 6.

Sustainable Development Models



The weakness or strength of the sustainable development model is determined by the discussion within its economic dimension (Bilgili, 2017). Weak sustainability is a human-centered model that thinks that the decrease in the value of environmental elements in the system can be replaced by the economic dimension. According to the model, environmental losses that are accepted from the beginning can be balanced with economic gains and there can be a payback. Strong sustainable development, on the other hand, defends the idea that the environmental dimension is complementary to other dimensions and states that environmental losses cannot be compensated or replaced. At this point, it is understood that strong sustainability is opposed to weak sustainability. In both weak and strong sustainability, the zero waste approach is important. The raw material and financial contribution of sustainable development in the economic dimension, the conservation of natural resources in the environmental dimension and the ideal of leaving a better environment to future generations, and the fair sharing of welfare in the social dimension can be strengthened by the catalyzing effect of the zero waste approach.

Specific paths have been drawn for the realization of sustainable development, which strives to provide a sustainable system structure for our planet. For this purpose, 17 Sustainable Development Goals (SDGs) were set by the United Nations (UN) and its member states in 2015 (Halkos & Gkampoura, 2021). These goals serve as a guide on the journey to achieve sustainable development by 2030. UN Turkey and its partners are working to achieve these goals. These goals are presented in Figure 7 (UN, 2015):

Figure 7.

The Seventeen Sustainable Development Goals



The most relevant sustainable development goals for the zero waste approach are the following:

- SDG 6 (Clean Water and Sanitation) is linked to the zero waste approach through its target of eliminating littering in water by 2030.
- SDG 7 (Affordable and Clean Energy) is linked to the zero waste approach through its content on global energy efficiency by 2030.
- SDG 8 (Decent Work and Economic Growth) is linked to the zero waste approach with its content on economic efficiency, global resource efficiency in consumption and production, and preventing the negative impact of economic development on the environment by 2030.
- SDG 12 (Responsible Consumption and Production) is linked to the zero waste approach with its content on sustainability of natural resources, reducing global food waste, considering the health of the environment in the life cycle of all wastes and their proper disposal, reducing the amount of waste through prevention, reduction, recycling and reuse in accordance with the zero waste approach flow, and living in harmony with nature by 2030.
- SDG 15 (Life on Land) is linked to the zero waste approach through its content on creating a neutral world, protecting biodiversity and ecosystems and preventing degradation by 2030.

Sustainable development is directly included among the specific objectives of

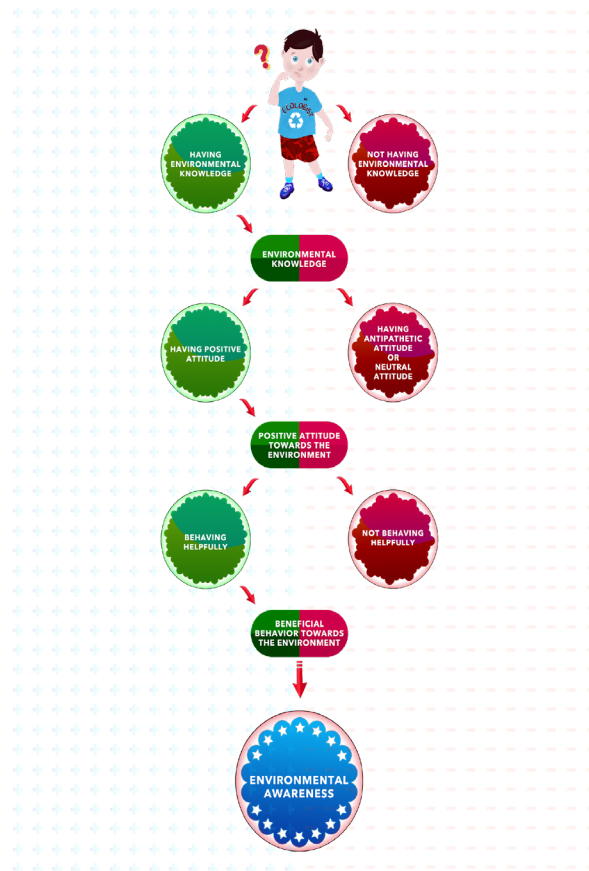
the Turkish science curriculum (Ministry of National Education [MoNE], 2018). The reflections of this aim are seen in the learning outcomes. Activities related to waste hierarchy and zero waste are reflected in textbooks.

Zero waste and environmental awareness

As with the zero waste approach, environmental awareness has a direct relationship with environmental problems. Growth and developments in the economic field have led to overuse of the ecosystem, and while the growth of the global economy has increased rapidly, the world ecosystem has deteriorated at the same rate (Jackson, 2009), resulting in environmental problems. Environmental education mobilizes individuals and raises awareness to solve environmental problems such as waste (Lai, 2018). Environmental education aims to develop knowledge, attitudes and behaviors towards the environment (Ardoin et al., 2015), as well as achievements related to the world (Vasconcelos & Calheiros, 2022). The point that environmental education aims to reach individuals is environmental awareness (Erten, 2019). An environmentally conscious individual is also an environmentally friendly individual, and the process of raising awareness of this individual proceeds in the flow in Figure 8 (Candan-Helvaci & Erten, 2022):

Figure 8.

Environmental Awareness Path



Adopting a zero waste approach as a way of life follows the same path. Cognitive processes such as knowing the zero waste approach and its positive effects on the

environment are within the scope of environmental knowledge. Affective acquisitions such as liking this approach after acquiring knowledge about zero waste and the tendency to ritualize it out of concern for the future of the environment are related to positive attitudes towards the environment. Actions such as categorizing waste and throwing it into appropriate waste bins, applying the 3R, 5R and 9R processes are useful behaviors. At this point, it is seen that environmental awareness is the enabler of the realization of the zero waste approach. Education is at the top of the hierarchy put forward in the researches on transforming zero waste into a way of life and establishing zero waste cities. It is known that environmental awareness is important for zero waste to achieve its goals (Zaman & Lehmann, 2013).

Zero waste approach and recycling

Over one billion tons of solid waste is generated anthropogenically in the world annually, and this waste is dispersed into the environment, causing social, economic and environmental problems (Sharma & Garg, 2019). Zero waste and recycling, attempting to tackle this problem, are associated with realizing the goal of a sustainable world. Looking at the waste management approaches adopted in zero waste (such as 3Rs, 5Rs and 9Rs), it is seen that recycling is included as a step in all of them, that is, recycling is an element of the zero waste approach. The belief that recycling is the right thing to do and has a positive impact on the environment saves energy and materials by making waste reusable (Ackerman, 1997). By reducing waste through recycling, the zero waste approach and sustainable development are served. Waste types in the zero waste approach are as follows Ministry of Environment, Urbanization and Climate Change, 2019b):

Figure 9.

Waste Types



There are two different trends in recycling: Upcycle and Downcycle. To recycle some waste means using more energy and can be reused to make it more valuable (Oyenuga & Bhamidimarri, 2017). Upcycle is the transformation of waste material into a more valuable product. The fact that waste material loses its value/quality when recycled

(Bursaligil, 2019) and can be recycled until it loses its value/quality is called downcycle. The transformation of paper is an example of this.

Recycling is an opportunity for waste to be “reborn”. The way the circular economy works, waste should be in the cycle for as long as possible. By recycling, waste does not have a single life cycle. The number of times materials of some recyclable waste types can be recycled, namely the number of life cycles, is as follows (Table 1):

Table 1.
Number of Recyclable Wastes Recycled

Waste Type	The Number of Life Cycles
Plastic	Theoretically, all plastics can be recycled, but this is an inefficient and costly process. Depending on the plastic resin identification code, plastics can be recycled mechanically 3-7 times (Reed & Chen, 2022).
Glass	They can be recycled unlimited times (Robert et al., 2021).
Paper	They can be recycled a maximum of 6-7 times (Villanueva & Wenzel, 2007).
Metal	They can be recycled almost infinitely. Examples include aluminum (Brough & Jouhara, 2020) and steel (Yellishetty et al., 2011).
Composite Waste	They can be recycled 5 times (Hamad et al., 2013).

The efficiency of recycling, an important step in waste management, is related to the effective use of waste bins. Depending on the type of waste, there may be slight differences between countries in determining the color of the recycling bin or the number of waste classifications. The colors of waste bins in Turkey were standardized by the Zero Waste Regulation published by the Ministry of Environment and Urbanization (the name of the Ministry was changed to the Ministry of Environment, Urbanization and Climate Change) (2019c). Accordingly, the colors of waste bins are as follows:

- Blue color if paper, glass, metal, plastic waste is collected together, dark gray for other waste,
- Blue for paper waste, yellow for plastic waste, green for glass waste, and light gray for metal waste, if they are to be disposed of in separate waste bins,
- The color brown is used in places that provide/serve food where biodegradable waste is high and collected separately.

Conclusion

Along with metropolises, other cities around the world are now growing rapidly and consuming the resources of the ecosystem. Until very recently, unconscious consumption was followed by a huge garbage problem. It was thought that this could be dealt with by burning it, throwing it out of sight or dumping it in the sea. Following the shift from a linear economy, contributing significantly to pollution, to a circular economy and the realization that the environment needs protection, new concepts have entered our lives. Zero waste approach, recycling and sustainable development are important variables that support each other and intersect at certain points in solving the waste problem. Reducing the amount of waste is important in the zero waste approach and thus environmental pollution can be prevented. Recycling ensures efficient use of energy and resources. The combination of recycling and the zero waste approach, as a concept that encompasses it, reflects positively on the welfare level of the society as well as environmental and economic returns. Since environmental, economic and social impacts directly point to sustainable development, an organic link is established between the zero waste approach and sustainable development.

The adoption of the zero waste approach as a way of life and the realization of the efficient functioning of recycling are clearly seen to be possible through environmental education and the acquisition of environmental awareness. The path of knowledge-attitude-behavior should be completed for the zero waste approach and other accompanying concepts through the development/change of environmental awareness. The zero waste approach, perceived as a waste collection task, should be put into action by leaving aside the lifestyle in which individual tasks are not completed for sustainable development and the reductionist perspective towards recycling.

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